based communication system. Similarly, a CAZAC sequence in the time domain may also be used to produce a modified CAZAC sequence in the frequency domain that satisfies the IEEE 802.16 transmit frequency spectrum mask for the guard bands and channel selective filtering.

**[0040]** FIGS. 1A and 1B illustrate one exemplary method of construction of a preamble sequence **170** with a length of 2L in the time domain from a CAZAC sequence **120** with a length of L in the frequency domain. FIG. 1A shows the processing steps according to an exemplary operation flow and FIG. 1B shows the resulting sequence of each processing step in FIG. 1A.

**[0041]** Initially at step **102** in FIG. 1A, a CAZAC sequence of a length L is selected as the basis for construction of the preamble sequence. An example of such a CAZAC sequence **120** in the frequency domain is shown in FIG. 1B, where the sequence **120** is partitioned into a left or first portion C1, a center or second portion C2, and a right or third portion C3. The sizes of C1, C2 and C3 may vary depending on the specific requirements of the left guard band size, the right guard band size, and the length L. Next, the CAZAC sequence **120** in the frequency domain is transformed into a first modified CAZAC sequence **130** and a second modified CAZAC sequence **140**, still in the frequency domain, as shown in FIG. 1B through the processing steps **104** and **106**, respectively. The first and second modified CAZAC sequences **130** and **140** may be carried out in any order or simultaneously.

**[0042]** As illustrated, the first modified CAZAC sequence **130** is the right buffer and is formed by setting the amplitude of each component in C3 to zero and by adding a phase shift factor $e^{j\theta}$ for each component in C2. The frequency components in the left portion C1 are not changed. The second modified CAZAC sequence **140** is the left buffer and is formed by setting the amplitude of each component in

C1 to zero and by adding a phase shift factor $e^{-j\theta}$ for each component in C2. This phase shift is opposite to the phase shift in the first modified CAZAC sequence 130. The right portion C3 is not changed. These processing steps set the amplitudes of the guard bands of the OFDMA spectral components to zeros. In FIG.1A, the Left Buffer is at the left side of the DC component in the frequency spectrum under the Nyquist sampling rate and the Right Buffer is at the right side of the DC component. The DC component is the first frequency component in the first modified CAZAC sequence and is represented by the index "1" in FIG. 1B. Hence, the name designations do not reflect whether they appear on the left or right in FIG.1B. In Step **108**, the amplitude of the DC component is set to zero, if the DC subcarrier is not used, for example, as in the IEEE 802.16 OFDMA system.

**[0043]** Next in step **110**, the first and second modified CAZAC sequences **150** and **140** are joined together in the frequency domain to construct a new sequence **160** of a length 2L, where the C3 of the first modified CAZAC sequence **150** is connected to the C1 of the second modified CAZAC sequence **140** in the frequency domain. In step **112**, an inverse FFT is then performed on the new sequence **160** in the frequency domain to form the near-CAZAC sequence **170** as the preamble sequence in the time domain.

**[0044]** The above process forms one preamble sequence for identifying a particular cell sector or segment in a particular cell among many segments of adjacent cells within the radio ranges of the base stations in these adjacent cells. Different preamble sequences for different IDcells and different segments may be generated in different ways. As one exemplary implementation, a new preamble sequence may be generated by first performing a cyclic shift of components of the initial CAZAC sequence **120** in the frequency domain to produce a new initial CAZAC sequence.

FIG. 2A illustrates this cyclic shift of the frequency components to generate two new CAZAC sequences **210** and **220** from the initial CAZAC sequence **120** of L components in the frequency domain. Then the two new initial CAZAC sequences **210** and **220** are processed according to step **104** to step **112** in FIG. 1A, respectively, to produce two corresponding near-CAZAC sequences in the time domain. Under this approach, a total of L different preamble sequences can be generated from the cyclic shift of the L components.

**[0045]** FIG. 2B shows another way of generating different preamble sequences based on a cyclic shift of CAZAC sequence components in the time domain. The components of the near-CAZAC preamble sequence **170** generated from an initial CAZAC sequence **120** can be shifted in time to produce different near-CAZAC preamble sequences in time. As illustrated, the cyclic shift of preamble sequence **170** is used to generate two new preamble sequences **230** and **240**. A total of 2L different preamble sequences can be generated from the cyclic shift of the 2L components. These sequences are sufficient to represent all IDcell and cell sectors/segments.

**[0046]** As an example, FIG. 3 shows a 3-tier cell design used in various OFDM or OFDMA systems where a base station can reach three layers of cells and each cell may have up to 6 cell segments and 6 adjacent cells. Hence, under this specific 3-tier cell design, the maximum number of cell segments in the total of 19 reachable cells from one base station is 19X6 = 114. Therefore, a CAZAC sequence of a length of at least 114 can have sufficient number of sequences for carry IDcell and segment numbers based on the above described implementation.

**[0047]** For illustration purpose, an exemplary OFDMA system with a 1024-FFT (Fast Fourier Transform) size, a left guard band of 87 FFT bins, commonly referred to as subcarriers, a right guard band of 86 subcarriers, and a configuration of four preamble carrier-sets is described here. For those skilled in the art, different values for the FFT size, the left and right guard band sizes, or the number of preamble carrier-sets may be used.

**[0048]** In the case of four-sector configuration in which each cell contains four sectors, one way to generate preambles is to divide the entire 1024 subcarriers into four equal subset, arranged in an interlaced manner. Effectively, there are four preamble carrier-sets. The subcarriers are modulated, for example, using a level boosted Phase Shift Keying (PSK) modulation with a CAZAC sequence cyclically shifted with a code phase defined by IDcell and Segment, which are the base station identity. More specifically, the four preamble carrier-sets are defined using the following formula:

$$PreambleCarrierSet_m = m+4*k \qquad (18)$$

where $PreambleCarrierSet_m$ specifies all subcarriers allocated to the specific preamble, $m$ is the number of the preamble carrier-set indexed as 0, 1, 2, or 3, and $k$ is a running index. Each segment of a cell is assigned one of the four possible preamble carrier-sets in this particular example.

**[0049]** To further illustrate, let the 1024-FFT OFDMA sampling rate be 20 MHz at the Nyquist rate. The basic preamble time-domain symbol rate is 10MHz. The frequency-domain components are composed of a Chu sequence described in Equations (1) and (2) of length 128 that is zero-inserted to length 512 by inserting CAZAC symbols one for every four frequency bins. In the following, it can be established that a time-domain CAZAC sequence at the symbol rate (10MHz) introduces a CAZAC sequence in frequency domain after spectrum folding. Its frequency-domain CAZAC sequence can be computed using a 512-FFT operation instead of a 1024-FET operation.

**[0050]** Let $\mathbf{h}=[h_0,h_1,...,h_{2L-1}]^T$ be a time-domain waveform of length 2L at the Nyquist rate. Its spectral components can be computed using Equation (14) as follows:

$$\mathbf{g}_h=\sqrt{2L}\mathbf{F}_{2L}\mathbf{h}=\begin{bmatrix}\mathbf{g}_{HL}\\ \mathbf{g}_{HU}\end{bmatrix} \qquad (19)$$

where $\mathbf{F}_{2L}$ is the Fourier transform matrix of dimension $2L$x$2L$ and $\mathbf{g}_{HL}$ and $\mathbf{g}_{HU}$ are lower and upper portions of the frequency spectrum. When subsampling (i.e., down sampling) the waveform at the mobile station receiver at the symbol rate which is one half of the Nyquist rate, a spectrum folding in the frequency domain is introduced in the sampled signal at the mobile station. Let $\mathbf{h}_E=[h_0,h_2,h_4,...,h_{2L-2}]^T$ be the subsampled sequence of the even-numbered samples and $\mathbf{h}_O=[h_1,h_3,h_5,...,h_{2L-1}]^T$ the odd-numbered samples. Define **S** to be the matrix operation that rearranges matrix columns into even and odd columns:

$$\mathbf{S}=[\mathbf{e}_0 \quad \mathbf{e}_2 \quad \cdots \quad \mathbf{e}_{2L-2} \vdots \mathbf{e}_1 \quad \mathbf{e}_3 \quad \cdots \quad \mathbf{e}_{2L-1}]. \qquad (20)$$

Therefore,

$$\begin{bmatrix}\mathbf{h}_E\\ \mathbf{h}_O\end{bmatrix}=\mathbf{S}^{-1}\mathbf{h}=\frac{1}{\sqrt{2L}}\mathbf{S}^{-1}\mathbf{F}_{2L}^H\begin{bmatrix}\mathbf{g}_{HL}\\ \mathbf{g}_{HU}\end{bmatrix} \qquad (21)$$

**[0051]** When simplified, the following can be derived:

$$\mathbf{h}_E=\frac{1}{\sqrt{L}}\mathbf{F}_L^H(\frac{\mathbf{g}_{HL}+\mathbf{g}_{HU}}{2})=\frac{1}{\sqrt{L}}\mathbf{F}_L^H\mathbf{g}_{HE} \qquad (22)$$

$$\mathbf{h}_O=\frac{1}{\sqrt{L}}\mathbf{F}_L^H\mathbf{\Lambda}_\varepsilon(\frac{\mathbf{g}_{HL}-\mathbf{g}_{HU}}{2})=\frac{1}{\sqrt{L}}\mathbf{F}_L^H\mathbf{g}_{HO} \qquad (23)$$

where $\mathbf{g}_{HE}$ and $\mathbf{g}_{HO}$ are spectral components of the even and odd sample sequences, and $\mathbf{\Lambda}_{\varepsilon} = diag\{1, \varepsilon, \varepsilon^2, \ldots \varepsilon^{L-1}\}$, $\varepsilon = \exp(j\pi / L)$.

**[0052]** Equations (22) and (23) can be used to derive the following spectrum folding relationships:

$$g_{HE}(k) = \frac{g_{HL}(k) + g_{HU}(k)}{2} \quad (24)$$

$$g_{HO}(k) = \varepsilon^k \left(\frac{g_{HL}(k) - g_{HU}(k)}{2}\right) \quad (25)$$

**[0053]** Equations (24) and (25) sum up the spectral folding phenomenon of the waveform subsampling of the downlink preamble signal at the mobile station. Hence, the subsampling is likely to introduce frequency folding, or spectrum aliasing. If the subsampling frequency is sufficiently low when sampling a received preamble sequence in time, the spectral components of the sampled signal overlap, resulting in the frequency folding. In some OFDM/OFDMA applications, this phenomenon is intentionally avoided in order to perfect the signal restoration.

**[0054]** The spectral folding via sub-sampling at the mobile station receiver, however, may be advantageously used as a technique to recover the CAZAC property of a unfortunately truncated CAZAC sequence due to spectral filtering described above. This is in part based on the recognition that, if the coherent channel bandwidth is much smaller than the sub-sampled signal bandwidth, there is little adverse effect to the preamble signals (not true for voice or data signals, however). As an example, a 1/2 sub-sampling can be used to intentionally create a "folded" or "aliased" spectrum that is exactly the CAZAC sequence. By virtue of the time-frequency duality property of a CAZAC sequence, the corresponding sequence in the time-domain is also a CAZAC sequence. Although the sub-sampled sequences maintain the desired CAZAC property, the non-sub-sampled (transmitted) sequences do not maintain the CAZAC property. For example, the PAPR is about 4.6 dB when the phase rotation shown in FIG. 1B is $\theta = \pi/3$. To achieve lower PAPR, the phase $\theta$ can be adjusted to $\pi/4$. Although the "folded spectrum" is no longer an exact CAZAC sequence in the frequency domain, the resulting time domain waveform has a low PAPR of 3.0dB.

**[0055]** This technique to preserve CAZAC sequence characteristics of the folded frequency spectrum in both frequency and time domains is now further described below.

**[0056]** Following on the above example, the above described construction of the CAZAC sequence in FIGS. 1A and 1B is used to reconstruct the 1024 subcarriers using the 4:1 zero-inserted 512-element frequency-domain CAZAC sequence of a 128-element Chu sequence such that, after the spectrum folding due to the down sampling at the mobile station receiver, the folded 512 spectral components form the frequency-domain CAZAC sequence of the Chu sequence.

**[0057]** Let $\mathbf{c}_{chu}$ denote the time-domain 512-element CAZAC sequence and its frequency-domain CAZAC sequence be denoted as $\mathbf{g}_{chu}$ (512 elements) and expressed as

$$\mathbf{g}_{chu}(4n+k) = \begin{cases} e^{j\frac{\pi n^2}{128}}, & n = 0,1,\ldots,127 \\ 0, & otherwise \end{cases}, \quad (26)$$

where $k$ denotes the fixed preamble carrier-set. $\mathbf{c}_{chu}$ and $\mathbf{g}_{chu}$ form a time-frequency pair and their relationship is expressed as

$$\mathbf{c}_{chu} = IFFT_{512}(\mathbf{g}_{chu}) . \quad (27)$$

**[0058]** In IEEE P802.16e/D3, the 1024-FFT OFDMA has 86 guard subcarriers on the left-hand side and 87 on the right-hand side. The DC (direct current) subcarrier resides on index

512. The construction procedures of assembling $\mathbf{g}_L$ and $\mathbf{g}_R$ of the left- and right-hand sides 1024-FFT OFDMA preambles are

$$g_R(1:86) = g_{Chu}(1:86) \quad (28)$$

$$g_R(87:425) = e^{-j\pi/3} g_{Chu}(87:425) \quad (29)$$

$$g_R(426:512) = 0 \quad (30)$$

$$g_L(1:86) = 0 \quad (31)$$

$$g_L(87:425) = e^{j\pi/3} g_{Chu}(87:425) \quad (32)$$

$$g_L(426:512) = g_{Chu}(426:512) \quad (33)$$

In addition, if the DC component is not used, for example in IEEE 802.16 OFDMA system, then

$$g_R(1) = 0 \quad (34)$$

The final reconstructed 1024-FFT frequency components of the preamble symbol is

$$q(1:1024) = [g_R(1:512) \vdots g_L(1:512)] \quad (35)$$

and its final reconstructed 1024 time-domain preamble sequence at Nyquist rate is

$$\mathbf{c} = IFFT_{1024}(\mathbf{q}) . \quad (36)$$

**[0059]** After spectrum folding due to subsampling at symbol rate in the time domain, the resulting folded frequency spectral components of even-numbered samples are, based on Equation (24),

$$g(1:512) \sim g_L(1:512) + g_R(1:512) \quad (37)$$

The overlapped area has the following relationship

$$g(87:425) \propto (e^{j\pi/3} + e^{-j\pi/3}) g_{Chu}(87:425) = g_{Chu}(87:425) . \quad (38)$$

**[0060]** Equations (28)-(33) suggest that the CAZAC property is preserved. Note also that overlapped area of odd-numbered samples has the following relationship according to Equation (25):

$$g'(87:425) \sim (e^{j\pi/3} - e^{-j\pi/3}) g_{Chu}(87:425) = j\sqrt{3} g_{Chu}(87:425). \qquad (39)$$

Therefore, the reconstructed time sequence has the lowest PAPR for the even-numbered sampled sequences and very low PAPR for the odd-numbered sampled sequences that only slightly deviate from the exact CAZAC sequences due to the guard bands requirement. The nominal PAPR of the time-domain sub-sampled sequences is less than 3dB at all different code-phases. The frequency components of the reconstructed 1024-FFT in the preamble sequence have constant amplitudes and thus may be used to facilitate the channel estimation.

**[0061]** In one implementation, fast cell searching can be performed as follows: The IDCell and Segment allocation to different sector are done via assigning different CAZAC code phases of cyclic shift of the $\mathbf{g}_{chu}$ sequence and forming the time-domain sequence in the same manners described in Equations (28)-(36).

**[0062]** FIG. 4 shows an example of the subcarrier allocations of the preamble sequence in segment 0.

**[0063]** FIG. 5 shows the corresponding amplitude of the waveform in the time domain. Because the frequency-domain spectral components form a CAZAC sequence, a new sequence formed by cyclically shifting the sequence of the spectral components, in the time domain (subsampled) also forms a CAZAC sequence. Due to the well-defined zero-autocorrelation properties, identifying code-phase and thereby identifying IDcell and segments can be made with optimal decision. The cyclic shifting of the order of different components in the PN sequence permits the MSS to retain one copy of the PN sequence without other shifted sequences. A simple look-up table may be used to provide the relationships between all sequences based on the cyclic shifting and the corresponding base stations and the associated cell sectors. Therefore, the present technique enables fast cell searching.

**[0064]** A CAZAC sequence has been used for channel sounding whereby the CIR (channel impulse response) can be uniquely determined because of the zero-autocorrelation property of the CAZAC sequence. In OFDMA or OFDM systems, we can use it not only to identify CIR but also to achieve fine timing synchronization whereby we can exclusively remove GI (guard interval) so as to minimize ISI.

**[0065]** FIG. 6 shows the time waveform of the result of matched filtering of the near-CAZAC sequence (spaced by symbols) without channel distortion and FIG. 7 shows the result of matched filtering of the near-CAZAC sequence in a multipath fading environment. The waveforms are CIRs of the tested RF multipath environment.

**[0066]** For a sensible and low-cost TCXO, the clock precision is usually about 5ppm for both the base station and the mobile station in some systems. At 10GHz the frequency offset becomes 50kHz. For a 11kHz FFT spacing it spans 5 subcarriers in both directions.

**[0067]** The near-CAZAC sequence in the frequency domain can be used to simplify identification of peak positions of the cross-correlation. For example, for a sensible and low-cost TCXO, the clock precision is usually about 5ppm (BS+SS). At 10GHz carrier frequency the frequency offset becomes 50kHz. For an 11kHz FFT spacing it spans 5 subcarriers in both directions. We can assign code phase for different sectors that have different IDCells and segments by at least 10 code phase apart that accommodates ±5 subcarrier drifts due to large frequency offset, then we can easily perform frequency offset cancellation to within 11kHz. Further fine correction utilizes pilot channel tracking.

**[0068]** The PAPR of the current preamble design is 4.6dB. The PAPR can be further reduced by selecting different phase factor in Equations (29) and (32). For example, if we change the phase factor in Equations (29) and (32) from $e^{j\pi/3}$ to $e^{j\pi/4}$ as shown in Equations (40) and (41), then PAPR is reduced to 3.0dB by compromising the CAZAC performance.

$$g_R(87:425) = e^{-j\pi/4} g_{Chu}(87:425) \qquad (40)$$

$$g_L(87:425) = e^{j\pi/4} g_{Chu}(87:425) \qquad (41)$$

**[0069]** Only a few implementations are described. Modifications, variations and enhancements may be made based on what is described and illustrated here.

CLAIMS

What is claimed is:

1. A method for communications based on OFDM or OFDMA, comprising:

selecting an initial CAZAC sequence;

modifying the initial CAZAC sequence to generate a modified sequence which has frequency guard bands; and

using the modified sequence as part of a preamble of a downlink signal from a base station to a mobile station.

2. The method as in claim 1, wherein the initial CAZAC sequence is a Chu sequence.

3. The method as in claim 1, wherein the initial CAZAC sequence is a Frank-Zadoff sequence.

4. The method as in claim 1, further comprising:

using an order of frequency components of the preamble sequence to identify a base station transmitter; and

using different orders of frequency components of the preamble sequence based on a cyclic shift of the orders of frequency components to identify different base station transmitter.

5. The method as in claim 4, further comprising using different orders of frequency components of the preamble sequence based on a cyclic shift of the orders of frequency components to further identify different cells sectors in each cell of a base station.

6. The method as in claim 1, wherein the modifying of the initial CAZAC sequence comprises:

selecting frequency components in the initial CAZAC sequence to create the frequency guard bands; and setting amplitudes of the selected frequency components in the initial CAZAC sequence to zero to create frequency guard bands.

7. The method as in claim 6, wherein the modifying of the initial CAZAC sequence further comprises:

adjusting a phase of a selected group of adjacent frequency components in the initial CAZAC sequence whose amplitudes are not changed.

8. The method as in claim 1, further comprising:

sub sampling the preamble at a mobile station receiver to create a frequency overlap and to minimize a variation in amplitude.

9. A method for communications based on OFDM or OFDMA, comprising:

selecting a CAZAC sequence of a length L in frequency which includes spectral components in first, second and third sequential portions in frequency;

modifying the CAZAC sequence to produce a first modified sequence by setting amplitudes of spectral components in the first portion of the CAZAC sequence to zeros and adding a first phase shift on spectral components of the second portion of the CAZAC sequence, without changing the third portion;

modifying the CAZAC sequence to produce a second modified sequence by setting amplitudes of spectral components in the third portion of the CAZAC sequence to zeros and adding a second phase shift spectral components of the second portion of the CAZAC sequence, without changing the first portion;

combining the first and second modified sequences to form a combined sequence in frequency of a length 2L, wherein the first portion from the first modified sequence is positioned next to the third portion from the second modified sequence in the combined sequence; and

performing an inverse fast Fourier transform on the combined sequence to generate a first preamble sequence in time for OFDM or OFDMA communication.

10. The method as in claim 9, further comprising setting widths of the first and third portions of the CAZAC sequence to achieve desired OFDMA guard bands.

11. The method as in claim 9, further comprising setting an amplitude of a DC subcarrier to zero when the DC subcarrier is not used.

12. The method as in claim 9, further comprising making the first phase shift and second phase shift to be opposite to each other.

13. The method as in claim 9, further comprising:

prior to generation of the first and the second modified sequences, performing a cyclic shift of frequency components of an initial CAZAC sequence to produce the CAZAC sequence which is subsequent used to generate the combined sequence; and

using an order of the spectral components of the CAZAC sequence to identify at least an identity of a base station which transmits the first preamble sequence as part of a downlink signal.

14. The method as in claim 13, further comprising using the cyclic shift of frequency components of the initial CAZAC sequence to generate different orders of the frequency components in frequency to identify at least different base stations and different cell sectors of cells of the different base stations.

15. The method as in claim 9, further comprising:

performing a cyclic shift of time components of the first preamble sequence to generate a second preamble sequence.

16. The method as in claim 15, further comprising using the cyclic shift of time components of the initial CAZAC sequence to generate different orders of the time components to identify at least different base stations.

17. The method as in claim 16, further comprising using the cyclic shift of time components of the initial CAZAC sequence to generate different orders of the time components to represent, in addition to the different base stations, different cell sectors of cells of the different base stations.

18. The method as in claim 9, wherein the initial CAZAC sequence is a Chu sequence.

19. The method as in claim 9, wherein the initial CAZAC sequence is a Frank-Zadoff sequence.

20. A method for communications based on OFDM or OFDMA, comprising:

sub sampling a preamble signal in a downlink signal received at a mobile station receiver to create a frequency overlap and to minimize a variation in amplitude, wherein the preamble signal is generated from an initial CAZAC sequence to preserve properties of the initial CAZAC sequence and has frequency guard bands; and

extracting an order of signal components in the preamble signal to identify at least a base station at which the downlink signal is generated.

21. The method as in claim 20, wherein the initial CAZAC sequence is a Chu sequence.

22. The method as in claim 20, wherein the initial CAZAC sequence is a Frank-Zadoff sequence.

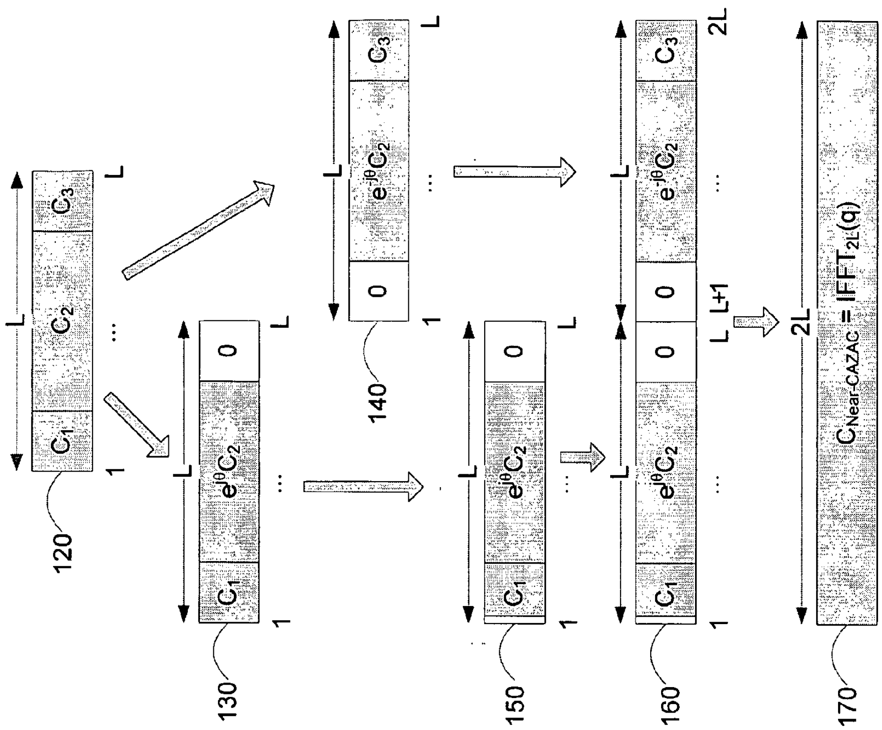

120
C1
C2
C3
1
L
130
C1
e^jθC2
0
140
0
e^jθC2
C3
150
160
L+1
2L
170
C_Near-CAZAC = IFFT_2L(q)

FIG. 1B

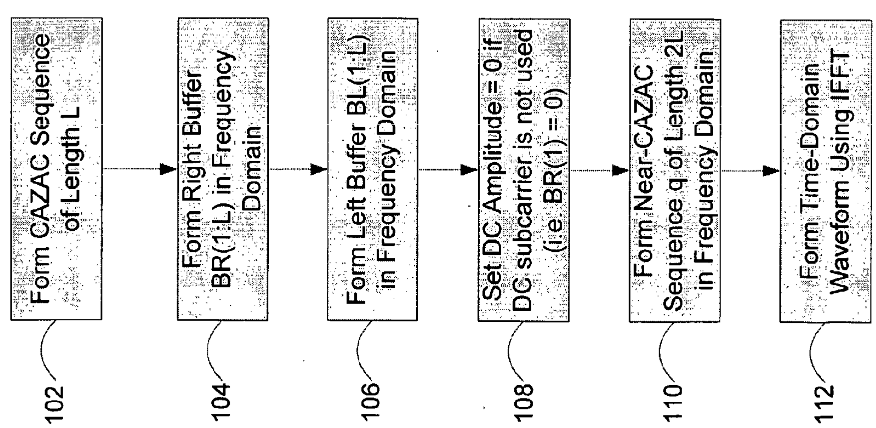

102
Form CAZAC Sequence of Length L
104
Form Right Buffer BR(1:L) in Frequency Domain
106
Form Left Buffer BL(1:L) in Frequency Domain
108
Set DC Amplitude = 0 if DC subcarrier is not used (i.e. BR(1) = 0)
110
Form Near-CAZAC Sequence q of Length 2L in Frequency Domain
112
Form Time-Domain Waveform Using IFFT

FIG. 1A

FIG. 2B

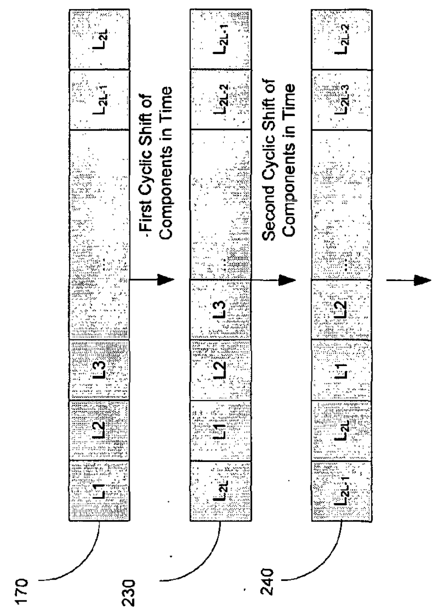
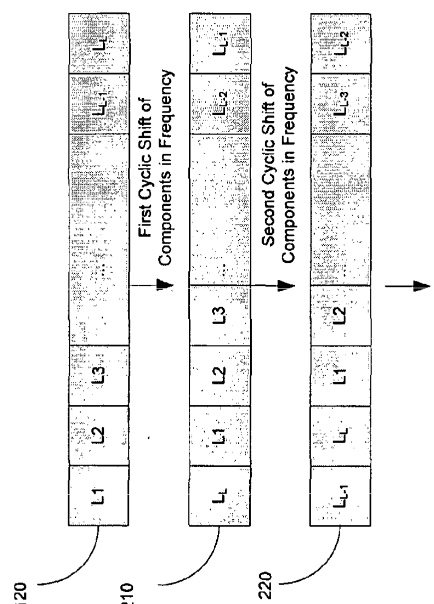

170
230
240
L1
L2
L3
$L_{2L-1}$
$L_{2L}$
First Cyclic Shift of Components in Time
Second Cyclic Shift of Components in Time

FIG. 2A


120
210
220
L1
L2
L3
$L_{L-1}$
$L_L$
First Cyclic Shift of Components in Frequency
Second Cyclic Shift of Components in Frequency

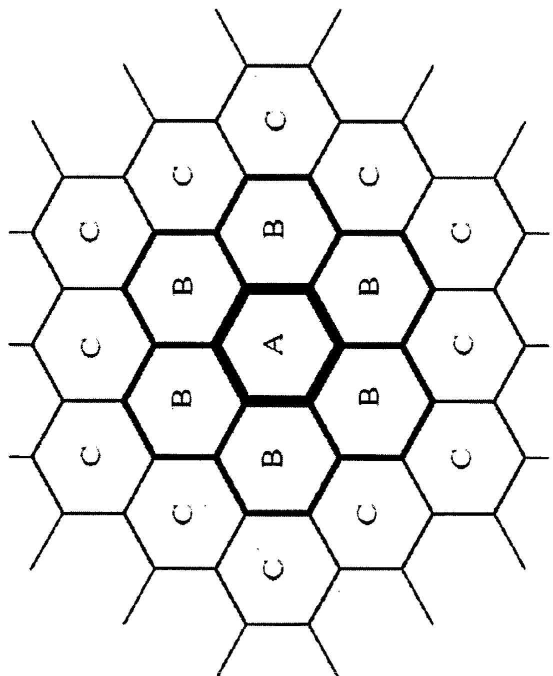



FIG. 3

FIG. 4

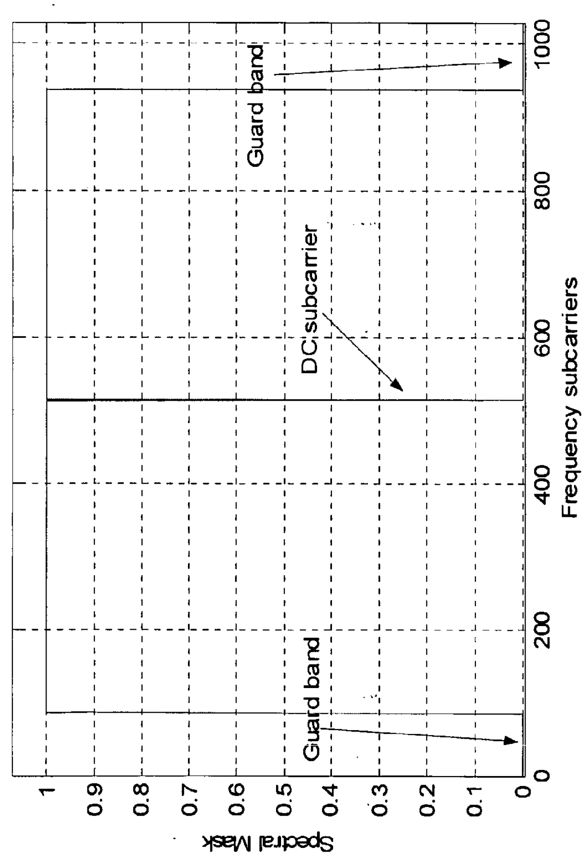

Guard band
DC subcarrier
Guard band
Spectral Mask
Frequency subcarriers
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
200
400
600
800
1000

FIG. 5

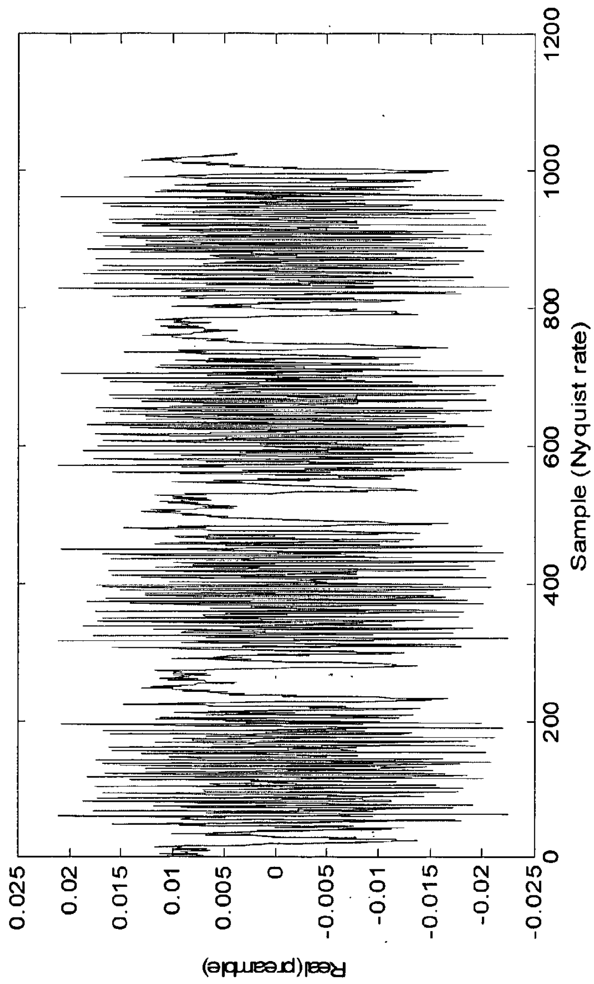

Real (preamble)
0.025
0.02
0.015
0.01
0.005
0
-0.005
-0.01
-0.015
-0.02
-0.025
0
200
400
600
800
1000
1200
Sample (Nyquist rate)

FIG. 6

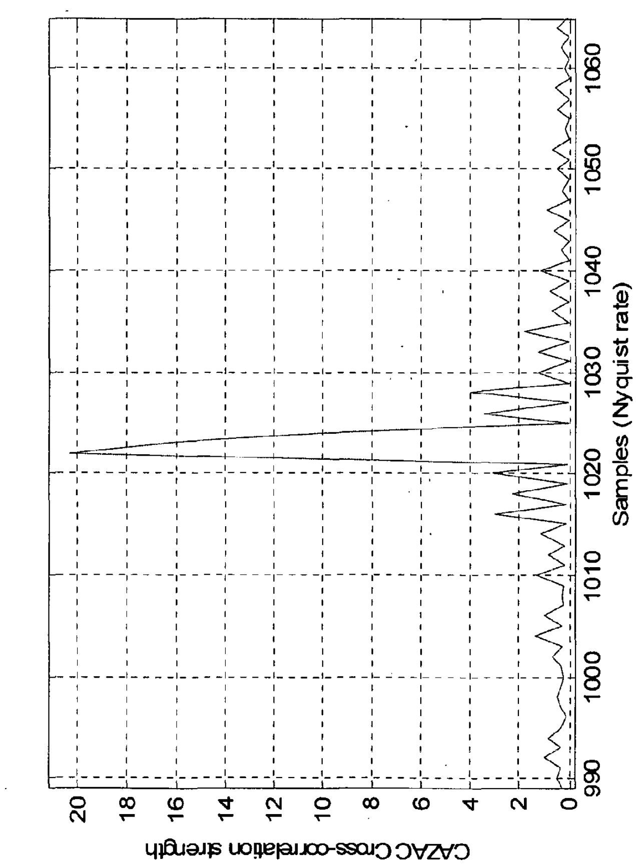
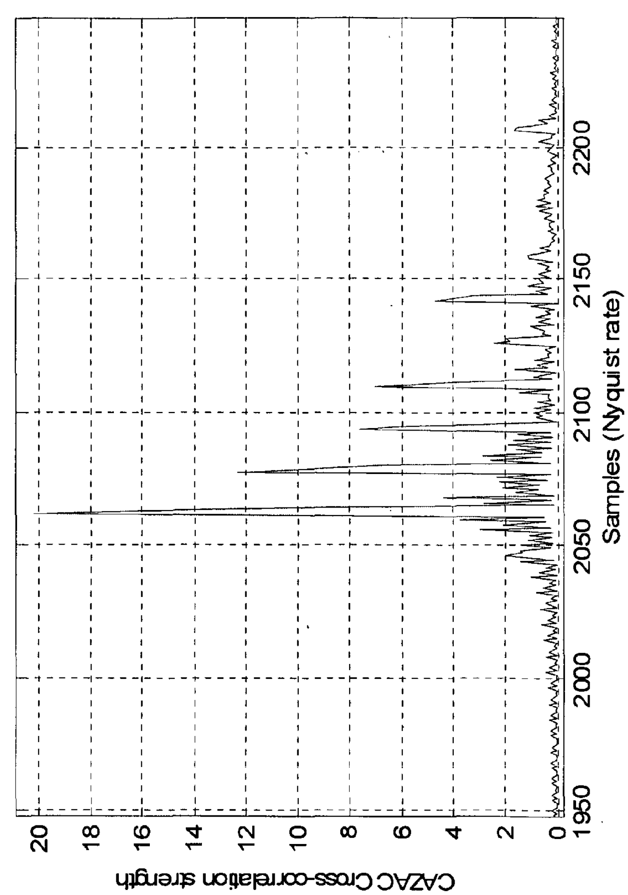

CAZAC Cross-correlation strength
Samples (Nyquist rate)
0
2
4
6
8
10
12
14
16
18
20
990
1000
1010
1020
1030
1040
1050
1060

FIG. 7


CAZAC Cross-correlation strength
Samples (Nyquist rate)
0
2
4
6
8
10
12
14
16
18
20
1950
2000
2050
2100
2150
2200

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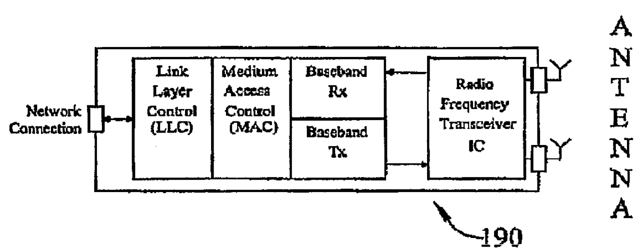


**(57) Abstract:** The present invention provides an iterative decoding circuit for a wireless multiuser communications receiver comprising a first signal processing means for receiving at least one received signal, said first signal processing means comprising at least two linear iterative filters such that the first linear iterative filter provides an estimate of a selected received signal to an estimated signal output and a second linear iterative filter provides estimates of at least one other received signal, delayed by one iteration cycle, to an input of said first linear iterative filter, a second signal processing means for receiving the estimated signal output of the first linear iterative filter and providing a further received signal estimate to the input of the first signal processing means in a succeeding iteration cycle of the decoding circuit. The application also includes a method of communication with packet sample hypothesis and a method of communicating using estimating time varying channel impairments.

WO 2005/011128 A1

# METHOD AND SYSTEM FOR COMMUNICATION IN A MULTIPLE ACCESS NETWORK

## RELATED APPLICATIONS

This application claims priority to Australian Provisional Patent Application No. 2003903826, filed 24 July 2003, entitled "An OFDM Receiver Structure", the specification thereof being incorporated herein by reference in its entirety and for all purposes.

## FIELD OF INVENTION

The present invention relates to the field of wireless communications. In particular, the present invention relates to improved multiple access communications. In one form, the invention relates to an improved signal processing method and apparatus for a multiple access communication system. It will be convenient to hereinafter describe the invention in relation to the use of an iterative method of determining the reception of a signal in a multi user packet based wireless OFDM (Orthogonal Frequency Division Multiplexing) communication system, however, it should be appreciated that the present invention may not be limited to that use, only. By way of further example, in other forms the present invention may relate to recursive filtering for joint iterative decoding in a variety of systems and functions such as linear multiple access channel decoders, iterative equalisation, iterative joint channel estimation and detection/decoding, iterative space-time processing, iterative multi user interference cancellation and iterative demodulation.

## RELATED ART

Throughout this specification the use of the word "inventor" in singular form may be taken as reference to one (singular) or more (plural) inventors of the present invention. The inventor has identified the following related art.

Most wireless communications systems are based on so-called multiple access techniques in which, information such as voice and data are communicated. This is a technology where many simultaneously active users share the same system resources in an organised manner. In most cases, sharing resources in a multiple access system means that if more than one user is active, then all active users interfere with each other. Traditionally, such interference has been considered to be part of the inevitable noise that corrupts transmissions.

Such interference increases with the number of active users and thus, the performance quality in terms of how many users (capacity) that can share the resources simultaneously becomes limited.

Figure 1 shows an exemplary multiple access scenario that may occur in Wireless Networks. The radio terminals 102, 104 and 100b transmit signals that are received at network access point 100a. In general not all of these signals are intended for radio terminal 100a. They maybe signals from devices that belong to other networks, presumably in unlicensed radio spectrum. In any case there are ordinarily some users of interest that belong to the network to which 100a provides access. The Network aims to make arrangements for all of these signals to be effectively transmitted. Commonly the users may be required to share the radio resource by, for example, transmitting on different frequencies or at different times. Such techniques may be wasteful in terms of the expensive radio resource.

The radio terminal 102 may have an associated user 103 who generates and receives information (in the form of voice, video, data etc). Similarly, the radio terminal 102 is associated with a user. In the case of a vehicular user 105, the vehicle (such as bus, train, or car) may generate and receive data to be communicated over the network. This data may also be generated and received by the passengers and/or operators of the vehicle. The network access point 100b may also wish to communicate with radio terminal 100a as may be the case in wireless backhaul or multihop networks. In this respect, it is also possible that the other users' radio terminals 102, 104 may form part of any multihopping network.

One way to improve capacity is to introduce error control coding. Applying coding allows performance to be improved by only allowing a few of all possible combinations of code symbols to be transmitted. Another way is to exploit the information contained in the interference. This is known as joint multiuser detection. In systems where both these techniques are used, a decoding strategy may be applied which is termed iterative decoding. Here, a multiuser detector first provides an estimate of the transmitted symbols in terms of reliability information. This information is forwarded to decoders that also provide reliability information based on the input from the detector. Information is then exchanged in an iterative fashion until there are no further improvements. This decoding strategy may increase capacity significantly, getting very close to theoretical capacity limits at a complexity level within reach of practical implementation. However, an optimal multiuser detector is prohibitively complex for practical implementation, as the inherent complexity grows exponentially with the number of active users. Instead, linear multiuser detection based on linear filtering may be applied, where the corresponding complexity only grows linearly with the number of active users. The inventor has identified that for practical reasons related art linear filters for iterative joint multiuser decoding are based on the received signal and the most recent information from the decoders as input to the filter. These filters have been designed based on various optimality criteria.

Where multiple users share common communications resources, access to channel resources may be addressed by a multiple access scheme, commonly executed by a medium access control (MAC) protocol. Channel resources such as available bandwidth are typically strictly limited in a wireless environment. It is therefore desirable to use these resources as efficiently as possible. Allowing multiple users to share common resources creates a risk for disturbances and interference caused by colliding access attempts. Such disturbances are usually referred to as multiple access interference. In wireless local area network (WLAN) systems the MAC attempts to schedule transmissions from Stations in order to avoid collisions. Sometimes the MAC fails, and Stations access the channel resources simultaneously. An example of this situation is illustrated in Figure 2, which shows the transmission of packets from a first transmitter station 1 a second transmitter station 2 and, a representation of received packets at the access point shown on the lowermost line. Physical layer receivers may fail to recover such collided packets. As the traffic load on the network increases, this problem becomes a significant limiting factor in terms of network capacity and quality of service.

A different problem, leading to similar effects, is caused by the multipath nature of communication channels associated with, for example, a WLAN. The multipath channel causes several delayed replicas of the same signal to arrive at the receiver. This, in turn, creates self-interference similar in nature to multiple access interference discussed above. In this case, the problem becomes a limiting factor for the required power to achieve acceptable performance, which translates into limitations on the coverage of the WLAN. An example of a direct and a reflected version of the original signal arriving at the receiver is shown in Figure 3, where the direct and reflected transmissions of the packet are illustrated on the top two lines as shown. The presence of self interference is indicated by shading in the received signal, represented by the access point on the lowermost line as shown. Transmission range may be affected by the interference mechanisms described above and also by the sophistication of the diversity signal processing at the Receiver. Physical Layer receiver designers therefore strive to ensure that effective use is made of all available time, frequency and space diversity (the latter may be provided through the use of multiple antennas).

The inventor has also identified that when synchronizing transmitted packets over wireless connections each packet ordinarily has a preamble of several repetitions of the same short signal. A received packet signal may be correlated with a delayed version of itself where commonly the delay equals the duration of the repeated signal component in the preamble. This correlation may be implemented repetitively over a given sample sequence. The output power of the resultant correlation may then be combined with the average power of the raw received signal to define a decision statistic. The point at which the decision statistic exceeds a given threshold is selected as the time of arrival of the packet. However, there are drawbacks with this technique in as much as signal distortions may be amplified or accentuated by the processing involved with the synchronization process producing uncertainties in the determination of packet timing.

Generally, in packet based communication systems it is important to reduce latency of a receiver or, in other words, provide as little delay as possible between arrival of signals and the decoding of the bits contained in those signals. Moreover, receiver processes are unable to determine the variation of a radio channel over the time of a packet length and the associated effect on the waveform of the transmitted signal. This may lead to lower than optimum data rates due to poorly tracked packets that are otherwise intact being discarded.

In OFDM packet based communication systems channel impairments may occur, which contribute to changing both the channel over which an OFDM signal travels and also the received signal itself. Collectively, these channel impairments comprise variations in the transmission channel due to multipath fading and, variations to OFDM symbols due to frequency and time offsets caused by receiver inaccuracies and phase offsets due to combined transmission and reception processes. These channel impairments may vary from OFDM symbol to OFDM symbol, in other words, they may not be invariant over the length of a packet. Traditionally, channel impairments are countered by estimates made using a packet preamble and maintained by pilot symbols throughout the received packet, which may assume invariance over the packet length. Other methods use data estimates to aid for example with channel estimation and these are implemented in the frequency domain and may result in power loss by discarding a cyclic prefix for each received symbol. Generally, there is no use made of all available received information to address channel impairments in such packet based communication systems.

With regard to space diversity, for multiple receiving antennae in wireless data packet communication systems related art schemes provide decisions on the synchronization of a received signal on the basis of per antenna and then a majority vote, otherwise the received measurements are added prior to the decision. These approaches do not address the variation of signal statistics across the number of antennae resulting in degraded synchronization accuracy and increased packet loss.

In EP 1387544 it is noted that time synchronisation of a receiver to the incoming signal is essential for effective decoding of that signal. In many packet based applications a special preamble is inserted by the transmitter at the start of every packet transmitted in order to assist the receiver with its timing estimation task. In OFDM systems the transmitter imparts a special structure on the signal called a cyclic prefix. This cyclic prefix is inserted for every OFDM symbol. A cyclic prefix is a replica of a small portion of the last section of a signal inserted at the start of the signal. There are many OFDM symbols transmitted sequentially in most forms of communication. In EP 1387544 the cyclic prefix, in the form of a guard interval as a cyclic continuation of the last part of the active symbol, is employed to time synchronise the receiver instead of a preamble. In EP 1387544 a two step time synchronisation approach is disclosed, namely a pre-FFT and post-FFT time synchronisation algorithm. These are complementary techniques and may be used together. The pre-FFT technique consists of a "delay and correlate" algorithm applied to find the cyclic prefix of the OFDM symbols. This is achieved by setting the delay in the "delay and correlate" algorithm to the distance between the cyclic prefix and the region from which it was copied. The output of the correlator is then filtered using an auto-regression filter comprising a recursive Infinite-Impulse Response (IIR) filter to determine an average of the correlation across OFDM symbols. A second filtering, by way of smoother 44 in Fig 2 of EP 1387544, is then applied to discard samples outside of the maximum delay measurable, namely, the cyclic prefix duration. However, EP 1387544 relates to a system which makes use of a streaming signal and not readily adapted for the random arrival of packets. In the case of streaming signal, the signal is always there but the fine timing associated with the OFDM symbol boundaries must be determined.

In US 6,327,314 (Cimini, Jr. et al) the problem of tracking the radio channel in a hostile propagation environment is addressed for wireless communications systems using OFDM and one or more antennae for reception. The solution disclosed by Cimini Jr. employs decoder and demodulator outcomes to generate a training or, reference signal, to drive the estimation of the channel for use in decoding the next symbol. The decoding, demodulation and channel estimation loops run according to the paradigm that the channel estimate may use all outcomes up to and including the symbol to be decoded. Each OFDM symbol is decoded once. The raw channel estimate is obtained by multiplying the received OFDM symbol with the training symbols. These training symbols may be from a decoding step. The raw channel estimate, corresponding to one OFDM symbol, is stored in a database. Each time a new OFDM symbol is to be processed all raw estimates in the database are employed to yield the channel estimate at the processing wavefront. In this disclosure the raw channel estimates are stored and a smoothing step is executed every time the data base is accessed, which entails a relative degree of complexity.

In US 6,477,210 (Chuang et al) the problem of tracking the radio channel in a hostile propagation environment is also addressed for wireless communications systems using OFDM and one or more antennae for reception. The solution provided in this disclosure augments that disclosed in US 6,327,314 by more clearly disclosing the processing flow and adding a backward recursion to the processing. The backward recursion includes the steps of demodulation, decoding and channel estimation, as in the forward recursion, but the processing commences from the end of the packet. Chuang et al is restricted to Maximum Likelihood decoding systems such as Viterbi decoders. There are many other types of FEC systems that do not employ ML decoding (e.g. Soft Output Decoders such as A-Posterior Probability techniques) and, moreover, for which Chuang is not adapted to operate within.

In a paper by Czylwik, A., entitled "Synchronization for systems with antenna diversity", IEEE Vehicular Technology Conference, Vol. 2, 19-22 Sep. 1999, pp 728-732 the time and frequency synchronisation of a receiver is considered. In order to successfully decode a packet the receiver must determine the packet time of arrival. Errors in this estimate may result in signal power loss or failures in the synchronisation of high layer structures such as error control coding and FFT windows. Another parameter to be estimated is residual frequency offset. This parameter must be accurately estimated and its effect removed or countered if the packet is to be decoded. Errors in this estimate may result in demodulator failure and subsequent packet decode failure. When a receiver has two antennae there is a possibility to employ these two signals to improve estimation of time and frequency offsets. As disclosed in Czylwik, conventional techniques for single antenna exist involving the calculation and subsequent combination of two components. In this paper two main methods are proposed for time and frequency offset estimation. In the first, one antenna is selected, based on received power strength, and conventional techniques are applied to only that signal. In the second method disclosed by Czylwik, first and second conventional components are computed for each antenna. The two first components from each antenna are added. The two second components from each antenna are added. The resulting sums are then treated conventionally as a first and second component. The option of weighting each component prior to combining across antenna according to a signal strength measure for each corresponding antenna is also disclosed in Czylwik. This later option is shown to perform better than any of the other proposals in the paper. Filtering of the resulting metric for time synchronisation is also disclosed.

Any discussion of documents, devices, acts or knowledge in this specification is included to explain the context of the invention. It should not be taken as an admission that any of the material forms a part of the prior art base or the common general knowledge in the relevant art in Australia, the United States of America or elsewhere on or before the priority date of the disclosure and claims herein.

**SUMMARY OF INVENTION**

It is an object of the present invention to overcome or mitigate at least one of the disadvantages of related art systems.

In one form the present invention provides an iterative decoding circuit for a wireless multiuser communications receiver comprising:

a first signal processing means for receiving at least one received signal, said first signal processing means comprising at least two linear iterative filters such that:

the first linear iterative filter provides an estimate of a selected received signal to an estimated signal output and;

a second linear iterative filter provides estimates of at least one other received signal, delayed by one iteration cycle, to an input of said first linear iterative filter;

a second signal processing means for receiving the estimated signal output of the first linear iterative filter and providing a further received signal estimate to the input of the first signal processing means in a succeeding iteration cycle of the decoding circuit.

In another form the present invention provides a method, apparatus and system of communicating in a multiple access network by iteratively receiving multi user signals comprising:

determining a first set of signal estimates for the multi user signals based on linear channel constraints;

determining a second set of signal estimates based on non-linear channel constraints and the first set of signal estimates;

providing the second set of signal estimates as input to the step of determining the first set of signal estimates;

repeating the above steps at least once.

In a further form the present invention provides an iterative receiver for receiving multi user signals comprising:

a first signal processing component for determining a first set of signal estimates for the multi user signals based on linear channel constraints;

a second signal processing component for receiving the first set of signal estimates and determining a second set of signal estimates based on non-linear channel constraints;

wherein the signal processing components are operatively connected so as to provide the second set of signal estimates as input to the first signal processing component in a succeeding iteration cycle.

In another form the present invention provides a method, apparatus and system of communicating in a multiple access network by iteratively receiving OFDM packets comprising:

a) sample a receiver input signal;

b) add the input signal with one of a plurality of prior stored received packet sample estimates to determine a packet sample hypothesis;

c) determine an information bit estimate from the sample hypothesis for storage in an information bit estimates list;

d) determine an updated received packet sample estimate from the sample hypothesis for updating the plurality of prior stored estimates;

e) subtract the updated sample estimate from the sample hypothesis to determine a noise hypothesis and provide the noise hypothesis as the receiver input signal;

f) repeat steps a) to e) until at least one or more complete packets are accumulated in the information bit estimates list.

In yet another form the present invention provides a method, apparatus and system of communicating in a multiple access network by iteratively providing a sample estimates list in an OFDM receiver comprising:

a) sample a receiver input signal;

b) determine a packet sample estimate from the sampled receiver input signal;

c) store the packet sample estimate;

d) determine a packet sample hypothesis by adding the receiver input with a selected previously stored packet sample estimate;

e) determine an updated packet sample estimate by decoding and re-transmission modelling the packet sample hypothesis;

f) update the selected previously stored packet sample estimate with the updated packet sample estimate.

In still another form the present invention provides a method, apparatus and system of communicating in a multiple access network by iteratively providing a packet information bit estimates list in an OFDM receiver comprising:

a) determine a packet sample hypothesis by adding a receiver input with a selected previously stored packet sample estimate;

b) determine an information bit estimate by decoding the packet sample hypothesis with one or more of a hard decoding technique and a soft decoding technique

c) storing the information bit estimate with one or more previously determined information bit estimates;

d) repeating steps a) to c) until a complete packet is accumulated.

In yet another form the present invention provides a method, apparatus and system of communicating in a multiple access network including determining a hybrid OFDM received packet sample estimate comprising:

multiplexing a time domain channel application received sample estimate with a frequency domain channel application received sample estimate, such that the multiplexed time domain sample estimate is mapped to correspond to one or more of:

an OFDM signal cyclic prefix;

an OFDM tail portion, and;

an OFDM guard period,

and wherein the multiplexed frequency domain sample estimate is mapped to correspond to one or more of:

an OFDM signal preamble and;

an OFDM payload data symbol.

In another form the present invention provides a method, apparatus and system of communicating in an OFDM multiple access network comprising:

performing multi-user interference cancelling which comprises adapting a single pass OFDM receiver to iteratively receive signals at the sampling level so as to allow the receiver to differentiate a desired packet from an observation of an interference signal at the receiver input.

In yet another form the present invention provides a method, apparatus and system of communicating in a multiple access communication network by synchronizing packets arriving at a receiver comprising:

receiving a packet input signal;

determining a correlation signal corresponding to the packet input signal;

processing the input and correlation signals such that at least one of the input signal and the correlation signal are filtered;

determining a decision statistic by combining a power component of the processed correlation signal with a power component of the processed input signal;

nominate a point in time given by a predetermined threshold condition of the decision statistic as a received packet arrival time.

In yet another form the present invention provides a method, apparatus and system of communicating by tracking time varying channels in a multiple access packet based communication network comprising:

a) initializing a channel estimate reference based on an initial channel estimate in a received packet preamble;

b) updating the channel estimate reference based on a packet data symbol channel estimate in a coded portion of the current and all prior received data symbols;

c) repeating step b) at the arrival of subsequent packet data symbols.

In yet another form the present invention provides a method, apparatus and system of communicating by estimating time varying channel impairments in a multiple access packet based communication network, where channel impairments comprise channel variation, signal frequency offset and signal time offset, comprising:

a) initializing a set of channel impairment estimates based on initial pilot and preamble symbols included in a received packet;

b) performing a decoder operation which comprises processing the set of channel impairment estimates and the received packet to determine a set of transmit symbol estimates;

c) updating the set of channel impairment estimates with the determined set of symbol estimates and received packet;

d) repeating steps b) and c).

In still another form the present invention provides a method, apparatus and system of communicating in a multiple access network by time varying channel estimation in a receiver for receiving transmitted packets, comprising:

a) estimating a frequency offset based on information included in a received packet preamble;

b) correcting a received signal using the estimated frequency offset;

c) determining a channel estimate using information included in the received packet preamble;

d) transforming a sample sequence of the received signal into the frequency domain such that the sample sequence includes OFDM symbols and intervening cyclic prefixes;

e) performing a decoding operation which comprises processing the determined channel estimate and received packet;

f) generating a transmission sample sequence using the decoding results and information in the received packet preamble;

g) transforming the transmission sample sequence into the frequency domain;

h) updating the determined channel estimate by combining the received sample sequence and the transmission sample sequence in the frequency domain;

i) repeating steps e) to h).

In a preferred embodiment, the combining operation of step h), which updates the determined channel estimate, is performed by dividing the received sample sequence and the transmission sample sequence in the frequency domain.

In a further form the present invention provides a method, apparatus and system of communicating in a multiple access network by time varying channel estimation in a receiver for receiving transmitted packets, where the receiver retrieves OFDM symbols from a received signal and transforms the retrieved symbols to the frequency domain, comprising:

a) determine a matrix of training symbols comprised of symbol estimates derived from a decoder;

b) determine a matrix of frequency domain received OFDM symbols;

c) determine an intermediate channel estimate matrix by multiplying the OFDM symbol matrix by the conjugate of the training symbol matrix;

d) determine an intermediate matrix of training weights comprising the absolute value of the training symbol matrix;

e) perform a smoothing operation on both intermediate matrices comprising 2 dimensional filtering;

f) determine the channel estimate by dividing the smoothed channel estimate matrix with the smoothed training weight matrix.

In embodiments of the invention, the step d) determining an intermediate matrix of training weights may comprise other functions such as, for example, (absolute value of the training symbol matrix)$^2$.

In still another form the present invention provides a method, apparatus and system of communicating in a multiple access network by estimating offsets in a receiver for receiving transmitted packets, comprising:

a) determine a matrix of received OFDM symbols;

b) determine a matrix of conjugated data symbols wherein the data symbols comprise one or more of preamble, training and estimated symbols;

c) determine a 2 dimensional Fourier transform matrix comprised of the received symbol matrix multiplied with the conjugated symbol matrix;

d) filter the Fourier transform matrix;

e) determine time and frequency offsets by locating peak power occurrences within the filtered Fourier transform.

In a particular embodiment, the above steps a) to e) for estimating offsets may be used effectively as a means of channel estimation. For example, in the above described form of the invention which provides communication by estimating time varying channel impairments, the step c) of updating the set of channel impairment estimates with the determined set of symbol estimates and received packet may comprise the above steps a) to e) for estimating offsets.

In a further embodiment, the above method may be used as the channel estimator as required herein, in as much as updating the set of channel estimates with the determined set of symbol estimates.

In yet a further form the present invention provides a method, apparatus and system of communicating in a multiple access packet communication network by synchronizing a received signal in a multi antenna receiver comprising:

correlating a received signal observation at each of a plurality of antennae with a known signal preamble to provide a received signal sequence;

determine a power signal of each received signal sequence;

combine the determined power signals in accordance with a time averaged weighting based on estimated antenna signal strength for each antenna;

determine a time of arrival for the received signal in accordance with a predetermined threshold condition.

In embodiments of the present invention there is provided a computer program product comprising:

a computer usable medium having computer readable program code and computer readable system code embodied on said medium for communicating in a multiple access communication network, said computer program product comprising:

computer readable code within said computer usable medium for performing the method steps as disclosed herein.

Other aspects and preferred aspects are disclosed in the specification and/or defined in the appended claims, forming a part of the description of the invention.

The present invention provides an improved or enhanced wireless link between two communicating devices, for example, an IEEE 802.11a Access

Point to an IEEE 802.11a Station or between two nodes in a wireless mesh. The present invention leads to enhanced key performance indicators for point to point links, namely, range, power, data rate and reliability. This is achieved by advanced signal processing techniques in the following areas to improve performance

- Decoding
- Synchronisation
- Equalisation
- Channel Estimation
- Full Exploitation of Multiple Receiver Antennae.

As would be understood by the person skilled in the art, in addition, techniques that exploit multiple antennas for transmission may be employed to provide electronically generated directional antennas in an adaptive manner. The following advantages stem from the present invention.

- Spatial rejection of interference,
- Significantly increased receiver sensitivity,
- Significantly increased robustness to fading, and
- Self configuration of antenna patterns

Spatial rejection of interference effectively ignores or rejects signals that are not emanating from the same location as the current or point of interest source. Rejecting these signals increases the probability that a signal may be received without errors thus increasing the reliability of the link and therefore the throughput to lower retransmissions and dropped packets. Interferers have a spatial signature as measured at the receive antenna that is substantially determined by their position. However, it is possible that transmitters that are not collocated could produce a similar spatial signature and it is also possible that collocated transmitters could produce different spatial signatures.

Significantly, increasing the receiver sensitivity means that the receiver may operate a lower SNR (Signal-to-Noise-Ratio) point which produces many benefits. Since the received power at which the signal may be successfully decoded has been reduced, the path loss may be increased by increasing the distance between the receiver and transmitter thereby increasing the range. Alternatively, the present invention allows the transmit power to be decreased and still a link may be maintained. Increasing the receiver sensitivity also means that less power is required per bit and accordingly, it may be possible to transmit a higher number of information bits per constellation symbol. This increases the data rate.

Robustness to fading provided by the inventive techniques disclosed herein may decrease the amount of packet errors due to extreme radio channel variations or fades. By increasing robustness, a more reliable link may be created ensuring a better user experience and increased throughput through less re-transmissions and fewer dropped packets.

The use of multiple antennas for transmit and receive functions allows the rejection of interference from outside the direction of interest. This functionality is adaptive so no hands-on antenna orientation is required at install-time or during the life of the installations.

By way of example, indicative performance measures of a sample communications link are given with and without the use of the Point-to-Point technology of the present invention.

| | Typical of Related Art | Present Invention |
|---|---|---|
| Range | 300m | 1km |
| Required $T_x$ Power | 1.0W | 0.1W |
| Maximum Data Rate | 500Kbps | 5Mbps |

The present invention also provides improved channel tracking capabilities. Channel tracking technology refers to the adaptation of the receiver, when the channel changes rapidly over the duration of a single packet. Typically, the channel estimate that is used to decode a received packet is determined from known sequences at the start of a packet. This estimate may be used to decode the whole packet. However, if the relative speed between the transmitter and receiver is great enough, the channel experienced at the beginning of the packet is substantially different from that at the end of a packet rendering the channel estimate incorrect for the end of the packet resulting in decoding errors. There are other processes that manifest themselves as the radio channel changing over the packet. These include mismatches between the Transmit and Receive Radio processing resulting in residual frequency offsets and misalignments in the time and frequency synchronisation. It is difficult to build transmit and receive radio devices that match perfectly.

The advanced signal processing techniques of the present invention allows a receiver circuit to build a progressive Channel Estimate that tracks the changes in the channel over the duration of a packet. The benefit of applying such Channel Tracking technology is the ability to communicate under high mobility conditions and under larger mismatches between the transmit and receive radio processing. By way of example, typical performance measures of a sample communications link are given with and without the use of the Channel Tracking technology.

| | Typical of Related Art | Present Invention |
|---|---|---|
| Maximum Mobility | 40 km/hr | 400 km/hr |

The present invention also provides interference cancelling allowing the removal of same standard interference from a signal. The term "same standard" refers to transmissions of similar packet structures from other users in a multiuser system, or multipath transmissions (reflections) from the same transmitter, or multiple transmit antenna in the case of a device equipped with multiple transmit antenna . In all wireless communications systems, multiple active transmitters share the wireless medium. This sharing may be done in a coordinated attempt in infrastructure networks by dividing the wireless medium into time and frequency slots or in an uncoordinated attempt in an-hoc networks by all active transmitters contesting for the right to use the medium. Both schemes limit the use of the medium to a well defined frequency and time where only one user may transmit. Packet collisions occur when two transmitters inadvertently choose to use the same frequency at the same time. The Interference Cancelling technology includes advance signal processing techniques that benefit the following areas

- Acquisition
- Interference Mitigation
- Range
- Network Throughput
- Reduced Control Overhead

Further benefits of the Interference Cancellation technologies of the present invention resolve collisions between two or more transmitters from the same standard transmitting at the same time on the same frequency. This has numerous advantages. Firstly, when collisions occur, all transmitted packets are received correctly increasing throughput and reliability by decreasing retransmissions and dropping packets. Secondly, by removing the requirement that only one transmitter may use a given frequency at a given time the amount of traffic that can be carried on the medium may be increased. Moreover, this may give greater flexibility in infrastructure design such as frequency planning and in the case of co-located competing networks such as two IEEE 802.11 networks from separate companies in adjoining offices.

In the case where the desired user and interfering users transmit according to different standards, the interference cancellation structure may employ a receiver and re-transmitter for all relevant standards. The receiver is then able to create hypotheses of the interfering signals thereby enabling interference cancellation.

Collisions may be resolved in the Physical Layer in accordance with embodiments of the present invention. The resulting reduction in network signaling overhead multiplies the benefits over and above the resolution of the two colliding packets. Typical quantitative measures are a doubling of network throughput and several orders of magnitude reduction in packet loss rate as follows:

| | Typical of Related Art | Present Invention |
|---|---|---|
| Throughput | 10 Mbps | 20 Mbps |

The multi-hop technology of embodiments of the present invention allows selected (and possibly all) wireless devices to act as routers, forwarding packets from one device to another in a communication network. This means that though two devices may not receive each others signals, if there is a set of intermediate devices that may be linked to form a radio path between them, then they may communicate to each other by passing their message through that intermediate set.

Depending on the particular network dynamics, the multi-hop technology may employ dynamic route determination techniques to build and maintain the required routing tables. Multi-hop networks provide many benefits in terms of flexibility, reliability and cost of infrastructure.

Flexibility is achieved through a self forming network that requires minimal planning. The only requirement is that no device may be isolated, in a radio range sense, from the core network. All configurations meeting this criterion may be possible.

If multiple paths between devices exist in the network, dynamic route determination may select a new route when the current route is blocked or congestion is best avoided. Therefore if a device was to go offline, the network may rearrange its routing tables to exclude that device from all routes and find a new path through the network thus creating a robust, self healing (and therefore more reliable network). Dynamic route determination continuously adapts to network configuration changes allowing for mobile network nodes.

Multi-hop networks in accordance with embodiments of the present invention offer a simple solution to provide a high bandwidth link over a wide area. Due to easy flexible installations, low infrastructure costs and a high rate, reliable link, multi-hop networks generally offer excellent return on investment.

Four areas of application in the communications field which best utilize the benefits of the technologies of embodiments of the present invention have been identified by the inventor as

- Mobile Multi-hop Radio Networks
- Fixed Multi-hop Radio Networks
- IEEE 802.11a Access Point Chipsets
- 802.16 Base Stations
- OFDM Baseband Receiver Co-processor

The following describes each of the above identified applications in turn. Other applications may also benefit from these technologies of embodiments of the present invention.

Firstly, a Mobile Multi-hop Radio Network requires effective real-time communication to networks of moving entities. This concept provides cost-effective bi-directional high bandwidth communication both between the mobile entities and between fixed networks and the mobile entities. Wireless Routers are placed where service is required with regular connections to a wideband backbone network. A fixed network may be used to connect to other networks such as the internet or other private networks. Other than access to power and a physical mounting point no other infrastructure is required for each wireless router. The wireless routers may be fixed or mobile. The routers adapt to their environment in terms of link quality using, for example, data communications methods as would be understood by the person skilled in the art. Embodiments of the present invention provide a competitive advantage relative to other Multi-hop Radio Networks in that the improved mobility and range, as noted above, leading to a more efficient network is provided. Relative to related art Private Communications Networks, embodiments of the present invention provide significant improvements in Data Rate, Range, Mobility and cost of Network as noted above.

Secondly, a Fixed Multi-hop Radio Networks is provided by installing Wireless Routers at fixed user locations with links available to one or more wideband backbone connections. The only requirement is that all routers must be able to form a link (direct or hopped) back to a backbone connection. There is no need for expensive base station configurations and ultimate range is not limited by signal strength. The Fixed Multi-hop radio Network forms a flexible, low infrastructure cost solution in providing a high bandwidth connection to a Wide Area Network that is reliable, easily managed and self healing.

Furthermore, the present invention enables all decoder outcomes to be employed (decoder outcomes are stored across all iterations and able to be combined) in the receiver filter structure providing improved estimate determination. The number of users that may be supported is greatly increased. Particularly advantageous, for example, in OFDM systems the present invention does not require prohibitively large matrices to be inverted in forming estimates. Receiver performance is superior to that of the related art due to the quality of the feedback symbol provided by including decoding in the iteration loop. Embodiments of the present invention are based on interference cancellation where previous estimates of the multi user received signals are subtracted from the received signal to cancel the interference they cause. Accordingly, these embodiments do not suffer the disadvantages and complexities of using tree search methodologies for multiuser signals which would necessitate exploring many paths through a given tree. The present invention advantageously enables decoding of each user's signal according to their Forward Error Correction encoding. This use of strong error control code structure provides for significantly improved symbol estimates, resulting in superior interference estimates. This in turn allows support for significantly higher numbers of users. Embodiments of the present invention do not require synchronised users to enable improved multi user reception. Embodiments of the present invention advantageously use decoder outcomes as training symbols rather than only using demodulator outcomes. Advantageously, receiver coefficients for beamforming may be determined without transmitter interaction. Also the use of decoder outcomes to improve channel estimates allows accurate estimation of the required beamforming coefficients. In accordance with embodiments of the present invention, smoothing of channel estimate taps is performed in the frequency domain as well as the time domain. Further to this, embodiments of the present invention allow decoding of symbols more than once as a channel estimate corresponding to its interval is improved resulting in increased receiver sensitivity.

Further scope of applicability of the present invention will become apparent from the detailed description given hereinafter. However, it should be understood that the detailed description and specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from this detailed description.

## BRIEF DESCRIPTION OF THE DRAWINGS

Further disclosure, improvements, advantages, features and aspects of the present invention may be better understood by those skilled in the relevant art by reference to the following description of preferred embodiments taken in conjunction with the accompanying drawings, which are given by way of illustration only, and thus are not limiting to the scope of the present invention, and in which:

Figure 1 illustrates a related art multiple access wireless communication system;

Figure 2 illustrates an example of a MAC failure in a related wireless communication system involving an access collision;

Figure 3 depicts self interference in WLAN network of a related art wireless communication system;

Figure 4 depicts a generic iterative receiver structure in accordance with a first embodiment;

Figure 5 depicts the transmission system model for coded CDMA;

Figure 6 depicts a canonical iterative multiuser decoder;

Figure 7 depicts an iterative multiuser decoder with linear multiuser estimation in accordance with a first embodiment;

Figure 8 depicts the recursive filter $\Lambda_k^{(n)}$ in accordance with a first embodiment for $n$ = 1 the input signal is r while for $n \geq$ the input signal is $\hat{x}_k^{(n-1)}$; and

Figure 9 depicts Bit Error Rate versus users after 10 iterations, $N$=8, $E_b$ / $N_0$ = 5 dB in accordance with a first embodiment;

Figure 10 shows a typical related art single pass OFDM receiver high level structure;

Figure 11 illustrates an adaptation of the single pass OFDM receiver high level structure of figure 10 in accordance with a second embodiment to facilitate iterative receiver technologies;

Figure 12 shows a OFDM Soft/Hard Decode and Re-transmit structure for use in Iterative Receive structure in accordance with a second embodiment;

Figure 13 shows a Hybrid Re-transmit in accordance with a second embodiment;

Figure 14 shows a Hard Decode and Re-Modulate for OFDM Soft/Hard Decode and Re-transmit structure in accordance with a second embodiment;

Figure 15 shows a Soft Decode and Re-Modulate for OFDM Soft/Hard Decode and Re-transmit structure in accordance with a second embodiment;

Figure 16 shows a structure for time domain channel application process in accordance with a second embodiment;

Figure 17 shows a structure for frequency domain channel application process in accordance with a second embodiment; and

Figure 18 shows an Example of a Typical OFDM Packet Physical layer Format and an associated Multiplexer mapping;

Figures 19a and 19b show a wireless modem incorporating a baseband receiver processor in accordance with preferred embodiments of the present invention;

Figure 20 illustrates a packet structure in accordance with related art;

Figure 21 illustrates an example related art time synchronisation decision;

Figure 22 shows triangle filter coefficients for a receiver filter in accordance with a third embodiment of the invention;

Figure 23 shows an example of a filtered decision statistic in accordance with a third embodiment of the invention;

Figure 24 represents an actual frequency domain of a related art radio channel;

Figure 25 represents the frequency domain of figure 24 after receiver phase and frequency offset correction;

Figure 26 represents an error pattern for a related art processing of a receiver;

Figure 27 represents a radio channel estimate after smoothing across OFDM symbols in accordance with a fourth embodiment of the invention;

Figure 28 represents an error pattern for a fourth embodiment of the invention using perfect training symbols;

Figure 29 represents a raw radio channel estimate or channel estimate database in accordance with a fourth embodiment of the invention;

Figure 30 is an example of a WLAN packet format in accordance with related art;

Figure 31 is an OFDM symbol sub-carrier matrix structure in accordance with a fifth embodiment of the invention;

Figure 32 is a representation of channel power (amplitude) over a sub-carrier and OFDM symbol resulting from application of a fifth embodiment of the invention;

Figure 33 is a representation of channel phase corresponding to the waveform represented in figure 32;

Figure 34 is a representation of a synchronisation metric of a sub-carrier and OFDM symbol in accordance with a fifth embodiment of the invention.

## DETAILED DESCRIPTION

### System Overview

In wireless networks a signal received at a network device comprises components from all active transmitters. These components, along with noise, add together resulting in the received signal. In some cases, only one of these components, corresponding to a specific transmitter, is of interest. In other cases, such as a reception at a network access point, several of the received components are of interest. In either case the presence of the other signal components in the received signal inhibits the accurate estimation of any given transmitted signal of interest. In accordance with embodiments of the present invention a system and methods and apparatus for processing a received signal comprising one or more received signal components from different transmitters is disclosed herein. The processing typically resides in the baseband receiver processing of a wireless transceiver 190 as illustrated in figures 19a and 19b. The Radio Frequency Transceiver Integrated Circuit (IC) is an analogue device that interfaces between the digital signal processing components LLC, MAC, Rx, Tx, and the antenna system of the transceiver. In receive mode IC amplifies and downconverts the received signal suitable for driving analogue to digital converters. In transmit mode it up converts and amplifies the signal for excitation of the antenna.

The baseband receiver is responsible for determining the existence of any packets and then to recover transmitted information estimates from the received signal if packet(s) are deemed to exist.

A canonical baseband receiver processor Rx is shown in figure 19b. The received signals for each antenna are supplied as input by the Radio Frequency Circuit IC. These signals are then filtered 302 by filters 302a, 302b to remove any out of band interference. The filtered signals 303 are then combined with the current Received Signal Estimates 306, implementing an interference cancellation function 304. Ideally, the interference cancellation module 304 removes the signal components in the received signal pertaining to all packets except for the packet of interest. The packet of interest is then decoded by feeding the Interference Cancelled output 309 to a Single Packet Processor 313.

The Single Packet Processor 313 takes a Multiantenna received signal as delivered by the Interference Cancellation module 304 and produces an estimate of the transmitted information bits 314 and an estimate of the received symbols 306 for the packet of interest. These symbols, along with the channel estimates for the packet of interest, are then fed back to the interference cancellation module 304. In some cases it is preferred to send back only the transmitted symbol estimates to the interference cancellation module 304.

The Single Packet Processor 313 may contain advanced or conventional single packet techniques. The multiuser interference rejection performance of the receiver will be better if the Single Packet Processor is of high quality. Techniques pertaining to synchronisation and channel estimation are key to the performance of the Single Packet Processor 313.

Techniques that improve the robustness of the synchronisation and channel estimation employed in decoder 310 are described herein. The synchronisation uses all antenna signals in its operation. The channel estimation makes use of the decoder outcomes to improve the channel estimation accuracy.

New packets are found by a searcher in the interference cancellation module 304. The searcher investigates an intermediate signal generated in the module 304. This intermediate signal is the received signal minus the estimated received signal for all currently detected packets and is referred to as a noise hypothesis since in ideal conditions all transmitter components are removed from the received signal leaving behind only the random noise.

In applications sensitive to latency the feedback loops, both inside 310 for decoder outcome assisted channel estimation, and between 304, 310 and 312 for multi packet interference cancellation may be executed at a rate higher than the packet rate. In OFDM based systems the preferred choice for the loop rates is the OFDM symbol rate with decoding and interference cancellation occurring at the OFDM symbol rate.

In applications where packet based decoding and interference cancellation may be performed at the packet rate additional packet-based techniques for the

Single Packet Processor 313 are disclosed. These techniques leverage the extra signal processing gain available when considering long sequences of symbols.

In either case, lists of current estimates of the quantities passed between the Interference Canceller 304 and the Single Packet Processor 313 are required. A controller determining which packet is to be updated may also be utilised.

With reference to figures 4 to 9, a first embodiment stems from the general realization that over a number of iterations using linear filters in a multiuser receiver, each iteration provides new information and, as the filter structure converges, the output of the decoders also converges and eventually becomes completely correlated. The linear filters of the multiuser decoding circuit means may be structured in accordance with at least one predetermined recursive expression.

An innovation in the filter design of a first embodiment disclosed herein is to exploit the fact that information provided by the decoders is initially only marginally correlated over iterations, i.e. in the first few iterations, each iteration provides new information. As the structure converges, the output of the decoders also converges and eventually becomes completely correlated.

The disclosed filter design is based on a technique to use all available information from all previous iterations. This implies that the filter grows linearly in size by a factor equal to the number of users. This is clearly impractical. Thus, the disclosed filter design makes it possible to use all the available information through recursive feedback of the filter output over iterations, without requiring a growing filter. The size of the filter remains the same. In order to achieve this, the filters in the structure may be designed according to the recursive expressions derived herein.

Related structures, having lower complexity implementations, are obtained by modifying the specific filters used in the structure. The general recursive structure, however, is still fundamental for such modified filters. In these cases, the individual filters are designed according to appropriately different strategies using the principles disclosed herein.

The recursive filtering structure for iterative signal processing disclosed herein is not limited to multiuser detection, but may also be directly applied within systems and functionalities of the same structure. Examples of such applications are iterative equalisation, iterative joint channel estimation and detection/decoding, iterative space-time processing, and iterative demodulation.

In a broad aspect of the first embodiment, an iterative signal processing arrangement shown generally in figure 3 as 10 having one or more pairs of first and second signal processing components 1, 2, the pairs of components being in iterative configuration, each of the first signal processing components having as input one or more received signals dependent upon one or more transmitted signals, wherein for each said signal processing component pair the output of said first signal processing component 1 is an estimate of a characteristic of a selected transmitted signal based on the current and one or more previous signals received by said first signal processing component 1, which is input to said corresponding second signal processing component 2 that provides a further estimate of said selected transmitted signal to the output of said second signal processing component 2, the outputs of all said second signal processing components of respective pairs are input to each said first signal processing components of all said pairs in a succeeding iteration cycle.

In a further aspect of the first embodiment, the iterative signal processing arrangement 10 according to that described above wherein said first signal processing component 1 comprises at least two linear iterative filters wherein a first of said linear iterative filters outputs an estimate of a selected characteristic of a selected one or said transmitted signals to said second signal processing component 2, and a second of said iterative filters having the same inputs as said first linear iterative filter provides an estimate of a characteristic of a selected of one or more transmitted signals and then delays by one iteration cycle said estimate and outputs said delayed estimate to an input of said first linear iterative filter.

This first embodiment is intended for application to any communication system described by a generic linear channel model. The received signal at the input to the receiver is described by a weighted sum of the transmitted signals plus noise. The set of weighting factors represents a set of linear constraints imposed on the transmitted signals. Other constraints could possibly have been imposed on the signals. These other constraints are independent of the linear constraints imposed by the linear channel.

The optimal receiver structure finds the estimates of the transmitted signals, subject to all the imposed constraints. This approach is prohibitively complex for most practical cases of interest. As an alternative, a generic iterative receiver structure comprises of two separate components (see Figure 4). The first component 1 finds the optimal estimates, only subject to the linear channel constraints, ignoring all other constraints. Only preferably these estimates are shuffled by reordering according to a pre-determined order (de-interleaved) and used as inputs to the second component 2 which finds the optimal estimates subject only to all the other constraints, ignoring the linear channel constraints. These estimates are in turn, preferably shuffled back into the original order (interleaved), undoing the pre-determined reordering, and used as inputs to the first component 1 in the succeeding iteration cycle.

The optimal design of the first component 1, enforcing the linear channel constraints is often also prohibitively complex. To limit complexity, the component design itself can be constrained to be linear, leading to a linear signal processing component. The design of this linear signal processing component, given selected inputs, is the main subject of this disclosure with respect to the first embodiment. For the following description, the first embodiment lies in the linear signal processing component, or signal processing component 1, corresponding to component 1 in Figure 4. The remaining part of Figure 4 is referred to as signal processing component 2.

The function of the linear signal processing component 1 is to separate a selected transmitted signal from other "interfering" transmitted signals, based on the received signal which is a weighted sum of all transmitted signal as described above.

The input to the linear signal processing component 1 are one or more received signals and one or more estimates of the transmitted signals, provided by signal processing component 2. The output of the linear signal processing component 1 is an estimate of the selected transmitted signal.

The linear signal processing component 1 comprises two linear filters. The first filter provides as output estimates of the selected transmitted signal based on inputs of one or more of the input signals to the linear signal processing component, the output of this first filter delayed by one processing time period of the iterative cycle, and the output of the second filter delayed by one processing time period of the iterative cycle.

The second filter provides as output estimates of one or more of the other transmitted signals (interfering with the selected transmitted signal) based on inputs of one or more of the input signals to the linear signal processing component, and the output of the second filter delayed by one processing time period of the iterative cycle.

The output of the first filter is the output of the linear signal processing component.

Specific embodiments of the first embodiment will now be described in some further detail with reference to and as illustrated in the accompanying figures. These embodiments are illustrative, and not meant to be restrictive of the scope of the embodiment. Suggestions and descriptions of other embodiments may be included but they may not be illustrated in the accompanying figures or alternatively features of the embodiment may be shown in the figures but not described in the specification.

This embodiment is described using linear multiuser estimators (MUEs) suitable for use as part of an iterative multiuser decoder. A specific application of the technique in the field of turbo-decoding in a transmission system for coded CDMA is provided. However, as stated previously the structure of the filter and the principles revealed are useful in many other areas of the communications field. Thus the embodiment provided should not be considered as limiting in any way.

The specification includes theoretical considerations expressed in an appropriately precise fashion and uses mathematical analysis to prove the correctness of the approach using assumptions as required. Not all proofs of theorems used are provided herein. A disclosure such as that contained herein has directed correlation to practical devices and configurations of filter elements of performing the functions described. Furthermore the disclosure provided herein would be readily understood by those skilled in the art. The disclosure is such that a person skilled in the art can readily translate the theoretical configurations of elements disclosed herein into a variety of devices to solve problems or improve the performance of devices and algorithm in a variety of application areas some of which have been described previously and that will be described herein.

This embodiment is intended for application to any communication system described by a generic linear channel model. The received signal at the input to the receiver is described by a weighted sum of the transmitted signals plus noise. There could be multiple received observables pertaining to the same symbol internal, ie, the received signal can be a vector of received observables,

$$\mathbf{r} = \sum_{i=1}^{K} s_i x_i + \mathbf{n} \qquad (1)$$

where a total $K$ signals are transmitted, $\mathbf{s}_k$ is the weighting factors for signal $x_k$ and $\mathbf{n}$ is a noise vector.

Here, the set of weighting factors, $\mathbf{s}_1, \mathbf{s}_2, \ldots, \mathbf{s}_K$ represents a set of linear constraints imposed on the transmitted signals. Other constraints could possibly have been imposed on the signals $x_1, x_2, \ldots, x_K$ such as error control encoding, channel fading etc. These other constraints are independent from the linear constraints imposed by the linear channel.

The optimal receiver structure finds the estimates of the transmitted signals, subject to all the imposed constraints. This approach is prohibitively complex for most practical cases of interest. As an alternative, a generic iterative receiver structure comprises of two separate components (see Figure 4). The first component 1 finds the optimal estimates, only subject to the linear channel constraints, ignoring all other constraints. These estimates are inputs to the second component 2 which finds the optimal estimates subject only to all the other constraints, ignoring the linear channel constraints. These estimates are in turn, provided as inputs to the first component 1 in the following iteration cycle.

The optimal design of the first component 1, enforcing the linear channel constraints is often also prohibitively complex. To limit complexity, the component 1 design itself can be constrained to be linear, leading to a linear filter. The design of this linear filter, given selected inputs to the filter, is disclosed herein. The function of the filter is to separate a selected signal from other "interfering" signals, based on the received signal which is a weighted sum of all transmitted signal as described in (1). All the references provided in this specification are incorporated herein by reference and for all purposes. An innovation in the filter design disclosed herein is to exploit the fact that information provided by the decoders is initially only marginally correlated over iterations, i.e., in the first few iterations, each iteration provides new information. The disclosed filter design is based on a technique to use all available information from all previous iterations.

This implies that the filter grows linearly in size by a factor equal to the number of users. This is clearly impractical. Thus, the disclosed filter design makes it possible to use all the available information through recursive feedback of the filter output over iterations, without requiring a growing filter. The size of the filter remains the same. The filter design is based on two linear iterative filters, where the first linear filter provides an estimate of the desired signal based on the received signal, the most current estimates of all user signals from signal processing component 2, and the output of the second linear filter which is a vector of estimates of all user signals based on all previous inputs to signal processing component 1. The two linear filters are shown explicitly in Figure 8.

The linear iterative filters may appropriately be designed based on the linear minimum mean squared error criterion, according to the recursive expressions derived therein.

This embodiment applies to any system described by such a generic linear channel model, and where an iterative receiver as described above, is to be applied. Examples of such applications include (but are not limited to) the following:

- Decoding of coded transmission in a linear multiple access system.
- Decoding of coded transmission over an inter-symbol interference channel.
- Joint channel estimation and detection/decoding of coded transmission over unknown channels.
- Decoding of space-time coded transmission.
- Decoding of coded transmission with higher order modulation formats.

In the following, the design is demonstrated for multiuser decoding for a general linear multiple access system.

System Model in Multiuser Decoding Example

The basic principle behind turbo decoding is to decode independently with respect to the various constraints imposed on the received signal. The overall constraint is accommodated by iteratively passing extrinsic information between the individual decoders. For turbo codes, these constraints are the parallel concatenated codes. For turbo-equalisation they are the channel code and the memory of the inter-symbol interference channel. For multiuser decoding, there are constraints due to the multiple-access channel and due to the individual users' encoders.

In this embodiment, a theoretical framework for the derivation of linear multiuser estimators (MUEs) suitable for use as part of an iterative multiuser decoder is disclosed. We consider a two-input linear minimum mean squared error (LMMSE) estimator which inspires our main result, the derivation of a recursive Bayesian estimator. The proposed estimator yields estimates based on the received signal and all the successive outputs provided by the error control code decoders over all previous iterations. This approach is motivated by an observation that these estimates are loosely correlated during initial iterations.

Notation: $P^n$ is the space of probability $n$-vectors (length $n$ non-negative vectors that sum to 1). For random vectors $\mathbf{x}$ and $\mathbf{y}$, $E[\mathbf{x}]$ is the expectation, $\operatorname{var}\mathbf{x} = E\left[\mathbf{x}^*\mathbf{x}\right]$ and $\operatorname{cov}\mathbf{x} = \langle\mathbf{x},\mathbf{x}\rangle = E\left[\mathbf{x}\mathbf{x}^*\right]$. Likewise $\operatorname{cov}(\mathbf{x},\mathbf{y}) = \langle x,y\rangle = E\left[\mathbf{x}\mathbf{y}^*\right]$.

We consider the $K$-use linear multiple-access system of Figure 5. User $k, k=1.2,\ldots,K$ encodes its binary information sequence $b_k[l]$ using a rate $R$ code $C$, to produce the coded binary sequence $d_k[l]$.

Consider transmission of $2L$ code bits per user. Each user independently permutes their encoded sequence with an interleaver $\pi_k$. Denote the sequence output from the interleaver of user $k$ as $u_k[l], l=1,2,\ldots 2L$. Pairs of interleaved code bits $u_k[l]$ are memorylessly mapped onto the quaternary phase-shift keyed (QPSK) signal constellation, $Q = \{\pm 1/\sqrt{2} \pm j/\sqrt{2}\}$, giving sequences of modulated code symbols $x_k[i]$, where $i=1,2,\ldots,L$ is the symbol time index. We

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choose QPSK only for simplicity and note that different code constraints and symbol maps across users are possible in general.

At symbol time $i$, each user transmits $\mathbf{s}_k[i]x_k[i]$, the multiplication of $x_k[i]$ with the real $N$-chip spreading sequence, $\mathbf{s}_k[i] \in \{-1,1\}^N$. We model the use of spreading sequences with period much longer than the data symbol duration by letting each element of $\mathbf{s}_k[i]$ be independent and identical distributed over users and time. For conceptual ease only, users are symbol synchronised, transmit over an additive white Gaussian noise (AWGN) channel, and are received at the same power level. These assumptions however are not required. Write the chip-match filtered received vector $\mathbf{r}[i] \in \square^N$ at symbol time $i = 1,2,\ldots,L$ as

$$\mathbf{r}[i] = \mathbf{s}[i]x[i] + \mathbf{n}[i] \quad (2)$$

where $\mathbf{S}[i] = (s_1[i], s_2[i], \ldots, s_k[i])$, is a $NxK$ matrix with the spreading sequence for user $k$ as column $k$. The symbol $\square$ represents the set of complex numbers. The vector $x[i] \in Q^K$ has elements $x_k[i]$ and the vector $\mathbf{n}[i] \in \square^N$ is a sampled circularly symmetric i.i.d. Gaussian noise process, with $\operatorname{cov} \mathbf{n}[i] = \sigma^2 \mathbf{I}$. The symbol $Q$ represents the set of possible modulated symbols, e.g. QPSK.

Henceforth, it is not required to identify specific symbol intervals and these indices will be omitted. For later use, we define $\mathbf{S}_{\bar{k}} = (\mathbf{s}_1, \mathbf{s}_2, \ldots, \mathbf{s}_{k-1}, \mathbf{s}_{k+1}, \ldots, \mathbf{s}_K)$ and $\mathbf{x}_{\bar{k}} = (x_1, x_2, \ldots, x_{k-1}, x_{k+1}, \ldots, x_K)^t$ to indicate deletion of user $k$ from $\mathbf{S}$ or $\mathbf{x}$.

**Recursive Filter from Multiuser Estimation**

Application of the turbo-principle to the coded linear multiple-access system, where for each user, we treat the error control code as one constraint and the multiuser channel (2) as the other constraint, results in the canonical receiver structure of Figure 6[1].

An iteration $n_1$, the multiuser APP takes an input $\mathbf{r}$ and the set of extrinsic probabilities $\mathbf{q}_k^{(n-1)}$ from user $k$ =1,2,…,$K$ calculated in the previous iteration $n-1$. $\mathbf{q}_k^{(n-1)}[i] \in P^{|Q|}$ is the extrinsic probability distribution on the transmitted symbols $x_k[i] \in Q$ of user $k$. The set $Q$ is the set of all possible modulated symbols at the transmitter. The multiuser APP calculates the updated extrinsic probability vector

$\mathbf{p}_k^{(n)}[i]$ for user $k$. After appropriate de-interleaving, the extrinsics $\mathbf{p}_k^{(n)}$ are used as priors for independent APP decoding of the code C by each user, producing (after interleaving) the extrinsics $\mathbf{q}_k^{(n)}$ which serve as priors for the subsequent iteration. The marginalisation in the multiuser APP requires summation over $|Q|^{K-1}$ terms. Many lower-complexity alternatives have been proposed while retaining the same basic architecture.

Consider the receiver structure shown in Figure 7. There is a bank of linear filters $\Lambda_k^{(n)}$, one for each user. The coefficients of these filter may be re-computed every iteration. For the first iteration, $n=1$, the input to $\Lambda_k^{(1)}$ is just $\mathbf{r}$. For subsequent iterations $n=2,3,\ldots$, the input to the filter for user $k$ is $\mathbf{r}$ and a set of signal estimates for all the other users from previous iterations, $\{\hat{x}_{k'}^{(m)} : k' \neq k, m \in M\}$, where $M \subseteq \{1,2,\ldots,n-1\}$ is a set defining the memory order of the iteration. Typically in the literature, M = $\{n-1\}$, although recently M = $\{n-1, n-2\}$ has been considered [2].

The output of the filter $\Lambda_k^{(n)}$ is an updated sequence of estimates $\hat{x}_k^{(n)}$ of the corresponding code symbol for user $k$. These estimates are mapped from the signal space onto the probability vector space using a symbol-wise mapping $T : \Box \to P^{|Q|}$. The resulting sequence of probability vectors $\mathbf{p}_k^{(n)}$ are used as priors for individual APP decoding of the code C. These APP decoders can output either posterior or extrinsic probabilities $\mathbf{q}_k^{(n)}$ (both approaches have been investigated in the literature). The sequence of probability vectors $\mathbf{q}_k^{(n)}$ is in turn mapped back onto the signal space by a symbol-wise function $U : P^{|Q|} \to \Box$. Typically, $T$ calculates the vectors $\mathbf{p}_k^{(n)}$ assuming that $\hat{x}_k^{(n)}$ is Gaussian distributed with known mean and variance, $\hat{x}_k^{(n)} : N(\tilde{\mu}_k^{(n)}, \tilde{\varsigma}_k^{(n)})$. Likewise, a common choice for $U$ is the conditional mean.

The following easily proved lemma provides a useful general framework for the derivation of filters $\Lambda_k^{(n)}$.

**Lemma 1**

*Suppose that for a parameter* $x$ *we have the vector observation* $\mathbf{c}=(\mathbf{a}^t\mathbf{b}^t)^t$, *the concatenation of two vector observations* **a** *and* **b**. *The LSE estimate of* $x$ *given* $\mathbf{c}$ *is*

$$\tilde{x}=\langle x,\mathbf{a}\rangle\langle\mathbf{a},\mathbf{a}\rangle^{-1}\mathbf{a}+\mathbf{m}\left(\mathbf{b}-\langle\mathbf{b},\mathbf{a}\rangle\langle\mathbf{a},\mathbf{a}\rangle^{-1}\mathbf{a}\right) \quad (3)$$

*where*

$$\mathbf{m}=\left(<x,\mathbf{b}>-<x,\mathbf{a}><\mathbf{a},\mathbf{a}>^{-1}<\mathbf{a},\mathbf{b}>\right)\left(<\mathbf{b},\mathbf{b}>-<\mathbf{b},\mathbf{a}><\mathbf{a},\mathbf{a}>^{-1}<\mathbf{a},\mathbf{b}>\right)^{-1}$$

We see that (3) can be written as $\tilde{x}=\mathbf{g}\mathbf{a}+\mathbf{m}(\mathbf{F}\mathbf{a}-\mathbf{b})$, where

$$\mathbf{m}=\left(<x,\mathbf{b}>-<x,\mathbf{a}><\mathbf{a},\mathbf{a}>^{-1}<\mathbf{a},\mathbf{b}>\right)\left(<\mathbf{b},\mathbf{b}>-<\mathbf{b},\mathbf{a}><\mathbf{a},\mathbf{a}>^{-1}<\mathbf{a},\mathbf{b}>\right)^{-1} \quad (4)$$

$$\mathbf{F}=<\mathbf{b},\mathbf{a}><\mathbf{a},\mathbf{a}>^{-1} \quad (5)$$

$$\mathbf{g}=<x,\mathbf{a}><\mathbf{a},\mathbf{a}>^{-1} \quad (6)$$

So far in the literature, linear filters $\Lambda_k^{(n)}$ for multiuser estimation in iterative decoding have been designed based on the received signal $\mathbf{r}$ and the most current code symbol estimates of the interfering users $\hat{x}_k^{(n)}$. After $n$ iterations, we have however a sequence of such estimates available, namely $\{\hat{\mathbf{x}}_k^{(1)},\hat{\mathbf{x}}_k^{(2)},\ldots\hat{\mathbf{x}}_k^{(n)}\}$ together with $\mathbf{r}$. It has been observed that the estimates are not strongly correlated during the initial iterations [2].

Consider the following recursively defined version of observables as input to the filter $\Lambda_k^{(n)}$,

$$\mathbf{c}_k^{(n)}=\begin{cases}\mathbf{r} & n=1\\ \begin{pmatrix}\mathbf{c}_k^{(n-1)}\\ \hat{\mathbf{x}}_k^{(n-1)}\end{pmatrix} & n=2,3,\ldots\end{cases} \quad (7)$$

Direct application of the LMMSE criterion results in $\Lambda_k^{(n)}=<x_k,\mathbf{c}_k^{(n)}><\mathbf{c}_k^{(n)},\mathbf{c}_k^{(n)}>^{-1}$. It is clear however that $\Lambda_k^{(n)}$ grows in dimension with $n$ which is impractical.

Inspired by recursive Bayesian estimation (RBE) [3], we can prove the following theorem that solves this dimensionality problem by giving a recursive form from $\Lambda_k^{(n)}$ (subject to certain constraints on the input signal).

**Theorem 1**

Make the following assumptions,

**A1:** *The received signal* $\mathbf{r} = \mathbf{S}\mathbf{x} + \mathbf{n}$, *is described according to (2) where* $\mathbf{n}$ *is circularly symmetric complex Gaussian with* $\operatorname{cov}\mathbf{n} = \sigma^2\mathbf{I}$, *and* $\sigma^2$ *and* $\mathbf{s}$ *are known.*

**A2:** *The interleaved code symbol estimates of the interfering users* $\hat{\mathbf{x}}_{\bar{k}}^{(n)}$ *coming out of the single user APP decoders can be written as* $\hat{x}_k^{(n)} = x_k^{(n)} + \hat{v}_k^{(n)}$ *where* $\hat{v}_k^{(n)}$ *is uncorrelated with* $\mathbf{x}$ *and also uncorrelated over time and iterations, but not over users at a given iteration, i.e.* $<\mathbf{x}, \hat{v}_k^{(n)}> = 0, <\hat{v}_k^{(n)}, \hat{v}_k^{(m)}> = 0$ *for* $n \neq m$ *and* $<\hat{v}_k^{(n)}, \hat{v}_j^{(n)}> = q_{kj}$.

*Define* $\mathbf{Q}_k^{(n)} = <\hat{v}_{\bar{k}}^{(n)}, \hat{v}_{\bar{k}}^{(n)}>$, *with elements determined as shown above.*

*Let* $\mathbf{c}_k^{(n)}$ *be according to (7). Under* ***A1*** *and* ***A2***, *the LMMSE estimate of* $x_k$ *given* $\mathbf{c}_k^{(n)}$ *is given by the output* $\tilde{x}_k^{(n)}$ *of the recursive filter shown in Figure 8.*

*The update for the estimate is*

$$\tilde{x}_k^{(n)} = \tilde{x}_k^{(n-1)} + \mathbf{m}_k^{(n)}\left(\hat{\mathbf{x}}_{\bar{k}}^{(n-1)} - \tilde{\mathbf{x}}_{\bar{k}}^{(n-1)}\right)$$

*The filters in the figure are defined as follows:*

$$\mathbf{m}_k^{(n)} = -\mathbf{w}_k^{(n)}\left(\mathbf{I} + \mathbf{Q}_k^{(n-1)} - \mathbf{W}_k^{(n)}\right)^{-1}$$

$$\mathbf{M}_k^{(n)} = \left(\mathbf{I} - \mathbf{W}_k^{(n)}\right)\left(\mathbf{I} + \mathbf{Q}_k^{(n-1)} - \mathbf{W}_k^{(n)}\right)^{-1}$$

*with the recursive update equations for* $n = 3,4,\ldots$

$$\mathbf{w}_k^{(n)} = \mathbf{w}_k^{(n-1)}\left[\mathbf{I} - \left(\mathbf{H}_k^{(n-1)}\right)^{-1}\left(\mathbf{I} - \mathbf{W}_k^{(n-1)}\right)\right]^{-1}$$

$$\mathbf{W}_k^{(n)} = \mathbf{W}_k^{(n-1)} + \left(\mathbf{I} - \mathbf{W}_k^{(n-1)}\right)\left(\mathbf{H}_k^{(n-1)}\right)^{-1}\left(\mathbf{I} - \mathbf{W}_k^{(n-1)}\right)$$

$$\mathbf{H}_k^{(n-1)} - \mathbf{I} + \mathbf{Q}_k^{(n-2)} - \mathbf{W}_k^{(n-1)}$$

*The initial conditions with* $\tilde{x}_k^{(0)} = 0$ *and* $\mathbf{x}_{\bar{k}}^{(0)} = 0$ *are* $\mathbf{m}_k^{(1)} = \mathbf{s}_k^t\left(\mathbf{S}\mathbf{S}^t + \sigma^2\mathbf{I}\right)^{-1}$, $\mathbf{M}_k^{(1)} = \mathbf{S}_{\bar{k}}^t\left(\mathbf{S}\mathbf{S}^t + \sigma^2\mathbf{I}\right)^{-1}$ *for* $n = 1$ *and* $\mathbf{w}_k^{(2)} = \mathbf{s}_k^t\left(\mathbf{S}\mathbf{S}^t + \mathbf{I}\right)^{-1}\mathbf{S}_{\bar{k}}$, $\mathbf{W}_k^{(2)} = \mathbf{S}_{\bar{k}}^t\left(\mathbf{S}\mathbf{S}^t + \sigma^2\mathbf{I}\right)^{-1}\mathbf{S}_{\bar{k}}$ *for* $n = 2$.

Computer simulations have been used to evaluate the proposed technique. For the purposes of simulation, each user used the maximum free distance 4 state convolutional code naturally mapped onto QPSK. Each user is therefore transmitting 1 bit per channel use. Binary spreading sequences with $N = 8$ were generated i.i.d. at each symbol for each user. Transmission is chip synchronous and all users are received at the same power level.

Indicative simulation results are shown in Figure 9. Three curves are shown. PIC is the parallel interference cancellation method of [4]. IPIC is the improved parallel interference cancellation of [2]. RBE is the proposed recursive Bayesian estimation technique. Each of the curves begins for small numbers of users at the single-user BER near $10^{-4}$. As each receiver fails to converge, its curve deviates from single-user. For PIC, this occurs at *K/N*=1.125. For IPIC, the limit is 1.625 and for RBE 1.875. The performance benefit of IPIC over PIC is reported in [2]. The recursive Bayesian technique supports even higher loads. In fact, further numerical investigations (for smaller systems) have shown that RBE supports almost the same load as using the multiuser APP.

Described herein is a computationally efficient recursive filter for use in iterative multiuser decoding. This filter uses the entire history of outputs from the single user decoders in order to accelerate convergence and to support greater loads.

With reference to figures 10 to 18 a second embodiment is described where there are a number of specific solutions offered which fall out from the general solution of (or realization that) adapting related art single pass OFDM receivers to iteratively receive signals at the sampling level allows the receiver to differentiate a desired packet from an observation of an interference (collision) signal at the receiver input. These solutions are as follows:

- An overall system solution – Iterative Receiver Structure itself.
- Additional solution aspect – Samples Estimates list.
- Additional solution aspect – Information Bit Estimates list.

- Additional solution aspect – Multiplexing of Time/Frequency Domain Channel Application Sample Estimates.

In one aspect, the second embodiment provides a system and method of receiving OFDM packets comprising the following:

a) sample a receiver input signal consisting of signals from one or more antenna;

b) add the input signal with one of a plurality of prior stored received packet sample estimates to determine a packet sample hypothesis;

c) determine an information bit estimate from the sample hypothesis for storage in an information bit estimates list;

d) determine an updated received packet sample estimate from the sample hypothesis for updating the plurality of prior stored estimates;

e) subtract the updated sample estimate from the sample hypothesis to determine a noise hypothesis and provide the noise hypothesis as the receiver input signal;

f) repeat steps a) to e) until at least one or more complete packets are accumulated in the information bit estimates list.

In another aspect, the second embodiment provides a system and method of providing a sample estimates list in an OFDM receiver comprising the following:

a) sample a receiver input signal;

b) determine a packet sample estimate from the sampled receiver input signal;

c) store the packet sample estimate;

d) determine a packet sample hypothesis by adding the receiver input with a selected previously stored packet sample estimate;

e) determine an updated packet sample estimate by decoding and re-transmission modelling the packet sample hypothesis;

f) update the selected previously stored packet sample estimate with the updated packet sample estimate.

In yet another aspect the second embodiment provides a system and method of providing a packet information bit estimates list in an OFDM receiver comprising the following:

a) determine a packet sample hypothesis by adding a receiver input with a selected previously stored packet sample estimate;

b) determine an information bit estimate by decoding the packet sample hypothesis with one or more of a hard decoding technique and a soft decoding technique

c) storing the information bit estimate with one or more previously determined information bit estimates;

d) repeating steps a) to c) until a complete packet is accumulated.

In still another aspect, the second embodiment provides a system and method of determining a hybrid OFDM received packet sample estimate comprising the step of:

multiplexing a time domain channel application received sample estimate with a frequency domain channel application received sample estimate, such that the multiplexed time domain sample estimate is mapped to correspond to one or more of;

an OFDM signal cyclic prefix;

an OFDM tail portion, and;

an OFDM guard period,

wherein the multiplexed frequency domain sample estimate is mapped to correspond to one or more of;

an OFDM signal preamble and;

an OFDM payload data symbol.

In another aspect the second embodiment provides an iterative sample estimation method for OFDM packet based network communication comprising the following steps:

a) selecting either the windowed matched received samples or the noise hypothesis as the input signal;

b) adding an empty packet estimate to a samples estimate list containing packet sample estimates;

c) selecting one of said list entries;

d) adding said packet samples estimate to said input signal to create a packet received samples hypothesis;

e) decoding and re-transmission modelling of said packet received samples hypothesis to create a new packet received samples estimate and new information bit estimates;

f) updating said information bit estimate list with new information bit estimates;

g) subtracting said new packet samples estimate from said packet received samples hypothesis to create a noise hypothesis; and

h) updating said samples estimate list entry with said new packet samples estimate;

all said steps being iterated at least once for each packet.

In a further aspect the second embodiment provides an iterative sample estimation method according to the previous paragraph wherein step e) further comprises:

i) soft decoding said selected packet sample estimate to create soft encoded bits and new packet information bit estimates for reinsertion into said information bit estimates list;

j) soft modulating said soft encoded bits to create a transmitted symbol estimate;

k) constructing the time domain channel estimate from said packet received samples hypothesis and said transmitted symbol estimates;

l) constructing the packet transmit sample estimate from said transmitted symbol estimate;

m) convolving said time packet transmit sample estimate with said time domain channel estimate to create the time domain channel applied received samples estimate; and in parallel with steps k) and m);

n) constructing the frequency domain channel estimate from said packet received samples hypothesis and said transmitted symbol estimates;

o) multiplying said frequency domain channel estimate with said transmitted symbol estimates to create packet received symbol estimates; then

p) constructing the frequency domain channel applied received samples estimate from the packet received symbol estimates; and

q) multiplexing the time domain channel applied received samples estimate with the frequency domain channel applied received samples estimate for reinsertion into said samples estimate list, wherein steps n) to p) are repeated for each OFDM symbol in a packet.

In still another aspect, the second embodiment provides an iterative sample estimation method according to the paragraph previous to the preceding paragraph wherein step e) further comprises:

r) hard decoding said selected packet sample estimate to create hard encoded bits and new packet information bit estimates for reinsertion into said information bit estimates list;

s) hard modulating said hard encoded bits to create a transmitted symbol estimate;

t) constructing the time domain channel estimate from said packet received samples hypothesis and said transmitted symbol estimates;

u) constructing the packet transmit sample estimate from said transmitted symbol estimate;

v) convolving said time packet transmit sample estimate with said time domain channel estimate to create the time domain channel applied received samples estimate; and in parallel with steps t) and u);

w) constructing the frequency domain channel estimate from said packet received samples hypothesis and said transmitted symbol estimates;

x) multiplying said frequency domain channel estimate with said transmitted symbol estimates to create packet received symbol estimates; then

y) constructing the frequency domain channel applied received samples estimate from the packet received symbol estimates; and

z) multiplexing the time domain channel applied received samples estimate for reinsertion into said list.

With reference to figures 10 to 18, the following blocks are used for receiver signal processing techniques in accordance with the second embodiment;

- OFDM Soft Output Decode 288
- OFDM Hard Output Decode 222
- Encode 224
- Soft Modulate 230

- Hard Modulate 226
- Acquisition 204
- Matched Filter 202
- Sum 208
- Subtract 212
- Convolve 236
- Multiply 240
- Time to Frequency Conversion (dependant on system standard) 234
- Time Domain Channel Estimator 232
- Frequency Domain Channel Estimator 238
- Time, Frequency Domain Multiplex 220
- Samples Estimate List (including associated Controller) 206
- Information Bit Estimates List (including associated Controller) 213

Table 1 and Table 2 provide a key for the number signals and process in each figure and the reference numbers in the text.

| | |
|---|---|
| 1002 | Received Samples |
| 1004 | Windowed Matched Received Samples |
| 1006 | Empty Sample Estimates |
| 108 | Previous Packet Received Samples Estimate |
| 110 | Packet Received Samples Hypotheses |
| 112 | New Packet Information Bit Estimates |
| 114 | New Packet Received Samples Estimate |
| 116 | Noise Hypothesis |
| 118 | Completed Packet Information Bit Estimates |
| 119 | Packet Transmit Symbol Estimates |
| 120 | Time Domain Channel Applied Received Samples Estimate |
| 122 | Frequency Domain Channel Applied Received Samples Estimate |
| 126 | Hard Encoded Information Bits |
| 128 | Soft Encoded Information Bits |
| 130 | Time Domain Channel Estimate |
| 132 | Packet Transmit Samples Estimate |
| 134 | Frequency Domain Channel Estimate |
| 136 | Packet Received Symbol Estimates |

**Table 1: Signals**

| | |
|---|---|
| 202 | p(t) - Bandwidth Limiting Filter – Matched Filter |
| 204 | Acquisition |
| 206 | Samples Estimate List |
| 208 | $\Sigma$-Add |
| 210 | OFDM Soft/Hard Decode and Re-transmit |
| 212 | $\Sigma$(-ve) -Subtract |
| 213 | Information Bit Estimates List |
| 214 | OFDM Soft/Hard Decode and Re-modulate |
| 215 | Hybrid Re-transmit |
| 216 | TDCA – Time Domain Channel Application |
| 218 | FDCA – Frequency Domain Channel Application |
| 220 | MUX – Time, Frequency Domain Multiplex |
| 222 | OFDM Hard Output Decode |
| 224 | Encode |
| 226 | Hard Modulate |
| 228 | OFDM Soft Output Decode |
| 230 | Soft Modulate |
| 232 | Time Domain Channel Estimator |
| 234 | F→T – 802.11a Frequency to Time Domain Conversion |
| 236 | Convolve – Linear Convolution |
| 238 | Frequency Domain Channel Estimator |
| 240 | Multiply |

**Table 2: Function Blocks**

The second embodiment of the invention is adapted for a Packet based OFDM WLAN system (eg IEEE 802.11a, IEEE 802.11g). A typical receiver for such a system performs processing tasks in accordance with figure 10. The input to the system is a complex, oversampled baseband received signal 1002 for each attached antenna. The signal received on each antenna is passed through a band limiting filter 202 which is then followed by a packet detection and synchronisation (Acquisition) processing block 204. This Acquisition block uses one or more of the matched filter antenna signals 1004. Once a packet is acquired it is decoded using either hard or soft decoding techniques and passed on to a higher processing layer (eg. MAC). The typical receiver structure figure 10 may be modified to an iterative structure that provides interference cancelling at the sample level.

**Iterative Receiver Structure & Function**

The input to the receiver is the oversampled digital I/Q baseband samples from each antenna connected to the receiver called the Received Samples 1002. The Received Samples 1002 are windowed over time and passed through a filter 202 matched to the pulse shape in order to produce windowed matched received samples 1004. This constitutes the Noise Hypothesis 116 for the first iteration (n=1). For all proceeding iterations (n>1), the Noise Hypothesis 116 is provided by the feedback of the interference signal. This is depicted in Figure 11 by the n conditioned switch $SW_n$.

An iteration of the receiver is a single execution of each of the following processes:

- Attempt to acquire a new Packet in the Noise Hypothesis 116 using the Acquisition 204 process.
- If a new packet is found, add empty entries 1006 to the Samples Estimate List 206 and Information Bit Estimates List 213. Each entry in the Samples Estimates List 206 has a corresponding entry in the Information Bit Estimate List 213.
- Determine, from the evolution of both Samples and Information Bit estimates list, Completed Packets $\{y_1 ... y_m\}$, in the Information Bit Estimates List 206.
- Release to higher layer (MAC) then Remove Completed Packets $\{y_1 ... y_m\}$ from the Information Bit Estimates List 213.
- Remove Completed Packets $\{y_1 ... y_m\}$ from the Samples Estimate List 206.
- Select a Packet $k$ in the Samples Estimate List 206 to Process.

- Add 208 the Previous Packet Received Samples Estimate 208 of selected packet $k$ from the Samples Estimate List 206 to the Noise Hypothesis 116 to produce the Packet Received Samples Hypothesis 110.
- Generate new Packet Received Samples Estimate 114 and new information bit estimates 112 for the selected packet $k$ from the Packet Received Samples Hypothesis 110 using OFDM Soft/Hard Decode and Re-transmit process 210.
- Update the selected packets' $k$ previous information bit estimates in the Information Bit Estimates List 213 with the New Information Bit Estimates 112.
- Update the selected packets' $k$ previous Samples Estimate in the Samples Estimate List 206 with the New Packet Received Samples Estimate 114.
- Subtract 212 the New Packet Received Samples Estimate 114 from the Packet Received Samples Hypothesis 110 to produce the Noise Hypothesis 116.

Iterations are continually performed until all packets have been released from the Information Bit Estimates List 213. Once this state has been reached, the lists 206, 213 are cleared, the time window is updated and the entire process repeated.

**Iterative Interference Cancelling**

Interference cancelling at the sample level requires the generation of New Packet Received Samples Estimate 114 for each antenna using the OFDM Soft/Hard Decode and Re-transmit 210 process for every Packet found by the Acquisition 204 process. Each packet's New Packet Received Samples Estimate 114 are stored in the Samples Estimate List 206. The interference cancelling structure requires that each packet Adds 208 its Previous Packet Received Samples Estimate 108 to the Noise Hypothesis 116 before the Soft/Hard Decode and Re-transmit 210 process to produce the Packet Received Sample Hypothesis 110 for each antenna. The New Packet Received Samples Estimate 114 produced by the Soft/Hard Decode and Re-transmit 210 process are then Subtracted 212 from the Packet Received Sample Hypothesis 110 to generate an updated Noise Hypothesis 116. The New Packet Received Samples Estimate 114 are also used to update the Samples Estimate List 206. The Noise

Hypothesis 116 is then fed back through the system (minus the latest estimated contribution of the previously processed packet) providing Iterative Interference Cancelling. Figure 11 provides a graphical reference for this process.

**Samples Estimate List**

The Samples Estimate List 206 contains the New Packet Received Samples Estimate 114 as generated by the OFDM Soft/Hard Decode and Re-transmit process 210 for each receive antenna for each Packet found by the Acquisition 204 process.

For each iteration, a packet to iterate ($k$) is selected from the Samples Estimate List 204. The selection $k$ can be based on numerous metrics e.g., sorted signal power, the minimum number of processing cycles performed, order of arrival. This selection is depicted by the $k$ controlled switch $SW_k$ in Figure 11, where $k$ is the current selected packet.

**Information Bit Estimates List**

The Information Bit Estimates List 213 contains the latest New Packet Information Bit Estimates 112 as generated by the OFDM Soft/Hard Decode and Re-transmit 215 process for each Packet found by the Acquisition 204 process.

Each iteration provides an opportunity to release Completed Information Bit Estimates 118 to higher layers (e.g. MAC). The choice of which packets are complete is made by evaluating a metric for each packet in the Samples Estimate List 206. For example, this metric may be based on indicators such as signal power, the number of iterations performed and number of completed packets. These metrics are then compared to a target value. All packets that meet their target are marked for release from the Information Bit Estimates List 213.

For each packet acquired there is an entry in both the Samples Estimate List 206 and the Information Bit Estimates List 213. The selection of completed packets is depicted by the $\{y_1 ... y_m\}$ controlled switch $SW_y$ in Figure 11, where $\{y_1 ... y_m\}$ is the list of Completed Packet Information Bit Estimates. A feature of the iterative receiver structure is that the packet's Packet Received Samples Estimate 114 remain subtracted from the Noise Hypothesis 116 even after it is released and its corresponding entries in both lists removed.

**Hybrid Re-transmission**

The Hybrid Re-transmission 215 process is depicted in Figure 12 and Figure 13. It uses both Time Domain Channel Application 216 and Frequency Domain Channel Application 218 processes to generate a New Packet Received Samples Estimate 114. Both processes use the Packet Received Samples Hypothesis 110 for each antenna and Packet Transmit Symbol Estimates 119 to create Channel Applied Received Samples Estimate 120, 122 for each receive antenna. The Time Domain Channel Application 216 process produces a Time Domain Channel Applied Received Samples Estimate 120. The Frequency Domain Channel Application 218 process produces a Frequency Domain Channel Applied Received Samples Estimate 122. The Channel Applied Received Samples Estimate 120, 122 are then multiplexed 220 together to form the New Packet Received Samples Estimate 113 for each antenna. Each of these processes is described in further detail below.

**Time Domain Channel Application (TDCA)**

The Time Domain Channel Application 216 process is further expanded in Figure 16. The Time Domain Channel Estimator 232 produces a Time Domain Channel Estimate 130 for each receive antenna using the Packet Transmit Symbol Estimates 119 from the OFDM Soft/Hard Decode and Re-modulate 214 process (see Figure 14 and Figure 15) and the Packet Received Sample Hypothesis 110 for each antenna. The Frequency to Time Conversion 234 then produces a Packet Transmit Samples Estimate 132 using the Packet Transmit Symbol Estimates 119. The Packet Transmit Samples Estimate 132 and Time Domain Channel Estimate 130 for each antenna are then linearly convolved via the Convolve 236 process to produce the Time Domain Applied Received Samples Estimates 120 for each antenna.

**Frequency Domain Channel Application (FDCA)**

The Frequency Domain Channel Application 218 process is further expanded in Figure 17. The Frequency Domain Channel Estimator 238 produces a Frequency Domain Channel Estimate 134 for each antenna using the Packet Transmit Symbol Estimates 119 from the OFDM Soft/Hard Decode and Re-modulate 214 process and the Packet Received Sample Hypothesis 110 for each antenna. The Packet Transmit Symbol Estimates 119 are then multiplied, one

OFDM symbol at a time, by the Frequency Domain Channel Estimate 134 via the Multiply 240 process to produce the Packet Received Symbol Estimates 136. The Packet Received Symbol Estimates 136 are then converted into the Frequency Domain Channel Applied Received Samples Estimate 122 using the Frequency-To-Time process 234.

**Time, Frequency Domain Channel Application Multiplexing (MUX)**

Referring now to Figure 13, the Multiplexing 220 process takes the Time Domain Channel Applied Received Samples Estimate 120 and the Frequency Domain Channel Applied Received Samples Estimate 122 and multiplexes them together to produce a hybrid New Packet Received Samples Estimate 114.

OFDM modulation scheme such as those used in this second embodiment, commonly employ a cyclic prefix to combat multi-path interference. Also, due to time dispersion characteristics of both the radio channel and band limiting filters, there are tails at the beginning and end of the New Packet Received Samples Estimate 114. New Packet Received Samples Estimate 114 corresponding to the OFDM portion of the signal are taken from the Frequency Domain Channel Applied Received Samples Estimate 122. The remaining samples in the New Packet Received Samples Estimate 114 are taken from the Time Domain Channel Applied Received Samples Estimate 120. In this embodiment those samples comprise the cyclic prefix and tail portions of the New Packet Received Samples Estimate 114.

An example of multiplexer mapping is shown in Figure 18.

**Preferred Area of Application**

The preferred areas of application for the second embodiment of the present invention are OFDM receivers that may be used with IEEE 802.11a, IEEE 802.11g, IEEE 802.16 and HiperLAN Wireless Local Area Network (WLAN) standards. However, the invention disclosed is useable in any packed based OFDM communications system as would be understood by the person skilled in the art.

With reference to figures 19 to 23 a third embodiment is described which stems from the realization that reducing the distortions in one or more of the raw signals arriving at a receiver used to provide a decision statistic leads to an overall improvement in the decision statistic itself. Furthermore, appropriate selection of the means of reducing these distortions leads to a more reliable determination of packet arrival time.

In one aspect the third embodiment provides a method and apparatus for communicating in a multiple access communication network by synchronizing packets arriving at a receiver comprising:

receiving a packet input signal;

determining a correlation signal corresponding to the packet input signal;

processing the input and correlation signals such that at least one of the input signal and the correlation signal are filtered;

determining a decision statistic by combining a power component of the processed correlation signal with a power component of the processed input signal;

nominate a point in time given by a predetermined threshold condition of the decision statistic as a received packet arrival time.

The processing of at least one of the input and correlation signals is performed by one of a centre weighted filter having a triangular impulse response, a root raised cosine filter, a Hanning window filter, a Hamming window filter, or a combined Hanning/Hamming window filter. The predetermined threshold condition may be one of the decision statistic crossing the predetermined threshold or a maximum of the decision statistic occurring above the predetermined threshold. The determination of the correlation signal may be performed every Kth sample of a sampled packet input signal, where K is an integer greater than or equal to 1. The third embodiment of the present invention is described in more detail below.

**Power averaging mask for FFT window synchronisation**

Synchronisation of packets transmitted, especially over wireless media, is ordinarily achieved by employing a preamble comprised of several repetitions of the same signal and correlating the received signal with a delayed version of itself. The delay may be chosen to equal the duration of the repeated signal component defining the preamble. The output power of this correlation process is then usually normalised against the average power in the received signal. The point at which the normalised correlator output exceeds a threshold is selected as the packet arrival time. This technique has a number of deficiencies. For example, it does not optimally exploit the statistics of the correlator outputs and thus may introduce larger error margins in the determination of data packet timing. In this third embodiment, a method is disclosed which permits a more accurate determination of arrival time of a data packet. Thus synchronisation errors may be reduced and, consequently, packet loss rates are reduced. Specifically, the method uses a linear filtering approach to interpret the correlator outputs prior to powers being calculated, thereby improving the quality of the statistic used for packet synchronisation. This is achieved primarily due to the noise suppression properties of the filter. The shape of the linear filter may be optimally designed against the characteristics of the preamble and the radio channel. An example would be a root raised cosine filter, or a Hanning/Hamming window filter. One preferred embodiment of the invention is the use of a centre weighted average filter with a triangular impulse response for application to the correlator outputs. This filter enables more accurate location of the time of the packet arrival than is achievable otherwise and has an efficient implementation. It is also proposed to use the maximum correlation power, once a threshold is exceeded, as the decision point rather than the time at which the correlation power first crosses a threshold. Those practiced in the art will recognise that this method has potential application to any communication system that uses a repetitive preamble for packet synchronisation. The inventor has recognised that filters are widely used in general applications and that the synchronisation of packets may be treated as a filtering problem. Accordingly, the inventor proposes to use raw correlator outputs as a preferred filter input. The use of a centre weighted (or other) filter on the correlator outputs prior to power calculation is used as a measure of the arrival timing of a packet. Threshold testing of the normalised power of the received signal correlated with a delayed version of itself is also contemplated. The delay is equal to the repetition size of the preamble. The normalisation is achieved by dividing by the sliding window averaged power of the received signal. In this third embodiment it is particularly advantageous to provide a receiver with the following functions:

Filtering of raw correlator outputs;

Centre weighted averaged filter, preferably a triangular filter which has an efficient implementation;

The above allows for basing a decision point on the maximum of correlator output power rather than a first level crossing leading to better characterisation of packet timing to avoid packet transmission loss/inefficiency. The third embodiment may comprise a receiver technology for packet data transmissions where a repetitive preamble is deployed to determine packet data timing and allowing for adaptive design of filter form against the statistics of the radio channel.

**Field of Application**

The third embodiment technology applies to a point to point communications link where transmissions are made using a waveform structure that has a preamble of a particular type. Specifically the preamble may be formed by one or more repetitions of a base signal. The functional device embodying the technology preferably resides in the baseband receiver processor Rx of a general receiver 190, as previously discussed and, in this embodiment, in the exemplary form of a wireless modem 190 as shown in figure 19. The relative logical location of the baseband receiver Rx is shown in figure 19 as the "Baseband Rx".

In more detail, in packet based communications systems the timing of the arrival of a packet is determined at the receiver 190. Once this timing is determined the alignment of the remaining (typically data bearing) portions of the packet may be determined using a-prior knowledge of the packet structure. Therefore without accurate determination of the packet time packet errors may be prevalent. A common technique employed is to transmit a preamble at the start of the packet transmission that has a special structure permitting efficient arrival time determination at the receiver 190. This structure requires the repetition of a short signal several times in the preamble. The structure of a typical packet is shown in figure 20 where the Sync Word (SW) is repeated several times at the beginning of the transmission.

The conventional time synchronisation technique correlates the received signal with a delayed version of itself. This delay may be set to the length of the Sync Word and the correlation length may be set to the number of SW repetitions ($L$) minus one. This correlation is implemented every sample (or every $K^{th}$

sample where $K$ is small, e.g. 4). If the received sample sequence is $\{r_{i-1}, r_i, r_{i+1}, r_{i+2}, \ldots\}$ then the correlator output at time $i$ is

$$\rho_i = \sum_{j=i}^{i+N(L-1)} r_j^* r_{j+N}$$

This correlation value is compared with the power in the observed sequence

$$\sigma_i = \sum_{j=i}^{i+N(L-1)} r_j^* r_j$$

to form a decision statistic $|\rho_i^2|/\sigma_i^2$. The arrival time $i$ is chosen when this metric exceeds a threshold.

The inventor has identified that any noise present in the received sequence $r_i$ is amplified by the squaring process and may cause the synchronisation technique to pick the incorrect arrival time. Rather than waiting for the statistic to cross a threshold, the algorithm may be adjusted to select the maximum statistic by including a small amount of decision delay. This maximum is chosen from those statistics above the threshold. A number of statistics crossing a given threshold is shown in figure 21.

**Preferred Method**

In this method according to the third embodiment of the invention the inventor exploits the profile of the autocorrelation of the preamble in order to mitigate the negative effects of noise of the time synchronisation performance. This may be achieved by filtering the sequences $\rho_i$ and $\sigma_i$ by a centre weighted low pass filter. Note that this filter is applied *prior* to the subsequent squaring of the sequences for decision statistic generation. Any noise presence will be better suppressed by filtering prior to squaring. The filter may be designed against the autocorrelation properties of the preamble but in a preferred embodied a triangle filter is employed.

A triangle filter has an impulse response that is triangular in nature, specifically the coefficients (taps) of the (discrete time) filter are

$$f_i = \frac{N-|i|}{N^2}$$

as shown in figure 22. If the filter described above is applied to the underlying sequences ($\rho_i$ and $\sigma_i$) then a typical result would be as shown in figure 23. It can be seen that the threshold crossing technique has benefited from the application of the filter, since it is now closer to the maximum as seen by inspection of figure 23. The effect of the noise has also been reduced therefore enhancing both the maximum and threshold crossing techniques. The preferred method is to apply the filter to both raw sequences, compute the metric using the filtered sequence and to use the maximum of the statistic that is above the threshold. Advantageously, a more accurate synchronisation of arrival time is achieved by filtering of the correlator output and power measurement processing prior to decision statistic generation; using a maximum search within a window defined by a threshold on the decision statistic.

By accurately estimating the arrival time of the preamble (and therefore the packet), the number of packet decoding failures may be significantly reduced. Apart from improving the chance of recovering the data payload this has flow on effects to the network users since both network control and data packets are now more reliably recovered.

With reference to figures 24 to 31 a fourth embodiment of the present invention is described in which the solution offered stems from the realization that receiver sensitivity may be improved by improving channel estimates using symbol estimates from the encoded portion of a packet and iteratively updating these channel estimates based on recently received data symbol channel estimates. A further aspect of the fourth embodiment resides in transforming each received data symbol to the frequency domain to enable the release of time smoothed channel estimates for improved decoding.

Advantageously, in the fourth embodiment, each OFDM symbol may be decoded more than once by obtaining a channel estimate for Symbol n, decoding symbol n, updating the channel estimate for symbol n, updating the channel estimate for symbol n-1 (by time domain smoothing from the new channel estimate for symbol n), decoding symbol n-1, updating channel estimate n-1.

In accordance with a fourth embodiment the present invention provides a method and system of tracking time varying channels in a packet based communication system comprising:

a) initializing a channel estimate reference based on an initial channel estimate derived from a received packet preamble;

b) updating the channel estimate reference based on a packet data symbol channel estimate in a coded portion of the current and all previous received data symbols;

c) repeating step b) at the arrival of subsequent packet data symbols.

The method preferably comprises storing the channel estimate reference in a channel estimate data base at the receiver. The method preferably comprises transforming the packet data symbol channel estimates to the frequency domain prior to updating the stored channel estimate reference to provide a time smoothed channel estimate reference. The method also preferably comprises for each subsequent received data symbol within step b), pipelining the steps of demodulating, modulating, and updating the channel estimate reference with the further step of FEC decoding.

In the current state of the art, high mobility high bandwidth transmission of information is limited by the inability of receiver processing techniques or methods to track the time varying nature of the radio channel and its effect on the transmitted signal and its waveform. Thus, related art systems for high mobility transmission support only low data rates. In this fourth embodiment, a receiver technique that exploits OFDM signal structures is disclosed and the fact that these OFDM signals are error control coded. Thus high mobility, high bandwidth data transmission is permitted. Additionally, the technique also benefits fixed communication radio networks by improving receiver sensitivity. Specifically, the fourth embodiment has been achieved by developing an algorithm that permits the reliable decoding of OFDM modulated packets of information that have been distorted by a rapidly varying radio channel, but without the need for compromising data rate by the excessive use of pilot or training signals.

In a preferred aspect of the fourth embodiment of the invention, an algorithm has been devised that may operate on a per OFDM symbol basis in order to avoid increased decoding latency and complexity. Correspondingly, in this embodiment, three statistics are exploited: the frequency domain statistics of the radio channel at the OFDM symbol rate; time domain statistics of the radio channel across OFDM symbols and; the outcomes of each decoded OFDM symbol. These statistics are used to estimate the radio channel from OFDM symbol to OFDM symbol. When a new OFDM symbol arrives the channel and data estimates are updated for the corresponding symbol and some small number of previous symbols. In this manner each OFDM symbol is decoded more than once with an improved channel estimate each time. Prediction of the radio channel from the received signal and knowledge of the preamble of the packet is deployed to initialise the process. That prediction uses the statistics of the radio channel. It will be evident to those practiced in the art that this embodiment permits the effective decoding of OFDM packets in rapidly varying radio environments. Thus it offers benefits in terms of supporting increased mobility at increased spectral efficiencies. It achieves this without increasing the implementation complexity, or latency, while simultaneously increasing receiver sensitivity. In this regard, it has potential in both high mobility and in fixed wireless networks. Those practiced in the art will recognise that this embodiment may be applied to any wide band modulation technique that shares a common underlying channel model similar to the preferred embodiment above. Some examples are the addition of multiple receive antennas, multi-carrier OFDM or multi-carrier CDMA.

Advantageously, the fourth embodiment provides:

- Iterative channel and data estimation whereby the initial estimates are improved using data aided techniques.
- Frequency domain smoothing stored across OFDM symbols enabling release of time smoothed channel estimates for improved decoding.
- Decoder outcomes derive channel estimates stored in "CEDB" (channel estimate data base) described in more detail, below.
- Prediction of channel from CEDB to start up OFDM symbol loop based processing.
- Consequent low latency, high bandwidth high mobility data.

In this fourth embodiment a baseband digital receiver technology that enables the effective reception of high data rate signals from a mobile device travelling at high speed is disclosed. A brief performance analysis is also presented.

**Field of Application**

This technology applies to a point to point communications link where transmissions are made using coded Orthogonal Frequency Division Multiplex (OFDM). In general, coded OFDM transmissions are formed by

1. forward error correction (FEC) encoding, over one (OFDM) symbol duration, the information bits, then
2. conventional OFDM modulation.

The FEC coding over one OFDM symbol may be block coded or the coding may continue across multiple OFDM symbols but per OFDM symbol decoding techniques must be available. The receiver will exploit the coding on the OFDM symbols to improve performance.

As with the third embodiment, the functional device embodying the technology preferably resides in the baseband receiver processor Rx of a receiver 190 in the exemplary form of a wireless modem 190 as shown in figure 19. The relative logical location of the baseband receiver Rx is shown in figure 19 as the "Baseband Rx".

**Latency and OFDM Symbol based Processing Loops**

In packet based communications systems it is important to implement the receiver processing with as little delay between the arrival of signals and the decoding of the bits contained in the signal as possible. This is important since the turn-around time for acknowledgements is a significant driver in the network performance. In OFDM modulated systems this requirement typically forces the use of per OFDM symbol processing. That is, when a new OFDM Symbols worth of signal arrives the Baseband Rx should release an OFDM symbols worth of information bits. The delay between the information enabling the decoding of an OFDM Symbol and the outcomes of decoding the Symbol must be of the order of a few OFDM Symbols duration.

**OFDM Channel Estimation in Mobile Environments**

In mobile radio communications systems coherent receiver designs typically require the use of accurate channel estimation methods in the baseband receiver. The channel to be estimated is a multipath fading channel induced by motion and reflections in the field. Among other uses, the channel estimate is employed to drive the FEC decoder, a critical aspect of the receiver. In the case of OFDM modulated signals the channel is normally measured in the frequency domain, after the received signal has been sliced up into OFDM Symbol sized pieces. In mobile communications systems the channel over which the signal travels changes with time and, if the vehicle speed is high enough, the channel may change during the reception of a packet. In related art receiver techniques it is assumed that the multipath fading channel is invariant over the packet enabling the one-off estimation of the channel at the start of the packet. In most standards (e.g. IEEE 802.11a) a preamble is transmitted at the start of a packet for exactly this purpose.

**Preferred Method**

In this method according to a fourth embodiment the partitioning of the received signal for OFDM to provide a convenient boundary for tracking time varying channels is exploited. The channel estimate changes from OFDM Symbol to OFDM Symbol. The preferred embodiment also exploits the fact that the OFDM symbol is encoded, enabling the use of decoded data as training information for the channel estimator. The statistics of the way that the channel changes with time and frequency are also exploited here.

An estimate of the channel in the frequency domain is obtained. The inventor defines the CEDB as a Channel Estimate Data Base containing channel estimates for each OFDM symbol, smoothed in the frequency dimension (across sub-carriers), but not in the time dimension. The method comprises the following steps, as set out below, for a packet with N OFDM symbols. Steps required for OFDM window synchronization occur prior to the processing shown here. The inner loop (3.4) is of length, L, OFDM Symbols and enables iterative channel and data estimation.

| Ref | Function | | |
|---|---|---|---|
| 1 | Estimate Time and Frequency Offsets based on Preamble | | |
| 2 | Initialise CEDB based on Preamble | | |
| 3 | For Each OFDM Symbol ($n$=1:$N$) { | | |
| 3.1 | | Transform Rx OFDM Symbol into Frequency Domain (apply FFT) | |
| 3.2 | | Correct Rx OFDM Symbol for Time and Frequency offsets | |
| 3.3 | | Generate Channel Estimate for OFDM Symbol $n$ by prediction from CEDB | |
| 3.4 | | For Each recent OFDM Symbol ($m$=$n$:-1:$n$-$L$) { | |
| 3.4.1 | | | Demodulate OFDM Symbol $m$ using Channel Estimate |
| 3.4.2 | | | FEC Decode OFDM Symbol (outcomes also released to upper layer) |
| 3.4.3 | | | Generate Training by remodulating FEC Decoder Outcomes |
| 3.4.4 | | | Update CEDB using Training and Corrected Rx OFDM Symbol |
| 3.4.5 | | | Generate Channel Estimate for OFDM Symbol $m$-1 from CEDB |
| | | } | |
| | } | | |

The channel prediction (step 3.3 above) and generate channel estimate (step 3.4.5 above) both apply CEDB time domain smoothing across OFDM symbols in their implementation. The strength of the smoothing (across Sub-Carrier and OFDM Symbol dimensions) are independently controlled by a process not described here.

Advantageously, the fourth embodiment provides:

1. Iterative Channel and Data Estimation whereby the initial estimates (resembling those that would be obtained conventionally) are improved (step 3.4) using data aided techniques.

2. Frequency Domain Smoothing stored across OFDM Symbols enabling release of time smoothed channel estimates for improved decoding (steps 2, 3.4.4).

3. Decoder outcomes drive channel estimates stored in CEDB (steps 3.4.3, 3.4.4).

4. Prediction of Channel from CEDB to start up loop based processing (step 3.3).

Parallelism may be exploited for implementation purposes by two processes running in parallel comprising.

1. demodulation, modulation and channel estimation stages (steps 3.4.1, 3.4.3, 3.4.4 & 3.4.5), and

2. FEC Decoding (step 3.4.2)

While Process 1 is working on OFDM Symbol n, Process 2 is working on OFDM symbol n-2. This offset requires the predictor in Ref 3.3 to look ahead one extra OFDM symbol.

The benefits obtained by use of this embodiment's technology are now described.

**Complexity**

By exploiting pipelining of the FEC decoder function the most difficult aspect of the receiver device is fully exploited while maintaining a highly adaptive capability in terms of the propagation environment.

**Sensitivity**

By accurately estimating the channel, the performance of the decoder stage may be significantly improved (typically in excess of 1 dB increase in receiver sensitivity). This has been found to be the case even for time-invariant channels and is realized by exploiting data symbols for training purposes. In the case where mobility exists the ability of the receiver to track the channel in time allows the receiver to operate effectively where conventional systems may fail. At the same time, the benefits of iterative (multi-visit) estimation of the data symbols are realized.

**Latency**

By employing per OFDM symbol processing and pipelining the FEC decoder the inventor has obtained the earliest possible release of high quality data estimates. Therefore the receiver operates without increasing latency relative to conventional techniques. It should be noted that conventional techniques may fail in high speed mobile conditions.Performance Analysis

In this section an example of the data and channel estimates that are obtained using conventional, idealised and the proposed receiver processing techniques are provided. The attributes of the communications link used in the example are shown in the table below.

| ***Quantity*** | ***Value*** | ***Unit*** |
|---|---|---|
| Bandwidth | 16.0 | MHz |
| Carrier Freqency | 5.0 | GHz |
| Number SubCarriers | 256 | SubCarriers |
| OFDM Symbol Duration | 16 | us |
| OFDM Symbols Per Packet | 38 | OFDM Symbols |
| Mobile Unit Velocity | 30 | $ms^{-1}$ |
| CoherenceFrequency | 3.0 | MHz |
| Bits Per SubCarrier | 2 | Bits |
| Pilot SubCarrier Spacing | 32 | SubCarriers |
| Eb/No | 8.0 | dB |
| FEC Rate | 1/2 | |
| FEC Memory | 5 | |
| ***Derived*** | | |
| Channel Coherence Frequency | 48.0 | SubCarriers |
| Channel Coherence Time | 62.5 | OFDM Symbols |
| Packet Length | 640.0 | us |
| Doppler Frequency | 0.5 | kHz |

The actual radio channel (measured after FFT application in the receiver) is shown in Figure 24. The rapid phase rotations in the Phase plot result from FFT window misalignment and residual intermediate frequency in the down-conversion step. These are both real-world impairments. The receiver estimates both of these parameters and may be compensated for them on a symbol by symbol basis. The result of this correction is shown in Figure 25. Note that this figure represents the actual radio channel corrected by an estimated quantity and is shown here for assessment purposes. An objective of the receiver is to accurately estimate this corrected channel.

**Conventional Processing**

In conventional processing the radio channel is estimated based on the preamble only. The main restriction with this approach is that the radio channel (after correction) must be invariant across the frame. As shown in figure 25 this is not the case since there is a phase change at around OFDM symbol 30 in some of the sub-carriers. It is therefore expected that decoder failures starting at around OFDM Symbol 30 of the packet will occur. This is indeed the case as shown in figure 26.

**Preferred Method (Perfect Training Symbols)**

Figure 28 shows the performance of the proposed system is shown with the possibility of decoder failures for training symbol generation eliminated. The decoder outcomes for data recovery are still recorded hence the errors in figure 28. This represents the best possible case for data aided radio channel estimation. It is possible to compare this result with that obtained using decoder outcomes for training in the following section. Note that the number of errors has dramatically reduced relative to the conventional technique.

**Preferred Method**

In this section the performance of the proposed method is evaluated. The CEDB is shown in figure 29 and represents a good estimate of the radio channel even though smoothing across OFDM symbols has not been employed. The smoothing across sub-carriers is however evident. Once the smoothing across OFDM symbols is employed a very good match to the actual radio channel is observed, as shown in figure 28. As can be seen in figure 28 and figure 29 the error obtained using the proposed method results in the same error pattern as the idealised method. The error performance is vastly superior to the conventional method as shown in figure 26.

With reference to figures 30 to 34 a fifth embodiment is described, which stems from the realization that receiver sensitivity may be improved by use of the outputs of a receiver's decoder as additional pilot or training symbols and updating these iteratively with each symbol received for the recalculation of a channel estimate, and frequency and time offsets as they vary throughout a packet.

In one aspect the fifth embodiment provides a system and method of communicating in a multiple access packet based network by estimating time varying channel impairments, where channel impairments comprise channel variation, signal frequency offset and signal time offset, comprising:

a) initializing a set of channel impairment estimates based on initial pilot and preamble symbols included in a received packet;

b) performing a decoder operation which comprises processing the set of channel impairment estimates and the received packet to determine a set of transmit symbol estimates;

c) updating the set of channel impairment estimates through use of the determined set of symbol estimates and received packet;

d) repeating steps b) and c).

In another aspect the fifth embodiment provides a system and method of communicating in a multiple access network by time varying channel estimation in a receiver for receiving transmitted packets, comprising:

a) estimating a frequency offset based on information included in a received packet preamble;

b) correcting a received signal using the estimated frequency offset;

c) determining a channel estimate using information included in the received packet preamble;

d) transforming a sample sequence of the received signal into the frequency domain such that the sample sequence includes OFDM symbols and intervening cyclic prefixes;

e) performing a decoding operation which comprises processing the determined channel estimate and received packet;

f) generating a transmission sample sequence using the decoding results and information in the received packet preamble;

g) transforming the transmission sample sequence into the frequency domain;

h) updating the determined channel estimate by combining the received sample sequence and the transmission sample sequence in the frequency domain;

i) repeating steps e) to h).

In a further aspect the fifth embodiment provides a system and method of communicating in a multiple access network by time varying channel estimation in a receiver for receiving transmitted packets, where the receiver retrieves OFDM symbols from a received signal and transforms the retrieved symbols to the frequency domain, comprising:

a) determine a matrix of training symbols comprised of symbol estimates derived from a decoder;

b) determine a matrix of frequency domain received OFDM symbols;

c) determine an intermediate channel estimate matrix by multiplying the OFDM symbol matrix by the conjugate of the training symbol matrix;

d) determine an intermediate matrix of training weights comprising the absolute value of the training symbol matrix;

e) perform a smoothing operation on both intermediate matrices comprising 2 dimensional filtering;

f) determine the channel estimate by dividing the smoothed channel estimate matrix with the smoothed training weight matrix.

In yet another aspect the fifth embodiment provides a system and method of communicating in a multiple access network by estimating offsets in a receiver for receiving transmitted packets, comprising:

a) determine a matrix of received OFDM symbols;

b) determine a matrix of conjugated data symbols wherein the data symbols comprise one or more of preamble, training and estimated symbols;

c) determine a 2 dimensional Fourier transform matrix comprised of the received symbol matrix multiplied with the conjugated symbol matrix;

d) filter the Fourier transform matrix;

e) determine time and frequency offsets by locating peak power occurrences within the filtered Fourier transform.

The fifth embodiment provides reliable estimation of channel impairments. In the related art, that is, in the theoretical rather than practical context, decoder outcomes are employed to assist with the estimation of channel coefficients and synchronisation of received signals in radio communications systems and radio networks. The difficulties encountered with these present theoretical approaches to decoder outcomes include the appropriate treatment of the uncertainty of these decoder outcomes in what would otherwise be conventional channel estimation and synchronisation techniques. In other words , the difficulty of applying one-shot or preamble-only channel estimation techniques or processing to an iterative process leads to less efficient and less accurate channel estimate and synchronisation performance. With this in mind, in this embodiment the use of a channel estimation and a synchronisation technique that employ an entire packet's worth of decoder outcomes (in addition to the preamble) is described. While others also have advocated this approach (at least in general terms), in the present embodiment, the specific method to manage uncertainty in the decoder outcomes and subsequent processing are distinguished from the related art by the features described here below. In this embodiment, in estimating the channel, the inventor first employs the frequency domain version of the remodulated decoder outcomes and preamble as training symbols. Then compute the frequency domain channel estimate from this training symbol sequence and from the frequency domain version of this the received signal. This may be achieved by either division or by minimum mean square error estimation or, via other estimation techniques. Any errors in the decoder outcomes will be dispersed similar to the use of an interleaver and not have direct impact on a local region of the channel estimate.

It should be noted that the channel estimation approach of the fifth embodiment is able to track the channel as it varies across the packet by slicing the packet up into segments that are assumed invariant. Thus the practical impact of this embodiment is that more reliable channel estimates provide the opportunity for significantly improved information packet recovery in radio communications.

In another aspect, the synchronisation technique, the inventor employs the preamble and decoder outcomes to remove the effects of data modulation on the received signal and then applies a 2 dimensional Fast Fourier Transform. By then executing a peak power search estimates of both the residual time and frequency offsets are obtained. These may then be employed to enable effective synchronisation.

In another aspect a channel estimator has been provided. This aspect employs the outcomes of soft FEC Decoding (e.g. SOVA) to improve the quality of the radio channel estimate so that repeating the decoding step, using the new channel estimate, offers improved outcomes. These soft outputs are used to generate soft training symbols. Firstly, multiply the received OFDM Symbol matrix by the conjugate of the Soft Training symbols to get an intermediate raw channel estimate. Then compute a further intermediate matrix of training weights equal to the absolute value, or absolute value squared, of the each of the soft training symbols. Both of these matrices are then smoothed using filters based on channel statistics. The channel estimate is then obtained by dividing the smoothed raw channel estimate by the smoothed training weight matrix in an element wise fashion. The impact of this aspect on high mobility, high data rate communications networks will be evident to those practiced in the art. Accordingly, lower packet loss rates impact on network capacity. The method also increases the ability to accommodate rapidly changing radio channels and more reliably decode data transmissions. Likewise, increased receiver sensitivity leads to reduced packet loss rates and increased range for OFDM based systems with high velocity nodes.

The following acronyms are used in this description of the fifth embodiment.

| | |
|---|---|
| APP | A-Posterior Probability |
| DSP | Digital Signal Processor |
| FEC | Forward Error Correction |
| FFT | Fast Fourier Transform |
| IF | Intermediate Frequency |
| IFFT | Inverse FFT |
| OFDM | Orthogonal Frequency Division Multiplex |
| RF | Radio Frequency |
| SOVA | Soft Output Viterbi Algorithm |

This fifth embodiment of the invention provides a suite of baseband digital receiver technologies that enables the effective reception of high data rate signals from a mobile device travelling at high speed.

**Field of Application**

This suite of technologies applies to point to point communications links where transmissions are made using coded Orthogonal Frequency Division Multiplex (OFDM). As noted above, coded OFDM transmissions are formed by

- forward error correction (FEC) encoding, over one (OFDM) symbol duration, the information bits, then
- conventional OFDM modulation.

The FEC coding over one OFDM symbol may be block coded or the coding may continue across multiple OFDM symbols but per OFDM symbol decoding techniques should be available. The receiver may exploit the coding on the OFDM symbols to improve performance.

Typically the technology resides in the baseband receiver processor of a wireless modem. This location is shown in figure 19 as the "Baseband Rx"

In packet based communications systems it is important to implement the receiver processing with as little delay between the arrival of signals and the decoding of the bits contained in the signal as possible. This is important since the turn-around time for acknowledgements is a significant driver in the network performance. In OFDM modulated systems this requirement typically forces the use of per OFDM symbol processing. However as signal processing capabilities improve it is envisaged that another, more powerful option, will become available to system designers. The more powerful technique will employ the entire observation in making decisions about every bit transmitted (e.g. Turbo Codes). In current techniques only a portion of the received signal is employed to assist with the decoding of any particular information bit. Typically, a local channel estimate may be formed using a portion of the observation and then decoding for that portion may be executed. The benefit of employing the observations, to follow, to assist with channel (or any other unknown parameter) estimation is currently not realised due to implementation complexity and performance of currently available DSP technology. Here the fifth embodiment provides techniques that employ the entire observation to improve the channel estimation and hence reduce decoder errors. In addition, the transmitted waveform is often structured to permit per OFDM symbol processing at the receiver. If this requirement is relaxed, frame based channel coding techniques may be applied to further improve the performance of the communications link. Examples of these techniques are the use of packet level interleaving and Block (e.g. Turbo) coding which may offer large performance benefits.

**OFDM Channel Estimation In Mobile Environments**

In mobile radio communications systems coherent receiver designs require the use of accurate channel estimation techniques in the baseband receiver. The channel to be estimated is a multipath fading channel induced by relative motion and multiple propagation paths between the transmitter and receiver and residual errors due to Transmit/Receive radio mismatch. The channel estimate is employed, among other uses, to drive the FEC decoder, a critical aspect of the receiver. In the case of OFDM modulated signals the channel is normally measured in the frequency domain, after the received signal has been separated into OFDM Symbol sized pieces and transformed via the application of an IFFT. In mobile communications systems the channel over which the signal travels changes with time and, if the vehicle speed is high enough, the channel may change over the duration of a packet. This translates to the channel experienced at the start of the packet being substantially different that experienced at the end of the packet when viewed from the receiver. Related art receiver techniques assume that the multipath fading channel is invariant over the packet, enabling the calculation of a single channel estimate at the start of the packet to decode the entire packet. In most standards that use OFDM transmission schemes (e.g. IEEE 802.11a) a preamble is transmitted at the start of each OFDM symbol in order to permit estimation of the radio channel at the start of the packet.

However, the quality of the communications link may be increased by employing the use of data aided techniques in the estimation of the radio channel. In this case, the result of applying the FEC decoder on the received signal generates an estimate of the transmitted symbols which, while not absolutely accurate, are suitable for exploitation as additional pilot symbols. Typical examples of data aided channel estimation for OFDM are implemented in the frequency domain and therefore suffer power losses due to discarding of the cyclic prefix from each received OFDM symbol. The discarded cyclic prefix is theoretically useful for channel estimation and typically accounts for 10-50 percent of the received signal energy. Since the transmitted symbols determining the cycling prefix may be estimated at the receiver, this energy is potentially useful, as illustrated below, in the estimation of the radio channel and should not be discarded.

**Frequency and Time Offset Estimation**

Frequency offset arises due to the imprecise down conversion of the received signal from RF or IF to baseband. Time Offsets are commonly caused by inaccuracies in the packet arrival time estimation due to the impact of multipath fading channel and noise. Multipath, or Time dispersive, channels result in multiple copies of the transmitted packet arriving at the receiver at different times therein decreasing the certainty in the time of arrival of the packet. Conventionally, estimates of the frequency and time offsets are initially made using the preamble of the packet and maintained using pilot symbols, inserted by the transmitter, throughout the packet (e.g. 802.11a). An example of this packet format for 802.11a is shown in figure 30.

Frequency offsets manifest as inter carrier interference and a constant phase rotation across OFDM Symbols and Time offsets manifest as phase rotations across the OFDM Sub-Carriers. The inventor assumes that fine Inter-frequency offset estimation is required consistent with the residual errors after an initial frequency offset correction. The phase offsets induced in the received symbols are due to the combined effects of the data modulation, transmission across the radio channel, imprecision in the frequency synchronisation during down conversion and imprecise time of alignment of the OFDM symbols during the time to frequency conversions. In order to estimate the radio channel, the effect of the data symbols (be it preamble, pilot or unknown) on the received signal must first be removed, thereby leaving only the effect of the radio channel and time/frequency offsets. In the case of preambles and pilots the symbols are known a-priori and hence their removal is possible at the receiver. Using related art methods, the parts of the observation that are effected by data are not available to aide in the estimation of the frequency and time offsets since the data symbols are not known at the receiver. The fifth embodiment, however, employs data aided techniques to significantly improve the performance of the estimation by making many more symbols available to the estimation process.

**Proposed Method**

The method proposed here is an iterative process that uses the outputs of the decoder as additional pilot symbols for recalculation of the channel estimate and for the recalculation of the frequency and time offsets as they vary across the packet. Collectively herein we shall refer to effects of the multipath channel combined with the frequency offsets induced by the RF or IF to baseband conversion and the time offsets caused by time misalignments in the time to frequency conversion as channel impairments. On the first iteration, the channel impairments are estimated using the pilot and preamble symbols nominated by the transmission scheme. These estimates are used to drive the initial execution of the decoder and generate the first transmit symbol estimates. Iterations thereafter use the transmit symbol estimates of the previous iteration as new pilot symbols to aid in the estimation of the channel impairments. The new channel impairment estimates are then used to re-run the decoder and generate new symbol estimates. This process may be repeated *I* times where *I* is the number of iterations and is an integer greater than equal to zero.

The details of the specific channel impairment estimators will be described in the following sections.

**Channel Estimation**

Two methods are available for estimation of the radio channel. One may be used when the radio channel is said to be invariant over the duration of the packet or discrete subsection thereof. The other is applicable when the radio channel varies over the duration of the packet.

**Sequence Based Channel Estimation for OFDM**

The sequence based channel estimator described here applies when the channel is invariant over a packet or, any substantial fraction thereof. This technique exploits all of the available received energy and is implemented prior to the OFDM symbol slicing conventionally employed in receivers for OFDM signals. The steps executed are as follows

| *Ref* | *Function* | |
|---|---|---|
| 1 | Estimate Frequency Offset using Preamble | |
| 2 | Correct Received Signal for Frequency Offset | |
| 3 | Estimate Channel using Preamble | |
| 4 | Convert Rx Sample Sequence to Frequency Domain | |
| 5 | For Some Number of Iterations { | |
| 5.1 | | Decode Packet using Current Channel Estimate |
| 5.2 | | Generate Tx Sample Sequence using Decoder Outcomes & Preamble/Pilots |
| 5.3 | | Convert Tx Sample Sequence to Frequency Domain |
| 5.4 | | Estimate Channel By Dividing Rx Sample and Tx Samples in Freq Domain |
| | } | |

Steps 1 through 3 are common operations performed in typical OFDM receivers. Step 4 would not normally be found in an OFDM receiver. Conventionally the received sequence is sliced up into small OFDM Symbol periods, separated by Cyclic Prefix regions which are discarded. Each of these OFDM Symbols is transformed into the frequency domain by an FFT for processing (channel estimation, decoding, etc) as in step 5.1. Step 4 converts all parts of the received sample sequence that represents an entire packet or, selected portion thereof, including the cyclic prefix regions into the frequency domain to enable frequency domain channel estimate at the sequence level. This requires the other steps (5.2 and 5.3) which produces a hypothesis of the entire packet's frequency domain transmitted signal. In the frequency domain the received signal is equal to the transmitted signal multiplied by the channel plus any noise. This fact is exploited in step 5.4. The step in 5.4 could be replaced with an optimal linear estimator based on the Minimum Mean Squared Error criterion.

**Channel Estimation with Soft Training Symbols**

The channel estimator described here operates in the frequency domain of a conventional OFDM receiver. It is assumed that the received signal has be sliced up into OFDM Symbols, the Cyclic prefix discarded and the resulting OFDM Symbols converted to the frequency domain, via the use of an FFT. These processes are found in conventional OFDM receivers. The proposed method of the fifth embodiment is an iterative process that uses the symbol estimate outputs of the FEC decoder as additional pilot symbols or "Soft Training Symbols" in a re-estimation of the radio channel. By doing so (while noting these symbol estimate outputs may not be precise) the estimate of the radio channel is improved such that a subsequent execution FEC decoder produces an improved result over the previous execution.

Many different types of "soft output" decoders are available presently, including Soft-Output Viterbi Algorithms (SOVA), A-Posteriori Probability (APP) Decoders and various types of Turbo Codes. These soft outputs are used to generate soft training symbols according to techniques that may be found in the relate art literature, which would be understood by the person skilled in the art. It is the use of these soft training symbols which requires careful consideration and an improved technique is proposed here.

In the absence of noise, and other impairments, a received OFDM Symbol is equal to the multiplication of the transmitted OFDM Symbol and the frequency domain channel. If an OFDM system has $N$ sub-carriers (frequency bins) then we may define vectors of length $N$ to represent the transmitted data $d_l$ and radio channel $h_l$ for some OFDM Symbol period $l$. The received OFDM symbol in this case is $r_l = d_l \;.\!*\; h_l$, where the operator '.*' corresponds to element-wise multiplication of the vectors. In the case where $d_l$ is known perfectly at the receiver (e.g. if it were a pilot symbol) then the channel could be recovered perfectly in this ideal noise free case as

$$\hat{h}_l = r_l \,./\, d_l = h_l$$

where, similar to the '.*' operator, the './' operator corresponds to an element-wise division of the vector elements. In data aided techniques the decoder outcome, $\hat{d}_l$ is used instead of the actual transmitted data. This estimate is subject to errors. The fifth embodiment involves a technique that accounts for this uncertainty in the "training" symbols. The method may be employed for time varying or invariant radio channels and takes a slightly different form depending of the channel variation. The following is a description of the estimator for time varying radio channels.

Assume the following is provided:

1. an entire packets worth of received OFDM Symbols $R$, and

2. an entire packets worth of soft training symbols $D$ (some may be "hard" pilot symbols).

It is possible to structure these two objects as matrices as shown in figure 31 for M sub-carriers and N OFDM Symbols, where the rows are sub-carriers (tones or frequency bins) and the columns are OFDM Symbols (time).

Firstly, multiply the received OFDM Symbol matrix by the conjugate (denoted $X^*$) of the Soft Training symbols to get an intermediate raw channel estimate $V = R.*D^*$. Note that the conventional step (as described above) would prescribe a division, not a multiplication. Then compute a further intermediate matrix of training weights $T = |D|$ or other functions such as absolution value squared. Then apply smoothing to both of these matrices using a two dimensional filter ( $f$ ) matched to the channel coherence time and frequency. This filter outcome may be approximated by implementing smoothing independently in the time and frequency domains (rows then columns or vice versa) to save complexity. The estimate of the time varying channel is then derived as

$$\hat{H}_t = f(V)./f(T) = f(R.*D^*)./f(|D|)$$

The uncertainty in the decoder outcomes is accounted for in the step where the absolute value of the training symbols was obtained. Small training symbols result from uncertain soft output from the FEC decoder step. A soft output FEC decoder will output a zero when a reliable estimate cannot be determined. Multiplication (in the $R.*D^*$ step) by a zero effectively excludes that symbol estimate from the channel estimation process. Note that in the next iteration the symbol estimate may have firmed up, due to improved statistics driving the FEC decoder, increasing its reliability and therefore it may now be included in the channel estimation process. In the ideal case the decoder will output correct, hard decisions and all data symbols will be used as perfect training to yield a very accurate channel estimate.

In the case that the channel is assumed time invariant across the packet the filtering function simply adds up the column and resulting in a column that is assume to apply over the entire packet.

In some cases, an approach whereby the two dimensional filter *f* applied to the raw channel estimate and training weight is different may be warranted. In these cases the time varying channel estimate would be

$$\hat{H}_i = f_1(V)./f_2(T) = f_1(R.*D^*)./f_2(|D|)$$

where $f_1$ and $f_2$ implement different filters.

**Joint Time and Frequency Offset Estimation using 2D FFT**

In this aspect of the fifth embodiment we remove the effect of the data on the phase difference between adjacent symbols in the OFDM received matrix as shown in figure 31 and then apply a 2 Dimensional FFT. This removal may be achieved by multiplying the observed OFDM Symbol matrix with a corresponding matrix of conjugated data symbols be they preamble, training or estimated. The FFT output is then filtered to suppress noise, and a search for the peak power across the resulting 2 Dimensional space of metrics is executed. The filtering will have an impact on the maximum offsets that may be measured and it is therefore recommended that only very weak filtering be employed. The location of the peak, in terms of relative position in the rectangle of figure 31, determines the time and frequency offsets.

The granularity and range of the estimation is limited as follows. If there are *M* Sub Carriers and *N* OFDM Symbols then the range and resolution available from this technique is as shown in the following

| | ***Resolution*** | ***Limit*** |
|---|---|---|
| ***Frequency Offset*** | OFDM Symbol Frequency / *N* | OFDM Symbol Frequency |
| ***Time Offset*** | OFDM Symbol Duration / *M* | OFDM Symbol Duration |

An example for the system parameterised by is now given.

| ***Parameter*** | ***Value*** |
|---|---|
| Number Of Tones | 256 |
| Number Of Symbols | 20 |
| Coherence Tones | 40 |
| Coherence Symbols | 50 |
| Actual Freq Offset | 0.05 |
| Actual Time Offset | 0.20 |

With the actual channel amplitude and phase shown in figure 32 and figure 33 we get the metric shown in figure 34 for peak detection. Note that the peak is in the expected relative position, i.e. a fraction of 0.05 along the OFDM Symbol dimension and a fraction of 0.2 along the sub-carrier dimension. These estimates match the actual time and frequency offsets as shown in the above table of parameter values in the model.

By accurately estimating the channel, the performance of the FEC decoder stage is significantly improved, typically in excess of 1 dB increase in receiver sensitivity. This is true even for time-invariant channels and is realized by exploiting data symbols for training purposes. In the case where mobility exists the ability of the receiver to track the channel in time allows the receiver to operate effectively where related art systems may fail. At the same time, the benefits of iterative estimation of the data symbols are realized.

In a sixth embodiment the present invention provides a solution predicated on the use of firstly correlating the received signal at each antenna of a multiple access communication network with a known signal preamble and then statistically combining the correlated signal sequence of each antenna based on estimated antenna signal strength. It should be noted that in order to determine the coefficients for combining an initial timing estimate must be determined. The calculation of these coefficients will require, in practice, initial coarse timing and frequency offset estimation by other means. The quality of the initial timing estimate may be worse than that desired ultimately. The inventor considers further processing on the combined signal will lead to a timing estimate of high quality.

In a first aspect the sixth embodiment provides a system and method of communicating in a multiple access packet network by synchronizing a received signal in a multi antenna receiver comprising:

correlating a received signal observation at each of a plurality of antennae with a known signal preamble to provide a received signal sequence;

determine a power signal of each received signal sequence;

combine the determined power signals in accordance with a time averaged weighting based on estimated antenna signal strength for each antenna;

determine a time of arrival for the received signal in accordance with a predetermined threshold condition.

An preferred aspect of the sixth embodiment of the invention comprises:

determining an estimate of the relative phase and amplitude coefficients of a receiving channel for each antenna;

combining a received signal with the estimated coefficients to provide a composite signal;

determining a time of arrival of the received signal by correlating the composite signal with a delayed version of itself.

In related art, metrics used for synchronisation are based on outputs of correlators for the preamble of a packet. In the case of multiple receive antennae, a method for either combining or deriving a new method of metric generation for synchronisation is desirable. Related art schemes propose making decisions per antenna and then majority voting or adding the metrics prior to decision. Neither of these approaches addresses sufficiently the variation of the signal statistics across antennae. The net result of this is degraded synchronisation accuracy and increased packet loss rates. A further issue relates to the effective use of multiple antennae for data carriage but poor use of multiple antennae for synchronisation. In this case packets that could otherwise be decoded may be missed by the synchronisation module.

In this sixth embodiment, we disclose a method for determining per antenna metrics and for subsequent combining across antennae in order to generate a metric for time of arrival estimation. The method involves essentially two steps. The per antenna metrics are derived by correlating the received signal with a known preamble in a first step. The power of the sequences for each antenna is determined and added across antenna according to the time averaged weight based on estimated antenna signal strength. A threshold is then applied in order to determine the time of arrival.

A further aspect of the sixth embodiment relates to obtaining a rapid estimate of the relative phase and amplitude of the channel on each antenna and then to combine the received signal according to the conjugate of these coefficients. The processing would then proceed as in the related art with correlation of this composite signal with a delay version of itself. Application of this aspect of the sixth embodiment is in the synchronisation of wireless communication links involving the simultaneous use of multiple receive antennae where the multiple antennae are used to increase the robustness of the communications link primarily through increased diversity.

In a further aspect, the signals from each antenna are combined according to Minimum Mean Square Error criteria where the combining coefficients are dependent on a background noise measure on each antenna as well as the received signal energy. The processing would then proceed as in the related art with correlation of this composite signal with a delay version of itself.

It is particularly advantageous that the sixth embodiment provides for: a combining method for the metrics over antennae; currently does not require OFDM specific characteristics, and; a version with OFDM specificity may be defined for clarity.

It will be appreciated by those skilled in the art, that the invention is not restricted in its use to this particular application described, neither is the present invention restricted to its preferred embodiment with regards to the particular elements and/or features described or depicted herein. It will be appreciated that various modifications can be made without departing from the principles of the invention. Therefore, the invention should be understood to include all such modifications within its scope.

While this invention has been described in connection with specific embodiments thereof, it will be understood that it is capable of further modification(s). This application is intended to cover any variations uses or adaptations of the invention following in general, the principles of the invention and comprising such departures from the present disclosure as come within known or customary practice within the art to which the invention pertains and as may be applied to the essential features hereinbefore set forth.

As the present invention may be embodied in several forms without departing from the spirit of the essential characteristics of the invention, it should be understood that the above described embodiments are not to limit the present invention unless otherwise specified, but rather should be construed broadly within the spirit and scope of the invention as defined in the appended claims. Various modifications and equivalent arrangements are intended to be included within the spirit and scope of the invention and appended claims. Therefore, the specific embodiments are to be understood to be illustrative of the many ways in which the principles of the present invention may be practiced. In the following claims, means-plus-function clauses are intended to cover structures as performing the defined function and not only structural equivalents, but also equivalent structures. For example, although a nail and a screw may not be structural equivalents in that a nail employs a cylindrical surface to secure wooden parts together, whereas a screw employs a helical surface to secure wooden parts together, in the environment of fastening wooden parts, a nail and a screw are equivalent structures.

"Comprises/comprising" when used in this specification is taken to specify the presence of stated features, integers, steps or components but does not preclude the presence or addition of one or more other features, integers, steps, components or groups thereof."

**References**

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[4] P.D. Alexander, A.J. Grant, and M.C. Reed, "Iterative detection on code-division multiple-access with error control coding," *European Transactions on Telecommunications*, vol. 9, pp. 419-426, Sept.-Oct. 1998.

**CLAIMS**

1. An iterative decoding circuit for a wireless multiuser communications receiver comprising:

a first signal processing means for receiving at least one received signal, said first signal processing means comprising at least two linear iterative filters such that:

the first linear iterative filter provides an estimate of a selected received signal to an estimated signal output and;

a second linear iterative filter provides estimates of at least one other received signal, delayed by one iteration cycle, to an input of said first linear iterative filter;

a second signal processing means for receiving the estimated signal output of the first linear iterative filter and providing a further received signal estimate to the input of the first signal processing means in a succeeding iteration cycle of the decoding circuit.

2. An iterative decoding circuit according to claim 1, wherein the linear filters function in accordance with at least one predetermined recursive Bayesian expression.

3. An iterative decoding circuit according to claim 2, wherein the predetermined recursive expression comprises the following recursive Bayesian estimation using the following assumptions:

**A1:** *The received signal is described as* $\mathbf{r}=\mathbf{S}\mathbf{x}+\mathbf{n}$, *where* $\mathbf{S}$ *is the constraint matrix, containing all the linear channel constraints,* $\mathbf{x}$ *is a vector containing all transmitted information symbols and* $\mathbf{n}$ *is circularly symmetric complex Gaussian with covariance matrix* $\operatorname{cov}\mathbf{n}=\sigma^2\mathbf{I}$, *and where the noise variance* $\sigma^2$ *and the constraint matrix* $\mathbf{S}$ *are known.*

**A2:** *The interleaved code symbol estimates of the interfering users* $\hat{\mathbf{x}}_{\bar{k}}^{(n)}$ *which is a vector containing all the signal estimates at iteration n for all users except userk , coming out of said corresponding signal processing* *component 2 can be modelled as* $\hat{x}_k^{(n)} = x_k + \hat{v}_k^{(n)}$ *where* $x_k$ *is the transmitted symbol for user k and* $\hat{v}_k^{(n)}$ *is the corresponding estimated noise sample which is uncorrelated with* $\mathbf{x}$*, which is a vector containing the transmitted symbols for all users , and also uncorrelated over time and iterations, but not over users at a given iteration, that is* $<\mathbf{x}, \hat{v}_k^{(n)}>= 0, <\hat{v}_k^{(n)}, \hat{v}_k^{(m)}>= 0 \; for \; n \neq m$*, where* $n$ *and* $m$ *denote different iteration numbers, and the estimated noise correlation for user* $k$ *and j at iteration* $n$ *is defined as* $<\hat{v}_k^{(n)}, \hat{v}_j^{(n)}>= q_{kj}$.

*Define the estimated noise covariance matrix* $\mathbf{Q}_k^{(n)} =< \hat{v}_k^{(n)}, \hat{v}_k^{(n)} >$*, with elements determined as shown above.*

*Let* $\mathbf{c}_k^{(n)}$ *be the auxiliary vector that contains all signals received from user k at iteration n and all previous iterations, according to the following recursively defined vector of observables as input to the said linear iterative filter denoted by* $\Lambda_k^{(n)}$*,*

$$\mathbf{c}_k^{(n)} = \begin{cases} \mathbf{r} & n = 1 \\ \begin{pmatrix} \mathbf{c}_k^{(n-1)} \\ \hat{\mathbf{x}}_k^{(n-1)} \end{pmatrix} & n = 2,3,... \end{cases}$$

*Under **A1** and **A2**, the linear minimum mean square error estimate of said signal* $x_k$ *given said signal* $\mathbf{c}_k^{(n)}$ *is given by the output* $\tilde{x}_k^{(n)}$ *of the recursive filter which is an updated estimate of the transmitted signal for user k at iteration n, defined as follows.*

$$\tilde{x}_k^{(n)} = \tilde{x}_k^{(n-1)} + \mathbf{m}_k^{(n)}\left(\hat{\mathbf{x}}_{\bar{k}}^{(n-1)} - \tilde{\mathbf{x}}_{\bar{k}}^{(n-1)}\right)$$

$$\tilde{\mathbf{x}}_{\bar{k}}^{(n)} = \tilde{\mathbf{x}}_{\bar{k}}^{(n-1)} + \mathbf{M}_k^{(n)}\left(\hat{\mathbf{x}}_{\bar{k}}^{(n-1)} - \tilde{\mathbf{x}}_{\bar{k}}^{(n-1)}\right)$$

$$\mathbf{m}_k^{(n)} = -\mathbf{w}_k^{(n)}\left(\mathbf{I} + \mathbf{Q}_k^{(n-1)} - \mathbf{W}_k^{(n)}\right)^{-1}$$

$$\mathbf{M}_k^{(n)} = \left(\mathbf{I} - \mathbf{W}_k^{(n)}\right)\left(\mathbf{I} + \mathbf{Q}_k^{(n-1)} - \mathbf{W}_k^{(n)}\right)^{-1}$$

*where for user k at iteration n* $\mathbf{m}_k^{(n)}$ *is the said first linear iterative filter,* $\mathbf{M}_k^{(n)}$ *is the said second linear iterative filter,* $\mathbf{I}$ *is an identity matrix with ones on the diagonal and zeros everywhere else,* $\mathbf{w}_k^{(n)}$ *is a recursive, complex auxiliary* *vector and* $\mathbf{W}_k^{(n)}$ *is a first recursive, complex auxiliary matrix, respectively, the recursive update equations for* $n = 3,4,\ldots$ *are as follows:*

$$\mathbf{w}_k^{(n)} = \mathbf{w}_k^{(n-1)}\left[\mathbf{I} - \left(\mathbf{H}_k^{(n-1)}\right)^{-1}\left(\mathbf{I} - \mathbf{W}_k^{(n-1)}\right)\right]^{-1}$$

$$\mathbf{W}_k^{(n)} = \mathbf{W}_k^{(n-1)} + \left(\mathbf{I} - \mathbf{W}_k^{(n-1)}\right)\left(\mathbf{H}_k^{(n-1)}\right)^{-1}\left(\mathbf{I} - \mathbf{W}_k^{(n-1)}\right)$$

$$\mathbf{H}_k^{(n-1)} - \mathbf{I} + \mathbf{Q}_k^{(n-2)} - \mathbf{W}_k^{(n-1)}$$

*where* $\mathbf{H}_k^{(n-1)}$ *is a second recursive, complex auxiliary matrix. The initial conditions with* $\tilde{x}_k^{(0)} = 0$ *and* $\mathbf{x}_{\bar{k}}^{(0)} = 0$ *are* $\mathbf{m}_k^{(1)} = \mathbf{s}_k^t\left(\mathbf{S}\mathbf{S}^t + \sigma^2\mathbf{I}\right)^{-1}$, $\mathbf{M}_k^{(1)} = \mathbf{S}_{\bar{k}}^t\left(\mathbf{S}\mathbf{S}^t + \sigma^2\mathbf{I}\right)^{-1}$ *for* $n = 1$ *and* $\mathbf{w}_k^{(2)} = \mathbf{s}_k^t\left(\mathbf{S}\mathbf{S}^t + \mathbf{I}\right)^{-1}\mathbf{S}_{\bar{k}}$, $\mathbf{W}_k^{(2)} = \mathbf{S}_{\bar{k}}^t\left(\mathbf{S}\mathbf{S}^t + \sigma^2\mathbf{I}\right)^{-1}\mathbf{S}_{\bar{k}}$ *for* $n = 2$, *where* $\mathbf{s}_k$ *is the linear constraint for user k,* $\mathbf{s}_k^t$ *denotes the complex conjugate transpose of said vector* $\mathbf{s}_k$, $\mathbf{S}_{\bar{k}}$ *is the constraint matrix with column k deleted and* $\mathbf{S}_{\bar{k}}$ *denotes the complex conjugate transpose of vector* $\mathbf{S}_{\bar{k}}$.

4. A method of communicating in a multiple access network by iteratively receiving multi user signals the method comprising the steps of:

determining a first set of signal estimates for the multi user signals based on linear channel constraints;

determining a second set of signal estimates based on non-linear channel constraints and the first set of signal estimates;

providing the second set of signal estimates as input to the step of determining the first set of signal estimates;

repeating the above steps at least once.

5. An iterative receiver for receiving multi user signals comprising:

a first signal processing component for determining a first set of signal estimates for the multi user signals based on linear channel constraints;

a second signal processing component for receiving the first set of signal estimates and determining a second set of signal estimates based on non-linear channel constraints;

wherein the signal processing components are operatively connected so as to provide the second set of signal estimates as input to the first signal processing component in a succeeding iteration cycle.

6. A method of communicating in a multiple access network by iteratively receiving OFDM packets the method comprising the following steps:

a) sample a receiver input signal consisting of signals from one or more antenna;

b) add the input signal with one of a plurality of prior stored received packet sample estimates to determine a packet sample hypothesis;

c) determine an information bit estimate from the sample hypothesis for storage in an information bit estimates list;

d) determine an updated received packet sample estimate from the sample hypothesis for updating the plurality of prior stored estimates;

e) subtract the updated sample estimate from the sample hypothesis to determine a noise hypothesis and provide the noise hypothesis as the receiver input signal;

f) repeat steps a) to e) until at least one or more complete packets are accumulated in the information bit estimates list.

7. A method of communicating in a multiple access network by iteratively providing a sample estimates list in an OFDM receiver, the method comprising the steps of:

a) sample a receiver input signal;

b) determine a packet sample estimate from the sampled receiver input signal;

c) store the packet sample estimate;

d) determine a packet sample hypothesis by adding the receiver input with a selected previously stored packet sample estimate;

e) determine an updated packet sample estimate by decoding and re-transmission modelling the packet sample hypothesis;

f) update the selected previously stored packet sample estimate with the updated packet sample estimate.

8. A method of communicating in a multiple access network by iteratively providing a packet information bit estimates list in an OFDM receiver the method comprising the steps of:

a) determine a packet sample hypothesis by adding a receiver input with a selected previously stored packet sample estimate;

b) determine an information bit estimate by decoding the packet sample hypothesis with one or more of a hard decoding technique and a soft decoding technique

c) storing the information bit estimate with one or more previously determined information bit estimates;

d) repeating steps a) to c) until a complete packet is accumulated.

9. A method of communicating in a multiple access network including determining a hybrid OFDM received packet sample estimate the method comprising the step of:

multiplexing a time domain channel application received sample estimate with a frequency domain channel application received sample estimate, such that the multiplexed time domain sample estimate is mapped to correspond to one or more of:

an OFDM signal cyclic prefix;

an OFDM tail portion, and;

an OFDM guard period,

and wherein the multiplexed frequency domain sample estimate is mapped to correspond to one or more of:

an OFDM signal preamble and;

an OFDM payload data symbol.

10. A method of communicating in an OFDM multiple access network comprising the step of:

performing multi-user interference cancelling which comprises adapting a single pass OFDM receiver to iteratively receive signals at the sampling level so as to allow the receiver to differentiate a desired packet from an observation of an interference signal at the receiver input.

11. A method of communicating in a multiple access communication network by synchronizing packets arriving at a receiver the method comprising the steps of:

receiving a packet input signal;

determining a correlation signal corresponding to the packet input signal;

processing the input and correlation signals such that at least one of the input signal and the correlation signal are filtered;

determining a decision statistic by combining a power component of the processed correlation signal with a power component of the processed input signal;

nominate a point in time given by a predetermined threshold condition of the decision statistic as a received packet arrival time.

12. A method according to claim 11, wherein the step of processing at least one of the input and correlation signals is performed by one of:

a center weighted filter having a triangular impulse response;

a root raised cosine filter;

a Hanning window filter;

a Hamming window filter;

a combined Hanning/Hamming window filter.

13. A method according to claim 11 or 12, wherein the predetermined threshold condition is one of:

the decision statistic crossing the predetermined threshold and;

a maximum of the decision statistic occurring above the predetermined threshold.

14. A method according to claim 11, 12 or 13, wherein the step of determining the correlation signal is performed every Kth sample of a sampled packet input signal, where K is an integer greater than or equal to 1.

15. A method of communicating by tracking time varying channels in a multiple access packet based communication network the method comprising the steps of:

a) initializing a channel estimate reference based on an initial channel estimate derived from a received packet preamble;

b) updating the channel estimate reference based on a packet data symbol channel estimate in a coded portion of the current and all previously received data symbols;

c) repeating step b) at the arrival of subsequent packet data symbols.

16. A method according to claim 15, further comprising the step of:

storing the channel estimate reference in a channel estimate data base at the receiver.

17. A method according to any one of claims 15 or 16, further comprising the step of:

transforming the packet data symbol channel estimates to the frequency domain prior to updating the stored channel estimate reference to provide a time smoothed channel estimate reference.

18. A method according to claim 15, wherein the method further comprises the steps of:

for each subsequent received data symbol within step b), pipelining the steps of demodulating and modulating, and;

updating the channel estimate reference with the further step of FEC decoding.

19. A method of communicating by estimating time varying channel impairments in a multiple access packet based communication network, where channel impairments comprise channel variation, signal frequency offset and signal time offset, the method comprising the steps of:

a) initializing a set of channel impairment estimates based on initial pilot and preamble symbols included in a received packet;

b) performing a decoder operation which comprises processing the set of channel impairment estimates and the received packet to determine a set of transmit symbol estimates;

c) updating the set of channel impairment estimates with the determined set of symbol estimates and the received packet;

d) repeating steps b) and c).

20. A method of communicating in a multiple access network by time varying channel estimation in a receiver for receiving transmitted packets, the method comprising the steps of:

a) estimating a frequency offset based on information included in a received packet preamble;

b) correcting a received signal using the estimated frequency offset;

c) determining a channel estimate using information included in the received packet preamble;

d) transforming a sample sequence of the received signal into the frequency domain such that the sample sequence includes OFDM symbols and intervening cyclic prefixes;

e) performing a decoding operation which comprises processing the determined channel estimate and received packet;

f) generating a transmission sample sequence using the decoding results and information in the received packet preamble;

g) transforming the transmission sample sequence into the frequency domain;

h) updating the determined channel estimate by combining the received sample sequence and the transmission sample sequence in the frequency domain;

i) repeating steps e) to h).

21. A method of communicating in a multiple access network by time varying channel estimation in a receiver for receiving transmitted packets, where the receiver retrieves OFDM symbols from a received signal and transforms the retrieved symbols to the frequency domain, the method comprising the steps of:

a) determine a matrix of training symbols comprised of symbol estimates derived from a decoder;

b) determine a matrix of frequency domain received OFDM symbols;

c) determine an intermediate channel estimate matrix by multiplying the OFDM symbol matrix by the conjugate of the training symbol matrix;

d) determine an intermediate matrix of training weights comprising the absolute value of the training symbol matrix;

e) perform a smoothing operation on both intermediate matrices comprising 2 dimensional filtering;

f) determine the channel estimate by dividing the smoothed channel estimate matrix with the smoothed training weight matrix.

22. A method of communicating in a multiple access network by estimating offsets in a receiver for receiving transmitted packets, the method comprising the steps of:

a) determine a matrix of frequency domain received OFDM symbols;

b) determine a matrix of conjugated data symbols wherein the data symbols comprise one or more of preamble, training and estimated symbols;

c) determine a 2 dimensional Fourier transform matrix comprised of the received symbol matrix multiplied with the conjugated symbol matrix;

d) filter the Fourier transform matrix;

e) determine time and frequency offsets by locating peak power occurrences within the filtered Fourier transform.

23. A method of communicating in a multiple access packet communication network by synchronizing a received signal in a multi antenna receiver the method comprising:

correlating a received signal observation at each of a plurality of antennae with a known signal preamble to provide a received signal sequence;

determine a power signal of each received signal sequence;

combine the determined power signals in accordance with a time averaged weighting based on estimated antenna signal strength for each antenna;

determine a time of arrival for the received signal in accordance with a predetermined threshold condition.

24. A method according to claim 33, further comprising the steps of:

determining an estimate of the relative phase and amplitude coefficients of a receiving channel for each antenna;

combining a received signal with the estimated coefficients to provide a composite signal;

determining a time of arrival of the received signal by correlating the composite signal with a delayed version of itself.

25. Apparatus adapted to communicate in a multiple access communication network, said apparatus comprising:

processor means adapted to operate in accordance with a predetermined instruction set,

said apparatus, in conjunction with said instruction set, being adapted to perform a method according to any one of claims 4, 6 to 24.

26. A computer program product comprising:

a computer usable medium having computer readable program code and computer readable system code embodied on said medium for communicating in a multiple access communication network, said computer program product comprising:

computer readable code within said computer usable medium for performing the method steps according to any one of claims 4, 6 to 24.

27. A method substantially as herein described with reference to the accompanying drawings.

28. Apparatus substantially as herein described with reference to the accompanying drawings.

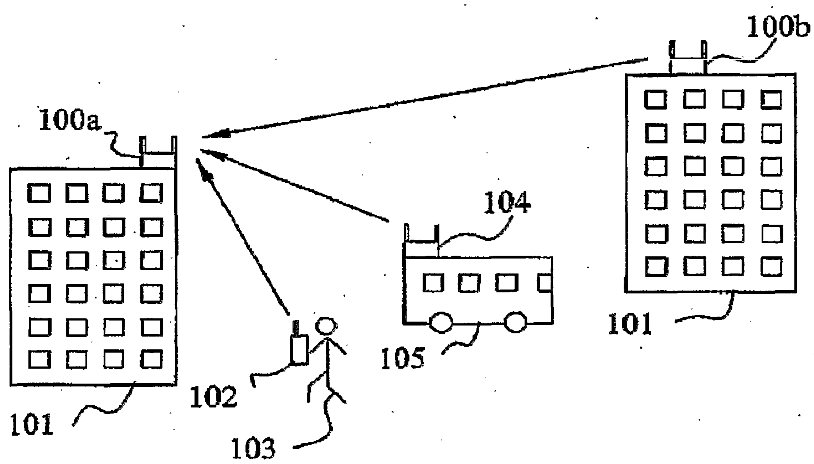



Figure 1

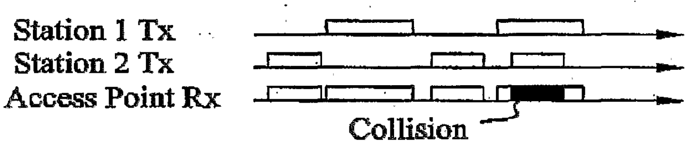



Figure 2 (Related Art)

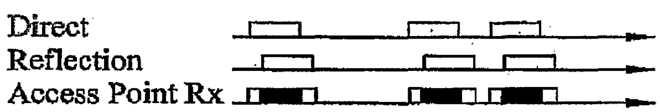



Figure 3 (Related Art)

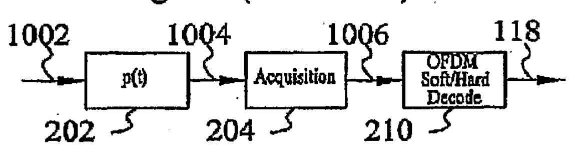
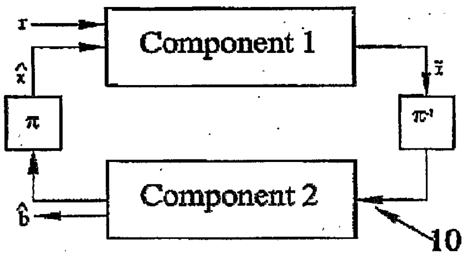
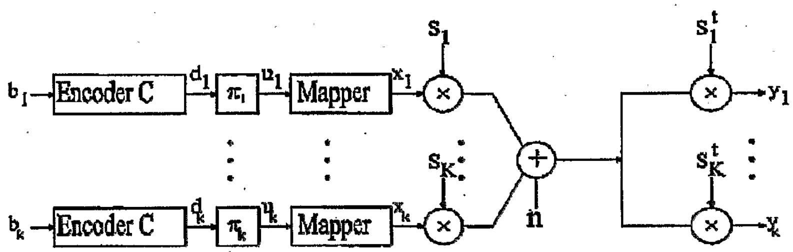


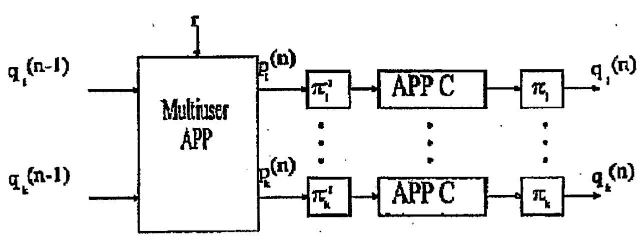

Figure 10 (Related Art)



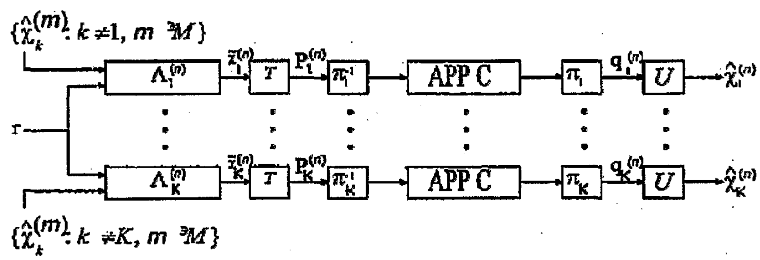

Generic iterative receiver structure
Figure 4



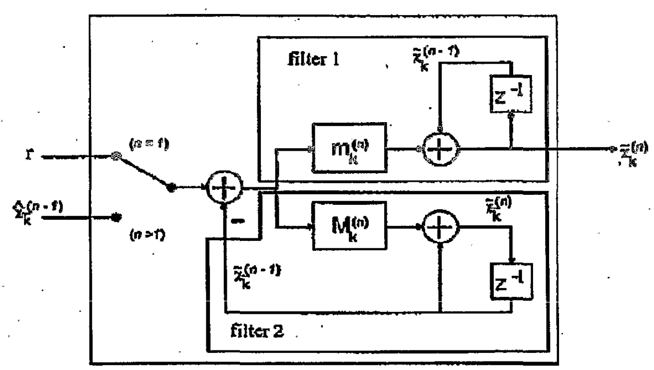

The transmission system model for coded CDMA
Figure 5



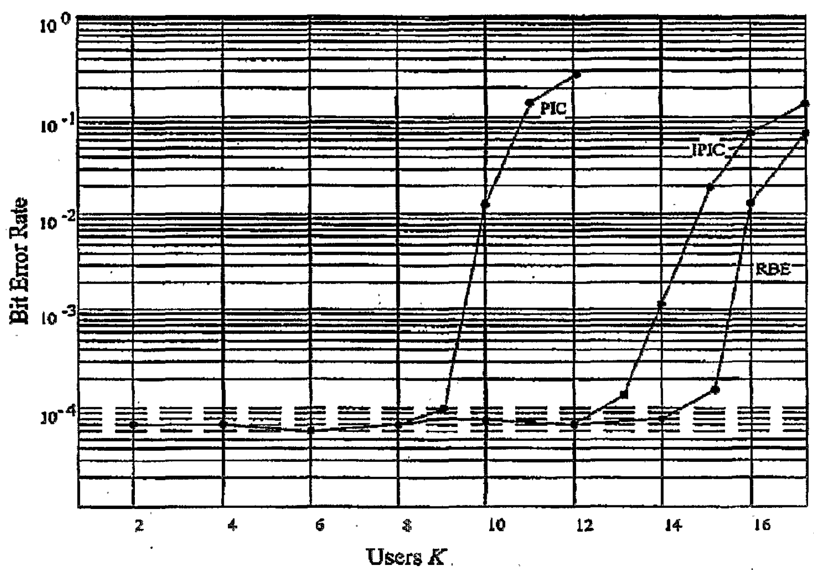

Canonical iterative multiuser decoder
Figure 6



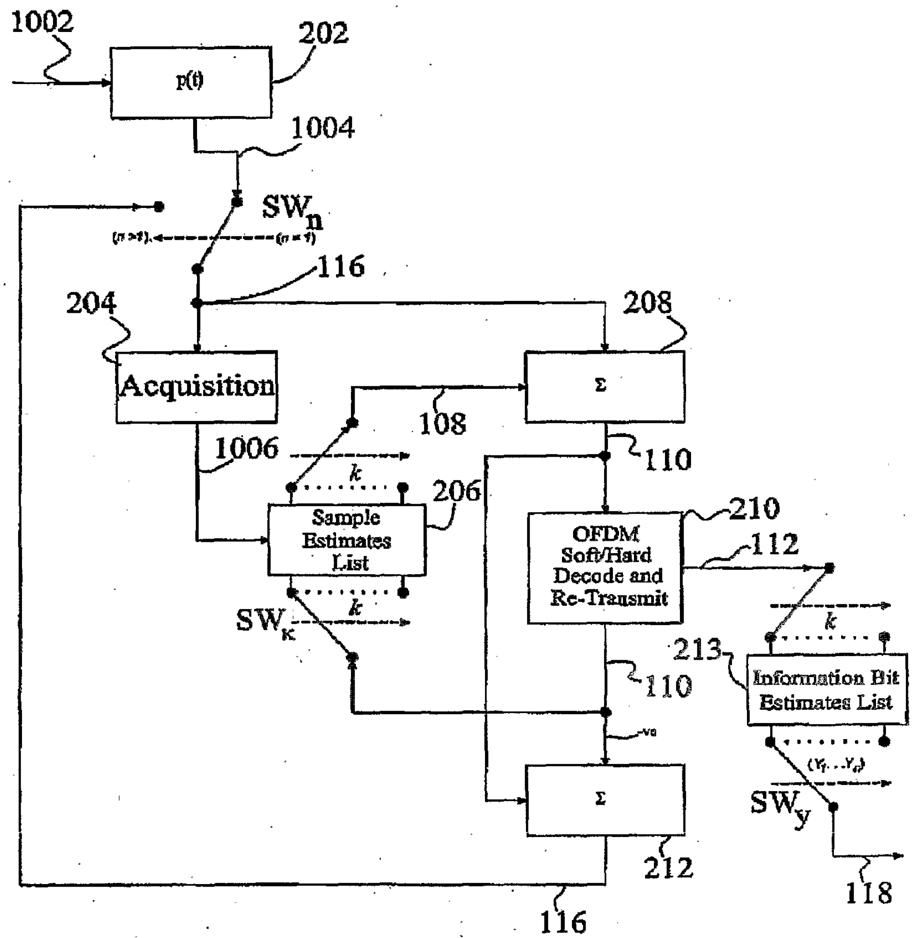

Iterative multiuser decoder with linear multiuser estimation
Figure 7




The recursive filter $\Lambda_k^{(n)}$ For $(n = 1)$ the input signal is r while for $n \geq 2$ the input signal is $\hat{\chi}_k(n - 1)$
Figure 8




BER versus users after 10 iterations, $N = 8$, $E_b / N_0 = 6$ dB
Figure 9




Iterative Interference Canceling Receiver Structure

Figure 11

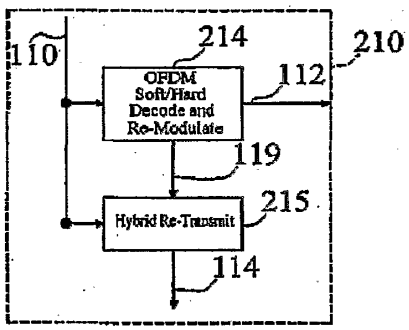



Figure 12

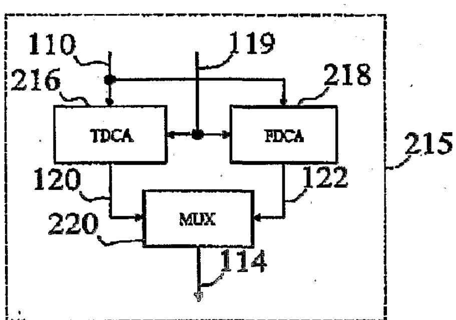



Figure 13

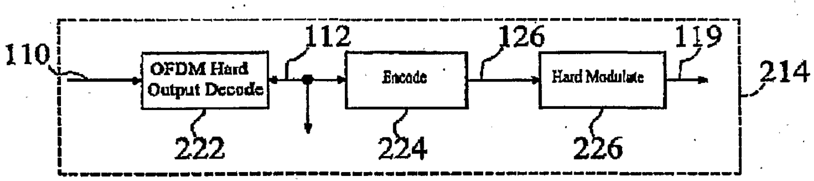



Figure 14

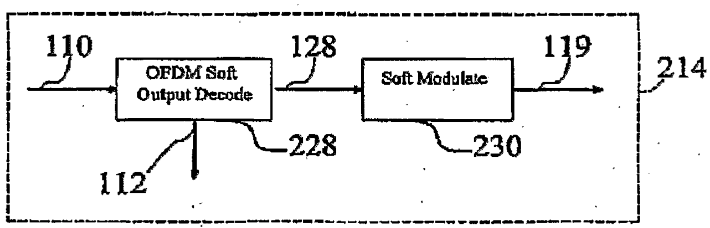



Figure 15

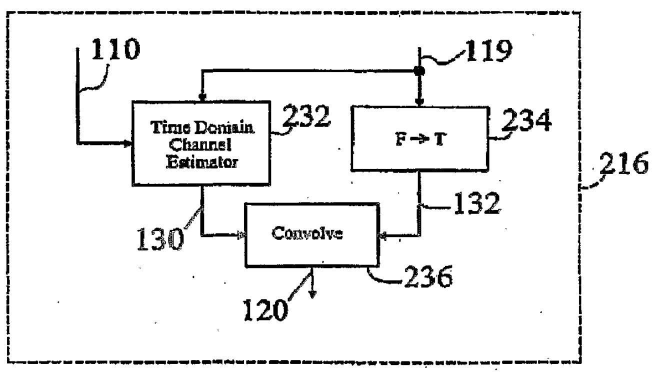



Figure 16

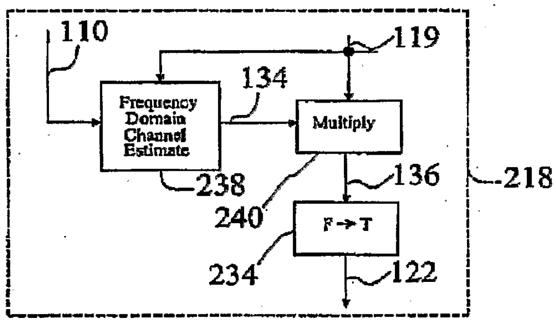



Figure 17

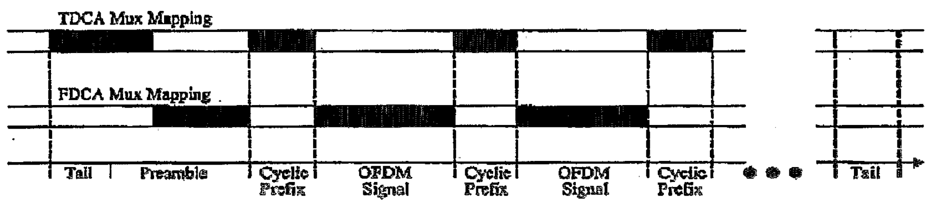



Figure 18

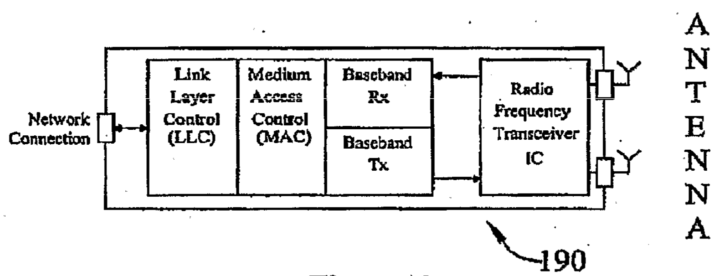



Figure 19a

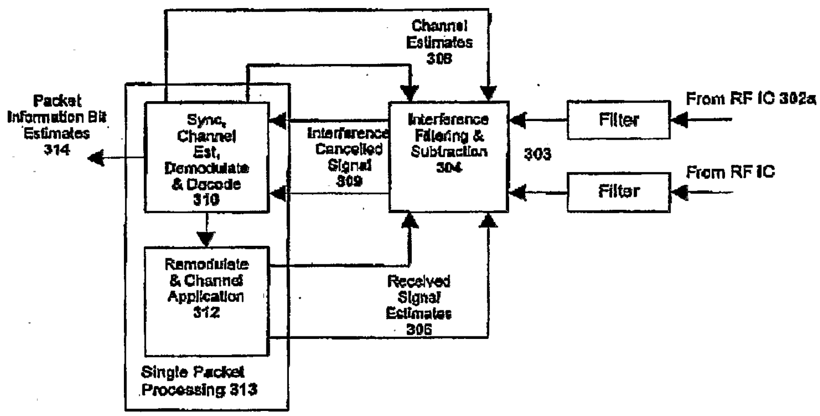



Figure 19b

EVOLVED-0002164

ZTE/SAMSUNG 1005-0522

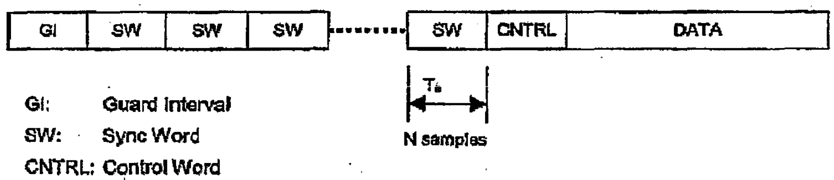



Figure 20

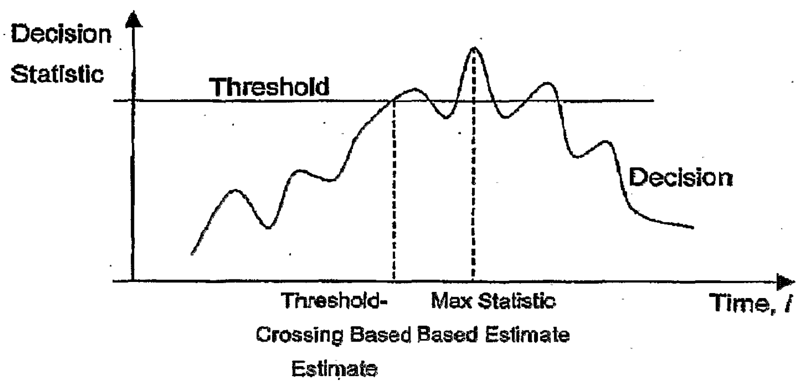



Figure 21

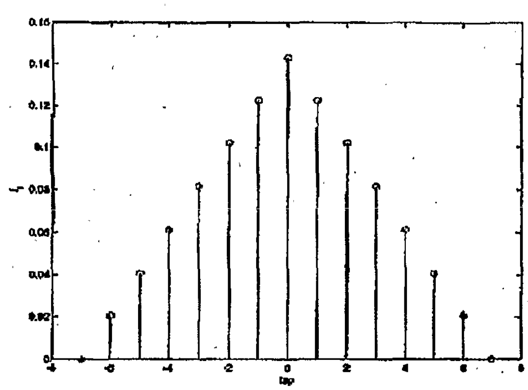


Figure 22

EVOLVED-0002165

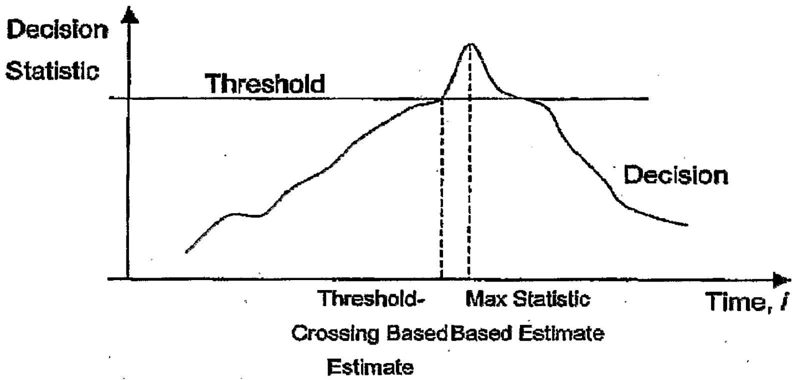



Figure 23

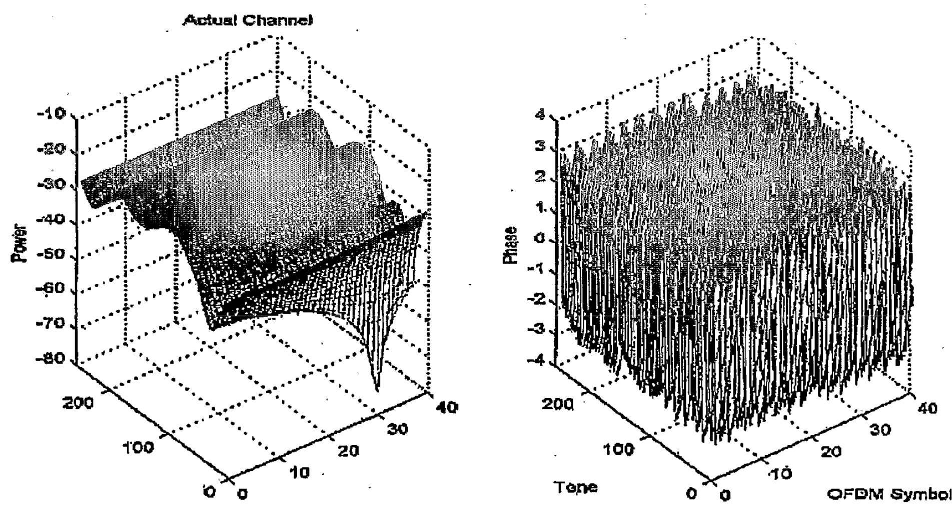



Figure 24

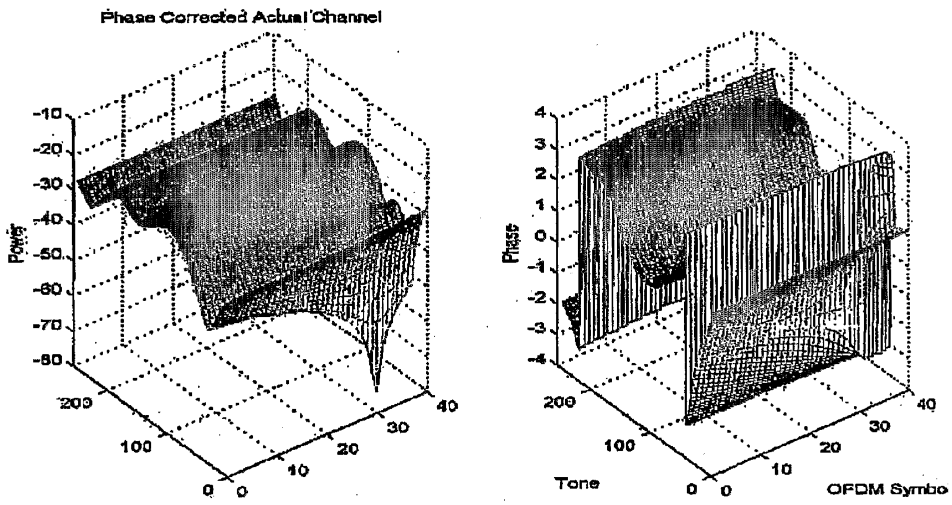

Phase Corrected Actual Channel
Power
-10
-20
-30
-40
-50
-60
-70
-80
200
100
0
0
10
20
30
40
Phase
4
3
2
1
0
-1
-2
-3
-4
200
100
Tone
0
0
10
20
30
40
OFDM Symbo

Figure 25

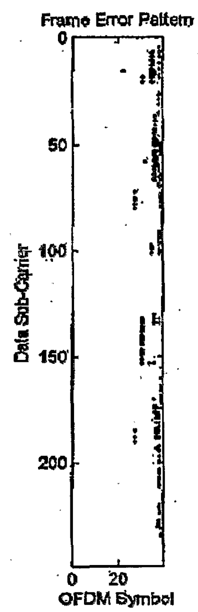



Figure 26

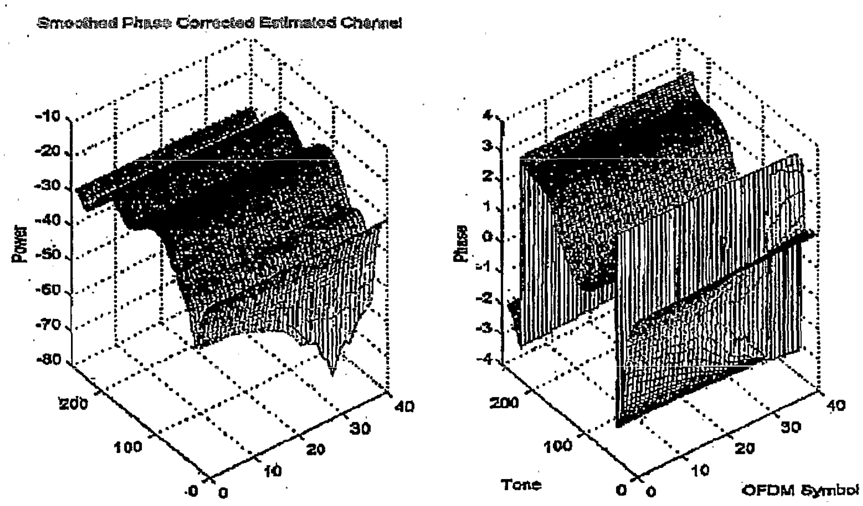



Figure 27

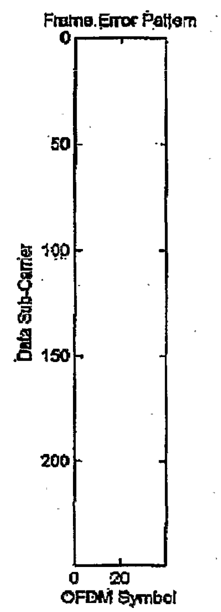



Figure 28

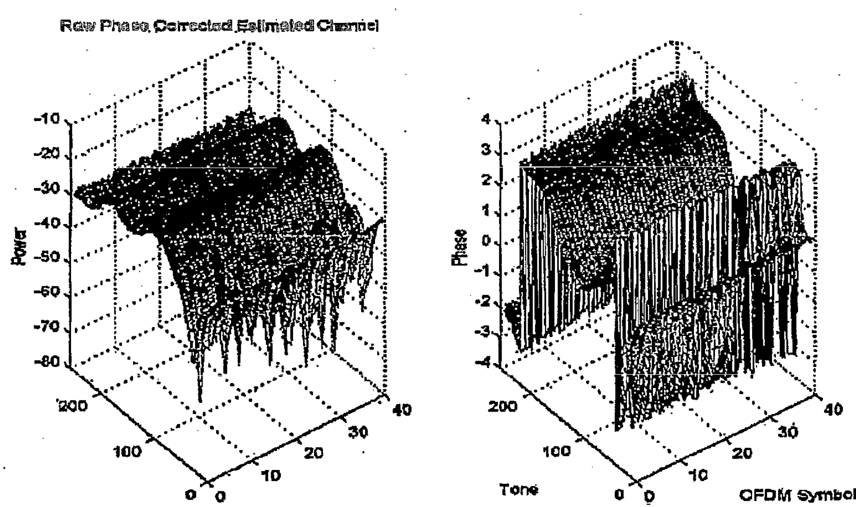



Figure 29

15/17

| Content | Short Training | Long Training | Signal | Data | Data | ..... |
|---|---|---|---|---|---|---|
| Pilot Mod. | QPSK | BPSK | BPSK | BPSK | BPSK | |
| Info. Mod. | na | na | BPSK | variable | variable | |
| Purpose | Signal Detect<br>AGC<br>Diversity Selection<br>Coarse IF Offset<br>Timing | Channel Estimation<br>Fine IF Offset | Rate<br>Length | Service<br>Data | Data | |

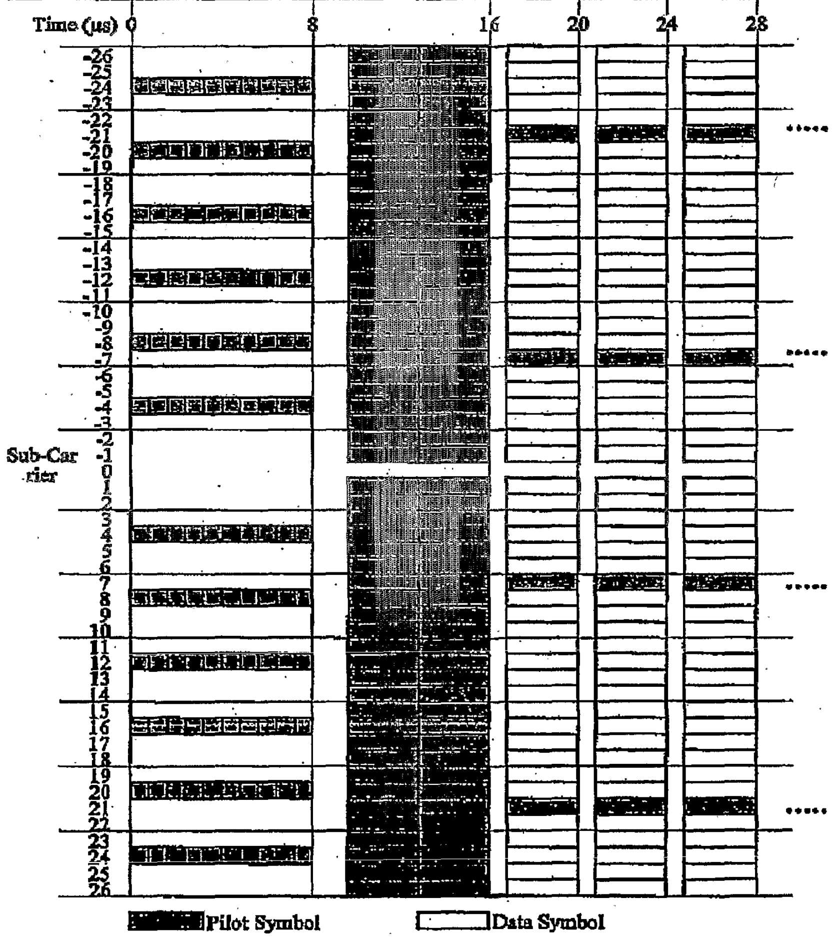



Figure 30

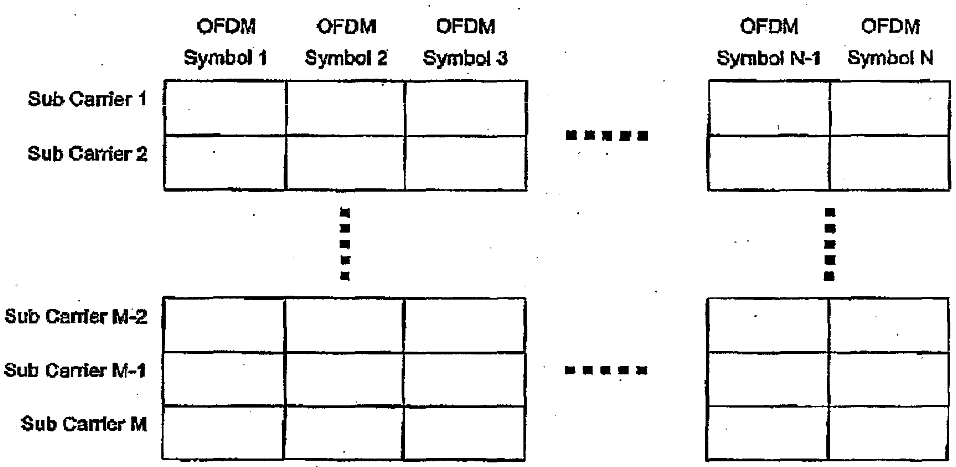



Figure 31

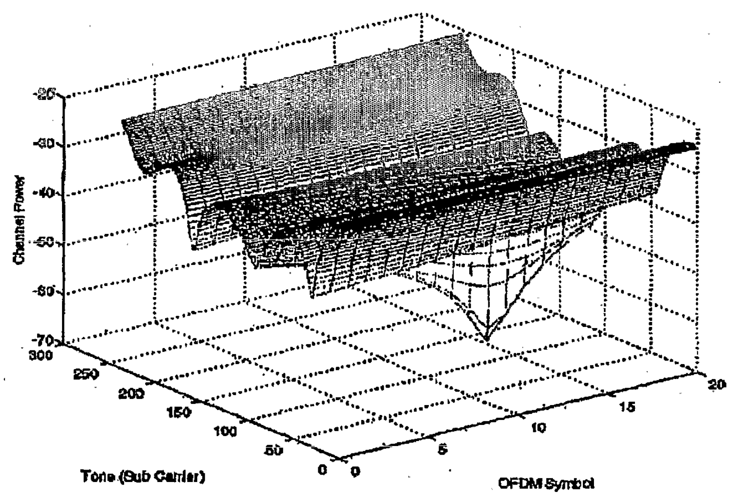



Figure 32

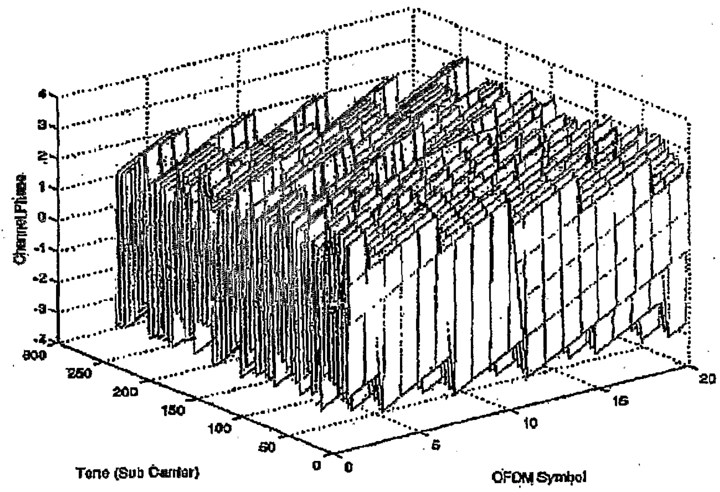



Figure 33

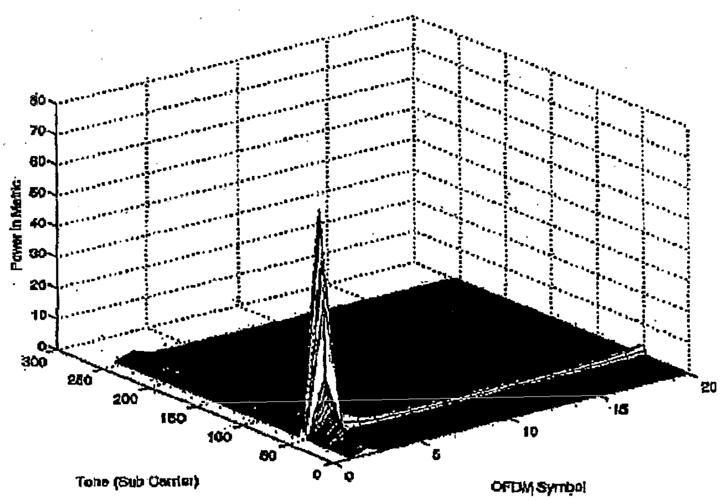



Figure 34

## INTERNATIONAL SEARCH REPORT

International application No.
**PCT/AU2004/001036**

**A. CLASSIFICATION OF SUBJECT MATTER**

Int. Cl. 7: H03M 13/00, H04L 27/26, H04B 7/208

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
**See Supplemental Box**

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| P,X | WO 2003/094037 A1 (UNIVERSITY OF SOUTH AUSTRALIA ET AL) 13 November 2003 whole document | 1-3 |
| P,A | US 2003/0185284 A1 (YOUSEF ET AL) 2 October 2003 whole document | 15-18 |
| X | Rasmussen et al : "Recursive Filters for Iterative Multiuser Decoding" ISIT 2002, Lausanne, Switzerland June 30-July 5 , 2002 page 445 | 1-3 |
| A | WO 2001/058105 A1 (AT&T CORP) whole document | 1-5,10,15-18 |

[X] Further documents are listed in the continuation of Box C    [X] See patent family annex

* Special categories of cited documents:

| | | | |
|---|---|---|---|
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| "E" | earlier application or patent but published on or after the international filing date | "X" | document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone |
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| "O" | document referring to an oral disclosure, use, exhibition or other means | "&" | document member of the same patent family |
| "P" | document published prior to the international filing date but later than the priority date claimed | | |

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 10 November 2004 | 22 NOV 2004 |
| Name and mailing address of the ISA/AU | Authorized officer |
| AUSTRALIAN PATENT OFFICE<br>PO BOX 200, WODEN ACT 2606, AUSTRALIA<br>E-mail address: pct@ipaustralia.gov.au<br>Facsimile No. (02) 6285 3929 | **JAMES WILLIAMS**<br>Telephone No : (02) 6283 2599 |

## INTERNATIONAL SEARCH REPORT

International application No.
**PCT/AU2004/001036**

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | WO 2002/039597 A2 (QUALCOMM Incorporated) 16 May 2002<br>whole document especially page 9 | 10 |
| P,A | US 2004/0062299 A1 (MCDONOUGH ET AL) 1 April 2004<br>whole document | 6-8 |
| P,A | US 2004/0062297 A1 (MCDONOUGH ET AL) 1 April 2004<br>whole document | 6-8 |
| A | US 2002/0031170 A1 (YOON) 14 March 2002<br>whole document | 6-8 |
| X<br>A | US 2003/0112825 A1 (WANG ET AL) 19 June 2003<br>whole document | 19<br>20 |
| X<br>A | AU 200038414 B2 (NIPPON TELEGRAPH AND TELEPHONE CORPORATION)<br>10 November 2000<br>whole document | 19<br>20 |

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ZTE/SAMSUNG 1005-0532

## INTERNATIONAL SEARCH REPORT

International application No.
**PCT/AU2004/001036**

**Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)**

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
   because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
   because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
   because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

**Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)**

This International Searching Authority found multiple inventions in this international application, as follows:
See Suplememntal Box

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☒ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
   Claims 1-5,10,15-18
   Claims 6-8
   Claims 19-20
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

**Remark on Protest** ☐ The additional search fees were accompanied by the applicant's protest.
☐ No protest accompanied the payment of additional search fees.

**Supplemental Box**
(To be used when the space in any of Boxes I to VIII is not sufficient)

**Continuation of Box No: B**

Group 1 Claims 1-5,10 and 15-18

WPAT: MULTI+ OR +DMA ,(ITERATIVE OR RECURSIVE) ,ESTIMAT+ , SIGNAL

Group 2 Claims 6-8

WPAT: OFDM OR ORTHOGONAL FREQUENCY DIVISION MULTIPLEXING, (SAMPLE? OR PART? OR SELECTION?), PACKET?, SAMPLE ,HYPOTHESIS

Group 3 Claims 19-20

WPAT: MULTIPLE ACCESS OR +DMA OR OFDM ,PACKET? , (CHANNEL OR TIME OR FREQUENCY) , (VARIA+ OR OFFSET? OR IMPAIRMENT)

## INTERNATIONAL SEARCH REPORT

| International application No. |
| --- |
| PCT/AU2004/001036 |

**Supplemental Box**
(To be used when the space in any of Boxes I to VIII is not sufficient)

**Continuation of Box No: III**

Group 1: Claims 1-5,10 and 15-18 method of communicating and decoding using iterative estimates

Group 2: Claims 6-8 method of communication with packet sample hypothesis

Group 3: Claim 9 method of communications with multiple time domain and frequency domain samples

Group 4: Claims 11-14 method of communicating by synchronising packets using input /output correlation

Group 5: Claims 19-20 method of communicating using estimating time varying channel impairments

Group 6: Claims 21-22 method of communicating using a training symbol matrix

Group 7: Claim 23 multi-antenna synchronising using received power

## INTERNATIONAL SEARCH REPORT

International application No.
**PCT/AU2004/001036**

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

| Patent Document Cited in Search Report | | Patent Family Member | | | | | |
|---|---|---|---|---|---|---|---|
| WO | 03094037 | | | | | | |
| US | 2003185284 | | | | | | |
| WO | 01058105 | | | | | | |
| US | 2004062299 | | | | | | |
| US | 2004062297 | JP | 2004289788 | | | | |
| US | 2003031170 | | | | | | |
| US | 2003112825 | US | 2003058951 | US | 2003058968 | WO | 03028205 |
| AU | 38414/00 | CA | 2346714 | EP | 1172956 | JP | 2001313624 |
| | | WO | 0065756 | | | | |
| WO | 0239597 | AU | 27299/02 | EP | 1336255 | US | 6788733 |

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

END OF ANNEX

EVOLVED-0002178

ZTE/SAMSUNG 1005-0536

| **INFORMATION DISCLOSURE STATEMENT BY APPLICANT** ( **Not for submission under 37 CFR 1.99)** | | |
|---|---|---|
| | Application Number | 12303947 |
| | Filing Date | 2010-07-07 |
| | First Named Inventor | Yeong Hyeon Kwon |
| | Art Unit | 2478 |
| | Examiner Name | KHAJURIA, SHRIPAL K |
| | Attorney Docket Number | 2101-3596 |

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|---|---|---|---|---|---|---|---|---|
| | 1 | 2005/011128 | WO | | 2005-02-03 | COHDA WIRELESS PTY LTD | | ☐ |
| | 2 | 2006/015108 | WO | | 2006-02-09 | ZTE SAN DIEGO, INC | | ☐ |

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| **INFORMATION DISCLOSURE STATEMENT BY APPLICANT** ( **Not for submission under 37 CFR 1.99)** | | |
|---|---|---|
| | Application Number | 12303947 |
| | Filing Date | 2010-07-07 |
| | First Named Inventor | Yeong Hyeon Kwon |
| | Art Unit | 2478 |
| | Examiner Name | KHAJURIA, SHRIPAL K |
| | Attorney Docket Number | 2101-3596 |

| Examiner Initials* | Cite No | Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published. | T5 |
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| Examiner Signature | | Date Considered | |
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| INFORMATION DISCLOSURE STATEMENT BY APPLICANT ( Not for submission under 37 CFR 1.99) | | |
|---|---|---|
| | Application Number | 12303947 |
| | Filing Date | 2010-07-07 |
| | First Named Inventor | Yeong Hyeon Kwon |
| | Art Unit | 2478 |
| | Examiner Name | KHAJURIA, SHRIPAL K |
| | Attorney Docket Number | 2101-3596 |

**CERTIFICATION STATEMENT**

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☒ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

**OR**

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☐ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☐ A certification statement is not submitted herewith.

**SIGNATURE**

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

| Signature | /Harry Lee/ | Date (YYYY-MM-DD) | 2011-10-31 |
|---|---|---|---|
| Name/Print | Harry Lee | Registration Number | 56,814 |

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

## AMENDMENTS TO THE CLAIMS

**Please amend the claims as follows:**

1-30. (Canceled)

31. (Currently Amended) A method of transmitting a preamble sequence in a mobile communication system, the method comprising:

~~generating said preamble sequence by repeating a specific sequence at least one time and concatenating a cyclic prefix (CP) to a front end of said repeated sequence, said CP being identical to a part of a rear end of said specific sequence; and~~

repeating a specific sequence, having a length (L), N times to generate a consecutive sequence having a length (N*L);

generating said preamble sequence by concatenating a single cyclic prefix (CP) to a front end of said consecutive sequence; and

transmitting, on a random access channel, said preamble sequence to a receiving side ~~on a random access channel~~.

32. (Currently Amended) The method of claim 31, further comprising generating said specific sequence from a Constant Amplitude Zero Auto Correlation (CAZAC) ~~(Constant Amplitude Zero Auto Correlation)~~ sequence.

33. (Currently Amended) The method of claim 32, further comprising applying a cyclic shift to said specific sequence generated from said CAZAC sequence.

34. (Currently Amended) The method of claim 33, wherein a value of said applied cyclic shift is determined as an integer ~~value~~ multiple of a predetermined circular shift unit.

35. (Previously Presented) The method of claim 33, wherein a value of said applied cyclic shift is used as additional information.

36. (Previously Presented) The method of claim 33, wherein applying said cyclic shift comprises multiplying said specific sequence by an exponential sequence.

37. (Currently Amended) The method of claim 31, further comprising generating said specific sequence by combining at least two code sequences mapped with at least one information bit~~, respectively~~.

38. (Currently Amended) A transmitter for transmitting a preamble sequence in a mobile communication system, the transmitter comprising:

a preamble generation unit configured to generate said preamble sequence by repeating a specific sequence, having a length (L), N times to generate a consecutive sequence having a length (N*L) and concatenating a single cyclic prefix (CP) to a front end of said consecutive sequence;

~~means for generating said preamble sequence by repeating a specific sequence at least one time and concatenating a cyclic prefix (CP) to a front end of said repeated sequence, said cyclic prefix being identical to a rear end of said specific sequence; and~~

~~means for transmitting~~ a transmission unit configured to transmit, on a random access channel, said preamble sequence to a receiving side ~~on a random access channel~~.

39. (Currently Amended) The transmitter of claim 38, wherein ~~said means for generating said preamble are~~ said preamble generation unit is further configured to generate said specific sequence from a Constant Amplitude Zero Auto Correlation (CAZAC) ~~(Constant Amplitude Zero Auto Correlation)~~ sequence.

40. (Currently Amended) The transmitter of claim 39, wherein said preamble generation unit ~~said means for generating said preamble are~~ is further configured to apply a cyclic shift to said specific sequence generated from said CAZAC sequence.

41. (Currently Amended) The transmitter of claim 40, wherein a value of said applied cyclic shift is determined as an integer ~~value~~ multiple of a predetermined circular shift unit.

42. (Currently Amended) The transmitter of ~~claim 39~~ claim 40, wherein a value of said applied cyclic shift is used as additional information.

43. (Currently Amended) The transmitter of claim 39 claim 40, wherein said preamble generation unit means for generating said preamble are is further configured to apply a cyclic said cyclic shift by multiplying said specific sequence by an exponential sequence.

44. (Currently Amended) The transmitter of claim 38, wherein said preamble generation unit means for generating said preamble are is further configured to generate said specific sequence by combining at least two code sequences mapped with at least one information bit, respectively.

45. (New) The method of claim 31, wherein:

said consecutive sequence comprises at least a first sequence, a second sequence, and an N-th sequence; and

said CP is identical to a rear part of said N-th sequence.

46. (New) The transmitter of claim 38, wherein:

said consecutive sequence comprises at least a first sequence, a second sequence, and an N-th sequence; and

said CP is identical to a rear part of said N-th sequence.

## REMARKS

Claims 31-46 are pending in the application. Claims 31-34 and 37-44 are currently amended. Claims 45 and 46 are newly submitted. No new matter has been added as the amendments and newly submitted claims have support in the specification as originally filed. It is submitted that the application, as amended, is in condition for allowance. Reconsideration is respectfully requested.

Applicant notes with appreciation the Examiner's acknowledgement of Applicant's claim for foreign priority under 35 USC 119(a)-(d) and that all certified copies of the priority documents have been received.

Claims 31-44 are rejected under 35 U.S.C. 102(b) as being anticipated by Jung et al. (US 2006/0153282). Applicant respectfully traverses these rejections, and requests reconsideration and allowance of the pending claims in view of the following arguments.

As amended, independent claim 31 recites repeating a specific sequence, having a length (L), N times to generate a consecutive sequence having a length (N*L) and generating said preamble sequence by concatenating a single cyclic prefix (CP) to a front end of said consecutive sequence.

Page 2 of the Office Action states that paragraphs 0064 and 0068 of Jung disclose generating said preamble sequence by repeating a specific sequence at least one time and concatenating a cyclic prefix (CP) to a front end of said repeated sequence. Applicant provides the following remarks.

A review of cited paragraph 0064 of Jung reveals that Jung arguably discloses repeatedly transmitting a second preamble sequence. Furthermore, cited paragraph 0064 of Jung discloses that a combination of second preamble sequences is transmitted through, for example, odd and even frames. Accordingly, Jung discloses that the second preamble sequence is repeated through separate frames, such as, odd and even frames (Jung, paragraph 0064). Applicant submits that repeating a preamble via separate frames, each of which including an individual cyclic prefix and first preamble sequences, is patentably distinguishable from repeating a specific sequence, having a length (L), N times to generate a consecutive sequence having a length (N*L), as recited in independent claim 31. More specifically, since the second preamble sequence of Jung is repeated in different frames, the second preamble sequence of Jung is not a consecutive sequence as required by independent claim 31. Therefore, since Jung fails to disclose generating a consecutive sequence by repeating a specific sequence, Jung cannot teach or suggest "repeating a specific sequence, having a length (L), N times to generate a consecutive sequence having a length (N*L)," as recited in independent claim 31.

Furthermore, cited paragraph 0068 of Jung discloses that "the guard interval signal is inserted using a cyclic prefix scheme in which the last predetermined samples of a time domain OFDM symbol are copied and inserted into an effective OFDM symbol or a cyclic postfix scheme in which the first predetermined samples of a time domain OFDM symbol are copied and inserted into an effective OFDM symbol."

A review of cited paragraph 0068 of Jung reveals that an OFDM symbol or a cyclic postfix scheme are copied and inserted into an effective OFDM symbol. Similar to the arguments presented above with regard to cited paragraph 0064 of Jung, Applicant submits that although paragraph 0068 of Jung arguably discloses copying and inserting OFDM symbols into an effective OFDM symbol, paragraph 068 of Jung fails to disclose generating a consecutive sequence by repeating a specific sequence, as required by independent claim 31.

Furthermore, Applicant has reviewed Jung and has found no discussion with regard to "generating said preamble sequence by concatenating a single cyclic prefix to a front end of said consecutive sequence," as recited in independent claim 31. Rather, a review of FIG. 2 of Jung reveals that a preamble sequence of Jung may include more than one cyclic prefix. Therefore, Applicant submits that Jung cannot teach or suggest generating said preamble sequence by concatenating a single cyclic prefix (CP) to a front end of said consecutive sequence, as recited in independent claim 31.

To assist the Examiner in understanding the Applicant's position with regard to Jung, Applicant provides below relevant portions of FIG. 2 of Jung, which has been annotated in accordance with Applicant's position.

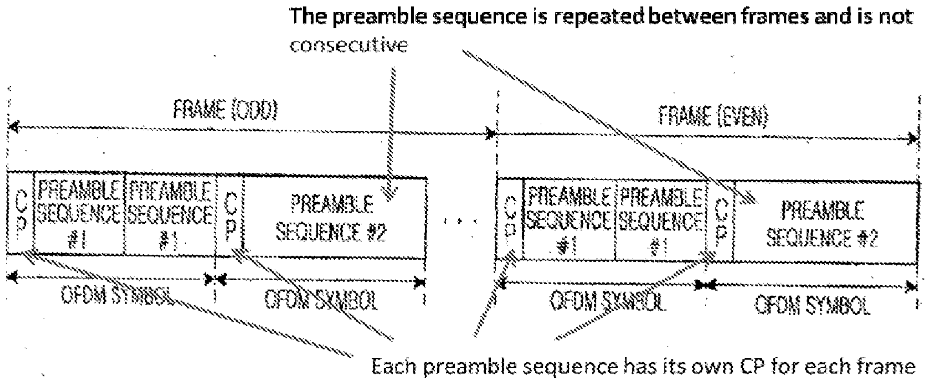


FIG.2

As illustrated in annotated FIG. 2 of Jung, the preamble sequences do not form a consecutive sequence, rather, the preamble sequences are repeated in different frames. For example, the preamble sequence #2 is split between two frames, and therefore, since the preamble sequence #2 is split between two frames, the preamble sequence #2 is not a consecutive sequence. Accordingly, as previously discussed, Jung cannot teach or suggest "repeating a specific sequence, having a length (L), N times to generate a consecutive sequence having a length (N*L)," as recited in independent claim 31.

Furthermore, as illustrated in annotated FIG. 2, each of the frames, even and odd, has its own CP. Therefore, since each frame has its own CP, the preamble sequences of Jung are not concatenated with a single CP to a front end of the consecutive sequence, as required in independent claim 31. In other words, each preamble sequence of Jung has its own CP, as opposed to a single CP concatenated to a front end of the consecutive sequence to generate a preamble symbol. Therefore, as previously discussed, since Jung does not disclose concatenating a single CP to a front end of the consecutive sequence to generate a preamble symbol, Jung cannot teach or suggest "generating said preamble sequence by concatenating a single cyclic prefix (CP) to a front end of said consecutive sequence," as recited in independent claim 31.

Furthermore, FIG. 2 of Jung arguably illustrates a consecutive "preamble sequence #1." However, Applicant submits that the consecutive "preamble sequence #1," as illustrated in FIG. 2 of Jung is entirely different from the "consecutive sequence" required in independent claim 31.

Specifically, paragraph 0041 of Jung discloses that "the preamble sequence transmitted through the first transmit antenna is referred to as the first preamble sequence (Preamble Sequence #1)." Additionally, paragraphs 0046-0051 of Jung disclose that the first preamble sequence is divided into subsequences and the generated subsequences are transmitted through the first antenna. Accordingly, Applicant submits that in view of paragraphs 0041 and 0046-0051 of Jung, the "preamble sequence #1" of FIG. 2 of Jung is a consecutive sequence of subsequences of the first preamble sequence. In other words, Jung does not repeat the first preamble sequence in order to create a consecutive sequence, and therefore, the consecutive "preamble sequence #1" illustrated in FIG. 2 of Jung, is patentably distinguishable from the "consecutive sequence" of independent claim 31. Thus, notwithstanding the arguments presented above, Applicant submits that Jung cannot teach or suggest "repeating a specific sequence, having a length (L), N times to generate a consecutive sequence having a length (N*L)," as recited in independent claim 31.

Applicant has demonstrated above that Jung fails to teach or suggest various elements recited in independent claim 31, and therefore, independent claim 31 is allowable over the cited reference. Additionally, independent claim 38 recites elements similar to those recited in independent claim 31 and is allowable for reasons similar to those presented with regard to independent claims 31. Finally, claims 32-37 and 39-44 are allowable at least by virtue of their dependence on an allowable base claim.

Finally, although not formally rejected, newly submitted claims 45 and 46 are allowable at least by virtue of their dependence on an allowable base claim.

## CONCLUSION

In light of the above remarks, Applicant submits that the present Amendment places all claims of the present application in condition for allowance. Reconsideration of the application is requested.

If for any reason the Examiner finds the application other than in condition for allowance, the Examiner is requested to call the undersigned attorney at the Los Angeles, California, telephone number (213) 623-2221 to discuss the steps necessary for placing the application in condition for allowance. Please charge any additional fees and credit any overpayment to **Deposit Account No. 502290**.

Respectfully submitted,
Lee, Hong, Degerman, Kang & Waimey

Date: December 16, 2011

By: /Puya Partow-Navid/
Puya Partow-Navid
Registration No. 59,657
Attorney for Applicant(s)

Customer No. 035884

# Electronic Acknowledgement Receipt

| | |
|---|---|
| **EFS ID:** | 11645476 |
| **Application Number:** | 12303947 |
| **International Application Number:** | |
| **Confirmation Number:** | 1730 |
| **Title of Invention:** | METHOD OF TRANSMITTING DATA IN A MOBILE COMMUNICATION SYSTEM |
| **First Named Inventor/Applicant Name:** | Yeong Hyeon Kwon |
| **Customer Number:** | 35884 |
| **Filer:** | Puya Partow-Navid/Anna Tounian |
| **Filer Authorized By:** | Puya Partow-Navid |
| **Attorney Docket Number:** | 2101-3596 |
| **Receipt Date:** | 16-DEC-2011 |
| **Filing Date:** | 07-JUL-2010 |
| **Time Stamp:** | 21:12:07 |
| **Application Type:** | U.S. National Stage under 35 USC 371 |

## Payment information:

| | |
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| Submitted with Payment | no |

## File Listing:

| Document Number | Document Description | File Name | File Size(Bytes)/ Message Digest | Multi Part /.zip | Pages (if appl.) |
|---|---|---|---|---|---|
| 1 | Transmittal Letter | 2101-3596-Transmittal-ROA.pdf | 67361<br>a432e136d927bfa7fba080b33d204dcc1e700b42 | no | 1 |

**Warnings:**

**Information:**

| | | | | | |
|---|---|---|---|---|---|
| 2 | | 2101-3596-ROA.pdf | 472138<br>3885157e7a60e672eea6582bce42f585d0a5074f | yes | 10 |

| Multipart Description/PDF files in .zip description | | |
|---|---|---|
| **Document Description** | **Start** | **End** |
| Amendment/Req. Reconsideration-After Non-Final Reject | 1 | 1 |
| Specification | 2 | 2 |
| Claims | 3 | 5 |
| Applicant Arguments/Remarks Made in an Amendment | 6 | 10 |

**Warnings:**

**Information:**

**Total Files Size (in bytes):** 539499

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**New Applications Under 35 U.S.C. 111**
**If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.**

**National Stage of an International Application under 35 U.S.C. 371**
**If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.**

**New International Application Filed with the USPTO as a Receiving Office**
**If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.**

**AMENDMENT TO THE SPECIFICATION**

Please insert the following paragraph on page 1 of the Specification, after the title of the invention and before the section titled TECHNICAL FIELD, with the following heading and paragraph:

**CROSS-REFERENCE TO RELATED APPLICATIONS**

This application is the National Stage filing under 35 U.S.C. § 371 of International Application No. PCT/KR07/02784, filed on January 8, 2007, which claims the benefit and right of priority to Korean Application Nos. 10-2006-0052167, filed on June 9, 2006 and 10-2006-0057488, filed on June 26, 2006.

**Customer No. 035884** **Docket No. 2101-3596**

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

In re application of:
Yeong Hyeon KWON et al.

Serial No.: 12/303,947

Filed: July 7, 2010

For: METHOD OF TRANSMITTING DATA IN A MOBILE COMMUNICATION SYSTEM

Art Unit: 2478

Examiner: Khajuria, Shripal K.

Conf. No. 1730

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:
Transmitted herewith is an AMENDMENT in the above-identified application.

☐ A petition for extension of time for _ month(s) is enclosed.
☒ No additional fee is required.

The fee has been calculated as shown below:

| | (Col. 1) CLAIMS REMAINING AFTER AMENDMENT | | (Col. 2) HIGHEST NUMBER PREVIOUSLY PAID FOR | | (Col. 3) PRESENT EXTRA* | LG/SM $ ENTITY FEE | | ADD'L FEE DUE |
|---|---|---|---|---|---|---|---|---|
| TOTAL CLAIMS FEE | 16 | - | 31 | ** | 0 | LG=$60 SM=$30 | $60 | $ 0 |
| INDEPENDENT CLAIMS FEE | 2 | - | 7 | *** | 0 | LG=$250 SM=$125 | $250 | $ 0 |
| FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIMS | | | | | | LARGE ENTITY FEE = $450 SMALL ENTITY FEE = $225 | | $ 0 |
| | | | | | | | TOTAL | $ 0 |

* If the entry in Col. 1 is less than the entry in Col. 2, write "0" in Col. 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, write "20" in this space.
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, write "3" in this space. The "Highest Number Previously Paid For" (Total or Independent) is the highest number found from the equivalent box on Col. 1 of a prior amendment or the number of claims originally filed.

☒ The Commissioner is hereby authorized to charge payment of the following fees associated with this communication or credit any overpayment to **Deposit Account No. 502290**:
- ☐ Excess claim(s) fee in the amount of $___.
- ☐ RCE fee in the amount of $___.
- ☐ Extension fees in the amount of $____.
- ☐ Petition fee in the amount of $____.
- ☐ Terminal Disclaimer fee in the amount of $___.
- ☒ Any filing fees under 37 CFR 1.16 for the presentation of extra claims.
- ☒ Any patent application processing fees under 37 CFR 1.17.

Respectfully submitted,
Lee, Hong, Degerman, Kang & Waimey

Date: December 16, 2011

By: /Puya Partow-Navid/
Puya Partow-Navid
Registration No. 59,657
Attorney for Applicant(s)

**EVOLVED-0002194**

ZTE/SAMSUNG 1005-0552

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

| | | | |
|---|---|---|---|
| In re application of: | Yeong Hyeon KWON et al. | Art Unit: | 2478 |
| Serial No.: | 12/303,947 | Examiner: | Khajuria, Shripal K. |
| Filed: | July 7, 2010 | Conf. No. | 1730 |
| For: | METHOD OF TRANSMITTING DATA IN A MOBILE COMMUNICATION SYSTEM | | |

**AMENDMENT**

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

In response to the Office Action dated September 16, 2011, for which the Examiner set a three-month period for response, Applicant provides the following.

PTO/SB/06 (07-06)
Approved for use through 1/31/2007. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

# PATENT APPLICATION FEE DETERMINATION RECORD
Substitute for Form PTO-875

Application or Docket Number: 12/303,947
Filing Date: 07/07/2010
☐ To be Mailed

## APPLICATION AS FILED – PART I

| FOR | NUMBER FILED (Column 1) | NUMBER EXTRA (Column 2) | SMALL ENTITY ☐ RATE ($) | SMALL ENTITY FEE ($) | OR | OTHER THAN SMALL ENTITY RATE ($) | OTHER THAN SMALL ENTITY FEE ($) |
|---|---|---|---|---|---|---|---|
| ☐ BASIC FEE (37 CFR 1.16(a), (b), or (c)) | N/A | N/A | N/A | | | N/A | |
| ☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m)) | N/A | N/A | N/A | | | N/A | |
| ☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q)) | N/A | N/A | N/A | | | N/A | |
| TOTAL CLAIMS (37 CFR 1.16(i)) | 14 minus 20 = | * 0 | X $ = | | OR | X $52 = | 0 |
| INDEPENDENT CLAIMS (37 CFR 1.16(h)) | 2 minus 3 = | * 0 | X $ = | | | X $220 = | 0 |
| ☐ APPLICATION SIZE FEE (37 CFR 1.16(s)) | If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s). | | | | | | |
| ☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j)) | | | | | | | |
| * If the difference in column 1 is less than zero, enter "0" in column 2. | | | TOTAL | | | TOTAL | 0 |

## APPLICATION AS AMENDED – PART II

| AMENDMENT | CLAIMS REMAINING AFTER AMENDMENT (Column 1) | | HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2) | PRESENT EXTRA (Column 3) | SMALL ENTITY RATE ($) | SMALL ENTITY ADDITIONAL FEE ($) | OR | OTHER THAN SMALL ENTITY RATE ($) | OTHER THAN SMALL ENTITY ADDITIONAL FEE ($) |
|---|---|---|---|---|---|---|---|---|---|
| 12/16/2011 | | | | | | | | | |
| Total (37 CFR 1.16(i)) | * 16 | Minus | ** 20 | = 0 | X $ = | | OR | X $60= | 0 |
| Independent (37 CFR 1.16(h)) | * 2 | Minus | ***3 | = 0 | X $ = | | OR | X $250= | 0 |
| ☐ Application Size Fee (37 CFR 1.16(s)) | | | | | | | | | |
| ☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j)) | | | | | | | OR | | |
| | | | | | TOTAL ADD'L FEE | | OR | TOTAL ADD'L FEE | 0 |

| AMENDMENT | CLAIMS REMAINING AFTER AMENDMENT (Column 1) | | HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2) | PRESENT EXTRA (Column 3) | SMALL ENTITY RATE ($) | SMALL ENTITY ADDITIONAL FEE ($) | OR | OTHER THAN SMALL ENTITY RATE ($) | OTHER THAN SMALL ENTITY ADDITIONAL FEE ($) |
|---|---|---|---|---|---|---|---|---|---|
| Total (37 CFR 1.16(i)) | * | Minus | ** | = | X $ = | | OR | X $ = | |
| Independent (37 CFR 1.16(h)) | * | Minus | *** | = | X $ = | | OR | X $ = | |
| ☐ Application Size Fee (37 CFR 1.16(s)) | | | | | | | | | |
| ☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j)) | | | | | | | OR | | |
| | | | | | TOTAL ADD'L FEE | | OR | TOTAL ADD'L FEE | |

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

Legal Instrument Examiner:
/GLENN BURNS JR/

| **INFORMATION DISCLOSURE STATEMENT BY APPLICANT** ( **Not for submission under 37 CFR 1.99)** | | |
|---|---|---|
| | Application Number | 12303947 |
| | Filing Date | 2010-07-07 |
| | First Named Inventor | Yeong Hyeon Kwon |
| | Art Unit | 2478 |
| | Examiner Name | KHAJURIA, SHRIPAL K |
| | Attorney Docket Number | 2101-3596 |

**U.S.PATENTS** Remove

| Examiner Initial* | Cite No | Patent Number | Kind Code[1] | Issue Date | Name of Patentee or Applicant of cited Document | Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear |
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| Examiner Initials* | Cite No | Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published. | T[5] |
|---|---|---|---|

| **INFORMATION DISCLOSURE STATEMENT BY APPLICANT** ( Not for submission under 37 CFR 1.99) | Application Number | 12303947 |
|---|---|---|
| | Filing Date | 2010-07-07 |
| | First Named Inventor | Yeong Hyeon Kwon |
| | Art Unit | 2478 |
| | Examiner Name | KHAJURIA, SHRIPAL K |
| | Attorney Docket Number | 2101-3596 |

| | | | |
|---|---|---|---|
| | 1 | CHANG ET AL: "Synchronization Method Based on a New Constant Envelop Preamble for OFDM Systems," IEEE TRANSACTIONS ON BROADCASTING, vol. 51, no. 1, March 2005, pp. 139-143, XP-011127926. | ☐ |
| | 2 | TEXAS INSTRUMENTS: "On Allocation of Uplink Pilot Sub-Channels in EUTRA SC-FDMA," R1-050822, 3GPP TSG-RAN WG1 Ad Hoc on LTE, August 2005, XP-002448008. | ☐ |

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**EXAMINER SIGNATURE**

| Examiner Signature | | Date Considered | |
|---|---|---|---|

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

| **INFORMATION DISCLOSURE STATEMENT BY APPLICANT** ( Not for submission under 37 CFR 1.99) | | |
|---|---|---|
| | Application Number | 12303947 |
| | Filing Date | 2010-07-07 |
| | First Named Inventor | Yeong Hyeon Kwon |
| | Art Unit | 2478 |
| | Examiner Name | KHAJURIA, SHRIPAL K |
| | Attorney Docket Number | 2101-3596 |

**CERTIFICATION STATEMENT**

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☒ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

**OR**

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

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| **EFS ID:** | 11671116 |
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| **First Named Inventor/Applicant Name:** | Yeong Hyeon Kwon |
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# Synchronization Method Based on a New Constant Envelop Preamble for OFDM Systems

Guangliang Ren, Yilin Chang, Hui Zhang, and Huining Zhang

***Abstract*—The synchronization method using the available constant envelop preamble is analyzed, and a new preamble weighted by pseudo-noise sequence is proposed, with which a novel timing and frequency offset estimation method is presented for orthogonal frequency division multiplexing (OFDM) systems in this paper. By the proposed method, the accuracy of the timing offset estimator is significantly improved, and the estimate range of the frequency offset estimator is greatly enlarged with no loss in accuracy. The performance of the proposed method is demonstrated by simulations.**

***Index Terms*—Constant envelop preamble, OFDM, synchronization.**

## I. Introduction

ORTHOGONAL frequency division multiplexing has been widely used in wireless communication systems such as WLANs, DAB, etc. due to its advantages. But it is very sensitive to nonlinear distortion and synchronization errors caused by Doppler shift and/or oscillator instabilities [1]. A number of synchronization methods [2]–[9] have been proposed to estimate the time and frequency offsets either jointly or individually.

In packet oriented application, the preamble based synchronization methods are often employed and most of them use the preamble whose length is more than two OFDM symbols to estimate the timing and frequency offsets [2]–[4]. In order to improve the efficiency of the transmission and the performance of the synchronization method, many algorithms [5]–[8] are investigated to estimate the timing offset and/or the frequency offset wherein the length of the preamble is the same as one OFDM symbol, and the preambles in [5]–[8] can be made by transmitting a pseudo-noise sequence and zeros at the special frequency respectively. However, the peak-to-average power ratio (PAPR) of the preambles is still large due to a large number of sub-carriers in the preamble. So the nonlinear distortion in the transmission degrades the performance of the synchronization method.

In order to achieve robustness to the nonlinear distortion, Andreas Cyzlwink proposed a synchronization method using a constant envelop preamble [9], but the performance of the method is not satisfactory and the ideas in [6]–[8] cannot be applied to the method since the data on the sub-carriers of the constant envelop preamble cannot be selected as those in [6]–[8]. To further improve the performance of the synchronization method with the constant envelop preamble, we propose a new constant envelop preamble weighted by the pseudo-noise sequence and the corresponding timing and frequency offset estimation method for wireless OFDM systems in this paper.

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## II. Signal Model

The samples of a complex-valued baseband OFDM symbol can be described as

$$x_n = \sum_{k=0}^{N-1} c_k e^{j2\pi kn/N} \quad (1)$$

where $c_k$ is the complex modulated symbol on the kth sub-carrier, N is the size of IFFT and n is the index of samples. The useful part of each OFDM symbol has a duration of T seconds and the intersymbol interference (ISI) can be easily eliminated by inserting a cyclic prefix that is longer than the channel impulse response.

At the receiver, the received waveform r(t) is sampled with period $T_s = T/N$. In the received signal models, the timing offset is often modeled as a delay and the frequency offset is modeled as a phase distortion of the received data in the time domain, so, the nth received sample may be represented as [6]

$$r(n) = y(n-\varepsilon)e^{j(2\pi vn/N)} + w(n) \quad (2)$$

where $\varepsilon$ is the integer-valued unknown arrival time of a symbol, v is the frequency offset normalized by the sub-carrier spacing, w(n) is the sample of zero-mean complex Gaussian noise process with variance $\sigma_w^2$, and

$$y(n) = \sum_{m=0}^{L-1} h(m)x_{n-m} \quad (3)$$

where h(m) is the channel impulse response, whose memory is denoted by L.

In OFDM systems, the task of synchronization is to estimate and compensate the timing and frequency offsets.

## III. The Available Constant Envelop Preamble Based Synchronization Method

The constant envelop preamble generated from DFT of a CAZAC sequence [10], [11] in [9] can be described as

$$X_{\text{preamble}} = [x_0, x_1, \ldots, x_{N-1}] \quad (4)$$

where $x_i$ with i = 0 to N − 1 is the sample of the preamble in time domain. The samples in the preamble satisfy

$$x_i = x_{i+N/2}, \qquad i = 0, \ldots, \frac{N}{2} - 1 \quad (5)$$

and

$$\|x_k\| = C, \qquad k = 0, \ldots, N-1 \tag{6}$$

where C is a constant number.

The constant envelop preamble contains the two identical halves and has the same structure as that in [4]. In fact, the synchronization algorithms in [4], [9] are essentially based on finding the highest correlation between two repeated sample sequences. Therefore, the metric used to estimate the timing offset in [9] can be defined as

$$M(d) = \frac{|P(d)|^2}{(R(d))^2} \tag{7}$$

where

$$P(d) = \sum_{k=0}^{N/2-1} r^*(d+k) r\left(d+k+\frac{N}{2}\right) \tag{8}$$

$$R(d) = \frac{1}{2}\sum_{k=0}^{N-1} |r(d+k)|^2. \tag{9}$$

The timing offset can be estimated from

$$\hat{\varepsilon} = \arg\max_{d}(M(d)). \tag{10}$$

Using (10), the correct starting point of OFDM symbol $\varepsilon_{\text{opt}}$ can be estimated. At the correct starting point, the metric $P(\varepsilon_{\text{opt}})$ is used to estimate the frequency offset, which is given by

$$\hat{v} = \frac{1}{\pi}\text{angle}(P(\varepsilon_{\text{opt}})). \tag{11}$$

In the timing offset estimation, it can be seen from (7) that the difference between M(d) and M(d + 1) in (7) is too small for they have all the same sum of the product terms

$$r^*(d+1) r\left(d+1+\frac{N}{2}\right) + r^*(d+2) r\left(d+2+\frac{N}{2}\right) + \cdots + r^*\left(d+\frac{N}{2}-1\right) r(d+N-1)$$

with the exception of only two product terms $r^*(d)r(d+N/2)$ and $r^*(d+N/2)r(d+N)$, and the timing metric has a plateau due to the cyclic prefix of the preamble, which causes a large variance in the estimation. In the frequency offset estimation, the estimate range defined by (11) is too small, and the large frequency offset deteriorates the performance of the OFDM systems greatly.

In the development of the synchronization methods, based on the method in [4], Minn and Park modified the structure of the preamble by transmitting different data on different sub-carriers to improve the performance of the timing synchronization [5], [6], and Morelli and Song proposed the modified preamble to estimate the frequency offset with a wide estimating range in [7], [8] respectively, but all the ideas in the modified preambles cannot be used to modify the constant envelop preamble since the data of the preamble on the sub-carriers cannot be selected as those for modified preambles. It is also noted that the constant envelop property of the preamble is not utilized in synchronization.

To make full use of the advantages of the constant envelop preamble in the transmission, we introduce a PN sequence weighted factor into the preamble to improve the performance of the synchronization method.

## IV. Proposed Synchronization Method

### A. New Preamble

To enlarge the difference between M(d) and M(d + 1) of the preamble given by (7), the pseudo-noise (PN) sequence weighted factors are introduced, and the new preamble can be defined as

$$x'_k = s_k x_k, \qquad k = 0, 1, \ldots, N-1 \tag{12}$$

where $s_k$ is the PN sequence weighted factor of the kth sample of the original preamble. The value of the PN sequence is +1 or −1.

### B. Timing Offset Estimation

At the correct starting point of the proposed preamble, the weighted factors can be removed by multiplying the preamble by the corresponding PN sequence. The two identical parts in the processed preamble are fully correlated. So, the new timing metric can be defined as

$$M(d) = \frac{|P(d)|^2}{(R(d))^2} \tag{13}$$

where

$$P(d) = \sum_{k=0}^{N/2-1} s_k s_{k+N/2} r * (d+k) r\left(d+k+\frac{N}{2}\right) \tag{14}$$

$$R(d) = \frac{1}{2}\sum_{k=0}^{N-1} |r(d+k)|^2. \tag{15}$$

It is obvious from (14) that the correlation property of the PN sequence weighted factors ensures that the proposed timing metric M(d) has its peak value at the correct symbol starting point, while the values at all other points are comparatively smaller, which leads to a much smaller error of timing offset estimation. The new timing metric like that in [4]–[6] is robust to the frequency offset.

### C. Frequency Offset Estimation

After the timing synchronization, the starting point of the received preamble can be determined. Similar to frequency offset estimation in [4], [9], the metric P(d) at the correct starting point $\varepsilon_{\text{opt}}$ can also be used to estimate the frequency offset

$$\hat{v}_1 = \frac{1}{\pi}\text{angle}(P(\varepsilon_{\text{opt}})). \tag{16}$$

The range of the frequency estimate given by (16) is ±1 due to the period of phase function angle(·). When the absolute frequency offset v is greater than 1, the relation between v and $\hat{v}_1$ can be represented as

$$v \approx 2q + \hat{v}_1 \tag{17}$$

where q is the number of the ambiguity period. In the frequency synchronization, it is necessary to estimate q when the absolute frequency offset is greater than one.

In order to estimate q in a simple way, the received preamble is first compensated by $\hat{v}_1$, which can be represented as

$$\begin{aligned} r_1(k) &= r(k)e^{-j(2\pi\hat{v}_1 k/N)} \\ &= y_k e^{j(2\pi(v-\hat{v}_1)k/N)} + w(k)e^{-j(2\pi\hat{v}_1 k/N)} \\ &= y_k e^{j(2\pi 2qk/N)} + w_1(k) \\ &= h_0 s_k x_k e^{j(4\pi qk/N)} \\ &\quad + \sum_{m=1}^{L-1} h_m s_k x_{k-m} e^{j(4\pi qk/N)} + w_1(k) \end{aligned} \quad (18)$$

where $w_1(k) = w(k)e^{-j(2\pi\hat{v}_1 k/N)}$. Then, multiply the samples of the compensated received preamble in (18) with the samples of the transmitted constant envelop preamble given by (12), which can be described as

$$\begin{aligned} r_2(k) &= r_1(k)x_k'^* \\ &= h_0|x_k|^2 e^{j(4\pi qk/N)} \\ &\quad + \sum_{m=1}^{L-1} h_m s_k s_{k-m} x_{k-m} x^*_k e^{j(4\pi qk/N)} + s_k x_k^* w_1(k) \\ &= h_0 C e^{j(4\pi qk/N)} + w_2(k) \end{aligned} \quad (19)$$

where

$$w_2(k) = \sum_{m=1}^{L-1} h_m s_k s_{k-m} x_{k-m} x^*_k e^{j(4\pi qk/N)} + s_k x_k^* w_1(k). \quad (20)$$

It is easy to find from (19) that the frequency offset estimation turns to be the frequency estimation of a complex tone. There are many algorithms [12] for the frequency estimation, and most of them are based on the periodogram. So, the simple standard periodogram algorithm with high performance in [12] is applied. Therefore, the estimate of q can be defined as

$$\hat{q} = \arg\max_q (I(q)) \quad (21)$$

where

$$I(q) = \left|\sum_{i=0}^{N-1} r_2(k)e^{-j4\pi qk/N}\right|^2, \qquad q = -\frac{N}{4}, \ldots, 0, 1, \ldots, \frac{N}{4}. \quad (22)$$

Therefore, the total frequency offset can be represented as

$$\hat{v} = 2\hat{q} + \hat{v}_1. \quad (23)$$

From (23), it can be found that the range of the new frequency offset method is ±N/2.

In the AWGN channel, the Cramer-Rao lower bound (CRLB) for $\hat{v}_1$ [4] is

$$\text{var}(\hat{v}_1) \geq \frac{2}{\pi^2 N \cdot SNR} \quad (24)$$

where the SNR is the ratio of the signal to noise power, and the Cramer-Rao lower bound (CRLB) for $\hat{q}$ [12] is

$$\text{var}(\hat{q}) \geq \frac{3}{4\pi^2 N(N^2-1)\cdot SNR}. \quad (25)$$

Since the error generated by $\hat{v}_1$ and the error by $\hat{q}$ are independent, the errors in two estimators may be assumed to be independent, and the Cramer-Rao lower bound (CRLB) for $\hat{v}$ can be represented as

$$\text{var}(\hat{v}) \geq \frac{12}{4\pi^2 N(N^2-1)\cdot SNR} + \frac{2}{\pi^2 N \cdot SNR}. \quad (26)$$

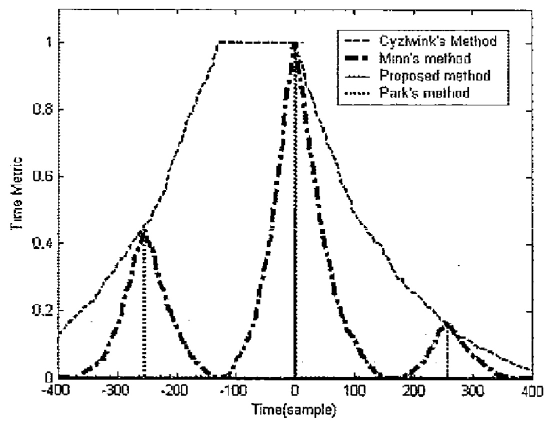


Fig. 1. The timing metric of estimators.

## V. Performance Evaluation, Simulation Results, and Discussion

### A. Simulation Parameters

The performance of the proposed synchronization method is investigated by computer simulation. The OFDM system parameters used are 1024 subcarriers, 1024 point IFFT/FFT, and 12.5% guard interval (128 samples). Unless stated otherwise, 10 000 simulation runs will be applied.

The channels considered are described in the following. All channels have 16 taps with an equal tap spacing of 8 samples. The Rayleigh fading channel has an exponential power delay profile and the ratio of the first fading tap to the last fading tap is set to be 24 dB. The channel coefficient is time-invariant since the coherence time is much longer than the burst duration.

### B. Timing Synchronization Performance

In order to make a convenient comparison with the proposed method, the timing synchronization methods with constant envelop and nonconstant envelop preambles in [5], [6] are also simulated. Fig. 1 shows the timing metrics of Cyzlwink's method [9], Minn's method [5], Park's method [6] and the proposed method under the circumstances of no noise and no channel distortion. The correct timing point is indexed as 0 in the Fig. 1 and taken as the starting position of the useful part of the OFDM symbol.

As seen in Fig. 1, the timing metric of the proposed method and that of Park's method have an impulse-like shape, and the impulses of the two methods overlap at the correct timing point. Compared with the values of the timing metric of Park's

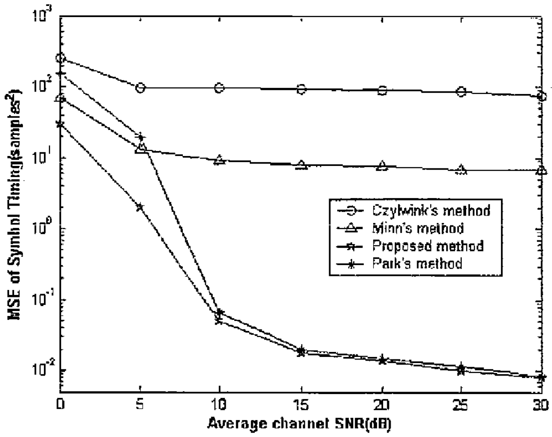


Fig. 2. MSE of timing offset versus SNR for four methods.

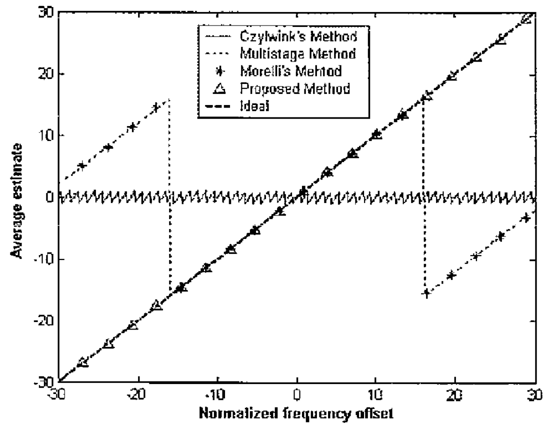


Fig. 3. Average frequency estimate versus normalized frequency offset.

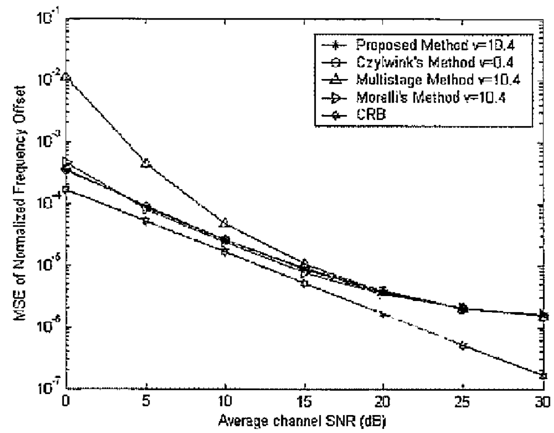


Fig. 4. MSE of frequency offset estimation versus SNR.

method, those of the proposed method at the other positions are much smaller, which makes the proposed method offer a more accurate timing offset estimation.

The mean square error (MSE) reflects both the bias and the variance of the estimation. Therefore, the performance of the proposed estimator is evaluated by the mean square error (MSE), and compared with Minn's method, Park's method and Cyzlwink's method. Fig. 2 shows the MSEs of the four methods in the Rayleigh channel. We can see that the proposed method has a much smaller MSE than Minn's method and Cyzlwink's method. Compared with Park's method, when the SNR is less than 15 dB, it can be seen that the MSE of the proposed method is smaller than that of Park's method, but that they are almost the same when the SNR is greater than 15 dB.

### C. Frequency Synchronization Performance

Based on the timing synchronization, the starting point of the preamble can be determined. The performance of the frequency offset estimation in Cyzlwink's method is the same as that in Minn's method and Park's method, and therefore, in simulation, only the frequency synchronization method in Cyzlwink's method is simulated. In order to make a convenient comparison with the proposed method, the multistage method in [8] and Morelli's method in [7] are also simulated.

In the multistage method and Morelli's method, the number of the identical parts in the preambles is limited due to the average operations. In order to enlarge the estimation range of the multistage method and Morelli's method further, the preambles consisting of 32 identical parts are considered. Fig. 3 illustrates the average estimate as a function of the real normalized offset for the SNR = 20 dB. The ideal curve is also shown for comparison. We can see from the curves in Fig. 3 that the available normalized frequency offset estimation range of the multistage method and Morelli's method is ±16, and that of Czylwink's method in [9] is only ±1. The average estimate of the proposed method is almost the same as that for the ideal case, and the tested estimation range of the proposed method in the simulation is ±512, which is consistent with (15). Therefore, the estimation range of the proposed method is wider than those of the methods in [7], [8] since the number of the identical parts in the preamble is much less than 1024.

The mean square errors (MSEs) of the four methods versus SNR and the Cramer-Rao lower bound (CRLB) of the proposed method are shown in Fig. 4. The normalized frequency offset is set to be $v = 0.4$ and 10.4. It is obvious that the MSE of the proposed method is almost the same as those of Czylwink's method with $v = 0.4$ and Morelli's method, but less than that of the multistage method at a low SNR. Therefore, the proposed method has a wider estimation range with no loss in accuracy. For the same estimate range, the computational complexity of the proposed method is about the same order as that of Morelli's method.

## VI. Conclusions

In order to improve the synchronization performance of wireless OFDM systems with the constant envelop preamble, we suggested a new constant envelop preamble weighted by the pseudo-noise sequence and the corresponding timing and frequency offset estimation method. The new synchronization algorithm exploits the correlation property of the PN sequence and the two identical parts in the preamble to estimate the timing offset, and the constant envelop property of the preamble is used to estimate the frequency offset with a wide estimate range. Simulations show that the timing accuracy and the estimate range of the frequency offset in the proposed synchronization are significantly improved. Therefore, the proposed method is suitable for improving the performance of the synchronization for the OFDM system in wireless channels with a large frequency offset.


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**3GPP TSG RAN WG1 Ad Hoc on LTE** **R1-050822**
**London, UK, 29 August - 02 September, 2005**

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|---|---|
| **Source:** | **Texas Instruments** |
| **Title:** | **On Allocation of Uplink Pilot Sub-Channels in EUTRA SC-FDMA** |
| **Agenda Item:** | **10.3** |
| **Document for:** | **Discussion** |

## 1. Introduction

### 1.1 Problem Formulation

One of the two possible TTI structures for uplink Single Carrier FDMA (SC-FDMA) as proposed by Drafting group 1 is given in Figure 1 below.

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CP0 | LB | CP | SB | CP | LB | CP | LB | CP | LB | CP | LB | CP | SB | CP | LB |

Figure 1: Uplink TTI structure for SC-FDMA.

In Figure 1, LB represents a "Long Block," which can contain only data symbols, and SB represents a "Short Block," which can contain either pilot or data symbols. Therefore, the uplink pilot is always confined inside the SB field. The time duration of the SB field is half of the time duration of the LB field. The rest of the numerology for the uplink frame structure is given in [1].

The proposed uplink TTI structure results in the frequency set where the width of pilot subcarriers is twice the width of data subcarriers. For example, in the baseline case of 5MHz bandwidth, pilot and data subcarriers are as given in Figure 2 below.

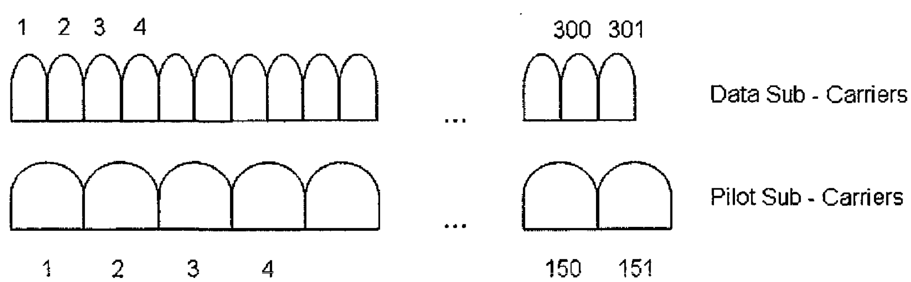


Figure 2: Frequency Set for SC-OFDM.

In the case of distributed (IFDMA) uplink transmission, each mobile is allocated a set of non-contiguous tones for data subcarriers. In this case, it is unclear as to which is the most appropriate allocation of uplink pilot resources. The following options should be considered.

### 1.2 Possible Allocations for Orthogonal Uplink Pilot

a) Time Domain Orthogonality

Time domain orthogonality is the most obvious alternative for usage of the SB field for pilot transmission. However, such a solution may result in a high peak to average ratio (PAR) for uplink transmission, which would decrease coverage due to the amplifier back-off.

b) Frequency Domain Orthogonality
Frequency domain orthogonality is another proposed solution for the uplink orthogonal pilot, which is a topic of current studies. The main difficulty faced by a frequency domain orthogonal pilot is for UE's near the cell border when the neighboring cell utilizes the same uplink pilot channel. For this reason, frequency domain orthogonality of the uplink pilot requires careful frequency planning and reuse patterns.

c) Code Domain Orthogonality
Code domain orthogonality can be achieved with a use of Constant Amplitude Zero Autocorrelation (CAZAC) sequences, as we demonstrate in the remainder of this document. Furthermore, CAZAC sequences have a flat frequency domain response, which makes them attractive for SC – OFDMA systems.

d) Code-Frequency Domain Orthogonality
Code-Frequency domain orthogonality is a hybrid alternative between b) and c), which uses a combination of CAZAC sequences and distributed FDMA transmission to achieve an uplink orthogonal pilot.

In this contribution, we focus on the Code Domain Orthogonality.

### 1.3 Background on CAZAC Sequences

An example of CAZAC sequences is given as follows. Let L be any positive integer, and let k be any number which is relatively prime with L. Then the n-th entry of the k-th Zadoff-Chu CAZAC sequence [2] is given as follows:

$$c_k(n) = \exp\left[\frac{j2\pi k}{L}\left(n + n\frac{n+1}{2}\right)\right] \qquad \text{if L is odd}$$

$$c_k(n) = \exp\left[\frac{j2\pi k}{L}\left(n + \frac{n^2}{2}\right)\right] \qquad \text{if L is even}$$

The set of Zadoff-Chu CAZAC sequences has the following properties:

- Constant magnitude
- Zero circular autocorrelation
- Flat frequency domain response
- Low, constant magnitude, cross-correlation, provided that L is a prime number.

## 2. Proposal: Allocation of Uplink Pilot Sub-Channels

In this section we demonstrate how to achieve the uplink orthogonal pilot in the code domain with the use of CAZAC sequences. The main idea is to use a single CAZAC sequence per sector and exploit the property of zero circular autocorrelation along with the cyclic prefix transmission.

### 2.1 Allocation of Pilot Sub-Channels for a Single Sector

#### 2.1.1 Option 1: Orthogonality in the Code Domain

In order to illustrate how to achieve orthogonality in the code domain, we let the CAZAC sequence be "c," and let its right cyclic shift by Q be specified as $S_Q(c)$. Since the sequence has zero cyclic autocorrelation, then $S_0(c)$, $S_Q(c)$, $S_{2Q}(c)$ … $S_{MQ}(c)$ are all orthogonal provided that MQ does not exceed the length of the sequence. Furthermore, even when $S_0(c)$ is cyclically right-shifted by less than Q samples, it remains orthogonal to the rest of $S_Q(c)$, $S_{2Q}(c)$ … $S_{MQ}(c)$. Next, we simply allocate $S_0(c)$ to be the pilot sequence for UE#0, $S_Q(c)$ to be the pilot sequence for UE#1, and proceed accordingly until we allocate $S_{MQ}(c)$ to be the pilot sequence for UE#M. Such an allocation is illustrated in the following figure.

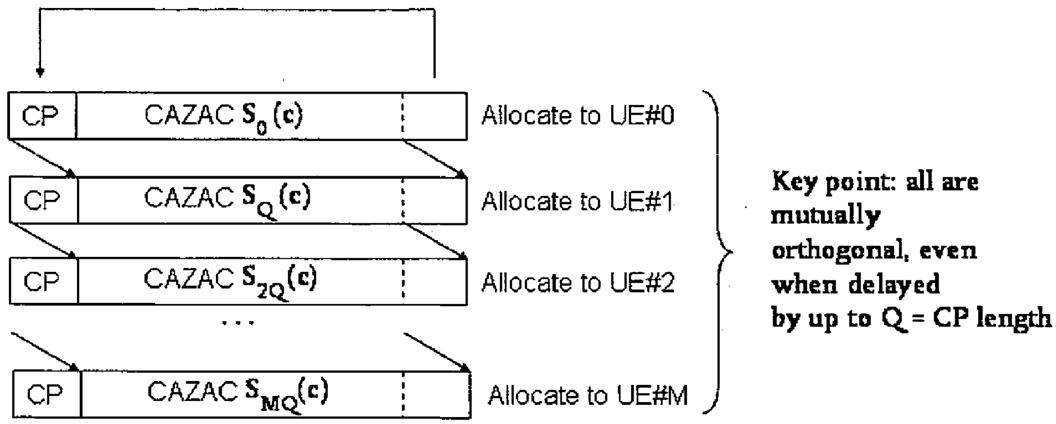


Figure 3: Proposed Allocation of Uplink Pilot Sequences.

With such an allocation, the arriving multipath signal from each UE will be orthogonal, under the assumption that Q is longer than each delay profile. For this reason an appropriate choice for Q is the prefix length of the transmission. Alternatively, a more conservative allocation would accommodate scenarios where the delay profile is longer than the prefix length. In such cases, Q should be longer than the transmission prefix.

**2.1.2 Option 2: Orthogonality in the Code-Frequency Domain**

Since distributed (IFDMA) transmission can be simply achieved by block repetition in the time domain, the extension of section 2.1.1 to orthogonality in the Code-Frequency domain is straightforward. Namely, upon the above described uplink pilot sequence allocation, one can perform block repetition to achieve distributed FDMA transmission. In this manner, multiple UE's utilize the same IFDMA uplink pilot channel through the use of cyclically shifted CAZAC sequences.

**2.2 Allocation of Pilot Sub-Channels in Softer Handover**

For UE's which are in the Softer Handover, the transmitted signal is received with significant power level in two sectors of the Node B. In order to avoid UE self-interference, we propose that both serving sectors allocate the same CAZAC sequence, with the exact same shift, to UE's which are shared in the Softer Handover. Hence, each sector of a single Node B will utilize the same CAZAC sequence.

**2.3 Allocation of Pilot Sub-Channels between different Node B's**

Neighboring Node B's should utilize different CAZAC sequences for the uplink pilot channel in order to achieve interference averaging. For this reason, the most appropriate choice for CAZAC sequences are Zadoff-Chu sequences of prime length (see Background section above), which have low constant magnitude cyclic cross-correlation. Since the number of different Zadoff-Chu sequences is close to the length of the sequence itself (hence large), there are no difficulties in constructing the reuse pattern for distant Node B's.

## 2.4 Number of CAZAC sequences

As stated earlier in the background section, Zadoff – Chu sequences have low constant magnitude cross – correlation, provided that their length is a prime number. In this section, we present the number of possible sequences, assuming the exact uplink numerology from [1], Option2.

**Table 1**: Number of CAZAC Sequences

| | 1.25MHz | 2.5MHz | 5MHz | 10MHz | 15MHz | 20MHz |
|---|---|---|---|---|---|---|
| LB Samples | 128 | 256 | 512 | 1024 | 1536 | 2048 |
| Used Subcarriers in LB | 76 | 151 | 301 | 601 | 901 | 1201 |
| SB Samples | 64 | 128 | 256 | 512 | 768 | 1024 |
| Used Subcarriers in SB | 37 | 73 | 151 | 293 | 449 | 601 |
| CP Samples | 7 | 15 | 31 | 63 | 95 | 127 |
| # of distinct CAZACs not including shifts | 36 | 72 | 150 | 292 | 448 | 600 |
| # of distinct CAZACs including 8 shifts | 288 | 576 | 1200 | 2336 | 3584 | 4800 |
| | | | | | | |

Table 1 is derived as follows. Rows 2 and 4 are from the uplink proposal in [1], Option2. Row 3 hasn't been agreed upon yet (for the uplink), which is why we assumed the downlink numerology from [1]. Row 5 is proposed to be the prime number which is closest to half of the Row 3. Row 6 is directly from [1]. Row 7 is derived based of properties (see background section) of Zadoff – Chu sequences. Finally, Row 8 is 8 * Row 7, since the SB (Row 4) accepts 8 distinct circular shifts by the cyclic prefix (Row 6).

## 2.5 Simulation Results

**Table 2**: Simulation Assumptions

| Parameter | | Assumption |
|---|---|---|
| Bandwidth | | 5 MHz (2.6 GHz) |
| Channel Model | | TU |
| Data Channel Turbo Coding | | Rate ½ |
| Data Modulation | | 16QAM |
| Uplink Numerology | | Option 2 in [1] (Table 9.1.1.2) |
| Pilot Sequence/Modulation | | QPSK Random Sequence vs. Constant Amplitude Zero Autocorrelation (CAZAC) |
| Pilot Average Power Boost | | 2.5 dB (Peak Pilot Power = Peak Data Power) |
| Data Channel | | IFDMA which occupies each 4th tone. Number of Subcarriers = 64 |
| Pilot Channel | | Occupies the entire transmission band with 2 short blocks per TTI |
| Antenna Configuration | | 1 at Transmitter, 2 at Receiver |
| Channel Estimation | Time Interpolation | Doppler dependent filter coefficients<br>MF – Wiener Matched Filter<br>ZF – Wiener Zero Forcing Filter |
| | Frequency Interpolation | Least Squares |
| | Interpolation Method | Past, Current and Future TTI |
| | | |

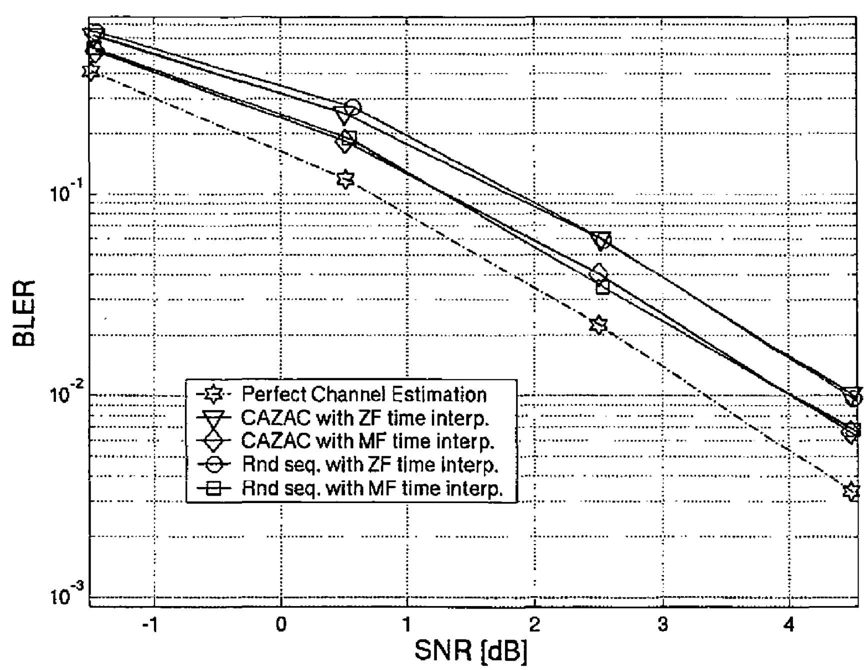


Figure 4: Block Error Rates (BLER) for Random QPSK Pilot, and CAZAC Pilot, at UE Speed = 3kmph.

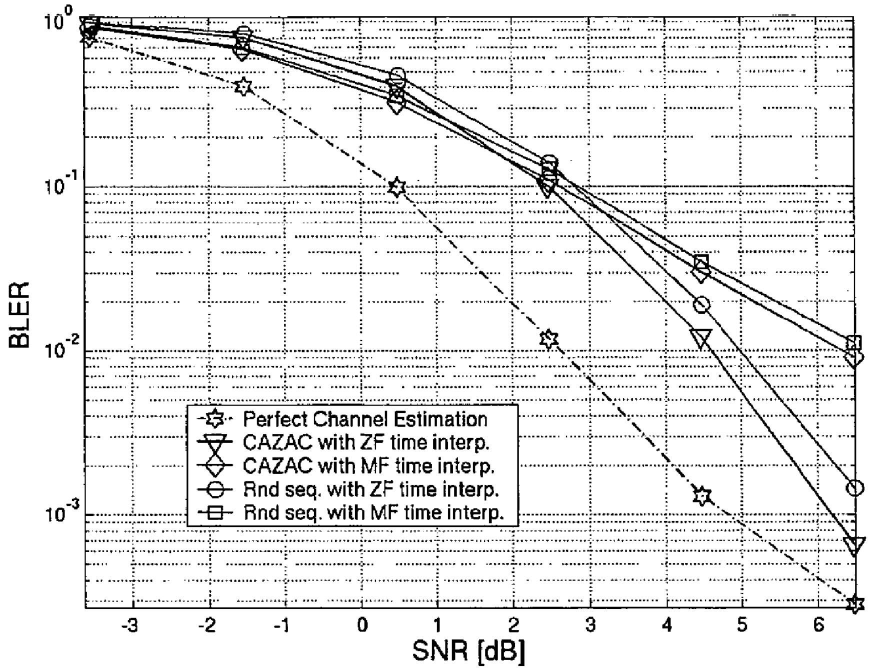


Figure 5: Block Error Rates for Random QPSK Pilot, and CAZAC Pilot, at UE Velocity = 150kmph

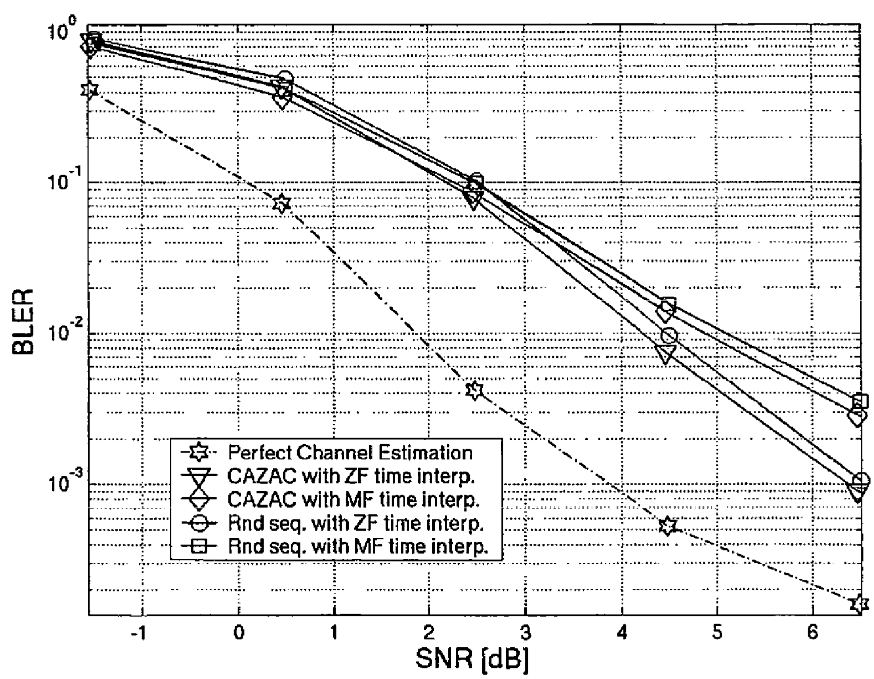


Figure6: Block Error Rates for Random QPSK Pilot, and CAZAC Pilot, at UE Velocity = 360kmph.

As we see from the above simulation results (for single UE), the choice of a CAZAC sequence offers superior channel estimation results at higher UE velocities. Specifically, the CAZAC pilot sequence offers up to 0.4dB gain when compared to the Random pilot sequence at 150kmph and 0.3dB at 360kmph. At 3kmph, the performance of CAZAC and Random pilot sequences are close. Furthermore, multiple UEs which utilize cyclic shifts of a single CAZAC sequence do not mutually interfere, which is not the case with Random sequences. Further simulations will be provided in future meetings.

## 3. Conclusion

The set of Zadoff-Chu CAZAC uplink pilot sequences presents an attractive solution for the uplink pilot design in LTE. In this document we presented a method for reuse of a single CAZAC sequence with cyclic shifts in order to achieve orthogonality in the uplink pilot channel. Furthermore, interference management between different cells is fairly simple because it reduces to assigning different CAZAC sequences to neighboring cells.

## 4. References


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Espacenet

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**APPARATUS AND METHOD FOR TRANSMITTING A BURST PILOT CHANNEL IN A MOBILE COMMUNICATION SYSTEM**

| | | |
|---|---|---|
| **Inventor(s):** | | |
| **Applicant(s):** | | |
| **Classification:** | **- international:** | ***H04B1/707; H04B1/76; H04B7/26; H04J13/00; H04W84/08;*** (IPC1-7): H04J13/00 |
| | **- European:** | H04B1/707; H04B1/76 |
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| **Priority number (s):** | KR20000061835 20001020; WO2001KR01781 20011020 | |
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**Abstract not available for JP2004512728 (A)**
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Disclosed are a method and apparatus for transmitting a time-discontinuous burst pilot channel being dependent on transmission data in a mobile communication system. In the apparatus, a modulator generates a modulated pilot symbol by outputting an input pilot symbol at a designated at least one of phase and on a designated complex channel according to an information bit for determining at least one of the phase and/or the complex channel, and a spreader spreads the modulated pilot symbol from the modulator with an orthogonal code selected among a plurality of orthogonal codes. The burst pilot channel transmits side information being dependent on the transmission data according to the phase, and/or the complex channel and the orthogonal code.

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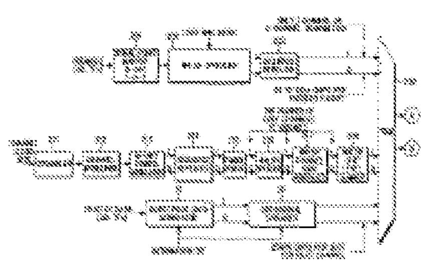
最終頁に続く

(54)【発明の名称】移動通信システムでのバーストパイロットチャネル送信装置及び方法

(57)【要約】
本発明は、移動通信システムで伝送されるデータに依存する時間的に不連続的なバーストパイロットチャネルを送信するための装置であって、少なくとも一つの位相及び複素チャネルを決定する情報ビットに応答して入力パイロットチャネルデータを少なくとも一つの決定された位相及び複素チャネル上に出力することによりパイロット変調シンボルを発生する変調器１０と、前記変調器から前記パイロット変調シンボルを入力し、複数の直交符号中、選択された直交符号に前記パイロット変調シンボルを拡散する拡散器２０とを備えて、前記バーストパイロットチャネルは前記少なくとも一つの位相、複素チャネル及び直交符号によって前記伝送されるデータに依存する付加情報を伝送することを特徴とする。



【特許請求の範囲】

【請求項１】

移動通信システムで伝送されるデータに依存する時間的に不連続的なバーストパイロットチャネルを送信するための装置において、

少なくとも一つの位相及び複素チャネルを決定する情報ビットに応答して入力パイロットチャネルデータを少なくとも一つの決定された位相で及び複素チャネル上に出力することによりパイロット変調シンボルを発生する変調器と、

前記変調器から前記パイロット変調シンボルを入力し、複数の直交符号中、選択された直交符号に前記パイロット変調シンボルを拡散する拡散器と

を備えて、

前記バーストパイロットチャネルは前記少なくとも一つの位相、複素チャネル及び直交符号によって前記伝送されるデータに依存する付加情報を伝送することを特徴とする装置。

【請求項２】

前記パイロット変調シンボルは、１２８チップの長さを有することを特徴とする請求項１に記載の装置。

【請求項３】

前記パイロット変調シンボルは、６４チップの長さを有することを特徴とする請求項１に記載の装置。

【請求項４】

前記複素チャネルは、ＩチャネルおよびＱチャネルに構成されることを特徴とする請求項１に記載の装置。

【請求項５】

移動通信システムでバーストパイロットチャネルを通じて付加情報を伝送するための装置において、

位相を決定する情報ビットに応答して入力パイロットチャネルデータを決定された位相で出力することによりパイロット変調シンボルを発生する変調器と、

前記変調器からのパイロット変調シンボルを予め設定された直交符号に拡散する拡散器と

を含むことを特徴とする装置。

【請求項６】

移動通信システムでバーストパイロットチャネルを通じて付加情報を伝送するための装置において、

複素チャネルを決定する情報ビットに応答して入力パイロットチャネルデータを決定された複素チャネル上に出力することによりパイロット変調シンボルを発生する変調器と、

前記変調器からのパイロット変調シンボルを予め設定された直交符号に拡散する拡散器と

を含むことを特徴とする装置。

【請求項７】

移動通信システムでバーストパイロットチャネルを通じて付加情報を伝送するための装置において、

バーストパイロットシンボルを発生する変調器と、

前記バーストパイロットシンボルを複数の直交符号中、情報ビットにより選択された直交符号に拡散する拡散器と

からなることを特徴とする装置。

【請求項８】

移動通信システムでバーストパイロットチャネルを通じて付加情報を伝送するための装置において、

位相を決定する情報ビットに応答して入力パイロットチャネルデータを決定された位相で出力することによりパイロット変調シンボルを発生する変調器と、

前記パイロット変調シンボルを複数の直交符号中、情報ビットにより選択された直交符号に拡散する拡散器と

からなることを特徴とする装置。

【請求項９】
移動通信システムでバーストパイロットチャネルを通じて付加情報を伝送するための装置において、
複素チャネルを決定する情報ビットに応答して入力パイロットチャネルデータを決定された複素チャネル上に出力することによりパイロット変調シンボルを発生する変調器と、
前記パイロット変調シンボルを複数の直交符号中、情報ビットにより選択された直交符号に拡散する拡散器と
からなることを特徴とする装置。
【請求項１０】
移動通信システムで伝送されるデータに依存する時間的に不連続的なバーストパイロットチャネルを送信するための方法において、
少なくとも一つの位相及び複素チャネルを決定する情報ビットに応答して入力パイロットシンボルを少なくとも一つの決定された位相で及び複素チャネル上に出力することによりパイロット変調シンボルを発生する過程と、
前記パイロット変調シンボルを複数の直交符号中、選択された直交符号に拡散する過程と
を備えて、
前記バーストパイロットチャネルは前記位相及び／または複素チャネル及び直交符号によって前記伝送されるデータに依存する付加情報を伝送することを特徴とする方法。
【請求項１１】
前記パイロット変調シンボルは、１２８チップの長さを有することを特徴とする請求項１０に記載の方法。
【請求項１２】
前記パイロット変調シンボルは、６４チップの長さを有することを特徴とする請求項１０に記載の方法。
【請求項１３】
前記複素チャネルは、Ｉチャネル及びＱチャネルに構成されることを特徴とする請求項１０に記載の前記方法。
【請求項１４】
移動通信システムでバーストパイロットチャネルを通じて付加情報を伝送するための方法において、
位相を決定する情報ビットに応答して入力パイロットシンボルを決定された位相で出力することによりパイロット変調シンボルを発生する過程と、
前記発生されたパイロット変調シンボルを予め設定された直交符号に拡散する過程と
を含むことを特徴とする方法。
【請求項１５】
移動通信システムでバーストパイロットチャネルを通じて付加情報を伝送するための方法において、
複素チャネルを決定する情報ビットに応答して入力パイロットシンボルを決定された複素チャネル上に出力することによりパイロット変調シンボルを発生する過程と、
前記発生されたパイロット変調シンボルを予め設定された直交符号に拡散する過程と
を含むことを特徴とする方法。
【請求項１６】
移動通信システムでバーストパイロットチャネルを通じて付加情報を伝送するための方法において、
パイロットシンボルを発生する過程と、
前記発生されたパイロットシンボルを複数の直交符号中、情報ビットにより選択された直交符号に拡散する過程と
からなることを特徴とする方法。
【請求項１７】
移動通信システムでバーストパイロットチャネルを通じて付加情報を伝送するための方法

において、
位相を決定する情報ビットに応答して入力パイロットシンボルを決定された位相で出力することによりパイロット変調シンボルを発生する過程と、
前記発生されたパイロット変調シンボルを複数の直交符号中、情報ビット入力信号により選択された直交符号に拡散する過程と
からなることを特徴とする方法。
【請求項１８】
移動通信システムでバーストパイロットチャネルを通じて付加情報を伝送するための方法において、
複数チャネルを決定する情報ビットに応答して入力パイロットシンボルを決定された複数チャネル上に出力することによりパイロット変調シンボルを発生する過程と、
前記発生されたパイロット変調シンボルを複数の直交符号中、情報ビットにより選択された直交符号に拡散する過程と
からなることを特徴とする方法。
【発明の詳細な説明】
【０００１】
【発明の属する技術分野】
本発明は移動通信システムに関するもので、特にパイロットチャネル（Ｐｉｌｏｔ ｃｈａｎｎｅｌ）を通じて情報を伝送するための装置及び方法に関する。
【０００２】
【従来の技術】
最近、高速データ伝送が要求されつつ、音声サービスだけではなく、高速パケットデータサービスを支援するための移動通信システムが提案されている。前記高速パケットデータ伝送を支援する移動通信システムは、送信端でパケットデータをＱＡＭ（Ｑｕａｄｒａｔｕｒｅ Ａｍｐｌｉｔｕｄｅ Ｍｏｄｕｌａｔｉｏｎ）変調して送信し、時間的に連続的な共通パイロット（ｃｏｍｍｏｎ Ｐｉｌｏｔ）チャネルと時間的に不連続的なバーストパイロット（ｂｕｒｓｔ Ｐｉｌｏｔ）チャネルなどを送信する。
【０００３】
一般的に、ＱＰＳＫ（Ｑｕａｄｒａｔｕｒｅ Ｐｈａｓｅ Ｓｈｉｆｔ Ｋｅｙｉｎｇ）のような位相変調方式は、変調シンボルの位相成分に情報が含まれている。従って、受信側では共通パイロットチャネルを位相基準信号に利用して変調シンボルを復調している。しかし、ＱＡＭ変調方式は変調シンボルの振幅及び位相成分に情報が含まれている。例えば、前記高速データ伝送を支援するシステムでパケットデータ伝送のため、１６－ＱＡＭ、または６４－ＱＡＭなどの変調方式を使用する場合、受信端で変調シンボルに含まれている情報量を正確に復調するためには、復調シンボルの振幅基準（Ａｍｐｌｉｔｕｄｅ ｒｅｆｅｒｅｎｃｅ）が必要である。そのため、変調シンボルの位相基準及び振幅基準になる信号をすべて伝送すべきである。即ち、送信端で一定の電力量にデータを伝送するＱＡＭ変調方式を使用する場合、共通パイロットチャネルを位相及び振幅基準に共に使用することができるが、伝送される電力量が特定周期ごとに変化する場合、伝送ＱＡＭ変調シンボルの振幅基準を提供する基準信号が必要である。前記ＱＡＭ変調シンボルの振幅基準を提供するために、前記バーストパイロットチャネルを使用する。即ち、前記バーストパイロットチャネルはＱＡＭ変調シンボルの振幅のみを提供するために使用される。一般的に、移動通信システムは制限された無線資源を効果的に使用するのが一番重要である。従って、複合的な機能を遂行する多くのチャネルが提案されている。前記バーストパイロットチャネルは変調シンボルの振幅基準を提供するために使用されているが、付加的に他の情報を提供することができると、すでに割り当てられているチャネルを使用するとの点で制限された資源を効果的に使用することができる方案になるだろう。
【０００４】
【発明が解決しようとする課題】
従って、本発明の目的は、変調シンボルの振幅基準を提供するバーストパイロットチャネ

ルを利用して付加情報を伝送するための装置及び方法を提供することにある。

【０００５】

本発明の他の目的は、変調シンボルの振幅基準を提供するバーストパイロット変調シンボルの位相成分を利用して付加情報を伝送するための装置及び方法を提供することにある。

【０００６】

本発明のさらに他の目的は、変調シンボルの振幅基準を提供するバーストパイロット変調シンボルの出力複素チャネルを利用して付加情報を伝送するための装置及び方法を提供することにある。

【０００７】

本発明のさらに他の目的は、変調シンボルの振幅基準を提供するバーストパイロット変調シンボルの拡散符号を利用して付加情報を伝送するための装置及び方法を提供することにある。

【０００８】

【課題を解決するための手段】

前記目的を達成するための本発明は、移動通信システムで伝送されるデータに依存する時間的に不連続的なバーストパイロットチャネルを送信するための装置を提供する。前記装置は、位相及び／または複素チャネルを決定する情報ビット入力信号に応答して入力パイロットシンボルを決定された位相で及び／または複素チャネル上に生成することによりパイロット変調シンボルを発生する変調器と、前記変調器からの前記パイロット変調シンボルを入力し、複数の直交符号中、選択された直交符号に前記パイロット変調シンボルを拡散する拡散器とを備えて、前記バーストパイロットチャネルは前記位相及び／またはチャネル及び直交符号によって前記伝送されるデータに依存する付加情報を伝送することを特徴とする。

【０００９】

【発明の実施の形態】

以下、本発明の望ましい実施形態について添付図を参照しつつ詳細に説明する。下記の発明において、本発明の要旨のみを明瞭にする目的で、関連した公知機能又は構成に関する具体的な説明は省略する。

【００１０】

以下、説明される本発明はＱＡＭ変調方式を利用してデータを伝送する時、ＱＡＭ変調シンボルを復調するために必要とする変調シンボルの振幅基準（Ａｍｐｌｉｔｕｄｅ ｒｅｆｅｒｅｎｃｅ）を提供するバーストパイロットチャネルを通じて付加情報を伝送するためのものである。前記付加情報はパケットデータ伝送に必要な情報として、例えば次のように使用される。

【００１１】

一番目、相異なる多数個のパケットデータを一つのパケットデータ使用者に連続されたスロット（Ｓｌｏｔ）を通じて伝送しようとする時、前記パケットデータ使用者は相異なるパケットデータであることを区別することができる情報を必要とする。この時、これを区分することができる情報として前記付加情報を使用することができる。

【００１２】

二番目、パケットデータ使用者が受信したパケットデータを正確にデコーディング（ｄｅｃｏｄｉｎｇ）するのに失敗した場合、基地局に再伝送を要求し、基地局は前記再伝送要求に応答して同一のパケットデータを再伝送する。この時、再伝送されるデータは以前に伝送されたデータと同一であるにも拘わらず、符号率（Ｃｏｄｅ Ｒａｔｅ）と変調方式を相異なるようにして伝送されることができる。この時、初めに伝送されるデータであるか、再伝送されるデータであるかを区分するために前記付加情報を使用することができる。

【００１３】

三番目、基地局は伝送されるパケットのデータ率をパケットデータ使用者に知らせるべきであるが、前記付加情報を利用してこれを知らせることもできる。

【００１４】
四番目、前記付加情報は多数のパケットデータ使用者が基地局にパケットデータを伝送する逆方向リンクのデータ率を制御する共通制御情報に使用されることができる。また前記付加情報は特定グループ、または使用者のデータ率を制御するためにも使用されることができる。さらに、上述の場合以外に対しても付加情報ビットを利用して特定情報を伝送することができる。

【００１５】
図１は本発明の実施形態によるパケットデータサービスのための順方向リンク送信装置の構成を示している。

【００１６】
特に、前記図１の送信装置は本発明によってバーストパイロットデータ変調部（Ｂｕｒｓｔ Ｐｉｌｏｔ Ｄａｔａ Ｍｏｄｕｌａｔｉｏｎ）１０と直交拡散部（ｏｒｔｈｏｇｏｎａｌ ｓｐｒｅａｄｅｒ）２０を含む。０シンボルが受信されると、前記バーストパイロットデータ変調部１０は伝送しようとする情報ビットによってＩチャネル、またはＱチャネルに前記受信されたシンボルを位置させるか、または０、または１のシンボルに変換させる。変換されたシンボルは前記直交拡散部２０で予め設定されたバーストパイロットチャネルの直交符号（例：ウォルシュ（Ｗａｌｓｈ）符号）に拡散されチップ単位に出力される。一方、前記変調部１０ではなく前記直交拡散部２０を利用して付加情報を伝送する場合、前記直交拡散部２０で伝送する情報ビットによって予め設定された直交符号と前記付加情報を乗せて伝送することもできる。

【００１７】
前記図１を参照すると、すべて‘０’の値に構成されるプリアンブルシンボルは、信号点写像器（Ｓｉｇｎａｌ Ｐｏｉｎｔ ｍａｐｐｅｒ）２０１に入力され‘＋１’にマッピング（ｍａｐｐｉｎｇ）される。前記信号点写像器２０１の出力シンボルは、ウォルシュ拡散器（ｗａｌｓｈ ｓｐｒｅａｄｅｒ）２０２に入力され、使用者固有のＭＡＣ識別子（ＩＤ：Ｉｄｅｎｔｉｆｉｃａｔｉｏｎ）（またはインデックス）に該当される特定な６４－ａｒｙ双直交（ｂｉｏｒｔｈｏｇｏｎａｌ）ウォルシュ符号（またはシーケンス）により拡散される。前記ウォルシュ拡散器２０２はＩチャネルのシーケンス及びＱチャネルのシーケンスを出力する。前記ウォルシュ拡散器２０２の出力シーケンスは、シーケンス反復器（ｓｅｑｕｅｎｃｅ ｒｅｐｅａｔｅｒ）２０３に入力され伝送率（ｔｒａｎｓｍｉｓｓｉｏｎ ｒａｔｅ）によってシーケンス反復されるようになる。前記ウォルシュ拡散器２０２の出力シーケンスは、前記シーケンス反復器２０３により伝送率に応じて最大１６回まで反復されることができる。従って、データトラヒックチャネル（ＤＴＣＨ：Ｄａｔａ Ｔｒａｆｆｉｃ ＣＨａｎｎｅｌ）の１スロット内に含まれるバーストパイロットチャネルは、伝送率に応じて６４チップ（ｃｈｉｐ）から最大１，０２４チップまで持続されることができる。前記シーケンス反復器２０３の出力（Ｉ、Ｑ）シーケンスは、時分割マルチプレクサ（Ｔｉｍｅ Ｄｉｖｉｓｉｏｎ Ｍｕｌｔｉｐｌｅｘｅｒ）２３０に入力され、前記データトラヒックチャネル及び前記バーストパイロットチャネルとマルチプレクシングされる。

【００１８】
チャネルコーディングされたビットシーケンスはスクランブラ（Ｓｃｒａｍｂｌｅｒ）２１１に入力されスクランブリング（Ｓｃｒａｍｂｌｉｎｇ）される。前記スクランブラ２１１の出力シーケンスはチャネルインタリーバ（ｃｈａｎｎｅｌ ｉｎｔｅｒｌｅａｖｅｒ）２１２に入力されインタリービング（ｉｎｔｅｒｌｅａｖｉｎｇ）される。この時、物理階層パケットの大きさによって前記チャネルインタリーバ２１２の大きさが決定される。前記チャネルインタリーバ２１２の出力シーケンスはＭ－ａｒｙシンボル変調器（ｓｙｍｂｏｌ ｍｏｄｕｌａｔｏｒ）２１３に入力されＭ－ａｒｙシンボルにマッピングされる。前記Ｍ－ａｒｙシンボル変調器２１３は伝送率に応じてＱＰＳＫ（Ｑｕａｄｒａｔｕｒｅ Ｐｈａｓｅ Ｓｈｉｆｔ Ｋｅｙｉｎｇ）、８－ＰＳＫ（８－ａｒｙ Ｐｈａｓｅ Ｓｈｉｆｔ Ｋｅｙｉｎｇ）、または１６－ＱＡＭ（Ｑｕａｄｒａｔｕｒｅ Ａｍｐｌｉｔ

ｕｄｅ　Ｍｏｄｕｌａｔｉｏｎ）変調器として動作し、可変の伝送率を有する物理階層パケット単位に変調方法も変わることができる。前記Ｍ－ａｒｙシンボル変調器２１３から出力されるＭ－ａｒｙシンボルのＩ、Ｑシーケンスは、シーケンス反復／シンボル穿孔器（ｓｅｑｕｅｎｃｅ　ｒｅｐｅａｔｅｒ／ｓｙｍｂｏｌ　ｐｕｎｃｔｕｒｅｒ）２１４に入力され、伝送率によってシーケンス反復／シンボル穿孔される。前記シーケンス反復／シンボル穿孔器２１４から出力されるＭ－ａｒｙシンボルのＩ、Ｑシーケンスは、シンボルデマルチプレクサ（ｓｙｍｂｏｌ　ｄｅｍｕｌｔｉｐｌｅｘｅｒ）２１５に入力される。前記シンボルデマルチプレクサ２１５に入力されたＭ－ａｒｙシンボルのＩ、Ｑシーケンスは、データトラヒックサブチャネル（ＤＴＳＣＨ：Ｄａｔａ　Ｔｒａｆｆｉｃ　Ｓｕｂ　ＣＨａｎｎｅｌ）に使用可能なＮ個のウォルシュ符号チャネルにデマルチプレクシング（ｄｅｍｕｌｔｉｐｌｅｘｉｎｇ）され出力される。前記ＤＴＳＣＨに使用されるウォルシュ符号の個数Ｎは可変的であり、これに対する情報はウォルシュ空間指示サブチャネル（ＷＳＩＳＣＨ：Ｗａｌｓｈ　Ｓｐａｃｅ　Ｉｎｄｉｃａｔｉｏｎ　Ｓｕｂ　ｃｈａｎｎｅｌ）を通じてブロードキャスティング（ｂｒｏａｄｃａｓｔｉｎｇ）され、移動局（ＭＳ）はこの情報を考慮して基地局の伝送率を決定し、これを基地局に伝送する。従って、移動局は現在受信されたＤＴＳＣＨに使用されたウォルシュ符号の割り当て状況を知ることができる。Ｎ個のウォルシュ符号チャネルにデマルチプレクシングされ出力されるシンボルデマルチプレクサ２１５の出力、Ｉ、Ｑシンボルはウォルシュ拡散器２１６に入力され、チャネル別に特定ウォルシュ符号により拡散される。前記ウォルシュ拡散器２１６から出力されるＩ、Ｑシーケンスは、ウォルシュチャネル利得制御器（Ｗａｌｓｈ　Ｃｈａｎｎｅｌ　Ｇａｉｎ　Ｃｏｎｔｒｏｌｌｅｒ）２１７に入力され利得制御される。前記ウォルシュチャネル利得制御器２１７から出力されるＩ、Ｑシーケンスは、ウォルシュチップ合算器（Ｗａｌｓｈ　Ｃｈｉｐ　Ｌｅｖｅｌ　Ｓｕｍｍｅｒ）２１８に入力されチップ単位に合算される。前記ウォルシュチップ合算器２１８から出力されるＩ、Ｑチップシーケンスは、前記時分割マルチプレクサ２３０に入力され前記バーストパイロットチャネル及びプリアンブルサブチャネル（ＰＳＣＨ：Ｐｒｅａｍｂｌｅ　Ｓｕｂ　ｃｈａｎｎｅｌ）とマルチプレクシングされる。

【００１９】

バーストパイロットデータ変調部（Ｂｕｒｓｔ　Ｐｉｌｏｔ　Ｄａｔａ　Ｍｏｄｕｌａｔｉｏｎ、以下、変調部）１０は基本的に、入力されるパイロットチャネルデータ（ａｌｌ　０’ｓ）をシグナルマッピング（０↑＋１、１↑－１）してパイロット変調シンボルを出力する。そして直交拡散部（ｏｒｔｈｏｇｏｎａｌ　ｓｐｒｅａｄｅｒ）２０は前記変調部１０から出力される信号に予め設定された直交符号を掛けて直交拡散して出力する。このような過程中に、前記変調部１０は入力情報ビットによって前記パイロット変調シンボルの符号（または位相）を決定して出力する。例えば、前記入力情報ビットが０であると、正（＋）の符号を有するパイロット変調シンボルを出力し、前記入力情報ビットが１であると、負（－）の符号を有するパイロット変調シンボルを出力する。

【００２０】

一方、他の例として、前記変調部１０は入力パイロットチャネルデータを信号マッピングし、前記マッピングされた信号を複素チャネル（Ｃｏｍｐｌｅｘ　Ｃｈａｎｎｅｌ）を構成する複数個のチャネル（Ｉチャネル及びＱチャネル）中、入力伝送情報ビットにより選択されたチャネルを通じて出力する。例えば、前記入力情報ビットが０であると、Ｉチャネルを通じて出力し、前記入力情報ビットが１であると、Ｑチャネルを通じて出力する。

【００２１】

このように、前記直交拡散部２０は前記変調器１０からのパイロット変調シンボルを予めバーストパイロットのため割り当てられた複数の直交符号中、入力情報ビットにより選択された所定の直交符号を有して拡散することによって付加情報を伝送することができる。

【００２２】

上述したように付加情報をバーストパイロットチャネルを通じて伝送する場合、前記バーストパイロットチャネルを通じて伝送される付加情報が前記バーストパイロットデータ変

調部１０と前記直交拡散部２０で、どのように表現されるかを送信端と受信端が互いに予め約束すべきである。前記バーストパイロット変調部１０での伝送情報ビット（０または１）によるシンボル表現方法及び情報ビット割り当て方法は下記＜表１＞のようである。下記表１で記号“Ｘ”は送信端と受信端との相互約束により前記シンボルの位置及び符号が固定されていることを意味する。

【表１】

| 伝送情報ビット | バーストパイロットデータ変調ブロック動作でのシンボル表現方法及びシンボル当たり情報ビット割り当て | | | 関連図 |
|---|---|---|---|---|
| | シンボル個数 | シンボル出力位置 | シンボル出力符号 | |
| 1 | 1シンボル (128チップ長さ) | X (0 bit/symbol) | 正/負 (1 bit/symbol) | 図3A |
| 1 | 1シンボル (128チップ長さ) | Iチャネル/Qチャネル (1 bit/symbol) | X (0 bit) | 図3B |
| 2 | 1シンボル (128チップ長さ) | Iチャネル/Qチャネル (1 bit/symbol) | 正/負 (1 bit/symbol) | 図3C |
| 2 | 2シンボル (64チップ長さ) | X (0 bit/symbol) | 正/負 (1 bit/symbol) | 図5A |
| 2 | 2シンボル (64チップ長さ) | Iチャネル/Qチャネル (1 bit/symbol) | X (0 bit) | 図5B |
| 4 | 2シンボル (64チップ長さ) | Iチャネル/Qチャネル (1 bit/symbol) | 正/負 (1 bit/symbol) | 図5C |

【００２３】

図２はパケット（Ｐａｃｋｅｔ）データシンボルとバーストパイロットシンボルに構成された１．２５ｍＳｅｃ単位のスロット（Ｓｌｏｔ）構造の一例を示している。図示されたように、一つのスロットは２個の１／２スロット（ｈａｌｆ　Ｓｌｏｔ）に構成され、バーストパイロットシンボルは１／２スロットの初めの部分に１２８チップの長さを有して構成される。前記図２のように、１２８チップのバーストパイロットシンボル１個が構成される場合、バーストパイロットシンボルの出力符号及び出力複素チャネルの位置によって最大２ビットの情報を伝送することができる。１ビットの情報を伝送するためには、シンボルの位相（＋／－）に情報を入れる第１方法、または変調シンボルが出力される複素チャネルの位置を決定する第２方法中の一つを選択することができる。以下、説明される図３Ａ乃至図３Ｃは前記図２のようなスロット構造の仮定下に説明されたものである。

【００２４】
図３Ａはバーストパイロットチャネルを通じて１個のパイロット変調シンボルが伝送される場合、前記パイロット変調シンボルの位相を決定することにより、１ビットの情報を伝送する場合を示す。前記パイロット変調シンボルは１２８チップの長さを有する。図３に示されたように、Ｉチャネルを通じて伝送される変調シンボルの符号（または位相）に情報を乗せる。例えば、情報ビットが０であると、前記変調シンボルの符号を正（または負）にして伝送し、情報ビットが１であると、変調シンボルの符号を負（または正）にして伝送する。この方法に、１ビット（ｂｉｔ）情報が伝送される。ここで、複素チャネル（ｃｏｍｐｌｅｘ　ｃｈａｎｎｅｌ）中，Ｉチャネルを通じて伝送される変調シンボルの位相を利用して情報を伝送する場合を説明しているが、他の例として、Ｉチャネルの代わりにＱチャネルを通じて伝送される前記変調シンボルの位相を利用して情報を伝送することもできる。前記情報ビット値による変調シンボルの位相は予め固定（または指定）される。

【００２５】
図３Ｂはバーストパイロットチャネルを通じて１個のパイロット変調シンボルが伝送される場合、前記パイロット変調シンボルが出力される複素チャネルを決定することによって，１ビットの情報を伝送する場合を示す。

【００２６】
図３Ｂに示されたように、情報ビットに従って複素チャネル中，選択されたチャネル（Ｉチャネル，またはＱチャネル）を通じて情報を伝送する方法である。シンボルの出力符号を正（＋）に予め設定し、前記選択されたチャネル上にパイロットシンボルを発生する。例えば、情報ビットが０であると、パイロットシンボルを複素チャネル中，Ｉチャネル（またはＱチャネル）を通じて伝送し，情報ビットが１であると，パイロットシンボルをＱチャネル（またはＩチャネル）を通じて伝送する。この方法に，１ビット（ｂｉｔ）の情報を伝送することができる。前記情報ビット値に対する出力複素チャネルは、予め固定（指定）され、変調シンボルの符号も正（＋）の代わりに負（－）に予め設定して使用することができる。

【００２７】
図３Ｃはバーストパイロットチャネルを通じて１個のパイロット変調シンボルが伝送される場合、前記パイロット変調シンボルの位相及び出力複素チャネルを指定することにより，２ビットの情報を伝送する場合を示す。これは前記図３Ａと図３Ｂの方法を組み合わせた場合である。

【００２８】
図示されたように，１番目情報ビットに対応して変調シンボルの符号（または出力複素チャネル）を決定し、２番目情報ビットに対応して前記変調シンボルの出力複素チャネル（または位相）を決定する方法である。例えば，２情報ビットを伝送する場合、伝送される２情報ビット中、一番目情報ビットが０であると、変調シンボルの符号を正（または負）にして伝送し、一番目情報ビットが１であると，変調シンボルの符号を負（または正）にして伝送する。そして、二番目情報ビットが０であると，パイロット変調シンボルを複素チャネル中，Ｉチャネル（またはＱチャネル）を通じて伝送し，二番目情報ビットが１であると、パイロット変調シンボルを複素チャネル中、Ｑチャネル（またはＩチャネル）を通じて伝送する。

【００２９】
他の例として、伝送される２ビット情報中、一番目情報ビットが０であると、パイロット変調シンボルを複素チャネル中、Ｉチャネル（またはＱチャネル）を通じて伝送し，一番目情報ビットが１であると，前記パイロット変調シンボルをＱチャネル（またはＩチャネル）を通じて伝送する，二番目情報ビットが０であると，前記パイロット変調シンボルの符号を正（または負）にして伝送し，二番目情報ビットが１であると，前記パイロット変調シンボルの符号を負（または正）にして伝送する。

【００３０】

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図４はパケット（Ｐａｃｋｅｔ）データシンボルとバーストパイロットシンボルに構成された１．２５ｍＳｅｃ単位のスロット（Ｓｌｏｔ）構造の他の例を示している。図示されたように、一つのスロットは２個の１／２スロットに構成され、各バーストパイロットチャネルは１／２スロットの初めの部分に位置した６４チップの２個の連続されたバーストパイロットシンボルに構成される。前記図４のように、６４チップのバーストパイロットシンボル２個が構成される場合、パイロット変調シンボルの符号（または位相）及び変調シンボルを伝送する複素チャネルの選択を通じて最大４ビットの情報を伝送することができる。以下、説明される図５Ａ乃至図５Ｃは前記図４のようなスロット構造の仮定下に説明されたものである。

【００３１】

図５Ａはバーストパイロットチャネルを通じて２個のパイロット変調シンボルが伝送される場合、前記パイロット変調シンボルそれぞれに対して位相を指定することによって２ビットの情報を伝送する場合を示す。前記パイロット変調シンボルは６４チップの長さを有する。

【００３２】

図示されたように、１／２スロットの初めの部分に６４チップのバーストパイロットシンボル２個が構成された場合、２個のパイロット変調シンボルそれぞれの符号（または位相）を伝送される情報ビットによって決定して伝送する。ここで、パイロット変調シンボルを複素チャネル中、Ｉチャネルのみ利用して伝送するものに仮定する。例えば、２個の情報ビット中、一番目情報ビットが０であると、一番目パイロット変調シンボルの符号を正（または負）にして伝送し、一番目情報ビットが１であると、変調シンボルの符号を負（または正）にして伝送する。二番目情報ビットが０であると、二番目パイロット変調シンボルの符号を正（または負）にして伝送し、二番目情報ビットが１であると、前記パイロット変調シンボルの符号を負（または正）にして伝送する。即ち、一つのパイロット変調シンボル当たり１ビットの情報を伝送するので、２個のパイロット変調シンボル区間（１２８チップ）間、２個の情報ビットを伝送することができる。前記情報ビットの値による変調シンボルの位相は、予め正（＋）、または負（－）に固定して使用する。例えば、情報ビットが０であると正（＋）に、情報ビットが１であると負（－）に固定されることができる。

【００３３】

図５Ｂはバーストパイロットチャネルを通じて２個のパイロット変調シンボルが伝送される場合、前記パイロット変調シンボルそれぞれに対して出力複素チャネルを決定することにより、２ビットの情報を伝送する場合を示す。

【００３４】

図示されたように、２個のパイロット変調シンボルそれぞれに対して出力複素チャネルを分離して指定することにより情報ビットを伝送する。例えば、２個の情報ビット中、一番目情報ビットが０であると、一番目パイロット変調シンボルをＩチャネル（またはＱチャネル）を通じて伝送し、一番目情報ビットが１であると、前記一番目パイロット変調シンボルをＱチャネル（またはＩチャネル）を通じて伝送する。また、二番目情報ビットが０であると、二番目パイロット変調シンボルをＩチャネル（またはＱチャネル）を通じて伝送し、二番目情報ビットが１であると、前記二番目パイロット変調シンボルをＱチャネル（またはＩチャネル）を通じて伝送する。即ち、一つのパイロット変調シンボル当たり１個の情報ビットを６４チップ区間の間伝送するので、２個のパイロット変調シンボル区間（１２８チップ）間、２個の情報ビットを伝送することができる。

【００３５】

図５Ｃはバーストパイロットチャネルを通じて２個のパイロット変調シンボルが伝送される場合、前記パイロット変調シンボルそれぞれに対して位相及び出力複素チャネルを指定することにより、４ビットの情報を伝送する場合を示す。前記パイロット変調シンボルは６４チップの長さを有する。これは前記図５Ａと図５Ｂの方法を組み合わせた場合である。

【００３６】
図５Ｃに示されたように、パイロット変調シンボルの符号（または位相）及び複素チャネルを決定することによって、４ビットの情報を伝送している。ここで、情報ビットの値による変調シンボルの符号及び複素チャネルは予め決定して使用する。例えば、４個の情報ビットを伝送する場合、前記４個の情報ビット中、一番目情報ビットによって一番目パイロット変調シンボルの符号を負（－）、または正（＋）にして伝送し、二番目情報ビットによって前記一番目パイロット変調シンボルを複素チャネル中、Ｉチャネル、またはＱチャネルを通じて伝送する。そして、三番目情報ビットによって二番目パイロット変調シンボルの符号を負、または正に伝送し、四番目情報ビットによって前記二番目パイロット変調シンボルをＩ、またはＱチャネルを通じて伝送する。

【００３７】
一方、前述のように変調部１０ではなく、直交拡散部２０を使用して付加情報を伝送することもできる。一般的に、前記変調部１０で出力される変調シンボルは直交拡散部２０に入力される。前記直交拡散部２０はバーストパイロット変調シンボルを他の符号チャネル（ｃｏｄｅ　ｃｈａｎｎｅｌ）と区分するために、所定の直交符号（例：ウォルシュ符号）に拡散させる。前記バーストパイロットチャネルのため予め定義した直交符号の数が１個であると、付加情報を伝送することができない。しかし、前記直交符号を２個使用すると、１ビットの情報を伝送することができる。もし、前記変調部１０で出力されるバーストパイロット変調シンボルを$2^n$個の直交符号中、一つを選択して拡散する場合には、ｎビットの情報を伝送することができる。ここで、$2^n$個の直交符号は送信器と受信器で事前に使用可能なものであると約束されているべきである。

【００３８】
図６Ａ乃至図６Ｂは本発明の他の実施形態によるバーストパイロットチャネルの拡散符号を利用して付加情報を伝送する方法を示す。

【００３９】
前記図６Ａはバーストパイロットチャネルを通じて１個のパイロット変調シンボルを伝送する場合、バーストパイロット変調部１０で出力されたパイロット変調シンボルを２個の直交符号中、伝送情報ビットによって選択された一つの直交符号により拡散するものを示す。２個の直交符号中のいずれかを使用するかは伝送情報ビットにより決定される。一つの変調シンボルを１２８チップに拡散させるためのｉ番目とｊ番目インデックス（ｉｎｄｅｘ）を有する直交符号をそれぞれＷ（１２８，ｉ）とＷ（１２８，ｊ）と定義する時、伝送しようとする情報ビットが０である場合，前記直交拡散部２０は前記変調部１０からの出力変調シンボルをＷ（１２８，ｉ）（またはＷ（１２８，ｊ））に拡散させ、伝送しようとする情報ビットが１である場合、Ｗ（１２８，ｊ）（またはＷ（１２８，ｉ））に拡散させ１ビットの情報を伝送する。

【００４０】
ここで、$2^n$個の直交符号中、一つを選択して拡散すると、ｎビットの情報を伝送することができ，図３Ａの方法と共に使用すると、ｎ＋１個の情報ビットを伝送することができる。同様に、図３Ｂの方法と共に使用すると，ｎ＋１個の情報ビットを伝送することができる。また図３Ｃの方法と共に使用すると、ｎ＋２個の情報ビットを伝送することができる。これは、前記図３Ｃに示したように変調部１０はパイロット変調シンボルに２個の情報ビットを乗せることができ，前述のような拡散方式によりｎ個の情報ビットをさらに乗せることができるためである。

【００４１】
前記図６Ｂはバーストパイロットチャネルを通じて２個のパイロット変調シンボルを伝送する場合、バーストパイロット変調部１０で出力される２個のパイロット変調シンボルをそれぞれ２個の直交符号中、伝送情報ビットによって選択された一つの直交符号を有して拡散することを示す。ここで、前記変調部１０で出力される変調シンボルは６４チップ長さの直交符号により拡散される。ｉ番目とｊ番目インデックス（ｉｎｄｅｘ）を有する直交符号をそれぞれＷ（６４，ｉ）とＷ（６４，ｊ）とし、２個の情報ビットを伝送しよう

とする時、前記２個の情報ビット中、一番目情報ビットが０である場合、直交拡散部２０は前記変調部１０からの一番目パイロット変調シンボルをＷ（６４，ｉ）（またはＷ（６４，ｊ））に拡散させ、伝送しようとする前記一番目情報ビットが１である場合、Ｗ（６４，ｊ）（またはＷ（６４，ｉ））に拡散させ１個の情報ビットを伝送する。そして、前記２個の情報ビット中、二番目情報ビットが０である場合、直交拡散部２０は前記変調部１０で出力される二番目パイロット変調シンボルをＷ（６４，ｉ）（またはＷ（６４，ｊ））に拡散させ、前記二番目情報ビットが１である場合、前記二番目パイロット変調シンボルをＷ（６４，ｊ）（またはＷ（６４，ｉ））に拡散させ１個の情報ビットを伝送する。

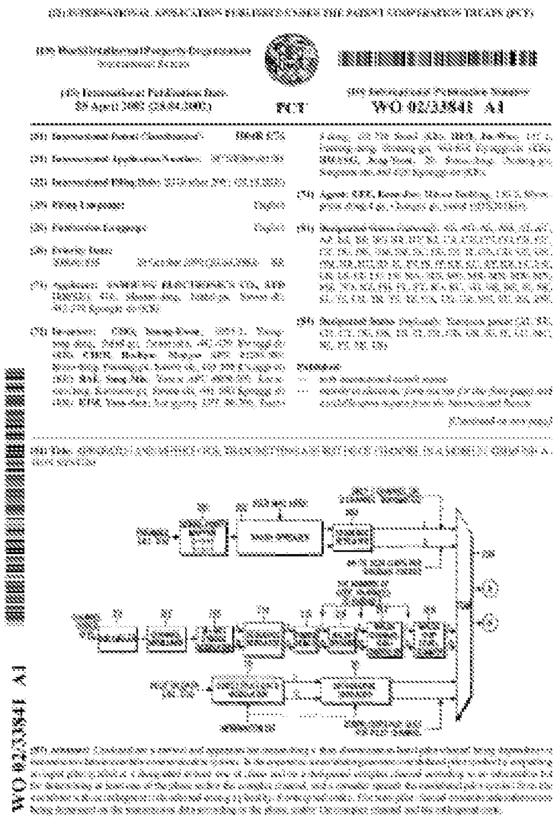
【００４２】
もし、$2^n$個の直交符号中、一つを選択して拡散すると、２ｎ個の情報ビットを伝送することができ、図５Ａの方法と共に使用すると、２ｎ＋２個の情報ビットを伝送することができる。同様に、図５Ｂの方法と共に使用すると、２ｎ＋２個の情報ビットを伝送することができ、図５Ｃの方法を共に使用すると、２ｎ＋４個の情報ビットを伝送することができる。

【００４３】
【発明の効果】
上述したように、本発明はバーストパイロット（ｂｕｒｓｔ　Ｐｉｌｏｔ）チャネルを通じて伝送されるパイロット変調シンボルの個数、前記パイロット変調シンボルが伝送される複素チャネル及び前記パイロット変調シンボルの符号、そして前記パイロットチャネルのため使用される直交拡散符号の個数によって、バーストパイロットチャネルを通じて復調のための振幅基準だけではなく、付加情報を伝送することができる利点がある。

【図面の簡単な説明】
【図１】本発明の実施形態によるパケットデータサービスのための順方向リンク送信装置の構成を示す図である。
【図２】パケット（Ｐａｃｋｅｔ）データシンボルとバーストパイロットシンボルに構成された１．２５ｍｓｅｃ単位のスロット（Ｓｌｏｔ）構造の一例を示す図である。
【図３Ａ】本発明の一実施形態によるバーストパイロットチャネルを通じて１個のパイロット変調シンボルを伝送する場合、前記パイロット変調シンボルを利用して付加情報を伝送する多様な方法を示す図である。
【図３Ｂ】図３Ａと同様の図である。
【図３Ｃ】図３Ａと同様の図である。
【図４】パケット（Ｐａｃｋｅｔ）データシンボルとバーストパイロットシンボルに構成された１．２５ｍｓｅｃ単位のスロット（Ｓｌｏｔ）構造の他の例を示す図である。
【図５Ａ】本発明の実施形態によるバーストパイロットチャネルを通じて２個のパイロット変調シンボルを伝送する場合、前記パイロット変調シンボルを利用して付加情報を伝送する多様な方法を示す図である。
【図５Ｂ】図５Ａと同様の図である。
【図５Ｃ】図５Ａと同様の図である。
【図６Ａ】本発明の実施形態によるバーストパイロット変調シンボルの拡散符号を利用して付加情報を伝送する多様な方法を示す図である。
【図６Ｂ】図６Ａと同様の図である。
【符号の説明】
１０　バーストパイロットデータ変調部
２０　直交拡散部
２０１　信号点写像器
２０２，２１６　ウォルシュ拡散器
２０３　シーケンス反復器
２１１　スクランブラ
２１２　チャネルインタリーバ

２１３　Ｍ－ａｒｙシンボル変調器
２１４　シーケンス反復／シンボル穿孔器
２１５　シンボルデマルチプレクサ
２１７　ウォルシュチャネル利得制御器
２１８　ウォルシュチップ合算器
２３０　時分割マルチプレクサ

【国際公開パンフレット】



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# APPARATUS AND METHOD FOR TRANSMITTING A BURST PILOT CHANNEL IN A MOBILE COMMUNICATION SYSTEM

## BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to a mobile communication system, and in particular, to an apparatus and method for transmitting information over a pilot channel.

2. Description of the Related Art

Recently, a mobile communication system supporting not only a voice service but also a high-speed packet data service has been proposed to meet the growing requirement for high-speed data transmission. In the mobile communication system supporting the high-speed packet data transmission, a transmitter performs QAM (Quadrature Amplitude Modulation) on transmission packet data. Further, the transmitter transmits a time-continuous common pilot channel and a time-discontinuous burst pilot channel.

Generally, a phase modulation scheme such as QPSK (Quadrature Phase Shift Keying) includes information in a phase component of a modulated symbol. Therefore, a receiver demodulates the modulated symbol by utilizing the common pilot channel as a phase reference signal. However, a QAM scheme includes information in amplitude and phase components of the modulated symbol. For example, when the system supporting the high-speed data transmission employs 16-QAM (16-ary QAM) or 64-QAM for packet data transmission, the receiver requires an amplitude reference of a demodulated symbol in order to correctly demodulate the information included in the modulated symbol. Therefore, the transmitter must transmit both a phase reference signal and an amplitude reference signal of the modulated symbol. That is, when the transmitter employing the QAM modulation transmits data at constant transmission power, the common pilot channel can be used as both the phase reference and the amplitude reference. However, when the transmission power varies at stated periods, a reference signal providing an amplitude reference of the QAM-modulated symbol is required. To provide the amplitude reference of the QAM-modulated symbol, the burst pilot channel is typically used. The burst pilot channel is used to provide only the amplitude reference of the QAM-modulated symbol. Generally, it is most important for the mobile communication system to efficiently utilize the limited radio resources. To this end, many multi-function channels have been proposed. Although the burst pilot channel is used to provide the amplitude reference of the modulated symbol, it can also provide other side information (or additional information), thus contributing to its efficient utilization.

## SUMMARY OF THE INVENTION

It is, therefore, an object of the present invention to provide an apparatus and method for transmitting side information using a burst pilot channel providing an amplitude reference of a modulated symbol.

It is another object of the present invention to provide an apparatus and method for transmitting side information using a phase component of a modulated burst pilot symbol providing an amplitude reference of a modulated symbol.

It is further another object of the present invention to provide an apparatus and method for transmitting side information using a complex output channel for a modulated burst pilot symbol providing an amplitude reference of a modulated symbol.

It is yet another object of the present invention to provide an apparatus and method for transmitting side information using a spreading code for a modulated burst pilot symbol providing an amplitude reference of a modulated symbol.

To achieve the above and other objects, there is provided an apparatus for transmitting a time-discontinuous burst pilot channel being dependent on transmission data in a mobile communication system. In the apparatus, a modulator generates a modulated pilot symbol by generating an input pilot symbol in a designated phase and/or on a designated complex channel in response to an information bit input signal for designating the phase and/or the complex channel, and a spreader spreads the modulated pilot symbol from the modulator with an orthogonal code selected among a plurality of orthogonal codes. The burst pilot channel transmits side information being dependent on the transmission data according to the phase, and/or the channel and the orthogonal code.

## BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and advantages of the present invention will become more apparent from the following detailed description when taken in conjunction with the accompanying drawings in which:

FIG. 1 illustrates a structure of a forward link transmitter for a packet data service according to an embodiment of the present invention;

FIG. 2 illustrates a structure of a 1.25msec slot comprised of packet data symbols and burst pilot symbols;

FIGs. 3A, 3B, and 3C illustrate various methods of transmitting side information using one modulated pilot symbol transmitted over a burst pilot channel according to an embodiment of the present invention;

FIG. 4 illustrates another structure of a 1.25msec slot comprised of packet data symbols and burst pilot symbols;

FIGs. 5A, 5B, and 5C illustrate various methods of transmitting side information using two modulated pilot symbols transmitted over a burst pilot channel according to an embodiment of the present invention; and

FIGs. 6A and 6B illustrate various methods of transmitting side information using a spreading code for a modulated burst pilot symbol according to an embodiment of the present invention.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

A preferred embodiment of the present invention will be described herein below with reference to the accompanying drawings. In the following description, well-known functions or constructions are not described in detail since they would obscure the invention in unnecessary detail.

The present invention transmits side information over a burst pilot channel providing an amplitude reference of a modulated symbol, required for demodulating the QAM-modulated symbol received from a transmitter. The side information is required for packet data transmission, as follows:

(1) When a plurality of different packet data are transmitted to a packet data user over consecutive slots, the packet data user requires information to indicate the different packet data. The side information can be used to provide this information.

(2) Upon failure to correctly decode received packet data, the packet data user sends a retransmission request to a base station, and the base station then retransmits the same packet data in response to the retransmission request. The retransmitted data, though identical to the previously transmitted data, may be transmitted at a different code rate in a different modulation mode. The side information can be used to indicate whether to be first transmission data and to be retransmission data.

(3) The base station must inform the packet data user of a data rate of the packets being transmitted., the side information can be used to provide the data rate.

(4) The side information can be used as common control information for controlling a data rate of a reverse link used by a plurality of packet data users to transmit packet data to the base station. Further, the side information can also be used to control a data rate of a specific group or user. In addition, the side information bit can be used to transmit specific information even in a case other than the above-stated cases.

FIG. 1 illustrates a structure of a forward link transmitter for a packet data service according to an embodiment of the present invention. Particularly, the transmitter shown in FIG. 1 includes a burst pilot data modulator 10 and an orthogonal spreader (or Walsh cover generator) 20 according to the present invention. Upon receiving a symbol of '0', the burst pilot data modulator 10 positions the received symbol in an I channel or a Q channel according to an information bit to be transmitted, or converts the received symbol to a symbol of '0' or '1'. The converted symbol is spread with a predefined orthogonal code (e.g., Walsh code) for the burst pilot channel by the orthogonal spreader 20, and then, output in a chip unit. When transmitting side information using the orthogonal spreader 20 rather than the burst pilot data modulator 10, the orthogonal spreader 20 can multiply the side information by an orthogonal code, which is previously determined according to the information bit to be transmitted.

Referring to FIG. 3, input preamble symbols of all '0's are mapped to '+1' by a signal point mapper 201. The output symbols of the signal point mapper 201 are spread by a Walsh spreader 202 with a specific 64-ary biorthogonal Walsh code (or sequence) associated with a user's unique MAC ID (identification or index). The Walsh spreader 202 outputs an I-channel sequence and a Q-channel sequence. The output sequences of the Walsh spreader 202 are provided to a sequence repeater 203 where they are subject to sequence repetition according to a transmission rate (or data rate). The output sequences of the Walsh spreader 202 can be repeated by the sequence repeater 203 as many as a maximum of 16 times according to the transmission rates. Therefore, the burst pilot channel included in one slot of a data traffic channel (DTCH) can continue for 64 chips to 1,024 chips according to the transmission rates. The I and Q-channel sequences output from the sequence repeater 203 are provided to a time division multiplexer (TDM) 230 where they are multiplexed with the data traffic channel and the burst pilot channel.

An input channel-coded bit sequence is scrambled by a scrambler 211, and then, interleaved by a channel interleaver 212. The size of the channel interleaver 212 depends on the size of a physical layer packet. The output sequence of the channel interleaver 212 is mapped to M-ary symbols by an M-ary symbol modulator 213. The M-ary symbol modulator 213 serves as the QPSK(Quadrature Phase Shift Keying), 8-PSK (8-ary Phase Shift Keying) or 16-QAM(Quadrature Amplitude Modulation) modulator according to the transmission rates, and it is also possible to change the modulation mode in a unit of the physical layer packet having a variable transmission rate. The I and Q sequences of the M-ary symbols output from the M-ary symbol modulator 213 are subjected to sequence repetition/symbol puncturing according to the transmission rate in a sequence repeater/symbol puncturer 214. The I and Q sequences of the M-ary symbols output from the sequence repeater/symbol puncturer 214 are provided to a symbol demultiplexer (DEMUX) 215 where they are demultiplexed into N Walsh code channels available for data traffic sub-channels (DTSCHs). The number, N, of the Walsh codes used for the DTSCHs is variable; this information is broadcast over a Walsh space indication sub-channel (WSISCH), and a mobile station (MS) determines a transmission rate of a base station (BS), considering the received information, and then sends the determined transmission rate information to the base station. Therefore, the mobile station can determine which Walsh codes are assigned to the currently received DTSCH. The I and Q sequences, demultiplexed into N Walsh code channels, output from the symbol demultiplexer 215 are provided to a Walsh spreader (or a Walsh cover generator) 216 where they are spread with a specific Walsh code according to the respective channels. The I and Q sequences output from the Walsh spreader 216 are gain-controlled by a Walsh channel gain controller 217. The I and Q sequences output from the Walsh channel gain controller 217 are summed up in a chip unit by a Walsh chip level summer 218. The I and Q chip sequences output from the Walsh chip level summer 218 are provided to the time division multiplexer 230 where they are multiplexed with the burst pilot channel(PICH) and a preamble sub-channel (PSCH).

The burst pilot data modulator 10 (hereinafter, referred to as "modulator" for simplicity) performs signal mapping (0→+1, 1→-1) on the input pilot channel data of all '0's, and outputs modulated pilot symbols. The orthogonal spreader 20 orthogonally spreads the signals output from the modulator 10 by multiplying the modulated pilot symbols by a predefined orthogonal code. In this process, the modulator 10 defines a sign (or phase) of the modulated pilot symbols according to the input information bit. For example, the modulator 10 outputs a modulated pilot symbol having a positive sign (+) for the input information bit of '0', and a modulated pilot symbol having a negative sign (-) for the input information bit of '1'.

As another example, the modulator 10 performs signal mapping on the input pilot channel data, and outputs the mapped signal through a channel selected according to the input transmission information bit, among a plurality of channels (I channel and Q channel) constituting complex channels. For example, the modulator 10 outputs its output signal through the I channel for the input information bit of '0', and through the Q channel for the input information bit of '1'.

In an alternative embodiment, the orthogonal spreader 20 can transmit the side information by spreading the modulated pilot symbol output from the modulator 10 with a specific orthogonal code selected according to the input information bit, among a plurality of orthogonal codes previously assigned for the burst pilot.

When the side information is transmitted over the burst pilot channel as stated above, a method for expressing the side information transmitted over the burst pilot channel by the burst pilot data modulator 10 and the orthogonal spreader 20 should be previously agreed between the transmitter and the receiver. Table 1 shows a method for expressing symbols selected according to the transmission information bit (0 or 1) and a method for assigning the information bit by the burst pilot data modulator 10. In Table 1, 'X' indicates that the position and the sign of the symbol are fixed according to the agreement between the transmitter and the receiver.

Table 1

| Tx Info Bit(s) | Method of Expressing Symbols and Assigning Info Bits Per Symbol by Burst Pilot Data Modulator | | | Related Drawing |
|---|---|---|---|---|
| | Symbol Num. | Symbol output Pos. | Symbol output Sign | |
| 1 | 1 symbol (128-chip length) | X (0 bit/symbol) | Positive/Negative (1 bit/symbol) | FIG. 3A |
| 1 | 1 symbol (128-chip length) | I channel/Q channel (1 bit/symbol) | X (0 bit) | FIG. 3B |
| 2 | 1 symbol (128-chip length) | I channel/Q channel (1 bit/symbol) | Positive/Negative (1 bit/symbol) | FIG. 3C |
| 2 | 2 symbols (64-chip | X (0 bit/symbol) | Positive/Negative (1 bit/symbol) | FIG. 3A |

| | | | | |
|---|---|---|---|---|
| | length) | | | |
| 3 | 2 symbols (64-chip length) | I channel/Q channel (1 bit/symbol) | X (0 bit) | FIG. 3B |
| 4 | 2 symbols (64-chip length) | I channel/Q channel (1 bit/symbol) | Positive/Negative (1 bit/symbol) | FIG. 3C |

FIG. 2 illustrates a structure of a 1.25msec slot comprised of packet data symbols and burst pilot symbols. As illustrated, one slot is comprised of two half slots, and the burst pilot symbol is positioned in a leading 128-chip part of each half slot. When one 128-chip burst pilot symbol is constructed as shown in FIG. 2, it is possible to transmit a maximum of 2 information bits according to a sign of the output burst pilot symbol and a position of the complex output channel. In order to transmit one information bit, it is possible to select one method out of a first method for loading the information on a phase (+/-) of the symbol and a second method for designating a position of the complex channel for outputting the modulated symbol. A description of FIGs. 3A to 3C will be given under the assumption that the slot has the structure shown in FIG. 2.

FIG. 3A illustrates a method for transmitting one information bit by designating a phase of one modulated pilot symbol transmitted over a burst pilot channel. The modulated pilot symbol has a length of 128 chips. As illustrated in FIG. 3A, information is loaded on a sign (or phase) of a modulated symbol transmitted over the I channel. For example, the modulated symbol is transmitted with a positive sign (or negative sign) for the information bit of '0', while the modulated symbol is transmitted with a negative sign (or positive sign) for the information bit of '1'. In this manner, the one information bit is transmitted. Although the description has been made of the method for transmitting information using a phase of the modulated symbol transmitted over the I channel out of the complex channels, it is also possible to transmit the information using a phase of a modulated symbol transmitted over the Q channel rather than the I channel. The phase of the modulated symbol, associated with the information bit value, is previously fixed (or designated).

FIG. 3B illustrates a method for transmitting one information bit by designating one channel out of complex channels, for outputting one modulated pilot symbol transmitted over the burst pilot channel. As illustrated in FIG. 3B, information is transmitted through a selected channel (I channel or Q channel) out of the complex channels according to the information bit. An output sign of the symbol is preset to a positive value (+), and then, the pilot symbol is generated on the selected channel. For example, the pilot symbol is transmitted through the I channel (or Q channel) out of the complex channels for the information bit of '0', while the pilot symbol is transmitted through the Q channel (or I channel) for the information bit of '1'. In this manner, it is possible to transmit the one information bit. The complex output channel for the information bit is previously fixed (designated). It is also possible to previously set the sign of the modulated symbol to a negative value (-) rather than a positive value (+).

FIG. 3C illustrates a method for transmitting two information bits by designating a phase of one modulated pilot symbol transmitted over a burst pilot channel and also designating a complex output channel for the modulated pilot symbol. This method is a combination of the methods of FIGs. 3A and 3B. As illustrated, a sign (or complex output channel) of a modulated symbol is designated in association with a first information bit, and a complex output channel (or phase) of the modulated symbol is designated in association with a second information bit. For example, if a first information bit out of the two information bits to be transmitted is '0', the modulated symbol is transmitted with a positive sign (or negative sign). Otherwise, if the first information bit is '1', the modulated symbol is transmitted with a negative sign (or positive sign). In addition, if a second information bit out of the two transmission information bits is '0', the modulated pilot symbol is transmitted through the I channel (or Q channel) out of the complex channels. Otherwise, if the second information bit is '1', the modulated pilot symbol is transmitted through the Q channel (or I channel) of the complex channels.

As another example, if the first information bit of the two transmission information bits is '0', the modulated pilot symbol is

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transmitted through the I channel (or Q channel). If the first information bit is '1', the modulated pilot symbol is transmitted through the Q channel (or I channel). If the second information bit is '0', the modulated pilot symbol is transmitted with a positive sign (or negative sign). If the second information bit is '1', the modulated pilot symbol is transmitted with a negative sign (or positive sign).

FIG. 4 illustrates another structure of a 1.25msec slot comprised of packet data symbols and burst pilot symbols. As illustrated, one slot is comprised of two half slots, and each burst pilot channel is comprised of two consecutive 64-chip burst pilot symbols positioned in a leading part of each half slot. When two 64-chip burst pilot symbols are constructed as shown in FIG. 4, it is possible to transmit a maximum of 4 information bits by selecting a sign (or phase) of the modulated pilot symbols and selecting a complex channel for transmitting the modulated symbols. A description of FIGs. 5A to 5C will be given under the assumption that the slot has the structure illustrated in FIG. 4.

FIG. 5A illustrates a method for transmitting 2 information bits by separately designating a phase of two modulated pilot symbols transmitted over a burst pilot channel. The modulated pilot symbol has a length of 64 chips. As illustrated, the information bits are transmitted by separately designating a sign (or phase) of the two 64-chip modulated pilot symbols positioned in the leading part of each half slot. Here, it is assumed that the modulated pilot symbols are transmitted through only the I channel out of the complex channels. For example, if the first information bit out of the two information bits is '0', the first modulated pilot symbol is transmitted with a positive sign (or negative sign). If the first information bit is '1', the first modulated pilot symbol is transmitted with a negative sign (or positive sign). In addition, if the second information bit of the two information bits is '0', the second modulated pilot symbol is transmitted with a positive sign (or negative sign). If the second information bit is '1', the second modulated pilot symbol is transmitted with a negative sign (or positive sign). That is, one information bit is transmitted per one modulated pilot symbol, so that it is possible to transmit two information bits for a 128-chip period of the two modulated pilot symbols. The phase of the modulated symbols, which is associated with the information bit values, are previously fixed to a positive value (+) or a negative value (-). For example, the phase can be fixed to a positive value (+) for the information bit of '0', and a negative value (-) for the information bit of '1'.

FIG. 5B illustrates a method for transmitting two information bits by separately designating a complex output channel for two modulated pilot symbols transmitted over the burst pilot channel. As illustrated, the information bits are transmitted by separately designating a complex output channel for the two modulated pilot symbols. For example, if the first information bit of the two information bits is '0', the first modulated pilot symbol is transmitted through the I channel (or Q channel). If the first information bit is '1', the first modulated pilot symbol is transmitted through the Q channel (or I channel). In addition, if the second information bit of the two information bits is '0', the second modulated pilot symbol is transmitted through the I channel (or Q channel). If the second information bit is '1', the second modulated pilot symbol is transmitted through the Q channel (or I channel). That is, one information bit is transmitted per one modulated pilot symbol for a 64 chips period, so that it is possible to transmit two information bits for a 128 chip period of the two modulated pilot symbols.

FIG. 5C illustrates a method for transmitting four information bits by separately designating a phase of two modulated pilot symbols transmitted over a burst pilot channel and also separately designating a complex output channel for the modulated pilot symbols. The modulated pilot symbols has a length of 64 chips. This method is a combination of the methods of FIGs. 5A and 5B. As illustrated in FIG. 5C, Thus, four information bits are transmitted by designating a sign(or phase) of the modulated pilot symbol and also designating an complex output channel for the modulated pilot symbol. Here, the sign and the complex channel of the modulated symbols, which are associated with the information bit values, are previously designated. For example, to transmit 4 information bits, the first modulated pilot symbol is transmitted with a negative sign (-) or a positive sign (+) according to the first information bit of the four information bits, and the first modulated pilot symbol is transmitted through the I channel or the Q channel of the complex channels according to the second information bit. In addition, the second modulated pilot symbol is transmitted with a negative sign (-) or a positive sign (+) according to the third information bit, and the second modulated pilot symbol is transmitted through the I channel or the Q channel of the complex channels according to the fourth information bit.

In an alternative embodiment, it is also possible to transmit the side information using the orthogonal spreader 20, rather than the modulator 10. The modulated symbols output from the modulator 10 are provided to the orthogonal spreader 20. The orthogonal spreader 20 spreads the modulated symbols with a predefined orthogonal code (e.g., Walsh code) in order to distinguish the modulated burst pilot symbols from other code channels. If the number of the predetermined orthogonal codes for the burst pilot channel is one, it is not possible to transmit the side information. However, when two orthogonal codes are used, it is possible to transmit one information bit. If the modulated burst pilot symbols output from the modulator 10 are spread with a selected one of $2^n$ orthogonal codes, it is possible to transmit n information bits. In this case, it should be previously agreed between the mobile station and the base station that there are $2^n$ available orthogonal codes.

FIGs. 6A and 6B illustrate a method for transmitting side information using spreading codes for a burst pilot channel according to different embodiments of the present invention. Specifically, FIG. 6A illustrates a method for transmitting one modulated pilot symbol over the burst pilot channel, wherein the modulated pilot symbols output from the burst pilot data modulator 10 are spread with an orthogonal code selected according to the transmission information bit, out of two orthogonal codes. Which orthogonal code is to be selected out of the two orthogonal codes is determined according to the transmission information bit. When orthogonal codes having $i^{th}$ and $j^{th}$ indexes for spreading one modulated symbol into 128 chips are defined as W(128,i) and W(128,j), respectively, the orthogonal spreader 20 spreads the modulated symbol output from the modulator 10 with W(128,i) (or W(128,j)) for the transmission information bit of '0', and spreads the modulated symbol with W(128,j) (or W(128,i)) for the transmission information bit of '1', thereby transmitting one information bit.

In this manner, it is possible to transmit n information bits by alternately selecting one of the $2^n$ orthogonal codes for spreading. When used along with the methods of FIG. 3A and FIG. 3B, this scheme can transmit (n+1) information bits. Further, when used along with the method of FIG. 3C, this scheme can transmit (n+2) information bits, because the modulator 10 can load two information bits on the modulated pilot symbol as shown in FIG. 3C and then n information bits can be further loaded by the above-stated spreading code selecting method.

FIG. 6B illustrates a method for transmitting two modulated pilot symbols over the burst pilot channel, wherein the two modulated pilot symbols output from the burst pilot data modulator 10 are spread with an orthogonal code selected according to the transmission information bit, out of two orthogonal codes. The modulated symbols output from the modulator 10 are spread with a 64-chip orthogonal code. When orthogonal codes having $i^{th}$ and $j^{th}$ indexes for spreading one modulated symbol into 64 chips are defined as W(64,i) and W(64,j), respectively, the orthogonal spreader 20, to transmit two information bits, spreads the first modulated symbol output from the modulator 10 with W(64,i) (or W(64,j)) for the first information bit of '0', and spreads the first modulated symbol with W(64,j) (or W(64,i)) for the first information bit of '1', thereby transmitting one information bit. In addition, the orthogonal spreader 20 spreads the second modulated symbol output from the modulator 10 with W(64,i) (or W(64,j)) for the second information bit of '0', and spreads the second modulated symbol with W(64,j) (or W(64,i)) for the second information bit of '1', thereby transmitting one information bit.

In this way, it is possible to transmit 2n information bits by alternately selecting one of the $2^n$ orthogonal codes for spreading. When used along with the methods of FIG. 3A and FIG. 3B, this scheme can transmit (2n+2) information bits. Further, when used along with the method of FIG. 3C, this scheme can transmit (2n+4) information bits.

As described above, the apparatus and method according to the present invention can transmit side information as well as amplitude reference for demodulation over the burst pilot channel according to the number of modulated pilot symbols transmitted over the burst pilot channel, the complex channels for transmitting the modulated pilot symbols, the sign of the modulated pilot symbols, and the number of the orthogonal spreading codes used for the pilot channel.

While the invention has been shown and described with reference to a certain preferred embodiment thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention as defined by the appended claims.

**WHAT IS CLAIMED IS:**

1. An apparatus for transmitting a time-discontinuous burst pilot channel dependent on transmission data in a mobile communication system, comprising:

a modulator for generating a modulated pilot symbol by outputting an input pilot channel data on at least one of a designated phase and on a designated complex channel according to an information bit for designating at least one of the phase and the complex channel; and

a spreader for spreading the modulated pilot symbol from the modulator with an orthogonal code selected among a plurality of orthogonal codes;

wherein the burst pilot channel transmits side information being dependent on the transmission data according to at least one of the phase, and the complex channel and the orthogonal code.

2. The apparatus as claimed in claim 1, wherein the modulated pilot symbol has a length of 128 chips.

3. The apparatus as claimed in claim 1, wherein the modulated pilot symbol has a length of 64 chips.

4. The apparatus as claimed in claim 1, wherein the complex channel includes an I channel and a Q channel.

5. An apparatus for transmitting side information over a burst pilot channel in a mobile communication system, comprising:

a modulator for generating a modulated pilot symbol by outputting an input pilot channel data at a designated phase according to an information bit for determining the phase; and

a spreader for spreading a modulated pilot symbol output from the modulator with a predefined orthogonal code.

6. An apparatus for transmitting side information over a burst pilot channel in a mobile communication system, comprising:

a modulator for generating a modulated pilot symbol by outputting an input pilot channel data on a designated complex channel according to an information bit for determining the complex channel; and

a spreader for spreading a modulated pilot symbol output from the modulator with a predefined orthogonal code.

7. An apparatus for transmitting side information over a burst pilot channel in a mobile communication system, comprising:

a modulator for generating a burst pilot symbol; and

a spreader for spreading the burst pilot symbol with an orthogonal code selected according to an information bit, from a plurality of orthogonal codes.

8. An apparatus for transmitting side information over a burst pilot channel in a mobile communication system, comprising:

a modulator for generating a modulated pilot symbol by outputting an input pilot channel data at a designated phase according to an information bit for designating the phase; and

a spreader for spreading the modulated pilot symbol with an orthogonal code selected according to the information bit, from a plurality of orthogonal codes.

9. An apparatus for transmitting side information over a burst pilot channel in a mobile communication system, comprising:

a modulator for generating a modulated pilot symbol by outputting an input pilot channel data on a designated complex channel according to an information bit for determiningthe complex channel; and

a spreader for spreading the modulated pilot symbol with an orthogonal code selected according to the information bit, from a plurality of orthogonal codes.

10. A method for transmitting a time-discontinuous burst pilot channel dependent on transmission data in a mobile communication system, comprising the steps of:

generating a modulated pilot symbol by outputting an input pilot symbol at at least one of a designated phase and on a designated complex channel according to an information bit for determining at least one of the phase and the complex channel, and

spreading the modulated pilot symbol with an orthogonal code selected from a plurality of orthogonal codes,

wherein the burst pilot channel transmits side information being dependent on the transmission data according to the phase, and/or the complex channel and the orthogonal code.

11. The method as claimed in claim 10, wherein the modulated pilot symbol has a length of 128 chips.

12. The method as claimed in claim 10, wherein the modulated pilot symbol has a length of 64 chips.

13. The method as claimed in claim 10, wherein the complex channel includes an I channel and a Q channel.

14. A method for transmitting side information over a burst pilot channel in a mobile communication system, comprising the steps of:

generating a modulated pilot symbol by outputting an input pilot symbol at a designated phase according to an information bit for determining the phase; and

spreading the generated modulated pilot symbol with a predefined orthogonal code.

15. A method for transmitting side information over a burst pilot channel in a mobile communication system, comprising the steps of:

generating a modulated pilot symbol by outputting an input pilot symbol on a designated complex channel according to an information bit for determining the complex channel; and

spreading the generated modulated pilot symbol with a predefined orthogonal code.

16. A method for transmitting side information over a burst pilot channel in a mobile communication system, comprising the steps of:

generating a pilot symbol; and

spreading the generated pilot symbol with an orthogonal code selected according to an information bit, from a plurality of orthogonal codes.

17. A method for transmitting side information over a burst pilot channel in a mobile communication system, comprising the steps of:

generating a modulated pilot symbol by outputting an input pilot symbol at a designated phase according to an information bit for determining the phase; and

spreading the generated modulated pilot symbol with an orthogonal code selected according to the information bit input signal, from a plurality of orthogonal codes.

18. A method for transmitting side information over a burst pilot channel in a mobile communication system, comprising the steps of:

generating a modulated pilot symbol by outputting an input pilot symbol on a designated complex channel according to an information bit for determining the complex channel; and

spreading the generated modulated pilot symbol with an orthogonal code selected according to the information bit, from a plurality of orthogonal codes.

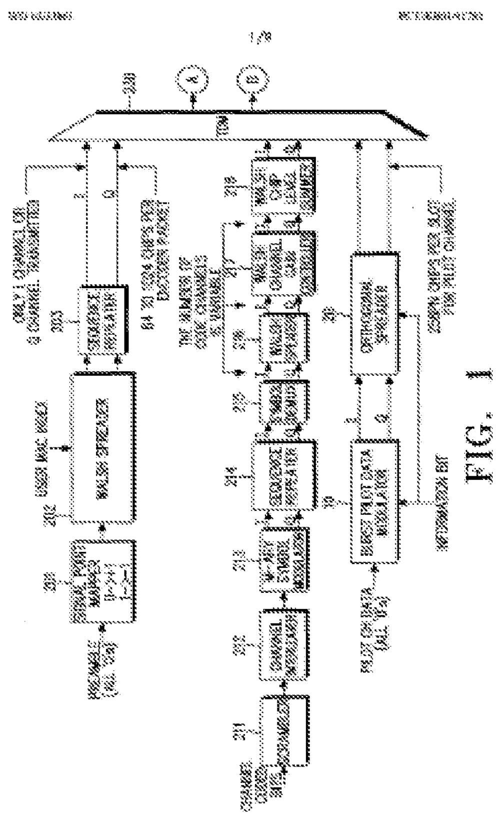

FIG. 1

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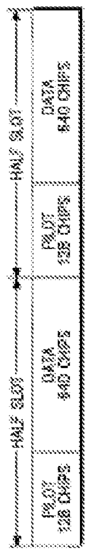
HALF SLOT
HALF SLOT
PILOT
128 CHIPS
DATA
640 CHIPS
PILOT
128 CHIPS
DATA
640 CHIPS

FIG. 2

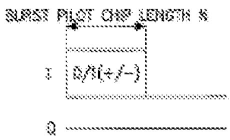
BURST PILOT CHIP LENGTH N
I
0/1(+/-)
Q

FIG. 3A

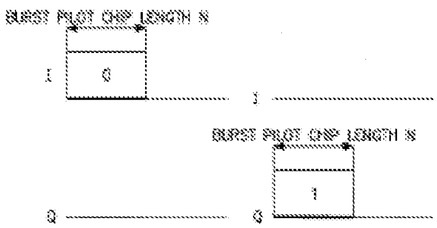
BURST PILOT CHIP LENGTH N
I
0
Q
I
BURST PILOT CHIP LENGTH N
1
Q

FIG. 3B

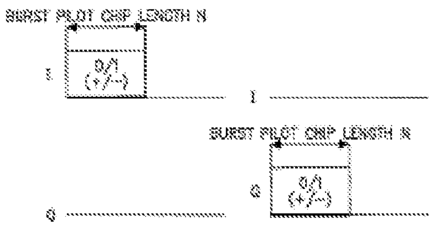
BURST PILOT CHIP LENGTH N
I
0/1
(+/-)
I
BURST PILOT CHIP LENGTH N
Q
0/1
(+/-)
Q

FIG. 3C

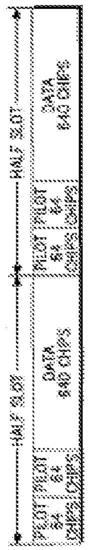
HALF SLOT
HALF SLOT
PILOT 64 CHIPS
PILOT 64 CHIPS
DATA 640 CHIPS
PILOT 64 CHIPS
PILOT 64 CHIPS
DATA 640 CHIPS

FIG. 4

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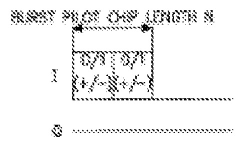


FIG. 5A

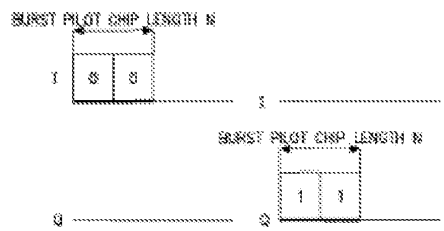


FIG. 5B

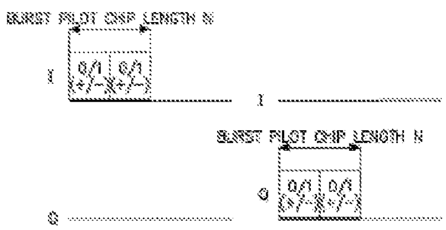
BURST PILOT CHIP LENGTH N
I
0/1
(+/-)
0/1
(+/-)
I
BURST PILOT CHIP LENGTH N
Q
0/1
(+/-)
0/1
(+/-)
Q

FIG. 5C

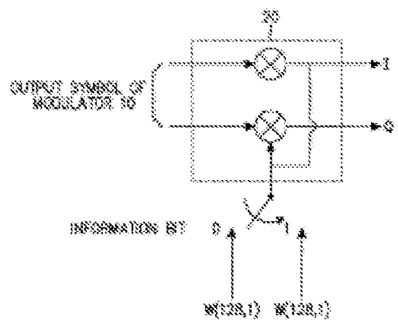


FIG. 6A

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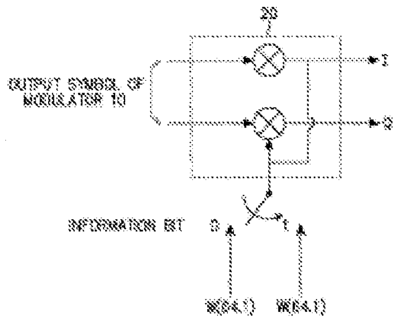


FIG. 6B

【国際調査報告】

INTERNATIONAL SEARCH REPORT

International application No. [illegible]

A. CLASSIFICATION OF SUBJECT MATTER

[illegible]

B. FIELDS SEARCHED

[illegible]

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
| --- | --- | --- |
| PX | [illegible] | 1, 3, 6 |
| PX | [illegible] | 1 |
| A | [illegible] | 1, 3, 6 |
| A | [illegible] | 1, 3, 6 |
| A | [illegible] | 1 |

[illegible]

## INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
[illegible]

| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
| --- | --- | --- | --- |
| US [illegible] A | [illegible] | none | |
| US [illegible] A | [illegible] | EP [illegible] | [illegible] |
| US [illegible] A | [illegible] | none | |
| US [illegible] A | [illegible] | EP [illegible] | [illegible] |
| US [illegible] A | [illegible] May [illegible] | EP [illegible] | [illegible] |

Form PCT/ISA/210 (patent family annex) [illegible]

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ZTE/SAMSUNG 1005-0620

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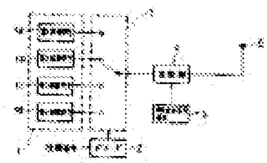
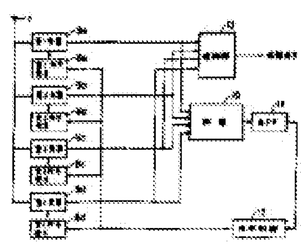
(21)Application number : **02-138759**
(22)Date of filing : **28.05.1990**

(71)Applicant : **SANYO ELECTRIC CO LTD**
(72)Inventor : **HIRAMATSU TATSUO**

(54) **SPREAD SPECTRUM COMMUNICATION SYSTEM**

(57)Abstract:
PURPOSE: To improve S/N by constituting this system with a 1st equipment having a transmission means, a means receiving a spread spectrum signal, M-sets of code generating means, a means adding outputs of M inverse spread means and a 2nd equipment having a phase control means for a spread code.
CONSTITUTION: A decoder 2 outputs a signal selecting a spread code in response to transmission information, a spread code outputted from a selective circuit 3 is fed to a spread section 4 and a spread spectrum signal is sent via a trans mission antenna 6. A reception side multiplyes a spread spectrum signal received by a reception antenna 7 with codes from 1st - 4th code generating sections 8a - 8d to apply inverse spread processing to the spread spectrum signal.





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⑲日本国特許庁（JP）　⑪特許出願公開

⑫公開特許公報（A）　平4－35332

⑤Int. Cl.⁵　識別記号　庁内整理番号　㊸公開　平成4年(1992)2月6日
H 04 J 13/00　A　7117－5K

審査請求　未請求　請求項の数　1　（全5頁）

㉔発明の名称　スペクトラム拡散通信システム

㉑特　願　平2－138759
㉒出　願　平2(1990)5月28日

㉒発明者　平松　達夫　大阪府守口市京阪本通2丁目18番地　三洋電機株式会社内
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明　細　書

1．発明の名称

スペクトラム拡散通信システム

2．特許請求の範囲

（1）異なるM個の拡散符号を発生する拡散符号発生手段、この拡散符号発生手段からのM個の拡散符号が供給され、情報信号に応じて1つの拡散符号を選択する選択手段、この選択手段にて選択された拡散符号と搬送波信号発生手段からの搬送波信号に関する信号とに基づき搬送波信号のスペクトラムを拡散するスペクトラム拡散手段、このスペクトラム拡散手段からのスペクトラム拡散信号を送信する送信手段を有する第1の装置と、

前記送信手段からのスペクトラム拡散信号を受信する受信手段、前記拡散符号発生手段から出力される各拡散符号と同一若しくは相関の大きいM個の符号を発生する符号発生手段、前記受信手段からの受信信号と前記符号発生手段からの各拡散符号とに基づき受信信号のスペクトラムを逆拡散するM個の逆拡散手段、このM個の逆拡散手段の出力を加算する加算手段、この加算手段の出力端に接続されたフィルタ手段、このフィルタ手段の出力に基づき前記符号発生手段から出力される拡散符号の位相を制御する位相制御手段を有する第2の装置とよりなるスペクトラム拡散通信システム。

3．発明の詳細な説明

（イ）産業上の利用分野

本発明はスペクトラム拡散通信システムに関する。

（ロ）従来の技術

従来、情報信号よりも充分広いスペクトラム幅を有する、例えば2進の疑似雑音符号（Pseudo Noise Code）（以下、PN符号と称す）でスペクトラムが拡散された搬送波信号を送信し、受信側では送信側で用いたのと同一のPN符号で受信信号を乗算することにより元の情報を復調する、所謂スペクトラム拡散通信が知られている（例えば、電子科学1978年11月号参照）。

また、近年では周波数利用効率の優れたものと

して、Ｍ－ａｒｙ方式によるスペクトル拡散通信方式が提案されている（例えば、電子情報通信学会ＳＳＴＡ８９－３７；１９８９年１１月８、９日参照）。

此種Ｍ－ａｒｙ方式について簡単に説明すると、送信側に各々符号長及び発生速度が同一で且つ符号間で同期がとれている、異なるＭ個の拡散符号を発生する拡散符号発生器を設け、この拡散符号発生器からの拡散符号を情報信号に応じて選択し、この選択された拡散符号にて搬送波信号のスペクトラムを拡散して送信する。

一方、受信側では、前記拡散符号発生器からの各拡散符号と同じ若しくは相関の大きい、Ｍ個の符号を発生する符号発生器とを設け、受信信号と符号発生器からの符号とを各々乗算することにより、受信信号のスペクトラムを逆拡散する。

このとき、受信信号に含まれる拡散符号と同一若しくは相関の大きい符号が供給される乗算器の出力にのみ搬送波信号が再生されるので、この搬送波信号を検出することにより情報信号を復元することができる。

（ハ） 発明が解決しようとする課題

ところで、スペクトラム拡散通信では、受信側で情報信号を正確に再生するためには、受信側で発生する符号を送信側の符号と同期させることが不可欠である。

上述したＭ－ａｒｙ方式では、情報によって送信される符号系列が異なり、これを用いて同期確立を行なうことは難しいため、別途同期用の符号系列を同一帯域で同時に送るようにしている。

然し乍ら、この場合送信電力の一部を同期系列に割り与えるので、情報信号の拡散用系列のＳ／Ｎが少し下がり、復調時のデータ誤り率の増加を招いたり、同期用系列の電力が小さいと、同期補促に時間がかかるという問題を有していた。

（ニ） 課題を解決するための手段

上記の点に鑑み、本発明は異なるＭ個の拡散符号を発生する拡散符号発生手段、この拡散符号発生手段からのＭ個の拡散符号が供給され、情報信号に応じて１つの拡散符号を選択する選択手段、この選択手段にて選択された拡散符号と搬送波信号発生手段からの搬送波信号とに基づき搬送波信号のスペクトラムを搬送するスペクトラム拡散手段、このスペクトラム拡散手段からのスペクトラム拡散信号を送信する送信手段を有する第１の装置と、前記送信手段からのスペクトラム拡散信号を受信する受信手段、前記拡散符号発生手段から出力される各拡散符号と同一若しくは相関の大きいＭ個の符号を発生する符号発生手段、前記受信手段からの受信信号と前記符号発生手段からの各拡散符号とに基づき受信信号のスペクトラムを逆拡散するＭ個の逆拡散手段、このＭ個の逆拡散手段の出力を加算する加算手段、この加算手段の出力端に接続されたフィルタ手段、このフィルタ手段の出力に基づき前記符号発生手段から出力される拡散符号の位相を制御する位相制御手段を有する第２の装置とよりなることを特徴とする。

（ホ） 作用

本発明に依れば、拡散符号発生手段からのＭ個の拡散符号の内、１つを情報信号に応じて選択してこの選択された拡散符号にて搬送波信号のスペクトラムを拡散して送信し、受信側では、前記拡散符号発生手段からの拡散符号と同一若しくは相関の大きい、Ｍ個の符号を発生させ、この符号と受信信号とに基づき受信信号のスペクトラムを逆拡散する。次いで、この逆拡散された信号を加算し、フィルタを通過させることにより位相制御情報を抽出してこの位相制御情報に基づき符号発生手段から出力される符号の位相を制御する。

（へ） 実施例

第１図は本発明システムに係る送信機の一実施例を示す図である。第１図において、(１)は異なるＭ個（図示の場合では、４個）の拡散符号を発生する拡散符号発生器で、第１拡散符号（ＰＮ１）を発生する第１拡散符号発生部（１ａ）と、第２拡散符号（ＰＮ２）を発生する第２拡散符号発生部（１ｂ）と、第３拡散符号（ＰＮ３）を発生する第３拡散符号発生部（１ｃ）と、第４拡散符号（ＰＮ４）を発生する第４拡散符号発生部（１ｄ）とより構成されている。尚、各拡散符号

の符号長、発生速度は全く同じであり、また各符号間では同期が完全にとれているものとする。(2)は情報信号に応じて選択信号を出力するデコーダ、(3)は第1～第4拡散符号発生部からの拡散符号の内、1つの拡散符号をデコーダ(2)からの選択信号に応じて選択する選択回路、(4)は選択回路(3)にて選択された拡散符号と搬送波信号発生回路(5)からの搬送波信号とに基づき搬送波信号のスペクトラムを拡散する拡散部で、乗算器より構成されている。(6)はスペクトラム拡散された信号を送信する送信アンテナである。

第2図は本発明システムに係る受信機の一実施例を示す図である。第2図において、(7)は受信アンテナ、(8a)は第1拡散符号発生部(1a)からの第1拡散符号(PN1)と同一若しくは相関の大きい第1符号(PN1')を発生する第1符号発生部、(8b)は第2拡散符号発生部(1b)からの第2拡散符号(PN2)と同一若しくは相関の大きい第2符号(PN2')を発生する第2符号発生部、(8c)は第3拡散発生部(1c)からの第3拡散符号発生部(PN3)と同一若しくは相関の大きい第3符号(PN')を発生する第3符号発生部、(8d)は第4拡散符号発生部(1d)からの第4拡散符号(PN4)と同一若しくは相関の大きい第4符号(PN4')を発生する第4符号発生部である。この第1～第4符号発生部にて符号発生器を構成しており、各符号は符号長、発生速度が同一で、然も同期しているものとする。(9a)は受信信号と第1符号(PN1')とを乗算する第1乗算器、(9b)は受信信号と第2符号(PN2')とを乗算する第2乗算器、(9c)は受信信号と第3符号(PN3')とを乗算する第3乗算器、(9d)は受信信号と第4符号(PN4')とを乗算する第4乗算器、(10)は第1～第4乗算器(9a)～(9d)の出力を加算する加算器、(11)は加算器(10)の出力端に接続され、搬送波信号成分を通過させるバンドパスフィルタ、(12)はバンドパスフィルタ(11)を通過した信号に基づき符号発生部から出力される符号の位相を制御する位相制御回路で、タウ・ディザ回路や遅延ロックループ回路である。(13)は情報信号を復調する復調部である。

次に、動作について説明する。

今、伝達すべき情報が「00」、「01」、「10」、「11」の4つであったとすると、デコーダ(2)は前記情報に応じて拡散符号を選択する選択信号を出力する。即ち、情報「00」のとき、第1拡散符号(PN1)を選択する信号を、情報「01」のとき、第2拡散符号(PN2)を選択する信号を、情報「10」のとき、第3拡散符号(PN3)を選択する信号「11」のとき、第4拡散符号(PN4)を選択する信号を出力する。

情報が上述した順番に発生すると、選択回路(3)から出力される符号は、第3図に示す如く第1拡散符号(PN1)、第2拡散符号(PN2)第3拡散符号(PN3)、第4拡散符号(PN4)の順になる。

斯様に選択回路(3)で選択された拡散符号は、拡散部(4)に供給され、拡散部(4)において搬送波信号発生回路(5)からの搬送波信号と乗算される。その結果、搬送波信号のスペクトラムが拡散される。斯るスペクトラム拡散信号は、送信アンテナ(6)を介して送信される。

一方、受信側では、受信アンテナ(7)にて受信されたスペクトラム拡散信号と第1～第4符号発生部(8a)～(8d)からの符号とを各々乗算し、前記スペクトラム拡散信号を逆拡散する。

今、受信側符号と送信側符号とが同期し、且つスペクトラム拡散信号に含まれる符号系列が第4図(a)に示す如くなっていたとすると、このスペクトラム拡散信号と第1符号とを乗算する第1乗算器(9a)の出力端には、第4図(c)に示す如く、受信信号に含まれる第1拡散符号の期間だけ搬送波信号が再生される。尚、第2拡散符号～第4拡散符号の期間には、各拡散符号にてスペクトラム拡散されている信号が第1符号(PN1')にて更にスペクトラムが拡散されることになり、搬送波信号は再生されない。

以下、同様に第2乗算器(9b)の出力端に

は、第2拡散符号の期間だけ、第3乗算器(9c)の出力端には、第3拡散符号の期間だけ、第4乗算器(9d)の出力端には、第4拡散符号の期間だけ搬送波信号が再生される〔第4図(e)(g)(i)参照〕。

而して、加算器(10)の出力端には、搬送波信号が略連続して出力されることになり、これをBPF(11)を通過させることにより不要信号成分を除去した後、位相制御回路(12)に供給することにより符号発生器から発生される符号の位相を制御することが可能になる。

即ち、BPF(11)の出力は、従来の単一符号系列にてスペクトラム拡散した場合と同様に、送信側符号と受信側符号との位相関係に応じてレベルが変化するため、このレベル変化を利用して位相制御を達成することが出来る。

尚、受信側符号と送信側符号との同期点の検出は、従来と同様に受信側符号の位相を順次変化させることにより達成されるものとする。

上述の如く本発明の動作は達成されるが、本発明は上記実施例に限定されるものではなく、変調された、搬送波信号をスペクトラム拡散する等種々変更が可能であり、また使用される符号系列も4つに限定されるものではない。

(ト) 発明の効果

本発明に依れば、拡散符号発生手段からのM個の拡散符号の内、1つを情報信号に応じて選択して、この選択された拡散符号にてスペクトラム拡散された信号を送信し、受信側では、M個の符号と受信信号とを各々乗算し、その乗算出力を加算して得られた信号に基づき位相制御を行なうようにしたので、格別に同期制御用の符号系列を送る必要がなく、情報信号の拡散用系列のS／Nの向上を計れる。同時に、システム全体の構成が簡単になり、コストの低減が計れる。

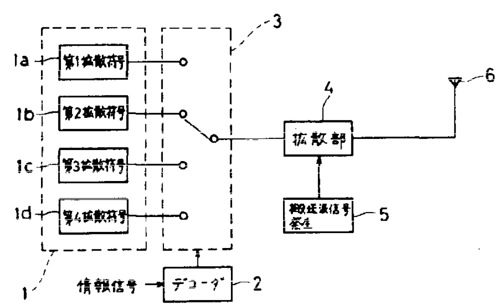
4．図面の簡単な説明

第1図は本発明システムの送信側を示す図、第2図は本発明システムの受信側を示す図、第3図(a)(b)は送信側の動作を説明するための図、第4図は受信側の動作を説明するための各部波形図である。

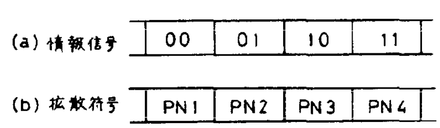
(1)…拡散符号発生器、(2)…デコーダ、(3)…選択回路、(4)…拡散部、(5)…搬送波信号発生回路、(6)…送信アンテナ(送信手段)、(7)…受信アンテナ(受信手段)、(8a)(8b)(8c)(8d)…符号発生部、(9a)(9b)(9c)(9d)…乗算器、(10)…加算器、(11)…BPF、(12)…位相制御回路、(13)…復調部。

出願人　三洋電機株式会社
代理人　弁理士　西野卓嗣(外2名)

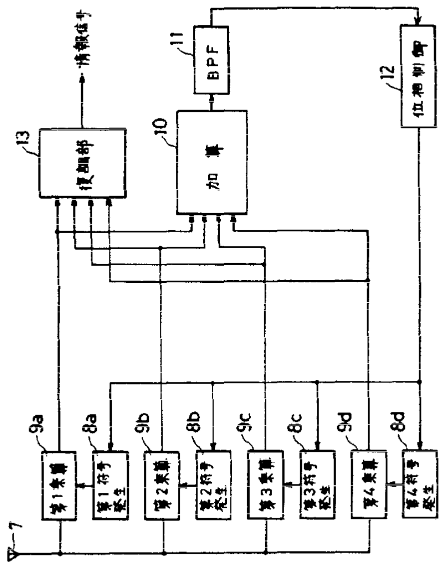
第1図



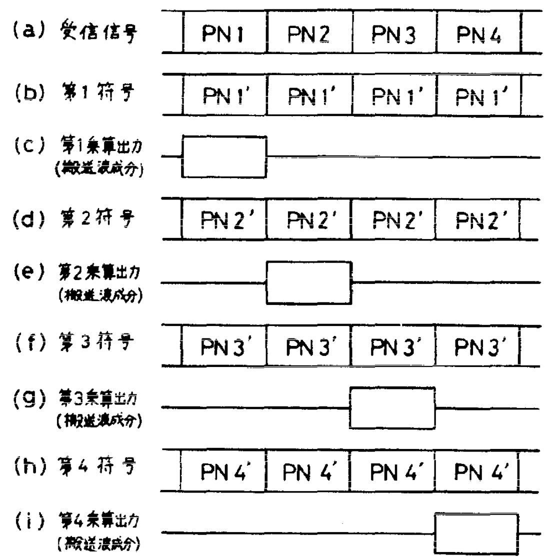

第3図



第2図


情報信号
11
BPF
12
位相制御
13
復調部
10
加算
7
9a
8a
9b
8b
9c
8c
9d
8d
第1乗算
第1符号発生
第2乗算
第2符号発生
第3乗算
第3符号発生
第4乗算
第4符号発生

第4図


(a) 受信信号
PN1 PN2 PN3 PN4
(b) 第1符号
PN1' PN1' PN1' PN1'
(c) 第1乗算出力
(搬送波成分)
(d) 第2符号
PN2' PN2' PN2' PN2'
(e) 第2乗算出力
(搬送波成分)
(f) 第3符号
PN3' PN3' PN3' PN3'
(g) 第3乗算出力
(搬送波成分)
(h) 第4符号
PN4' PN4' PN4' PN4'
(i) 第4乗算出力
(搬送波成分)

Espacenet

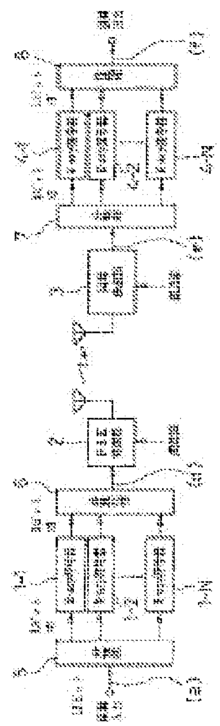
# Bibliographic data: JP11154929 (A) — 1999-06-08

**DIGITAL MODULATION DEMODULATION SYSTEM FOR RADIO COMMUNICATION**


| | | |
|---|---|---|
| **Inventor(s):** | YAMAO YASUSHI; ITOU SHIYOUGO; OKUBO SHINZO; SHIMADA KOHARUTO; ADACHI FUMIYUKI + | |
| **Applicant(s):** | NIPPON TELEGRAPH & TELEPHONE + | |
| **Classification:** | **- international:** | ***H04J13/00; H04L27/00;*** (IPC1-7): H04J13/00; H04L27/00 |
| | **- European:** | |
| **Application number:** | JP19970319939 19971120 | |
| **Priority number (s):** | JP19970319939 19971120 | |


**Abstract of JP11154929 (A)**

PROBLEM TO BE SOLVED: To provide a digital modulation demodulation system for radio communication where error hardly takes place in fading while keeping a feature of the M-ary modulation demodulation system immune to interference. SOLUTION: A division section 5 divides transmission information into blocks each consisting of LN bits and further divides each block into N L-bits information series. Each M-ary coder 2 generates an M-ary orthogonal code for each L-bits information series. N-sets of orthogonal codes per block are multiplexed, each orthogonal code is spreaded into a length multiplica by N on a time base, and the carrier is digitally modulated by the multiplexed signal in order to be transmitted. A synchronization detector 3 at a receiver side detects a reception signal, a detection output is demultiplexed into N-sets of orthogonal codes, each M-ary decoder 4 determines correlation of each orthogonal code and discriminates an orthogonal code having the highest correlation, and the signal is demodulated. The L-bits information series corresponding to the orthogonal code are outputted, and the outputted N L-bits information series are restored to a signal in LN bits per reception unit.



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| H04J 13/00 | | H04J 13/00 | A |
| H04L 27/00 | | H04L 27/00 | Z |

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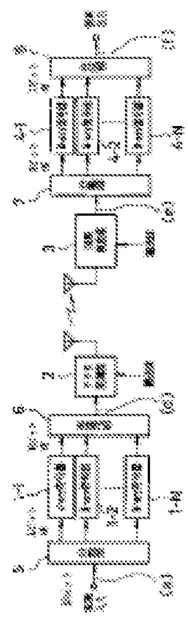
最終頁に続く

(54)【発明の名称】　無線通信用ディジタル変復調方式

(57)【要約】
【課題】　干渉に強いM−ary変復調方式の特徴を保持しつつ、フェージングに対しても誤りの発生しにくい無線通信用ディジタル変復調方式を提供する。
【解決手段】　送信情報を分割部5でLNビットずつにブロック化し、各ブロックをN個のLビット情報系列に分割し、各M−ary符号器1で各Lビット情報系列に対してM−aryの直交符号を発生し、ブロック当りN個の直交符号を多重化して各直交符号を時間軸上でN倍の長さに拡散し、該多重化信号で搬送波をディジタル変調して送信し、受信側では同期検波器3で受信信号を検波し、検波出力をN個の直交符号に分離し、各M−ary復号器4は各直交符号の相互相関を求め、最も相関の高い直交符号を判定して信号を復調し、該直交符号に対応したLビット情報系列を出力し、この出力される受信単位当りN個のLビット情報系列をLNビットの信号に復元する。



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【特許請求の範囲】

【請求項1】　送信側と受信側の間で無線通信を行う場合の無線通信用ディジタル変復調方式であって、

送信側は、送信情報を予めＬＮビット（Ｌ，Ｎは２以上の自然数）ずつのブロックとし、それぞれのブロックをＮ個のＬビット情報系列に分割する分割手段と、Ｌビット情報系列をＬビットの符号として見た場合に各符号に対して一意に定めたＭビット長の直交符号を発生する符号化手段と、該符号化手段から出力されるブロック当りＮ個の直交符号を多重化する多重化手段と、この多重化された信号で搬送波をディジタル変調する変調手段とを有し、

受信側は、送信側から受信した信号を検波する検波手段と、該検波手段からの検波出力を送信側での多重化に同期したＮＭビット時間長の受信単位とし、それぞれの受信単位をＮ個のＭビット系列に分離する分離手段と、各Ｍビット系列に対して送信側で定めたすべての種類の直交符号との相互相関を求め、最も相関の高い直交符号を判定する相関検出手段と、該相関検出手段で判定された直交符号に対応したＬビット情報系列を出力する復号手段と、該復号手段から出力される受信単位当りＮ個のＬビット情報系列を送信側と逆の操作によりＬＮビットの信号に復元する合成手段とを有することを特徴とする無線通信用ディジタル変復調方式。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、移動通信等の端末と基地局間で無線通信を行う場合の無線通信用ディジタル変復調方式に関し、特にフェージングによる受信信号強度の変動に強く、誤りの発生を軽減し得る無線通信用ディジタル変復調方式に関する。

【０００２】

【従来の技術】従来、移動通信など端末と基地局間で無線通信を行う場合のディジタル変復調方式としては様々な方式が知られているが、最近、注目されている方式に、直交符号によるＭ－ａｒｙ変復調方式がある。Ｍ－ａｒｙ変復調方式については、例えば、「横山光雄著"スペクトル拡散通信システム"第１９７ページ～２１９ページ、科学技術出版社発行１９８８年」に記述されている。

【０００３】図９は従来のＭ－ａｒｙ変復調方式のブロック構成例であり、１はＭ－ａｒｙ符号器、２はＰＳＫ変調器、３は同期検波器、４はＭ－ａｒｙ復号器である。変調入力端子に入力されたディジタル信号は、予めＬビット（Ｌは２以上の自然数）ずつにブロック化され、このＬビット情報系列をＬビット符号として見た場合に各符号に対して一意に定めたＭ＝$2^L$ ビット長の直交符号をＭ－ａｒｙ符号器１から発生する。例えば、図１０に示した例（Ｌ＝２）では、Ｍ＝４となる。この場合、入力された情報２ビット（ａ１，ａ２）は同図の変換規則により、４ビット長の直交符号Ｃ１～Ｃ４のいずれかに変換されて出力される。この直交符号でＰＳＫ変調器２は搬送波を２相位相変調（ＢＰＳＫ）する。受信側では、同期検波器３で信号を検波し、Ｍ－ａｒｙ復号器４は検波した信号に対して考えられる全ての直交符号Ｃ１～Ｃ４を掛け算して相互相関値を算出する。この結果、最も相関値の高い直交符号を受信信号と判定する。更にＭ－ａｒｙ復号器４では判定された直交符号に対応する源情報２ビットを図１０の変換規則により出力する。

【０００４】なお、直交符号としては、通常の直交符号の他、階直交符号も使用できることが知られており（例えば、「横山光雄著"スペクトル拡散通信システム"第２０３ページ～２１３ページ、科学技術出版社発行１９８８年」）、この場合Ｍ＝$2^{L-1}$ （Ｌ≧３）となる。

【０００５】Ｍ－ａｒｙ変復調方式では、異なる入力情報に対しては互いに直交する符号を用いるので、信号間の相互相関が０となる。これにより同一チャネル干渉が少ないという特徴を持つ。この特徴は、ＣＤＭＡ方式のように、同一周波数で複数の信号を多重化する場合の変復調方式として都合が良い。

【０００６】しかしながら、移動通信環境では、フェージングによる受信電力の落ち込みが頻繁に発生し、熱雑音および急激な搬送波位相の回転によるバースト誤りが一般的に発生する。図１１は、図１０に示した例（Ｌ＝２）におけるフェージング時の誤りの発生の様子を示す。図１１において、フェージングによる受信電力の落ち込み時間$T_f$ が複数ビットに渡る場合、フェージングの落ち込みに遭遇した直交符号（図１１では斜線で示す）は熱雑音によって相関検出が困難となる。この結果、別の直交符号として誤って復号される可能性が高く、その場合、Ｌビット程度の長さのバースト誤りが発生する。

【０００７】

【発明が解決しようとする課題】上述したように、従来のＭ－ａｒｙ変復調方式では、フェージングによる受信電力の落ち込みによってバースト誤りが発生するという問題がある。

【０００８】本発明は、上記に鑑みてなされたもので、その目的とするところは、干渉に強いＭ－ａｒｙ変復調方式の特徴を保持しつつ、フェージングに対しても誤りの発生しにくい無線通信用ディジタル変復調方式を提供することにある。

【０００９】

【課題を解決するための手段】上記目的を達成するため、請求項１記載の本発明は、送信側と受信側の間で無線通信を行う場合の無線通信用ディジタル変復調方式であって、送信側が、送信情報を予めＬＮビット（Ｌ，Ｎは２以上の自然数）ずつのブロックとし、それぞれのブロックをＮ個のＬビット情報系列に分割する分割手段

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と、Ｌビット情報系列をＬビットの符号として見た場合に各符号に対して一意に定めたＭビット長の直交符号を発生する符号化手段と、該符号化手段から出力されるブロック当りＮ個の直交符号を多重化する多重化手段と、この多重化された信号で搬送波をディジタル変調する変調手段とを有し、受信側が、送信側から受信した信号を検波する検波手段と、該検波手段からの検波出力を送信側での多重化に同期したＮＭビット時間長の受信単位とし、それぞれの受信単位をＮ個のＭビット系列に分離する分離手段と、各Ｍビット系列に対して送信側で定めたすべての種類の直交符号との相互相関を求め、最も相関の高い直交符号を判定する相関検出手段と、該相関検出手段で判定された直交符号に対応したＬビット情報系列を出力する復号手段と、該復号手段から出力される受信単位当りＮ個のＬビット情報系列を送信側と逆の操作によりＬＮビットの信号に復元する合成手段とを有することを要旨とする。

【0010】請求項1記載の本発明にあっては、送信側で送信情報をＬＮビットずつにブロック化し、各ブロックをＮ個のＬビット情報系列に分割し、符号化手段でそれぞれのＬビット情報系列に対してＭ－ａｒｙの直交符号を発生し、この結果のブロック当りＮ個の直交符号を多重化して各直交符号を時間軸上でＮ倍の長さに拡散し、この多重化された信号で搬送波をディジタル変調して送信する。受信側では受信信号を検波し、検波出力を送信側での多重化に同期するような受信単位でＮ個の直交符号（雑音を含む）に分離し、この分離された各直交符号と送信側で定めた全ての種類の直交符号との相互相関を求め、最も相関の高い直交符号を判定して信号を復調し、判定された直交符号に対応した元のＬビット情報系列を出力し、この出力される受信単位当りＮ個のＬビット情報系列を送信側と逆の操作によりＬＮビットの信号に復元する。

【0011】

【発明の実施の形態】以下、図面を用いて本発明の実施の形態について説明する。

【0012】図1は、本発明の第1の実施形態に係る無線通信用ディジタル変復調方式の構成を示すブロック図である。同図において、5は送信すべき情報ＬＮビットをＮ個のＬビット情報系列に分割する分割部、1－1～1－ＮはＮ系列のＭ－ａｒｙ符号器、6はＮ個の直交符号を多重化する多重化部、2はＰＳＫ変調器、3は同期検波器、7は検波信号をＮ個のＭビット系列に分離する分離部、4－1～4－ＮはＮ系列のＭ－ａｒｙ復号器、8はＮ個のＬビット情報系列を送信側と逆の操作によりＬＮビットの信号に復元する合成部である。

【0013】図1において、変調入力端子に入力されたディジタル信号は、分割部5においてＬＮビット（Ｌ、Ｎは2以上の自然数）ずつにブロック化され、各ブロックはさらにＮ個のＬビット情報系列に分割されて出力され、それぞれがＭ－ａｒｙ符号器1－1～1－Ｎへ入力される。次にＭ－ａｒｙ符号器1－1～1－Ｎでは、入力に対してそれぞれ対応するＭ－ａｒｙの直交符号を従来技術の場合と同様に発生する。例えば、Ｌ＝2で通常の直交符号を使用した場合、Ｍ－ａｒｙ符号器1－ｋ（1≦ｋ≦Ｎ）に入力された情報2ビット（ａ1、ａ2）は、図10の変換規則により、4ビット長の直交符号Ｃ1～Ｃ4のいずれかに変換されて出力される。また直交符号として、通常の直交符号の他、陪直交符号も使用でき、$M=2^{L-1}$（Ｌ≧3）となることは従来技術の説明で述べたとおりである。この結果得られたＮ個の直交符号を多重化部6が多重化する。多重化部6の出力はＰＳＫ変調器2に入力され、搬送波を位相変調する。

【0014】ＰＳＫ変調器2の入力までの信号処理の詳細の例を図2に示す。図2はＬ＝2、Ｎ＝4、Ｍ＝4の場合の例である。入力信号（ａ）は分割部5において、8ビットずつにブロック化され、この8ビットは2ビットずつの4系列に分割されてＭ－ａｒｙ符号器1－1～1－4へ入力される。8ビットを4系列に分割する方法は任意であり、図では入力された順番に2ビットずつまとめて系列を作る例を示している。多重化部6では、4つのＭ－ａｒｙ符号器から出力された信号をビット単位で多重化する。すなわち、Ｍ－ａｒｙ符号器1－1から出力された4ビット長の直交符号は、図2の（ｄ）の斜線でハッチングした4ケ所（ｂ11，ｂ12，ｂ13，ｂ14）に配置され、Ｍ－ａｒｙ符号器1－2から出力された4ビット長の直交符号は、それぞれ1ビットずれた4ケ所（ｂ21，ｂ22，ｂ23，ｂ24）に配置される。

【0015】受信側では、同期検波器3で信号を検波する。検波された信号は分離部7に入力され、送信側での多重化に同期したＮＭビット時間長の受信単位とされる。更に分離部7は、それぞれの受信単位をＮ個のＭビット系列に分離して出力する。このＮ個の出力はそれぞれＭ－ａｒｙ復号器4－1～4－Ｎへ入力される。次にＭ－ａｒｙ復号器4－1～4－Ｎでは、入力された検波信号に対して考えられる全ての直交符号を掛け算して相互相関値を算出する。この結果、最も相関値の高い直交符号を受信信号と判定する。更にＭ－ａｒｙ復号器では判定された直交符号に対応する原情報Ｌビットを送信側で用いた変換規則により出力する。合成部8は全てのＭ－ａｒｙ復号器から出力されたＮ個のＬビット情報系列を送信側と逆の操作によりＬＮビットの信号に復元する。

【0016】同期検波器3の出力以降の信号処理の詳細の例を図3に示す。図3は図2に対応する例である。4多重された検波器出力（ｅ）は、分離部7において、送信側の多重化部6と逆の操作により、4系列の信号に分離される。分離された4系列の信号はそれぞれＭ－ａｒｙ復号器4－1～4－4へ入力される。Ｍ－ａｒｙ復号

器4－1～4－4では、入力に対して最も相関値の高い直交符号を受信信号と判定し、判定された直交符号に対応する源情報2ビットを送信側で用いた変換規則（図10）により出力する。M－ary復号器4－1～4－4から出力された4系列の2ビット情報は合成部8で送信側と逆の操作により8ビットの信号に復元される。

【0017】次に、フェージングによる受信電力の落ち込みに対して、本実施形態では誤りが発生しにくいことを説明する。図2において斜線でハッチングした入力情報ビットa1（またはa2）に対応する直交符号4ビットは、変調器入力（d）ではb11～b14の位置に時間拡散されて配置されている。このため、図3に示したフェージングによる受信電力の落ち込み時間$T_f$（$T_f$は図11と同一とする）内にはb14の1ビットのみが遭遇する。このため、相関検出時に異なる直交符号に誤って判定される確率が小さい。これに対して従来例の図11では、1つの直交符号の4ビットが連続して配置されていたために、フェージングによる受信電力の落ち込み時間内に複数ビット（図示では4ビット）が遭遇するので、誤判定の確率が大きい。

【0018】図1では、変復調方式としてPSK同期検波を示した。しかしながらフェージング環境では単に受信電力の落ち込みが発生するだけでなく、急激な搬送波位相の回転が起こるので、PSK同期検波では急激な搬送波位相の回転に追従できず、誤りが多く発生して良好な特性が得られない場合がある。このような場合には、PSK同期検波より、FSKエネルギ検波を用いた方が良好な特性が得られる。FSKエネルギ検波を用いる場合、図中のPSK変調器2の代わりにFSK変調器を用い、同期検波器3の代わりにFSKエネルギ検波器を用いれば、本発明の効果を得ることができる。

【0019】図4は、本発明の第2の実施形態の構成を示すブロック図である。第2の実施形態は、多値の変調方式を用いた場合のものである。図4において、5，1－1～1－Nは第1の実施形態と同様であり、9は多値変調に対応した多重化部、10は多値変調器、11は多値検波器、12は多値変調に対応した分離部、4－1～4－N、8は第1の実施形態と同様である。以下では、本実施形態の動作について、第1の実施形態と異なる多重化部9から分離部12までを主に説明する。

【0020】図4において、変調入力端子から多重化部9の入力までの各部の動作および信号の状態は図1の場合と同一である。多重化部9では、N個の直交符号を多重化して多値数に対応した個数の信号系列を出力する。多重化部9の出力は多値変調器10に入力され、搬送波を多値変調する。多値変調器10の入力までの信号処理の詳細の例を図5に示す。

【0021】図5は図2と同じL＝2，N＝4，M＝4で、多値数が4値の場合の例である。入力信号（a）は分割部5において、8ビットずつにブロック化され、この8ビットは2ビットずつの4系列に分割されてM－ary符号器1－1～1－4へ入力される。多重化部9では、4つのM－ary符号器から出力された信号をビット単位で多重化する。この例ではM－ary符号器1－1と1－3からの信号を多重化して（g1）なる系列を発生し、M－ary符号器1－2と1－4からの信号を多重化して（g2）なる系列を発生している。すなわち、M－ary符号器1－1から出力された4ビット長の直交符号は、図5の（g1）の斜線でハッチングした4ケ所（b11，b12，b13，b14）に配置され、M－ary符号器1－2から出力された4ビット長の直交符号は、（g2）の4ケ所（b21，b22，b23，b24）に配置される。（g1）と（g2）の同時刻の2ビットの情報を1シンボルとして、4値の変調を行うことができる。

【0022】多値変調の一例として、4値FSKエネルギ検波の場合の多値変調器および多値検波器の構成を図6に示す。図6において、13は4値FSK変調器、14は4値FSKエネルギ検波器である。4値FSK変調器13では、変調入力としてg1，g2があり、g1，g2の値に対して表に示す周波数を出力する。4値FSKエネルギ検波器14では、それぞれ中心周波数$f_1$，$f_2$，$f_3$，$f_4$を有する帯域通過フィルタBPF1～BPF4で受信信号をろ波した後、4つの検波出力を得、最も大きな検波出力が得られた周波数に対応する信号2ビットをh1，h2として出力する。

【0023】このようにして多値検波器11から出力された信号$h_j$は分離部12に入力される。多値検波器出力以降の信号処理の詳細の例を図7に示す。

【0024】図7は図5に対応する例である。4多重された検波器出力（h1）と（h2）は、分離部12において、送信側の多重化部9と逆の操作により、4系列の信号に分離される。分離された4系列の信号はそれぞれM－ary復号器4－1～4－4へ入力される。M－ary復号器4－1～4－4では、入力に対して最も相関値の高い直交符号を受信信号と判定し、判定された直交符号に対応する源情報2ビットを送信側で用いた変換規則（図10）により出力する。M－ary復号器4－1～4－4から出力された4系列の2ビット情報は合成部8で送信側と逆の操作により8ビットの信号に復元される。

【0025】次に、フェージングによる受信電力の落ち込みに対して、本実施形態での誤りの影響について説明する。図5において斜線でハッチングした入力情報ビットa1（またはa2）に対応する直交符号4ビットは、変調器入力（g1）ではb11～b14の位置に時間拡散されて配置されている。このため、図7に示したフェージングによる受信電力の落ち込み時間内にはb14の1ビットのみが遭遇する。フェージングによる受信電力の落ち込み時間$T_f$は、図3および図11と同一として

おり、図7のこの結果は、第1の実施形態で説明した結果と同じである。したがって、本実施形態においても、第1の実施形態と同様、相関検出時に異なる直交符号に誤って判定される確率が小さく、従来例に比べてフェージングによるバースト誤りの発生を軽減することが可能となる。

【0026】なお多値数としては、4値の他、8値、16値なども考えられ、変調器入力信号系列（$a_i$）および検波器出力信号系列（$b_i$）の数Hも、3系列（$2^3$＝8値）、4系列（$2^4$＝16値）と増えていく。このとき本発明による時間拡散の効果を得るには、分割数Nを上記系列数H以上の数とすればよい。分割数Nが大きい程、時間拡散の効果は大きく、フェージングによるバースト誤りの発生を著しく軽減することが可能となる。

【0027】多値の変復調方式としては、多値FSKエネルギ検波の他か、多値PSK同期検波や16QAM（直交振幅変調）パイロット同期検波（三瓶政一著“陸上移動通信用16QAMのフェージングひずみ補償方式”、電子情報通信学会論文誌（B－II），vol．J72－B－II，No．1を参照）など、様々な方式が使用可能である。

【0028】また、直交符号長Mが大きい程、時間拡散の効果は大きく、フェージングによるバースト誤りの発生を軽減することが可能となる。

【0029】次に、図8を参照して、本発明の効果の一例を従来技術と比較して説明する。図8に示す例は、L＝4，M＝16、4FSK変調エネルギ検波を用い、最大ドップラー周波数4Hzの条件で200bpsの変調信号を伝送した場合である。横軸は1ビットで規格化した受信S／N比（$E_b$／$N_0$）、縦軸は平均ビット誤り率である。従来の場合に比べ、本発明（N＝8および44）ではビット誤り率が大きく改善されることがわかる。また、Nが大きい程、平均化効果が大きいため、改善効果が大きいことがわかる。

【0030】上述した実施形態で参照した各構成図は本発明による動作原理を説明するための図であり、装置化にあたっては様々な実施形態が可能である。例えば、分割部、M－ary符号器、多重化部、分離部、M－ary復号器、合成部は、ハードウェア（論理回路）によって実現してもよいし、ソフトウェア（プログラム）による実現も可能である。

【0031】

【発明の効果】以上説明したように、本発明によれば、送信すべき直交符号を時間軸上でN倍の長さに拡散してから送信し、受信側では時間拡散された状態で直交符号（雑音を含む）を相関検出することにより、フェージングによる受信電力の落ち込みの影響を回避し、時間軸上で元の信号に復元するので、フェージングによるバースト誤りの発生を軽減することができ、これにより受信所要S／Nを低減できる。この結果、端末送信出力または上り信号の受信に必要な受信局数を低減でき、経済的なシステムを構築し得る。また、CDMA方式に用いた場合、容量を増大することができる。

【図面の簡単な説明】

【図1】本発明の第1の実施形態に係る無線通信用ディジタル変復調方式の構成を示すブロック図である。

【図2】図1に示す実施形態における送信側の信号処理を示す説明図である。

【図3】図1に示す実施形態における受信側の信号処理とフェージング時の誤りの影響の様子を示す説明図である。

【図4】本発明の第2の実施形態に係る無線通信用ディジタル変復調方式の構成を示すブロック図である。

【図5】図4に示す実施形態における送信側の信号処理を示す説明図である。

【図6】図4に示す実施形態に使用されている多値変調器および多値検波器の構成例を示す図である。

【図7】図4に示す実施形態における受信側の信号処理とフェージング時の誤りの影響の様子を示す説明図である。

【図8】本発明の効果例を示すグラフである。

【図9】従来のM－ary変復調方式の構成を示すブロック図である。

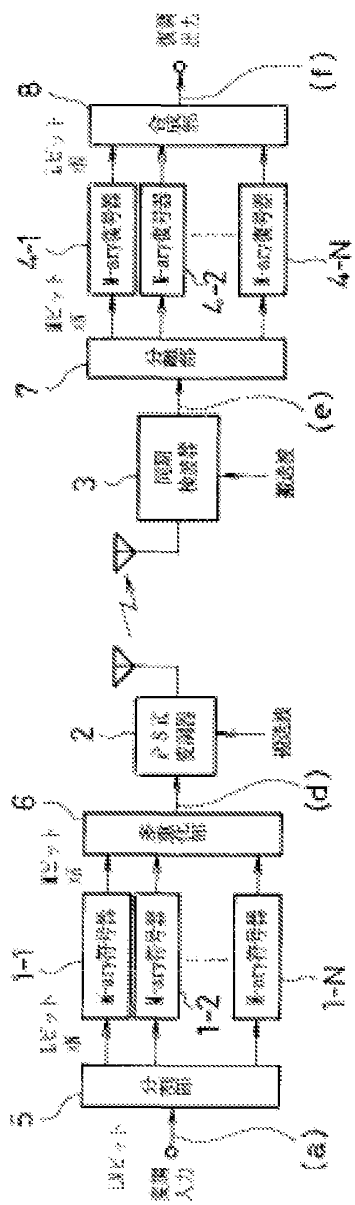
【図10】M－ary符号器における変換規則を示す図である。

【図11】図9に示す従来例におけるフェージング時の誤りの影響の様子を示す説明図である。

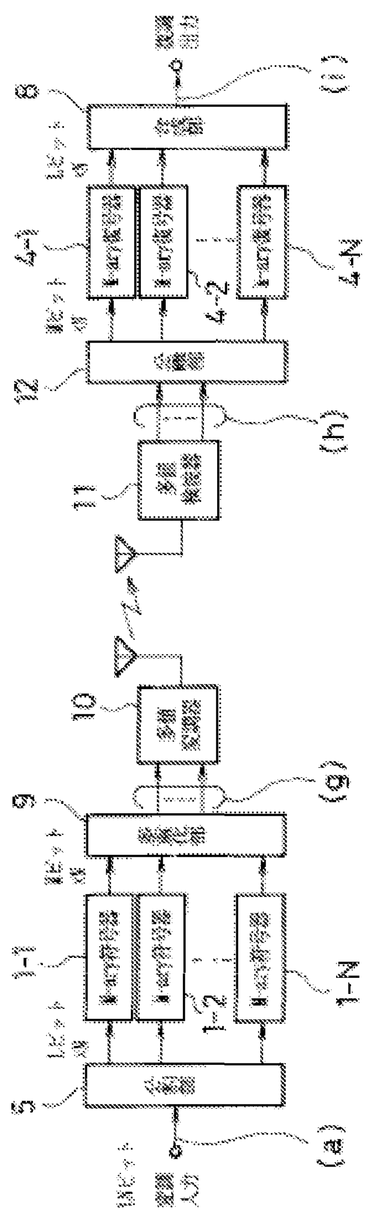
【符号の説明】

1－1～1－N　M－ary符号器
2　PSK変調器
3　PSK同期検波器
4－1～4－N　M－ary復号器
5　分割部
6，9　多重化部
7，12　分離部
8　合成部
10　多値変調器
11　多値検波器

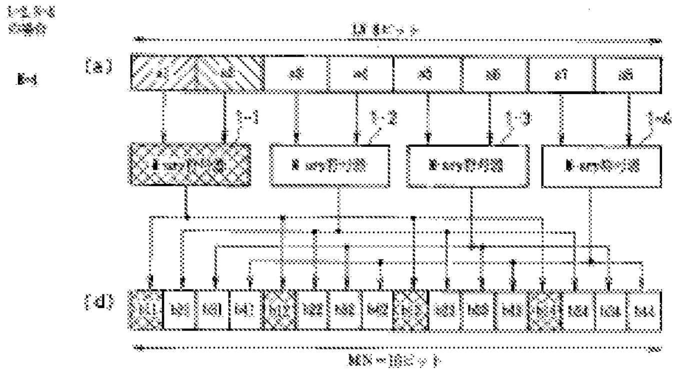
【図1】



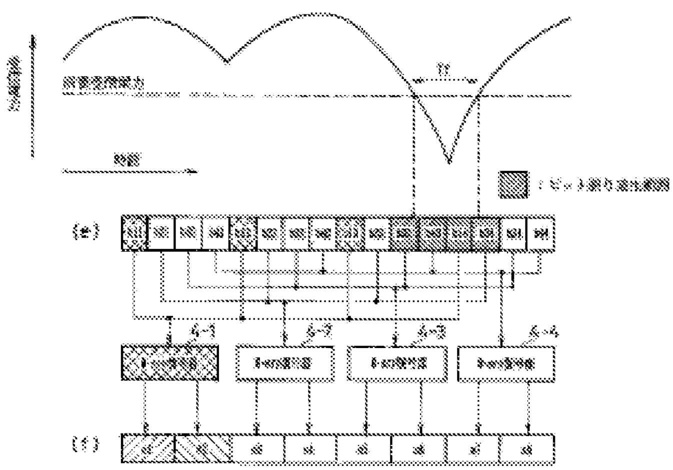

【図4】



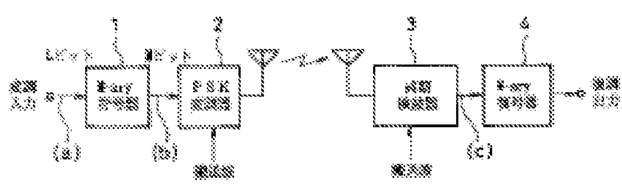
【図2】



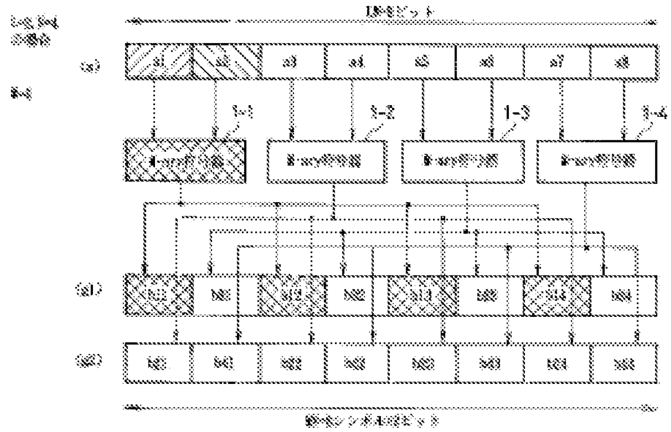
【図3】



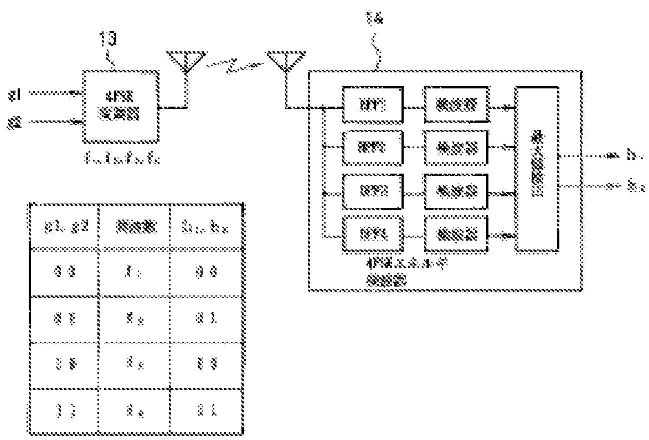
【図9】



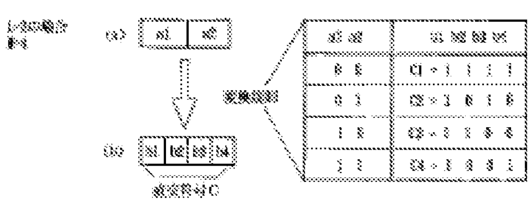
【図5】


(a)
1-1
1-2
1-3
1-4
(d1)
(d2)

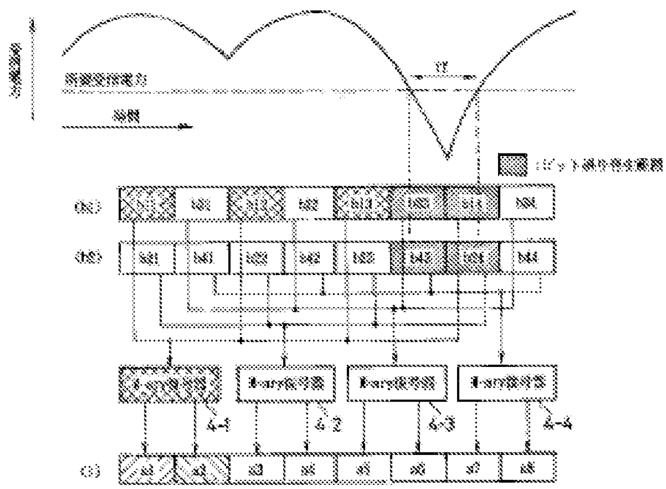
【図6】


13
14
a1
a2
BPF1
BPF2
BPF3
BPF4

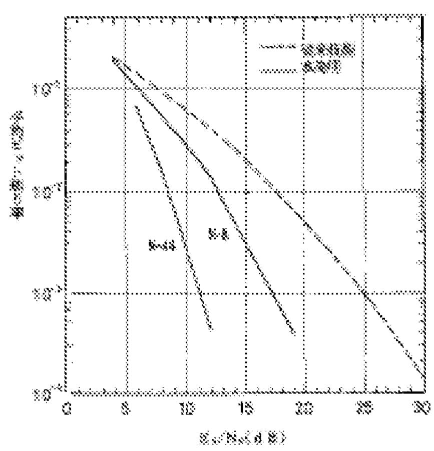
【図10】


(a)
a1
a2
(b)
b1
b2
b3
b4

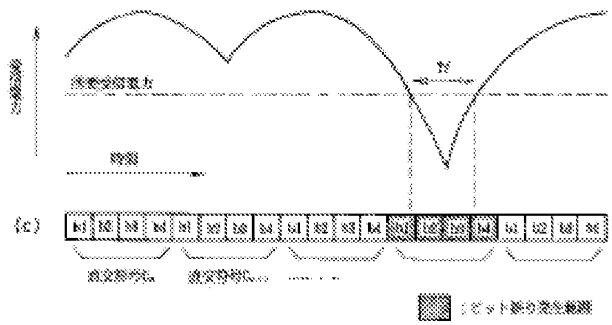
【図7】



【図8】



【図11】




フロントページの続き

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**METHOD FOR GENERATING CODE RELATED TO PREAMBLE IN RANDOM ACCESS CHANNEL**


| | | |
|---|---|---|
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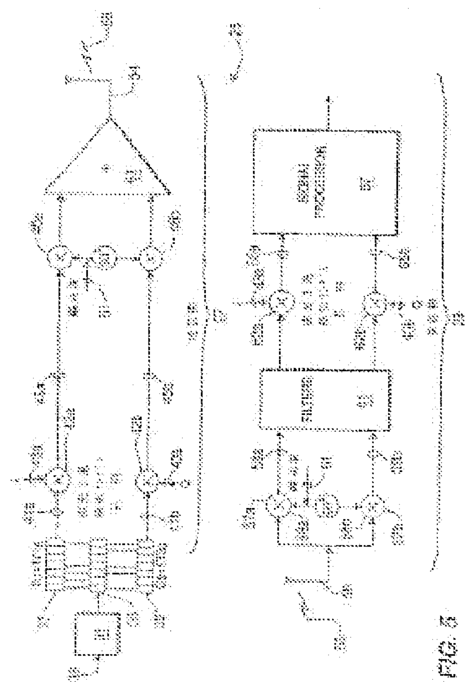
**Abstract of JP2004274794 (A)**

PROBLEM TO BE SOLVED: To provide a CDMA transmission and reception system that ensures high quality transmission and reception notwithstanding a communication distance and the Doppler effects. ; SOLUTION: A detector of the system detects a received digital signature using an energy output from a matched filter. The energies are tabulated according to an anticipated signature pattern for variable transmission distances. The tabulation accounts for expected round trip transmission delays and allows processing of the accumulated symbols to derive a correct signature independently of whether coherent or non-coherent signature coding is used and multiple Doppler channels are present. ; COPYRIGHT: (C) 2004,JPO&NCIPI

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(54)【発明の名称】ランダムアクセスチャネルのプリアンブルに関連づけた符号を発生する方法

(57)【要約】
【課題】 交信距離およびドップラー効果に影響されることなく高品質送受信を確保できるCDMA送受信システムを提供する。
【解決手段】整合フィルタからのエネルギー出力を用いて受信ディジタルシグネチャを検出する検出器を提供する。変動し得る伝送距離について予測されるシグネチャパターンにしたがってそれらエネルギー値を表にする。この表は往復伝搬遅延の予想値を算入したものであり、累算ずみのシンボルの処理は、採用シグネチャ符号化がコヒーレント型か非コヒーレント型かに関わりなく、また複数ドップラーチャネルの有無に関わりなく、正しいシグネチャの抽出を可能にする。
【選択図】 図5

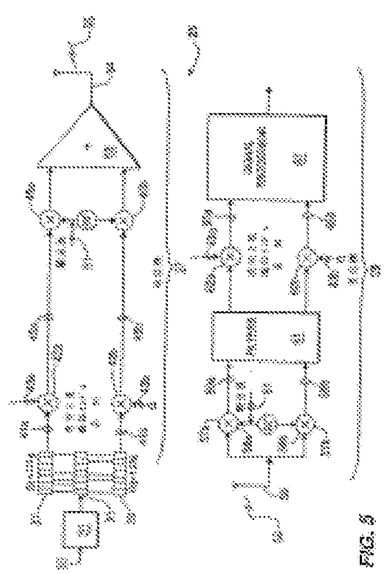

FIG. 5

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【特許請求の範囲】
【請求項1】
ランダムアクセスチャネル（ＲＡＣＨ）伝送信号のプリアンブルと関連づけた符号を生ずる方法であって、
　各々が１６個のシンボルを有する１６個のプリアンブルシグネチャから一つのプリアンブルシグネチャを選択する過程と、
　プリアンブルの符号系列に基づき符号を発生する過程と、
　プリアンブル符号を生ずるように位相回転を行う過程と
を含む方法。
【請求項2】
前記発生する過程により発生した符号を、受信した符号系列との間で相関をとるのに用いる請求項１記載の方法。
【請求項3】
前記発生する過程により発生した符号を、受信したＲＡＣＨ伝送信号についてのドップラーを解消するのに用いる請求項１記載の方法。
【請求項4】
ランダムアクセスチャネル（ＲＡＣＨ）伝送信号のプリアンブルと関連づけた符号を用いる加入者局ユニットであって、
　各々が１６個のシンボルを有する１６個のプリアンブルシグネチャから一つのプリアンブルシグネチャを選択する手段と、
　プリアンブルの符号系列に基づき符号を発生する手段と、
　プリアンブル符号を生ずるように位相回転を行う手段と
を含む加入者局ユニット。
【請求項5】
前記発生する手段により発生した符号を、受信した符号系列との間で相関をとるのに用いる請求項４記載の加入者局ユニット。
【請求項6】
前記発生する手段により発生した符号を、受信したＲＡＣＨ伝送信号についてのドップラーを解消するのに用いる請求項４記載の加入者局ユニット。

【発明の詳細な説明】
【技術分野】
【0001】
　この発明は概括的には２進符号変調を受けた信号の伝送システムおよび伝送方法に関する。より詳細にいうと、この発明は伝送距離の変動する移動通信環境で被変調信号を伝送する符号分割多元接続（ＣＤＭＡ）伝送システムに関する。
【背景技術】
【0002】
　通信システムは送信元から送信先へ情報を伝送する一つの主要機能を有する。送信元の生ずる信号は時間とともに変動する電気信号で通常は構成される。
【0003】
　送信元から送信先までの情報信号の伝送は、通常チャネルと呼ばれる適切な媒体を通じて行われる。チャネルの特性に整合するように情報信号を変化させる一つの方法を変調という。情報を帯びた信号の再生を復調という。復調プロセスは変調プロセスと論理的に逆のプロセスを用いて被変調信号を変換する。伝送チャネルが理想的な媒体であれば送信先における信号は送信元における信号と同じになるはずである。しかし、実際には伝送プロセスの期間中に信号は多様な変形を受けそのために歪が生ずる。送信先における受信機は原信号以外の影響をすべて除去して原情報を再生しなければならない。
【0004】
　現在の通信の大部分は、原アナログ信号をディジタル量に変換して伝送し、伝送されてきた情報の種類に応じてアナログ形式に再変換する手法によっている。最も単純なディジ

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タル表示は任意のビット期間における情報が1または0の2進数値である表示である。その情報のとり得る値の範囲を拡大するために、3以上の値を表示するシンボルを用いる。3値シンボルおよび4値シンボルは三つの値および四つの値をそれぞれとり得る。変動する値は正負の整数で表示され、通常は対称的である。シンボルの考え方は、各シンボルのビット内容が特有のパルス形状を定めるので、情報のより大きい精細度を可能にする。シンボルのレベル数に応じて、それと同じ数の特有のパルス波形が存在する。送信元の情報をシンボルに変換し、そのシンボルで変調をかけてチャネル経由で伝送し送信先で復調する。

【0005】
通信システムの通常のプロセスが伝送情報に与える影響は計算でき制御できる。しかし、送信元から送信先への伝送の期間中で計算不可能な要素は雑音である。ディジタル伝送に雑音が加わると信号が劣化し伝送誤りの可能性が増大する。もう一つの伝送信号劣化は信号の同期関係に影響する地形、建造物および伝搬距離に起因するマルチパス歪である。通信システムは情報信号の遭遇する予測可能な変形を画定する必要があり、伝送中に実際に生じたそれら予測可能な変形を分析する手段を受信装置は受信時に備えている必要がある。

【0006】
単純な2進伝送システムは論理1に正極性のパルス、論理0に負極性パルスをそれぞれ用い、送信元から方形パルスを伝送する。送信先で受信するパルスは雑音やそれ以外の歪などを含む上記変形を受けたパルスである。

【0007】
誤りの発生を最少に抑えるために、受信装置で用いるフィルタの応答特性を送信元のパルス波形に整合させる。整合フィルタとして周知の受信装置フィルタは、伝送されてきたパルス波形が論理1か論理0かを容易に判定でき、ディジタル通信に広く用いられている。整合フィルタは送信装置がシンボルに対応して生ずる特定のパルス波形にそれぞれ整合させてある整合フィルタをシンボル周波数でサンプルして、入力パルス波形とフィルタ応答特性とを相関させる出力を生ずる。入力がフィルタ応答特性と同じであれば、そのフィルタ出力はその信号パルスの全エネルギーを代表する大きい値を生ずる。その出力は通常入力に対して複素数で表示される量である。その整合フィルタの性能の最適値は正確な位相同期を要する受信信号パルスの正確なコピーに左右される。位相同期は位相同期ループ（ＰＬＬ）の利用により容易に維持できる。しかし、パルス同期は整合フィルタにとって問題である。パルス列がシンボル時間に同期していなければシンボル間干渉（ＩＳＩ）が生ずる。

【0008】
従来技術による通信システムの例を図1に示す。このシステムは、符号分割多重化、より一般的には符号分割多元接続ＣＤＭＡとして知られる手法を用いている。

【0009】
ＣＤＭＡは、伝送すべきデータを擬似雑音信号で変調することによりデータを拡大帯域（スペクトラム拡散した帯域）で伝送する通信技術である。伝送すべきデータの数千ヘルツに過ぎない帯域幅が数百万ヘルツに及ぶ周波数帯域に拡散されるのである。通信チャネルは互いに独立なｍ個のサブチャネルに同時並行的に利用される。

【0010】
図示のとおり、ある帯域幅の一つのサブチャネルを、広帯域擬似雑音（ｐｎ）系列発生器で発生した所定のパルス系列パターンを繰り返す特有の拡散符号と混合する。これら特有のユーザ用拡散符号は通常は互いに直交関係にあり拡散符号相互間の交叉相関をほぼ零にしている。データ信号を上記ｐｎ系列で変調してディジタルスペクトラム拡散信号を生ずる。次に、そのディジタルスペクトラム拡散信号で搬送波信号を変調して順方向リンクを構成し送信する。受信装置は伝送されてきた信号を復調してディジタルスペクトラム拡散信号を抽出する。伝送されてきたデータを、合致したｐｎ系列との相関を経て再生する。拡散符号が互いに直交関係にあれば、受信信号は特定の拡散符号と関連した特定のユー

ザ信号との間で相関をとることができ、その特定の拡散符号と関連した所望のユーザ信号だけを集めてそれ以外のユーザ向けのユーザ信号は集めない。これと同じ信号処理が逆方向リンクにも適用される。

【0011】

位相偏移変調（ＰＳＫ）などのコヒーレント変調手法を固定式または移動式の複数の加入者局ユニットに用いる場合は、加入者局ユニットとの同期を確保するために基地局からグローバルパイロット信号を継続的に送信する。加入者局は基地局と常に同期しそのパイロット信号の情報を用いてチャネル位相および振幅パラメータを推算する。

【0012】

逆方向リンクについては、共通のパイロット信号は実現不可能である。逆方向リンクを形成するための基地局による初期捕捉のために、加入者局は所定のランダムアクセスチャネル（ＲＡＣＨ）経由でランダムアクセスパケットを送信する。このランダムアクセスパケットは二つの機能を備える。第１の機能は加入者局ユニットが送信中で基地局がその送信を高速受信し受信内容を判定する必要のある初期捕捉のための機能である。ＲＡＣＨは基地局への逆方向リンクを立ち上がらせる。ランダムアクセスパケットの第２の機能は低データ速度の情報を専用の通話音声伝送チャネルを占有することなく伝達する機能である。クレジットカード情報など少量のデータを発呼データでなくランダムアクセスパケットのデータ部分に挿入する。基地局に送られると、その情報は交信中の他のユーザに転送できる。ランダムパケットデータ部分をアドレス用およびデータ用に用いることによって、利用可能な無線周波数信号の資源に負担をかけることなくより高速のデータ通信用に効率的利用ができる。

【0013】

ランダムアクセスパケットはプリアンブル部分とデータ部分とを含む。データ部分はプリアンブルと並列的に送ることもできる。従来技術ではランダムアクセスチャネルはプリアンブルおよびデータの両方に直交位相偏移変調（ＱＰＳＫ）を通常用いている。

【0014】

基地局は受信したプリアンブルを調べて特有の拡散符号を検出する。ＲＡＣＨプリアンブルの各シンボルは一つのｐｎ系列でスペクトラム拡散されている。整合フィルタを用いて基地局は相関を示す符号を継続的にサーチする。このデータ部分は所望のサービスについての命令を含む。基地局はデータ部分を復調し、音声、ファクスなど要求呼の種類を判定する。次に、基地局は逆方向リンクで加入者局ユニットが用いる特定の通信チャネルを割り当て、そのチャネルのための拡散符号を特定する。通信チャネルが割り当てられると、ＲＡＣＨは他の加入者局ユニット用に解放される。追加のＲＡＣＨは複数の加入者局ユニットからの同時発呼により起こり得る衝突を除去してより高速の基地局捕捉を可能にする。

【0015】

逆方向リンクにおけるパルス同期をもたらす加入者局ユニットパイロット信号がなければ、伝送路アンビギュイティにより複合化したＰＳＫなどのコヒーレント符号化手法を用いた場合に移動加入者局装置からのＲＡＣＨの捕捉が困難になる。移動加入者局は基地局と同期しているので、ＲＡＣＨプリアンブルは所定の速度で伝送される。

【0016】

従来技術によるプリアンブルシグネチャの一つの例はシンボル１６個で構成される。コヒーレントＲＡＣＨプリアンブルシグネチャ１６個の例を図２に示す。各シンボルは複素数であり拡散ｐｎ系列２５６チップを含むパルス波形を備えるので、各シグネチャは４０９６チップを含む。ＲＡＣＨプリアンブルシグネチャ全体は１ミリ秒あたり４０９６チップ、すなわち１マイクロ秒あたり０．２４４チップのチップ速度で伝送される。

【0017】

各加入者局ユニットはグローバルパイロット信号からフレーム境界情報を受ける。基地局と加入者局との間の距離に応じて、フレーム境界情報は順方向リンク伝送遅延を受ける。逆方向伝送のＲＡＣＨプリアンブルは同一の伝送遅延を受ける。伝搬遅延のためにＲＡ

ＣＨプリアンブルの基地局への受信到達時間は

$$\Delta t = 2（距離）/ C \qquad （式１）$$

で与えられる。ここで$C=3.0\times10^{8}$ m/sである。

【0018】

この伝送遅延のために、加入者局ユニットについての距離アンビギュイティは距離に左右される。距離１００ｍでは影響は無視できる。距離３０kmでは遅延が４シンボルの伝送時間に近づく。表１は往復伝送遅延の影響を示す。

【0019】

【表１】

| 距離(km) | 往復伝送時間(msec) | チップ値 | シンボル間隔 |
|---|---|---|---|
| 0 | 0 | 0 | 1 |
| 5 | 0.033 | 137 | 1 |
| １０ | 0.067 | 273 | 2 |
| １５ | 0.100 | 410 | 2 |
| ２０ | 0.133 | 546 | 3 |
| ２５ | 0.167 | 683 | 3 |
| ３０ | 0.200 | 819 | 4 |

表１　距離アンビギュイティの影響

第１欄は移動局ユニットと一つの基地局との間の距離をkmで示す。第２欄はその基地局と加入者局との間の往復伝送遅延をミリ秒で示す。第３欄は基地局における整合フィルタのチップクロック位置を伝送フレーム境界の始点を０として示す。この数値はフレーム境界の始点を基準として加入者局ユニットからの最初のチップの受信時点を表す。第４欄は２５６個の受信チップの組上げのあとで生ずる最初の整合フィルタ出力の見込みの位置（基準はフレーム境界の始点）を示す。加入者局ユニットの距離に応じて初めの四つのシンボルの任意の一つの期間中にシンボルが出力される。

【0020】

基地局は加入者局ユニットと同期しておらず搬送波基準も備えていないので、受信チップ系列のどこでＲＡＣＨプリアンブルシンボルの始点が始まるか基地局には不明である。整合フィルタは有効なシンボルパルス波形対応の合計２５６チップの期間をとらなければならない。当業者には周知のとおり、チップを受信しながら整合フィルタの２５６個のチップを組み立ててパルス波形対応の最初の出力を生ずる。整合フィルタからの継続出力を後続の受信チップの各々について発生する。

【0021】

移動加入者局ユニットは基地局からのＲＡＣＨにアクセスするためにプリアンブル部分を初めに送信する。シグネチャ１６個のうちの１個をランダムに選び時間的にずれた５個のうちの１個をランダムに選んで伝送中の距離アンビギュイティを解消する。移動加入者局ユニットは基地局からのフレーム境界情報の一斉報知を絶えず受信する。ＲＡＣＨを要求するには、移動加入者ユニットは図３に示すとおり受信フレーム境界情報からｎ×２ms（ｎ＝０，１，・・・４）時間的にずれたランダムバーストを送信する。この時間オフセット（ｎの値）をランダムアクセス試行の度ごとにランダムに選ぶ。

【0022】

基地局が受信した四つの受信プリアンブルシグネチャａ，ｂ，ｃおよびｄを図４ａ乃至

図４ｄに示す。各シンボルシグネチャは往復伝搬遅延のために１シンボル幅（0.0625ms）遅れて到着し、各シグネチャが基地局と移動加入者局ユニットとの間の互いに異なる距離を表す。距離アンビギュイティがシグネチャ相互間の直交性を損ない性能を劣化させることが知られている。基地局受信機が整合フィルタから生じ得る１９個の出力の任意の組合せを誤ったシグネチャと識別する可能性がある。

【0023】

【特許文献1】ＥＰ　０　３７８　４１７
【非特許文献1】IEEETransactions on Communications, Vol.COM-34, No.3 pp.219-226（1986年3月）
【特許文献2】ＵＳＰ　５　６９６　７６２
【特許文献3】ＷＯ　９８　４９８５９

【発明の開示】

【発明が解決しようとする課題】

【0024】

したがって、伝送距離の大きさおよびドップラー効果に関わりなく正確に動作するＣＤＭＡ送信および検出方式が必要になっている。

【課題を解決するための手段】

【0025】

この発明は、整合フィルタからのエネルギー出力を正確な相関検出との連携で用いることにより、伝送されてきたディジタルシグネチャを検出する検出器に関する。変動する伝送距離について見込まれるシグネチャパターンにしたがってエネルギーを累積する。この累積は往復伝送遅延見込値を説明し、累計シンボルの処理が、利用符号化動作のコヒーレント型非コヒーレント型の区別に関わりなく、また複合ドップラーチャネルの有無に関わりなく、正しいシグネチャを検出できるようにする。この発明の上記以外の実施例には、ＲＡＣＨプリアンブルシグネチャを差動符号化する新たな手法が含まれる。

【発明の効果】

【0026】

送信距離およびドップラー効果に影響されることなく高品質受信を確保できるＣＤＭＡ送受信システムを提供できる。

【発明を実施するための最良の形態】

【0027】

同じ構成要素には同じ参照数字を付けて示した図面を参照して好ましい実施例を次に説明する。

【0028】

図５に示したＣＤＭＡ通信システム２５は送信機２７と受信機２９とを含み、これら送信機２５および受信機２９は基地局にも移動加入者局ユニットにも配置できる。送信機２７は音声信号および非音声信号を多様な速度、例えば8kbps、１６kbps、３２kbps、６４kbpsなど所望の速度で符号化するシグナルプロセッサ３１を含む。シグナルプロセッサ３１は信号の種類に応じ、または所定のデータ速度に応答して速度を選択する。

【0029】

背景を述べると、多元接続環境においては、送信信号の発生に二つのステップが伴う。第１に、２相位相変調を受けた被変調信号と考えることができる入力データ３３を前向き誤り訂正（ＦＥＣ）符号化装置３５により符号化する。例えば、Ｒ＝１／２畳込み符号を用いた場合は、単一の２相位相被変調データ信号が二つの２相位相被変調信号になる。一つの信号は同相チャネルＩ４１ａで表す。もう一つの信号は直角位相チャネルＱ４１ｂで示す。複素数はａ＋ｂｊの形になる。ここで、ａとｂとは実数であり、$j^2=-1$である。２相位相被変調信号ＩおよびＱは通常ＱＰＳＫと呼ぶ。

【0030】

第２のステップでは、二つの２相位相被変調データすなわちシンボル４１ａ、４１ｂを複素擬似雑音（ｐｎ）系列４３ａ、４３ｂでスペクトラム拡散する。ＱＰＳＫシンボルストリーム４１ａ、４１ｂを特有の複素ｐｎ系列４３ａ、４３ｂと乗算する。Ｉ系列および

Q系列４３ａ、４３ｂの両方ともシンボル速度の通常１００倍乃至２００倍の速度で発生したビットストリームから成る。複素ｐｎ系列４３ａ、４３ｂをミキサ４３ａ、４３ｂで複素シンボルビットストリーム４１ａ、４１ｂと混合してディジタルスペクトラム拡散信号４５ａ、４５ｂを生ずる。このスペクトラム拡散信号４５ａ、４５ｂの構成部分はパルス幅のずっと小さいチップとして知られる。これらディジタルスペクトラムＩおよびQ信号４５ａ、４５ｂをミキサ４６ａ、４６ｂにより無線周波数にアップコンバートとして、コンバイナ５３で拡散符号の異なる他のスペクトラム拡散信号（チャネル）と合成し、搬送波５１と混合してその信号をＲＦにアップグレードし、アンテナ５４から一斉報知信号５５として放射される。この送信信号５５には互いに異なるデータ速度の個別の複数のチャネルが含まれる。

【0031】

受信機２９は、アンテナ５６で受けた広帯域送信信号５５の受信出力を中間周波数搬送波５９ａ、５９ｂにダウンコンバートするミキサ５７ａ、５７ｂを含む。ミキサ５８ａ、５８ｂにおける第２段ダウンコンバート動作でこの信号をベースバンド信号に変換する。次に、ＱＰＳＫ信号をフィルタ６１によりフィルタ処理して、送信側複素符号の共役値と一致するミキサ６２ａ、６２ｂでローカルに発生した複素ｐｎ系列４３ａ、４３ｂと混合する。送信機２７における拡散符号と同じ符号で拡散された原波形だけが実効的に逆拡散される。それ以外の受信信号波形は受信機２９には雑音として認識される。次に、データ６５ａ、６５ｂをシグナルプロセッサ６７に送り、畳込み符号化ずみデータをＦＥＣ復号化する。

【0032】

信号を受信し復号化したあとでは、ベースバンド信号はチップレベルにある。信号のＩ成分およびQ成分の両方をスペクトラム拡散動作で用いたｐｎ系列の共役値を用いて逆拡散し、信号をシンボルレベルに戻す。

【0033】

移動加入者局ユニットから基地局への逆方向リンクを確立するために移動加入者局ユニットはＲＡＣＨで伝送されるランダムアクセスパケットを送信する。ＲＡＣＨの送信は、ＲＡＣＨがＦＥＣを受けない以外は上述の場合と同じである。通信システム２５において二つ以上のＲＡＣＨを用いる場合もある。

【0034】

上記１６個のコヒーレントＰＳＫ変調ずみＲＡＣＨ７１プリアンブルシグネチャ７３の表を図２に示す。各シグネチャは１６個のシンボルを含む。各シンボルAは複素数Ａ＝１＋ｊである。符号化の手法および複素数の説明はこの明細書の対象外であり当業者に周知である。

【0035】

従来技術によるコヒーレントＲＡＣＨ７１検出器７５を図６Ａに示す。受信機２９がＲＡＣＨ７１搬送波を復調したのち、復調出力信号７７がＲＡＣＨプリアンブル７３の逆拡散のために整合フィルタ７９に入力される。整合フィルタ７９の出力をプリアンブル相関器８１に加えて、ＲＡＣＨプリアンブル７３とプリアンブル符号８３表示の既知プリアンブルｐｎ系列との間の相関をとる。プリアンブル相関器８１の出力は、上記特定のプリアンブル符号８３による受信ランダムアクセスバーストのタイミング８７に対応するピーク値８５を有する。次に、この推定したタイミング８７は通常のＲＡＫＥ８９コンバイナでＲＡＣＨ７１バーストのデータ部分の受信用に用いることができる。この検出器７５は図２に示したコヒーレントＰＳＫ符号化プリアンブルシグネチャで理想的な条件の下では十分に動作するが、位相アンビギュイティおよびドップラー効果によって動作が劣化することもあり得る。

【0036】

この発明の第１の実施例では、非コヒーレント検出を利用可能である。その実施例では、図２に示したコヒーレントＲＡＣＨプリアンブルシグネチャ７３は差動符号化される（すなわち、差動位相偏移変調（ＤＰＳＫ）処理される）。したがって、上記コヒーレント

プリアンブルシグネチャ７３は送信前にまず非コヒーレントＤＰＳＫ符号化信号に変換され、受信後に差動復号化される。

【0037】

コヒーレントシンボルの非コヒーレントシンボルへの変換の方法は次のステップを経て実施される（ここで、ｉ＝行、ｊ＝列である）。すなわち、まず

$S_{old}(i,1)=-A$の場合：ｉ対応の全ｊに－１を乗算。　（式２）

例えば、図２に示したシグネチャ４（ｉ＝４）については、

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | -A | A | -A | A | -A | -A | -A | -A | -A | A | -A | A | -A | A | A | A |

に－１を乗算して、

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | A | -A | A | -A | A | A | A | A | A | -A | A | -A | A | -A | -A | -A |

が得られる。この第１のステップのあとでは、プリアンブルシグネチャは元の非変換シグネチャ（１、３、５、８、９、１１、１２および１３）と－１乗算ずみのシグネチャ（２、４、６、７、１０、１４、１５および１６）とから成る。

【0038】

この変換処理の第２ステップはプリアンブルシグネチャ７３の各連続シンボルを変換する。この処理は次式、すなわち

$S_{old}(i,j)=S_{new}(i,j-1)$の場合；$S_{new}(i,j)=A$　（式３）

$S_{old}(i,j)\neq S_{new}(i,j-1)$の場合；$S_{new}(i,j)=-A$　（式４）

で表される。この例をさらに続けると、シグネチャ４（ｉ＝４）については

$S_{old}(4,2)\neq S_{new}(4,2-1)$，$-A\neq A$

したがって、

$S_{new}(4,2)=-A$

となる。

【0039】

ＤＰＳＫ符号化処理のこのあとの部分を、与えられたプリアンブルシグネチャ７３の各連続シンボルについて行う。この処理により、１６個のプリアンブルシグネチャ７３のすべてを、図１０に示した差動プリアンブルシグネチャ９７に変換する。このＤＰＳＫ変換は予め計算して移動加入者ユニットの一部としてファームウェアにロードすることができ、また基地局受信機の性能の程度に応じて発呼時に計算することもできる。ＤＰＳＫプリアンブルシグネチャについては、プリアンブルシグネチャとの相関の前に受信信号を差動復号化により再生する必要がある点を除き、上述の処理と同じ処理を行う。

【0040】

この発明により構成したＲＡＣＨ検出器１０１を図６Ｂに示す。従来技術による受信機７５について上に述べたとおり、受信ＲＡＣＨ７７は復調して整合フィルタ７９の入力に加える。整合フィルタ７９の出力をＲＡＫＥ８９，遅延手段１０３および第１のミキサ１０５に加える。受信シグネチャ９７の各々は１シンボル幅、すなわち２５６チップ分だけ遅延させる。遅延手段１０３の出力を共役複素算出器１０７に加えて受信シンボルをその共役複素に変換する。複素共役複素算出器１０７の出力を第１のミキサ１０５に加えて、このミキサ１０５により複素数の実部を選択１０６し、シグネチャと出力系列との間の相関をとる。この和をピーク値検出器８５で閾値と比較し、１６番目のシンボルの終端までにその和が閾値を超えた場合にシグネチャ検出と判定する。各シグネチャにつき１回の計算で合

計１６回の計算を伴うので、あるサンプル期間に累算値が２回以上閾値を超える場合もあり得る。その場合は最大の累算値を正しい累算結果として選択する。タイミング推算器８７の推算出力をＲＡＣＨ７１のバーストのデータ部分の受信のための通常のＲＡＫＥ８９コンバイナで用いることができる。

【0041】
この発明の第２の実施例によると、ＲＡＣＨ検出器整合フィルタ７９の各出力からの出力エネルギーを算出する。整合フィルタ７９は通常チップ速度でサンプリングするが、チップ速度の２倍または４倍（またはそれ以上）の速度でオーバーサンプリングすることもできる。この実施例ではチップ速度は毎秒４．０９６メガチップ、すなわち０．２４４マイクロ秒あたり１チップである。

【0042】
整合フィルタ７９からの各シンボル出力について算出したエネルギー値を蓄積したＲＡＭ１００内のメモリマトリクス１０１を図７Ａに示す。マトリクス１０１は、１００ｍから３０ｋｍの範囲の基地局・加入者局間伝送距離対応の遅延シンボル値のあり得る値すべてを蓄積するように構成してある。マトリクス１０１はＲＡＣＨプリアンブルシグネチャ期間中に送信されるチップの総数を表す２５６行（０乃至２５５）１０２、１９列（０乃至１８）１０４から成る。加入者局ユニットが基地局近傍の位置にあって伝搬遅延が無視できる場合は、２５６チップ受信後、すなわち点Ｐ（２５５，０）で第１のシンボルが出力される。加入者局ユニットが距離３０ｋｍに位置する場合は、第１のシンボルは８１９シンボル受信後、すなわち対応点Ｐ（５４，４）で出力される。伝送距離に関わりなく、２５６チップ分の時間の経過の度ごとに次のシンボルが出力され、それを繰り返して一つの行を完結させる。シンボル１６個で一つのプリアンブルシグネチャを画定しているので、マトリクス１０１は距離アンビギュイティを予期して追加のシンボル出力３個を収容できる（図４に示す。詳細についてはさらに後述）。マトリクス１０１がデータ収容すると、距離３０ｋｍまで移動加入者局ユニットの対象サンプル全部を含む。

【0043】
整合フィルタ７９からの各出力９７は複素数、すなわち

$z(l, k)=x(l, k)+jy(l, k)$,

ただし $l=0$ から２５５，$k=0$ から１８　（式５）

で与えられる。各出力の実部および虚部の２乗の和で表されるエネルギー瞬時値は次式、すなわち

$p(l, k)=z(l, k)z(l, k)^{*}=x^{2}+y^{2}$

（式６）

で与えられ、マトリクス１０１に蓄積される。

【0044】
プリアンブルシグネチャは各々が特定のチップパターンを有する１６個のシンボルひと組から成るので、整合フィルタ出力には平均値よりも大きい出力であって先行のものから各々が２５６チップ分の間隔を保った出力が１６回現れる。合成出力はこれら整合フィルタ出力の２５６チップごとの和である。ここで解消すべき問題は、最初の整合フィルタ出力が最初の２５６チップ期間中には自動的には生じないことである。表１に示すとおり、移動加入者局ユニットと基地局との間の距離に応じて遅れて生ずることがあり得る。

【0045】
プリアンブルシグネチャがある場合は、それに対応する整合フィルタ出力は２５６行（１０２）のうちの一つの１９個の要素のうちの１６個に格納される。各行について、その行のエネルギー加算値が所定の閾値を超えるとプリアンブルシグネチャ全部が検出される。

【0046】
図７Ｂを参照すると、プリアンブルシグネチャの検出の手順２００が示してある。マトリクス１０１にデータ格納すると（ステップ２０１）、各行についてエネルギー値を加算１０９し、同様に蓄積する（ステップ２０２）。加算出力の和の値が閾値を超えた行に

ついては、その行で「仮検出」があったと考える。第１行についての和の値を所定の閾値を超えているか否かを判定する（２０６）。超えている場合は、その行に仮検出と印を付ける（ステップ２０８）。各行についての加算が行われなかった場合は（ステップ２１０）、次の行を検索して（ステップ２１２）上記プロセスを反復する（ステップ２０６～２１０）。これら行のすべてについて加算を行うと、仮検出の各々について距離アンビギュイティは解消し（ステップ２１４）、（さらに詳しく後述）、候補の値が出力される（ステップ２１６）。

【0047】

上述のとおり移動加入者局ユニットの位置によっては距離アンビギュイティが生じ、プリアンブルシグネチャが最大４シンボル分の期間にわたり生じない場合があり得る。この距離アンビギュイティを解消する必要がある。したがって、仮検出と印を付けた行の各々について、その行の中で加算出力最大値を生ずる１６個の互いに連続の位置のエネルギーの値を決定しなければならない。距離アンビギュイティのために、プリアンブルシグネチャの受信出力から四つのケース１、２、３および４を導き出さなければならない。これら四つのケースを図８に示す。この例では、シグネチャ１は送信されて１９個の受信シンボルからアッセンブルされて、メモリマトリクス１０１の一つの列を形成する。これらケースの各々について、１９個のシンボルのうちの互いに連続した１６個のシンボルを１６個のあり得るプリアンブルシグネチャの各々と相関をとり、６４個の相関出力を生ずる。これら６４個の相関出力のうちの一つが受信エネルギー最大のシグネチャとなる。これら６４個の相関出力の最大値はケース１で生ずる。ケース１は互いに連続したシンボル全部を含んでおり、雑音を含んでいないからである。ケース２、３および４は雑音成分から導かれたシンボルを含んでおり、１６個のプリアンブルシグネチャの一つと相関しない。

【0048】

図７Ｃを参照すると、この発明による距離アンビギュイティ解消の手順３００が示してある。図８を参照して述べたとおり、各行は合計１９の位置を備える。図７Ｃにおいて、仮検出とみられた一つの行の初めから１６個の互いに連続した位置のエネルギーの値を分析する（ステップ３０１）。これら１６個の位置のエネルギー総和を算出し（ステップ３０２）、蓄積する（ステップ３０４）。その行のすべての位置の合計値が算出されなかった場合は（ステップ３０６）、要素２乃至１７に対応する次の１６個の互いに連続する位置を見直す（ステップ３０８）。次に、カウンタを歩進させて（ステップ３１０）、上記手順を反復する（ステップ３０２乃至３０６）。すべての位置についての合計を算出すると、合計値すべてを比較してその行の互いに連続した１６の位置に最大合計値を示す位置があるか否かを判定する。次に、このシステムは最大合計値を示す１６個の連続位置の初めに対応する列（ｋ）の値を出力する（ステップ３１４）。これが被選択候補値である。上述の手順を仮検出の各々について反復する。

【0049】

図７を参照して述べたプロセスは擬似符号を用いて次のとおり要約できる。

【0050】

行ｉ（ｉ＝０乃至２５５）

和(ｋ)＝０，ｋ＝０,１,２,３

ｋ＝０乃至３につき次式を計算，すなわち

和(ｋ)＝和(ｋ)＋Ｐ(ｉ，ｎ＋ｋ－１)

次のｋ．

次に、

最大の和（ｋ）についてｋを選択する

maxｋ＝０

max＝和（０）

ｋ＝１乃至３について

和(ｋ)＞maxの場合

max＝和（ｋ）

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max k＝k

次のk；

上述の検索関係結果をコヒーレントまたは非コヒーレントＰＳＫ符号化のための通常の相関検出プロセスの出力と比較する。通常の相関検出プロセスはこの明細書による説明の範囲外であり、当業者には周知である。

【0051】

図９を参照すると、直交性と距離アンビギュイティとの関係の表が示してある。第１列は受信信号が相関を示すシグネチャである。第２列乃至第５列はケース１乃至４の相関値である。相関値が大きいほど受信信号との一致度が高い。相関係数は受信シンボルがそれぞれのシグネチャシンボルと直交関係にあることを示す。明らかに理解されるとおり、ケース２、３および４についてはそれぞれのシグネチャ相互間には直交性がない。

【0052】

図９に示した相関値は次式、すなわち

【式７】

【0053】

$$\frac{100}{1024}\left|\bar{s}^{(1)}\bullet\bar{s}^{*(k)}\right|^2=\frac{100}{1024}\left|\sum_{i=0}^{15}P_i^{(1)}\bullet P_{i+l}^{*(k)}\right|^2, k=1,2,\ldots16; \quad \textbf{Equation 7}$$

で与えられる。ここで、シグネチャ１についてｋ＝１、シグネチャ２についてｋ＝２、・・・、シグネチャ１６についてｋ＝１６；ケース１についてｌ＝０、ケース２についてｌ＝１、ケース３についてｌ＝２、ケース４についてｌ＝３。値１０２４は次式、すなわち

【式８】

【0054】

$$1024=\left|\bar{s}^{(1)}\cdot\bar{s}^{*(1)}\right|^2\text{、ここで}\bar{s}^{(1)}=\text{シグネチャ１}\qquad(\text{式８})$$

で算出される。また、次式

【式９】

【0055】

$$\bar{s}^{(1)}\bullet\bar{s}^{*(1)}=\left[\underbrace{A\ A\ A\ -A\ -A\ -A\ A\ -A\ -A\ A\ A\ -A\ A\ -A\ A\ A}_{16\ \text{symbols}}\right]\begin{bmatrix}A^*\\A^*\\A^*\\-A^*\\-A^*\\-A^*\\A^*\\-A^*\\-A^*\\A^*\\A^*\\-A^*\\A^*\\-A^*\\A^*\\A^*\end{bmatrix} \quad \textbf{Equation 9}$$

＝１６×Ａ＊Ａ'
＝１６×｛Ｈｊ｝｛(１－ｊ)
＝１６×２
＝３２　　　　および
Ａ＝１＋ｊの場合、
Ａ*＝Ａ(１－ｊ)の共役値、
したがって３２²＝１０２４が得られる。

【0056】

この発明の実施例により構成したＲＡＣＨ検出器９５を図１１に示す。図６Ａの従来技術による受信機について上に述べたとおり、受信したＲＡＣＨ７７を復調して整合フィルタ７９の入力に供給する。整合フィルタ７９の出力をＲＡＫＥ８９、時間遅延ユニット１０３、第1段ミキサ１０５、および第１のプロセッサ９９に接続する。受信プリアンブルシグネチャ９７の各々を１シンボル長$T_s$、すなわち２５６チップだけ遅延ユニット１０３により遅延させる。遅延ユニット１０３の出力を、受信シンボルを複素共役値に変換する共役値発生器１０７に供給する。共役値発生器１０７の出力を第１のミキサ１０５に接続し、このミキサ１０５により上記複素数の実部にプリアンブルシグネチャを乗算しプリアンブル相関器８１に出力する。プリアンブル相関器８１はあり得るシグネチャとシンボル系列ベースの出力系列との間の相関をとる。その和を閾値と比較して、その和が１６番目のシンボルの終わりまでの間にその閾値を超えた場合は、シグネチャが検出される。各シグネチャに１回ずつ合計１６回の計算が行われるので、あるサンプル時間に閾値を超える累算が２回以上あり得る。その場合、最大値の累算値を正しい値として選択する。

【0057】

上述のシグネチャ相関演算と同時に整合フィルタ７９の出力９７を第１のプロセッサに供給して各シンボル出力についてのエネルギー値を算出する。算出したエネルギー値の各々をメモリマトリクス１０１に蓄積する。上述のとおり、シンボル１９個の行についてエネルギー値の算出が終わったあと、第２のプロセッサ１０９がその列についてのエネルギー合算値を算出し、それを第２のメモリ１１１に蓄積する。なお、メモリマトリクス１０１および第２のメモリ１１１は図示の二つの別個の部品でなく、実際には単一のＲＡＭにより構成する。所定の閾値を超えるエネルギーを仮検出出力とする。シンボル１９個から成る２５６個のあり得るシグネチャを第２のメモリ１１１に累算したあと、第３のプロセッサ１１３が２５６個のエネルギーレベルを一つずつ正常シグネチャ検出と比較し、各プロセスを相互検証し、正しい受信シグネチャ系列に到達する。

【0058】

複数ドップラーチャネルに対処するために、代替の実施例では上述の四つのケースに基づくアプローチと同様のチャネル分析を行う。ドップラーチャネルに対処するために位相回転を導入する。この位相回転はドップラー拡散に起因する位相変動を補正し補償する。ｍ個のドップラーチャネルにおけるコヒーレント検出にはｍ×４／１６個の仮検出出力を生ずる。これらｍ個の仮検出出力のうちの最大値を選択し、それと対応するシグネチャを特定する。

【0059】

受信した系列がｒ(ｔ)である場合は、１９個のサンプルｒ(ｎｔ)(ｎ＝１，２，３，・・・，１９)が収集された度ごとに、四つのケース、すなわちｎ＝１，２，３，・・・１６(ケース１)，ｎ＝２，３，４，・・・，１７(ケース２)，ｎ＝３，４，５，・・・，１８(ケース３)，およびｎ＝４，５，６，・・・，１９(ケース４)を検討する。ドップラーを解消するために、ｍ個のドップラーチャネルに対応するＮ個の互いに異なる位相回転で１６個のシグネチャと各ケースとの相関をとる。これら位相回転との相関の出力は次式、すなわち

【式１０】

【0060】

$$y_{ik}=\sum_{n=1}^{16}\left|r\left(n\Delta t\right)\times\vec{s}_i\times\exp\left(-j\bullet 2\pi f_{0k}n\Delta t\right)\right|^2, \textbf{Equation 10}$$

で与えられる。ここでi＝1,2,3,・・・,16；k＝1,2,3,・・・,m；$2\pi f_{0k}$はk番目のドップラーチャネルの位相回転；$S_i$はi＝1,2,3,・・・,16についてあり得るシグネチャである。

【0061】

五つのドップラーチャネルの周波数回転の例は：($f_{01}$、$f_{02}$、$f_{03}$、$f_{04}$、$f_{05}$)＝(−２００Hz、−１００Hz、０、１００Hz、２００Hz)で相互間の間隔は１００Hzである。各ケースはm×１６個の復調出力を生ずる。四つのケースでm×１６×４個の復調出力を生ずる。これらm×１６×４個の復調出力との対応の最も大きいプリアンブルシグネチャを選択する。

【0062】

この発明の実施例により構成した複数ドップラーチャネル間のコヒーレント検出を用いた受信機を図１２Aおよび図１２Bに示す。図１２Aにおいて、受信したRACH７７を整合フィルタ７９に加えて拡散符号（２５６チップ）との相関をとる。上述のとおり、２５６チップごとに整合フィルタから一つのシンボルが出力され、１９個のシンボル出力が集められてメモリマトリクス１０１に蓄積されるまでその出力が続く。これら１９個のシンボル出力のうち１６個の互いに連続したシンボル出力をアッセンブルして四つのケースを形成する。

【0063】

これら１６個の連続サンプルの四つのケースの各々をプリアンブル相関器１１９でm個のドップラーチャネル上の１６個のプリアンブル系列の各々との間で相関をとる。これによって生じたm×１６×４個の相関値を第2のメモリ１２１に蓄積する。これらm×１６×４個の相関値のうちエネルギーの最も大きいケースを選択し１２３、それに対応するプリアンブルシグネチャを特定する。図１２Bはあるプリアンブル系列とあるドップラーチャネル（すなわち周波数回転$f_{0k}$（k＝1,・・・,m）を有するチャネル）との間のプリアンブル相関器の詳細なブロック図を示す。

【0064】

この発明の代替的実施例は図１３に示した１６×１６シグネチャマトリクスに基づいている。この実施例を用いる際には、図１３のシグネチャマトリクスの差動符号化により新たなシグネチャ組を形成する。この符号化規則は次のとおりである。すなわち、まずS(i，k)，M(i，k)およびR(i，k)をつぎのとおり定義する。

S(i，k)＝シグネチャiのk番目の要素；

M(i，k)＝ここに提案する新たな被伝送シグネチャ組のk番目の要素；

R(i，k)＝ここに提案する新たなコピー組のk番目の要素、受信機蓄積用

次に、これら要素を次のとおりマップする。すなわち、A・・・>1およびB・・・>j＝sqrt（−1）にマップし、M(i，0)＝A＝1およびR(i，0)＝A＝1にセットする。k＝1乃至15について次式を得る。すなわち、

M(i，k)＝M(i，k−1)×S(i，k)　　　　（式11）

R(i，k)＝S*(i，k)

（式12）

ここで、*は複素共役値を表す。

【0065】

S(i，k)＝1の場合、R(i，k)＝1

S(i，k)＝jの場合、R(i，k)＝−j

この規則は図１４に示すとおり総括でき、この図において左欄はM(i，k)の四つのと

り得る値を表し、第１行はS(i，k)の四つのとり得る値を表す。図１５は未符号化の原系列および差動符号化による変換後の系列を示す。

【0066】

受信機ではこれらシンボルを差動符号化する。D(0)＝１から始めて、復号化ずみシンボルD(k)（k＝0，・・・，１５）が受信符号化ずみシンボルC(k)で次のとおり与えられる。

【0067】

D(i，k)=C(i，k)×C(i，k－1)*　　（式１３）

次にプリアンブルシグネチャとの相関をとり、Sum(i)＝０が得られる。i＝０乃至１５について、次式すなわち

Sum(i)=Sum(i)+D(i，k)×R(i，k)　　（式１４）

が得られる。新たな被送信シグネチャ全体を図１６に示す。ＡをＢに置換しＢをＡに置換することによって上述の手法と同じ手法を図１３にプリアンブルシグネチャに適用できる

。

【産業上の利用可能性】

【0068】

ＣＤＭＡ技術を用いた第３世代携帯電話システムの通話品質の改善およびシステム容量拡大に利用できる。

【図面の簡単な説明】

【0069】

【図1】従来技術によるＣＤＭＡ通信システムの単純化したブロック図。

【図2】１６個のコヒーレントＲＡＣＨシグネチャの表。

【図3】並列ＲＡＣＨ試行の送信タイミングを示すタイミング図。

【図4】図４Ａは第１のシンボル期間中に受信した１６シンボルＲＡＣＨプリアンブルシグネチャを示すタイミング図、図４Ｂは第２のシンボル期間中に受信した１６シンボルＲＡＣＨプリアンブルシグネチャを示すタイミング図、図４Ｃは第３のシンボル期間中に受信した１６シンボルＲＡＣＨプリアンブルシグネチャを示すタイミング図、図４Ｄは第４のシンボル期間中に受信した１６シンボルＲＡＣＨプリアンブルシグネチャを示すタイミング図。

【図5】ＣＤＭＡ通信システムの詳細なブロック図。

【図6】図６Ａは従来技術によるランダムアクセスチャネルプリアンブルデコーダのシステム図、図６Ｂはこの発明により構成したランダムアクセスチャネルプリアンブル検出器

。

【図7A】シンボルメモリマトリクスの図。

【図7B】プリアンブルシグネチャの仮検出の手順の流れ図。

【図7C】距離アンビギュイティ解消の手順の流れ図。

【図8】距離アンビギュイティ解消のための受信プリアンブルシグネチャの四つの可能性ある組合せを示す表。

【図9】直交性と距離アンビギュイティとの関係を示す表。

【図10】１６個の非コヒーレントＲＡＣＨシグネチャの表。

【図11】非コヒーレントプリアンブル検出器のシステム図。

【図12】図１２Ａは複数ドップラーチャネル補正用のコヒーレントＲＡＣＨプリアンブル検出器のシステム図、図１２Ｂはプリアンブル相関器の詳細図。

【図13】この発明の代わりの実施例。

【図14】この発明の上記代わりの実施例の符号化規則。

【図15】未符号化系列およびそれの差動符号化系列への変換。

【図16】図１５の系列の被送信シグネチャ。

【符号の説明】

【0070】

２５　　ＣＤＭＡ通信システム

２７　　　　　送信機
２９　　　　　受信機
３１　　　　　シグナルプロセッサ
３３　　　　　入力データ
３５　　　　　前向き誤り訂正符号器
４１ａ，４１ｂ　ＱＰＳＫシンボルストリーム
４３ａ，４３ｂ　複素擬似雑音系列
４５ａ，４５ｂ　ディジタルスペクトラム拡散信号
４６ａ，４６ｂ，５７ａ，５７ｂ　　ミキサ
５３　　　　　コンバイナ
５９ａ，５９ｂ　中間周波数信号
６１　　　　　フィルタ
６２ａ，６２ｂ　ミキサ
６７　　　　　シグナルプロセッサ
７９　　　　　整合フィルタ
８１　　　　　プリアンブル相関器
８５　　　　　ピーク検出器
８７　　　　　タイミング推定器
８９　　　　　ＲＡＫＥユニット
１０１　　　　ランダムアクセスチャネル（ＲＡＣＨ）検出器
１０３　　　　遅延手段
１０６　　　　実部選択器
１０７　　　　複素共役値プロセッサ
２００　　　　プリアンブルシグネチャ仮検出手順
２０１　　　　マトリクスにデータを格納する
２０２　　　　各行内のエネルギーの和を算出して蓄積する
２０４　　　　第１行についての和を所定の閾値と比較する
２０６　　　　和は閾値よりも大きい？
２０８　　　　仮検出と印をつける
２１０　　　　各行についての和を比較ずみ？
２１２　　　　次の行についての和に進む
２１４　　　　距離アンビギュイティを解消する
２１６　　　　候補を出力する
３００　　　　距離アンビギュイティを解消する手順
３０１　　　　初めの１６個の位置に進む（k=0）
３０２　　　　それら１６個の位置についてのエネルギー値の和を算出
　する
３０４　　　　エネルギー値の和を蓄積する
３０６　　　　全位置についての和を算出した？
　　　　　　　（すなわち k=3 成立？）
３０８　　　　次の１６個の位置に進む
３１２　　　　和を互いに比較して最大値を示す位置を判定する
３１４　　　　和の最大値に対応するものの値を出力する

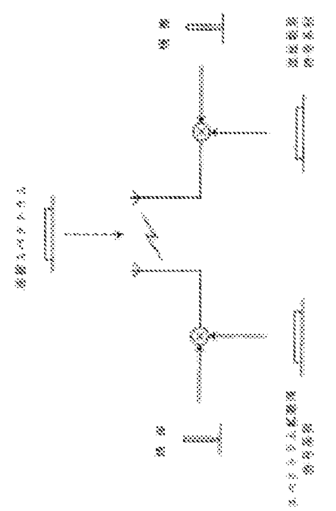

FIG. 1 PRIOR ART

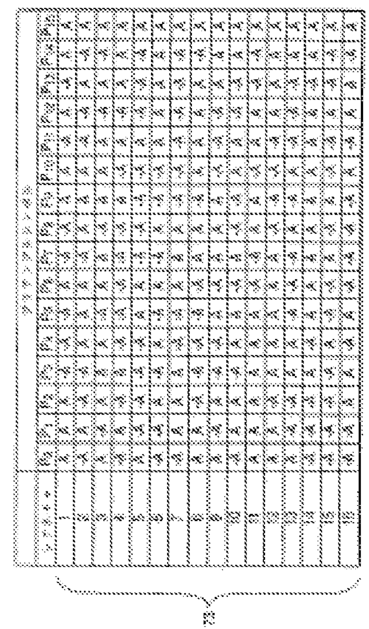

FIG. 2 PRIOR ART

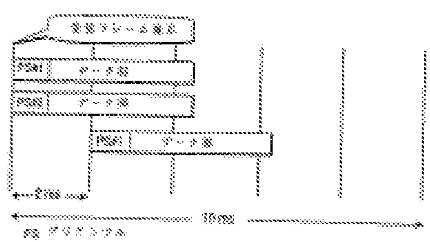

FIG. 3

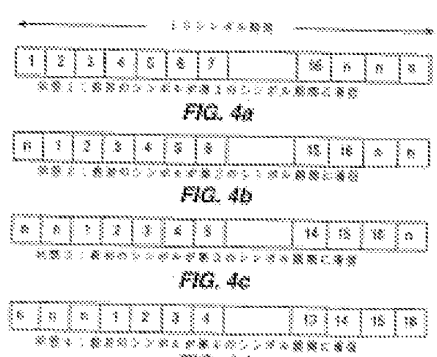

FIG. 4a

FIG. 4b

FIG. 4c

FIG. 4d

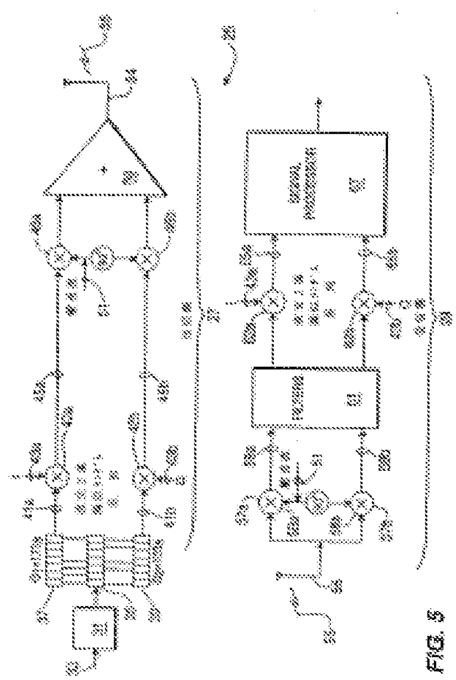

FIG. 5

【図6】

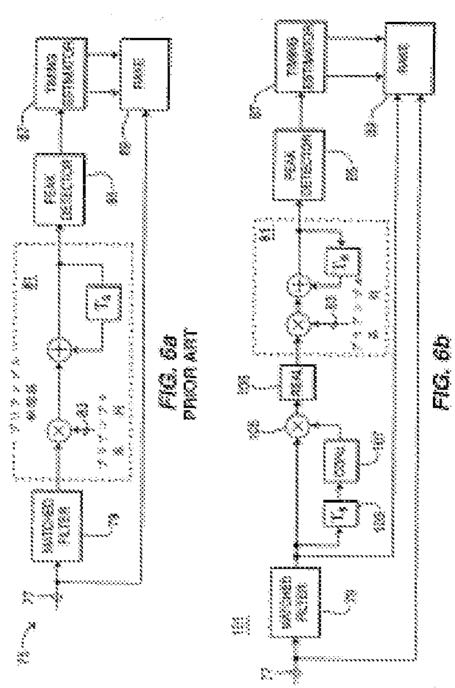

FIG. 6a PRIOR ART

FIG. 6b

【図7A】

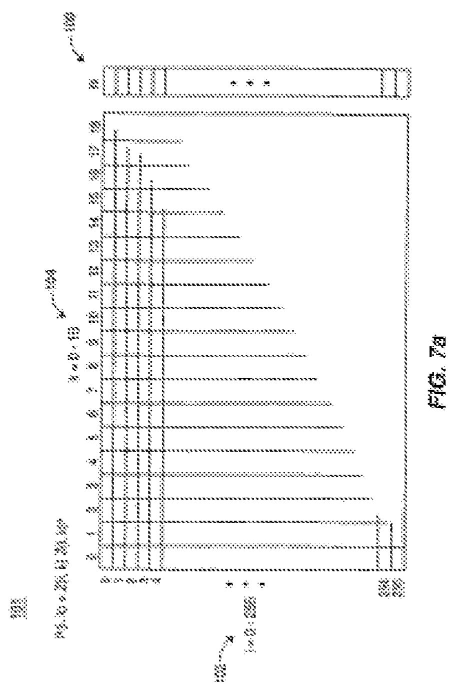

FIG. 7a

【図7B】

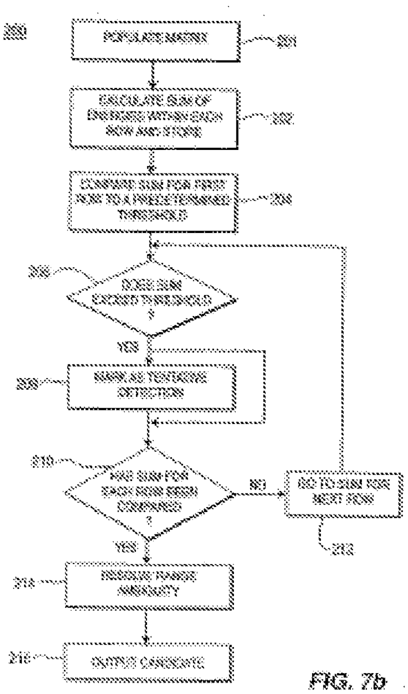


FIG. 7b

【図7C】

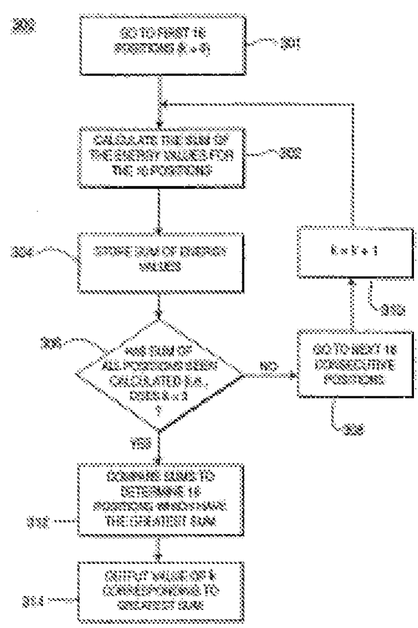


FIG. 7c

【図8】

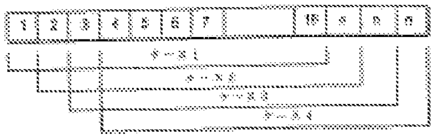

FIG. 8

【図9】

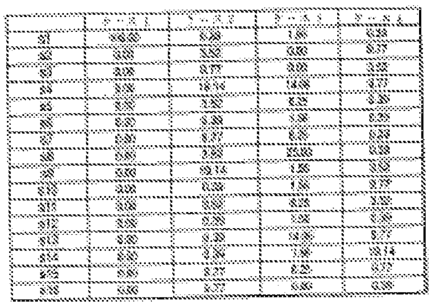

FIG. 9

【図10】

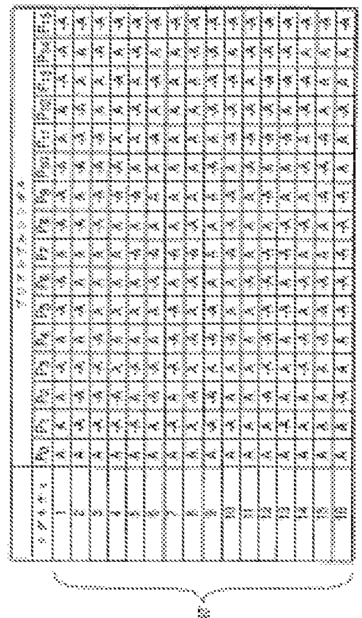

FIG. 10

【図11】

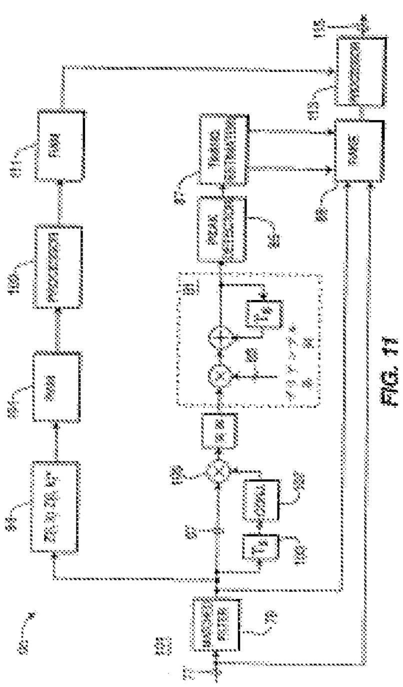

FIG. 11

【図12】

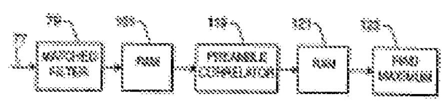


FIG. 12a

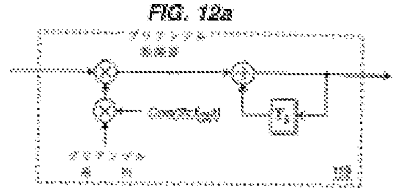

FIG. 12b

【図13】

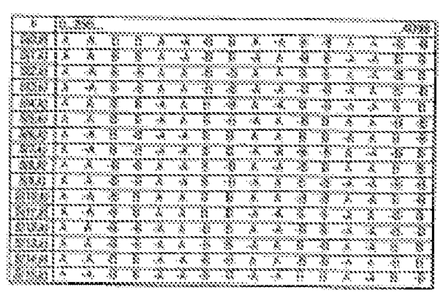

FIG. 13

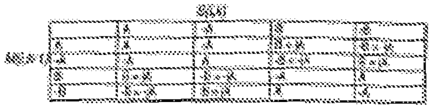

FIG. 14

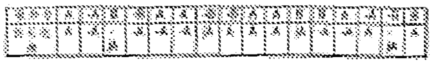

FIG. 15

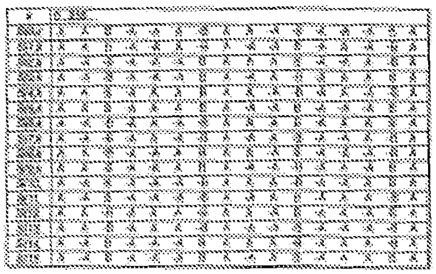

FIG. 16

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(32)優先日　　　　　平成11年4月14日(1999.4.14)
(33)優先権主張国　　米国(US)

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Fターム(参考) 5K022 EE02 EE13 EE25 EE32

# Electronic Acknowledgement Receipt

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|---|---|
| **EFS ID:** | 11682132 |
| **Application Number:** | 12303947 |
| **International Application Number:** | |
| **Confirmation Number:** | 1730 |
| **Title of Invention:** | METHOD OF TRANSMITTING DATA IN A MOBILE COMMUNICATION SYSTEM |
| **First Named Inventor/Applicant Name:** | Yeong Hyeon Kwon |
| **Customer Number:** | 35884 |
| **Filer:** | Harry Sung Lee/Diana Kim |
| **Filer Authorized By:** | Harry Sung Lee |
| **Attorney Docket Number:** | 2101-3596 |
| **Receipt Date:** | 21-DEC-2011 |
| **Filing Date:** | 07-JUL-2010 |
| **Time Stamp:** | 17:55:43 |
| **Application Type:** | U.S. National Stage under 35 USC 371 |

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| 3 | Foreign Reference | F2_JP2004274794.pdf | 1107072<br>e6cbc6d65227bdd2afc551995cf282c1b2d9427e | no | 21 |
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| **Information:** | | | | | |
| 4 | Foreign Reference | F3_JP2004512728.pdf | 2041519<br>b4a13e394d4362b4b462048a25315a26190e73e0 | no | 46 |
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| 5 | Foreign Reference | F4_JP435332.pdf | 518705<br>e21659cdf70051c8bc483e2b9f3e92f4af549ff7 | no | 6 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 6 | Foreign Reference | F5_JP11154929.pdf | 612130<br>b9dcdcd0301b90d5548c8c91206ed3b0dd9bef34 | no | 11 |
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| | Application Number | 12303947 |
| | Filing Date | 2010-07-07 |
| | First Named Inventor | Yeong Hyeon Kwon |
| | Art Unit | 2478 |
| | Examiner Name | Khajuria, Shripal K. |
| | Attorney Docket Number | 2101-3596 |

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| | 1 | 2005260337 | JP | | 2005-09-22 | Renesas Tech Corp. | | ☐ |
| | 2 | 2004274794 | JP | | 2004-09-30 | Interdigital Tech Corp. | | ☐ |
| | 3 | 2004512728 | JP | | 2004-04-22 | Samsung Electronics Co., Ltd. | | ☐ |

| INFORMATION DISCLOSURE STATEMENT BY APPLICANT ( Not for submission under 37 CFR 1.99) | Application Number | 12303947 |
|---|---|---|
| | Filing Date | 2010-07-07 |
| | First Named Inventor | Yeong Hyeon Kwon |
| | Art Unit | 2478 |
| | Examiner Name | Khajuria, Shripal K. |
| | Attorney Docket Number | 2101-3596 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 4 | 04-035332 | JP | | 1992-02-06 | Sanyo Electric Co., Ltd. | | ☐ |
| | 5 | 11-154929 | JP | | 1999-06-08 | Nippon Telegraph & Telephone | | ☐ |

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|---|---|---|
| | Application Number | 12303947 |
| | Filing Date | 2010-07-07 |
| | First Named Inventor | Yeong Hyeon Kwon |
| | Art Unit | 2478 |
| | Examiner Name | Khajuria, Shripal K. |
| | Attorney Docket Number | 2101-3596 |

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| Signature | /David G. Majdali/ | Date (YYYY-MM-DD) | 2011-12-22 |
|---|---|---|---|
| Name/Print | David G. Majdali | Registration Number | 53,257 |

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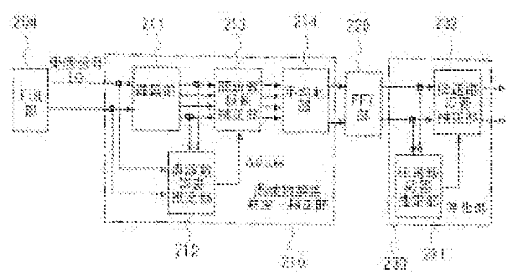
# Bibliographic data: JP2005260337 (A) — 2005-09-22

**DEMODULATION CIRCUIT AND RADIO COMMUNICATION SYSTEM**

| | | |
|---|---|---|
| **Inventor(s):** | MATSUDA KEISUKE; OKUBO TAKASHI; HORI JINICHI; TAKADA KAZUYUKI + | |
| **Applicant(s):** | RENESAS TECH CORP + | |
| **Classification:** | **- international:** | ***H04J11/00; H04L25/02; H04L27/14; H04L27/26; H04L27/38; H04L27/00;*** (IPC1-7): H04J11/00 |
| | **- European:** | H04L25/02C5; H04L27/26M5C3; H04L27/38A |
| **Application number:** | JP20040065567 20040309 | |
| **Priority number (s):** | JP20040065567 20040309 | |
| **Also published as:** | US2005213689 (A1) | |

**Abstract of JP2005260337 (A)**

PROBLEM TO BE SOLVED: To provide a semiconductor integrated circuit for communication having a built-in OFDM demodulation circuit capable of reducing a delay time from packet reception to demodulated data output, and a radio communication system employing the same. ; SOLUTION: The demodulation circuit demodulates a reception signal of a packet modulated in an orthogonal frequency division multiplexing system and containing a preamble having two or more continuous fixed signal sequences. The circuit is provided with a frequency error estimation/correction processing function (210) for estimating a frequency error of a reception signal using the received preamble to correct the reception signal, a fast Fourier transform processing function (FFT section 220) for transforming time axis information into frequency axis information from the received reception signal, a transmission path response estimation/correction processing function (230) for estimating the status of a transmission path from the transformed signal to correct the reception signal, and an averaging processing function (214); for averaging the reception signal after the frequency error correction. The circuit is configured so that the averaging processing may be executed before execution of the fast Fourier transform processing. ; COPYRIGHT: (C) 2005,JPO&NCIPI



(19)日本国特許庁(JP)　　(12)公開特許公報(A)　　(11)特許出願公開番号
特開2005-260337
(P2005-260337A)
(43)公開日　平成17年9月22日(2005.9.22)

| (51)Int.Cl.[7] | F I | | テーマコード（参考） |
|---|---|---|---|
| H04J 11/00 | H04J 11/00 | Z | 5K022 |

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(22)出願日　平成16年3月9日(2004.3.9)

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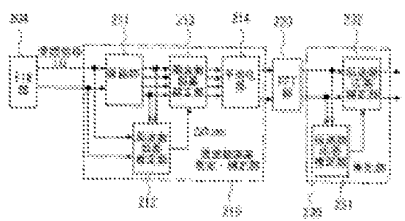
最終頁に続く

(54)【発明の名称】復調回路および無線通信システム

(57)【要約】
【課題】パケット受信から復調データ出力までの遅延時間を小さくできるOFDM復調回路を内蔵した通信用半導体集積回路とそれを用いた無線通信システムを提供する。
【解決手段】直交周波数分割多重方式で変調され、2以上の既定信号系列が連続したプリアンブルを含むパケットの受信信号を復調する復調回路において、受信した前記プリアンブルを用いて受信信号の周波数誤差を推定し受信信号を補正する周波数誤差推定・補正処理機能（210）と、補正された受信信号から時間領域情報を周波数領域情報に変換する高速フーリエ変換処理機能（FFT部220）と、変換された信号から伝送路の状態を推定し受信信号を補正する伝送路応答推定・補正処理機能（230）と、周波数誤差補正後の受信信号の平均を取る平均化処理機能（214）とを設け、前記平均化処理が前記高速フーリエ変換処理の前に実行されるように構成した。
【選択図】図4



【特許請求の範囲】

【請求項1】

直交周波数分割多重方式で変調され、2以上の固定信号系列が連続したプリアンブルを含むパケットの受信信号を復調する復調回路であって、

受信した前記プリアンブルを用いて受信信号の周波数誤差を推定し受信信号を補正する周波数誤差推定・補正処理機能と、

補正された受信信号を時間軸情報から周波数軸情報の信号に変換する高速フーリエ変換処理機能と、

変換された信号から伝送路の状態を推定し受信信号を補正する伝送路応答推定・補正処理機能と、

周波数誤差補正後の受信信号の平均を取る平均化処理機能とを備え、

前記平均化処理が前記高速フーリエ変換処理の前に実行されるように構成された復調回路が１つの半導体チップに形成されてなることを特徴とする通信用半導体集積回路。

【請求項2】

受信したプリアンブルを所定時間だけ遅延する遅延手段を備え、

該遅延手段により遅延されたプリアンブルと該プリアンブルの受信後に受信したプリアンブルとに基づいて周波数誤差推定・補正処理が行われるように構成されていることを特徴とする請求項１に記載の通信用半導体集積回路。

【請求項3】

前記周波数誤差推定・補正処理により補正された後のプリアンブルを遅延する第２の遅延手段を備え、

連続したプリアンブルを周波数誤差推定・補正処理により順次補正し、

補正されたプリアンブルを前記第２の遅延手段で遅延させ、

該遅延されたプリアンブルと前記周波数誤差推定・補正処理により補正されたプリアンブルとを用いて前記平均化処理を行い、該平均化処理が前記高速フーリエ変換処理の前に実行されるように構成されていることを特徴とする請求項２に記載の通信用半導体集積回路。

【請求項4】

受信したプリアンブルを保持するメモリ回路を備え、

該メモリ回路に格納されているプリアンブルと該プリアンブルの受信後に受信したプリアンブルとに基づいて周波数誤差推定・補正処理が行われるように構成されていることを特徴とする請求項１に記載の通信用半導体集積回路。

【請求項5】

前記パケットは前記プリアンブルとシグナルとデータで構成され、

前記シグナルは前記データのデータ転送レートとデータ長を指し示す情報を含み、

前記平均化処理は前記シグナルが入力されている間に行われるように構成されていることを特徴とする請求項１ないし４に記載の通信用半導体集積回路。

【請求項6】

前記平均化処理は、２つのプリアンブルを加算して２で割る処理ことを特徴とする請求項１ないし５に記載の通信用半導体集積回路。

【請求項7】

前記平均化処理は、連続する２つのプリアンブルの時間平均を取る処理であることを特徴とする請求項１ないし５に記載の通信用半導体集積回路。

【請求項8】

受信信号を順次遅延させる直列形態の複数の遅延段と、

各遅延段に対応された掛け算器とからなり受信信号から帯域外の周波数成分を除去する有限インパルス応答型フィルタを備え、

前記有限インパルス応答型フィルタは受信信号が通過する前記遅延段の数が切替え可能に構成されていることを特徴とする請求項１ないし７に記載の通信用半導体集積回路。

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【請求項9】
前記有限インパルス応答型フィルタは、いずれか1または2以上の前記遅延段を通過せずに受信信号を伝達させるバイパス経路と、該バイパス経路を通過した受信信号または前記いずれか1または2以上の前記遅延段を通過した受信信号のいずれか一方を選択する選択手段を備えていることを特徴とする請求項8に記載の通信用半導体集積回路。

【請求項10】
前記高速フーリエ変換処理機能は、バタフライ演算の複素乗算が可能な第1演算手段と、該第1演算手段による演算結果を保持するメモリ回路と、高速フーリエ変換処理のいずれかのステージの演算が可能な第2演算手段とを備え、
前記第2演算手段の演算は前記第1演算手段の演算よりも単純な演算であることを特徴とする請求項1ないし9に記載の通信用半導体集積回路。

【請求項11】
前記第1演算手段は、入力信号に基づく第1ステージの演算と前記メモリ回路に保持されている演算結果に基づく第2ステージの演算とを順次実行し、前記第2演算手段は前記第1演算手段における第2ステージの演算と並行して第3ステージの演算を実行するように構成されていることを特徴とする請求項10に記載の通信用半導体集積回路。

【請求項12】
直交周波数分割多重方式で変調され、2以上の固定信号系列が連続したプリアンブルを含むパケットの受信信号を復調する復調回路であって、
受信した前記プリアンブルを用いて受信信号の周波数誤差を推定し受信信号を補正する周波数誤差推定・補正処理機能と、
補正された受信信号から時間軸情報を周波数軸情報に変換する高速フーリエ変換処理機能と、
変換された信号から伝送路の状態を推定し受信信号を補正する伝送路応答推定・補正処理機能と、
周波数誤差補正後の受信信号の平均を取る平均化処理機能と、受信信号から帯域外の周波数成分を除去するためのフィルタとを備え、
前記フィルタは受信信号を順次遅延させる直列形態の複数の遅延段と、前記各遅延段に対応された掛け算器とからなり受信信号が通過する前記遅延段の数が切替え可能に構成された復調回路が1つの半導体チップに形成されてなることを特徴とする通信用半導体集積回路。

【請求項13】
前記フィルタは、いずれか1または2以上の遅延段を通過せずに受信信号を伝達させるバイパス経路と、該バイパス経路を通過した受信信号または前記いずれか1または2以上の前記遅延段を通過した受信信号のいずれか一方を選択する選択手段を備えていることを特徴とする請求項12に記載の通信用半導体集積回路。

【請求項14】
前記パケットには、第1の固定信号系列が連続した第1のプリアンブルに続いて前記第1の固定信号系列よりも長い第2の固定信号系列が連続した第2のプリアンブルが含まれ、
前記フィルタは前記第1のプリアンブルを処理する際に受信信号が通過する前記遅延段の数が減少するように制御されることを特徴とする請求項12または13に記載の通信用半導体集積回路。

【請求項15】
直交周波数分割多重方式で変調され、2以上の固定信号系列が連続したプリアンブルを含むパケットの受信信号を復調する復調回路であって、
受信した前記プリアンブルを用いて受信信号の周波数誤差を推定し受信信号を補正する周波数誤差推定・補正処理機能と、
補正された受信信号から時間軸情報を周波数軸情報に変換する高速フーリエ変換処理機能と、

変換された信号から伝送路の状態を推定し受信信号を補正する伝送路応答推定・補正処理機能と、

前記推定補正後の受信信号の平均を取る平均化処理機能とを備え、

前記高速フーリエ変換処理機能は、バタフライ演算の複素乗算が可能な第１演算手段と、該第１演算手段による演算結果を保持するメモリ回路と、高速フーリエ変換処理のいずれかのステージの演算が可能な第２演算手段とを備え、

前記第２演算手段の演算は前記第１演算手段の演算よりも単純な演算である復調回路が１つの半導体チップに形成されてなることを特徴とする通信用半導体集積回路。

【請求項16】

前記第１演算手段は、入力信号に基づく第１ステージの演算と前記メモリ回路に保持されている演算結果に基づく第２ステージの演算とを順次実行し、前記第２演算手段は前記第１演算手段における第２ステージの演算と並行して第３ステージの演算を実行するように構成されていることを特徴とする請求項１５に記載の通信用半導体集積回路。

【請求項17】

請求項１ないし１６に記載の復調回路と、

受信信号をデジタル信号に変換して前記復調回路に入力するＡ／Ｄ変換回路と、

直交周波数分割多重方式の変調を行なう変調回路と、

該変調回路により変調された信号をアナログ信号に変換して出力するＤ／Ａ変換回路とが１つの半導体チップに形成されてなることを特徴とする通信用半導体集積回路。

【請求項18】

請求項１ないし１７に記載の通信用半導体集積回路と、

受信信号をベースバンド信号に周波数変換する周波数変換回路および周波数変換された受信信号を所定のレベルに増幅する可変利得増幅回路と送信信号を高周波信号に周波数変換する周波数変換回路とを有する高周波用半導体集積回路とを備え、

前記可変利得増幅回路は前記通信用半導体集積回路から供給されるゲイン設定信号に基づいて増幅率が設定されるようにされていることを特徴とする無線通信システム。

【請求項19】

前記高周波用半導体集積回路は受信した前記パケットに含まれるプリアンブルに基づいて受信信号の強度を検出して外部へ検出信号を出力する受信強度検出回路を備え、

前記通信用半導体集積回路は前記受信強度検出回路から出力された検出信号に基づいて前記可変利得増幅回路のゲインを決定しゲイン設定信号を生成して出力するゲイン設定回路を備えることを特徴とする請求項１８に記載の無線通信システム。

【請求項20】

前記ゲイン設定回路は前記復調回路に入力された受信信号に基づいて受信信号の強度を検出して前記可変利得増幅回路のゲインを決定しゲイン設定信号を生成して出力する機能を備え、

前記受信強度検出回路から出力された検出信号に基づいて前記可変利得増幅回路のゲインを粗く設定するための第１ゲイン設定信号を生成して出力した後、前記復調回路に入力された受信信号に基づいて前記可変利得増幅回路のゲインを精密に設定するための第２ゲイン設定信号を生成して出力することを特徴とする請求項１９に記載の無線通信システム。

【発明の詳細な説明】

【技術分野】

【0001】

本発明は、ＯＦＤＭ(Orthogonal Frequency Division Multiplexing:直交周波数分割多重)変調方式を用いた復調回路および無線通信システムに関し、特に受信処理遅延時間の短縮に有効な技術に関するものである。

【背景技術】

【0002】

近年、無線通信やデジタル放送の送信信号の変調方式の一つにＯＦＤＭ変調方式を用いいものがある。ＯＦＤＭ変調方式は直交性を有する複数のキャリアを用いるデジタル変調方

式であるため、一般にマルチパス干渉に対して優れた特性を有している。しかし、複数のキャリアを用いる為に周波数誤差による信号歪みが大きく、高精度の周波数同期が必要である。また、マルチパス干渉に対して優れた特性を生かすためには、各サブキャリアの伝送路応答（ゴーストなど周囲の状況に応じて変化する受信状態）を適切に補正する必要がある。

【0003】

また、ＯＦＤＭ変調方式を採用する無線ＬＡＮなどはデータの伝送をパケット方式で行なうが、パケット伝送では高速にパケットの検出や同期処理を行う必要がある。そのため、一般にＯＦＤＭパケット信号では、パケット先頭に既知パターンの繰り返し信号(プリアンブル信号：以降プリアンブルと記述)が付加されており、プリアンブルを用いてパケット検出、同期処理、伝送路応答補正が行われる。一例として図２に、5GHz帯無線ＬＡＮの規格であるIEEE802.11aで規定されているパケットの構成を示す。

【0004】

図２に示されているように、IEEE802.11aパケットは、ショートプリアンブル部ＳＰＡ（ｔ１～ｔ10）、ロングプリアンブル部ＬＰＡ（Ｔ１，Ｔ２）、シグナル部（SIGNAL）、データ部（DATA）からなる。このうち、ショートプリアンブル部ＳＰＡは、0.8μs周期の固定パターンが１０回繰り返されており、主にタイミング検出、受信同期処理に用いられる。ロングプリアンブルＬＰＡは3.2μs周期の固定パターンが２回繰り返されている。ロングプリアンブルＬＰＡの終端３２サンプル分(1.6μs)のコピーが、ガードインターバルＧＩとしてロングプリアンブルの先頭に付加され、全体で8μsの長さとされており、主に周波数誤差補正、伝送路応答補正等に用いられる。シグナル部（SIGNAL）は、これに続いて送られるデータ部（DATA）のデータ転送レートとデータ長等が格納されたシンボルで、データ部（DATA）とともに、そのシンボルの終端１６サンプル分(0.8μs)のコピーがガードインターバルＧＩとしてシンボルの先頭に付加され、それぞれ全体で4μsの長さとされている。図２のようなパケット構成を持つ無線通信信号に関する伝送路応答推定方式については、例えば非特許文献１に開示されている。

【非特許文献1】社団法人電子情報通信学会発行、信学技報"TECHNICAL REPORT OF IEICE RCS2000-54(2000-06)"「ＯＦＤＭ通信システムにおける伝送路推定方式に関する検討」

【発明の開示】

【発明が解決しようとする課題】

【0005】

図１にはＯＦＤＭ変調信号復調回路のこの発明に先立って本発明者によって検討された構成が示され、図３にはこの発明に先立って本発明者によって検討された復調回路における周波数誤差推定・補正部２１０と等化部２３０の詳細が示されている。アンテナ２０１で受信されたパケットはＲＦ部２０２でベースバンド信号にダウンコンバートされ、Ａ／Ｄ変換部２０３にてデジタル信号に変換される。その後、受信信号はＦＩＲ(Finite Impulse Response:有限インパルス応答型)フィルタ２０４にて帯域外の高周波成分が除去される。ＲＦ部２０２は、受信信号のレベルがＡ／Ｄ変換部２０３のダイナミック・レンジに入るようにＡＧＣ(Auto Gain Control:自動利得制御)部２０５によってゲイン設定が行われる。

【0006】

同期部２０６では、デジタル信号に変換された受信パケットのプリアンブルの繰り返しパターンを用いて、同期検出部２０７により同期位置検出および同期処理を行い、周波数誤差推定・補正部２１０により周波数誤差の推定および周波数誤差補正を行う。また、この時点でガードインターバルの除去が行われる。ＦＦＴ(Fast Fourier Transform:高速フーリエ変換)部２２０では、受信信号を時間軸情報から周波数軸情報へ変換する処理を行う。

【0007】

等化部２３０では、周波数軸情報に変換された受信プリアンブルパターンと既知プリアンブルパターンとを比較することで伝送路応答を推定し、伝送路応答の補正を行う。この

時、通常受信パケットには伝送路応答とノイズの両方が含まれた状態で受信されるため、単純に既知プリアンブルパターンと比較するとノイズ分が伝送路応答推定誤差として現れ、伝送路応答の補正を正確に行うことができない。そのため、プリアンブルパターンが複数回繰り返されていることを利用して、図3に示すようにＦＦＴ部２２０で周波数軸情報に変換された受信プリアンブルパターンを平均化部２３４で平均化してノイズ低減を行い、伝送路応答推定部２３１での推定誤差を少なくする。

【0008】

図１及び３で示された復調方式では、パケットが受信されてから伝送路応答の補正が行われるまでの遅延時間が大きく、アンテナ端で受信完了してから、復調したパケットに対する送信を開始までの時間が長くなるという不具合がある。以下に、上記不具合を解消する上で問題となる課題を説明する。

【0009】

図１１（Ｂ）にこの発明に先立って本発明者によって検討されたＯＦＤＭ変調信号復調部でのタイミングチャートを示す。伝送路応答補正出力まで遅延時間Ｔdを大きくしている要因は、第一に、周波数誤差推定・補正部２１０で繰り返しパターン（プリアンブルＴ１，Ｔ２）に対する補正を順番に行っていること、第２に、周波数誤差推定・補正部２１０で周波数誤差を推定するために繰り返しパターンを受信データ保持部２１１で一度保持し、さらに等化部２３０で伝送路応答の推定を行う際に繰り返しパターンを平均化する為に平均化部２３４で保持していること、にある。

【0010】

第二の課題は、以下の点にある。上述したように、パケットを受信すると自動利得制御でＡ／Ｄ変換のダイナミック・レンジに収まるようにゲイン設定が行われるが、パケット受信からゲイン設定までの時間が大きくなると、その分ダイナミック・レンジを無視した受信データで復調することになる。そのため、より早くパケットを受信したことを検知し、適正なゲイン設定をすることが重要となる。一般に、受信信号の検知はＲＳＳＩ(Received Signal Strength Indicator:受信信号強度表示)や受信信号を用いた電力計算等により行われる。受信データは、同期検出、周波数補正処理を行う前に図２０に示すようなＦＩＲフィルタを通して帯域外の高周波成分を取り除く。通常、このＦＩＲフィルタ出力を用いて電力計算が行われる。この時、ＦＩＲフィルタのタップ数（遅延素子と掛け算器の組の数）を多くすると、受信信号が通過する遅延素子の数が多くなるため、信号がフィルタに入力されてから出力されるまでの遅延時間が大きくなりパケット検出までの時間も大きくなる。逆にタップ数を少なくすると遅延時間は減少するが、フィルタ性能が劣化して十分な復調処理ができなくなる。

【0011】

第三の課題は、以下の点にある。ＦＦＴ（高速フーリエ変換部）では一般にバタフライ演算が行われるが、回路規模を抑えて処理を行うには図１９のような構成が採用される。すなわち、時間軸方向のデータは一度入力データ格納用メモリ２２１に格納され、演算に必要なデータが揃うとセレクタ２２５を通ってバタフライ演算部２２２でバタフライ演算を行い、その演算結果を演算結果格納用メモリ２２３に格納する(第１ステージ)。次にセレクタ２２５を切り替え演算結果格納用メモリ２２３からデータを読み出し、再びバタフライ演算部２２２で演算を行い、演算結果を演算結果格納用メモリ２２３に格納する(第２ステージ)。さらに格納したデータから、もう一度バタフライ演算部２２２で演算を行い、その演算結果を周波数軸方向のデータとして出力する(第三ステージ)。従って、図９（Ｂ）に示すように、各ステージの処理をシリアルに行うことになる為、処理時間が大きい。バタフライ演算部２２２は加算器と複素乗算器等で構成されており、処理時間を抑える為には、各ステージ処理を並列処理する必要があるが、並列処理をするには複数の加算器と複素乗算器等が必要であり、回路規模が極めて大きくなる。

【0012】

本発明の目的は、上記のような課題を解決することで、パケット受信から復調データ出力までの遅延時間を小さくできるＯＦＤＭ復調回路を内蔵した通信用半導体集積回路とそ

れを用いた無線通信システムを提供することにある。

この発明の前記ならびにそのほかの目的と新規な特徴については、本明細書の記述および添付図面から明らかになるであろう。

【課題を解決するための手段】

【0013】

本願において開示される発明のうち代表的なものの概要を説明すれば、下記のとおりである。

すなわち、本出願に係る発明は、固定信号系列を一区間とし、該固定信号系列の少なくとも二区間以上の繰り返しを含むプリアンブルを送信パケットに有するＯＦＤＭ変調信号の伝送システムに適用され、受信側で前記プリアンブルの受信信号を用いて周波数誤差の推定と補正を行う周波数誤差補正機能と、前記プリアンブルの受信信号を用いて伝送路応答の推定と補正を行う伝送路応答補正機能を有するＯＦＤＭ復調回路において、受信したプリアンブルを遅延させる為の遅延手段と、受信したプリアンブルと前記遅延手段を用いて遅延させたプリアンブルとから周波数誤差推定を行い、該推定信号をもとに周波数誤差補正を行う周波数誤差補正機能と、前記周波数誤差補正機能で補正した受信プリアンブルをＦＦＴ処理前に平均化処理する平均化手段と、該平均化処理されたプリアンブルのＦＦＴ処理結果に基づいて伝送路応答の推定を行い、該伝送路応答の推定結果からＯＦＤＭ変調信号を復調する伝送路応答補正機能とを有することを特徴とする。

【0014】

上記した手段によれば、プリアンブルの平均化処理が時間軸において行われ、周波数軸情報に変換されるのは平均化された後のプリアンブルとなるため、パケットが受信されてから伝送路応答補正までの遅延時間を短縮することができる。前記周波数誤差補正機能は、遅延手段を用いて遅延させたプリアンブルとその後受信したプリアンブルに対して前記周波数誤差推定に基づいて同時に周波数誤差補正を行ってから平均化するように構成（図４）しても良いし、前記遅延手段とは別個に周波数誤差補正された受信プリアンブルを遅延させる為の第２の遅延手段を設け、複数のプリアンブルを順次別々に周波数誤差補正し、前のプリアンブルのサンプルを第２の遅延手段で遅延して、後から受信したプリアンブルのサンプルの補正出力と同時に平均化するように構成（図１２）しても良い。

【0015】

また、本出願に係る発明は、受信したプリアンブルを保持する為の記憶手段と、受信したプリアンブルと記憶手段を用いて保持したプリアンブルとから周波数誤差推定を行い、該推定信号をもとに周波数誤差を行う周波数誤差補正機能と、前記周波数誤差補正機能で補正した受信プリアンブルをＦＦＴ処理前に平均化処理する平均化手段と、該平均化処理されたプリアンブルのＦＦＴ処理結果に基づいて伝送路応答の推定を行い、該伝送路応答の推定結果からＯＦＤＭ変調信号を復調する伝送路応答補正機能とを有することを特徴とする。受信したプリアンブルを保持する記憶手段を設けることによって、記憶したプリアンブルを任意のタイミングで読み出すことができるため、時間的に離れたプリアンブルに基づいて周波数誤差推定を行うことができるようになり、これによってより精度の高い推定が可能となる。

【0016】

さらに、本出願に係る発明は、受信信号のゲイン調整を行うゲイン調整手段と、ゲイン調整された受信信号をアナログ信号からデジタル信号に変換するデジタル変換手段と、前記デジタル変換された受信信号の帯域外信号を除去する有限インパルス応答型フィルタ（ＦＩＲフィルタ）と、該ＦＩＲフィルタの出力から前記ゲイン調整手段を用いて自動利得制御を行う自動利得制御を有し、利得制御を行う前後で上記ＦＩＲフィルタの段数を切り替えることを特徴とする。フィルタの段数を切り替え可能に構成することで、自動利得制御の際にＦＩＲフィルタの段数を減らして遅延時間を少なくすることができ、それによって利得制御に要する時間を短縮することができるようになる。

【0017】

さらにまた、本出願に係る発明は、前記周波数誤差補正を行った受信信号を時間軸情報

から周波数軸情報に変換する高速フーリエ変換（ＦＦＴ）処理機能を有し、該ＦＦＴ処理にバタフライ演算を用い、バタフライ演算の一部を並列に実行することを特徴とする。ＦＦＴ処理におけるバタフライ演算は、複雑な演算を行うステージと単純な演算を行う複数のステージからなるので、そのうち演算が複雑なステージは共通の演算回路を用いて時分割で実行し、演算が単純なステージは別個の専用の演算回路を用いて実行することで、回路規模の増加を抑えつつ、処理時間を短縮することができる。

【発明の効果】

【0018】

本願において開示される発明のうち代表的なものによって得られる効果を簡単に説明すれば下記のとおりである。

パケットが受信されてからベースバンド信号に変換された後、復調された信号が得られるまでの遅延時間を短縮することができる。

【発明を実施するための最良の形態】

【0019】

以下、本発明を、一例としてIEEE802.11a規格に準拠した無線ＬＡＮシステムを構成するＯＦＤＭ復調回路に適用した場合の実施例を示す。

【0020】

（実施例１）

図4は、ＯＦＤＭ復調回路の第１の実施例を示す。本実施例のＯＦＤＭ復調回路は、この発明に先立って本発明者によって検討されたＯＦＤＭ復調回路と同様に、Ａ／Ｄ変換された受信信号Ｉ，Ｑから帯域外の高周波成分を除去するＦＩＲフィルタ２０４と、周波数誤差の推定と補正を行う周波数誤差推定・補正部２１０と、受信信号を時間軸情報から周波数軸情報に変換するＦＦＴ部２２０と、周波数軸情報に変換された受信パケットのプリアンブルパターンと既知プリアンブルパターンとを比較することで伝送路応答を推定し、伝送路応答の補正を行う等化部２３０などから構成されている。

【0021】

周波数誤差推定・補正部２１０は、遅延素子で構成され受信した受信パケットのショートプリアンブルを１６サンプル期間だけ遅延させる遅延部２１１と、遅延されたショートプリアンブルのパターンと続いて受信されたショートプリアンブルのパターンとから周波数誤差の推定を行う周波数誤差推定部２１２と、検出された周波数推定値と遅延されたショートプリアンブルのパターンおよび続いて受信されたショートプリアンブルのパターンとから周波数誤差の補正を行う周波数誤差補正部２１３と、補正後の受信信号の時間平均を取る平均化部２１４とから構成されている。

【0022】

図5に周波数誤差推定部２１２のブロック図、図6に周波数誤差推定部２１２の動作タイミングチャートを示す。周波数誤差推定部２１２は、自己相関演算部１２１と相関値誤差保持部１２２と周波数誤差演算部１２３とから構成されている。

【0023】

この実施例の周波数誤差推定部２１２における周波数誤差の推定は、受信パケットのショートプリアンブルとロングプリアンブルにおいて繰り返しパターン信号間の相関を利用して、繰り返し信号区間（１６サンプル期間）だけ遅延させた信号の複素共役信号とその後に続く繰り返し信号との複素乗算を行って位相回転量を検出することで行うことができる。具体的には、１６サンプル期間遅延されたショートプリアンブルの繰り返しパターンtaと、続いて受信されたショートプリアンブルの繰り返しパターンtbとからそれらの相関を自己相関演算部１２１でとる。

【0024】

ここで、自己相関値は、１６サンプル期間遅延させたショートプリアンブルの受信信号Ｉ，Ｑをそれぞれshort00_i,short00q、続けて受信されてくるショートプリアンブルの受信信号Ｉ，Ｑをそれぞれshort16_i,short16_qとすると、

I成分相関値：(short00_i×short16_i)+(short00_q×short16_q)

Q成分相関値：(short00_i×short16_q)－(short00_q×short16_i)
であり、ノイズの影響を低減する為に、上記相関値を16サンプル分それぞれ加算したものをquad16_i，quad16_qとすると、粗い周波数誤差推定値$\Delta\theta_{short}$は、

$\Delta\theta_{short}$＝arctan(quad16_q／quad16_i)

で求められる。

【0025】

こうして求められた粗周波数誤差推定値$\Delta\theta_{short}$は、粗周波数誤差保持部122に格納される。次に、続いて受信されたロングプリアンブルT1を遅延部211で64サンプル周期遅延させたものを、続いて受信されてくるロングプリアンブルT2とともに自己相関演算部121に入力し、64サンプルの各サンプルから相関を取り、先に推定した粗周波数誤差と合わせて周波数誤差演算部123で、より精密な周波数誤差推定を行う。

【0026】

64サンプル周期遅延させたロングプリアンブルの受信信号I，Qをそれぞれlong00_i，long00_qとし、続いて入力されてくるロングプリアンブルの受信信号I，Qをそれぞれ、long64_i，long64_qとすると、

I成分相関値：(long00_i×long64_i)＋(long00_q×long64_q)

Q成分相関値：(long00_i×long64_q)－(long00_q×long64_i)

であり、ノイズの影響を低減する為に、上記相関値を32サンプル分それぞれ加算したものをquad64_i，quad64_qとすると、密周波数推定値$\Delta\theta_{long}$は、

$\Delta\theta_{long}$＝arctan(quad64_q/quad64_i)＋α($\Delta\theta_{short}$，quad64_i，quad64_q)

で求められる。

【0027】

ここで、α($\Delta\theta_{short}$，quad64_i，quad64_q)は$\Delta\theta_{short}$，quad64_i，quad64_qの値によって決まる位相補正値である。こうして求められた周波数誤差推定値$\Delta\theta_{long}$は周波数誤差補正部213に入力される。

【0028】

図7に周波数誤差補正部213及び平均化部214の構成例を示す。

周波数誤差補正部213は、周波数誤差補正値演算部131と2つの複素乗算器132，133とからなり、前記遅延部211にて64サンプル周期遅延されたロングプリアンブルが入力パスA1から一方の複素乗算器132に入力され、続けて受信されたロングプリアンブルが入力パスB1から他方の複素乗算器133に入力され、同時に周波数補正が行われる。周波数誤差補正値演算部131では、シンボルタイミングからのサンプル位置をk(k=0,1,…,63)とすると、一番目のロングプリアンブルに対応した周波数誤差補正値A2としてcos($\Delta\theta_{long}$×k)，sin($\Delta\theta_{long}$×k)を出力し、2番目のロングプリアンブルに対応した周波数誤差補正値B2としてcos($\Delta\theta_{long}$×(64+k))，sin($\Delta\theta_{long}$×(64+k))を出力する。

【0029】

複素乗算器132，133では、補正する前の64サンプル周期遅延のロングプリアンブルのサンプル位置kでのI成分，Q成分をそれぞれlong0_i[k]，long0_q[k]とし、補正後の64サンプル周期遅延のロングプリアンブルのサンプル位置kでのI成分、Q成分をそれぞれlong0f_i[k]，long0f_q[k]とすると、

long0f_i[k]=long0_i[k]×cos($\Delta\theta_{long}$×k)－long0_q[k]×sin($\Delta\theta_{long}$×k)

long0f_q[k]=long0_i[k]×sin($\Delta\theta_{long}$×k)＋long0_q[k]×cos($\Delta\theta_{long}$×k)

で周波数誤差の補正がなされる。

【0030】

また、続けて受信されてきたロングプリアンブルの補正前のサンプル位置kでのI成分，Q成分をそれぞれ、long1_i[k]，long1_q[k]とし、続けて受信されてきたロングプリアンブルの補正後のサンプル位置kでのI成分，Q成分をlong1f_i[k]，long1f_q[k]とすると、

long1f_i[k]＝long1_i[k]×cos($\Delta\theta_{long}$×(64+k))

　　　　－long1_q[k]×sin($\Delta\theta_{long}$×(64+k))

$$long1f\_q[k] = long1\_i[k] \times \sin(\Delta\theta_{long} \times (64+k)) + long1\_q[k] \times \cos(\Delta\theta_{long} \times (64+k))$$

で周波数誤差の補正がなされる。

【0031】

上記周波数誤差補正部２１３で周波数誤差補正されたそれぞれのロングプリアンブルは平均化部２１４に入力される。平均化部２１４は、２つの加算器１４１，１４２と２つの１／２回路１４３，１４４と２つのセレクタ１４５，１４６とからなり，周波数誤差補正されたそれぞれのロングプリアンブル６４サンプルについて各サンプルタイミング毎に加算器１４１，１４２による加算と１／２回路１４３，１４４による１／２演算を行うことで平均化し、出力する。

【0032】

ロングプリアンブルに続くシグナルシンボルSIGNAL、データシンボルDATAは平均化処理が不要の為、平均化したロングプリアンブルを出力した以降は、入力バスＢ１からの受信データと周波数誤差補正値Ｂ２を複素乗算器１３２，１３３へ入力して周波数補正を行い、セレクタ１４５，１４６を切り替えて平均化せずにそのまま出力する。なお、この時点で出力されるのは1シンボル当り６４サンプルであり，ガードインターバルは除去されている。

【0033】

上記のようにして平均化されたロングプリアンブルはＦＦＴ部２２０に入力され，時間軸方向のＯＦＤＭ変調信号から周波数軸方向のサブキャリア信号に変換するマルチキャリア復調が行われる。サブキャリア信号に変換されたロングプリアンブルは等化部２３０に入力され、伝送路歪等推定部２３１で伝送路歪等の推定と補正が行われる。

【0034】

図８に本実施例におけるＦＦＴ部２２０の構成例を示す。

本実施例のＦＦＴ部２２０は、周波数誤差推定補正部２１０からの入力を一時保持するためのメモリ２２１と、バタフライ演算を行う演算部２２２と、演算結果を保持するメモリ２２３およびメモリ２２４と、周波数誤差推定補正部２１０からの入力またはメモリ２２３に保持されている演算結果をバタフライ演算部２２２へ選択的に入力するためのセレクタ２２５と、符号変換と加算を行う加算部２２６とから構成されている。ＦＦＴにおけるバタフライ演算には、Radix2の バタフライ演算とRadix4のバタフライ演算が知られているが、本実施例においては、バタフライ演算部２２２はRadix4のバタフライ演算を行うように構成されている。Radix4のバタフライ演算は３つのステージ演算からなる。

【0035】

以下、６４ポイントＦＦＴによるRadix4のバタフライ演算x[n] → X[k]　(n=0,1,…,63 ; k=0,1,…,63)のアルゴリズムを説明する。

【0036】

［第１ステージ］

Radix4の第１ステージの演算を数式１に示す。本実施例のＦＦＴ部２２０では、この演算をバタフライ演算部２２２で行い、演算結果をメモリ２２３に格納する。

【0037】

【数1】

$$n = 16n_1 + n'_2 \ (n_1 = 0,1,2,3; n'_2 = 0,1,\ldots,15)$$

$$k = k_1 + 4k'_2 \ (k_1 = 0,1,2,3; k'_2 = 0,1,2,\ldots,15)$$

$$\begin{aligned} X[k] &= \sum_{n=0}^{63} x[n] W_{64}^{nk} \\ &= \sum_{n_2'=0}^{15} \sum_{n_1=0}^{3} x[16n_1 + n_2'] W_{64}^{(16n_1+n_2')(k_1+4k_2')} \\ &= \sum_{n_2'=0}^{15} \sum_{n_1=0}^{3} x[16n_1 + n_2'] W_{64}^{16n_1k_1} W_{64}^{64n_1k_2'} W_{64}^{n_2'k_1} W_{64}^{4n_2'k_2'} \\ &= \sum_{n_2'=0}^{15} \left( \sum_{n_1=0}^{3} x[16n_1 + n_2'] W_4^{n_1k_1} W_{64}^{n_2'k_1} \right) W_{16}^{n_2'k_2'} \\ &= \sum_{n_2'=0}^{15} \tilde{x}_1[k_1, n_2'] W_{16}^{n_2'k_2'} \end{aligned}$$

$$W_N^{nk} = \exp\left(-\frac{2\pi nk}{N}\right) = \cos\left(\frac{2\pi nk}{N}\right) - j \cdot \sin\left(\frac{2\pi nk}{N}\right)$$

【0058】

〔第2ステージ〕

Radix4の第2ステージの演算を数式2に示す。本実施例のFFT部220では、この演算をメモリ223に格納されている値を読み出してセレクタ225を介してバタフライ演算部222へ入力させて行い、演算結果をメモリ224に格納する。

【0059】

【数2】

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$$n'_2 = 4n_2 + n_3 \quad (n_2 = 0,1,2,3; n_3 = 0,1,2,3)$$

$$k'_2 = k_2 + 4k_3 \quad (k_2 = 0,1,2,3; k_3 = 0,1,2,3)$$

$$\sum_{n_2'=0}^{15} \tilde{x}_1[k_1, n_2'] W_{16}^{n_2' k_2'}$$

$$= \sum_{n_3=0}^{3} \sum_{n_2=0}^{3} \tilde{x}_1[k_1, 4n_2 + n_3] W_{16}^{(4n_2+n_3)(k_2+4k_3)}$$

$$= \sum_{n_3=0}^{3} \sum_{n_2=0}^{3} \tilde{x}_1[k_1, 4n_2 + n_3] W_{16}^{4n_2k_2} W_{16}^{16n_2k_3} W_{16}^{n_3k_2} W_{16}^{4n_3k_3}$$

$$= \sum_{n_3=0}^{3} \left( \sum_{n_2=0}^{3} \tilde{x}_1[k_1, 4n_2 + n_3] W_4^{n_2k_2} W_{16}^{n_3k_2} \right) W_4^{n_3k_3}$$

$$= \sum_{n_3=0}^{3} \tilde{x}_2[k_1, k_2, n_3] W_4^{n_3k_3}$$

【0040】

［第３ステージ］

Radix4の第３ステージの演算を数式３に示す。本実施例のＦＦＴ部２２０では、この演算を演算部２２６で行い、演算結果を出力する。

【0041】

【数3】

$$\sum_{n_3=0}^{3} \tilde{x}_2[k_1, k_2, n_2, n_3] W_4^{n_3k_3}$$

【0042】

上記アルゴリズムにおいて第３ステージに着目すると、数式３の中の$W_4^{n_3k_3}$の項は数式４で表わされ、数式４中のｃｏｓ、ｓｉｎの値として－１、０、１のいずれの値しか取らない。

【0043】

【数4】

$$W_4^{nk} = \exp\left(-\frac{2\pi nk}{4}\right) = \cos\left(\frac{2\pi nk}{4}\right) - j \cdot \sin\left(\frac{2\pi nk}{4}\right)$$

【0044】

従って、第３ステージの乗算処理はそれぞれ符号反転、０、変換無しのいずれかで実現できるため、実質的に乗算処理が不要で、符号変換と加算処理のみで実行することができ

るので、第１ステージ，第２ステージに比べ演算処理が軽くなる。そこで、本実施例のＦＦＴ部２２０では、演算部２２６を乗算器に比べて回路規模が小さな加算器で構成するとともに、第３ステージの演算は第２ステージの演算と並列に行うようにしている。

【0045】

本実施例のＦＦＴ部２２０では、前記周波数誤差推定・補正部２１０にて周波数誤差補正された受信信号がメモリ２２１に格納され、第１ステージの演算に必要なデータが入力されるまで一時保持する。必要なデータが揃うと演算部２２２で第１ステージの演算（数式１）を行い、その結果をメモリ２２３に格納し、第１ステージの演算が完了するまで一時保持する。次に、セレクタ２２５を切り替えて第１ステージの演算結果を用いて演算部２２２で第２ステージの演算（数式２）を行い、その結果をメモリ２２４に格納する。この時，メモリ２２４には第３ステージの演算に必要最小限な分だけ保持し、第２ステージの完了を待つことなく加算部２２６で第３ステージの演算（数式３）を行う。

【0046】

このようにすることで、図９（Ａ）のタイミングチャートに示すように、第２ステージの演算処理と第３ステージの演算処理とを並列に行うことができる。図１９にこの発明に先立って本発明者によって検討されたＦＦＴ部の構成例を示す。この発明に先立って本発明者によって検討されたＦＦＴ部は、メモリ２２４と加算部２２６がなく、上記第１～第３のステージの演算をすべて１つの演算部２２２により時分割で順に行うようになっていた。従って、この発明に先立って本発明者によって検討されたＦＦＴ部のタイミングチャートを示す図９（Ｂ）におけるデータ入力の開始からデータ出力の開始までのＦＦＴ処理時間と比較して、図９（Ａ）に示す本実施例におけるデータ入力の開始からデータ出力までのＦＦＴ処理時間の方が、約１ステージ分だけ短縮される。

【0047】

また、第１ステージの演算を行う演算部と第２ステージの演算を行う演算部とを別個に設けることにより全ステージを並列できるように構成することもできるが、本実施例のように、第３ステージのみ並列処理化したことにより第２ステージの演算を行う演算部が不要となり、全ステージを並列化する場合に比べて回路規模の増加が抑えられる。前述したように、第３ステージの演算は簡単な符号変換と加算処理で行えるので、本実施例のように第３ステージの演算を行う回路（加算器２２６）を追加したとしても回路規模の増加はわずかなもので済む。

【0048】

図１０には，伝送路応答推定部２３１及び伝送路応答補正部２３２のブロック図を示す。伝送路応答推定部２３１では、ロングプリアンブルパターン生成部３１１により既知のロングプリアンブルの符号情報が生成されて符号正負変換器３１２へ供給され、受信ロングプリアンブルの符号をあわせることで伝送路応答の推定値が求められる。その後、各サブキャリア毎にパワー演算部３１３にて推定値の大きさ（推定値の２乗|・|²）を、また複素乗算・除算部３１４で推定値の逆数を求めることで伝送路応答補正値が算出され、補正データ保持用のメモリ３２１に格納される。次に、ＦＦＴ部２２０にてサブキャリア信号に変換された、ロングプリアンブルの後続のシグナルシンボルSIGNALとデータシンボルDATAが、メモリ３２１に格納されている伝送路応答補正値を用いて複素乗算器３２２で複素乗算され、伝送路応答の補正が行われる。

【0049】

上記処理を、図１１（Ａ）に示すタイミングチャートで説明する。なお、図１１（Ａ）のタイミングチャートでは，ショートプリアンブルについては図示を省略している。

【0050】

ロングプリアンブルＴ１，Ｔ２から周波数誤差を推定し、ロングプリアンブルの周波数誤差補正出力では周波数誤差補正されたプリアンブルＴ１'，Ｔ２'が順番に出力される。この後、平均化処理を行い、ＦＦＴ出力ではノイズ低減されたロングプリアンブルＴ'がサブキャリア信号として出力される。従って，Ｔ'の出力と同時に伝送路応答の推定を開始することができ，続いてやってくるシグナルシンボルSIGNALから伝送路応答補正を行

うことも可能となる。これによって、図3のような構成を有するこの発明に先立って本発明者によって検討された復調回路のタイミングチャートを示す図１１（Ｂ）と比較すると分かるように、受信パケットのシグナルシンボルSIGNALの入力からシグナルシンボルSIGNALの伝送路応答補正出力までの遅延時間Ｔｄが、図１１（Ａ）に示すように１シンボル分だけ短いＴｄ’に短縮される。

【0051】

さて、ここでＦＦＴ処理前での平均化とＦＦＴ処理後での平均化が等価であることを示す。

２つの異なる時間において、同一期間をサンプリングした信号(サンプリング数N)を、$x(n)=(x_0,x_1,x_2,\cdots,x_{N-1})$、$y(n)=(y_0,y_1,y_2,\cdots,y_{N-1})$とおき、それぞれの信号について離散フーリエ変換を行うと、次の数式５のようになる。

【0052】

【数5】

$$X(k_x)=\sum_{n=0}^{N-1}(x_{re}(n)+jx_{im}(n))(\cos\frac{2\pi nk_x}{N}-j\sin\frac{2\pi nk_x}{N})$$

$$Y(k_y)=\sum_{n=0}^{N-1}(y_{re}(n)+jy_{im}(n))(\cos\frac{2\pi nk_y}{N}-j\sin\frac{2\pi nk_y}{N})$$

【0053】

IEEE802.11a規格ではサンプリング周波数誤差が±２０ppm以内であることが規定されており、平均化を行う2つの期間は、時間的に同一シンボル(ロングプリアンブル)内で連続していることを考慮すると、サンプリング周波数誤差については無視できるほど小さい。従って、$k=k_x=k_y$とみなすことができる。また、プリアンブルでの伝送路応答の時間的変化は無視できるものとする。これらを周波数軸上で各サブキャリア毎に平均すると、数式６のようになる。

【0054】

【数6】

$$\frac{X(k)+Y(k)}{2}=$$

$$\sum_{n=0}^{N-1}(\frac{x_{re}(n)+y_{re}(n)}{2}+j\frac{x_{im}(n)+y_{im}(n)}{2})(\cos\frac{2\pi nk}{N}-j\sin\frac{2\pi nk}{N})$$

【0055】

この数式は、時間軸上で各サンプルタイミング毎に平均した後に離散フーリエ変換したものを表した式と等価であり、上述した条件の下ではＦＦＴ処理前で平均化した場合とＦＦＴ処理後で平均化した場合とで違いは発生しないことが分かる。従って、本実施例のようにＦＦＴ処理の前でロングシンボルの平均化処理を行なうことが可能である。

【0056】

（変形例）

実施例１（図４）の遅延素子からなる遅延部２１１は、ＲＡＭ（ランダム・アクセス・メモリ）のようなメモリに置き換えることが可能である。かかる変形例では、ショートプリアンブルｔａを一時的にメモリに格納し、格納したショートプリアンブルtaを、続いて入力されてくるショートプリアンブルtbと共に周波数誤差推定部２１２に入力する。周波数誤差推定部２１２は実施例１と同様な構成を有しており、自己相関演算部１２１で

繰り返しパターンの１６サンプルの各サンプルからｔａとｔｂの相関を取り、粗く周波数誤差の推定し、粗周波数誤差保持部１２２に格納する。

【0057】

次に、続いて入力されてくるロングプリアンブルＴ１を一時的にメモリに格納し、格納したロングプリアンブルＴ１を続いて入力されてくるロングプリアンブルＴ２と共に自己相関演算部１２１に入力し、６４サンプルの各サンプルからＴ１とＴ２の相関を取り、先に推定した粗周波数誤差と合わせて周波数誤差演算部１２３で、より精密な周波数誤差推定を行い、推定値を出力する。それ以降の処理は実施例１と同様であるので、説明を省略する。

【0058】

この変形例の場合、入力される受信信号を遅延する遅延部の代わりに受信信号を記憶するメモリを用いた構成としているため、受信信号を一度格納すると任意のタイミングで読み出すことが可能となる。そのため、例えば前段のＲＦ部２０２において高速なゲイン設定により適正レベルのショートプリアンブルがより長く得られるような場合、粗周波数誤差推定において、図６の連続するショートプリアンブルｔａとｔｂの自己相関を取る代わりに、ｔａとその２つ後のショートプリアンブルｔｃによる３２サンプル間隔での自己相関を取ること、あるいはｔａとｔｄによる４８サンプル間隔での自己相関を取ることも可能となる。これによって、より精度の高い誤差推定が可能となる。

【0059】

これに対し、実施例１（図４）のように周波数誤差推定補正部２１０の入力部を遅延素子からなる遅延部２１１で構成すると、３２サンプル間隔での自己相関を取る場合には、ショートプリアンブルｔａとｔｂの２つのショートプリアンブル分遅延素子が必要となり、１６サンプル間隔での自己相関を取る場合と比べて回路規模が増加するが、本変形例の場合はメモリへの書込み・読み出しタイミングを制御することで、１６サンプル間隔での自己相関を取る場合と比べて回路規模の増加を伴うことなくサンプル間隔の異なる相関を取ることができる。

【0060】

（実施例２）

本発明に係るＯＦＤＭ復調回路の第２の実施例を図１２に示す。この実施例は、周波数誤差推定補正部２１０に、周波数誤差推定を行う為にショートプリアンブル又はロングプリアンブルを保持する遅延部２１１とは別に、ロングプリアンブルの平均化処理を行う為に補正後のロングプリアンブルを遅延する遅延部２１５を設けたものである。周波数誤差推定値出力までは実施例１と同様であるので説明は省略する。周波数誤差補正部２１３は、図１３のように構成される。実施例１における周波数誤差補正部２１３の構成を示す図７と比較すると明らかなように、この実施例では、複素乗算器が１つ少なくて済む。

【0061】

また、実施例１では周波数誤差補正値演算部１３１は６４サンプル分先の周波数誤差を加味して周波数誤差補正値を求める必要があったが、本実施例ではその必要がなく、周波数誤差補正値演算部１３１は最初のロングプリアンブル開始点を基準に各サンプルに対応した周波数誤差補正値Ａ２を逐次出力すれば良い。そして、複素乗算器１３２にて上記補正値Ａ２で周波数誤差補正された最初のロングプリアンブルＴ１’は遅延部２１５にて一時保持される。次に、２回目のロングプリアンブルＴ２を各サンプルに対し周波数誤差補正を行うと同時に、遅延部２１５に保持されている周波数誤差補正済みの最初のロングプリアンブルＴ１’の対応するサンプルを出力し、平均化部２１４にて補正後のプリアンブルＴ２’との平均化を行う。

【0062】

上記処理を、図１４に示すタイミングチャートで説明する。なお、図１４のタイミングチャートでは、ショートプリアンブルについては図示を省略している。

入力されたロングプリアンブルＴ１，Ｔ２に基づいて周波数誤差を推定し、ロングプリアンブルの周波数誤差補正出力では周波数誤差補正されたプリアンブルＴ１’，Ｔ２’が

順次に出力される。そして、T2'の出力と並行して平均化処理を行い、FFT出力ではノイズ低減されたロングプリアンブルT'がサブキャリア信号として出力される。この実施例では、FFTの出力T'の開始と同時に伝送路応答の推定を開始することができ、続いてやってくるシグナルシンボルSIGNALの先頭から伝送路応答補正を行うことが可能となる。

【0063】

(実施例3)

図15には本発明に係るOFDM復調回路の第3の実施例で用いられるFIR部の構成例を、図16にはそのFIR部を適用したOFDM復調回路を無線LANの復調部に使用した場合のシステム構成例を示す。

【0064】

本実施例におけるFIR部204は、図15に示すように、受信信号I用のフィルタ410と受信信号Q用のフィルタ420とからなり、各フィルタは、複数(n個)の遅延素子461a～461nが直列に接続された遅延段と、それぞれの遅延素子に対応して設けられ遅延された信号と所定の係数a1～anとを掛け算する乗算器462a～462nからなる掛け算部と、各乗算器462a～462nの出力を加算する加算部470などからなる。さらに、この実施例のFIR部204においては、m番目の遅延素子461bとm+1番目の遅延素子461cとの間に、入力信号を遅延素子461aから461bまでを通さずに直接m+1番目の遅延素子461cに入力させるためのセレクタ481と、m+1番目以降の遅延素子461c～461nに対応した乗算器462c～462nに、係数am+1～anに代えて係数bm+1～bnを与えるセレクタ483c～483nが設けられている。なお、この発明に先立って本発明者によって検討されたFIRフィルタは、セレクタ481と483c～483nがなく、タップ数(段数)は固定で1つの係数a1～anのみで動作する構成とされる。

【0065】

図16の実施例のシステムは、アンテナ部201で受信した信号がRF部202でベースバンド信号にダウンコンバートされて増幅され、受信信号I,Qと受信信号の強度を示すRSSI信号とがRF部202から出力される。出力された受信信号I,QとRSSI信号は、A/D変換部203内のA/D変換器301,302,303でデジタル信号に変換される。デジタル信号に変換されたRSSI信号は、パケット検出部501にて随時監視され、所定の判断基準を満たすかどうかでパケットを受信したか否かが決定される。パケット検出部501がパケットの受信を検出すると、その時のRSSI信号の値からAGC設定部502でRF部202内のAGC回路の大まかなゲインが決定され、ゲイン設定制御信号がRF部202へ供給される。

【0066】

この実施例のシステムでは、受信開始の際にFIR部204は、図15に示されている受信信号I用フィルタ410,受信信号Q用フィルタ420のそれぞれのセレクタ481を制御して見かけ上の遅延段の段数を減らした状態に設定しておき、フィルタの入力から出力までの遅延時間を短縮するようにしている。そのため、RF部202にて増幅された受信信号I,QはA/D変換部203でデジタル変換され、FIR部204に入力され帯域外の高周波成分を除去されるが、FIR部204は遅延段の段数が少ない状態に設定されているため、遅延時間が短くされる。

【0067】

次に、受信パケットが検出されると、FIRフィルタから出力される受信信号に基づいて自動利得制御部205内の電力計算部503が受信電力を計算し、その値からRF部203内のAGC回路の精密なゲインを決定して設定を行う。この時AGCゲイン設定終了信号をFIR部204に伝達し、セレクタ481及び加算部470、係数選択用セレクタ483a～483nを通常動作に必要な性能となる段数と係数に切り替える。このようにすることで、パケット受信からAGCゲイン設定までの所要時間を短縮することが可能となる。

【0068】
図１７（Ａ）には本実施例のＦＩＲフィルタを適用したシステムにおける処理のタイミングチャートが、図１７（Ｂ）にはこの発明に先立って本発明者によって検討されたＦＩＲフィルタを適用したシステムにおける処理のタイミングチャートが示されている。

【0069】
本実施例を適用したシステムでは、パケットを受信してからＡＧＣのゲイン設定を行うまでの間、ＦＩＲフィルタは段数が少ない状態で動作するため、ショートプリアンブルは段数の多いこの発明に先立って本発明者によって検討されたＦＩＲフィルタを適用したシステムに比べてＡＧＣの粗設定までの時間が短縮されることが分かる。なお、その後、ＦＩＲフィルタの段数を通常動作に必要な性能に切り替えるため、ＡＧＣ設定後のショートプリアンブルとロングプリアンブル、データは同一の遅延をもって出力される。従って、適正レベルの受信信号がより早く得られることになる。また、適正レベルのショートプリアンブルをより長く受信することができるようになるため、実施例２で述べた３２サンプル間隔でのショートプリアンブルの自己相関による周波数誤差推定も容易となる。

【0070】
図１８は、本発明に係るＯＦＤＭ復調回路を、IEEE802.11a規格に準拠した無線ＬＡＮシステムに適用した場合のシステム全体の構成例を示す。アンテナ２０１ａまたは２０１ｂで受信された信号は、ダイバーシティ・送受信切り替えスイッチ６０１を通り、バンドパスフィルタ６０２で不要波が抑制されて、ＲＦ－ＩＣ２０４に入力される。ＲＦ－ＩＣ２０４でベースバンド信号に周波数変換されＡＧＣ回路で増幅された受信信号は、前記実施例のＯＦＤＭ復調回路および変調回路を内蔵したベースバンドＬＳＩ６１０に入力され、Ａ／Ｄ変換器６１１でデジタル信号に変換された後、ベースバンドプロセッサ６１２で復調処理が行われる。復調された信号は媒体アクセス制御部(Medium Access Control,MAC)６１３に入力され、プロトコルに則ったデータアクセス制御が行われ、Ｉ／Ｏインタフェース６１４を通して上位層とデータのやり取りが行われる。

【0071】
以上の実施例によれば、時間軸においてプリアンブルの平均化処理を行うことにより、周波数補償情報に変換するのは平均化されたプリアンブルとなるため、パケットが受信されてからベースバンド信号に変換された後、伝送路応答補正復調された信号が得られるまでの遅延時間を短縮することができる。

【0072】
また、パケット受信時の自動利得制御においてＦＩＲフィルタを切り替えて段数を減らすことにより自動利得制御完了までの時間を短縮することができる。

【0073】
さらに、ＦＦＴ処理におけるバタフライ演算の一部を並列に実行することにより、回路規模の増加を抑え、処理時間を短縮することができる。これらの結果、パケット受信から復調データ出力までの遅延時間を大幅に短縮することができる。

【0074】
送信時は上位層からＩ／Ｏインタフェース６１４を通してアクセス制御部６１３に送られプロトコルに則ったデータアクセス制御が行われ、ベースバンドプロセッサ６１２に送信データが送られる。ベースバンドプロセッサ６１２では送信データをＯＦＤＭ信号に変調し、Ｄ／Ａ変換器６１５でアナログ信号に変換した後、ＲＦ－ＩＣ２０４に入力され、ＲＦ－ＩＣ２０４で５ＧＨｚ帯の信号に周波数変換され、送信用バンドパスフィルタ６０３で不要波を抑制した後、パワーアンプ６０４で送信信号を所望の信号強度まで電力増幅し、ダイバーシティ・送受切り替えスイッチ６０１を通してアンテナ２０１ａまたは２０１ｂから送信される。

【0075】
以上本発明者によってなされた発明を実施例に基づき具体的に説明したが、本発明は上記実施例に限定されるものではなく、その要旨を逸脱しない範囲で種々変更可能であることはいうまでもない。例えば前記実施例では、バタフライ演算としてRadix4を使用してい

るが、Radix2を用いるようにしても良い。

【産業上の利用可能性】

【0076】

以上の説明では主として本発明者によってなされた発明をその背景となった利用分野であるIEEE802.11a規格の無線ＬＡＮシステムにおけるＯＦＤＭ復調回路に適用した場合を説明したが、本発明はそれに限定されるものでなく、ＯＦＤＭ変調方式を用いた無線通信システムにおける復調回路や放送システムにおける復調回路に利用することができる。

【図面の簡単な説明】

【0077】

【図1】この発明に先立って本発明者によって検討されたＯＦＤＭ復調回路の構成例を示すブロック図である。

【図2】IEEE802.11a規格で規定されているパケットの構成を示す説明図である。

【図3】この発明に先立って本発明者によって検討されたＯＦＤＭ復調回路における周波数誤差推定・補正部から等化部までの構成を示すブロック図である。

【図4】本発明に係るＯＦＤＭ復調回路における周波数誤差推定・補正部から等化部までの構成を示すブロック図である。

【図5】実施例のＯＦＤＭ復調回路における周波数誤差推定部の構成を示すブロック図である。

【図6】実施例のＯＦＤＭ復調回路における周波数誤差推定のタイミングチャートである。

【図7】実施例のＯＦＤＭ復調回路における周波数誤差補正部及び平均化部の構成を示すブロック図である。

【図8】実施例のＯＦＤＭ復調回路におけるＦＦＴ部の構成を示すブロック図である。

【図9】（Ａ）は実施例のＯＦＤＭ復調回路のＦＦＴ部におけるタイミングチャート、（Ｂ）はこの発明に先立って本発明者によって検討されたＯＦＤＭ復調回路のＦＦＴ部におけるタイミングチャートである。

【図10】実施例のＯＦＤＭ復調回路における伝送路応答推定部及び伝送路応答補正部の構成を示すブロック図である。

【図11】（Ａ）は実施例のＯＦＤＭ復調回路におけるタイミングチャート、（Ｂ）はこの発明に先立って本発明者によって検討されたＯＦＤＭ復調回路におけるタイミングチャートである。

【図12】ＯＦＤＭ復調回路の第２の実施例を示すブロック図である。

【図13】第２の実施例のＯＦＤＭ復調回路における周波数誤差補正部及び平均化部及び遅延部の構成を示すブロック図である。

【図14】第２の実施例のＯＦＤＭ復調回路におけるタイミングチャートである。

【図15】第３の実施例のＯＦＤＭ復調回路におけるＦＩＲフィルタ部の構成を示すブロック図である。

【図16】第３の実施例のＯＦＤＭ復調回路の構成を示すブロック図である。

【図17】（Ａ）は第３の実施例のＯＦＤＭ復調回路におけるタイミングチャート、（Ｂ）はこの発明に先立って本発明者によって検討されたＯＦＤＭ復調回路におけるタイミングチャートである。

【図18】本発明に係るＯＦＤＭ復調回路を、IEEE802.11a規格に準拠した無線ＬＡＮシステムに適用した場合のシステム全体の構成例を示すブロック図である。

【図19】この発明に先立って本発明者によって検討されたＯＦＤＭ復調回路におけるＦＦＴ部の構成を示すブロック図である。

【図20】この発明に先立って本発明者によって検討されたＯＦＤＭ復調回路におけるＦＩＲフィルタ部の構成を示すブロック図である。

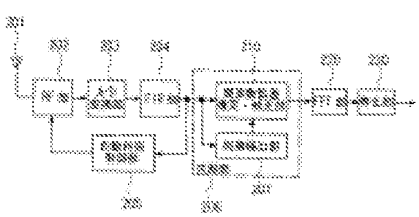
【符号の説明】

【0078】

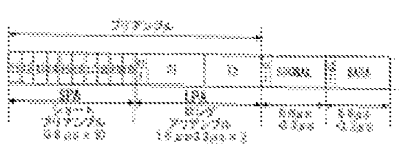
２０１　アンテナ

２０２　ＲＦ部
２０３　Ａ／Ｄ変換部
２０４　ＦＩＲ部
２１０　２１２　周波数誤差推定・補正部
２１１　遅延部
２１２　周波数誤差推定部
２１３　周波数誤差補正部
２１４　平均化部
２２０　ＦＦＴ部
２３０　等化部
２３１　伝送路応答推定部
２３２　伝送路応答補正部
４６１　遅延素子
４６２　乗算器
４７０　加算部
４８１　段数切り替え用セレクタ
４８３　係数選択用セレクタ

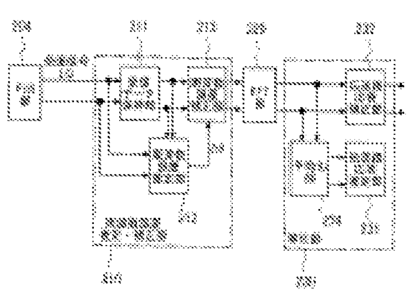
【図1】



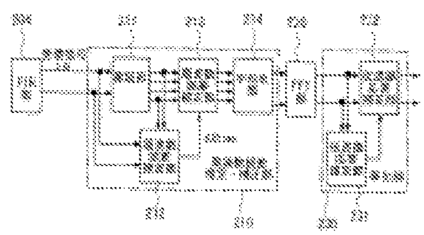
【図2】



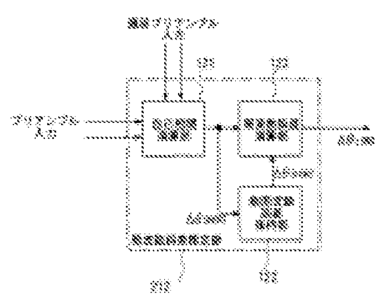
【図3】



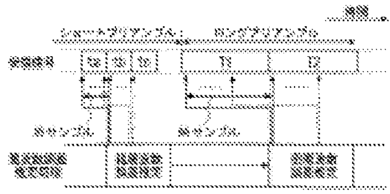
【図4】



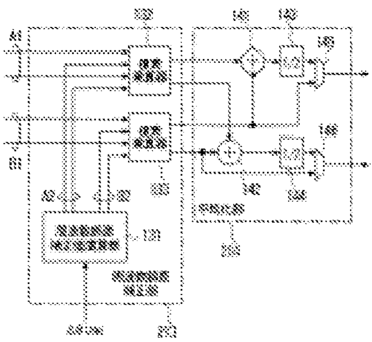
【図5】



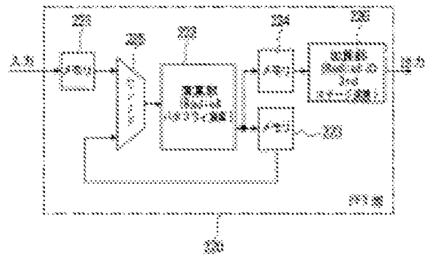
【図6】



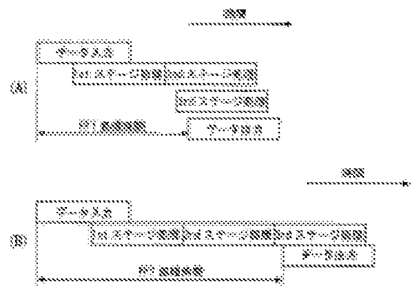
【図7】



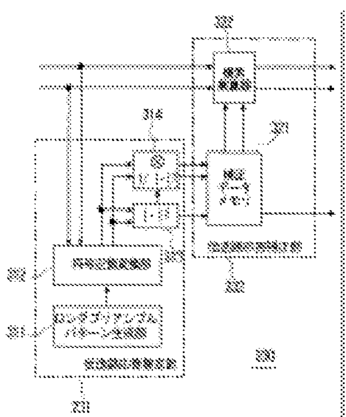
【図8】



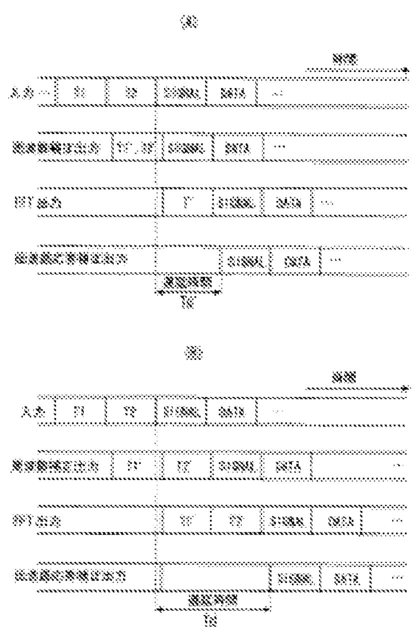
【図9】



【図10】



【図11】



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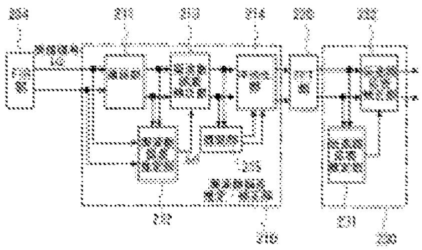
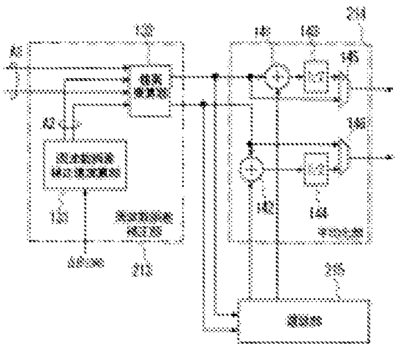
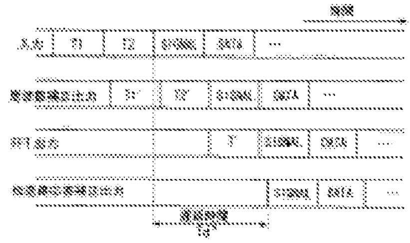
【図12】



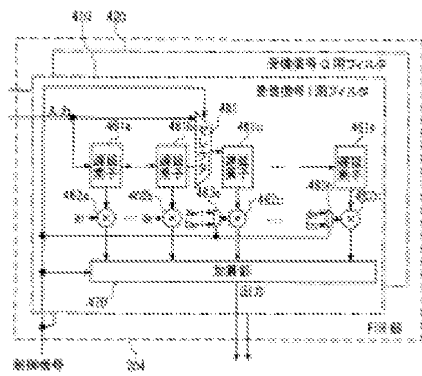
【図13】



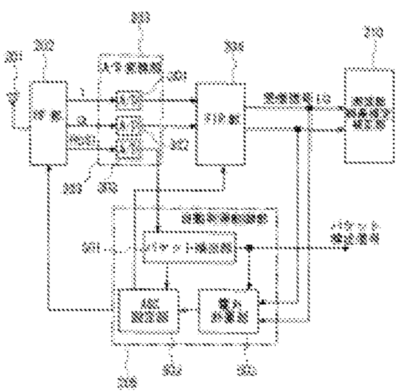
【図14】



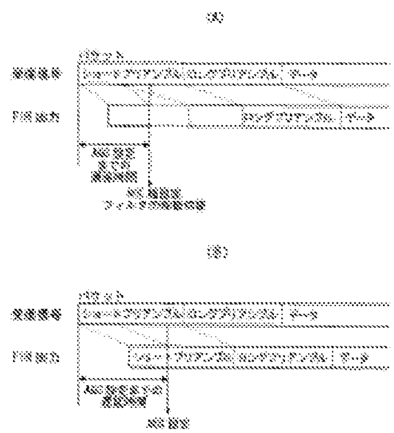
【図15】



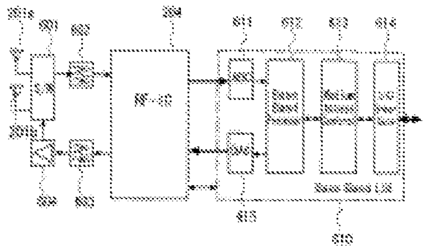
【図16】



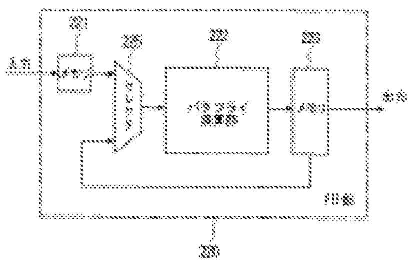
【図17】



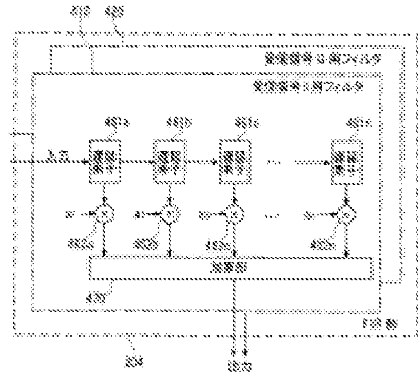
【図18】



【図19】



【図20】



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Fターム(参考) 5K022 DD01 DD13 DD19 DD33

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| **Examiner** | **Art Unit** |
| SHRIPAL KHAJURIA | 2478 |

| ORIGINAL | | INTERNATIONAL CLASSIFICATION | | | | | |
|---|---|---|---|---|---|---|---|
| CLASS | SUBCLASS | CLAIMED | | | | | NON-CLAIMED |
| 370 | 328 | H | 0 | 4 | L | 12 / 50 (2006.0) | |

**CROSS REFERENCE(S)**

| CLASS | SUBCLASS (ONE SUBCLASS PER BLOCK) | | | | |
|---|---|---|---|---|---|
| 370 | 329 | 330 | | | |

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

| Final | Original | Final | Original | Final | Original | Final | Original | Final | Original | Final | Original | Final | Original | Final | Original |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 31 | | | | | | | | | | | | | | |
| 2 | 32 | | | | | | | | | | | | | | |
| 3 | 33 | | | | | | | | | | | | | | |
| 4 | 34 | | | | | | | | | | | | | | |
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| 15 | 45 | | | | | | | | | | | | | | |
| 16 | 46 | | | | | | | | | | | | | | |

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|---|---|---|---|
| /S.K./<br>Examiner.Art Unit 2478<br><br>(Assistant Examiner) | 02/24/2012<br><br>(Date) | **Total Claims Allowed:**<br>16 | |
| /JEFFREY PWU/<br>Supervisory Patent Examiner.Art Unit 2478<br><br>(Primary Examiner) | 02/25/2012<br><br>(Date) | O.G. Print Claim(s)<br>1 | O.G. Print Figure<br>12 |

| *Index of Claims* | Application/Control No.<br>12303947 | Applicant(s)/Patent Under Reexamination<br>KWON ET AL. |
|---|---|---|
| | Examiner<br>SHRIPAL KHAJURIA | Art Unit<br>2478 |

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|---|---|
| ✓ | Rejected |
| = | Allowed |

| | |
|---|---|
| - | Cancelled |
| ÷ | Restricted |

| | |
|---|---|
| N | Non-Elected |
| I | Interference |

| | |
|---|---|
| A | Appeal |
| O | Objected |

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

| CLAIM | | DATE | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Final | Original | 09/07/2011 | 02/24/2012 | | | | | | | |
| 1 | 31 | ✓ | = | | | | | | | |
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35884 7590 03/06/2012
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| EXAMINER | |
|---|---|
| KHAJURIA, SHRIPAL K | |
| ART UNIT | PAPER NUMBER |
| 2478 | |

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TITLE OF INVENTION: METHOD OF TRANSMITTING DATA IN A MOBILE COMMUNICATION SYSTEM

| APPLN. TYPE | SMALL ENTITY | ISSUE FEE DUE | PUBLICATION FEE DUE | PREV. PAID ISSUE FEE | TOTAL FEE(S) DUE | DATE DUE |
|---|---|---|---|---|---|---|
| nonprovisional | NO | $1740 | $300 | $0 | $2040 | 06/06/2012 |

**THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.**

**THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.**

**HOW TO REPLY TO THIS NOTICE:**

I. Review the SMALL ENTITY status shown above.

If the SMALL ENTITY is shown as YES, verify your current SMALL ENTITY status:

A. If the status is the same, pay the TOTAL FEE(S) DUE shown above.

B. If the status above is to be removed, check box 5b on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and twice the amount of the ISSUE FEE shown above, or

If the SMALL ENTITY is shown as NO:

A. Pay TOTAL FEE(S) DUE shown above, or

B. If applicant claimed SMALL ENTITY status before, or is now claiming SMALL ENTITY status, check box 5a on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and 1/2 the ISSUE FEE shown above.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

**IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.**

## PART B - FEE(S) TRANSMITTAL

**Complete and send this form, together with applicable fee(s), to: Mail** **Mail Stop ISSUE FEE**
**Commissioner for Patents**
**P.O. Box 1450**
**Alexandria, Virginia 22313-1450**
**or Fax (571)-273-2885**

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

35884 7590 03/06/2012

LEE, HONG, DEGERMAN, KANG & WAIMEY
660 S. FIGUEROA STREET
Suite 2300
LOS ANGELES, CA 90017

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

**Certificate of Mailing or Transmission**

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 12/303,947 | 07/07/2010 | Yeong Hyeon Kwon | 2101-3596 | 1730 |

TITLE OF INVENTION: METHOD OF TRANSMITTING DATA IN A MOBILE COMMUNICATION SYSTEM

| APPLN. TYPE | SMALL ENTITY | ISSUE FEE DUE | PUBLICATION FEE DUE | PREV. PAID ISSUE FEE | TOTAL FEE(S) DUE | DATE DUE |
|---|---|---|---|---|---|---|
| nonprovisional | NO | $1740 | $300 | $0 | $2040 | 06/06/2012 |

| EXAMINER | ART UNIT | CLASS-SUBCLASS |
|---|---|---|
| KHAJURIA, SHRIPAL K | 2478 | 370-328000 |

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
   - ❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
   - ❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
   (1) the names of up to 3 registered patent attorneys or agents OR, alternatively,
   (2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.
   1 ______________________________
   2 ______________________________
   3 ______________________________

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. The following fee(s) are submitted:
- ❑ Issue Fee
- ❑ Publication Fee (No small entity discount permitted)
- ❑ Advance Order - # of Copies ______________________

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**
- ❑ A check is enclosed.
- ❑ Payment by credit card. Form PTO-2038 is attached.
- ❑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number _____________ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)
- ❑ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.
- ❑ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature ______________________________ Date ______________________________

Typed or printed name ______________________________ Registration No. ______________________________

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 12/303,947 | 07/07/2010 | Yeong Hyeon Kwon | 2101-3596 | 1730 |

35884 7590 03/06/2012

LEE, HONG, DEGERMAN, KANG & WAIMEY
660 S. FIGUEROA STREET
Suite 2300
LOS ANGELES, CA 90017

| EXAMINER | |
|---|---|
| KHAJURIA, SHRIPAL K | |
| **ART UNIT** | **PAPER NUMBER** |
| 2478 | |

DATE MAILED: 03/06/2012

**Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)**
(application filed on or after May 29, 2000)

The Patent Term Adjustment to date is 5 day(s). If the issue fee is paid on the date that is three months after the mailing date of this notice and the patent issues on the Tuesday before the date that is 28 weeks (six and a half months) after the mailing date of this notice, the Patent Term Adjustment will be 5 day(s).

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

## Privacy Act Statement

**The Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

| Notice of Allowability | Application No. 12/303,947 | Applicant(s) KWON ET AL. | |
|---|---|---|---|
| | **Examiner** SHRIPAL KHAJURIA | **Art Unit** 2478 | |

***-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--***

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *the amendment filed on 12/16/11*.

2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

3. ☒ The allowed claim(s) is/are *31-46 (Renumbered 1-16)*.

4. ☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
   a) ☒ All b) ☐ Some* c) ☐ None of the:
   1. ☒ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
**THIS THREE-MONTH PERIOD IS NOT EXTENDABLE**.

5. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.

6. ☐ CORRECTED DRAWINGS ( as "replacement sheets") must be submitted.
   (a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review ( PTO-948) attached
   1) ☐ hereto or 2) ☐ to Paper No./Mail Date _____.
   (b) ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

   **Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).**

7. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

**Attachment(s)**
1. ☐ Notice of References Cited (PTO-892)
2. ☐ Notice of Draftperson's Patent Drawing Review (PTO-948)
3. ☒ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date 10/31/11; 12/20/11; 12/21/11
4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
5. ☐ Notice of Informal Patent Application
6. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
7. ☐ Examiner's Amendment/Comment
8. ☐ Examiner's Statement of Reasons for Allowance
9. ☐ Other _____.

| /S. K./<br>Examiner, Art Unit 2478 | /J. P./<br>Supervisory Patent Examiner, Art Unit 2478 |
|---|---|

| **INFORMATION DISCLOSURE STATEMENT BY APPLICANT** ( **Not for submission under 37 CFR 1.99)** | | |
|---|---|---|
| | Application Number | 12303947 |
| | Filing Date | 2010-07-07 |
| | First Named Inventor | Yeong Hyeon Kwon |
| | Art Unit | 2478 |
| | Examiner Name | Khajuria, Shripal K. |
| | Attorney Docket Number | 2101-3596 |

**U.S.PATENTS** Remove

| Examiner Initial* | Cite No | Patent Number | Kind Code1 | Issue Date | Name of Patentee or Applicant of cited Document | Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear |
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|---|---|---|---|---|---|---|---|---|
| /S.K./ | 1 | 2005260337 | JP | | 2005-09-22 | Renesas Tech Corp. | | ☐ |
| /S.K./ | 2 | 2004274794 | JP | | 2004-09-30 | Interdigital Tech Corp. | | ☐ |
| /S.K./ | 3 | 2004512728 | JP | | 2004-04-22 | Samsung Electronics Co., Ltd. | | ☐ |

| Receipt date: 12/21/2011 | Application Number | 12303947 | 12303947 - GAU: 2478 |
|---|---|---|---|
| **INFORMATION DISCLOSURE STATEMENT BY APPLICANT** ( **Not for submission under 37 CFR 1.99)** | Filing Date | 2010-07-07 | |
| | First Named Inventor | Yeong Hyeon Kwon | |
| | Art Unit | 2478 | |
| | Examiner Name | Khajuria, Shripal K. | |
| | Attorney Docket Number | 2101-3596 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| /S.K./ | 4 | 04-035332 | JP | | 1992-02-06 | Sanyo Electric Co., Ltd. | | ☐ |
| /S.K./ | 5 | 11-154929 | JP | | 1999-06-08 | Nippon Telegraph & Telephone | | ☐ |

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**NON-PATENT LITERATURE DOCUMENTS** Remove

| Examiner Initials* | Cite No | Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published. | T5 |
|---|---|---|---|
| | 1 | | ☐ |

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**EXAMINER SIGNATURE**

| Examiner Signature | /Shripal Khajuria/ | Date Considered | 02/24/2012 |
|---|---|---|---|

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

| Search Notes | Application/Control No.<br>12303947 | Applicant(s)/Patent Under Reexamination<br>KWON ET AL. |
|---|---|---|
| | **Examiner**<br>SHRIPAL KHAJURIA | **Art Unit**<br>2478 |

## SEARCHED

| Class | Subclass | Date | Examiner |
|---|---|---|---|
| 370 | 328 | 9/7/2011 | skk |
| 370 | 328 | 2/24/2012 | skk |

## SEARCH NOTES

| Search Notes | Date | Examiner |
|---|---|---|
| Text search of East (USPat, USPG_Pub, JPO, EPO, Derwent, IBM_TDB) and Inventor search | 9/7/2011 | skk |
| Updated Text search of East (USPat, USPG_Pub, JPO, EPO, Derwent, IBM_TDB) | 2/24/2012 | skk |
| Limited class search of 370/329 and 370/330 | 2/24/2012 | skk |
| Consulted Jeff Pwu on allowable subject matter | 2/24/2012 | skk |

## INTERFERENCE SEARCH

| Class | Subclass | Date | Examiner |
|---|---|---|---|
| PgPub and UnPub | see attached search history | 2/24/2012 | skk |

**EAST Search History**

**EAST Search History (Prior Art)**

| Ref # | Hits | Search Query | DBs | Default Operator | Plurals | Time Stamp |
|---|---|---|---|---|---|---|
| L1 | 14884 | kwon.in. | US-PGPUB; USPAT; USOCR | OR | OFF | 2012/02/24 22:58 |
| L2 | 29796 | han.in. | US-PGPUB; USPAT; USOCR | OR | OFF | 2012/02/24 22:58 |
| L3 | 55702 | park.in. | US-PGPUB; USPAT; USOCR | OR | OFF | 2012/02/24 22:58 |
| L4 | 125629 | kim.in. | US-PGPUB; USPAT; USOCR | OR | OFF | 2012/02/24 22:58 |
| L5 | 195557 | lee.in. | US-PGPUB; USPAT; USOCR | OR | OFF | 2012/02/24 22:58 |
| L6 | 1930 | noh.in. | US-PGPUB; USPAT; USOCR | OR | OFF | 2012/02/24 22:58 |
| L7 | 4 | (L1 L2 L3 L4 L5 L6) and (preamble same prefix same repeated).clm. | US-PGPUB; USPAT; USOCR | OR | OFF | 2012/02/24 22:58 |
| L8 | 8822 | (370/328).CCLS. | US-PGPUB; USPAT; USOCR | OR | OFF | 2012/02/24 22:58 |
| L17 | 455 | cyclic near prefix and preamble same repeat$3 and length | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | OFF | 2012/02/24 23:02 |
| L19 | 87 | cyclic near prefix and preamble and concatenating | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | OFF | 2012/02/24 23:03 |
| L20 | 176 | prefix and preamble and concatenating | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | OFF | 2012/02/24 23:03 |
| L21 | 166 | prefix and preamble and concatenating and length | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | OFF | 2012/02/24 23:03 |
| L23 | 8753 | (370/329).CCLS. | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | OFF | 2012/02/24 23:05 |
| L24 | 1248 | (370/330).CCLS. | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | OFF | 2012/02/24 23:06 |
| L25 | 9909 | (l23 l24) prefix and preamble and concatenating | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | OFF | 2012/02/24 23:06 |
| L26 | 11 | (l23 l24) and prefix and preamble and | US-PGPUB; USPAT; USOCR; FPRS; EPO; | OR | OFF | 2012/02/24 23:06 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | concatenating | JPO; DERWENT; IBM_TDB | | | |
| L27 | 9903 | (l23 l24) prefix and preamble and concatenating and length | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | OFF | 2012/02/24 23:06 |
| L28 | 7 | (l23 l24) and prefix and preamble and concatenating and length | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | OFF | 2012/02/24 23:06 |
| S1 | 7734 | (370/328).CCLS. | US-PGPUB; USPAT; USOCR | OR | OFF | 2011/09/01 18:00 |
| S2 | 13808 | kwon.in. | US-PGPUB; USPAT; USOCR | OR | OFF | 2011/09/01 18:08 |
| S3 | 27622 | han.in. | US-PGPUB; USPAT; USOCR | OR | OFF | 2011/09/01 18:08 |
| S4 | 52224 | park.in. | US-PGPUB; USPAT; USOCR | OR | OFF | 2011/09/01 18:08 |
| S5 | 117541 | kim.in. | US-PGPUB; USPAT; USOCR | OR | OFF | 2011/09/01 18:08 |
| S6 | 185530 | lee.in. | US-PGPUB; USPAT; USOCR | OR | OFF | 2011/09/01 18:08 |
| S7 | 1736 | noh.in. | US-PGPUB; USPAT; USOCR | OR | OFF | 2011/09/01 18:08 |
| S8 | 4 | (S2 S3 S4 S5 S6 S7) and (preamble same prefix same repeated).clm. | US-PGPUB; USPAT; USOCR | OR | OFF | 2011/09/01 18:08 |
| S9 | 1 | ("20050286409").PN. | US-PGPUB; USPAT; USOCR | OR | OFF | 2011/09/01 19:55 |
| S10 | 463 | cyclic near prefix and preamble same repeat$3 | US-PGPUB; USPAT; USOCR | OR | OFF | 2011/09/07 10:52 |
| S11 | 51 | cyclic near prefix and preamble same repeat$3 and CAZAC | US-PGPUB; USPAT; USOCR | OR | OFF | 2011/09/07 10:52 |

**EAST Search History (Interference)**

| Ref # | Hits | Search Query | DBs | Default Operator | Plurals | Time Stamp |
|---|---|---|---|---|---|---|
| L9 | 14899 | kwon.in. | US-PGPUB; USPAT; UPAD | OR | OFF | 2012/02/24 22:59 |
| L10 | 29820 | han.in. | US-PGPUB; USPAT; UPAD | OR | OFF | 2012/02/24 22:59 |
| L11 | 55137 | park.in. | US-PGPUB; USPAT; UPAD | OR | OFF | 2012/02/24 22:59 |
| L12 | 125838 | kim.in. | US-PGPUB; USPAT; UPAD | OR | OFF | 2012/02/24 23:00 |
| L13 | 187828 | lee.in. | US-PGPUB; USPAT; UPAD | OR | OFF | 2012/02/24 23:00 |
| L14 | 4 | (l9 l10 l11 l12 l13) and (preamble same prefix same repeated).clm. | US-PGPUB; USPAT; UPAD | OR | OFF | 2012/02/24 23:01 |
| L15 | 523 | cyclic near prefix and preamble same repeat$3 | US-PGPUB; USPAT; UPAD | OR | OFF | 2012/02/24 23:02 |
| L16 | 455 | cyclic near prefix and preamble same repeat$3 and length | US-PGPUB; USPAT; UPAD | OR | OFF | 2012/02/24 23:02 |

| | | | | | | |
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| L18 | 26 | cyclic near prefix and preamble and concatenating | USPAT; UPAD | OR | OFF | 2012/02/24 23:03 |
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| | Application Number | 12303947 |
| | Filing Date | 2010-07-07 |
| | First Named Inventor | Yeong Hyeon Kwon |
| | Art Unit | 2478 |
| | Examiner Name | KHAJURIA, SHRIPAL K |
| | Attorney Docket Number | 2101-3596 |

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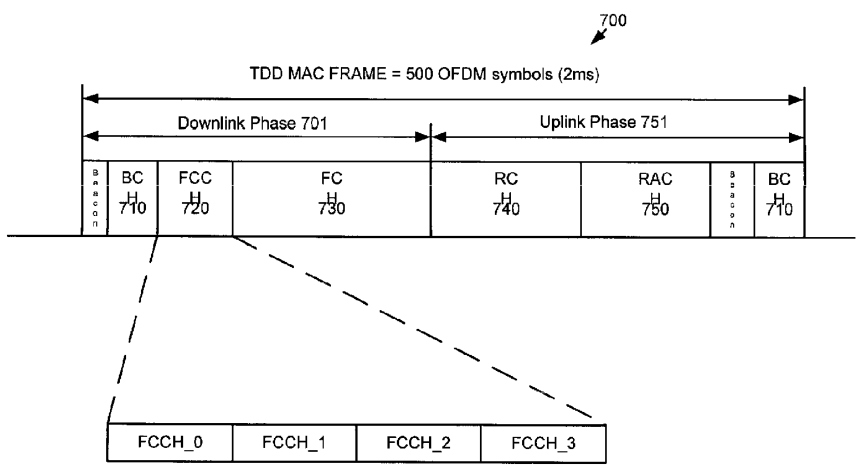
(54) **Title:** METHOD AND APPARATUS FOR PROVIDING AN EFFICIENT CONTROL CHANNEL STRUCTURE IN A WIRELESS COMMUNICATION SYSTEM




(57) **Abstract:** According to one aspect of the invention, a method is provided in which a control channel used for transmitting control information is partitioned into a plurality of subchannels each of which is operated at a specific data rate. For each of one or more user terminals, one of the subchannels is selected based on one or more selection criteria for transmitting control information from an access point to the respective user terminal. Control information is transmitted from the access point to a user terminal on a particular subchannel selected for the respective user terminal. At the user terminal, one or more subchannels are decoded to obtain control information designated for the user terminal.

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# METHOD AND APPARATUS FOR PROVIDING AN EFFICIENT CONTROL CHANNEL STRUCTURE IN A WIRELESS COMMUNICATION SYSTEM

## BACKGROUND

### I. Field

[0001] The present invention relates generally to data communication and processing, and more specifically to a method and apparatus for providing an efficient control channel structure in a wireless local area network (WLAN) communication system.

### II. Background

[0002] Wireless communication systems have been widely deployed to provide various types of communication such as voice, packet data, and so on. These systems may be multiple-access systems capable of supporting communication with multiple users sequentially or simultaneously by sharing the available system resources. Examples of multiple-access systems include Code Division Multiple Access (CDMA) systems, Time Division Multiple Access (TDMA) systems, and Frequency Division Multiple Access (FDMA) systems.

[0003] In recent years, wireless local area networks (WLANs) have also been widely deployed in accordance with various WLAN standards (e.g., IEEE 802.11a, 802.11b, and 802.11g, etc.) to enable communication among wireless electronic devices (e.g., computers) via wireless link. A WLAN may employ devices called access points (or base stations) that act like hubs and/or routers and provide connectivity for other wireless devices in the network (e.g. user terminals or user stations). The access points may also connect (or "bridge") the WLAN to wired LANs, thus allowing the wireless devices access to LAN resources.

[0004] In a wireless communication system, a radio frequency (RF) modulated signal from a transmitter unit may reach a receiver unit via a number of propagation paths. The characteristics of the propagation paths typically vary over time due to a number of factors, such as fading and multipath. To provide diversity against deleterious path effects and improve performance, multiple transmit and receive antennas may be used. If the propagation paths between the transmit and receive antennas are linearly independent (e.g., a transmission on one path is not formed as a linear combination of the transmissions on the other paths), then the likelihood of correctly receiving a data transmission increases as the number of antennas increases. Generally, diversity increases and performance improves as the number of transmit and receive antennas increases.

[0005] A MIMO system employs multiple ($N_T$) transmit antennas and multiple ($N_R$) receive antennas for data transmission. A MIMO channel formed by the $N_T$ transmit and $N_R$ receive antennas may be decomposed into $N_S$ spatial channels, with $N_S \leq \min\{N_T, N_R\}$. Each of the $N_S$ spatial channels corresponds to a dimension. The MIMO system can provide improved performance (e.g., increased transmission capacity and/or greater reliability) if the additional dimensionalities created by the multiple transmit and receive antennas are utilized.

[0006] An exemplary MIMO WLAN system is described in the aforementioned U.S. Patent Application Serial No. 10/693,419, assigned to the assignee of the present invention. Such a MIMO WLAN system may be configured to provide various types of services and support various types of applications, and achieve a high level of system performance. In various embodiments, MIMO and orthogonal frequency division multiplexing (OFDM) may be employed to attain high throughput, combat deleterious path effects, and provide other benefits. Each access point in the system may be configured to support multiple user terminals. The allocation of downlink and uplink resources may be dependent on the requirements of the user terminals, the channel conditions, and other factors.

[0007] In one embodiment, the WLAN system as disclosed in the aforementioned U.S. Patent Application employs a channel structure designed to support efficient downlink and uplink transmissions. Such a channel structure may comprise a number of transport channels that may be used for various functions, such as signaling of system parameters and resource assignments, downlink and uplink data transmissions, random access of the system, and so on. Various attributes of these transport channels may be configurable, which allows the system to easily adapt to changing channel and loading conditions. One of these transport channels, called forward control channel (FCCH), may be used by the access point to allocate resources (e.g., channel assignments) on the downlink and uplink. The FCCH may also be used to provide acknowledgment for messages received on another transport channel.

[0008] As disclosed in the aforementioned U.S. Patent Application, in one embodiment, the FCCH can be transmitted or operable at different data rates (e.g., four different data rates). For example, the different data rates may include 0.25 bps/Hz, 0.5 bps/Hz, 1 bps/Hz, and 2 bps/Hz. However, in such a configuration, the rate employed on the FCCH is dictated by the worst case user in the system (i.e., the user that operates at the lowest data rate). This scheme is inefficient because a single user that cannot operate at a higher rate may reduce the efficiency and utilization of the FCCH, even though other users in the system may be able to operate at higher data rates.

[0009] There is, therefore, a need in the art for a method and apparatus to provide a more efficient control channel structure that is able to accommodate different users that may operate at different data rates.

## SUMMARY

[0010] The various aspects and embodiments of the invention are described in further detail below. According to one aspect of the invention, a method is provided in which a control channel used for transmitting control information is partitioned into a plurality of subchannels each of which is operated at a specific data rate. For each of one or more user terminals, one of the subchannels is selected based on one or more selection criteria for transmitting control information from an access point to the respective user terminal. Control information is transmitted from the access point to a user terminal on a particular subchannel selected for the respective user terminal. At the user terminal, one or more subchannels are decoded to obtain control information designated for the user terminal.

## BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The various features and aspects of the invention can be understood from the detailed description set forth below in conjunction with the following drawings, in which:

[0012] FIG. 1 shows a block diagram of a MIMO WLAN system in which the teachings of the invention are implemented;

[0013] FIG. 2 shows a layer structure for the MIMO WLAN system;

[0014] FIG. 3 is a block diagram illustrating various components of an access point and user terminals;

[0015] FIGS. 4A, 4B and 4C show a TDD-TDM frame structure, an FDD-TDM frame structure, and an FDD-CDM frame structure, respectively;

[0016] FIG. 5 shows the TDD-TDM frame structure with five transport channels - BCH, FCCH, FCH, RCH, and RACH;

[0017] FIGS. 6A and 6B illustrate various PDU formats for the various transport channels;

[0018] FIG. 7 shows a new FCCH structure, in accordance with one embodiment of the invention;

[0019] FIG. 8 shows a flow diagram of a method, in accordance with one embodiment of the invention; and

[0020] FIG. 9 shows a flow diagram of a decoding process in accordance with one embodiment of the invention.

## DETAILED DESCRIPTION

[0021] The word "exemplary" is used herein to mean "serving as an example, instance, or illustration." Any embodiment or design described herein as "exemplary" is not necessarily to be construed as preferred or advantageous over other embodiments or designs.

[0022] **FIG. 1** shows a MIMO WLAN system 100 in which the teachings of the present invention are implemented. As shown in FIG. 1, MIMO WLAN system 100 includes a number of access points (APs) 110 that support communication for a number of user terminals (UTs) 120. For simplicity, only two access points 110 are shown in FIG. 1. An access point may also be referred to as a base station, access controller, or communication controller herein.

[0023] User terminals 120 may be dispersed throughout the system. Each user terminal may be a fixed or mobile terminal that can communicate with the access point. A user terminal may also be referred to as a mobile station, a remote station, an access terminal, a user equipment (UE), a wireless device, or some other terminology herein. Each user terminal may communicate with one or possibly multiple access points on the downlink and/or uplink at any given moment. The downlink (also called forward link) refers to transmission from the access point to the user terminal, and the uplink (also called reverse link) refers to transmission from the user terminal to the access point.

[0024] In FIG. 1, access point 110a communicates with user terminals 120a through 120f, and access point 110b communicates with user terminals 120f through 120k. Depending on the specific design of system 100, an access point may communicate with multiple user terminals simultaneously (e.g., via multiple code channels or subbands) or sequentially (e.g., via multiple time slots). At any given moment, a user terminal may receive downlink transmissions from one or multiple access points. The downlink transmission from each access point may include overhead data intended to be received by multiple user terminals, user-specific data intended to be received by specific user terminals, other types of data, or any combination thereof. The overhead data may include pilot, page and broadcast messages, system parameters, and so on.

[0025] In one embodiment, the MIMO WLAN system is based on a centralized controller network architecture. Thus, a system controller 130 couples to access points 110 and may further couple to other systems and networks. For example, system controller 130 may couple to a packet data network (PDN), a wired local area network (LAN), a wide area network (WAN), the Internet, a public switched telephone network (PSTN), a cellular communication network, etc. System controller 130 may be designed to perform a number of functions such as (1) coordination and control for the access points coupled to it, (2) routing of data among these access points, (3) access and control of communication with the user terminals served by these access points, and so on. The MIMO WLAN system as shown in FIG. 1 may be operated in various frequency bands (e.g., the 2.4 GHz and 5.x GHz U-NII bands), subject to the bandwidth and emission constraints specific to the selected operating band.

[0026] In one embodiment, each access point may be equipped with multiple transmit and receive antennas (e.g., four transmit and receive antennas) for data transmission and reception. Each user terminal may be equipped with a single transmit/receive antenna or multiple transmit/receive antennas for data transmission and reception. The number of antennas employed by each user terminal type may be dependent on various factors such as, for example, the services to be supported by the user terminal (e.g., voice, data, or both), cost considerations, regulatory constraints, safety issues, and so on.

[0027] For a given pairing of multi-antenna access point and multi-antenna user terminal, a MIMO channel is formed by the $N_T$ transmit antennas and $N_R$ receive antennas available for use for data transmission. Different MIMO channels are formed between the access point and different multi-antenna user terminals. Each MIMO channel may be decomposed into $N_S$ spatial channels, with $N_S \le \min\{N_T, N_R\}$. $N_S$ data streams may be transmitted on the $N_S$ spatial channels. Spatial processing is required at a receiver and may or may not be performed at a transmitter in order to transmit multiple data streams on the $N_S$ spatial channels.

[0028] The $N_S$ spatial channels may or may not be orthogonal to one another. This depends on various factors such as (1) whether or not spatial processing was performed at the transmitter to obtain orthogonal spatial channels and (2) whether or not the spatial processing at both the transmitter and the receiver was successful in orthogonalizing the spatial channels. If no spatial processing is performed at the transmitter, then the $N_S$ spatial channels may be formed with $N_S$ transmit antennas and are unlikely to be orthogonal to one another.

[0029] The $N_S$ spatial channels may be orthogonalized by performing decomposition on a channel response matrix for the MIMO channel, as described in the aforementioned U.S. Patent Application. For a given number of (e.g., four) antennas at the access point, the number of spatial channels available for each user terminal is dependent on the number of antennas employed by that user terminal and the characteristics of the wireless MIMO channel that couples the access point antennas and the user terminal antennas. If a user terminal is equipped with one antenna, then the four antennas at the access point and the single antenna at the user terminal form a multiple-input single-output (MISO) channel for the downlink and a single-input multiple-output (SIMO) channel for the uplink.

[0030] The MIMO WLAN system as shown in FIG. 1 may be designed and configured to support various transmission modes, as illustrated in Table 1 below.

Table 1

| Transmission modes | Description |
|---|---|
| SIMO | Data is transmitted from a single antenna but may be received by multiple antennas for receive diversity. |
| Diversity | Data is redundantly transmitted from multiple transmit antennas and/or multiple subbands to provide diversity. |
| Beam-steering | Data is transmitted on a single (best) spatial channel at full power using phase steering information for the principal eigenmode of the MIMO channel. |

| | |
|---|---|
| Spatial multiplexing | Data is transmitted on multiple spatial channels to achieve higher spectral efficiency. |

[0031] The transmission modes available for use for the downlink and uplink for each user terminal are dependent on the number of antennas employed at the user terminal. Table 2 lists the transmission modes available for different terminal types for the downlink and uplink, assuming multiple (e.g., four) antennas at the access point.

Table 2

| **Transmission modes** | **Downlink** | | **Uplink** | |
|---|---|---|---|---|
| | Single-antenna user terminal | Multi-antenna user terminal | Single-antenna user terminal | Multi-antenna user terminal |
| MISO (on downlink)/ SIMO (on uplink) | X | X | X | X |
| Diversity | X | X | | X |
| Beam-steering | X | X | | X |
| Spatial multiplexing | | X | | X |

[0032] In an embodiment, the MIMO WLAN system employs OFDM to effectively partition the overall system bandwidth into a number of ($N_F$) orthogonal subbands. These subbands are also referred to as tones, bins, or frequency channels. With OFDM, each subband is associated with a respective subcarrier that may be modulated with data. For a MIMO system that utilizes OFDM, each spatial channel of each subband may be viewed as an independent transmission channel where the complex gain associated with each subband is effectively constant across the subband bandwidth.

[0033] In one embodiment, the system bandwidth can be partitioned into 64 orthogonal subbands (i.e., $N_F = 64$), which are assigned indices of –32 to +31. Of these 64 subbands, 48 subbands (e.g., with indices of ±{1, ..., 6, 8, ..., 20, 22, ... , 26}) can be used for data, 4 subbands (e.g., with indices of ±{7, 21}) can be used for pilot and possibly signaling, the DC subband (with index of 0) is not used, and the remaining subbands are also not used and serve as guard subbands. This OFDM subband structure is described in further detail in a document for IEEE Standard 802.11a and entitled

"Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications: High-speed Physical Layer in the 5 GHz Band," September 1999, which is publicly available. In other embodiments, different numbers of subbands and various other OFDM subband structures may also be implemented for the MIMO WLAN system. For example, all 53 subbands with indices from -26 to +26 may be used for data transmission. As another example, a 128-subband structure, a 256-subband structure, or a subband structure with some other number of subbands may be used.

**[0034]** For OFDM, the data to be transmitted on each subband is first modulated (i.e., symbol mapped) using a particular modulation scheme selected for use for that subband. Zeros are provided for the unused subbands. For each symbol period, the modulation symbols and zeros for all $N_F$ subbands are transformed to the time domain using an inverse fast Fourier transform (IFFT) to obtain a transformed symbol that contains $N_F$ time-domain samples. The duration of each transformed symbol is inversely related to the bandwidth of each subband. In one specific design for the MIMO WLAN system, the system bandwidth is 20 MHz, $N_F = 64$, the bandwidth of each subband is 312.5 KHz, and the duration of each transformed symbol is 3.2 μsec.

**[0035]** OFDM can provide certain advantages, such as the ability to combat frequency selective fading, which is characterized by different channel gains at different frequencies of the overall system bandwidth. It is well known that frequency selective fading causes inter-symbol interference (ISI), which is a phenomenon whereby each symbol in a received signal acts as distortion to subsequent symbols in the received signal. The ISI distortion degrades performance by impacting the ability to correctly detect the received symbols. Frequency selective fading can be conveniently combated with OFDM by repeating a portion of (or appending a cyclic prefix to) each transformed symbol to form a corresponding OFDM symbol, which is then transmitted.

**[0036]** The length of the cyclic prefix (i.e., the amount to repeat) for each OFDM symbol is dependent on the delay spread of the wireless channel. In particular, to effectively combat ISI, the cyclic prefix should be longer than the maximum expected delay spread for the system.

**[0037]** In an embodiment, cyclic prefixes of different lengths may be used for the OFDM symbols, depending on the expected delay spread. For the MIMO WLAN system described above, a cyclic prefix of 400 nsec (8 samples) or 800 nsec (16 samples) may be selected for use for the OFDM symbols. A "short" OFDM symbol uses the 400 nsec cyclic prefix and has a duration of 3.6 μsec. A "long" OFDM symbol uses the 800 nsec cyclic prefix and has a duration of 4.0 μsec. Short OFDM symbols may be used if the maximum expected delay spread is 400 nsec or less, and long OFDM symbols may be used if the delay spread is greater than 400 nsec. Different cyclic prefixes may be selected for use for different transport channels, and the cyclic prefix may also be dynamically selectable, as described below. Higher system throughput may be achieved by using the shorter cyclic prefix when possible, since more OFDM symbols of shorter duration can be transmitted over a given fixed time interval.

[0038] **FIG. 2** illustrates a layer structure 200 that may be used for the MIMO WLAN system. As shown in FIG. 2, in one embodiment, layer structure 200 includes (1) applications and upper layer protocols that approximately correspond to Layer 3 and higher of the ISO/OSI reference model (upper layers), (2) protocols and services that correspond to Layer 2 (the link layer), and (3) protocols and services that correspond to Layer 1 (the physical layer).

[0039] The upper layers includes various applications and protocols, such as signaling services 212, data services 214, voice services 216, circuit data applications, and so on. Signaling is typically provided as messages and data is typically provided as packets. The services and applications in the upper layers originate and terminate messages and packets according to the semantics and timing of the communication protocol between the access point and the user terminal. The upper layers utilize the services provided by Layer 2.

[0040] Layer 2 supports the delivery of messages and packets generated by the upper layers. In the embodiment shown in FIG. 2, Layer 2 includes a Link Access Control (LAC) sublayer 220 and a Medium Access Control (MAC) sublayer 230. The LAC sublayer implements a data link protocol that provides for the correct transport and delivery of messages generated by the upper layers. The LAC sublayer utilizes the services provided by the MAC sublayer and Layer 1. The MAC sublayer is responsible for transporting messages and packets using the services provided by Layer 1. The MAC sublayer controls the access to Layer 1 resources by the applications and services in the upper layers. The MAC sublayer may include a Radio Link Protocol (RLP) 232, which is a retransmission mechanism that may be used to provide higher reliability for packet data. Layer 2 provides protocol data units (PDUs) to Layer 1.

[0041] Layer 1 comprises physical layer 240 and supports the transmission and reception of radio signals between the access point and user terminal. The physical layer performs coding, interleaving, modulation, and spatial processing for various transport channels used to send messages and packets generated by the upper layers. In this embodiment, the physical layer includes a multiplexing sublayer 242 that multiplexes processed PDUs for various transport channels into the proper frame format. Layer 1 provides data in units of frames.

[0042] It should be understood by one skilled in the art that various other suitable layer structures may also be designed and used for the MIMO WLAN system.

[0043] **FIG. 3** shows a block diagram of one embodiment of an access point 110x and two user terminals 120x and 120y within the MIMO WLAN system.

[0044] On the downlink, at access point 110x, a transmit (TX) data processor 310 receives traffic data (e.g., information bits) from a data source 308 and signaling and other information from a controller 330 and possibly a scheduler 334. These various types of data may be sent on different transport channels that are described in more details below. TX data processor 310 "frames" the data (if necessary), scrambles the framed/unframed data, encodes the scrambled data, interleaves (i.e., reorders) the coded data, and maps the interleaved data into modulation symbols. For simplicity, a "data symbol" refers to a modulation symbol for traffic data, and a "pilot symbol" refers to a modulation symbol for pilot. The scrambling randomizes the data bits. The encoding increases the reliability of the data transmission. The interleaving provides time, frequency, and/or spatial diversity for the code bits. The scrambling, coding, and modulation may be performed based on control signals provided by controller 330. TX data processor 310 provides a stream of modulation symbols for each spatial channel used for data transmission.

[0045] A TX spatial processor 320 receives one or more modulation symbol streams from TX data processor 310 and performs spatial processing on the modulation symbols to provide four streams of transmit symbols, one stream for each transmit antenna.

[0046] Each modulator (MOD) 322 receives and processes a respective transmit symbol stream to provide a corresponding stream of OFDM symbols. Each OFDM symbol stream is further processed to provide a corresponding downlink modulated signal. The four downlink modulated signals from modulator 322a through 322d are then transmitted from four antennas 324a through 324d, respectively.

[0047] At each user terminal 120, one or multiple antennas 352 receive the transmitted downlink modulated signals, and each receive antenna provides a received signal to a respective demodulator (DEMOD) 354. Each demodulator 354 performs processing complementary to that performed at modulator 322 and provides received symbols. A receive (RX) spatial processor 360 then performs spatial processing on the received symbols from all demodulators 354 to provide recovered symbols, which are estimates of the modulation symbols sent by the access point.

[0048] An RX data processor 370 receives and demultiplexes the recovered symbols into their respective transport channels. The recovered symbols for each transport channel may be symbol demapped, deinterleaved, decoded, and descrambled to provide decoded data for that transport channel. The decoded data for each transport channel may include recovered packet data, messages, signaling, and so on, which are provided to a data sink 372 for storage and/or a controller 380 for further processing.

[0049] For the downlink, at each active user terminal 120, RX spatial processor 360 further estimates the downlink to obtain channel state information (CSI). The CSI may include channel response estimates, received SNRs, and so on. RX data processor 370 may also provide the status of each packet/frame received on the downlink. A controller 380 receives the channel state information and the packet/frame status and determines the feedback information to be sent back to the access point. The feedback information is processed by a TX data processor 390 and a TX spatial processor 392 (if present), conditioned by one or more modulators 354, and transmitted via one or more antennas 352 back to the access point.

[0050] At access point 110, the transmitted uplink signal(s) are received by antennas 324, demodulated by demodulators 322, and processed by an RX spatial processor 340 and an RX data processor 342 in a complementary manner to that performed at the user terminal. The recovered feedback information is then provided to controller 330 and a scheduler 334.

[0051] In one embodiment, scheduler 334 uses the feedback information to perform a number of functions such as (1) selecting a set of user terminals for data transmission on the downlink and uplink, (2) selecting the transmission rate(s) and the transmission mode for each selected user terminal, and (3) assigning the available FCH/RCH resources to the selected terminals. Scheduler 334 and/or controller 330 further uses information (e.g., steering vectors) obtained from the uplink transmission for the processing of the downlink transmission.

[0052] As mentioned above, a number of services and applications may be supported by the MIMO WLAN system and various transport channels may be defined for the MIMO WLAN system to carry various types of data. Table 3 lists an exemplary set of transport channels and also provides a brief description for each transport channel.

Table 3

| Transport channels | | Description |
|---|---|---|
| Broadcast channel | BCH | Used by the access point to transmit pilot and system parameters to the user terminals. |
| Forward control channel | FCCH | Used by the access point to allocate resources on the downlink and uplink. The resource allocation may be performed on a frame-by-frame basis. Also used to provide acknowledgment for messages received on the RACH. |
| Forward channel | FCH | Used by the access point to transmit user-specific data to the user terminals and possibly a reference (pilot) used by the user terminals for channel estimation. May also be used in a broadcast mode to send page and broadcast messages to multiple user terminals. |
| Random access channel | RACH | Used by the user terminals to gain access to the system and send short messages to the access point. |
| Reverse channel | RCH | Used by the user terminals to transmit data to the access point. May also carry a reference used by the access point for channel estimation. |

[0053] As shown in Table 3, the downlink transport channels used by the access point includes the BCH, FCCH, and FCH. The uplink transport channels used by the user terminals include the RACH and RCH. It should be recognized by one skilled in the art that the transport channels listed in Table 3 represent an exemplary embodiment of a channel structure that may be used for the MIMO WLAN system. Fewer, additional, and/or different transport channels may also be defined for use for the MIMO WLAN system. For example, certain functions may be supported by function-specific transport channels (e.g., pilot, paging, power control, and sync channel channels). Thus, otl channel structures with different sets of transport channels may be defined and used the MIMO WLAN system, within the scope of the invention.

[0054] A number of frame structures may be defined for the transport channels. T specific frame structure to use for the MIMO WLAN system is dependent on varic factors such as, for example, (1) whether the same or different frequency bands are us for the downlink and uplink and (2) the multiplexing scheme used to multiplex t transport channels together.

[0055] If only one frequency band is available, then the downlink and uplink may transmitted on different phases of a frame using time division duplexing (TDD). If t frequency bands are available, then the downlink and uplink may be transmitted different frequency bands using frequency division duplexing (FDD).

[0056] For both TDD and FDD, the transport channels may be multiplexed togetl using time division multiplexing (TDM), code division multiplexing (CDM), frequen division multiplexing (FDM), and so on. For TDM, each transport channel is assign to a different portion of a frame. For CDM, the transport channels are transmitt concurrently but each transport channel is channelized by a different channelizati code, similar to that performed in a code division multiple access (CDMA) system. F FDM, each transport channel is assigned a different portion of the frequency band t the link.

[0057] Table 4 lists the various frame structures that may be used to carry the transp channels. Each of these frame structures is described in further detail below.

Table 4

| | Shared frequency band for downlink and uplink | Separate frequency bands fc downlink and uplink |
|---|---|---|
| Time division | TDD-TDM frame structure | FDD-TDM frame structure |
| Code division | TDD-CDM frame structure | FDD-CDM frame structure |

[0058] **FIG. 4A** illustrates an embodiment of a TDD-TDM frame structure 400a tl may be used if a single frequency band is used for both the downlink and uplink. D transmission occurs in units of TDD frames. Each TDD frame may be defined to spar particular time duration. The frame duration may be selected based on various fact such as, for example, (1) the bandwidth of the operating band, (2) the expected sizes the PDUs for the transport channels, and so on. In general, a shorter frame duration may provide reduced delays. However, a longer frame duration may be more efficient since header and overhead may represent a smaller fraction of the frame. In one embodiment, each TDD frame has a duration of 2 msec.

[0059] As shown in FIG. 4A, each TDD frame can be partitioned into a downlink phase and an uplink phase. The downlink phase is further partitioned into three segments for the three downlink transport channels - the BCH, FCCH, and FCH. The uplink phase is further partitioned into two segments for the two uplink transport channels - the RCH and RACH.

[0060] The segment for each transport channel may be defined to have either a fixed duration or a variable duration that can change from frame to frame. In one embodiment, the BCH segment is defined to have a fixed duration, and the FCCH, FCH, RCH, and RACH segments are defined to have variable durations.

[0061] The segment for each transport channel may be used to carry one or more protocol data units (PDUs) for that transport channel. In the embodiment shown in FIG. 4A, a BCH PDU is transmitted in a first segment 410, an FCCH PDU is transmitted in a second segment 420, and one or more FCH PDUs are transmitted in a third segment 430 of the downlink phase. On the uplink phase, one or more RCH PDUs are transmitted in a fourth segment 440 and one or more RACH PDUs are transmitted in a fifth segment 450 of the TDD frame.

[0062] Frame structure 400a represents one arrangement of the various transport channels within a TDD frame. This arrangement can provide certain benefits such as reduced delays for data transmission on the downlink and uplink. The BCH is transmitted first in the TDD frame since it carries system parameters that may be used for the PDUs of the other transport channels within the same TDD frame. The FCCH is transmitted next since it carries resource allocation (e.g., channel assignment) information indicative of which user terminal(s) are designated to receive downlink data on the FCH and which user terminal(s) are designated to transmit uplink data on the RCH within the current TDD frame. Other TDD-TDM frame structures may also be defined and used for the MIMO WLAN system.

[0063] **FIG. 4B** illustrates an embodiment of an FDD-TDM frame structure 400b that may be used if the downlink and uplink are transmitted using two separate frequency bands. Downlink data is transmitted in a downlink frame 402a, and uplink data is transmitted in an uplink frame 402b. Each downlink and uplink frame may be defined to span a particular time duration (e.g., 2 msec). For simplicity, the downlink and uplink frames may be defined to have the same duration and may further be defined to be aligned at the frame boundaries. However, different frame durations and/or non-aligned (i.e., offset) frame boundaries may also be used for the downlink and uplink.

**[0064]** As shown in FIG. 4B, the downlink frame is partitioned into three segments for the three downlink transport channels. The uplink frame is partitioned into two segments for the two uplink transport channels. The segment for each transport channel may be defined to have a fixed or variable duration, and may be used to carry one or more PDUs for that transport channel.

**[0065]** In the embodiment shown in FIG. 4B, the downlink frame carries a BCH PDU, an FCCH PDU, and one or more FCH PDUs in segments 410, 420, and 430, respectively. The uplink frame carries one or more RCH PDUs and one or more RACH PDUs in segments 440 and 450, respectively. This arrangement may provide the benefits described above (e.g., reduced delays for data transmission). Other FDD-TDM frame structures may also be defined and used for the MIMO WLAN system, and this is within the scope of the invention.

**[0066]** **FIG. 4C** illustrates an embodiment of an FDD-CDM/FDM frame structure 400c that may also be used if the downlink and uplink are transmitted using separate frequency bands. Downlink data may be transmitted in a downlink frame 404a, and uplink data may be transmitted in an uplink frame 404b. The downlink and uplink frames may be defined to have the same duration (e.g., 2 msec) and aligned at the frame boundaries.

**[0067]** As shown in FIG. 4C, the three downlink transport channels are transmitted concurrently in the downlink frame, and the two uplink transport channels are transmitted concurrently in the uplink frame. For CDM, the transport channels for each link are "channelized" with different channelization codes, which may be Walsh codes, orthogonal variable spreading factor (OVSF) codes, quasi-orthogonal functions (QOF), and so on. For FDM, the transport channels for each link are assigned different portions of the frequency band for the link. Different amounts of transmit power may also be used for different transport channels in each link.

**[0068]** Other frame structures may also be defined for the downlink and uplink transport channels, and this is within the scope of the invention. Moreover, it is possible to use different types of frame structure for the downlink and uplink. For example, a TDM-based frame structure may be used for the downlink and a CDM-based frame structure may be used for the uplink.

[0069] In one embodiment, the transport channels as described above are used to send various types of data and may be categorized into two groups: common transport channels and dedicated transport channels.

[0070] The common transport channels, in one embodiment, may include the BCH, FCCH, and RACH. These transport channels are used to send data to or receive data from multiple user terminals. The BCH and FCCH can be transmitted by the access point using the diversity mode. On the uplink, the RACH can be transmitted by the user terminals using the beam-steering mode (if supported by the user terminal). The BCH can be operated at a known fixed rate so that the user terminals can receive and process the BCH without any additional information. As described in more details below, the FCCH support multiple rates to allow for greater efficiency. Each "rate" or "rate set" may be associated with a particular code rate (or coding scheme) and a particular modulation scheme.

[0071] The dedicated transport channels, in one embodiment, include the FCH and RCH. These transport channels are normally used to send user-specific data to or by specific user terminals. The FCH and RCH may be dynamically allocated to the user terminals as necessary and as available. The FCH may also be used in a broadcast mode to send overhead, page, and broadcast messages to the user terminals. In general, the overhead, page, and broadcast messages are transmitted prior to any user-specific data on the FCH.

[0072] **FIG. 5** illustrates an exemplary transmission on the BCH, FCCH, FCH, RCH, and RACH based on TDD-TDM frame structure 400a. In this embodiment, one BCH PDU 510 and one FCCH PDU 520 are transmitted in BCH segment 410 and FCCH segment 420, respectively. FCH segment 430 may be used to send one or more FCH PDUs 530, each of which may be intended for a specific user terminal or multiple user terminals. Similarly, one or more RCH PDUs 540 may be sent by one or more user terminals in RCH segment 440. The start of each FCH/RCH PDU is indicated by an FCH/RCH offset from the end of the preceding segment. A number of RACH PDUs 550 may be sent in RACH segment 450 by a number of user terminals to access the system and/or to send short messages.

[0073] In one embodiment, the BCH is used by the access point to transmit a beacon pilot, a MIMO pilot, and system parameters to the user terminals. The beacon pilot is used by the user terminals to acquire system timing and frequency. The MIMO pilot is used by the user terminals to estimate the MIMO channel formed by the access point antennas and their own antennas. The system parameters specify various attributes of the downlink and uplink transmissions. For example, since the durations of the FCCH, FCH, RACH, and RCH segments are variable, the system parameters that specify the length of each of these segments for the current TDD frame are sent in the BCH.

[0074] **FIG. 6A** illustrates an embodiment of BCH PDU 410. In this embodiment, BCH PDU 410 includes a preamble portion 510 and a message portion 516. Preamble portion 510 further includes a beacon pilot portion 512 and a MIMO pilot portion 514. Portion 512 carries a beacon pilot and has a fixed duration of $T_{CP} = 8\mu\text{sec}$. Portion 514 carries a MIMO pilot and has a fixed duration of $T_{MP} = 32\mu\text{sec}$. Portion 516 carries a BCH message and has a fixed duration of $T_{BM} = 40\mu\text{sec}$. A preamble may be used to send one or more types of pilot and/or other information. A beacon pilot comprises a specific set of modulation symbols that is transmitted from all transmit antennas. A MIMO pilot comprises a specific set of modulation symbols that is transmitted from all transmit antennas with different orthogonal codes, which then allows the receivers to recover the pilot transmitted from each antenna. Different sets of modulation symbols may be used for the beacon and MIMO pilots.

[0075] In one embodiment, the BCH message carries system configuration information. Table 5 lists the various fields for an exemplary BCH message format.

Table 5 - BCH Message

| **Fields/ Parameter Names** | **Length** (bits) | **Description** |
|---|---|---|
| Frame Counter | 4 | TDD frame counter |
| Net ID | 10 | Network identifier (ID) |
| AP ID | 6 | Access point ID |
| AP Tx Lvl | 4 | Access point transmit level |
| AP Rx Lvl | 3 | Access point receive level |
| FCCH Length | 6 | Duration of FCCH (in units of OFDM symbols) |
| FCCH Rate | 2 | Physical layer rate of FCCH |

| | | |
|---|---|---|
| FCH Length | 9 | Duration of FCH (in units of OFDM symbols) |
| RCH Length | 9 | Duration of RCH (in units of OFDM symbols) |
| RACH Length | 5 | Duration of RACH (in units of RACH slots) |
| RACH Slot Size | 2 | Duration of each RACH slot (in units of OFDM symbols) |
| RACH Guard Interval | 2 | Guard interval at the end of RACH |
| Cyclic Prefix Duration | 1 | Cyclic prefix duration |
| Page Bit | 1 | "0" = page message sent on FCH<br>"1" = no page message sent |
| Broadcast Bit | 1 | "0" = broadcast message sent on FCH<br>"1" = no broadcast message sent |
| RACH Acknowledgment Bit | 1 | "0" = RACH acknowledgment sent on FCH<br>"1" = no RACH acknowledgment sent |
| CRC | 16 | CRC value for the BCH message |
| Tail Bits | 6 | Tail bits for convolutional encoder |
| Reserved | 32 | Reserved for future use |

[0076] The Frame Counter value may be used to synchronize various processes at the access point and user terminals (e.g., the pilot, scrambling codes, cover code, and so on). A frame counter may be implemented with a 4-bit counter that wraps around. This counter is incremented at the start of each TDD frame, and the counter value is included in the Frame Counter field. The Net ID field indicates the identifier (ID) of the network to which the access point belongs. The AP ID field indicates the ID of the access point within the network ID. The AP Tx Lvl and AP Rx Lvl fields indicate the maximum transmit power level and the desired receive power level at the access point, respectively. The desired receive power level may be used by the user terminal to determine the initial uplink transmit power.

[0077] The FCCH Length, FCH Length, and RCH Length fields indicate the lengths of the FCCH, FCH, and RCH segments, respectively, for the current TDD frame. In one embodiment, the lengths of these segments are given in units of OFDM symbols. The OFDM symbol duration for the BCH can be fixed at 4.0 μsec. The OFDM symbol duration for all other transport channels (e.g., the FCCH, FCH, RACH, and RCH) is variable and depends on the selected cyclic prefix, which is specified by the Cyclic Prefix Duration field. The FCCH Rate field indicates the rate used for the FCCH for the current TDD frame.

[0078] The RACH Length field indicates the length of the RACH segment, which is given in units of RACH slots. The duration of each RACH slot is given by the RACH Slot Size field, in units of OFDM symbols. The RACH Guard Interval field indicates the amount of time between the last RACH slot and the start of the BCH segment for the next TDD frame.

[0079] The Page Bit and Broadcast Bit indicate whether or not page messages and broadcast messages, respectively, are being sent on the FCH in the current TDD frame. These two bits may be set independently for each TDD frame. The RACH Acknowledgment Bit indicates whether or not acknowledgments for PDUs sent on the RACH in prior TDD frames are being sent on the FCCH in the current TDD frame.

[0080] The CRC field includes a CRC value for the entire BCH message. This CRC value may be used by the user terminals to determine whether the received BCH message is decoded correctly or in error. The Tail Bits field includes a group of zeros used to reset the convolutional encoder to a known state at the end of the BCH message.

[0081] As shown in Table 5, the BCH message includes a total of 120 bits. These 120 bits may be transmitted with 10 OFDM symbols. Table 5 shows one embodiment of the format for the BCH message. Other BCH message formats with fewer, additional, and/or different fields may also be defined and used, and this is within the scope of the invention.

[0082] In one embodiment, the access point may allocate resources for the FCH and RCH on a per frame basis. The FCCH is used by the access point to convey the resource allocation information for the FCH and RCH (e.g., the channel assignments).

[0083] **FIG. 6B** illustrates an embodiment of FCCH PDU 420. In this embodiment, the FCCH PDU includes only a portion 520 for an FCCH message. The FCCH message has a variable duration that can change from frame to frame, depending on the amount of scheduling information being carried on the FCCH for that frame. The FCCH message duration is in even number of OFDM symbols and given by the FCCH Length field on the BCH message. The duration of messages sent using the diversity mode (e.g., BCH and FCCH messages) is given in even number of OFDM symbols because the diversity mode transmits OFDM symbols in pairs.

[0084] In an embodiment, the FCCH can be transmitted using four possible rates. The specific rate used for the FCCH PDU in each TDD frame is indicated by the FCCH Phy Mode field in the BCH message. Each FCCH rate corresponds to a particular code rate and a particular modulation scheme and is further associated with a particular transmission mode.

[0085] An FCCH message may include zero, one, or multiple information elements (IEs). Each information element may be associated with a specific user terminal and may be used to provide information indicative of the assignment of FCH/RCH resources for that user terminal. Table 6 lists the various fields for an exemplary FCCH message format.

Table 6 - FCCH Message

| **Fields/ Parameter Names** | **Length** (bits) | **Description** |
|---|---|---|
| N_IE | 6 | Number of IEs included in the FCCH message |
| N_IE information elements, each including: | | |
| IE Type | 4 | IE type |
| MAC ID | 10 | ID assigned to the user terminal |
| Control Fields | 48 or 72 | Control fields for channel assignment |
| Padding Bits | Variable | Pad bits to achieve even number of OFDM symbols in the FCCH message |
| CRC | 16 | CRC value for the FCCH message |
| Tail Bits | 6 | Tail bits for convolutional encoder |

[0086] The N_IE field indicates the number of information elements included in the FCCH message sent in the current TDD frame. For each information element (IE) included in the FCCH message, the IE Type field indicates the particular type of this IE. Various IE types are defined for use to allocate resources for different types of transmissions, as described below.

[0087] The MAC ID field identifies the specific user terminal for which the information element is intended. Each user terminal registers with the access point at the start of a communication session and is assigned a unique MAC ID by the access point. This MAC ID is used to identify the user terminal during the session.

[0088] The Control Fields are used to convey channel assignment information for the user terminal and are described in detail below. The Padding Bits field includes a sufficient number of padding bits so that the overall length of the FCCH message is an even number of OFDM symbols. The FCCH CRC field includes a CRC value that may be used by the user terminals to determine whether the received FCCH message is decoded correctly or in error. The Tail Bits field includes zeros used to reset the convolutional encoder to a known state at the end of the FCCH message. Some of these fields are described in further detail below.

[0089] A number of transmission modes are supported by the MIMO WLAN system for the FCH and RCH, as indicated in Table 1. Moreover, a user terminal may be active or idle during a connection. Thus, a number of types of IE are defined for use to allocate FCH/RCH resources for different types of transmissions. Table 7 lists an exemplary set of IE types.

Table 7 - FCCH IE Types

| **IE Type** | **IE Size (bits)** | **IE Type** | **Description** |
|---|---|---|---|
| 0 | 48 | Diversity Mode | Diversity mode only |
| 1 | 72 | Spatial Multiplexing Mode | Spatial multiplexing mode - variable rate services |
| 2 | 48 | Idle Mode | Idle state - variable rate services |
| 3 | 48 | RACH Acknowledgment | RACH acknowledgment – diversity mode |
| 4 | | Beam Steering Mode | Beam steering mode |
| 5-15 | - | Reserved | Reserved for future use |

[0090] For IE types 0, 1 and 4, resources are allocated to a specific user terminal for both the FCH and RCH (i.e., in channel pairs). For IE type 2, minimal resources are allocated to the user terminal on the FCH and RCH to maintain up-to-date estimate of the link. An exemplary format for each IE type is described below. In general, the rates and durations for the FCH and RCH can be independently assigned to the user terminals.

[0091] IE type 0 and 4 are used to allocate FCH/RCH resources for the diversity and beam-steering modes, respectively. For fixed low-rate services (e.g., voice), the rate remains fixed for the duration of the call. For variable rate services, the rate may be selected independently for the FCH and RCH. The FCCH IE indicates the location of the FCH and RCH PDUs assigned to the user terminal. Table 8 lists the various fields of an exemplary IE Type 0 and 4 information element.

Table 8 - FCCH IE Type 0 and 4

| **Fields/ Parameter Names** | **Length** (bits) | **Description** |
|---|---|---|
| IE Type | 4 | IE type |
| MAC ID | 10 | Temporary ID assigned to the user terminal |
| FCH Offset | 9 | FCH offset from start of the TDD frame (in OFDM symbols) |
| FCH Preamble Type | 2 | FCH preamble size (in OFDM symbols) |
| FCH Rate | 4 | Rate for the FCH |
| RCH Offset | 9 | RCH offset from start of the TDD frame (in OFDM symbols) |
| RCH Preamble Type | 2 | RCH preamble size (in OFDM symbols) |
| RCH Rate | 4 | Rate for the RCH |
| RCH Timing Adjustment | 2 | Timing adjustment parameter for RCH |
| RCH Power Control | 2 | Power control bits for RCH |

[0092] The FCH and RCH Offset fields indicate the time offset from the beginning of the current TDD frame to the start of the FCH and RCH PDUs, respectively, assigned by the information element. The FCH and RCH Rate fields indicate the rates for the FCH and RCH, respectively.

[0093] The FCH and RCH Preamble Type fields indicate the size of the preamble in the FCH and RCH PDUs, respectively. Table 9 lists the values for the FCH and RCH Preamble Type fields and the associated preamble sizes.

[0094]

Table 9 - Preamble Type

| Type | Bits | Preamble Size |
|---|---|---|
| 0 | 00 | 0 OFDM symbol |
| 1 | 01 | 1 OFDM symbol |
| 2 | 10 | 4 OFDM symbols |
| 3 | 11 | 8 OFDM symbols |

[0095] The RCH Timing Adjustment field includes two bits used to adjust the timing of the uplink transmission from the user terminal identified by the MAC ID field. This timing adjustment is used to reduce interference in a TDD-based frame structure where the downlink and uplink transmissions are time division duplexed. Table 10 lists the values for the RCH Timing Adjustment field and the associated actions.

Table 10 - RCH Timing Adjustment

| Bits | Description |
|---|---|
| 00 | Maintain current timing |
| 01 | Advance uplink transmit timing by 1 sample |
| 10 | Delay uplink transmit timing by 1 sample |
| 11 | Not used |

[0096] The RCH Power Control field includes two bits used to adjust the transmit power of the uplink transmission from the identified user terminal. This power control is used to reduce interference on the uplink. Table 11 lists the values for the RCH Power Control field and the associated actions.

Table 11 - RCH Power Control

| Bits | Description |
|---|---|
| 00 | Maintain current transmit power |
| 01 | Increase uplink transmit power by $\delta$ dB, where $\delta$ is a system parameter. |
| 10 | Decrease uplink transmit power by $\delta$ dB, where $\delta$ is a system parameter. |
| 11 | Not used |

[0097] The channel assignment for the identified user terminal may be provided in various manners. In an embodiment, the user terminal is assigned FCH/RCH resources for only the current TDD frame. In another embodiment, the FCH/RCH resources are assigned to the terminal for each TDD frame until canceled. In yet another embodiment, the FCH/RCH resources are assigned to the user terminal for every *n*-th TDD frame, which is referred to as "decimated" scheduling of TDD frames. The different types of assignment may be indicated by an Assignment Type field in the FCCH information element.

[0098] IE type 1 is used to allocate FCH/RCH resources to user terminals using the spatial multiplexing mode. The rate for these user terminals is variable, and may be selected independently for the FCH and RCH. Table 12 lists the various fields of an exemplary IE type 1 information element.

Table 12 - FCCH IE Type 1

| Fields/ Parameter Names | Length (bits) | Description |
|---|---|---|
| IE Type | 4 | IE type |
| MAC ID | 10 | Temporary ID assigned to the user terminal |
| FCH Offset | 9 | FCH offset from end of FCCH (in OFDM symbols) |
| FCH Preamble Type | 2 | FCH preamble size (in OFDM symbols) |
| FCH Spatial Channel 1 Rate | 4 | Rate for the FCH for spatial channel 1 |
| FCH Spatial Channel 2 Rate | 4 | Rate for the FCH for spatial channel 2 |
| FCH Spatial Channel 3 Rate | 4 | Rate for the FCH for spatial channel 3 |
| FCH Spatial Channel 4 Rate | 4 | Rate for the FCH for spatial channel 4 |
| RCH Offset | 9 | RCH offset from end of FCH (in OFDM symbols) |
| RCH Preamble Type | 2 | RCH preamble size (in OFDM symbols) |
| RCH Spatial Channel 1 Rate | 4 | Rate for the RCH for spatial channel 1 |
| RCH Spatial Channel 2 Rate | 4 | Rate for the RCH for spatial channel 2 |
| RCH Spatial Channel 3 Tate | 4 | Rate for the RCH for spatial channel 3 |
| RCH Spatial Channel 4 Rate | 4 | Rate for the RCH for spatial channel 4 |

| | | |
|---|---|---|
| RCH Timing Adjustment | 2 | Timing adjustment parameter for RCH |
| Reserved | 2 | Reserved for future use |

[0099] For IE type 1, the rate for each spatial channel may be selected independently on the FCH and RCH. The interpretation of the rates for the spatial multiplexing mode is general in that it can specify the rate per spatial channel (e.g., for up to four spatial channels for the embodiment shown in Table 12). The rate is given per eigenmode if the transmitter performs spatial processing to transmit data on the eigenmodes. The rate is given per antenna if the transmitter simply transmits data from the transmit antennas and the receiver performs the spatial processing to isolate and recover the data (for the non-steered spatial multiplexing mode).

[00100] The information element includes the rates for all enabled spatial channels and zeros for the ones not enabled. User terminals with less than four transmit antennas set the unused FCH/RCH Spatial Channel Rate fields to zero. Since the access point is equipped with four transmit/receive antennas, user terminals with more than four transmit antennas may use them to transmit up to four independent data streams.

[00101] IE type 2 is used to provide control information for user terminals operating in an *Idle* state. In an embodiment, when a user terminal is in the *Idle* state, steering vectors used by the access point and user terminal for spatial processing are continually updated so that data transmission can start quickly if and when resumed. Table 13 lists the various fields of an exemplary IE type 2 information element.

Table 13 - FCCH IE Type 2

| **Fields/ Parameter Names** | **Length** (bits) | **Description** |
|---|---|---|
| IE Type | 4 | IE type |
| MAC ID | 10 | Temporary ID assigned to the user terminal |
| FCH Offset | 9 | FCH offset from end of FCCH (in OFDM symbols) |
| FCH Preamble Type | 2 | FCH preamble size (in OFDM symbols) |
| RCH Offset | 9 | RCH offset from end of FCH (in OFDM symbols) |
| RCH Preamble Type | 2 | RCH preamble size (in OFDM symbols) |
| Reserved | 12 | Reserved for future use |

[00102] IE type 3 is used to provide quick acknowledgment for user terminals attempting to access the system via the RACH. To gain access to the system or to send a short message to the access point, a user terminal may transmit an RACH PDU on the uplink. After the user terminal sends the RACH PDU, it monitors the BCH to determine if the RACH Acknowledgement Bit is set. This bit is set by the access point if any user terminal was successful in accessing the system and an acknowledgment is being sent for at least one user terminal on the FCCH. If this bit is set, then the user terminal processes the FCCH for acknowledgment sent on the FCCH. IE Type 3 information elements are sent if the access point desires to acknowledge that it correctly decoded the RACH PDUs from the user terminals without assigning resources. Table 14 lists the various fields of an exemplary IE Type 3 information element.

Table 14 - FCCH IE Type 3

| **Fields/ Parameter Names** | **Length** (bits) | **Description** |
|---|---|---|
| IE Type | 4 | IE type |
| MAC ID | 10 | Temporary ID assigned to user terminal |
| Reserved | 34 | Reserved for future use |

[00103] A single or multiple types of acknowledgment may be defined and sent on the FCCH. For example, a quick acknowledgment and an assignment-based acknowledgment may be defined. A quick acknowledgment may be used to simply acknowledge that the RACH PDU has been received by the access point but that no FCH/RCH resources have been assigned to the user terminal. An assignment-based acknowledgment includes assignments for the FCH and/or RCH for the current TDD frame.

[00104] A number of different rates are supported for the transport channels. Each rate is associated with a particular code rate and a particular modulation scheme, which collectively results in a particular spectral efficiency (or data rate). Table 15 lists the various rates supported by the system.

Table 15

| **Rate Word** | **Spectral Efficiency** | **Code Rate** | **Modulation Scheme** | **Info bits/ OFDM** | **Code bits/ OFDM** |
|---|---|---|---|---|---|

| | (bps/Hz) | | | symbol | symbol |
|---|---|---|---|---|---|
| 0000 | 0.0 | - | off | - | - |
| 0001 | 0.25 | ¼ | BPSK | 12 | 48 |
| 0010 | 0.5 | ½ | BPSK | 24 | 48 |
| 0011 | 1.0 | ½ | QPSK | 48 | 96 |
| 0100 | 1.5 | ¾ | QPSK | 72 | 96 |
| 0101 | 2.0 | ½ | 16 QAM | 96 | 192 |
| 0110 | 2.5 | 5/8 | 16 QAM | 120 | 192 |
| 0111 | 3.0 | ¾ | 16 QAM | 144 | 192 |
| 1000 | 3.5 | 7/12 | 64 QAM | 168 | 288 |
| 1001 | 4.0 | 2/3 | 64 QAM | 192 | 288 |
| 1010 | 4.5 | ¾ | 64 QAM | 216 | 288 |
| 1011 | 5.0 | 5/6 | 64 QAM | 240 | 288 |
| 1100 | 5.5 | 11/16 | 256 QAM | 264 | 384 |
| 1101 | 6.0 | ¾ | 256 QAM | 288 | 384 |
| 1110 | 6.5 | 13/16 | 256 QAM | 312 | 384 |
| 1111 | 7.0 | 7/8 | 256 QAM | 336 | 384 |

**[00105]** While the FCCH channel structure as described above can be operable at different data rates, this structure may not be efficient because the rate employed on the FCCH is dictated or limited by the worst-case user in the system (e.g., the user that operates at the lowest data rate). For example, if one of the users can only receive and decode information on the FCCH at a low data rate of 0.25 bps/Hz, other users in the system will be adversely affected even though they are capable of operating at higher data rates. This is because the rate employed on the FCCH structure will be limited to that of the worst-case user, which is 0.25 bps/Hz. Thus, the FCCH performance and efficiency may be reduced by a single user. As described in more details below, the present invention provides a novel and more efficient FCCH channel structure that can be used to accommodate different users operable at different data rates.

**[00106]** In one embodiment, the new FCCH structure, also referred to as a tiered control channel structure or segregated control channel structure herein), comprises multiple control channels (e.g., 4 distinct control channels). Each of these distinct control channels, also called control subchannel or FCCH subchannel herein, can operate at one of the multiple overhead data rates (e.g., one or four different data rates as mentioned above).

[00107] FIG. 7 illustrates a diagram of a new FCCH structure within a TDD MAC frame, in accordance with one embodiment of the invention. It should be understood by one skilled in the art that while TDD-TDM frame structure is used in this example for the purposes of illustration and explanation, the teachings of the present invention are not limited to TDD frame structure but can also be applied to various other frame structures of various durations (e.g., FDD-TDM, etc). As shown in FIG. 7, the TDD MAC frame is partitioned into a downlink phase (also called downlink segment) 701 and an uplink phase (also called uplink segment) 751. In this embodiment, the downlink phase is further divided into three segments for the three corresponding transport channels – the BCH 710, the FCCH 720, and the FCH 730. The uplink phase is further partitioned into two segments for the two corresponding transport channels – the RCH 740 and the RACH 750.

[00108] As shown in FIG. 7, the FCCH segment is divided or partitioned into multiple distinct FCCH segments or subchannels, each of which may operate at a specific data rate. In this example, the FCCH segment is divided into four FCCH subchannels (FCCH_0, FCCH_1, FCCH_2, and FCCH_3). In other embodiments of the invention, the FCCH segment may be divided into different numbers of subchannels (e.g., 8 subchannels, etc.), depending on the particular applications or implementations of the invention. In one embodiment, each FCCH subchannel may be associated with a specific set of operating and processing parameters (e.g., code rate, modulation scheme, SNR, etc.). For example, Table 16 below illustrates the code rates, modulation scheme, SNR, etc., that are associated with each FCCH subchannel. In this example, STTD is employed for each of the subchannels, in which case the length of each subchannel is a multiple of two OFDM symbols.

Table 16 – FCCH Subchannel Data Rates (STTD)

| FCCH Subchannel | Efficiency (bps/Hz) | Code Rate | Modulation | Information Bits Per STTD OFDM | Total SNR for 1% Frame Error Rate (FER) |
|---|---|---|---|---|---|

| | | | | symbol | |
|---|---|---|---|---|---|
| FCCH_0 | 0.25 | 0.25 | BPSK | 24 | -2.0 dB |
| FCCH_1 | 0.5 | 0.5 | BPSK | 48 | 2.0 dB |
| FCCH_2 | 1 | 0.5 | QPSK | 96 | 5.0 dB |
| FCCH_3 | 2 | 0.5 | 16 QAM | 192 | 11.0 dB |

[00109] As shown in Table 16, each FCCH subchannel has a distinct operating point (e.g., SNR and other processing parameters) associated with it. A user terminal (UT) that is assigned a specific FCCH subchannel (e.g., FCCH_n at a particular rate) can correctly decode all lower rate subchannels, but not those operating at the higher rates. For example, if a particular user terminal is assigned subchannel FCCH_2, that user terminal can decode FCCH_0 and FCCH_1 subchannels because FCCH_0 and FCCH_1 operate at the lower rates. However, that user terminal cannot decode FCCH_3 because FCCH_3 operates at a higher rate. In one embodiment, the access point (AP) decides which FCCH subchannel to send control data to a UT based on various factors or selection criteria. These various factors or selection may include link quality information or operating conditions of the user terminals (e.g., C/I, Doppler, etc.), quality of service (QoS) requirements associated with the user terminals, and control subchannel preference indicated by the user terminals, etc. As described in more details below, the user terminals then attempt to decode each of the FCCH subchannels to determine if they have been allocated resources (e.g., FCH/RCH channel resources).

[00110] Table 17 illustrates the structure for the various FCCH subchannels, in accordance with one embodiment of the present invention. As shown in Table 17, the FCCH subchannel structure for subchannel FCCH_0 is distinct from the structure used for other FCCH subchannels (FCCH_1, FCCH_2, and FCCH_3). In one embodiment, the FCCH_MASK field in the FCCH_0 structure is used to indicate the presence/absence of higher rate FCCH subchannels in a particular order. For example, the FCCH_MASK field may comprise three bits each of which corresponds to a particular subchannel and is used to indicate whether the particular subchannel is present in an order from subchannel 1 (MASK bit 0), subchannel 2 (MASK bit 1), and subchannel 3 (MASK bit 2). The corresponding subchannel MASK bit is set to a particular value (e.g., 1) to indicate the presence of the respective subchannel. For example, if the value of MASK bit number 0 (the least significant MASK bit) is set to

"1", this indicates the presence of FCCH_1 subchannel. Pad bits are provided to achieve an even number of OFDM symbols in each subchannel. In one embodiment, each FCCH subchannel is capable of providing scheduling information for multiple user terminals (e.g., 32 users). The IE types described above can be used for the FCCH subchannels.

Table 17 – FCCH Subchannel Structure

| FCCH_0: | Bits |
|---|---|
| FCCH MASK | 3 |
| No. IE Rate 0 | 5 |
| Rate 0 IE's | |
| 0 Padding | |
| CRC | 16 |
| Tail | 6 |
| FCCH_1: | Bits |
| No. IE Rate 1 | 5 |
| Rate 1 IE's | |
| 0 Padding | |
| CRC | 16 |
| Tail | 6 |
| FCCH_2: | Bits |
| No. IE Rate 2 | 5 |
| Rate 2 IE's | |
| 0 Padding | |
| CRC | 16 |
| Tail | 6 |
| FCCH_3: | Bits |
| No. IE Rate 3 | 5 |
| Rate 3 IE's | |
| 0 Padding | |
| CRC | 16 |
| Tail | 6 |

[00111] FIG.8 illustrates a flow diagram of a method 800 in accordance with one embodiment of the present invention. At block 810, as described above, a control channel is segregated or partitioned into a plurality of subchannels each of which being operable at a specific data rate. At block 820, control information including resource allocation information is transmitted from an access point to a user terminal on a particular subchannel of the plurality subchannels selected for the user terminal, based on one or more selection criteria, as described above. At block 830, at the user terminal, one or more subchannels of the plurality of subchannels are decoded to obtain control information (e.g., channel assignments) designated for the user terminal. In one embodiment, as explained in more details below, the decoding procedure performed at the user terminal starts with the FCCH subchannel operated at the lowest data rate (FCCH_0 in this example) and continues until at least one of a plurality of conditions is satisfied.

[00112] FIG. 9 shows a flow diagram of a decoding procedure 900 performed by a user terminal in decoding the new FCCH structure, in accordance with one embodiment of the present invention. The user terminal starts by decoding the subchannel FCCH_0. In one embodiment, decoding is considered successful if the CRC test passes. The user terminal terminates FCCH decoding process whenever any of the following events occurs:

(i) Failure to correctly decode an FCCH subchannel;

(ii) Receipt of an assignment;

(iii) Decoding of all active FCCH subchannels without receiving an assignment.

[00113] Referring again to FIG. 9, at block 910, the process begins by initializing n to 0. In this example, n is a variable used to indicate the current FCCH subchannel being decoded in the current iteration of the process. At block 915, the current FCCH_n subchannel is decoded. For example, in the first iteration, FCCH_0 is decoded at block 915. At block 920, it is determined whether the CRC test with respect to the current FCCH_n subchannel passes. If the CRC test passes, the process proceeds to block 925 to determine whether the corresponding MAC ID is present, otherwise the process proceeds to block 930 to process the next MAC frame. At block 925, if the corresponding MAC ID is present, the process proceeds to block 940 to obtain the assignment information provided by the access point. Otherwise, the process proceeds to block 935 to check if n is equal to 3. At block 935, if n is equal to 3, the process

proceeds to block 945 to initialize the FCCH_MASK field to indicate that all FCCH subchannels have been processed. As described above, in one embodiment, the FCCH_MASK field in the FCCH_0 subchannel structure comprises three bits each of which is used to indicate the presence/absence of a corresponding higher rate FCCH subchannel. For example, the first bit (bit 0 or the least significant bit) of the FCCH_MASK field is used to indicate the presence/absence of subchannel 1, the second bit (bit 1 or the next significant bit) of the FCCH_MASK field is used to indicate the presence/absence of subchannel 2, and so on. The process then proceeds to block 950 to determine whether there are any active FCCH subchannels remaining to be decoded. If there are more active FCCH subchannels to be decoded, the process proceeds to block 960 to increment n to the next active FCCH subchannel. Otherwise the process proceeds to block 955 to process the next MAC frame.

[00114] Various parts of the MIMO WLAN system and various techniques described herein may be implemented by various means. For example, the processing at the access point and user terminal may be implemented in hardware, software, or a combination thereof. For a hardware implementation, the processing may be implemented within one or more application specific integrated circuits (ASICs), digital signal processors (DSPs), digital signal processing devices (DSPDs), programmable logic devices (PLDs), field programmable gate arrays (FPGAs), processors, controllers, micro-controllers, microprocessors, other electronic units designed to perform the functions described herein, or a combination thereof.

[00115] For a software implementation, the processing may be implemented with modules (e.g., procedures, functions, and so on) that perform the functions described herein. The software codes may be stored in a memory unit and executed by a processor. The memory unit may be implemented within the processor or external to the processor, in which case it can be communicatively coupled to the processor via various means as is known in the art.

[00116] Headings are included herein for reference and to aid in locating certain sections. These headings are not intended to limit the scope of the concepts described therein under, and these concepts may have applicability in other sections throughout the entire specification.

[00117] The previous description of the disclosed embodiments is provided to enable any person skilled in the art to make or use the present invention. Various modifications to

these embodiments will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other embodiments without departing from the spirit or scope of the invention. Thus, the present invention is not intended to be limited to the embodiments shown herein but is to be accorded the widest scope consistent with the principles and novel features disclosed herein.

**WHAT IS CLAIMED IS:**

## CLAIMS

1. A method for processing information in a communication system, comprising:

partitioning a control channel used for transmitting control information into a plurality of subchannels, each subchannel being operated at a specific data rate;

selecting, for each of one or more user terminals, one of the subchannels to be used for transmitting control information from an access point to the respective user terminal, based on one or more selection criteria; and

transmitting control information from the access point to a particular user terminal on a particular subchannel selected for the respective user terminal.

2. The method of claim 1 wherein the control information is transmitted in a segment of a data frame specifically allocated for the control channel.

3. The method of claim 1 wherein each subchannel is associated with a specific set of operating parameters.

4. The method of claim 3 wherein the operating parameters are selected from the group consisting of a code rate, a modulation scheme, and a signal-to-noise ratio (SNR).

5. The method of claim 1 wherein the plurality of subchannels are transmitted sequentially in an order from a subchannel with a lowest data rate to a subchannel with a highest data rate.

6. The method of claim 5 wherein a subchannel that is transmitted first in the plurality of subchannels includes a field to indicate whether other subchannels are also being transmitted.

7. The method of claim 6 wherein the field comprises a plurality of bits each of which corresponds to a particular subchannel and is used to indicate whether the corresponding subchannel is present in the segment allocated for transmitting control information.

8. The method of claim 1 wherein the one or more selection criteria are selected from the group consisting of a first criterion corresponding to a link quality associated with the respective user terminal, a second criterion corresponding to quality of service requirements associated with the respective terminal, and a third criterion corresponding to a subchannel preference indicated by the respective terminal.

9. A method for processing information in a communication system, comprising:

segregating a control channel into a plurality of subchannels each of which being operable at a specific data rate;

transmitting control information including resource allocation information from an access point to a user terminal on particular subchannel of the plurality subchannels selected for the user terminal, based on one or more selection criteria; and

decoding, at the user terminal, one or more subchannels of the plurality of subchannels to obtain control information designated for the user terminal.

10. The method of claim 9 wherein decoding comprises:

performing a decoding procedure to decode the one or more subchannels, starting with a subchannel operated at a lowest data rate, until at least one of a plurality of conditions is met.

11. The method of claim 10 further comprising:

terminating the decoding procedure if one of the plurality of conditions is met.

12. The method of claim 11 wherein the plurality of conditions includes a first condition indicating a failure to correctly decode one of the plurality of subchannels.

13. The method of claim 11 wherein the plurality of conditions includes a second condition indicating that control information designated for the user terminal has been obtained from one of the plurality of subchannels.

14. The method of claim 11 wherein the plurality of conditions includes a third condition indicating that all subchannels have been processed.

15. The method of claim 10 wherein performing a decoding procedure comprises:

determining whether information transmitted on a subchannel has been correctly received, based on a quality metric corresponding to the respective subchannel.

16. The method of claim 15 wherein the quality metric comprises a cyclic redundancy check (CRC).

17. The method of claim 10 wherein performing a decoding procedure comprises:

determining whether control information designated for the user terminal is present in the respective subchannel, based on an identifier associated with the user terminal.

18. The method of claim 17 wherein the identifier comprises a Medium Access Control (MAC) identifier.

19. The method of claim 9 wherein the one or more selection criteria are selected from the group consisting of a first criterion corresponding to operating conditions of the respective user terminal, a second criterion corresponding to quality of service requirements associated with the respective terminal, and a third criterion corresponding to a subchannel preference indicated by the respective terminal.

20. An apparatus for processing information in a communication system, comprising:

means for partitioning a control channel that is used for transmitting control information into a plurality of subchannels, each subchannel being operated at a specific data rate;

means for selecting, for each of one or more user terminals, one of the subchannels to be used for transmitting control information from an access point to the respective user terminal, based on one or more selection criteria; and

means for transmitting control information from the access point to a particular user terminal on a particular subchannel selected for the respective user terminal.

21. The apparatus of claim 20 wherein each subchannel is associated with a distinct set of operating parameters including a code rate, a modulation scheme, and an SNR.

22. The apparatus of claim 20 wherein the plurality of subchannels are transmitted sequentially in an order from a subchannel with a lowest data rate to a subchannel with a highest data rate.

23. The apparatus of claim 22 wherein a subchannel that is transmitted first in the plurality of subchannels includes a field to indicate whether other subchannels are also being transmitted.

24. The apparatus of claim 20 wherein the one or more selection criteria including a first criterion corresponding to a link quality associated with the respective user terminal, a second criterion corresponding to quality of service requirements associated with the respective terminal, and a third criterion corresponding to a subchannel preference indicated by the respective terminal.

25. An apparatus for processing information in a communication system, comprising:

means for segregating a control channel into a plurality of subchannels each of which being operable at a specific data rate;

means for transmitting control information including resource allocation information from an access point to a user terminal on particular subchannel of the plurality subchannels selected for the user terminal, based on one or more selection criteria; and

means for decoding, at the user terminal, one or more subchannels of the plurality of subchannels to obtain control information designated for the user terminal.

26. The apparatus of claim 25 wherein means for decoding comprises:

means for performing a decoding procedure to decode the one or more subchannels, starting with a subchannel operated at a lowest data rate, until at least one of a plurality of conditions is met.

27. The apparatus of claim 26 wherein the plurality of conditions includes a first condition indicating a failure to correctly decode one of the plurality of subchannels, a second condition indicating that control information designated for the user terminal has been obtained from one of the plurality of subchannels, and a third condition indicating that all subchannels have been processed.

28. The apparatus of claim 25 wherein means for performing a decoding procedure comprises:

means for determining whether information transmitted on a subchannel has been correctly received, based on a quality metric corresponding to the respective subchannel; and

means for determining whether control information designated for the user terminal is present in the respective subchannel, based on an identifier associated with the user terminal.

29. The apparatus of claim 25 wherein the one or more selection criteria including a first criterion corresponding to operating conditions of the respective user terminal, a second criterion corresponding to quality of service requirements associated with the respective terminal, and a third criterion corresponding to a subchannel preference indicated by the respective terminal.

30. An apparatus for processing information in a communication system, comprising:

a controller configured to select one of a plurality of control subchannels to send control information to a user terminal, based on one or more selection criteria, each subchannel being operable at a specific data rate; and

a transmitter to send the control information designated for the user terminal on the subchannel selected for the user terminal.

31. The apparatus of claim 30 wherein each subchannel is associated with a specific set of operating parameters, including a data rate at which control information is transmitted, a code rate, a modulation scheme, and an SNR.

32. The apparatus of claim 30 wherein the plurality of subchannels are transmitted sequentially in an order from a subchannel with a lowest data rate to a subchannel with a highest data rate.

33. The apparatus of claim 30 wherein the one or more selection criteria including a first criterion corresponding to a link quality associated with the respective user terminal, a second criterion corresponding to quality of service requirements associated with the respective terminal, and a third criterion corresponding to a subchannel preference indicated by the respective terminal.

34. An apparatus for processing information in a wireless communication system, comprising:

a receiver to receive information on one or more control subchannels each of which being operated at a specific data rate; and

a decoder to decode the one or more control subchannels to obtain control information designated for a particular user terminal, starting with a subchannel operated at a lowest data rate, until at least one of a plurality of conditions is met.

35. The apparatus of claim 34 wherein the plurality of conditions includes a first condition indicating a failure to correctly decode one of the plurality of subchannels, a second condition indicating that control information designated for the user terminal has been obtained from one of the plurality of subchannels, and a third condition indicating that all subchannels have been processed.

36. The apparatus of claim 34 wherein the decoder is configured to determine whether information transmitted on a subchannel has been correctly received, based on a quality metric corresponding to the respective subchannel and to determine whether control information designated for the user terminal is present in the respective subchannel, based on an identifier associated with the user terminal.

37. A machine-readable medium comprising instructions which, when executed by a machine, cause the machine to perform operations including:

partitioning a control channel that is used for transmitting control information into a plurality of subchannels, each subchannel being operated at a specific data rate;

selecting, for each of one or more user terminals, one of the subchannels to be used for transmitting control information from an access point to the respective user terminal, based on one or more selection criteria; and

transmitting control information from the access point to a particular user terminal on a particular subchannel selected for the respective user terminal.

38. The machine-readable medium of claim 37 wherein each subchannel is associated with a set of operating parameters, including a data rate at which control information is transmitted, a code rate, a modulation scheme, and an SNR.

39. The machine-readable medium of claim 37 wherein the one or more selection criteria including a first criterion corresponding to a link quality associated with the respective user terminal, a second criterion corresponding to quality of service requirements associated with the respective terminal, and a third criterion corresponding to a subchannel preference indicated by the respective terminal.

40. A machine-readable medium comprising instructions which, when executed by a machine, cause the machine to perform operations including:

receiving information on one or more control subchannels each of which being operated at a specific data rate; and

decoding the one or more control subchannels to obtain control information designated for a particular user terminal, starting with a subchannel operated at a lowest data rate, until at least one of a plurality of conditions is met.

41. The machine-readable medium of claim 40 wherein the plurality of conditions includes a first condition indicating a failure to correctly decode one of the plurality of subchannels, a second condition indicating that control information designated for the user terminal has been obtained from one of the plurality of subchannels, and a third condition indicating that all subchannels have been processed.

42. The machine-readable medium of claim 40 wherein the decoder is configured to determine whether information transmitted on a subchannel has been correctly received, based on a quality metric corresponding to the respective subchannel and to determine whether control information designated for the user terminal is present in the respective subchannel, based on an identifier associated with the user terminal.

43. A method for processing information in a system, comprising:

receiving information on one or more control subchannels each of which being operated at a specific data rate; and

decoding the one or more control subchannels to obtain control information designated for a particular user terminal, starting with a subchannel operated at a lowest data rate, until at least one of a plurality of conditions is met.

44. The method of claim 43 wherein the plurality of conditions includes a first condition indicating a failure to correctly decode one of the plurality of subchannels, a second condition indicating that control information designated for the user terminal has been obtained from one of the plurality of subchannels, and a third condition indicating that all subchannels have been processed.

45. The method of claim 43 wherein decoding comprises:

determining whether information transmitted on a subchannel has been correctly received, based on a quality metric corresponding to the respective subchannel; and

determining whether control information designated for the user terminal is present in the respective subchannel, based on an identifier associated with the user terminal.

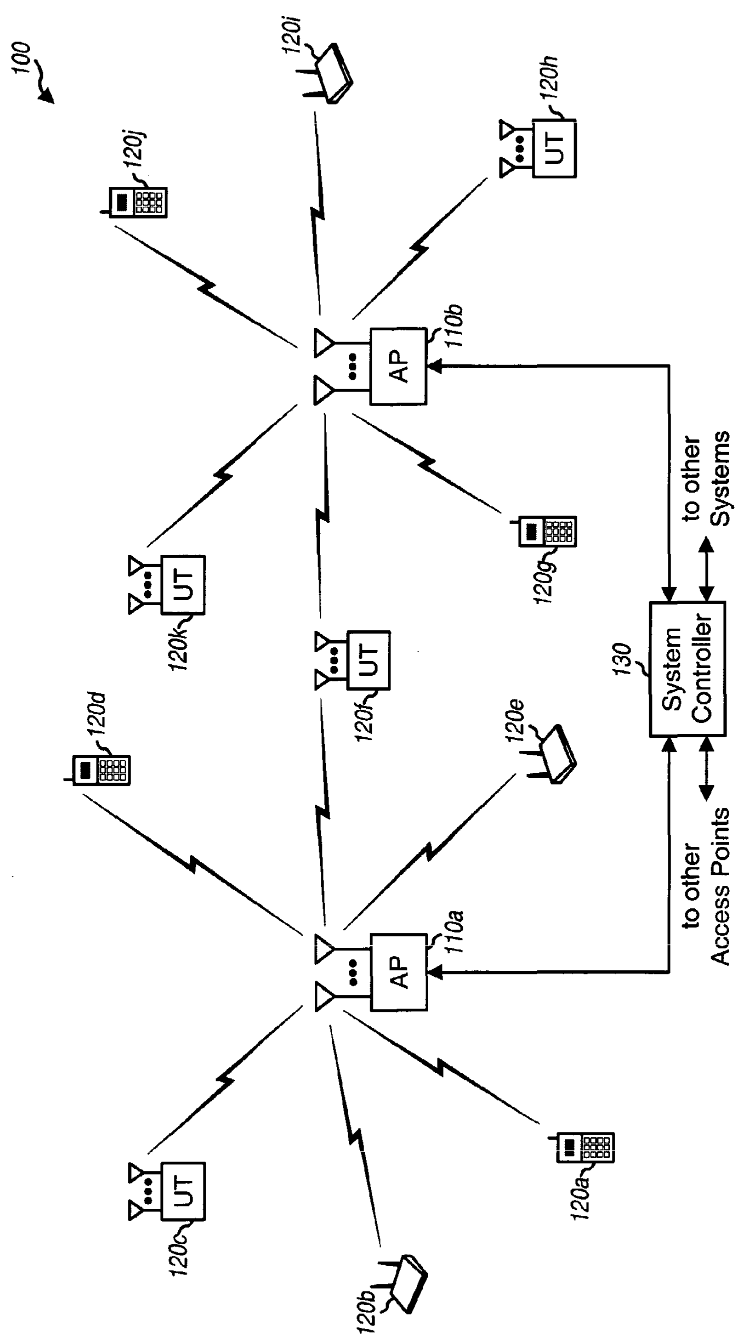

100
120i
120h
UT
120j
AP
110b
UT
120k
UT
120f
120g
to other
Systems
130
System
Controller
120d
120e
to other
Access Points
AP
110a
UT
120c
120b
120a

FIG. 1

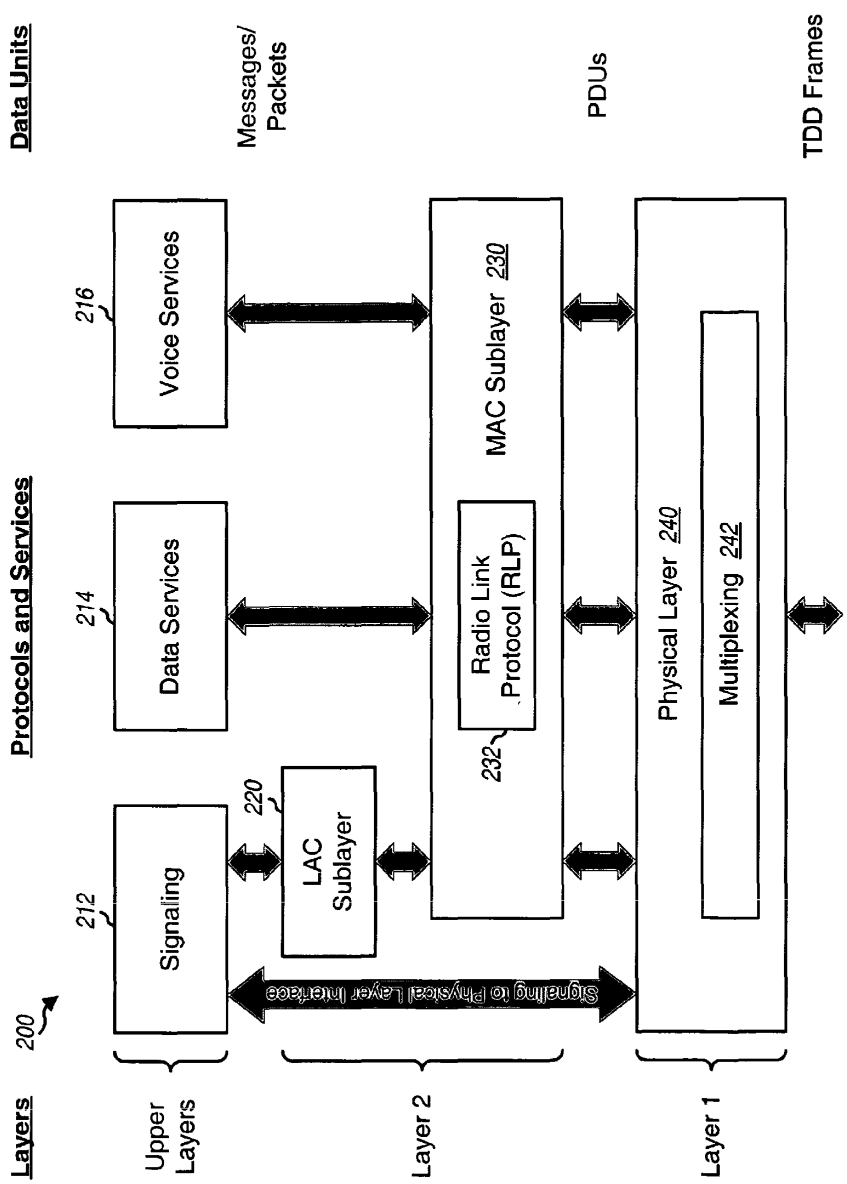

Layers
Protocols and Services
Data Units
200
Upper Layers
Layer 2
Layer 1
212
Signaling
214
Data Services
216
Voice Services
Messages/ Packets
220
LAC Sublayer
MAC Sublayer 230
Radio Link Protocol (RLP)
232
PDUs
Signaling to Physical Layer Interface
Physical Layer 240
Multiplexing 242
TDD Frames

FIG. 2

3/10

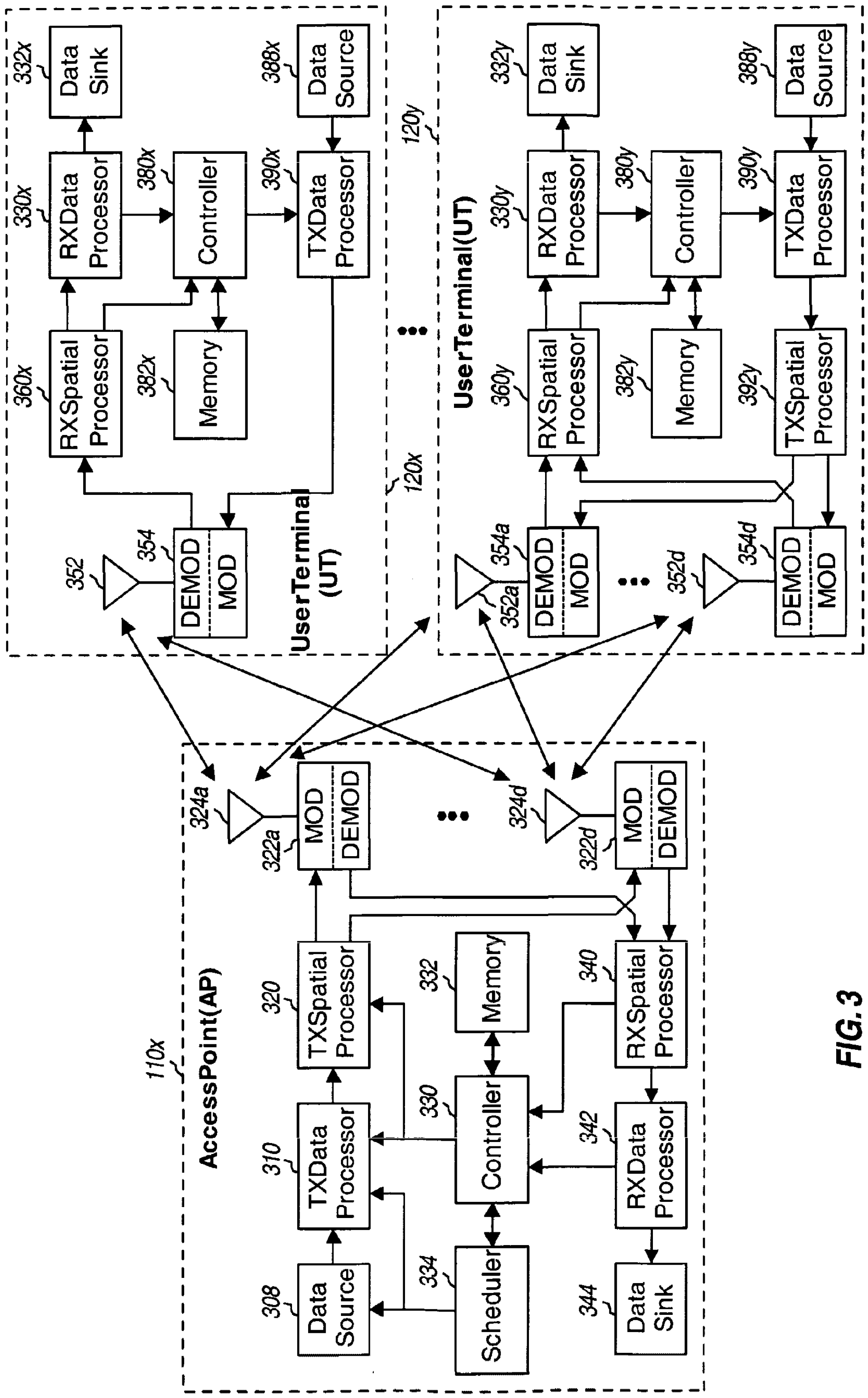

Data Sink
332x
RXData Processor
330x
Controller
380x
Data Source
388x
TXData Processor
390x
RXSpatial Processor
360x
Memory
382x
352
354
DEMOD
MOD
UserTerminal (UT)
120x
120y
UserTerminal(UT)
Data Sink
332y
RXData Processor
330y
Controller
380y
Data Source
388y
TXData Processor
390y
RXSpatial Processor
360y
Memory
382y
TXSpatial Processor
392y
354a
352a
354d
352d
AccessPoint(AP)
110x
Data Source
308
TXData Processor
310
TXSpatial Processor
320
MOD
DEMOD
322a
324a
322d
324d
Scheduler
334
Controller
330
Memory
332
RXSpatial Processor
340
RXData Processor
342
Data Sink
344

FIG.3

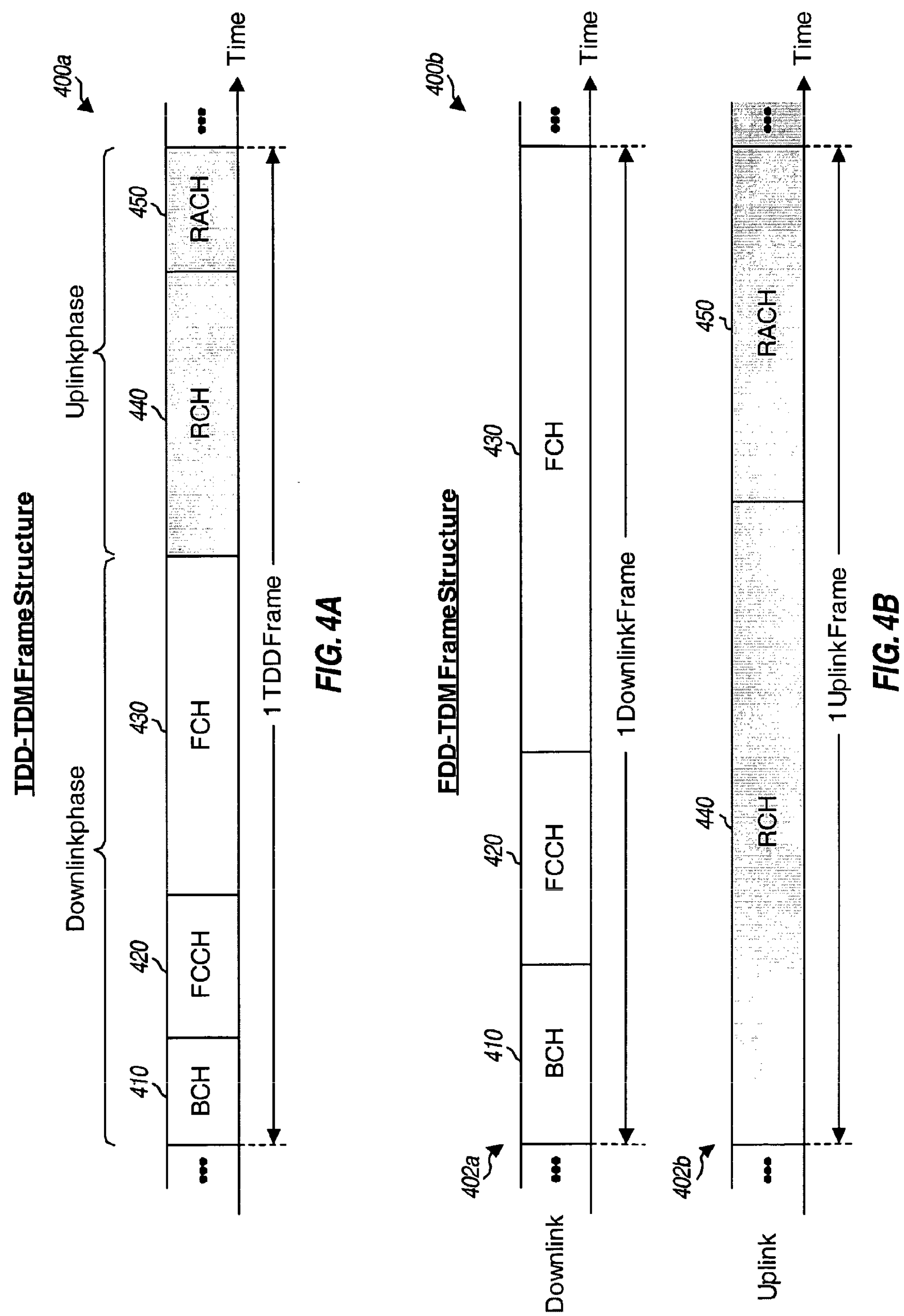

TDD-TDM Frame Structure
400a
Downlink phase
Uplink phase
410
BCH
420
FCCH
430
FCH
440
RCH
450
RACH
Time
1 TDD Frame
FDD-TDM Frame Structure
400b
402a
Downlink
402b
Uplink
1 Downlink Frame
1 Uplink Frame

FIG. 4A

FIG. 4B

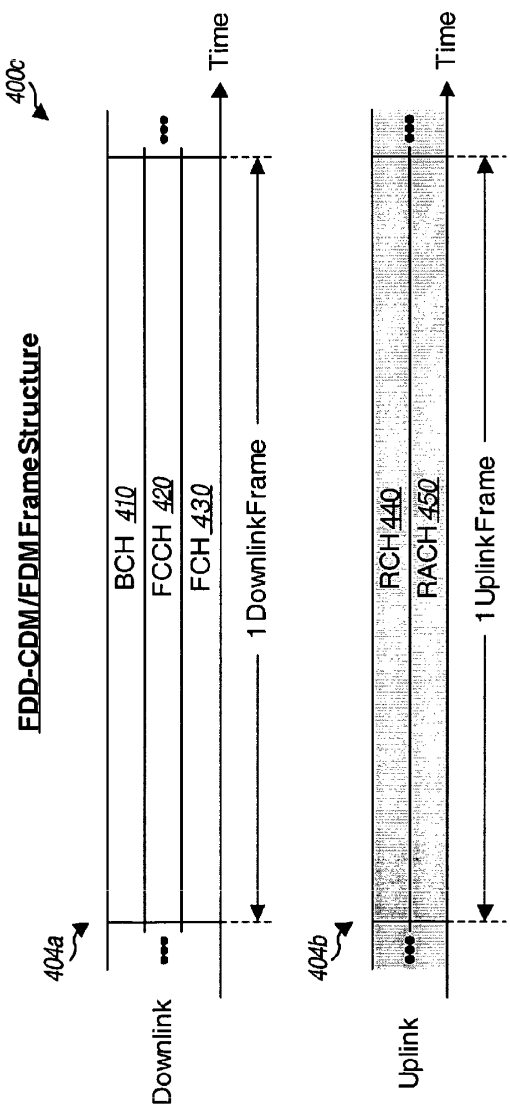

FDD-CDM/FDM Frame Structure
400c
404a
Downlink
BCH 410
FCCH 420
FCH 430
1 Downlink Frame
Time
404b
Uplink
RCH 440
RACH 450
1 Uplink Frame
Time

FIG. 4C

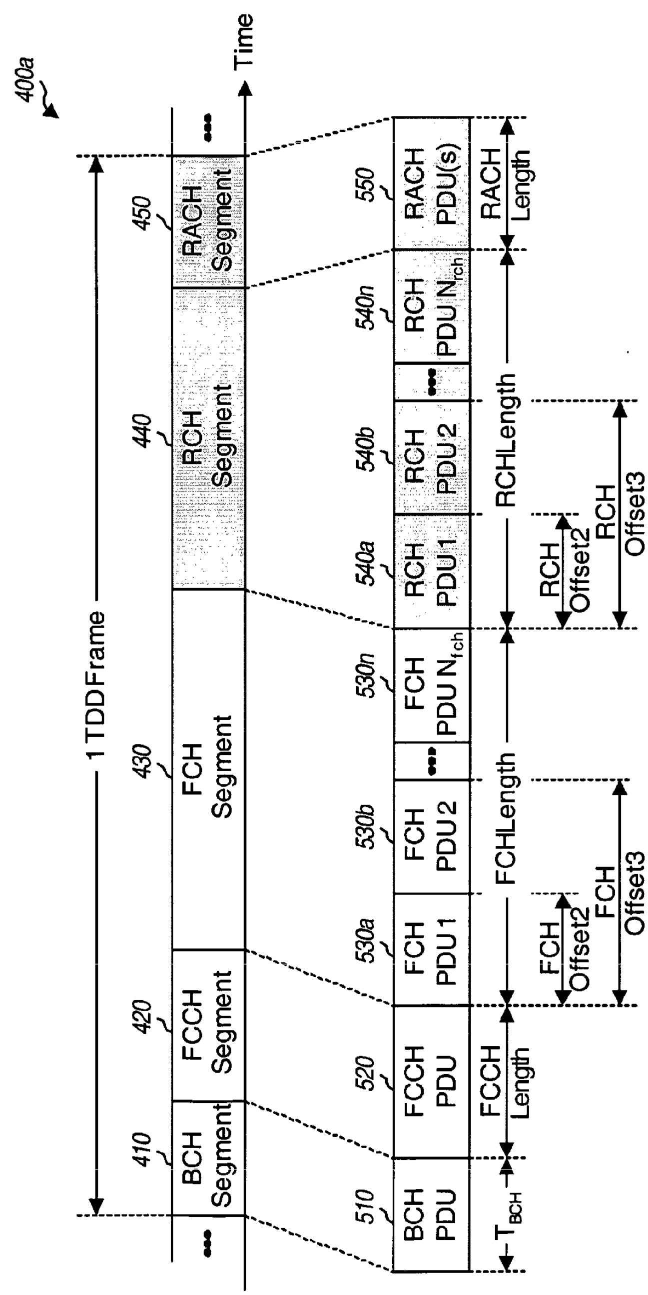
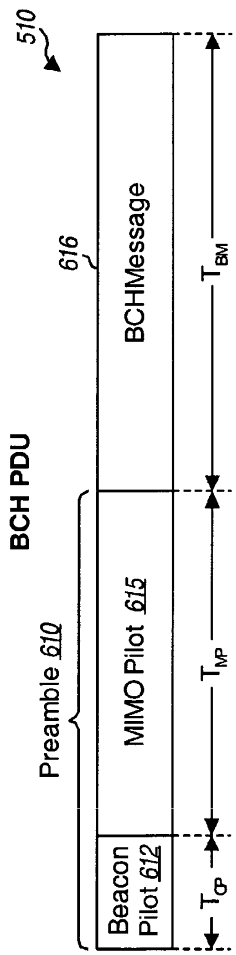
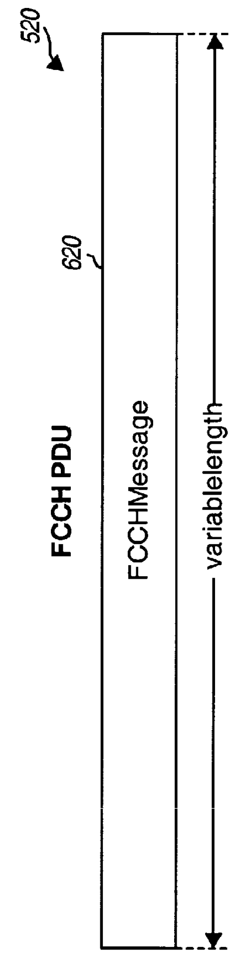

400a
Time
1 TDD Frame
410
BCH Segment
420
FCCH Segment
430
FCH Segment
440
RCH Segment
450
RACH Segment
510
BCH PDU
520
FCCH PDU
530a
FCH PDU1
530b
FCH PDU 2
530n
FCH PDU $N_{fch}$
540a
RCH PDU1
540b
RCH PDU 2
540n
RCH PDU $N_{rch}$
550
RACH PDU(s)
$T_{BCH}$
FCCH Length
FCH Length
RCH Length
RACH Length
FCH Offset2
FCH Offset3
RCH Offset2
RCH Offset3

FIG. 5



510
BCH PDU
Preamble 610
616
Beacon Pilot 612
MIMO Pilot 615
BCHMessage
$T_{CP}$
$T_{MP}$
$T_{BM}$


FIG. 6A



520
FCCH PDU
620
FCCHMessage
variablelength


FIG. 6B

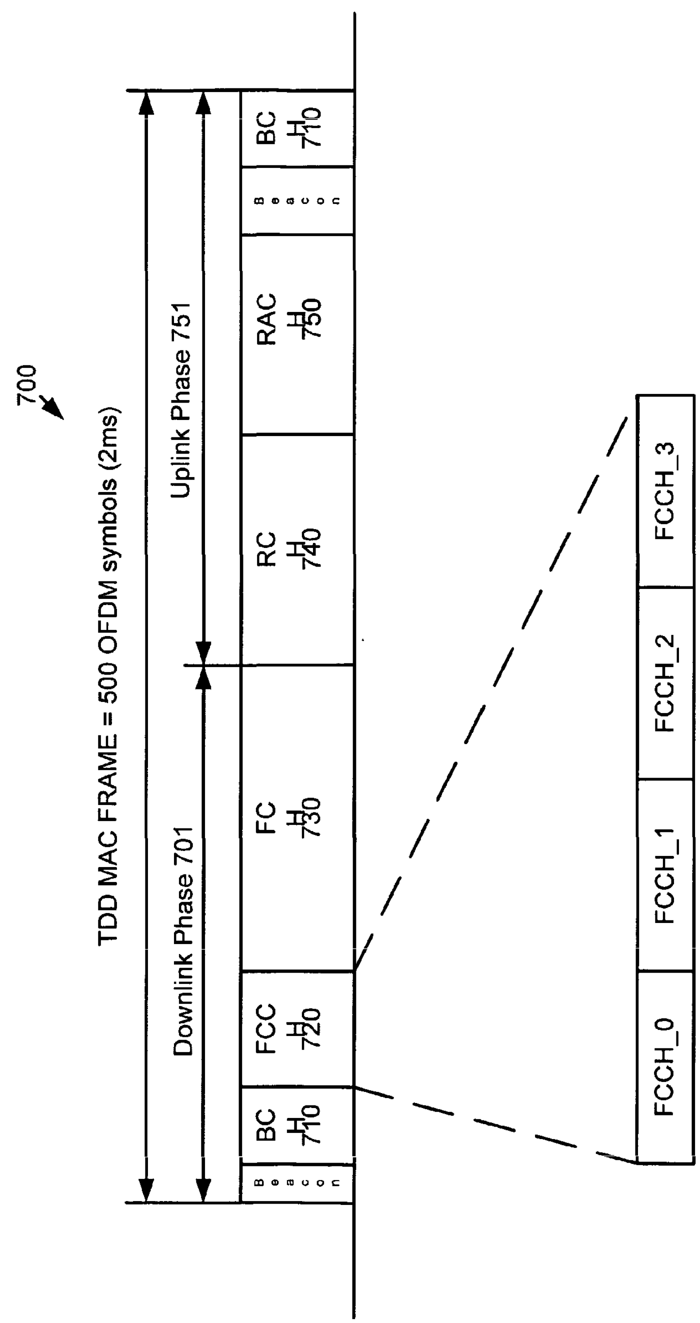



*FIG. 7*

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ZTE/SAMSUNG 1005-0757

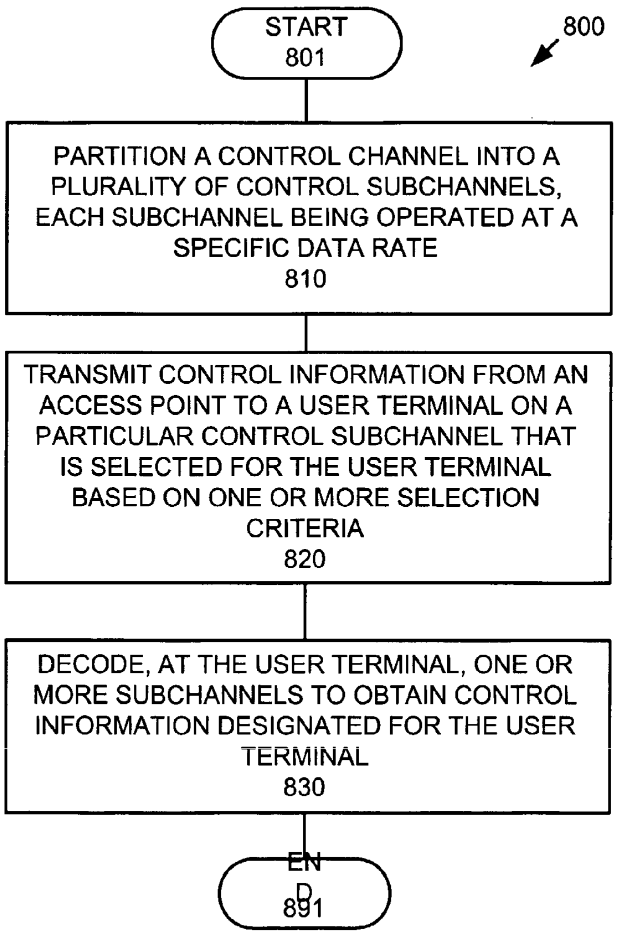
START
801
800
PARTITION A CONTROL CHANNEL INTO A PLURALITY OF CONTROL SUBCHANNELS, EACH SUBCHANNEL BEING OPERATED AT A SPECIFIC DATA RATE
810
TRANSMIT CONTROL INFORMATION FROM AN ACCESS POINT TO A USER TERMINAL ON A PARTICULAR CONTROL SUBCHANNEL THAT IS SELECTED FOR THE USER TERMINAL BASED ON ONE OR MORE SELECTION CRITERIA
820
DECODE, AT THE USER TERMINAL, ONE OR MORE SUBCHANNELS TO OBTAIN CONTROL INFORMATION DESIGNATED FOR THE USER TERMINAL
830
END
891

*FIG. 8*

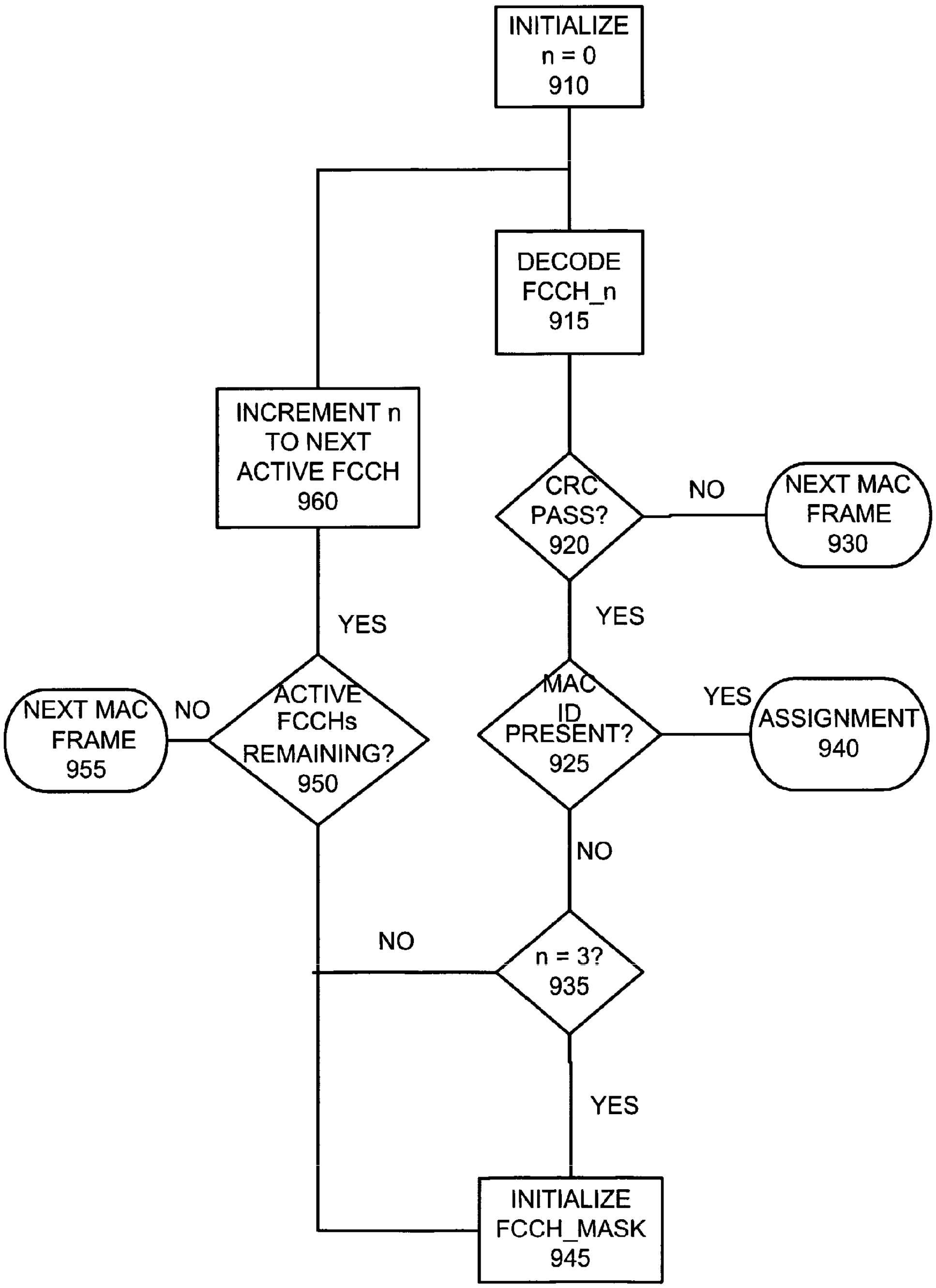
INITIALIZE
n = 0
910
DECODE
FCCH_n
915
INCREMENT n
TO NEXT
ACTIVE FCCH
960
CRC
PASS?
920
NO
NEXT MAC
FRAME
930
YES
YES
NEXT MAC
FRAME
955
NO
ACTIVE
FCCHs
REMAINING?
950
MAC
ID
PRESENT?
925
YES
ASSIGNMENT
940
NO
NO
n = 3?
935
YES
INITIALIZE
FCCH_MASK
945

*FIG. 9*

# INTERNATIONAL SEARCH REPORT

International Application No
PCT/US2004/038198

**A. CLASSIFICATION OF SUBJECT MATTER**
IPC 7 H04L12/28 H04L12/56 H04Q7/38 H04L1/00 H04L27/26
H04L1/06 H04B7/26

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04B H04L H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, COMPENDEX, INSPEC

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category ° | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | WO 03/010984 A (NORTEL NETWORKS LIMITED) 6 February 2003 (2003-02-06)<br><br>abstract<br>page 1, line 1 - page 2, line 26<br>page 9, line 16 - page 19, line 11<br>figures 1-5<br>claims 1-18<br>----- | 1,2,9, 20,25, 30,34, 37,40,43 |
| A | US 2002/071445 A1 (WU GENG ET AL) 13 June 2002 (2002-06-13)<br>paragraphs '0001! - '0011!<br>paragraphs '0023! - '0034!<br>paragraphs '0047!, '0048!<br>figures 1,2a,2b,3a,3b,3c,4a,4b,4c<br>-----<br>-/-- | 1-45 |

[X] Further documents are listed in the continuation of box C. [X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 21 March 2005 | 04/04/2005 |

| Name and mailing address of the ISA | Authorized officer |
|---|---|
| European Patent Office, P.B. 5818 Patentlaan 2<br>NL – 2280 HV Rijswijk<br>Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,<br>Fax: (+31-70) 340-3016 | Gavin Alarcon, O |

1

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

| Category ° | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | "Broadband Radio Access Networks (BRAN); HIPERLAN Type 2; Data Link Control (DLC) Layer; Part 1: Basic Data Transport Functions; ETSI TS 101 761-1" ETSI STANDARDS, EUROPEAN TELECOMMUNICATIONS STANDARDS INSTITUTE, SOPHIA-ANTIPO, FR, vol. BR, no. V131, December 2001 (2001-12), XP014006627 ISSN: 0000-0001 page 12 - page 14 page 16 page 18 - page 36 page 48 - page 53 pages 82-86 | 1-45 |
| A | US 2003/147371 A1 (CHOI SUNG-HO ET AL) 7 August 2003 (2003-08-07) abstract paragraphs ‘0003!, ‘0005!, ‘0007! paragraphs ‘0019! - ‘0035! paragraphs ‘0038!, ‘0039! paragraphs ‘0062! - ‘0070! figures 1,3,4,11 | 1-45 |
| A | US 2003/157953 A1 (DAS ARNAB ET AL) 21 August 2003 (2003-08-21) paragraphs ‘0001! - ‘0011! paragraphs ‘0023! - ‘0027! paragraphs ‘0041! - ‘0051! figure 6 | 1-45 |

1

## INTERNATIONAL SEARCH REPORT

International Application No
PCT/US2004/038198

| Patent document cited in search report | | Publication date | Patent family member(s) | | Publication date |
|---|---|---|---|---|---|
| WO 03010984 | A | 06-02-2003 | WO | 03010984 A1 | 06-02-2003 |
| | | | US | 2004013103 A1 | 22-01-2004 |
| US 2002071445 | A1 | 13-06-2002 | NONE | | |
| US 2003147371 | A1 | 07-08-2003 | CN | 1477886 A | 25-02-2004 |
| | | | DE | 10305096 A1 | 18-09-2003 |
| | | | FR | 2835669 A1 | 08-08-2003 |
| | | | GB | 2386513 A ,B | 17-09-2003 |
| | | | JP | 2003284135 A | 03-10-2003 |
| | | | KR | 2003067556 A | 14-08-2003 |
| US 2003157953 | A1 | 21-08-2003 | NONE | | |

Form PCT/ISA/210 (patent family annex) (January 2004)

Espacenet

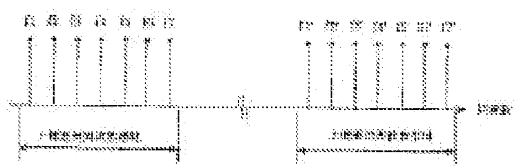
# Bibliographic data: JP2000102067 (A) — 2000-04-07

## COMMUNICATION SYSTEM AND SLAVE SET

| | | |
|---|---|---|
| **Inventor(s):** | HAMADA TOMOICHI; MORIYA YOICHI; KAWABATA TAKASHI; SOGABE TORU + | |
| **Applicant(s):** | MITSUBISHI ELECTRIC CORP + | |
| **Classification:** | **- international:** | ***H04J3/00; H04Q7/36;*** (IPC1-7): H04J3/00; H04Q7/36 |
| | **- European:** | |
| **Application number:** | JP19980272924 19980928 | |
| **Priority number (s):** | JP19980272924 19980928 | |
| **Also published as:** | JP3436151 (B2) | |

**Abstract of JP2000102067 (A)**

PROBLEM TO BE SOLVED: To improve the frequency utilizing efficiency of operating frequency bands by dividing each of two frequency bands into carrier frequencies whose number is the same as a prescribed number of radio cells, assigning two carrier frequencies to each radio cell and operating a time division multiple access/time division duplex system with the respective frequencies.
SOLUTION: Frequency bands are divided into two frequency bands being upper and lower frequencies with an equal band width, and let number of repetition of cell arrangement be, e.g. 7, then the upper/lower frequency bands are divided respectively into 7 carrier frequencies f1-f7 and f1'-f7' and two optional carrier frequencies are assigned as operating frequencies of each cell among the carrier frequencies in total of 14.; One system of a transmitter-receiver is enough by allocating slots of each carrier so that the slot assigned to the two carriers is not in duplicate at the same time and the configuration of the slave set is simplified.





EVOLVED-0002405

ZTE/SAMSUNG 1005-0763

(19)日本国特許庁（ＪＰ）　(12) 公開特許公報（Ａ）　(11)特許出願公開番号
特開2000－102067
（P2000－102067A）
(43)公開日　平成12年４月７日(2000.4.7)

| (51)Int.Cl.⁷ | 識別記号 | ＦＩ | | テーマコード（参考） |
|---|---|---|---|---|
| Ｈ０４Ｑ　7/36 | | Ｈ０４Ｂ　7/26 | １０５Ｄ | ５Ｋ０２８ |
| Ｈ０４Ｊ　3/00 | | Ｈ０４Ｊ　3/00 | Ｈ | ５Ｋ０６７ |

審査請求　未請求　請求項の数６　ＯＬ　（全７頁）

(21)出願番号　特願平10－272924
(22)出願日　平成10年９月28日(1998.9.28)

(71)出願人　000006013
三菱電機株式会社
東京都千代田区丸の内二丁目２番３号
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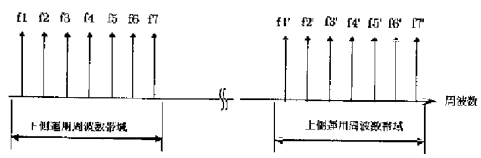
(74)代理人　100102439
弁理士　宮田　金雄　（外２名）

最終頁に続く

(54)【発明の名称】　通信方式及び子機装置

(57)【要約】
【課題】　時分割多元接続／時分割複信（ＴＤＭＡ／ＴＤＤ）通信方式に運用周波数帯が２つの領域に分離されて割当てられた場合、運用周波数帯全体の全てを有効に利用することができなかった。
【解決手段】　２つの周波数領域をそれぞれ繰返しセル数と同じキャリア数に分割し、各セルに対して各々割当てた２つのキャリアでＴＤＭＡ／ＴＤＤ通信方式を運用するようにした。



【特許請求の範囲】

【請求項１】　無線回線の多元接続方式として時分割多元接続／時分割複信方式を採用した無線セルでサービスエリアを覆い、一定の無線セル数毎に同一キャリア周波数による無線セルを繰返して配置する通信方式において、システムの運用周波数帯が２つの領域に分離して割当てられており、２つの領域の周波数帯のそれぞれを上記一定の無線セル数と同じ数のキャリア周波数に分割し、各無線セルに対してキャリア周波数を２つずつを割当て、それぞれのキャリア周波数で時分割多元接続／時分割複信方式を運用するとともに、各無線セル内の基地局と子機との間の通信に対して当該２つの時分割多元接続／時分割複信フレーム上からそれぞれタイムスロットを割当てることを特徴とする通信方式。

【請求項２】　子機に割当てるタイムスロットの位置が２つの時分割多元接続／時分割複信フレームにおいて同一時刻に重ならないように割当てることを特徴とする請求項１記載の通信方式。

【請求項３】　２つに分離されたシステムの運用周波数帯は帯域幅が異なっており、各無線セルに対して割当てるキャリア周波数は各々の領域から一つずつ割当てていることを特徴とする請求項１記載の通信方式。

【請求項４】　基地局から子機への同報チャネルを２つのキャリア周波数上の時分割多元接続／時分割複信フレームにおいて各々送信し、子機は両同報チャネルの内受信状況の良好な方を選択して受信することを特徴とする請求項１記載の通信方式。

【請求項５】　基地局からの２つの同報チャネルを2つのキャリア周波数上の時分割多元接続／時分割複信フレームにおいて一定時間差があるタイムスロットで各々送信し、子機は両同報チャネルの内受信状況の良好な方を選択して受信することを特徴とする請求項４記載の通信方式。

【請求項６】　請求項２の通信方式で基地局と通信する子機であって、送受信装置の送受信周波数を設定する局部発振器の発振周波数を２つのキャリア周波数の送受信のタイミングに応じて切換えるようにしたことを特徴とする子機装置。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】この発明は、一定の無線セル数毎に同一キャリア周波数による無線セルを繰返して配置する通信方式において、例えば、多元接続方式として時分割多元接続／周波数分割複信方式などを運用することを考慮して、2つの領域に分離して割当てられたシステムの運用周波数帯で時分割多元接続／時分割複信方式を運用するための方式及び子機装置に関するものである。

【０００２】

【従来の技術】時分割多元接続／時分割複信（Ｔｉｍｅ Ｄｉｖｉｓｉｏｎ Ｍｕｌｔｉｐｌｅ Ａｃｃｅｓｓ ／ Ｔｉｍｅ Ｄｉｖｉｓｉｏｎ Ｄｕｐｌｅｘ 以下、ＴＤＭＡ／ＴＤＤと称す。）通信方式を採用するセルラ通信方式に対する運用周波数の割当て例として、“第二世代コードレス電話システム標準規格”（ＲＣＲ ＳＴＤ－２８、財団法人電波システム開発センター、平成５年１２月２０日策定）の第３．２．１項無線周波数帯（以下、文献１と称す。）に記載されたものがある。文献1にも示されているように、ＴＤＭＡ／ＴＤＤ通信方式においては、一般的に一つのまとまった周波数帯域において複数のキャリア周波数が割当てられる。また、セルラ通信方式については“移動通信の基礎”、奥村善久、進士昌明監修、昭和６１年電子情報通信学会発行の第８章（以下、文献２と称す。）に述べられている。以下、上記のような一つのまとまった領域の周波数帯を割当てるＴＤＭＡ／ＴＤＤによるセルラ通信方式について概略を説明する。

【０００３】図9はＴＤＭＡ／ＴＤＤ方式で使用されるフレーム構成の一例である。ＴＤＭＡ／ＴＤＤ方式では時間領域で複数のチャネルを構成するためにフレームをチャネルに対応するタイムスロット（以下、単にスロットと略称する。）に分割している。図において、Ｂは下り放送チャネル用スロットで、基地局から無線セル（以下、単にセルと略称する。）内の複数の子機に向けた同報チャネルで子機全体に対する制御情報や個々の子機に対する制御情報などが含まれる。また、下り放送チャネル用スロットＢはセル内のＴＤＭＡ／ＴＤＤフレームの時間基準としても利用される。Ｒは上りランダムアクセス用スロットで、セル内の子機から基地局に向けた制御チャネルで子機側から通信要求を行う時などに使用する。一般的に、このＲチャネルはそれぞれの子機がランダムにアクセスする方式がとられることが多い。Ｕ１からＵｍまでのスロットは子機から基地局に向けた通信チャネル（上り通信チャネル）、Ｄ１からＤｎまでのスロットは基地局から子機に向けた通信チャネル（下り通信チャネル）である。

【０００４】このようにＴＤＭＡ／ＴＤＤ通信方式では１フレーム内に複数の上り通信チャネルＵ１～Ｕｍと下り通信チャネルＤ１～Ｄｎを設けることにより、１つのキャリア周波数で基地局と複数の子機間の全二重通信を行うようにしている。文献１はＴＤＭＡ／ＴＤＤ通信方式を採用している第二世代コードレス電話システム（ＰＨＳ）の周波数割当てを示しているが、本発明を端的に説明するため、従来のキャリア周波数の割当て例を図１０に示す。図１０においてはシステムに割当てられた運用周波数帯を7つのキャリア周波数ｆ１～ｆ７に分割している。キャリア周波数ｆ１～ｆ７は分割されたそれぞれの周波数帯の中心周波数である。また、図１１は文献２にも述べられている７セル繰返しによるセル配置の一例であり、図において１～7はセルであり、それぞれの

セルでは、それらの中に記入された図１０に対応するキャリア周波数１～７を使用していることを示している。

【０００５】また、図１２はＴＤＭＡ／ＴＤＤ通信方式で使用される基地局と子機の送受信装置の概略構成図であり、図において８は送受信アンテナ、９は送信系回路、１０はこの送信系回路９に送信データを入力する送信データ入力端子、１１は受信系回路、１２はこの受信系回路１１が受信データを出力する受信データ出力端子、１３はアンテナ８を送信系回路９又は受信系回路１１の何れかに接続するスイッチ、１４は送信系回路９及び受信系回路１１の送受信周波数を設定・選択する局部発信器、15は送受信制御及びスイッチ１３の切換タイミングを制御する制御回路、16は制御信号の入力端子である。

【０００６】例えば、図１１のセル１内で基地局と通信する子機を例に信号の送受信の動作を図１２で説明する。図１２において、送信データは送信データ入力端子１０に入力される。入力されたデータは送信系回路９でディジタル変調され送信キャリア周波数ｆ１でＴＤＭＡフレーム上の所定のスロット（上り通信チャネル）Ｕ１～Ｕｍにおいて送信系回路９の出力側からスイッチ１３を経由してアンテナ８に接続され基地局に向けて送信される。一方、アンテナ８で受信された基地局からのキャリア周波数ｆ１の電波はスイッチ１３を経由して受信系回路１１に導かれ受信処理され受信データ出力端子１２に出力される。なお、送受信系回路９、１１の送受信周波数は、局部発信器１４の設定によってｆ１が選択される。また、制御回路１５は制御信号の入力端子１６からの制御信号によってアンテナ８の切換えや送受信系回路９、１１の処理内容を制御する。

【０００７】以上のように、ＴＤＭＡ／ＴＤＤ通信方式ではそれぞれのセルに割当てられたキャリア上で図９の例のようＴＤＭＡ／ＴＤＤフレームを構成し、基地局と子機の送信を時間軸上で区分けすることにより同一のキャリア周波数で基地局と複数の子機が通信を行うことができる。

【０００８】上記したように、ＴＤＭＡ／ＴＤＤ通信方式では送受信を同一のキャリア上で時間で区分して行う。このため、各セルに対する周波数割当てに関しては、システムの運用周波数帯を繰返しセル数で等分し、それぞれの周波数帯を繰返しセル群（図１１の例ではてセル１～７）を構成するセルに順に割当て、繰返しセル数毎にこれらの周波数帯を繰返し利用するのが基本である。

【０００９】

【発明が解決しようとする課題】従来のＴＤＭＡ／ＴＤＤ通信方式においては、図１０及び図１１のようにまとまった周波数帯域内でキャリア周波数が割当てられることが一般的である。しかしながら、ＴＤＭＡ／ＴＤＤ通信方式の運用周波数帯が、例えば基地局とそれぞれの子機の送信の区別を周波数領域で行う時分割多元接続／周波数分割複信（Ｔｉｍｅ　Ｄｉｖｉｓｉｏｎ　Ｍｕｌｔｉｐｌｅ　Ａｃｃｅｓｓ　／　Ｆｒｅｑｕｅｎｃｙ　Ｄｉｖｉｓｉｏｎ　Ｄｕｐｌｅｘ：以下、ＴＤＭＡ／ＦＤＤと称す。）方式を採用するシステムとの混在や選択的な使用を考慮し、図１３に示すように上下２つの周波数領域に分離され割当てられることもある。これは、ＴＤＭＡ／ＦＤＤ通信方式にとっては運用周波数帯がある程度以上の周波数差がある上りチャネル用と下りチャネル用の２つの周波数領域に分けられていることが必須であり、一方ＴＤＭＡ／ＴＤＤ通信方式は基本的には運用周波数帯が一つにまとめられていても、２つに分けられていても対応できるためである。

【００１０】しかしながら、例えば図１１に示した繰返しセル数７のセル配置において、図１３のように上下２つの等しい帯域幅の運用周波数帯が割当てられたとすると、図１１のセル配置を構成するために必要な７つのキャリア周波数に割当てられた運用周波数帯の全体を等分することはできない。このため図１３に示すように、例えば上下の周波数帯をそれぞれ４つ、すなわち合計８つの周波数帯に等分しその内７つの周波数帯を図１１のように割当てたとすると、１キャリア周波数が余ってしまい与えられた運用周波数帯の全てを有効に利用することができないという主たる問題があった。

【００１１】この発明は上記のような問題を解消するためになされたもので、２つの領域に分離されて割当てられた運用周波数帯を使用して周波数利用効率の良いＴＤＭＡ／ＴＤＤ通信方式によるセルラ通信を行うことを目的としており、さらにこれを実現するための送受信装置が簡単に構成できる方式及び装置を提供すること、及び２つの領域に分割されていることを利用し通信の信頼性を高める方式を提供することを目的としている。

【００１２】

【課題を解決するための手段】この発明の請求項１に係る通信方式は、無線回線の多元接続方式として時分割多元接続／時分割複信方式を採用した無線セルでサービスエリアを覆い、一定の無線セル数毎に同一キャリア周波数による無線セルを繰返して配置する通信方式において、システムの運用周波数帯が２つの領域に分離して割当てられており、２つの領域の周波数帯のそれぞれを上記一定の無線セル数と同じ数のキャリア周波数に分割し、各無線セルに対してキャリア周波数を２つずつを割当て、それぞれのキャリア周波数で時分割多元接続／時分割複信方式を運用するとともに、各無線セル内の基地局と子機との間の通信に対して当該２つの時分割多元接続／時分割複信フレーム上からそれぞれタイムスロットを割当てるようにしたものである。

【００１３】この発明の請求項２に係る通信方式は、請求項１における通信方式であって、子機に割当てるタイムスロットの位置が２つの時分割多元接続／時分割複信

フレームにおいて同一時刻に重ならないように割当てるようにしたものである。

【0014】この発明の請求項3に係る通信方式は、請求項1における通信方式であって、2つに分離されたシステムの運用周波数帯は帯域幅が異なっており、各無線セルに対して割当てるキャリア周波数は各々の領域から一つずつ割当てるようにしたものである。

【0015】この発明の請求項4に係る通信方式は、請求項1における通信方式であって、基地局から子機への同報チャネルを2つのキャリア周波数上の時分割多元接続/時分割複信フレームにおいて各々送信し、子機は両同報チャネルの内受信状況の良好な方を選択して受信するようにしたものである。

【0016】この発明の請求項5に係る通信方式は、請求項4における通信方式であって、基地局からの2つの同報チャネルを2つのキャリア周波数上の時分割多元接続/時分割複信フレームにおいて一定時間差があるタイムスロットで各々送信し、子機は両同報チャネルの内受信状況の良好な方を選択して受信するようにしたものである。

【0017】この発明の請求項6に係る通信方式は、請求項2の通信方式で基地局と通信する子機であって、送受信装置の送受信周波数を設定する局部発振器の発振周波数を2つのキャリア周波数の送受信のタイミングに応じて切換えるように構成したものである。

【0018】

【発明の実施の形態】実施の形態1．以下、この発明の実施の形態1を図について説明する。図1は下側と上側の等しい帯域幅の2つの領域に分離され割当てられたセルラ通信システムの運用周波数帯の例である。今、セル配置の例として繰返しセル数を7とする場合には、これら上下の周波数帯域をそれぞれ図中f1〜f7及びf1'〜f7'で示したように7つのキャリア周波数に分割し、合計14のキャリア周波数の中から任意の2キャリア周波数を各セルの運用周波数として割当てる。

【0019】図2に繰返しセル数が7の場合のセル配置とこの実施の形態によるキャリア周波数割当ての例を示す。図において、1〜7はセルであり、それぞれのセル1〜7では、それらの中に記入された図1に対応するキャリア周波数を使用することを例として示している。それぞれのキャリア周波数で運用されるTDMA/TDDのフレーム構成は基本的には図9の従来例で示したものと同様であり、図3は図2においてセル1でf1とf2のキャリア周波数で運用されるTDMA/TDDのフレーム構成の例を示す。図において各スロット信号の機能は図9に示した従来のTDMA/TDDフレームの例と同様である。また、図中ハッチングしたスロットはセル1内のある子機と基地局の間の通信に割当てられたスロットを示している。この図に示すように2つのキャリアの両方にスロットが割当てられる場合には、同一時刻における割当てを避けると同時に、必要に応じて一定以上の時間差を設けて割当てるようにすることによって送受信機の構成を簡単にすることができる。

【0020】すなわち、図2のように各セルに2つの送受信キャリアを割当てた場合の信号の送受信は同一時刻に2つのキャリアのスロットが割当てられる場合を想定して基本的には図4に示すように図12の従来例で示した送受信装置を各々のキャリアに対応し、各基地局と子機に各々2つずつ設置する必要がある。しかしながら、図3に示したように2つのキャリア上に割当てられるスロットが同一時刻に重ならないように各キャリアのスロットを割り当てておけば図5に示すように送受信周波数を選択する局部発振器14aの周波数をf1の送受信用とf2の送受信用に該当するスロットのタイミングに合わせて切換えることにより送受信装置は1系統だけでよくなり、装置構成を簡単にすることができる。なお、図4において図12と同じ記号で示した回路は図12のそれぞれの回路と同じ機能の回路であり、また、17は例としてここではキャリア周波数f1を、また、18は例としてキャリア周波数f2を送受信する装置である。

【0021】また、図5においても図12と同じ記号で示した回路は図12のそれぞれの回路と同じ機能の回路であり、図中、14aは送受信回路の送受信周波数を選択する局部発信器であるが、図3の例で示したTDMA/TDDフレーム上に割当てられた送受信スロットに対応して送受信周波数をf1かf2に切換えて選択する機能を有している。

【0022】実施の形態2．図6はこの発明の実施の形態2に係る運用周波数の分割例を示す図である。図6は図1において運用周波数帯の下側と上側の帯域幅が異なる場合の周波数分割例であり、それぞれの運用周波数帯を繰返しセル数と同じ数に分割している。この場合の各セルに対するキャリア周波数の割当て例を図7に示す。図中に示すように各セル1〜7には上下の運用周波数領域からキャリア周波数を1つずつ割当てることにより、各セル1〜7毎に同等の帯域を割当てることができる。このような場合の装置構成は図4と同じであるが、17と18の送受信装置の送受信帯域幅やデータの伝送速度は、図6に示した上下運用周波数帯に割当てられたキャリア周波数のそれぞれの帯域幅に応じて異なる。

【0023】実施の形態3．図3に示したように、基地局から子機に向けた制御情報などを伝送するBチャネルを両方のキャリアf1、f2のTDMA/TDDフレームに設け、基地局は同一の情報を両Bチャネルて伝送し、子機はこれら両Bチャネルを受信し、受信状況の良好な方の受信データを採用するようにすれば、制御チャンネルの信頼性を向上させることができる。

【0024】実施の形態4．図3で示した2つのキャリアf1、f2上のそれぞれのTDMA/TDDフレームのBチャネルのスロットを図8で示すように異なる位置

に配置し、子機はこれら両方のＢチャネルを受信し、受信状況の良好な方の受信データを採用するようにすれば、制御チャンネルの信頼性をさらに向上させることができる。

【００２５】

【発明の効果】この発明の請求項１における通信方式によれば、各無線セルに対してキャリア周波数を２つずつを割当て、それぞれのキャリア周波数で時分割多元接続／時分割複信方式を運用するとともに、各無線セル内の基地局と子機との間の通信に対して当該２つの時分割多元接続／時分割複信フレーム上からそれぞれタイムスロットを割当てるようにしたので、割当てられた周波数帯を余すことなく有効に利用することができる効果がある。

【００２６】また、この発明の請求項２における通信方式によれば、子機に割当てるタイムスロットの位置が２つの時分割多元接続／時分割複信フレームにおいて同一時刻に重ならないように割当てるようにしたので、子機の送受信器の構成を簡単にすることができる効果がある。

【００２７】また、この発明の請求項３における通信方式によれば、帯域幅の異なる２つの周波数帯から、各無線セルに対して割当てるキャリア周波数を各々の領域から一つずつ割当てるものとしたので、割当てられた周波数帯を余すことなく有効に利用することができ、かつ、各無線セルに同等の帯域を割当てるようにすることができる効果がある。

【００２８】また、この発明の請求項４における通信方式によれば、２つのキャリア周波数上にそれぞれ送信されてくる同報チャンネルの内、受信状況の良好な方を選択して受信するようにしたので、制御チャンネルの信頼性を向上できる効果がある。

【００２９】また、この発明の請求項５における通信方式によれば、２つの同報チャンネルを一定時間差のあるタイムスロットで送信するものとし、子機は受信状況の良好な方を選択して受信するようにしたので、制御チャンネルの信頼性をさらに向上できる効果がある。

【００３０】さらに、この発明の請求項６における子機装置によれば、送受信装置の送受信周波数を設定する局部発振器の発振周波数を２つのキャリア周波数の送受信のタイミングに応じて切換えるようにした送受信器の構成を簡単にすることができる効果がある。

【図面の簡単な説明】

【図１】　この発明の実施の形態１に係る運用周波数帯の分割例を示す図である。

【図２】　この発明の実施の形態１に係る各無線セルに対するキャリア周波数の割当て例を示し図である。

【図３】　この発明の実施の形態１に係る時分割多元接続／時分割複信フレームの構成を示す図である。

【図４】　この発明の実施の形態１に係る送受信装置の構成を示すブロック図である。

【図５】　この発明の実施の形態１に係る送受信装置の他の構成を示すブロック図である。

【図６】　この発明の実施の形態２に係る運用周波数帯の分割例を示す図である。

【図７】　この発明の実施の形態２に係る各無線セルに対するキャリア周波数の割当て例を示し図である。

【図８】　この発明の実施の形態２に係る時分割多元接続／時分割複信フレームの構成を示す図である。

【図９】　従来の時分割多元接続／時分割複信フレームの構成を示す図である。

【図１０】　従来の運用周波数帯の分割例を示す図である。

【図１１】　従来の各無線セルに対するキャリア周波数の割当て例を示し図である。

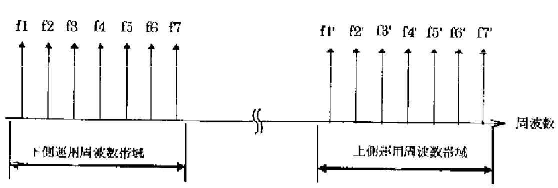
【図１２】　従来の送受信装置の他の構成を示すブロック図である。

【図１３】　従来の運用周波数帯の他の分割例を示す図である。

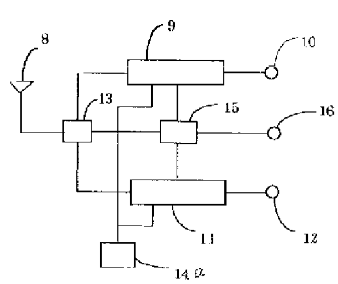
【符号の説明】

１～７　無線セル、　８　アンテナ、　９　送信系回路、　１１　受信系回路、　１４　局部発信器、　１５　制御部。

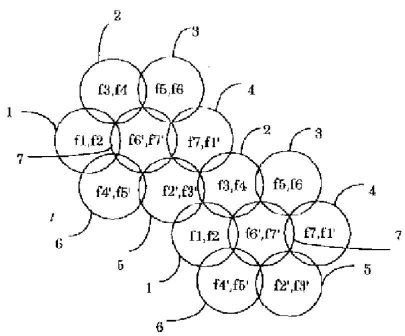
【図１】



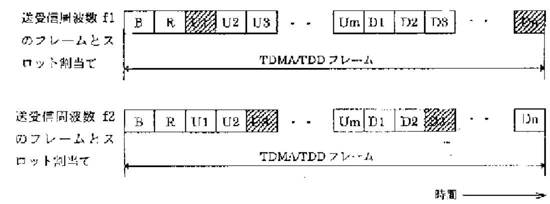

【図５】



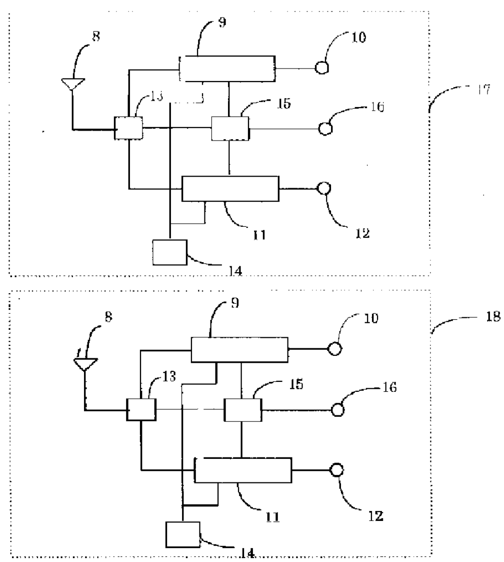
【図2】



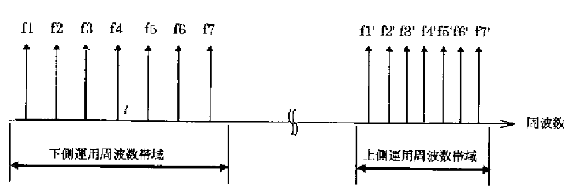

【図3】



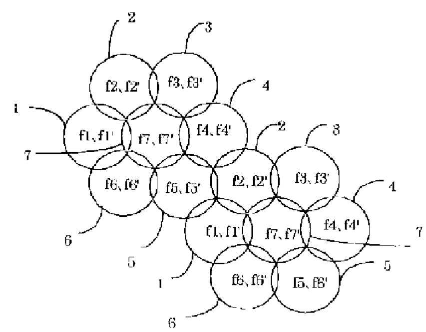

【図4】



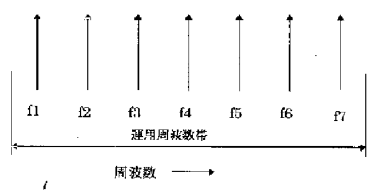
【図6】



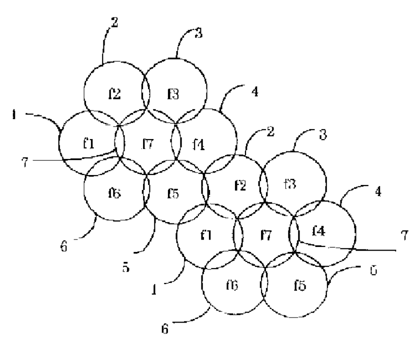

【図7】



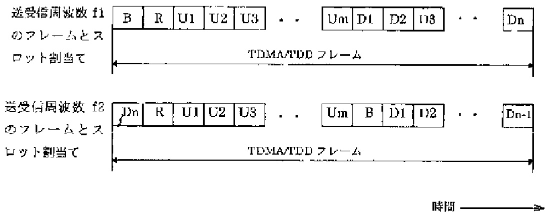

【図10】



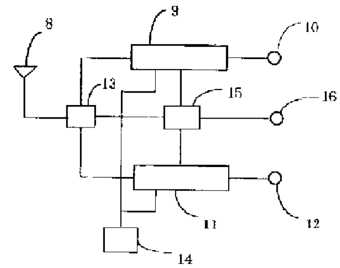

【図11】



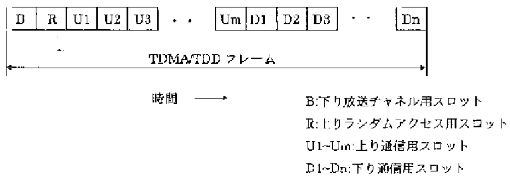
【図8】



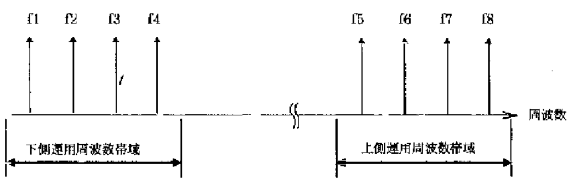

【図12】




【図9】




【図13】

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フロントページの続き


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## UP-LINK PACKET TRANSMISSION METHOD IN MULTI-CARRIER/DS- CDMA MOBILE COMMUNICATION SYSTEM

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**Applicant(s):** NTT DOCOMO INC +

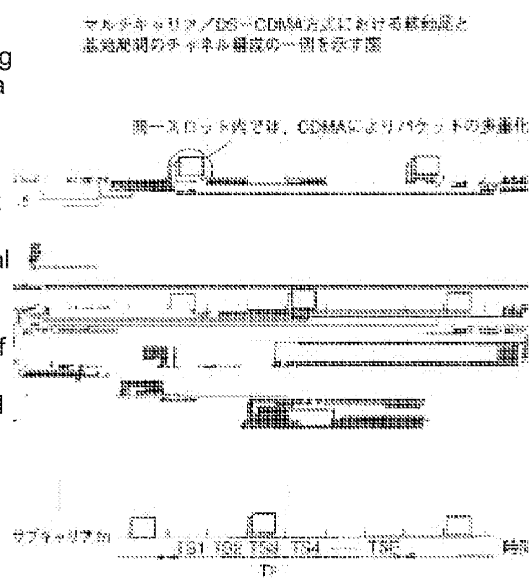
**Classification:**
- **international:** ***H04B7/26; H04J1/00; H04J13/04; H04J3/16; H04L12/56;*** (IPC1-7): H04B7/26; H04J1/00; H04J13/04; H04J3/16; H04L12/56
- **European:** H04W74/02

**Application number:** JP20000081051 20000322

**Priority number (s):** JP20000081051 20000322

### Abstract of JP2001268051 (A)

PROBLEM TO BE SOLVED: To provide an up-link packet transmission method in a novel multi- carrier DS-CDMA mobile communication system that can realize packet transmission at a variable transmission rate. SOLUTION: An operating frequency band is divided into n-sets (n is a natural number) of subcarrier f-fn, and the subcarriers f1-fn are furthermore used in time division. A frame (frame length is TF and in common to all the subcarriers) is set to each subcarrier. Moreover, the frame is temporally divided into F-sets (F is a natural number) of time slots TS1-TSF (one time slot length TS=TF/F). A mobile station transmits a packet in matching the timing of this time slot. The packet can be furthermore multiplexed by applying spread processing to the packet in the same time slot by different spread codes by the principle of code division (CDMA).





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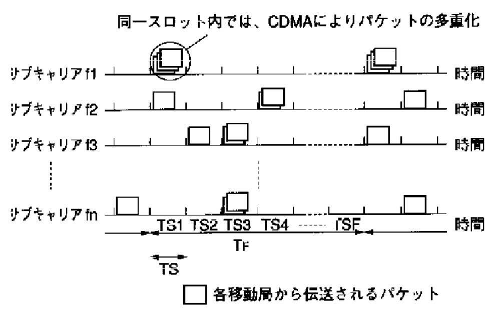
(54)【発明の名称】　マルチキャリア／ＤＳ－ＣＤＭＡ移動通信システムにおける上りリンクパケット伝送方法

(57)【要約】
【課題】　可変伝送速度のパケット伝送を実現することが可能な新規なマルチキャリア／ＤＳ－ＣＤＭＡ移動通信システムにおける上りリンクパケット伝送方法を提供することを目的とする。
【解決手段】　使用周波数帯をｎ個（ｎ：自然数）のサブキャリアｆ１～ｆｎに分割して、このサブキャリアｆ１～ｆｎを、更に、時分割で使用する。各サブキャリアにフレーム（フレーム長を$T_F$とする。全サブキャリアで共通とする。）を設定する。さらに、このフレームを、時間的にＦ個（Ｆ：自然数）のタイムスロットＴＳ１～ＴＳＦ（１タイムスロット長ＴＳ＝$T_F$／Ｆ）に分割する。移動局は、このタイムスロットのタイミングに合わせてパケットを伝送する。同一のタイムスロット内では、パケットを異なる拡散符号により拡散することで、符号分割（ＣＤＭＡ）の原理により、更に、多重化する。

マルチキャリア／DS－CDMA方式における移動局と基地局間のチャネル構成の一例を示す図



【特許請求の範囲】
【請求項１】　ｎ個（ｎは２以上の自然数）のサブキャリアを有するマルチキャリア／ＤＳ－ＣＤＭＡ移動通信システムにおける上りリンクパケット伝送方法において、
上記サブキャリアの通信チャネルそれぞれに、一定時間ごとの区切りであるフレームを設定し、さらに、前記フレームを時間的にＦ個（Ｆは、２以上の自然数）に分割したタイムスロットを設定し、
移動局は、伝送すべきパケットを、前記タイムスロットのタイミングに合わせて、拡散符号により拡散して、基地局に伝送することを特徴とする上りリンクパケット伝送方法。
【請求項２】　請求項１記載の上りリンクパケット伝送方法において、
前記移動局は、パケット伝送するに当たり、前記基地局に、タイムスロット及び拡散符号の割り当てを、予約要求パケットを伝送して要求し、
前記基地局は、要求した移動局にタイムスロット及び拡散符号を割り当て、
前記移動局は、前記基地局から割り当てられたタイムスロットにおいて、割り当てられた拡散符号によりパケットを拡散して伝送することを特徴とする上りリンクパケット伝送方法。
【請求項３】　請求項１記載の上りリンクパケット伝送方法において、
前記移動局は、タイムスロットの割り当てを前記基地局に要求することなく、前記通信チャネルのいずれかのタイムスロットにランダムアクセスしてパケット伝送することを特徴とする上りリンクパケット伝送方法。
【請求項４】　請求項１記載の上りリンクパケット伝送方法において、
前記移動局が伝送するパケットの伝送量の大きさに応じて、前記移動局の伝送速度を変更することを特徴とする上りリンクパケット伝送方法。
【請求項５】　請求項２記載の上りリンクパケット伝送方法において、
前記基地局は、前記予約要求パケット伝送用のタイムスロットとしてｋ１個（ｋ１は自然数、ｋ１≦Ｆ×ｎ）を割り当て、さらに、予約要求パケットの拡散用としてｍ１個（ｍ１は自然数、ｍ１≦使用できる拡散符号の総数）の拡散符号を割り当て、
前記移動局は、割り当てられたタイムスロットにおいて、割り当てられた拡散符号の１つで予約要求パケットを拡散して伝送することを特徴とする上りリンクパケット伝送方法。
【請求項６】　請求項５記載の上りリンクパケット伝送方法において、
前記基地局は、前記移動局からの所定期間における予約要求パケット数に応じて、
前記予約要求パケット伝送用のタイムスロットの個数ｋ１を変更することを特徴とする上りリンクパケット伝送方法。
【請求項７】　請求項５記載の上りリンクパケット伝送方法において、
前記基地局は、前記移動局からの所定期間における予約要求パケット数に応じて、
前記予約要求パケット伝送用の拡散符号の個数ｍ１を変更することを特徴とする上りリンクパケット伝送方法。
【請求項８】　請求項５記載の上りリンクパケット伝送方法において、
前記基地局は、前記移動局からの所定期間における予約要求パケット数に応じて、
前記予約要求パケット伝送用のタイムスロットの個数ｋ１及び前記予約要求パケット伝送用の拡散符号の個数ｍ１を変更することを特徴とする上りリンクパケット伝送方法。
【請求項９】　請求項５記載の上りリンクパケット伝送方法において、
前記基地局は、前記移動局からの所定期間における予約要求パケット数が多い場合、
前記移動局に予約要求パケットの伝送制限を通知し、
前記移動局は、その制限にしたがって予約要求パケットを伝送することを特徴とする上りリンクパケット伝送方法。
【請求項１０】　請求項３記載の上りリンクパケット伝送方法において、
前記基地局は、前記移動局がランダムアクセスしてパケット伝送可能なタイムスロットとしてｋ２個（ｋ２は自然数、ｋ２≦Ｆ×ｎ）を割り当て、さらに、ランダムアクセスパケットの拡散用としてｍ２個（ｍ２は自然数、ｍ２≦使用できる拡散符号の総数）の拡散符号を割り当て、
前記移動局は、割り当てられたタイムスロットにおいて、割り当てられた拡散符号の１つでランダムアクセスするパケットを拡散して伝送することを特徴とする上りリンクパケット伝送方法。
【請求項１１】　請求項１０記載の上りリンクパケット伝送方法において、
前記基地局は、前記移動局からの所定期間におけるランダムアクセスするパケット数に応じて、
前記ランダムアクセスパケット伝送用のタイムスロットの個数ｋ２を変更することを特徴とする上りリンクパケット伝送方法。
【請求項１２】　請求項１０記載の上りリンクパケット伝送方法において、
前記基地局は、前記移動局からの所定期間におけるランダムアクセスするパケット数に応じて、
前記ランダムアクセスパケット伝送用の拡散符号の個数ｍ２を変更することを特徴とする上りリンクパケット伝

送方法。

【請求項１３】　請求項１０記載の上りリンクパケット伝送方法において、

前記基地局は、前記移動局からの所定期間におけるランダムアクセスするパケット数に応じて、

前記ランダムアクセスパケット伝送用のタイムスロットの個数ｋ２及び前記ランダムアクセスパケット伝送用の拡散符号の個数ｍ２を変更することを特徴とする上りリンクパケット伝送方法。

【請求項１４】　請求項10記載の上りリンクパケット伝送方法において、

前記基地局は、前記移動局からの所定期間におけるランダムアクセスするパケット数が多い場合、

前記移動局にランダムアクセスパケットの伝送制限を通知し、

前記移動局は、その制限にしたがってランダムアクセスを行うことを特徴とする上りリンクパケット伝送方法。

【請求項１５】　請求項4記載の上りリンクパケット伝送方法において、

前記基地局は、前記移動局の伝送量の大きさに応じて、移動局にｐ個（ｐは自然数、ｐ≦使用できる拡散符号の総数）の拡散符号を割り当てることを特徴とする上りリンクパケット伝送方法。

【請求項１６】　請求項4記載の上りリンクパケット伝送方法において、

前記基地局は、前記移動局の伝送量の大きさに応じて、前記移動局に異なる拡散率の拡散符号を割り当てることを特徴とする上りリンクパケット伝送方法。

【請求項１７】　請求項4記載の上りリンクパケット伝送方法において、

前記基地局は、移動局の伝送量の大きさに応じて、

移動局にｑ個（ｑは自然数、ｑ≦Ｆ×ｎ）のタイムスロットを割り当てることを特徴とする上りリンクパケット伝送方法。

【請求項１８】　請求項4記載の上りリンクパケット伝送方法において、

前記基地局は、前記移動局の伝送量の大きさに応じて、拡散符号数ｐ（ｐは自然数、ｐ≦使用できる拡散符号の総数）、異なる拡散率の拡散符号、タイムスロット数ｑ（ｑは自然数、ｑ≦Ｆ×ｎ）の内、少なくとも２つを変更させて割り当てを行うことを特徴とする上りリンクパケット伝送方法。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、マルチキャリア／ＤＳ−ＣＤＭＡ移動通信システムにおける上りリンクパケット伝送方法に関する。

【０００２】

【従来の技術】マルチキャリア変調を用いた新しい符号分割多元接続（ＣＤＭＡ）方式が多数提案されている。マルチキャリア／ＤＳ−ＣＤＭＡ方式は、その中の１つであり、”Ｐｅｒｆｏｍａｎｃｅ ｏｆ ｏｒｔｈｏｇｏｎａｌ ＣＤＭＡ ｃｏｄｅｓ ｆｏｒ ｑｕａｓｉ−ｓｙｎｃｈｒｏｎｏｕｓ ｃｏｍｍｕｎｉｃａｔｉｏｎ ｓｙｓｔｅｍｓ”（Ｖ．ＤａＳｉｌｖａ，Ｅ．Ｓｏｕｓａ：Ｐｒｏｃ．ｏｆＩＣＵＰＣ’９３，ｖｏｌ．２，ｐｐ９９５−９９９，１９９３）において、最初の検討がなされている。

【０００３】マルチキャリア／ＤＳ−ＣＤＭＡは、１つのキャリアでＣＤＭＡ信号を伝送するシングルキャリア／ＤＳ−ＣＤＭＡとは異なり、無線伝送帯域を分割して複数のサブキャリアによりＣＤＭＡ信号の並列伝送を行うものである。

【０００４】これによりサブキャリア当たりの、情報伝送速度は小さくなり、それにともなって情報信号を拡散してＣＤＭＡ信号を生成する拡散信号の速度も小さくなる。その結果、シングルキャリア／ＤＳ−ＣＤＭＡに比較して、マルチキャリア／ＤＳ−ＣＤＭＡでは拡散信号のチップ長が長くすることができる。チップ長が長くなれば、拡散符号どうしの同期ずれの影響が緩和される。この特徴を利用して、上記論文では、マルチキャリア／ＤＳ−ＣＤＭＡを移動体通信システムの移動局から基地局への通信に適用し、準同期伝送を行う方法の提案を行っている。

【０００５】また、マルチキャリア／ＤＳ−ＣＤＭＡのリンクレベルでの性能評価が行われている。

【０００６】”Ｏｎ ｔｈｅ Ｐｅｒｆｏｍａｎｃｅ ｏｆ Ｍｕｌｔｉ−ｃａｒｒｉｅｒＤＳ ＣＤＭＡ Ｓｙｓｔｅｍｓ，”（Ｓ．Ｋｏｎｄｏ ａｎｄ Ｌ．Ｂ．Ｍｉｌｓｔｅｉｎ：ＩＥＥＥ Ｔｒａｎｓａｃｔｉｏｎｓ ｏｎ Ｃｏｍｍｕｎｉｃａｔｉｏｎｓ，ｖｏｌ．４４，ｎｏ．２，ｐｐ．２３８−２４６，Ｆｅｂｒｕａｒｙ １９９６）において、狭帯域干渉が存在する環境での性能評価では、マルチキャリア／ＤＳ−ＣＤＭＡは、シングルキャリア／ＤＳ−ＣＤＭＡよりも良好な特性となることが示されている。

【０００７】

【発明が解決しようとする課題】しかし、従来のマルチキャリア／ＤＳ−ＣＤＭＡ方式に関する検討ではリンクレベルでの性能評価が中心であり、この方式を移動体通信システムに適用した場合に、どのようにして移動局が基地局と通信のやり取りを行うか、そのための制御信号をどのように伝送するかといった検討がなされていない。

【０００８】さらに、これらの検討は、従来の移動体通信システムで通常用いられているような、送信機から受信機への信号伝送の際に、送信開始から終了まで常に専用の通信チャネルを確保する回線交換方式を基準にしたものである。

【０００９】ところで、伝送すべき信号の伝送量の大き

さが多様化すると、回線交換方式では伝送の効率が悪くなる。一方、パケット伝送は、伝送量の多様な信号を効率良く伝送することができるので、伝送すべき信号の伝送量の大きさが多様化した場合は、パケット伝送が有効となる。

【0010】そこで、本発明は、可変伝送速度のパケット伝送を実現することが可能な新規なマルチキャリア／DS−CDMA移動通信システムにおける上りリンクパケット伝送方法を提供することを目的とするものである。

【0011】

【課題を解決するための手段】上記課題を解決するために、本件発明は、以下の特徴を有する課題を解決するための手段を採用している。

【0012】請求項1に記載された発明は、n個（nは2以上の自然数）のサブキャリアを有するマルチキャリア／DS−CDMA移動通信システムにおける上りリンクパケット伝送方法において、上記n個サブキャリアの通信チャネルそれぞれに、一定時間ごとの区切りであるフレームを設定し、さらに、前記フレームを時間的にF個（Fは、2以上の自然数）に分割したタイムスロットを設定し、移動局は、伝送すべきパケットを、前記タイムスロットのタイミングに合わせて、拡散符号により拡散して、基地局に伝送することを特徴とする。

【0013】請求項2に記載された発明は、請求項1記載の上りリンクパケット伝送方法において、前記移動局は、パケット伝送するに当たり、前記基地局に、タイムスロット及び拡散符号の割り当てを、予約要求パケットを伝送して要求し、前記基地局は、要求した移動局にタイムスロット及び拡散符号を割り当て、前記移動局は、前記基地局から割り当てられたタイムスロットにおいて、割り当てられた拡散符号によりパケットを拡散して伝送することを特徴とする。

【0014】請求項3に記載された発明は、請求項1記載の上りリンクパケット伝送方法において、前記移動局は、タイムスロットの割り当てを前記基地局に要求することなく、前記通信チャネルのいずれかのタイムスロットにランダムアクセスしてパケット伝送することを特徴とする。

【0015】請求項4に記載された発明は、請求項1記載の上りリンクパケット伝送方法において、前記移動局が伝送するパケットの伝送量の大きさに応じて、前記移動局の伝送速度を変更することを特徴とする。

【0016】請求項5に記載された発明は、請求項2記載の上りリンクパケット伝送方法において、前記基地局は、前記予約要求パケット伝送用のタイムスロットとしてｋ１個（ｋ１は自然数、ｋ１≦Ｆ×ｎ）を割り当て、さらに、予約要求パケットの拡散用としてｍ１個（ｍ１は自然数、ｍ１≦使用できる拡散符号の総数）の拡散符号を割り当て、前記移動局は、割り当てられたタイムスロットにおいて、割り当てられた拡散符号の１つで予約要求パケットを拡散して伝送することを特徴とする。

【0017】請求項6に記載された発明は、請求項5記載の上りリンクパケット伝送方法において、前記基地局は、前記移動局からの所定期間における予約要求パケット数に応じて、前記予約要求パケット伝送用のタイムスロットの個数ｋ１を変更することを特徴とする。

【0018】請求項7に記載された発明は、請求項5記載の上りリンクパケット伝送方法において、前記基地局は、前記移動局からの所定期間における予約要求パケット数に応じて、前記予約要求パケット伝送用の拡散符号の個数ｍ１を変更することを特徴とする。

【0019】請求項8に記載された発明は、請求項5記載の上りリンクパケット伝送方法において、前記基地局は、前記移動局からの所定期間における予約要求パケット数に応じて、前記予約要求パケット伝送用のタイムスロットの個数ｋ１及び前記予約要求パケット伝送用の拡散符号の個数ｍ１を変更することを特徴とする。

【0020】請求項9に記載された発明は、請求項5記載の上りリンクパケット伝送方法において、前記基地局は、前記移動局からの所定期間における予約要求パケット数が多い場合、前記移動局に予約要求パケットの伝送制限を通知し、前記移動局は、その制限にしたがって予約要求パケットを伝送することを特徴とする。

【0021】請求項１０に記載された発明は、請求項3記載の上りリンクパケット伝送方法において、前記基地局は、前記移動局がランダムアクセスしてパケット伝送可能なタイムスロットとしてｋ２個（ｋ２は自然数、ｋ２≦Ｆ×ｎ）を割り当て、さらに、ランダムアクセスパケットの拡散用としてｍ２個（ｍ２は自然数、ｍ２≦使用できる拡散符号の総数）の拡散符号を割り当て、前記移動局は、割り当てられたタイムスロットにおいて、割り当てられた拡散符号の１つでランダムアクセスするパケットを拡散して伝送することを特徴とする。

【0022】請求項１１に記載された発明は、請求項１０記載の上りリンクパケット伝送方法において、前記基地局は、前記移動局からの所定期間におけるランダムアクセスするパケット数に応じて、前記ランダムアクセスパケット伝送用のタイムスロットの個数ｋ２を変更することを特徴とする。

【0023】請求項１２に記載された発明は、請求項１０記載の上りリンクパケット伝送方法において、前記基地局は、前記移動局からの所定期間におけるランダムアクセスするパケット数に応じて、前記ランダムアクセスパケット伝送用の拡散符号の個数ｍ２を変更することを特徴とする。

【0024】請求項１３に記載された発明は、請求項１０記載の上りリンクパケット伝送方法において、前記基地局は、前記移動局からの所定期間におけるランダムアクセスするパケット数に応じて、前記ランダムアクセス

パケット伝送用のタイムスロットの個数ｋ２及び前記ランダムアクセスパケット伝送用の拡散符号の個数ｍ２を変更することを特徴とする。

【００２５】請求項１４に記載された発明は、請求項10記載の上りリンクパケット伝送方法において、前記基地局は、前記移動局からの所定期間におけるランダムアクセスするパケット数が多い場合、前記移動局にランダムアクセスパケットの伝送制限を通知し、前記移動局は、その制限にしたがってランダムアクセスを行うことを特徴とする。

【００２６】請求項１５に記載された発明は、請求項４記載の上りリンクパケット伝送方法において、前記基地局は、前記移動局の伝送量の大きさに応じて、移動局にｐ個（ｐは自然数、ｐ≦使用できる拡散符号の総数）の拡散符号を割り当てることを特徴とする。

【００２７】請求項１６に記載された発明は、請求項４記載の上りリンクパケット伝送方法において、前記基地局は、前記移動局の伝送量の大きさに応じて、前記移動局に異なる拡散率の拡散符号を割り当てることを特徴とする。

【００２８】請求項１７に記載された発明は、請求項４記載の上りリンクパケット伝送方法において、前記基地局は、移動局の伝送量の大きさに応じて、移動局にｑ個（ｑは自然数、ｑ≦Ｆ×ｎ）のタイムスロットを割り当てることを特徴とする。

【００２９】請求項１８に記載された発明は、請求項４記載の上りリンクパケット伝送方法において、前記基地局は、前記移動局の伝送量の大きさに応じて、拡散符号数ｐ（ｐは自然数、ｐ≦使用できる拡散符号の総数）、異なる拡散率の拡散符号、タイムスロット数ｑ（ｑは自然数、ｑ≦Ｆ×ｎ）の内、少なくとも２つを変更させて割り当てを行うことを特徴とする。

【００３０】

【発明の実施の形態】次に、本発明の実施の形態について図面と共に説明する。

（チャネル構成）図1は、マルチキャリア／ＤＳ−ＣＤＭＡ方式における移動局と基地局間のチャネル構成の一例を示す図である。

【００３１】使用周波数帯をｎ個（ｎは2以上の自然数）のサブキャリアｆ１〜ｆｎに分割する。また、このサブキャリアｆ１〜ｆｎを時分割で使用する。そのため、各サブキャリアにフレーム（一定時間ごとの区切りであり、フレーム長を$T_F$とする。このフレームは、全サブキャリアで共通とする。）を設定する。さらに、このフレームを、時間的にＦ個（Ｆは、2以上の自然数）のタイムスロットＴＳ１〜ＴＳＦ（１タイムスロット長ＴＳ＝$T_F$／Ｆ）に分割する。

【００３２】したがって、全サブキャリアでは、１フレーム内にＦ×ｎ個のタイムスロットが存在する。

【００３３】移動局は、このタイムスロットのタイミングに合わせてパケットを伝送する。また、同一のタイムスロット内では、パケットを異なる拡散符号により拡散することで、符号分割（ＣＤＭＡ）の原理により多重化する。

【００３４】従って、図1のチャネル構成では、Ｆ×ｎ×（拡散符号多重数）の複数パケットの同時伝送が可能となる。

【００３５】図1の例では、サブキャリアｆ１のタイムスロットＴＳ１において、ＣＤＭＡにより３つのパケットが多重化されている。

（タイムスロット及び拡散符号を予約してパケット伝送する方法）図2は、移動局から基地局にパケット伝送する際に、移動局と基地局の間で行われる制御のやり取りの一例を示す図である。

【００３６】移動局は、まず、予約要求パケットを基地局に伝送して、パケットを伝送するためのタイムスロット及び拡散符号の割り当てを要求する（Ｓ１０１）。基地局は、移動局からの割り当て要求に対して、通信チャネル上のタイムスロット及び拡散符号の割り当てを行い（Ｓ１０２）、その結果を移動局に通知する（Ｓ１０３）。

【００３７】移動局は、基地局から割り当てられたタイムスロットで、かつ、割り当てられた拡散符号によりパケットを拡散して伝送する（Ｓ１０４）。

【００３８】これにより、タイムスロット及び拡散符号を割り当てられた移動局のみが、割り当てられたタイムスロットにおいて、割り当てられた拡散符号を用いてパケットを拡散して伝送を行うことができる。

【００３９】多くのタイムスロット又は多くの拡散符号を割り当てれば、同時に多くのパケットを伝送することができるので、伝送量が大きくなる。

【００４０】また、一つのタイムスロット又は一つの拡散符号を割り当てた場合でも、移動局が割り当てられたタイムスロット及び割り当てられた拡散符号を優先して使用し、移動局が、伝送する情報がなくなるまで、周期的にかつ確実に伝送ができれば、結果として、伝送量の大きなパケットが伝送できることとなる。

（予約無しのランダムアクセス）図3は、移動局から基地局にパケット伝送する際に、移動局と基地局で行われる制御のやり取りの一例を示す図である。

【００４１】移動局は、通信チャネル上のいずれかのタイムスロットにランダムアクセスしてパケットを伝送する（Ｓ１１１）。

【００４２】ここで、パケットの伝送に成功すれば、パケットの伝送は終了となる（Ｓ１１２：ＹＥＳ）。失敗した場合には（Ｓ１１２：ＮＯ）、移動局は再び、通信チャネル上のいずれかのタイムスロットにランダムアクセスしてパケットを伝送する（Ｓ１１１）。

【００４３】このように、移動局が、タイムスロットの割り当てを前記基地局に要求することなく、通信チャネ

ルのいずれかのタイムスロットにランダムアクセスしてパケット伝送する方法は、移動局から基地局に伝送量の少ない信号をパケット伝送する場合に適する。

（伝送量に応じたタイムスロットと拡散符号の割り当て）図4は、移動局が伝送すべきパケットの伝送量の大きさに応じて伝送速度を変更するための、移動局と基地局で行われる制御のやり取りの一例を示す図である。

【００４４】移動局は、まず、予約要求パケットを基地局に伝送して、タイムスロット及び拡散符号の割り当てを要求するとともに、伝送量の大きさも伝える（Ｓ１２０）。

【００４５】基地局は、移動局からの割り当て要求及び伝送量の情報に基づいて、通信チャネル上に移動局の伝送量に応じたタイムスロットや拡散符号の割り当てを行い、その結果を移動局に通知する（Ｓ１２１）。

【００４６】移動局は、この通知結果に基づいてパケット伝送を行う（Ｓ１２２）。

【００４７】これにより、移動局が伝送するパケットの伝送量が大きければ、基地局は、大きな伝送量が伝送可能なタイムスロット（例えば、複数のタイムスロット）及び拡散符号（例えば、複数の拡散符号、拡散率の小さい拡散符号）の割当を行い、移動局が必要とする伝送量が小さければ、基地局は、それに見合ったタイムスロット及び拡散符号の割当を行う。

【００４８】これにより、基地局は、移動局の伝送量に応じて、タイムスロットと拡散符号を適応的に割り当てる。

【００４９】一方、移動局は、伝送する伝送量に応じた伝送速度を得ることができる。

（予約要求パケット伝送用のタイムスロットと拡散符号の割り当て）次に、移動局が基地局に、予約要求パケットを伝送する場合に、基地局がどのように予約要求パケット伝送用のタイムスロットと拡散符号の割り当てを行うかを説明する。移動局から基地局には、図１に示したように、Ｆ×ｎ×（拡散符号多重数）の複数パケットの同時伝送が可能となる。

【００５０】本発明では、このＦ×ｎ×（拡散符号多重数）中の幾つかを、予約要求パケット伝送に用いる。

【００５１】図5は、一フレーム内に存在するＦ×ｎのタイムスロットの中から、基地局が予約要求パケット伝送タイムスロットとして任意のｋ１個（ｋ１：自然数、ｋ１≦Ｆ×ｎ）を割り当てる。そして、移動局は、この予約要求パケット伝送タイムスロットにおいて、基地局によって、あらかじめ決められたｍ１個（ｍ１：自然数、ｍ１≦使用できる拡散符号の総数）の拡散符号の１つで予約要求パケットを拡散して伝送する。

【００５２】図5では、サブキャリアｆ１のタイムスロットＴＳ１、サブキャリアｆ２のタイムスロットＴＳ１、サブキャリアｆ３のタイムスロットＴＳ２等が、予約要求パケット伝送タイムスロットとして割り当てられている。

【００５３】図6の場合は、全サブキャリアにおいて、毎フレームごとに発生するタイムスロットＴＳ１のタイムスロットを予約要求パケット伝送タイムスロットとして設定した場合（ｋ１＝ｎ）のチャネル構成の一例を示している。

【００５４】図6は、ｆ１～ｆｎの全てのサブキャリアにおいて、タイムスロットＴＳ１のタイムスロットを予約要求パケット伝送タイムスロットとして設定した場合である。

【００５５】図7の場合は、全サブキャリアにおいて、タイムスロットＴＳ１の一部を予約要求パケット伝送タイムスロットとして設定した場合（ｋ１＜ｎ）のチャネル構成の一例を示している。ｋ１個のタイムスロットの選び方は、サブキャリアを連続的に割り当てても、離散的に割り当ててもよい。

【００５６】図7では、サブキャリアｆ３のタイムスロットＴＳ１は、予約要求パケット伝送タイムスロットとして、割り当てられていない。

【００５７】図8の場合は、一つのサブキャリアの全タイムスロットを予約要求パケット伝送タイムスロットとして設定した場合（ｋ１＝Ｆ）のチャネル構成の一例を示している。なお、予約要求パケット伝送タイムスロットを設定するサブキャリアは、2以上であってもよい。

【００５８】図8では、サブキャリアｆ１の全タイムスロットが、予約要求パケット伝送タイムスロットとして、割り当てられている。

【００５９】図9の場合は、一つのサブキャリアの一部のタイムスロットを予約要求パケット伝送タイムスロットとして設定した場合（ｋ１＜Ｆ）のチャネル構成の一例を示している。ｋ１個のタイムスロットの選び方は、タイムスロットを連続的に割り当てても、離散的に割り当ててもよい。

【００６０】図9では、サブキャリアｆ１のＴＳ１、ＴＳ２、ＴＳ４等のタイムスロットが、予約要求パケット伝送タイムスロットとして、割り当てられている。

（予約要求パケット伝送用のタイムスロット数及び拡散符号数等の変更）移動局からの所定期間における予約要求パケット数が多いと、予約要求に応じられないことがある。そこで、予約要求パケット数に応じて、予約要求パケット伝送用のタイムスロット数及び拡散符号数等を変更する。

【００６１】図１０の場合は、移動局からの所定期間における予約要求パケット数に応じて、基地局が予約要求パケット伝送タイムスロットの個数ｋ１（ｋ１：自然数、ｋ１≦Ｆ×ｎ）を変更する際の、基地局で行われる制御の一例を示した図である。

【００６２】基地局は、移動局から伝送された予約要求パケット数を、一定時間測定する（Ｓ１３０）。

【００６３】測定した結果、予約要求パケット数がある

しきい値以上の場合（Ｓ１３１：ＹＥＳ）は、予約要求パケット伝送スロット数を増加させ、そのタイムスロットの位置を移動局に通知する（Ｓ１３３）。

【００６４】また、測定した結果、予約要求パケット数があるしきい値以下の場合（Ｓ１３２：ＹＥＳ）は、予約要求パケット伝送スロット数を減少させ、そのタイムスロットの位置を移動局に通知する（Ｓ１３４）。

【００６５】予約要求パケット数があるしきい値以上でなく（Ｓ１３１：ＮＯ）、かつ、予約要求パケット数があるしきい値以下でない（Ｓ１３２：ＮＯ）場合は、予約要求パケット伝送スロット数は変更しない。

【００６６】移動局は、基地局から通知された予約要求パケット伝送タイムスロットの位置にしたがって、予約要求パケットを伝送する。

【００６７】図１１は、移動局からの所定期間における予約要求パケット数に応じて、基地局が予約要求パケット伝送用の拡散符号の個数ｍ１（ｍ１：自然数、ｍ１≦使用できる拡散符号の総数）を変更する際の、基地局で行われる制御の一例を示した図である。

【００６８】基地局は、移動局から伝送された予約要求パケット数を、一定時間測定する（Ｓ１４０）。

【００６９】測定した結果、予約要求パケット数があるしきい値以上の場合（Ｓ１４１：ＹＥＳ）は、予約要求パケットを拡散する拡散符号数ｍ１を増加させ、その種類を移動局に通知する（Ｓ１４３）。

【００７０】また、測定した結果、予約要求パケット数があるしきい値以下の場合（Ｓ１４２：ＹＥＳ）は、予約要求パケットを拡散する拡散符号数ｍ１を減少させ、その種類を移動局に通知する（Ｓ１４４）。

【００７１】予約要求パケット数があるしきい値以上でなく（Ｓ１４１：ＮＯ）、かつ、予約要求パケット数があるしきい値以下でない（Ｓ１４２：ＮＯ）場合は、予約要求パケットを拡散する拡散符号数は変更しない。

【００７２】移動局は、基地局から通知された予約要求パケット伝送用の拡散符号の中から１つを選択して、予約要求パケットを拡散して伝送する。

【００７３】図１２は、移動局からの所定期間における予約要求パケット数に応じて、基地局が前記予約要求パケット伝送タイムスロットの個数ｋ１（ｋ１：自然数、ｋ１≦Ｆ×ｎ）及び予約要求パケット伝送用の拡散符号の個数ｍ１（ｍ１：自然数、ｍ１≦使用できる拡散符号の総数）を変更する際の基地局で行われる制御の一例を示した図である。

【００７４】基地局は、移動局から伝送された予約要求パケット数を、一定時間測定する（Ｓ１５０）。

【００７５】測定した結果、予約要求パケット数があるしきい値以上の場合（Ｓ１５１：ＹＥＳ）は、「予約要求パケットを拡散する拡散符号数ｍ１を増加」あるいは「予約要求パケット伝送スロット数ｋ１を増加」あるいは「その双方を増加」させ、その情報を移動局に通知する（Ｓ１５３）。

【００７６】また、測定した結果、予約要求パケット数があるしきい値以下の場合（Ｓ１５２：ＹＥＳ）は、「予約要求パケットを拡散する拡散符号数ｍ１を減少」あるいは「予約要求パケット伝送スロット数ｋ１を減少」あるいは「その双方を減少」させ、その情報を移動局に通知する（Ｓ１５４）

予約要求パケット数があるしきい値以上でなく（Ｓ１５１：ＮＯ）、かつ、予約要求パケット数があるしきい値以下でない（Ｓ１５２：ＮＯ）場合は、「予約要求パケットを拡散する拡散符号数」及び「予約要求パケット伝送スロット数」は変更しない。

【００７７】移動局は、基地局から通知された予約要求パケット伝送タイムスロットの位置、及び予約要求パケット伝送用の拡散符号の中から１つを選択して、予約要求パケットを拡散して伝送する。

【００７８】図１３は、予約要求パケット数が多くなると、予約要求パケットの伝送が、的確に伝送されない恐れがあることから、基地局が移動局に予約要求パケットの伝送を制限（例えば、予約要求パケットの伝送を時間的に制限する。）し、移動局がその制限にしたがって予約要求パケットを伝送する場合の基地局で行われる制御の一例を示した図である。

【００７９】基地局は、移動局から伝送された予約要求パケット数を、一定時間測定する（Ｓ１６０）。

【００８０】測定した結果、予約要求パケット数があるしきい値以上の場合（Ｓ１６１：ＹＥＳ）は、予約要求パケットの伝送制限を現状よりも厳しくし、移動局に通知する（Ｓ１６３）。

【００８１】また、測定した結果、予約要求パケット数があるしきい値以下の場合（Ｓ１６２：ＹＥＳ）には、予約要求パケットの伝送制限を現状よりも緩やかにし、移動局に通知する（Ｓ１６４）。

【００８２】予約要求パケット数があるしきい値以上でなく（Ｓ１６１：ＮＯ）、かつ、予約要求パケット数があるしきい値以下でない（Ｓ１６２：ＮＯ）場合は、伝送制限の変更を行わない。

（ランダムアクセス用のタイムスロット数及び拡散符号数等の割り当て）基地局は、移動局がランダムアクセスしてパケット伝送可能なタイムスロットとしてｋ２個（ｋ２：自然数、k2≦Ｆ×ｎ）を割り当て、さらに、ランダムアクセスパケットの拡散用としてｍ２個（ｍ２：自然数、ｍ２≦使用できる拡散符号の総数）の拡散符号を割り当てる。

【００８３】移動局は、割り当てられたタイムスロットにおいて、割り当てられた拡散符号の１つでランダムアクセスするパケットを拡散して伝送する。

【００８４】図１４に示されるように、一フレーム内に存在するＦ×ｎ個のタイムスロットの中から、基地局がランダムアクセスパケット伝送タイムスロットとして任

意のｋ２個（ｋ２：自然数、ｋ２≦Ｆ×ｎ）を割り当てる。そして、移動局はこのランダムアクセスパケット伝送タイムスロットにおいて、基地局によってあらかじめ決められたｍ２個（ｍ２：自然数、ｍ２≦使用できる拡散符号の総数）の拡散符号の１つでランダムアクセスパケットを拡散して伝送する。

【００８５】図１４では、サブキャリアｆ１のタイムスロットＴＳ１、サブキャリアｆ２のタイムスロットＴＳ１、サブキャリアｆ３のタイムスロットＴＳ２等が、ランダムアクセスパケット伝送タイムスロットとして割り当てられている。

【００８６】図１５は、全サブキャリアにおいて、毎フレームごとに発生するタイムスロットＴＳ１のタイムスロットをランダムアクセスパケット伝送タイムスロットとして設定した場合（ｋ２＝ｎ）のチャネル構成の一例を示している。

【００８７】図１５では、全サブキャリアのタイムスロットＴＳ１が、ランダムアクセスパケット伝送タイムスロットとして、割り当てられている。

【００８８】図１６は、一部のサブキャリアにおいて、毎フレームごとに発生するタイムスロットＴＳ１のタイムスロットをランダムアクセスパケット伝送タイムスロットとして設定した場合（ｋ２＜ｎ）のチャネル構成の一例を示している。ｋ２個のタイムスロットの選び方は、サブキャリアを連続的に割り当てても、離散的に割り当ててもよい。

【００８９】図１６では、サブキャリアｆ３のタイムスロットＴＳ１は、ランダムアクセスパケット伝送タイムスロットとして、割り当てられていない。

【００９０】図１７は、一つのサブキャリアの全タイムスロットをランダムアクセスパケット伝送タイムスロットとして設定した場合（ｋ２＝Ｆ）のチャネル構成の一例を示している。

【００９１】図１７では、サブキャリアｆ１の全タイムスロットが、ランダムアクセスパケット伝送タイムスロットとして、割り当てられている。

【００９２】図１８は、一つのサブキャリアの一部のタイムスロットをランダムアクセスパケット伝送タイムスロットとして設定した場合（ｋ２＜Ｆ）のチャネル構成の一例を示している。

【００９３】図１８では、サブキャリアｆ１のタイムスロットＴＳ１、タイムスロットＴＳ２、タイムスロットＴＳ４等が、ランダムアクセスパケット伝送タイムスロットとして、割り当てられている。

【００９４】ｋ２個のタイムスロットの選び方は、タイムスロットを連続的に割り当てても、離散的に割り当ててもよい。

（ランダムアクセスパケット伝送タイムスロット数及び拡散符号数等の変更）移動局からの所定期間内におけるランダムアクセスパケット数が多いと、通信できないことが生じる。そこで、所定期間内におけるランダムアクセスパケット数に応じて、ランダムアクセスパケット伝送タイムスロット数及び拡散符号数等を変更する。

【００９５】図１９の場合は、移動局からの所定期間におけるランダムアクセスパケット数に応じて、基地局がランダムアクセスパケット伝送タイムスロットの個数ｋ２（ｋ２：自然数、ｋ２≦Ｆ×ｎ）を変更する際の、基地局で行われる制御の一例を示した図である。

【００９６】基地局は、移動局から伝送されたランダムアクセスパケット数を、一定時間測定する（Ｓ２３０）。

【００９７】測定した結果、ランダムアクセスパケット数があるしきい値以上の場合（Ｓ２３１：ＹＥＳ）は、ランダムアクセスパケット伝送スロット数を増加させ、そのタイムスロットの位置を移動局に通知する（Ｓ２３３）。

【００９８】また、測定した結果、ランダムアクセスパケット数があるしきい値以下の場合（Ｓ２３２：ＹＥＳ）は、ランダムアクセスパケット伝送スロット数を減少させ、そのタイムスロットの位置を移動局に通知する（Ｓ２３４）。

【００９９】ランダムアクセスパケット数があるしきい値以上でなく（Ｓ２３１：ＮＯ）、かつ、ランダムアクセスパケット数があるしきい値以下でない（Ｓ２３２：ＮＯ）場合は、ランダムアクセスパケット伝送スロット数は変更しない。

【０１００】移動局は、基地局から通知されたランダムアクセスパケット伝送タイムスロットの位置にしたがって、ランダムアクセスパケットを伝送する。

【０１０１】図２０は、移動局からの所定期間におけるランダムアクセスパケット数に応じて、基地局がランダムアクセスパケット伝送用の拡散符号の個数ｍ２（ｍ２：自然数、ｍ２≦使用できる拡散符号の総数）を変更する際の、基地局で行われる制御の一例を示した図である。

【０１０２】基地局は、移動局から伝送されたランダムアクセスパケット数を、一定時間測定する（Ｓ２４０）。

【０１０３】測定した結果、ランダムアクセスパケット数があるしきい値以上の場合（Ｓ２４１：ＹＥＳ）は、ランダムアクセスパケットを拡散する拡散符号数ｍ２を増加させ、その種類を移動局に通知する（Ｓ２４３）。

【０１０４】また、測定した結果、ランダムアクセスパケット数があるしきい値以下の場合（Ｓ２４２：ＹＥＳ）は、ランダムアクセスパケットを拡散する拡散符号数ｍ２を減少させ、その種類を移動局に通知する（Ｓ２４４）。

【０１０５】ランダムアクセスパケット数があるしきい値以上でなく（Ｓ２４１：ＮＯ）、かつ、ランダムアクセスパケット数があるしきい値以下でない（Ｓ２４２：

ＮＯ）場合は、ランダムアクセスパケットを拡散する拡散符号数は変更しない。

【０１０６】移動局は、基地局から通知されたランダムアクセスパケット伝送用の拡散符号の中から１つを選択して、ランダムアクセスパケットを拡散して伝送する。

【０１０７】図２１は、移動局からの所定期間におけるランダムアクセスパケット数に応じて、基地局が前記ランダムアクセスパケット伝送タイムスロットの個数ｋ２（ｋ２：自然数、ｋ２≦Ｆ×ｎ）及びランダムアクセスパケット伝送用の拡散符号の個数ｍ２（ｍ２：自然数、ｍ２≦使用できる拡散符号の総数）を変更する際の基地局で行われる制御の一例を示した図である。

【０１０８】基地局は、移動局から伝送されたランダムアクセスパケット数を、一定時間測定する（Ｓ２５０）。

【０１０９】測定した結果、ランダムアクセスパケット数があるしきい値以上の場合（Ｓ２５１：ＹＥＳ）は、「ランダムアクセスパケットを拡散する拡散符号数ｍ２を増加」あるいは「ランダムアクセスパケット伝送スロット数ｋ２を増加」あるいは「その双方を増加」させ、その情報を移動局に通知する（Ｓ２５３）。

【０１１０】また、測定した結果、ランダムアクセスパケット数があるしきい値以下の場合（Ｓ２５２：ＹＥＳ）は、「ランダムアクセスパケットを拡散する拡散符号数ｍ２を減少」あるいは「ランダムアクセスパケット伝送スロット数ｋ２を減少」あるいは「その双方を減少」させ、その情報を移動局に通知する（Ｓ２５４）ランダムアクセスパケット数があるしきい値以上でなく（Ｓ２５１：ＮＯ）、かつ、ランダムアクセスパケット数があるしきい値以下でない（Ｓ２５２：ＮＯ）場合は、「ランダムアクセスパケットを拡散する拡散符号数」及び「ランダムアクセスパケット伝送スロット数」は変更しない。

【０１１１】移動局は、基地局から通知されたランダムアクセスパケット伝送タイムスロットの位置、及びランダムアクセスパケット伝送用の拡散符号の中から１つを選択して、ランダムアクセスパケットを拡散して伝送する。

【０１１２】図２２は、ランダムアクセスパケット数が多くなると、ランダムアクセスパケットの伝送が、的確に伝送されない恐れがあることから、基地局が移動局にランダムアクセスパケットの伝送を制限（例えば、伝送を時間的に制限する。）し、移動局がその制限にしたがってランダムアクセスパケットを伝送する場合の基地局で行われる制御の一例を示した図である。

【０１１３】基地局は、移動局から伝送されたランダムアクセスパケット数を、一定時間測定する（Ｓ２６０）。

【０１１４】測定した結果、ランダムアクセスパケット数があるしきい値以上の場合（Ｓ２６１：ＹＥＳ）は、ランダムアクセスパケットの伝送制限を現状よりも厳しくし、移動局に通知する（Ｓ２６３）。

【０１１５】また、測定した結果、ランダムアクセスパケット数があるしきい値以下の場合（Ｓ２６２：ＹＥＳ）には、ランダムアクセスパケットの伝送制限を現状よりも緩やかにし、移動局に通知する（Ｓ２６４）。

【０１１６】ランダムアクセスパケット数があるしきい値以上でなく（Ｓ２６１：ＮＯ）、かつ、ランダムアクセスパケット数があるしきい値以下でない（Ｓ２６２：ＮＯ）場合は、伝送制限の変更を行わない。

（伝送量に応じた伝送速度の変更）本発明では、移動局が伝送するパケットの伝送量の大きさに応じて、移動局の伝送速度を変更する。以下に、伝送量に応じた伝送速度の変更の態様を示す。

【０１１７】図２３では一例として、移動局２の伝送速度に対して、移動局１がｐ個の拡散符号を用いてパケットを多重化して伝送することによりｐ倍の伝送速度を実現する様子を示している。

【０１１８】図２４は、通信チャネルの一つのタイムスロットＴＳ内で、移動局の伝送量の大きさに応じて、基地局が移動局に異なる拡散率の拡散符号を割り当てることにより、可変伝送速度を実現する一例を示した図である。

【０１１９】図２４では、移動局２のパケットに用いられる拡散符号に対して、拡散率が１／ＳＦ倍の拡散符号により移動局１のパケットを拡散し、移動局１の伝送速度を移動局２に比較してＳＦ倍（チップレートは一定）にする様子を示している。

【０１２０】図２５は、通信チャネルの一フレーム内で、移動局の伝送量の大きさに応じて、基地局が移動局に任意のｑ個（ｑ：自然数、ｑ≦Ｆ×ｎ）のタイムスロットを割り当てることにより、可変伝送速度を実現する一例を示した図である。

【０１２１】図２６、図２７、図２８、図２９は、移動局の伝送量の大きさに応じて、基地局は、拡散符号数ｐ、異なる拡散率の拡散符号、タイムスロット数ｑの内、少なくとも２つを変更して割り当てる実施の形態を説明するための図である。

【０１２２】図２６では、図２４に対して、さらに、移動局１に移動局２の拡散符号の拡散率に対して１／ＳＦ倍の拡散率を持つｐ個の拡散符号を割り当てることにより、移動局１の伝送速度を移動局２に対してｐ×ＳＦ倍に設定している。

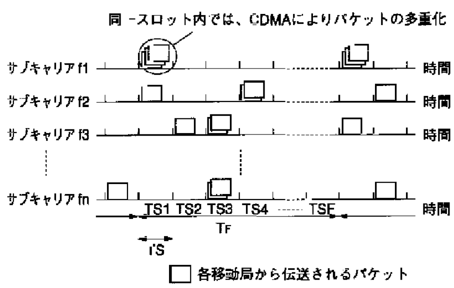
【０１２３】図２７では、図２５に対して、さらに、移動局１の各タイムスロットにｐ個の拡散符号を割り当てることにより、移動局１の伝送速度を移動局２に対してｐ×ｑ倍に設定している。

【０１２４】図２８では、一例として、移動局１に移動局２の拡散符号の拡散率に対して１／ＳＦ倍の拡散率を持つ拡散符号を割り当て、さらにｑ倍のタイムスロット

を割り当てることにより、移動局１の伝送速度を移動局２に対してq×ＳＦ倍に設定している。
【０１２５】図２９では、一例として、移動局１に移動局２のｑ倍のタイムスロットを割り当て、さらに、移動局１の各タイムスロットに移動局２の拡散符号の拡散率に対して１／ＳＦ倍の拡散率を持つｐ個の拡散符号を割り当てることにより、移動局１の伝送速度を移動局２に対してｐ×ｑ×ＳＦ倍に設定している
【発明の効果】本発明のマルチキャリア／ＤＳ−ＣＤＭＡでのパケット伝送方式を用いれば、タイムスロット予約型のパケット伝送、ランダムアクセス型のパケット伝送、可変伝送速度のパケット伝送を実現することが可能となり、多様な伝送量の信号を効率良く伝送することが実現できる。
【図面の簡単な説明】
【図１】マルチキャリア／ＤＳ−ＣＤＭＡ方式における移動局と基地局間のチャネル構成の一例を示す図である。
【図２】移動局から基地局にパケット伝送する際に、移動局と基地局の間で行われる制御のやり取りの一例を示す図（その１）である。
【図３】移動局から基地局にパケット伝送する際に、移動局と基地局の間で行われる制御のやり取りの一例を示す図（その２）である。
【図４】移動局から基地局にパケット伝送する際に、移動局と基地局の間で行われる制御のやり取りの一例を示す図（その３）である。
【図５】予約要求パケット伝送スロットの割り当てを説明するための図（その１）である。
【図６】予約要求パケット伝送スロットの割り当てを説明するための図（その２）である。
【図７】予約要求パケット伝送スロットの割り当てを説明するための図（その３）である。
【図８】予約要求パケット伝送スロットの割り当てを説明するための図（その４）である。
【図９】予約要求パケット伝送スロットの割り当てを説明するための図（その５）である。
【図１０】予約要求パケット伝送用のタイムスロット数の変更を説明するための図である。
【図１１】予約要求パケット伝送用の拡散符号数の変更を説明するための図である。
【図１２】予約要求パケット伝送用のタイムスロット数及び拡散符号数の変更を説明するための図である。
【図１３】予約要求パケットの伝送制限を説明するための図である。
【図１４】ランダムアクセスパケット伝送スロットの割り当てを説明するための図（その１）である。
【図１５】ランダムアクセスパケット伝送スロットの割り当てを説明するための図（その２）である。
【図１６】ランダムアクセスパケット伝送スロットの割り当てを説明するための図（その３）である。
【図１７】ランダムアクセスパケット伝送スロットの割り当てを説明するための図（その４）である。
【図１８】ランダムアクセスパケット伝送スロットの割り当てを説明するための図（その５）である。
【図１９】ランダムアクセスパケット伝送用のタイムスロット数の変更を説明するための図である。
【図２０】ランダムアクセスパケット伝送用の拡散符号数の変更を説明するための図である。
【図２１】ランダムアクセスパケット伝送用のタイムスロット数及び拡散符号数の変更を説明するための図である。
【図２２】ランダムアクセスパケットの伝送制限を説明するための図である。
【図２３】伝送量に応じた拡散符号の割り当てを説明するための図（その１）である。
【図２４】伝送量に応じた拡散符号の割り当てを説明するための図（その２）である。
【図２５】伝送量に応じたタイムスロット数の割り当てを説明するための図である。
【図２６】伝送量に応じた拡散符号の割り当てを説明するための図（その３）である。
【図２７】伝送量に応じたタイムスロット及び拡散符号の割り当てを説明するための図（その１）である。
【図２８】伝送量に応じたタイムスロット及び拡散符号の割り当てを説明するための図（その２）である。
【図２９】伝送量に応じたタイムスロット及び拡散符号の割り当てを説明するための図（その３）である。
【符号の説明】
ｆ１〜ｆｎ　サブキャリア
ＴＳ　タイムスロット
TF　フレーム長

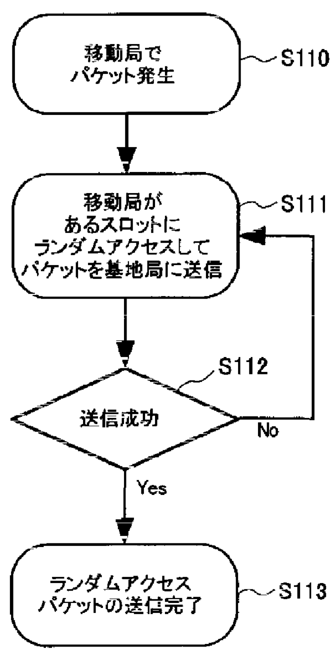
【図1】

マルチキャリア／DS－CDMA方式における移動局と
基地局間のチャネル構成の一例を示す図




【図3】

移動局から基地局にパケット伝送する際に、移動局と基地局の
間で行われる制御のやり取りの一例を示す図（その２）

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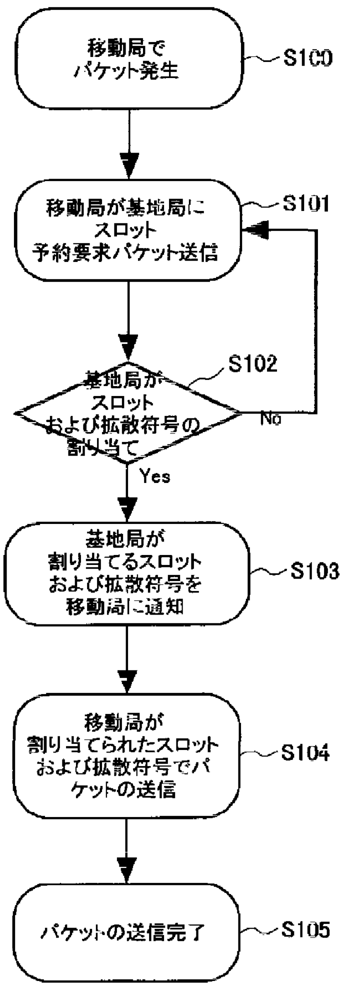
【図2】

移動局から基地局にパケット伝送する際に、移動局と基地局の
間で行われる制御のやり取りの一例を示す図（その１）

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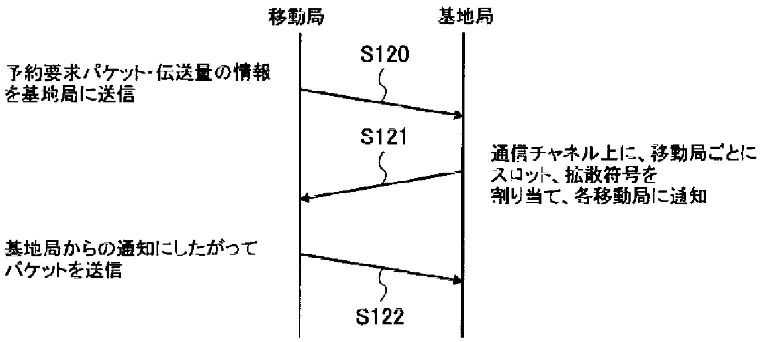
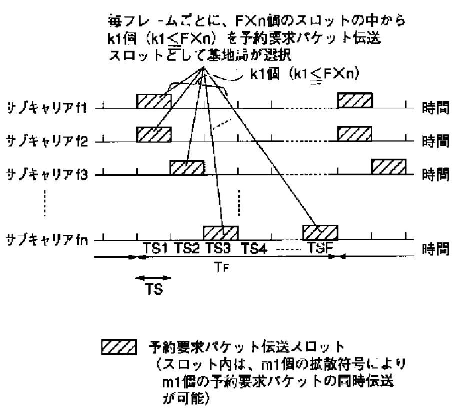
【図4】

移動局から基地局にパケット伝送する際に、移動局と基地局の
間で行われる制御のやり取りの一例を示す図（その３）



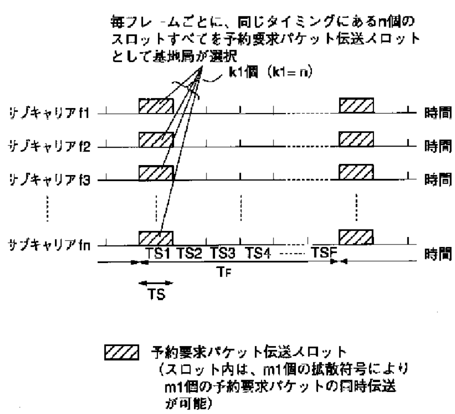

【図5】

予約要求パケット伝送スロットの割り当てを
説明するための図（その1）




【図6】

予約要求パケット伝送スロットの割り当てを
説明するための図（その2）

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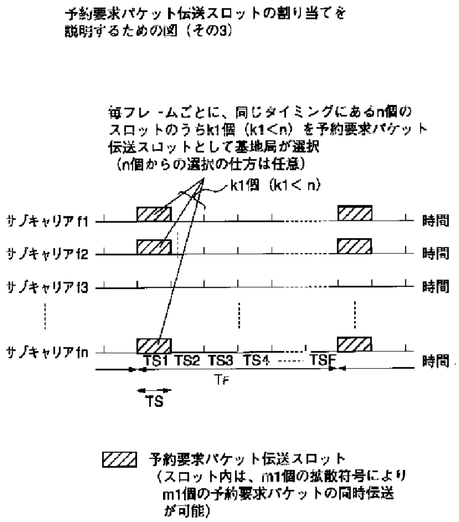
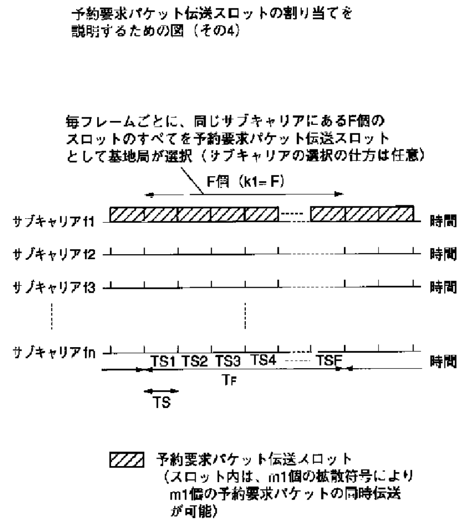
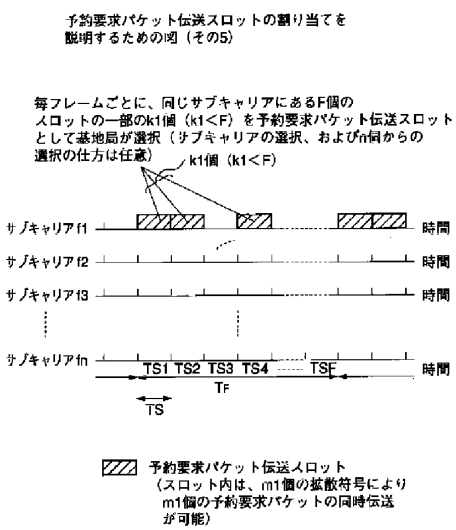
【図7】


予約要求パケット伝送スロットの割り当てを
説明するための図（その3）
毎フレームごとに、同じタイミングにあるn個の
スロットのうちk1個（k1<n）を予約要求パケット
伝送スロットとして基地局が選択
（n個からの選択の仕方は任意）
k1個（k1<n）
サブキャリアf1
サブキャリアf2
サブキャリアf3
サブキャリアfn
時間
TS1 TS2 TS3 TS4 TSF
TF
TS
予約要求パケット伝送スロット
（スロット内は、m1個の拡散符号により
m1個の予約要求パケットの同時伝送
が可能）

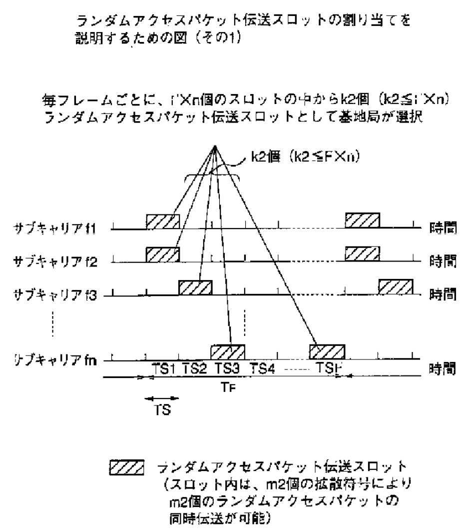
【図8】


予約要求パケット伝送スロットの割り当てを
説明するための図（その4）
毎フレームごとに、同じサブキャリアにあるF個の
スロットのすべてを予約要求パケット伝送スロット
として基地局が選択（サブキャリアの選択の仕方は任意）
F個（k1=F）
サブキャリアf1
サブキャリアf2
サブキャリアf3
サブキャリアfn
時間
TS1 TS2 TS3 TS4 TSF
TF
TS
予約要求パケット伝送スロット
（スロット内は、m1個の拡散符号により
m1個の予約要求パケットの同時伝送
が可能）

【図9】

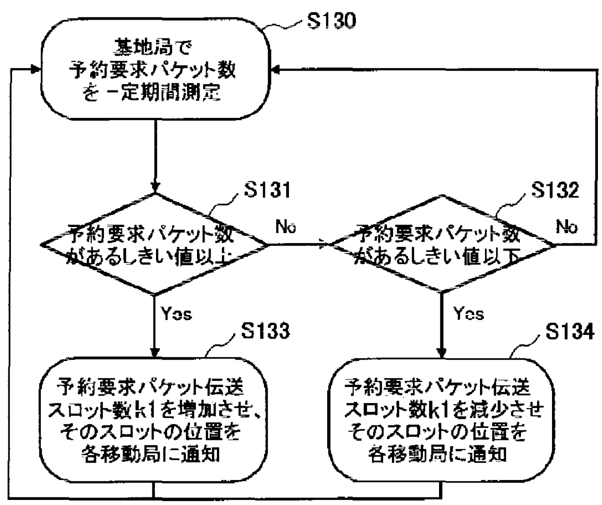

予約要求パケット伝送スロットの割り当てを
説明するための図（その5）
毎フレームごとに、同じサブキャリアにあるF個の
スロットの一部のk1個（k1<F）を予約要求パケット伝送スロット
として基地局が選択（サブキャリアの選択、およびn個からの
選択の仕方は任意）
k1個（k1<F）
サブキャリアf1
サブキャリアf2
サブキャリアf3
サブキャリアfn
時間
TS1 TS2 TS3 TS4 TSF
TF
TS
予約要求パケット伝送スロット
（スロット内は、m1個の拡散符号により
m1個の予約要求パケットの同時伝送
が可能）

【図14】


ランダムアクセスパケット伝送スロットの割り当てを
説明するための図（その1）
毎フレームごとに、F×n個のスロットの中からk2個（k2≦F×n）
ランダムアクセスパケット伝送スロットとして基地局が選択
k2個（k2≦F×n）
サブキャリアf1
サブキャリアf2
サブキャリアf3
サブキャリアfn
時間
TS1 TS2 TS3 TS4 TSF
TF
TS
ランダムアクセスパケット伝送スロット
（スロット内は、m2個の拡散符号により
m2個のランダムアクセスパケットの
同時伝送が可能）

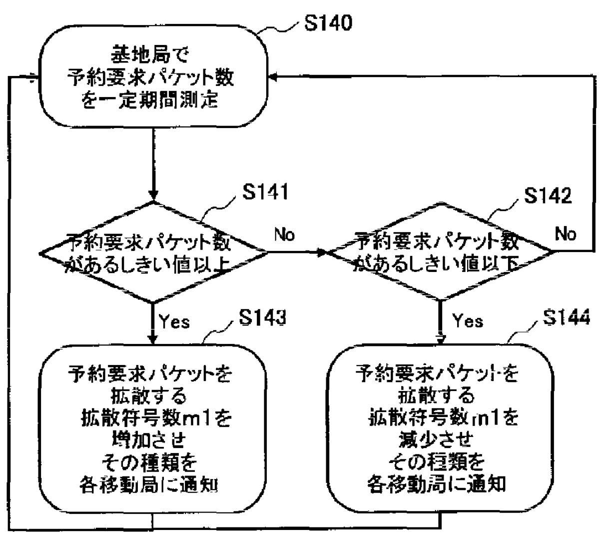
【図10】

予約要求パケット伝送用のタイムスロット数の変更を説明するための図




【図11】

予約要求パケット伝送用の拡散符号数の変更を説明するための図

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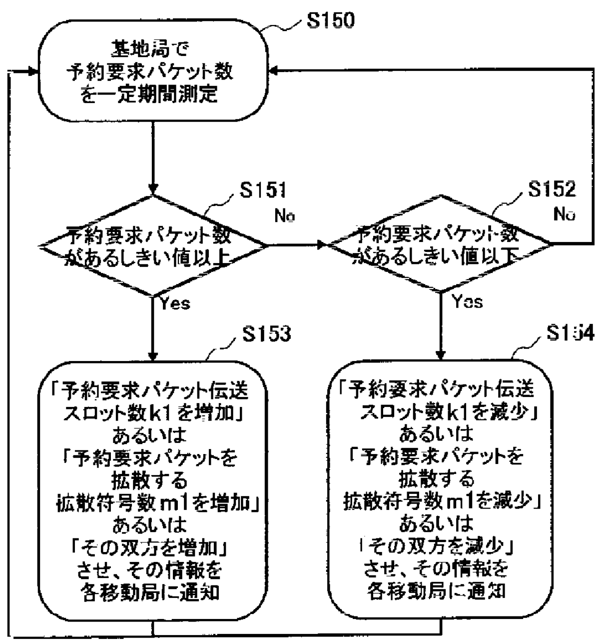
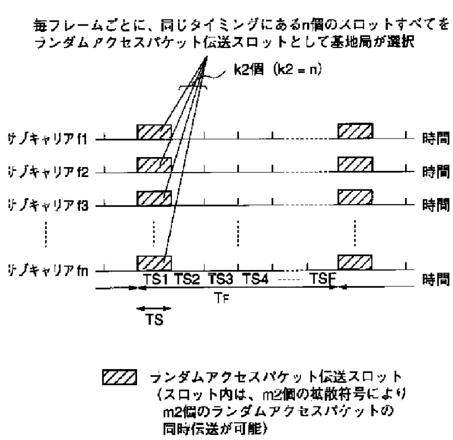
【図12】

予約要求パケット伝送用のタイムスロット数
及び拡散符号数の変更を説明するための図



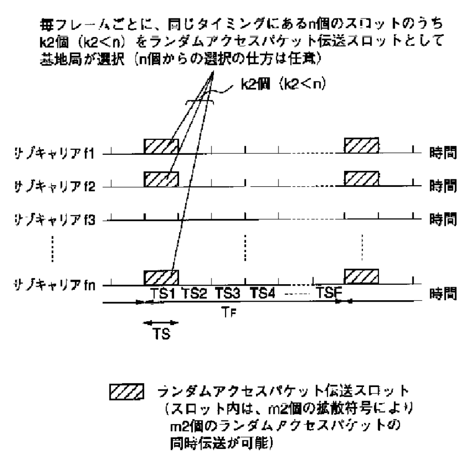

【図15】

ランダムアクセスパケット伝送スロットの割り当てを
説明するための図（その2）




【図16】

ランダムアクセスパケット伝送スロットの割り当てを
説明するための図（その3）

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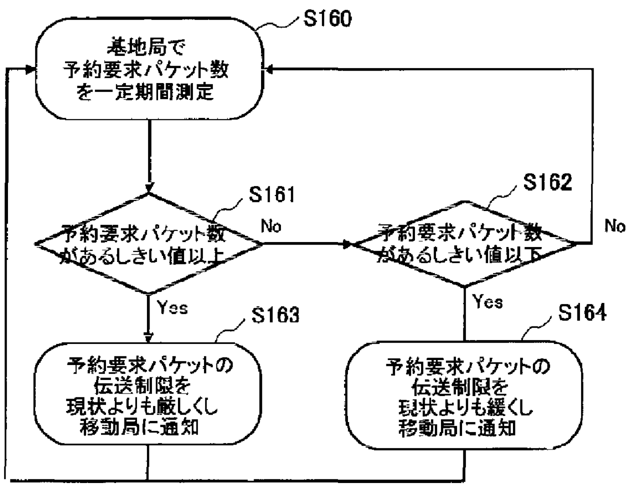
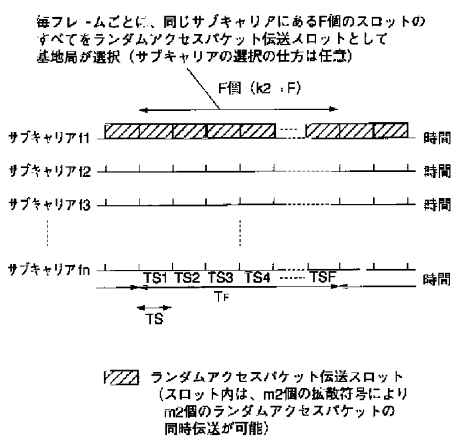
【図13】

予約要求パケットの伝送制限を説明するための図



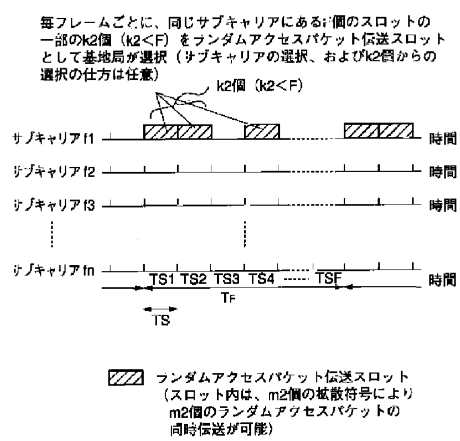

【図17】

ランダムアクセスパケット伝送スロットの割り当てを
説明するための図（その4）



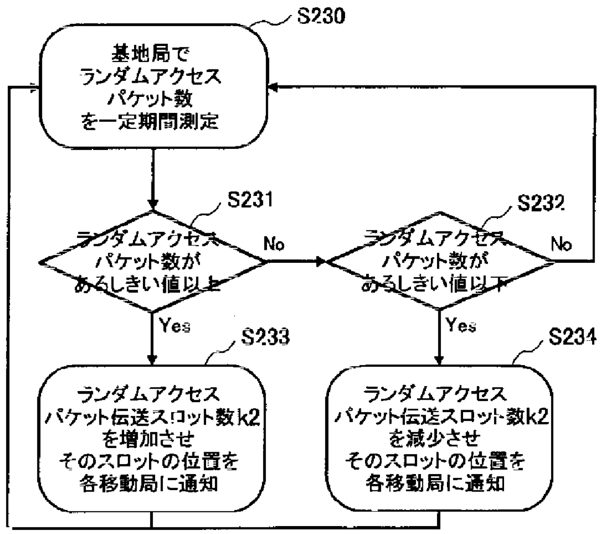

【図18】

ランダムアクセスパケット伝送スロットの割り当てを
説明するための図（その5）



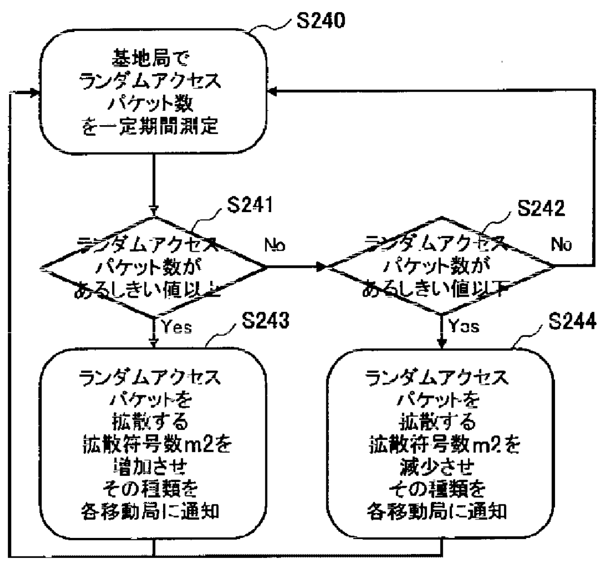
【図19】

ランダムアクセスパケット用のタイムスロット数の変更を説明するための図



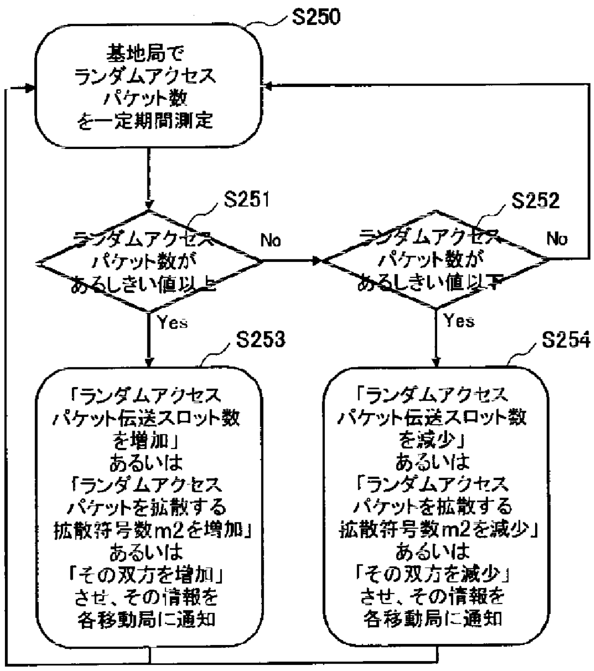

【図20】

ランダムアクセスパケット用の拡散符号数の変更を説明するための図



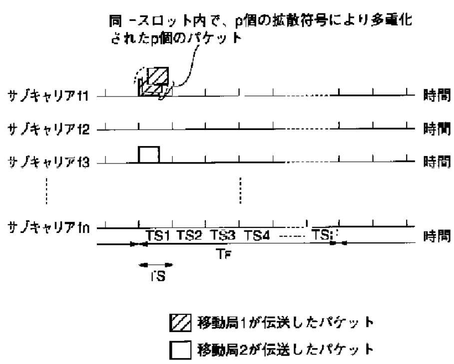
【図21】

ランダムアクセスパケット用のタイムスロット数
及び拡散符号数の変更を説明するための図



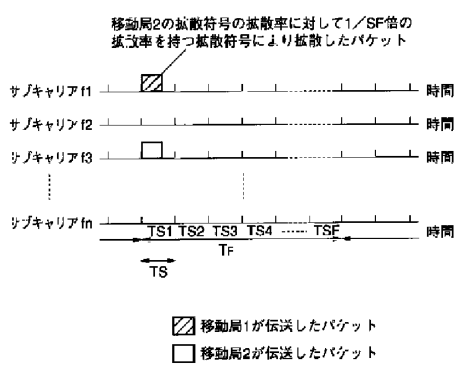

【図23】

伝送量に応じた拡散符号の割り当てを説明するための図（その1）



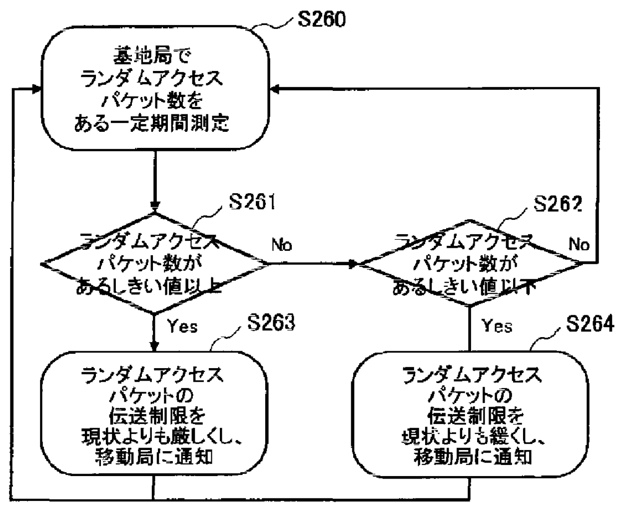

【図24】

伝送量に応じた拡散符号の割り当てを説明するための図（その2）



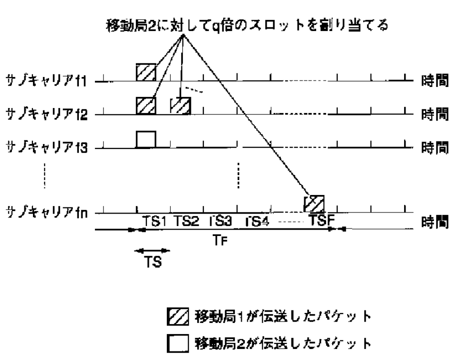
【図22】

ランダムアクセスパケットの伝送制限を説明するための図



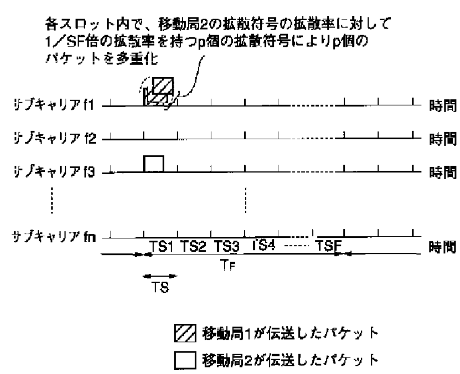

【図25】

伝送量に応じたタイムスロット数の割り当てを説明するための図（その2）

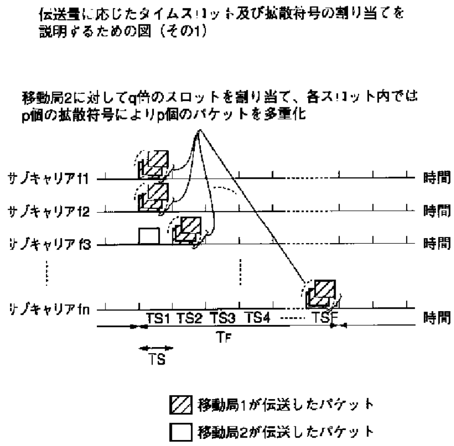



【図26】

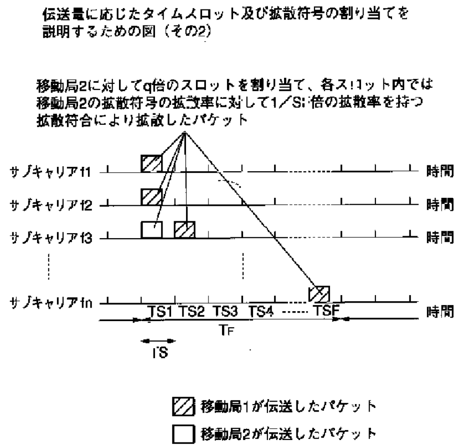
伝送量に応じた拡散符号の割り当てを説明するための図（その3）



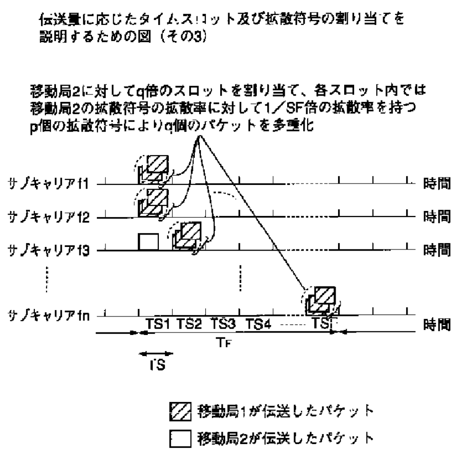
【図27】




【図28】




【図29】

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フロントページの続き

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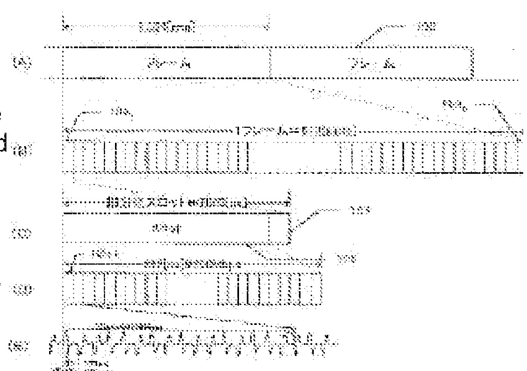
## RADIO COMMUNICATION SYSTEM, RADIO TRANSMISSION EQUIPMENT, RADIO RECEPTION EQUIPMENT, RADIO TRANSMISSION METHOD, RADIO RECEPTION METHOD, ITS PROGRAM AND PROGRAM RECORDING MEDIUM

| | | |
|---|---|---|
| **Inventor(s):** | SUZUKI MITSUHIRO + | |
| **Applicant(s):** | SONY CORP + | |
| **Classification:** | **- international:** | ***H04J13/00; H04L7/00;*** (IPC1-7): H04J13/00; H04L7/00 |
| | **- European:** | |
| **Application number:** | JP20020258743 20020904 | |
| **Priority number (s):** | JP20020258743 20020904; JP20010290227 20010921 | |

**Abstract of JP2003179576 (A)**

PROBLEM TO BE SOLVED: To provide a radio transmission system wherein data transmission is rightly enabled without receiving restriction of use of communication equipment, even if an interference due to another network is received, when at least two radio networks which are not adjusted to each other exist at positions where they receive interference mutually. ; SOLUTION: In an ultrawide band radio transmission system, subdivided slots 103 of frames 101, 102 are transmitted by changing the order at random by using a previously determined slot arrangement pattern, and received by returning the order of received slots to the original order by using the previously determined slot arrangement pattern. As a result, communication in the respective networks is rightly enabled when at least two unadjusted networks which obtain diversity effect to interference in an ultrawide band radio transmission system approach each other. 



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（P2003－179576A）

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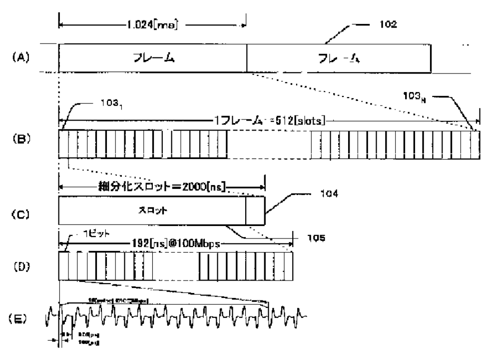
(54)【発明の名称】　無線通信システム、無線送信装置、無線受信装置、無線送信方法、無線受信方法、そのプログラム並びにプログラム記録媒体

(57)【要約】

【課題】　互いに調整されていない２つ以上の無線ネットワークが相互に干渉を受ける位置に存在する場合において、通信装置の使用の制限を受けることなく、他方のネットワークの干渉を受けても正しくデータ伝送できる無線伝送方式を提供する。

【解決手段】　ウルトラワイドバンド無線伝送方式において、フレーム１０１，１０２の細分化スロット１０３を予め定めたスロット配列パターンを用いてランダムに順番を入れ替えて送信し、かつ該予め定めたスロット配列パターンを用いて受信したスロットの順番を元に戻して受信することにより、干渉に対するダイバーシティ効果を得て調整されていない２以上のウルトラワイドバンド無線伝送方式によるネットワークが近接していても、それぞれのネットワークにおける通信が正しく行える。



【特許請求の範囲】
【請求項１】　二以上のネットワークが互いに調整されることなく存在し、各々のネットワークでは所定の周期を有する時分割フレームを用いて無線通信が行われる無線通信システムにおいて、
前記時分割フレームは細分化された複数の細分化スロットからなり、
各無線通信装置は、送信を行うために基地局から割り当てられた領域に対応する前記細分化スロットを、所定のスロット配列パターンに応じた順番に配列し、
前記配列された細分化スロットを用いて無線通信を行うことを特徴とする無線通信システム。
【請求項２】　請求項１に記載の無線通信システムにおいて、
前記スロット配列パターンは、前記細分化スロットを前記時分割フレーム全体の領域にランダムに配列させるものであることを特徴とする、無線通信システム。
【請求項３】　請求項１に記載の無線通信システムにおいて、
基地局から割り当てられた領域に対応する前記細分化スロット数はN個であり、
前記スロット配列パターンは、前記N個の細分化スロットをＪ個の連続したスロットを一つのグループとするＮ／Ｊ個のグループにし、各グループから細分化スロットを一つずつJ個のスロット群に割り振ることにより、各スロットの配列を行わせるものであることを特徴とする、無線通信システム。
【請求項４】　請求項1に記載の無線通信システムにおいて、
前記時分割フレームはコンテンション・ピリオドを含み、
各無線通信装置がコンテンション・ピリオドを使用して無線通信を行う場合、複数の連続した細分化スロットを送信領域として割当てた後に、所定のスロット配列パターンに応じた順番に配列することを特徴とする、無線通信システム。
【請求項５】　請求項１に記載の無線通信システムにおいて、
前記時分割フレームには、前記スロット配列パターンの同期を獲得するための所定の同期用パターンを含む同期用スロットを複数存在することを特徴とする、無線通信システム。
【請求項６】　請求項５に記載の無線通信システムにおいて、
前記所定の同期用パターンは、同期用スロット長と同じ長さであることを特徴とする、無線通信システム。
【請求項７】　請求項５に記載の無線通信システムにおいて、
前記所定の同期用パターンは同期用スロット長よりも短く、該同期用パターンの繰り返しを用いて、前記同期用スロットを構成することを特徴とする、無線通信システム。
【請求項８】　請求項５に記載の無線通信システムにおいて、
同期用スロット長が同期パターンの長さの整数倍でなく、
繰り返して生成される同期用パターンに同期用スロットを窓としてかけて取り出した窓同期ワードを同期用スロットとして伝送することを特徴とする、無線通信システム。
【請求項９】　二以上のネットワークが互いに調整されることなく存する環境の下、所定の周期を有する時分割フレームを使用して無線通信を行う無線送信装置であって、
前記時分割フレームは細分化された複数の細分化スロットからなり、
送信を行うために基地局から割り当てられた領域に対応する前記細分化スロットを、所定のスロット配列パターンに従って配列するよう制御するスロット配列制御手段と、
前記スロット配列制御手段の制御により細分化スロットの配列を行うスロット配列手段と、
前記所定のスロット配列パターンに従ったタイミングで、前記配列された細分化スロットを送信させるように送信手段を制御する送信タイミング制御手段と前記スロット配列手段から配列された細分化スロットを受け取り、これを前記送信タイミング制御手段により制御されたタイミングで無線通信する送信手段と、を有することを特徴とする、無線送信装置。
【請求項１０】　請求項９に記載の無線送信装置において、
前記スロット配列パターンは、前記細分化スロットを前記時分割フレーム全体の領域にランダムに配列させるものであることを特徴とする、無線送信装置。
【請求項１１】　請求項９に記載の無線送信装置において、
基地局から割り当てられた前記領域に対応する細分化スロット数はN個であり、
前記スロット配列パターンは、Ｎ個の細分化スロットを、J個の連続した細分化スロットを一つのグループとするＮ／Ｊ個のグループにし、各グループから細分化スロットを一つずつＪ個のスロット群に割り振ることにより、細分化スロットの配列を行うことを特徴とする、無線送信装置。
【請求項１２】　請求項９に記載の無線通信装置において、
前記時分割フレームには、前記スロット配列パターンの同期を獲得するための所定の同期用パターンを含む同期用スロットが複数存在することを特徴とする、無線通信装置。

【請求項１３】　二以上のネットワークが互いに調整されることなく存在する環境の下、所定の周期を有する時分割フレームを使用して通信を行う無線受信装置であって、
無線送信装置から無線信号を受信し、これを復調するための受信手段と、
前記無線送信装置が用いたスロット配列パターンを用いて所定のタイミングで受信信号の内必要なスロットに対応する部分を復調するように前記受信手段を制御する受信タイミング制御手段と、
前記スロット配列パターンに従って配列するよう制御するスロット配列制御手段と、
前記受信手段から復調された受信信号の内必要なスロットに対応する部分を受け取り、これを前記スロット配列制御手段の制御に従って配列するスロット配列手段とを有することを特徴とする、無線受信装置。
【請求項１４】　請求項１３に記載の無線受信装置において、
前記スロット配列パターンの同期を獲得するため、所定の同期用パターンを検出する相関検出手段をさらに備えることを特徴とする、無線受信装置。
【請求項１５】　請求項１３に記載の無線受信装置において、
この無線受信装置は、前記スロット配列手段により配列された受信データについて誤り訂正を行う誤り訂正手段をさらに有することを特徴とする、無線受信装置。
【請求項１６】　二以上のネットワークが互いに調整されることなく存在する環境の下、所定の周期を有する時分割フレームを使用して通信を行う無線送信方法であって、
前記時分割フレームは細分化された複数の細分化スロットからなり、
送信を行うために基地局から割り当てられた領域に対応する前記細分化スロットを、所定のスロット配列パターンに従って配列するステップと、
前記所定のスロット配列パターンに従ったタイミングで、前記配列された細分化スロットを送信する送信ステップと、を有することを特徴とする、無線送信方法。
【請求項１７】　請求項１６に記載の無線送信方法において、
前記スロット配列パターンは、前記細分化スロットを前記時分割フレーム全体の領域にランダムに配列させるものであることを特徴とする、無線送信方法。
【請求項１８】　請求項１６に記載の無線送信方法において、
基地局から割り当てられた領域に対応する前記細分化スロット数はＮスロットであり、
前記スロット配列パターンは、前記Ｎ個の細分化スロットをＪ個の連続したスロットを一つのグループとするＮ／Ｊ個のグループにし、各グループから細分化スロットを一つずつJ個のスロット群に割り振ることにより、各スロットの配列を行うことを特徴とする、無線送信方法。
【請求項１９】　二以上のネットワークが互いに調整されることなく存在する環境の下、所定の周期を有する時分割フレームを使用して無線通信を行う無線受信方法であって、
無線信号を所定のスロット配列パターンに応じたタイミングで受信するステップと、
送信装置が用いたスロット配列パターンに従ってスロットを配列するステップと、を有することを特徴とする無線受信方法。
【請求項２０】　請求項１９に記載の無線受信方法において、
前記スロット配列パターンの同期を獲得するため、所定の同期用パターンを検出する相関検出ステップをさらに備えることを特徴とする、無線受信方法。
【請求項２１】　二以上のネットワークが互いに調整されることなく存する環境の下、所定の周期を有する時分割フレームを複数の細分化スロットに細分化して無線通信を行う、演算装置を有する無線送信装置において、この演算装置を：送信を行うために基地局から割り当てられた領域に対応する前記細分化スロットを、所定のスロット配列パターンに従って配列するよう制御するスロット配列制御手段と、
前記スロット配列制御手段の制御により細分化スロットの配列を行うスロット配列手段と、
前記所定のスロット配列パターンに従ったタイミングで、前記配列された細分化スロットを送信させるように送信制御する送信タイミング制御手段ととして機能させるためのプログラム。
【請求項２２】　二以上のネットワークが互いに調整されることなく存在する環境の下、所定の周期を有する時分割フレームを使用して通信を行う、演算装置を有する無線受信装置において、この演算装置を：無線送信装置が用いたスロット配列パターンを用いて所定のタイミングで受信信号の内必要なスロットに対応する部分を復調するように無線信号の受信を制御する受信タイミング制御手段と、
前記スロット配列パターンに従って配列するよう制御するスロット配列制御手段と、
前記受信手段から復調された受信信号の内必要なスロットに対応する部分を受け取り、これを前記スロット配列制御手段の制御に従って配列するスロット配列手段として機能させる、プログラム。
【請求項２３】　二以上のネットワークが互いに調整されることなく存在する環境の下、所定の周期を有する時分割フレームを複数の細分化スロットに細分化して通信を行う無線送信方法を演算装置に実行させるプログラムにおいて、

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送信を行うために基地局から割り当てられた領域に対応する前記細分化スロットを、所定のスロット配列パターンに従って配列するステップと、
前記所定のスロット配列パターンに従ったタイミングで、前記配列された細分化スロットを送信する送信ステップと、を演算装置に実行させることを特徴とするプログラム。
【請求項２４】　二以上のネットワークが互いに調整されることなく存在する環境の下、所定の周期を有する時分割フレームを使用して無線通信を行う無線受信方法を演算装置に実行させるためのプログラムにおいて、
無線信号を所定のスロット配列パターンに応じたタイミングで受信させるステップと、
送信装置が用いたスロット配列パターンに従ってスロットを配列するステップとを演算装置に実行させることを特徴とするプログラム。
【発明の詳細な説明】
【０００１】
【発明の属する技術分野】本発明は、無線通信システム、無線送信装置、無線受信装置、無線送信方法、無線受信方法、そのプログラム並びにプログラム記録媒体に関する。
【０００２】
【従来の技術】近年の情報化によりＬＡＮ（Local Area Network）の普及に伴い、オフィス内の配線工事、工事期間の短縮、室内美観上の課題、保守運用管理の複雑などの問題から無線ＬＡＮへの要求が高まっている。かかる無線ＬＡＮに用いられる無線伝送方式としてウルトラワイドバンド（Ultra Wide Band：ＵＷＢ）無線伝送方式がある。
【０００３】ウルトラワイドバンド無線伝送方式は、基本的には、非常に細かいパルス幅（例えば１ｎｓ（ナノセコンド）以下）のパルス列からなる信号を用いて、ベースバンド伝送を行なうものである。このＵＷＢ無線伝送方式は、所定の無線信号に例えば送信する情報に所定の拡散符号系列を掛け合わせて拡散情報を形成する。さらに、数百ナノ秒の周期で一つの短いインパルスを発生させ、そのインパルス位相あるいは時間変化を、前述の拡散情報にあわせて変化させた信号を送信信号として利用し、一方情報を受信する装置は、前記送信されたインパルスの位相あるいは微妙な時間変化によってインパルス信号の情報ビットを識別し、これに所定の拡散符号系列を用いて逆拡散することによって、所望の情報ビットを得るというものである。また、その占有帯域幅は、占有帯域幅をその中心周波数（例えば１ＧＨｚから１０ＧＨｚ）で割った値がほぼ１となるようなＧＨｚオーダーの帯域幅であり、所謂Ｗ－ＣＤＭＡ方式やｃｄｍａ２０００方式、並びにＳＳ（Spread Spectrum）やＯＦＤＭ（Orthogonal Frequency Division Multiplexing)を用いた無線ＬＡＮで使用される帯域幅に比べて、超広帯域なものとなっている。
【０００４】また、ウルトラワイドバンド伝送方式は、その低い信号電力密度の特性により、特定の周波数帯域に高い信号電力密度特性を持つ既存の無線システムに対し干渉を与えにくい特徴を有しており、既存の無線システムが利用している周波数帯域にオーバーレイ可能な技術として期待されている。さらに広帯域であることからパーソナルエリアネットワーク（Personal Area Network:ＰＡＮ）の用途で、１００Ｍｂｐｓレベルの超高速無線伝送技術として有望視されている。
【０００５】一方で、ＵＷＢ無線伝送では、互いに調整されていない（uncoordinated）な２つ以上のＵＷＢ無線ネットワークが同一エリアにある場合を想定すると、各送受信機の位置関係によっては大きな干渉を与えることも想定される。この場合、ＵＷＢ無線伝送では超広帯域な占有帯域を用いているため、回避するための周波数チャンネルがなく、最悪の場合通信ができなくなってしまうといった懸念がある。ここで「互いに調整されていない（uncoordinated）」とは、個々のネットワークを制御する制御局間でチャネル割当情報などを共有しないことをいう。
【０００６】この問題を解決する手段の一つとして、１つのチャネルをフレームに分割し、フレーム毎にリソースの割り当てを行う時分割多元接続（Time Division Multiple Access）ＴＤＭＡ方式が用いられている。
【０００７】
【発明が解決しようとする課題】時分割多元接続方式では、ネットワーク中の１通信に対して、フレーム内の比較的長い時間にわたって連続的なリソースの割り当てをする。
【０００８】従来のＴＤＭＡ方式では、以下のようなフレーム構成を採用する。図１３にフレーム構成例を示す。
【０００９】ＴＤＭＡでは、図１３（Ａ）に示すように、例えばＴＤＭＡの単位フレーム（「ＴＤＭＡフレーム」という）１３０１，１３０２，１３０３が繰り返されている。このＴＤＭＡフレームの長さは、例えば１マイクロセカンドである。
【００１０】このＴＤＭＡフレームのそれぞれにおいては、図１３(Ｂ)に示すように、フレーム先頭に、無線リソースの割り当て情報（リソースアサイン情報）を含む識別信号であるビーコン１３０４が配置され、そのビーコン１３０４に続けて、該無線ネットワークに含まれる端末局（もしくはユーザ）宛ての領域が割り当てられる。図１３(Ｂ)に示す例では、ビーコン１３０４の後に、端末局Ａ、端末局Ｂ，端末局Ｃの順に割り当てられた領域（「ユーザ割当領域」という）１３０５，１３０６，１３０７が設定されている。各端末局に割り当てられた領域は、フレームごとに可変であってもよい。
【００１１】また、ビーコン１３０４，各ユーザ割当領

域１３０５，１３０６，１３０７以外の領域には、コンテンション・ピリオド１３０８が設定されている。コンテンション・ピリオド（Contention Period）は、端末局から基地局へのランダムアクセスチャネルや、端末局間の通信用に使用される領域である。このコンテンション・ピリオドでは、基地局により割り当てられた区間ではないので、ネットワーク内通信の衝突（Contention）が生じ得る。

【００１２】このようなＴＤＭＡフレームを用いた通信では、例えば、端末局からは、コンテンション・ピリオドにおいてランダムアクセスチャネル（ＲＡＣＨ）で次のフレームでのリソース割り当てを要求（送信要求）し、基地局はその要求に応じて次のフレームにおけるリソース割り当てのためにユーザ割当領域を定め、これを次のフレームのビーコン１３０９によって各端末局に報知する。そして、各端末局は、該ビーコンのリソース割り当て情報に基づいて通信を行う。

【００１３】上述のようなＴＤＭＡフレームを用いた通信を行う互いに調整されていない（Uncoordinate）２つ以上のＵＷＢネットワークが近接して配置されていると、ネットワーク内の局に対する干渉が連続的に起こりやすく、その場合、干渉を受けた局においてエラー訂正などではデータが復帰できず、通信ができなくなってしまうという問題点がある。

【００１４】図１４に、２つのネットワークが近接して配置されている図を示す。図のようにパーソナル・エリア・ネットワーク（Personal Area Network；以下ＰＡＮという）Ｘ１４０１とＰＡＮＹ１４０２が互いに調整されていない状態で近接して配されている。ＰＡＮＸ１４０１は、基地局Ｘ１４０３と、該基地局Ｘ１４０３によって制御される端末局Ａ１４０５、端末局Ｂ１４０６、端末局Ｃ１４０７、および端末局Ｆ１４１０とにより構成される。一方、ＰＡＮＹ１４０２は、基地局Ｙ１４０４と、該基地局Ｙ１４０４によって制御される端末局Ｄ１４０８および端末局Ｅ１４０９とにより構成されている。

【００１５】また、端末局Ｃ１４０７と端末局Ｅ１４０９は、一方が無線送信をした場合に他方の受信する無線信号に干渉するような位置関係にあるものとする。

【００１６】図１５に、上述のＰＡＮＸ１４０１とＰＡＮＹ１４０２のフレーム状態を示す。図１５(A)はある時点におけるＰＡＮＸ１４０１のフレームの状態を表し、図１３(B)は、同時点でのＰＡＮＹ１４０２のフレームの状態を表している。

【００１７】図に示すように、端末局Ｆ（端末局Ｆ１４１０から端末局Ｃ１４０７への通信とする）に割り当てられたユーザ割当領域１５０１と端末局Ｅ１２０７の送信に割り当てられたユーザ割当領域１３０２とは、時間的に重複した状態となっている。この図のように、互いの位置が近いパーソナル・エリア・ネットワークＸに属する端末局Ｃと、別のパーソナル・エリア・ネットワークＹに属する端末局Ｅが割り当てられたユーザ割当領域が衝突している場合は、通信が出来なくなるおそれが生ずる。

【００１８】したがって、上記のような状況にならないようにするためには、各ネットワークを構成する通信装置を使用する上で、何らかの制限を設ける必要があった。例えば、互いに調整されていない２つ以上のネットワークが同一エリアに存在しないようにする必要があった。

【００１９】本発明の目的は、互いに調整されていない２つ以上の無線ネットワークが相互に干渉を受ける位置に存在する場合においても、通信装置の使用の制限を受けることなく、他方のネットワークの干渉を受けても正しくデータ伝送できる無線伝送方式を提供することにある。

【００２０】

【課題を解決するための手段】上記の課題を解決する手段として、本発明は以下の特徴を有する。本発明の第１の態様は、二以上のネットワークが互いに調整されることなく存在し、各々のネットワークでは所定の周期を有する時分割フレームを用いて無線通信が行われる無線通信システムとして提案される。この無線通信システムでは、時分割フレームは細分化されて、複数の細分化スロットとして扱われる。この無線通信システムを構成する各無線通信装置は、送信を行うために基地局から割り当てられた領域に対応する前記細分化スロットを、所定のスロット配列パターンに応じて、順番に配列し、この配列後の細分化スロットを用いて無線通信を行う。

【００２１】本発明の第２の態様は、二以上のネットワークが互いに調整されることなく存する環境の下、所定の周期を有する時分割フレームを使用して無線通信を行う無線送信装置として提供される。この無線送信装置は、前記時分割フレームを複数の細分化スロットに細分化して扱う。この無線送信装置は、送信を行うために基地局から割り当てられた領域に対応する前記細分化スロットを、所定のスロット配列パターンに従って配列するよう制御するスロット配列制御手段と、前記スロット配列制御手段の制御により細分化スロットの配列を行うスロット配列手段と、前記所定のスロット配列パターンに従ったタイミングで、前記配列された細分化スロットを送信させるように送信手段を制御する送信タイミング制御手段と、前記スロット配列手段から配列された細分化スロットを受け取り、これを前記送信タイミング制御手段により制御されたタイミングで無線通信する送信手段とを有することを特徴としている。

【００２２】本発明の第３の態様は、二以上のネットワークが互いに調整されることなく存在する環境の下、所定の周期を有する時分割フレームを使用して通信を行う無線受信装置として提供される。この無線受信装置は、

無線送信装置から無線信号を受信し、これを復調するための受信手段と、前記無線送信装置が用いたスロット配列パターンを用いて所定のタイミングで受信信号の内必要なスロットに対応する部分を復調するように前記受信手段を制御する受信タイミング制御手段と、前記スロット配列パターンに従って配列するよう制御するスロット配列制御手段と、前記受信手段から復調された受信信号の内必要なスロットに対応する部分を受け取り、これを前記スロット配列制御手段の制御に従って配列するスロット配列手段とを有することを特徴としている。

【００２３】本発明の第４の態様は、二以上のネットワークが互いに調整されることなく存在する環境の下、所定の周期を有する時分割フレームを使用して通信を行う無線送信方法として提供する。この無線送信方法において、時分割フレームは複数の細分化スロット二分関されて扱われる。この無線送信方法は、送信を行うために基地局から割り当てられた領域に対応する前記細分化スロットを、所定のスロット配列パターンに従って配列するステップと、前記所定のスロット配列パターンに従ったタイミングで、前記配列された細分化スロットを送信する送信ステップとを有することを特徴としている。

【００２４】本発明の第５の態様は、二以上のネットワークが互いに調整されることなく存在する環境の下、所定の周期を有する時分割フレームを使用して無線通信を行う無線受信方法として成立する。本無線受信方法は、無線信号を所定のスロット配列パターンに応じたタイミングで受信するステップと、送信装置が用いたスロット配列パターンに従ってスロットを配列するステップとを有することを特徴としている。

【００２５】

【発明の実施の形態】次に、本発明の実施の形態について、図面を参照しながら説明する。

【００２６】［本実施の形態にかかるフレームの構成例］まず、本実施の形態において使用されるフレームの構成例について説明する。

【００２７】図１（Ａ）は、所定の長さを有するフレーム１０１，１０２，…が繰り返されるようになっている。例えば、図示の例では、１のフレームは１０２４［ｍｓ］とする。

【００２８】この1つのフレームはＮ個の細分化スロット１０３１～１０３Ｎ（以下、総称的に「細分化スロット１０３」と呼ぶ）で構成される。図１（Ｂ）に示す例では、１のフレームは５１２個の細分化スロット１０３から成り、この場合各細分化スロット１０３のスロット長は、１０２４［ｍｓ］／５１２＝２０００［ｎｓ］となる。

【００２９】次に細分化スロット１０３の構成について説明する。図1(C)は、本実施の形態にかかる細分化スロット１０３の構成例を示す。細分化スロット１０３のうちの一部は、ガード・ピリオド（guard period）１０４として、送信信号を含めない領域とする。ガード・ピリオド１０４は、連続する細分化スロット１０３が異なる送信装置により使用されている場合、各細分化スロットにおいて送信された送信信号が異なる伝搬遅延の後ある受信機に到達したとしても、送信信号を衝突させないために設けられている。

【００３０】該ガード・ピリオド１０４を除いた、細分化スロットの残りの領域１０５は、送信信号を含む領域である。図１に示す例では、ガード・ピリオドの長さは８０［ｎｓ］、領域１０５の長さは１９２０[ｎｓ]である。

【００３１】この領域１０５には情報ビットが含まれる。たとえば送信速度が１００［Ｍｂｐｓ］のときは１００［Ｍｂｐｓ］×１９２０[ｎｓ]＝１９２［ｂｉｔ］が１スロット内に含まれることになる。

【００３２】特に従来例に示したＵＷＢ伝送方式では、この１ビットは１６個のパルス（パルス幅は１００［ｐｓ］）によって表されている。図１（Ｅ）に示す例では、直接拡散コードの０または１にしたがいパルスの位相を反転させるBi-phase変調で変調されて構成されるパルス列がパルス間隔625[ps]おきに伝送されている。

【００３３】なお、上記説明では、一例として具体的数値を上げて説明したが、本発明はかかる数値に限定される趣旨ではない。また、ＵＷＢ伝送方式の変調方式は、パルス生成タイミングを微妙にずらした信号を用いる、いわゆるパルス位置変調であっても良い。

【００３４】［無線送信装置、無線受信装置の構成例］次に、上記の複数のスロットからなるフレームを用いた無線伝送方式を行うための、無線送信装置と無線受信装置の構成例について説明する。

【００３５】図2は、本実施の形態にかかる無線送信装置の構成例を示すブロック図である。送信装置は、符号化及びインターリーブ手段２０１と、スロット配列手段２０２と、送信タイミング制御手段２０３と、送信手段２０４と、アンテナ２０５と、スロット配列制御手段２０６とを有している。なお実際上、符号化及びインターリーブ手段２０１と、スロット配列手段２０２、送信タイミング制御手段２０３、及びスロット配列制御手段２０６は、中央演算装置（ＣＰＵ）によって構成されても良く、該ＣＰＵは図示しない記憶装置（例えば、ＥＥＰＲＯＭ（Electrically Erasable Programmable Read-Only Memory）など）に格納されたプログラムにしたがって、以下に述べるような処理を実行する。

【００３６】符号化及びインターリーブ手段（以下、「符号化手段」と略す）２０１は、送信すべき情報の提供先から情報データを受け取り、これを誤り訂正符号を用いて符号化し、バースト誤りをランダム誤りに置換して畳み込み符号の効果を引き出すようにインターリーブして得られる符号化データをスロット配列手段２０２に渡すように動作する。

【００３７】スロット配列手段２０２は、送信を行うために基地局から割り当てられたチャネル(例えば、図7(A)に示すような各端末に割当てられた時分割スロット)に含まれる複数の細分化スロットを、スロット配列制御手段２０６の制御により、所定のスロット配列パターンに従って配列若しくは並び替えを行うように動作する。

【００３８】今、送信しようとする情報ビットがスロット番号３，４，５，６に相当するスロットにあるものとする。なお、説明の便宜上スロット番号はフレームの最初のスロットを１番、最終のスロットをN番するように連続して付されているものとする。

【００３９】スロット配列制御手段２０６の制御により、所定の配列パターンは、スロット番号３，４，５，６のスロットがそれぞれスロット番号４４，１１，７９，５８に配列されるとすると、この４つのスロットに割り当てられたスロット化データは、｛４（１１），３（４４），６（５８），５（７９）｝という順に配列される。なお、かっこ内の数字は配列された後のスロット番号を示す。

【００４０】送信タイミング制御手段２０３は、前記所定のスロット配列パターンに従ったタイミングで、配列されたスロット化データを送信手段２０４に送信させるように動作する。

【００４１】前述の例によれば、スロット番号４，３，６，５に相当するスロット化データを、１１，４４，５８，７９のタイミングで送信手段に送信させる。なお、このスロット配列方法については別途詳述する。

【００４２】送信手段２０４は、送信タイミング制御手段２０３より受け取った送信タイミングで、データをＵＷＢ伝送方式により無線信号に変換して、アンテナ２０５より放射するように動作する。図3は、ウルトラワイドバンド伝送方式による送信手段の構成例を示すブロック図であり、図2の送信手段２０４，アンテナ２０５をより詳細に表したものである。

【００４３】拡散符号生成器３０２は、シンセサイザ３０１の周波数で拡散符号系列を乗算器３０３に出力する。乗算器３０３では、スロット化データに拡散符号系列が乗算されて拡散信号となり、この拡散信号がパルス発生器３０４に出力される。

【００４４】パルス発生器３０４では、拡散信号の０／１に対応して、例えば１００ｐｓの非常に細かいパルス信号を発生させる。このパルス信号は、バンドパスフィルタ３０５に出力され、そこで不要成分が除去されて送信信号となり、アンテナ３０６（図2における２０５に相当）を介して送信される。なお、バンドパスフィルタ３０５は必須の構成要素ではない。

【００４５】［無線受信装置の構成例］次に、本実施の形態における無線受信装置の構成例について説明する。

【００４６】図4は、本実施の形態における無線受信装置の構成例を示すブロック図である。受信装置は、アンテナ４００と、受信手段４０１と、受信タイミング制御手段４０２と、スロット配列手段４０３と、スロット配列制御手段４０５と、配列パターン同期検出用相関器４０６と、エラー（誤り）訂正手段４０４とを有している。なお実際上、受信タイミング制御手段４０２と、スロット配列手段４０３と、スロット配列制御手段４０５と、エラー訂正手段４０４とは中央演算装置（ＣＰＵ）によって構成されても良く、該ＣＰＵは図示しない記憶装置（例えば、ＥＥＰＲＯＭ（Electrically Erasable Programmable Read-Only Memory）など）に格納されたプログラムにしたがって、以下に述べるような処理を実行することにより、受信タイミング制御手段４０２と、スロット配列手段４０３と、スロット配列制御手段４０５と、エラー訂正手段４０４として機能する。

【００４７】受信手段４０１は、アンテナ４００を介して送信装置から送信された無線信号を受信し、これを復調して受信データを出力するように動作する。図5は、ウルトラワイドバンド信号を受信する受信手段４０１の構成例を示すブロック図である。アンテナ４００を介して受信された受信信号は、バンドパスフィルタ５０２で不要成分が除去された後に、乗算器５０７，５１３，５１０に出力される。なお、バンドパスフィルタ５０２は必須の構成要素ではない。

【００４８】拡散符号生成器５０４は、シンセサイザ５０３の周波数で拡散符号系列（図5に示す送信装置で用いた拡散符号系列と同じ拡散符号系列）をパルス発生器５０５に出力する。パルス発生器５０５では、パルスを発生させると共に、拡散符号生成器５０４から出力された拡散符号系列をパルスに重畳して、遅延器５０６，５１２及び乗算器５１０に出力する。

【００４９】遅延器５０６では、拡散符号系列を重畳したパルスを１／２パルス幅遅延させて乗算器５０７に出力する。また、遅延器５１２では、拡散符号系列を重畳したパルスを１パルス幅遅延させて乗算器５１３に出力する。

【００５０】したがって、乗算器５０７では、送信データを復調するための、拡散符号系列を重畳したパルスが受信信号に乗算され、逆拡散処理が行われる。乗算器５０７の乗算結果は、積分器５０８に出力され、積分器５０８で積分されて受信データとして出力される。

【００５１】また、乗算器５１０では、遅延器５０６の出力より１／２パルス幅先行したタイミングで、拡散符号系列を重畳したパルスが受信信号に乗算され、逆拡散処理が行われる。また、乗算器５１３では、遅延器５０６の出力より１／２パルス幅遅延した、拡散符号系列を重畳したパルスが受信信号に乗算され、逆拡散処理が行われる。

【００５２】乗算器５１０の乗算結果は、積分器５１１に出力され、積分器５１１で積分されて差分器５１５に

出力される。乗算器５１３の乗算結果は、積分器５１４に出力され、積分器５１４で積分されて差分器５１５に出力される。

【００５３】差分器５１５では、積分器５１１の出力と積分器５１４の出力の差分をとり、その差分をループフィルタ５１６に出力する。この差分についてループフィルタ５１６でフィルタリングした出力（差分）をシンセサイザ５０３にフィードバックすることによってウルトラワイドバンド信号を受信するためのタイミング同期が図られる。受信タイミングオフセットが前後にずれた場合にはタイミングオフセット信号として正負の値を出力する。参照符号５０９は、このようなタイミング同期を行うタイミング同期回路（ＤＬＬ：Delay Lock Loop）を示す。

【００５４】再び図4に戻って無線受信装置の構成例の説明を続ける。受信タイミング制御手段４０２は、無線送信装置が用いた配列パターンを用いて受信手段４０１が所定のタイミングで、受信信号の内必要な細分化スロットに対応する部分を受信するように制御する。例えば、先に送信装置の説明においてあげたスロット番号４，３，６，５に相当するスロット化データを、１１，４４，５８，７９のタイミングで送信手段に送信させる例によれば、受信タイミング制御手段４０２は１１，４４，５８，７９のタイミングで受信手段４０１に受信させるように制御する。スロット配列制御手段４０５は、前記配列パターンを参照して、フレームの１１，４４，５８，７９番スロットに対応する部分を復調するように制御する。端末の初期状態（電源ＯＮ直後など）では、配列パターンの同期を獲得する必要があるため、相関器４０６が必要となる。相関器の動作の具体的説明は後述する。

【００５５】スロット配列手段４０３は、受信手段４０１から出力される受信データを受け取る。スロット配列手段４０３は、受信データをスロット配列制御手段４０５の制御により当初の順番となるように配列を行う。例えば前記の例によれば、スロット配列手段４０３が受け取ったスロット化データは、スロット番号4，３，６，５の順になっているので、これを当初の順番であるスロット番号3，４，５、6となるように配列を行う。

【００５６】エラー訂正手段４０３は、配列されたスロット化データをまずデインターリーブ(De-Interleave)し、その後誤り訂正を行うことによって、情報データを生成し、出力する。

【００５７】この構成により、無線受信装置は前記の無線送信装置から送信された情報データを復元することができる。

【００５８】［無線送信装置及び無線受信装置の動作］次に、本実施の形態における無線送信装置及び無線受信装置の動作について説明する。まず、無線送信装置は、１フレーム時間に対応する情報データを、符号化及びインターリーブ手段２０１により符号化する。さらに符号化された情報ビットを符号化手段２０１によりインターリーブし、インターリーブした情報ビットを１スロット分のデータ（ビット）毎にスロット化データとしてまとめる。

【００５９】その後無線送信装置は、送信タイミング制御手段２０３によって予め定められたスロット配列パターンにしたがって決められたタイミングで該スロット化データを送信手段２０４に送信させる。

【００６０】無線送信装置から送信された無線信号は、伝送路で干渉波などの妨害をうけて受信信号として無線受信装置に到達する。

【００６１】無線受信装置は、受信タイミング制御手段４０２が前記予め定められたスロット配列パターン（送信装置が用いたスロットパターンと同一）に応じて、受信信号のうち必要なスロット部分を受信するように受信手段４０１を制御する。

【００６２】受信タイミング制御手段４０２によってタイミング制御されている受信手段４０１は、配列されたスロット化データを出力する。配列されたスロット化データはスロット配列手段４０３によって、前記スロット配列パターンに応じて配列されたスロット化データを配列する。

【００６３】スロット配列手段４０３によって配列されたスロット化データは、エラー訂正手段４０４によってデ・インターリーブ及び誤り訂正を施され、情報データに変換される。これにより、無線受信装置は、無線送信装置から送信された情報データを得ることができる。

【００６４】［本実施の形態にかかる無線ネットワークの動作例］次に、本実施の形態にかかる無線ネットワークの動作例について説明し、ランダムスロットアサイン（Random Slot Assign）方法と、それにより干渉波をどう扱うかをしめす。図6は、２つのネットワークＰＡＮＸ６０１とＰＡＮＹ６０２が近接して配置されている様子を示している。

【００６５】ネットワークＰＡＮＸ６０１は、基地局Ｘ６０３と、該基地局Ｘ６０３によって制御される端末局Ａ６０５、端末局Ｂ６０６、端末局Ｃ６０７および端末局Ｆ６１０とにより構成される。一方、ネットワークＰＡＮＹ６０２は、基地局Ｙ６０２と、該基地局Ｙ６０２によって制御される端末局Ｄ６０８および端末局Ｅ６０９とにより構成されている。なお、基地局及び各端末局は本実施の形態における無線送信装置、及び無線受信装置として機能する。

【００６６】また、端末局Ｃ６０７と端末局Ｅ６０９は、両局が同時に無線送信をした場合に一方の無線送信信号が他方の無線送信信号に無視できない妨害を与えるような距離にあるものとする。

【００６７】また、ネットワークＰＡＮＸ６０１と、ネットワークＰＡＮＹ６０２は互いに独立に運用されてい

て、互いに調整されていない（Uncoordinate）状態で運用されているものとする。

【００６８】図7は、ネットワークＰＡＮＸ６０１における、ある時点でのランダムスロットアサイン方法によるフレームの使用を説明する図である。図7(A)は、あるフレームにおけるチャネル割り当て状態を示している。このチャネル割り当ては、一般的には基地局が行う。この例では、ビーコン７０１，端末局Aへのユーザ割当領域７０２，端末局Ｂへのユーザ割当領域７０３，端末局Ｆへのユーザ割当領域７０４，コンテンション・ピリオド７０５がフレームに含まれている。端末局Ｆへのユーザ割当領域７０４においては、端末局Ｆ６１０から端末局Ｃ６０７に宛てての送信が行われる。

【００６９】図7(B)は、端末局Fへのユーザ割当領域７０４において送信される情報が複数の細分化スロットに割り付けられている状態を示す図である。ユーザ割当領域７０４は、細分化スロット７０６Ｌ、７０６Ｌ＋１、７０６Ｌ＋２，７０６Ｌ＋３、…、７０６Ｍに対応する。なお、Ｌは、ユーザ割当領域７０４の開始位置に対応するスロット番号、Mはユーザ割当領域７０４の終了位置に対応するスロット番号を表すものとする。

【００７０】端末局Fは、所定のスロット配列パターンに応じて、細分化スロットの配列を行い、該スロット配列パターンに応じたタイミングで情報データを送信する。図７（Ｃ）は、端末局Fが送信データをスロット配列パターンに応じたタイミングで送信する様子を示している。この例では、図7(B)におけるスロット７０６Ｌは、フレーム中の第3スロットのタイミングで送信され、スロット７０６Ｌ＋１は、フレーム中の第7スロットのタイミングで送信され、スロット７０６Ｌ＋２は、フレーム中の第１１スロットのタイミングで送信され、スロット７０６Ｌ＋３は、フレーム中の第１４スロットのタイミングで送信され、…、スロット７０６Ｍは、フレーム中の第（Ｎ－７）スロットのタイミングで送信される。このようにして、送信データはスロット配列パターンに応じたタイミングで送信される。

【００７１】スロット配列パターンは、スロット化データをフレーム内にランダムに配置するためのパターンであって、例えば所定の乱数によりスロット番号をシャッフル（permutate）することによって生成される。また、スロット配列パターンは１つのみでなく複数のものを用いるようにしても良い。但し、同一ネットワーク内における全ての基地局および端末局は所定の生成規則に従ってランダム化されていることを予め把握していることが望ましい。フレームの先頭を示すビーコンを含めてスロットをシャッフルしてしまうからである。

【００７２】図7(D)は、端末局F（端末局C宛の通信のためのリソース）へのユーザ割当領域７０４のみでなく、１フレーム全体、すなわちビーコン７０１，端末局Aへのユーザ割当領域７０２，端末局Bへのユーザ割当領域７０３，コンテンション・ピリオド７０５が細分化スロットに分割され、さらにこれらスロット位置を組みかえて送信されている様子を示す図である。図に示す例では、データ７０７は、端末局Aによってスロット配列パターンに応じたタイミングで送信されたデータの一つであり、データ７０８は、基地局によってスロット配列パターンに応じたタイミングで送信されたデータの一つ（ビーコンの一部）であり、データ７０９は、端末局Ｆによってスロット配列パターンに応じたタイミングで送信されたデータの一つであり、データ７１０は、端末局Ｂによってスロット配列パターンに応じたタイミングで送信されたデータの一つであり、データ７１１は、端末局のいずれかによってスロット配列パターンに応じたタイミングで送信されたデータの一つ（コンテンション・ピリオドで送信されるデータの一部）である。

【００７３】次に、端末局Ｃ６０７が端末局Ｆから送信された信号を受け取るに際して、他のパーソナル・エリア・ネットワークに属する端末局Ｅからの送信信号による干渉を受ける様子を説明する。

【００７４】図８（Ａ）は、ネットワークＰＡＮＹ６０２におけるフレームの送信状況を示す図である。ネットワークＰＡＮＹ６０２においても、ネットワークＰＡＮＸ６０１と全く独立のランダムスロットアサイン方法によってデータがランダムにフレーム内に配されて送信が行われている。図中、端末局Ｅにより送信されるデータを符号８０１によって示す。

【００７５】図８（Ｂ）はネットワークＰＡＮＸ６０１におけるフレームの送信状況を示す図であって、図７（Ｄ）と同じである。

【００７６】端末局Ｅからの送信データは、端末局Ｃがデータを受信するタイミング８０２において妨害を与えている。

【００７７】図8(C)は端末局Cが前記スロット配列パターンに応じたタイミングで受信信号のうち必要な部分を受信した信号を集めた様子を示している。集められた信号は端末局Ｅからの送信信号による干渉を受けないデータに対応する部分８０３と、端末局Ｅからの送信信号による干渉を受けるデータに対応する部分８０４とを有している。

【００７８】この集められたデータは、デ・インターリーブされ、符号化データに戻され、符号化データはエラー訂正により復号され、受信情報ビットが得られる。

【００７９】ここに示したように、ランダムスロットアサイン方法によって、フレーム内のランダムなスロット位置に配列されている端末局Ｅの送信信号は、端末局Ｃの受信に際し、確率的に低い確率で妨害を与えているのみであるので、この妨害によって生じたエラーは訂正され正しく復号されることが期待できる。

【００８０】［コンテンション・ピリオドの使い方］次に、ランダムスロットアサイン方法におけるコンテンシ

ョン・ピリオドの扱いについて説明する。

【0081】コンテンション・ピリオドに相当するスロットを使用する場合において、かかるスロットを使用する端末局は、所定の数（たとえば8）の連続したスロットを最小単位として利用する。連続したスロットを使用すれば、ランダムスロットアサイン方法におけるスロット配列パターンに従って、フレーム内にランダムに配置されるので、コンテンション・ピリオドにおいて送信するスロット化データについても、図8(C)に例示するような他の局の送信信号に対してランダムな部分的干渉を与えることになり、あるいは他の局の送信信号からランダムな干渉を被るようになるので、この妨害によって生じたエラーは訂正され正しく復号されることが期待できる。

【0082】［スロット配列の方法について］次に、本実施の形態におけるランダムスロットアサイン方法のスロットの配列方法について説明する。スロットの配列方法は、他の局の送信信号に対してランダムな部分的干渉を与えることになり、あるいは他の局の送信信号からランダムな干渉を被るようにする配列方法であればいずれであっても良く、たとえば以下のような配列方法が考えられる。0．図7に示したように、フレーム内の1チャネルを1フレーム全体にランダムに配列する方法である。説明は省略する。1．1フレーム若しくは1チャネル内の1番からN番までのN個のスロットを完全にランダムに配列する方法がある。図9（A）は、配列前のスロットを示し、図9(B)はN個のスロットがランダムに配列される様子を示している。2．別の配列方法として、スロットをグループ化してからランダムに配列する方法がある。この方法を図10（A）から(C)を参照しながら説明する。

【0083】まず、図10(A)に示すように、N個のスロットからなるフレームにおいて、J個（たとえばJ＝4）の連続したスロットを一つのグループ1001とし、N／J個のグループを作る。

【0084】次に、図10(B)に示すように、各グループ1001から1のスロットを一つずつJ個のスロット群1002に割り振る。各スロット群1002は、J個のスロットを有することになる。

【0085】最後に、各スロット群1002においてJ個のスロットをランダムに配列する。図10(C)は各スロット群1002においてJ個のスロットをランダムに配列された後の状態を示している。

【0086】この配列方法によれば、J個の連続するスロットはそれぞれ、フレーム内のJ個のブロック（スロット群）に分散して配列されることが保証され、その結果フレームの一部分に特定の領域のスロットが偏って配置されることがないようなランダムかつ分散された配置をおこなうことが可能となる。

【0087】［配列パターン同期方法］先に述べたように、本実施の形態においては、同一パーソナル・エリア・ネットワークにいる通信機（基地局、端末局双方を含む）はすべてスロット配列パターン若しくは該パターンを生成する生成規則を知っていることが望ましい。スロット配列パターンは数多くのフレームにわたって同一のものが出現しないほうが、他のネットワークの局との衝突をランダムにする目的において望ましい。

【0088】まず、図11（A）に示すように、基地局はフレーム1101毎に送信されるビーコンの1部として、同期用パターンを送信する。ところが、端末局は初期状態(電源ON直後など)では、基地局が使用するスロット配列パターン若しくはその生成規則を把握することはできるが、該スロット配列パターンのどこを今送信しているのかは知り得ない。

【0089】そこで配列パターン同期を獲得するための既知の同期用パターン（例えば細分化スロット長に等しい長さを有する同期ワード）をあらかじめ定められており、各通信機にこれを記憶させておく。この同期用パターンを含むスロットを複数用意し（1102）、これら信号列を含むスロット（同期用スロットという）1103が送信されるときはランダムスロットアサイン法によるスロット配列パターンに応じてフレーム内のランダムな位置に配置されるようにする(図11(B)参照)。

【0090】端末局側は、同期用スロット1103に含まれる配列パターンを獲得するための既知パターンに対応する相関器（図4，406）を用いて、同期用スロットの検出及び位置特定を行う。図11（C）は、かかる相関器の出力信号904を示す波形図であって、同期用スロット位置に対応した相関のピークが現れる。端末局はまず1つ1つの同期用スロットを検出する。次に同期用のパターンを検出し、検出された同期用スロットの位置パターンを記憶する。

【0091】この検出された同期用スロット位置のパターンと、スロット配列パターンとを比較して、現在送信されているスロット配列パターンの位置を特定する。これにより端末局は、スロット配列パターンのどこを送信しているのかを見つけ、それ以降は、記憶しているスロット配列パターン若しくはその生成規則を用いて、自立的に該スロット配列パターンを発生して、基地局が使用するスロット配列パターンとの同期をとることが出来る。

【0092】また、本方法によれば、矛盾なくスロット配列パターンの同期がとれることは、フレームの区切りにも同期したことになり、フレーム同期も同時に達成できることになる。

【0093】［同期用パターンの別の構成例］上述の同期用パターンは、1スロット長と同一となるような信号列を用いたが、スロット長よりも短い同期ワードの繰り返しを用いて同期用スロットを構成することも考えられる。スロット長が同期ワードの長さの整数倍になってい

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ない場合は、規則的に並べた同期ワードの繰り返しを用いる。

【0094】図１２に、規則的に並べた同期ワードの繰り返しを用いる同期用パターンの例を示す。

【0095】図１２(A)は、あるフレームにおける同期用スロット１２０１が配置されている様子を示す図である。

【0096】基地局は同期用スロット長より短い同期ワード１２０２を繰り返し生成する。図１２（Ｂ）は，同期ワードが繰り返し生成されている様子を示す図である。

【0097】基地局は、同期用スロット１２０１を窓として前記繰り返して生成される同期ワードにかけて取り出したもの（窓同期ワード）１２０３を得て、これを伝送する。図１２(C)は、取り出された窓同期ワード１２０３が同期用スロットに対応するタイミングで送信される様子を示す。

【0098】受信側では、同期ワードに対する相関をとる。最初の相関がとれれば、が異動期ワードの周期（ワード長）で巡回するカウンタ等を用いることにより、それ以降に受信する同期ワードとの同期をとることが可能となる。

【0099】かかる構成の同期方法を用いれば、同期ワードとスロット長の関係の制約を少なくすることが出来、同期ワードの選択及びスロット長の設定に関する自由度を増すことができる。

【0100】［変形例］上述の実施の形態においては、デ・インターリーブおよび符号化を行うとしたが、本実施の変形例では、妨害によってデータエラーが起こることを許容できる通信においては、相手に与える干渉をランダムにするためには行うが、自分の送信データは符号化しないようにしてもよい。

【0101】また、さらに別の変形例では、デ・インターリーブ、符号化をともに省略しても良い。

【0102】［その他の変形例］上述の無線送信装置、無線受信装置の構成例においては、中央制御部として機能するＣＰＵがＥＥＰＲＯＭなどに格納されたプログラムに基づいてランダムスロットアサイン法によるデータの無線送受信処理を行うものとしたが、本発明はこれに限らず、該プログラムが記録されたプログラム記録媒体からこのプログラムを無線送信装置、無線受信装置に読みとらせ、ランダムアサイン法によるデータの無線送受信処理の全部又は一部を無線送信装置、無線受信装置のＣＰＵに行わせるようにしても良い。

【0103】かかるプログラム記録媒体は、例えばフロッピー（登録商標）ディスク、ＣＤ−ＲＯＭ、ＤＶＤ等のパッケージメディアのみならず、プログラムが一時的若しくは永続的に格納される半導体メモリや磁気ディスクなどであってよい。また、これらプログラム記録媒体にプログラムを格納する手段としては、ローカルエリアネットワーク、インターネット、ディジタル通信衛星等の有線または無線通信手段を利用してプログラムをダウンロードし、これをプログラム記録媒体に書き込むようにしても良く、またルータやモデム等の通信機器を介在させて格納するようにしても良い。

【0104】

【発明の効果】互いに調整されていない２つ以上の無線ネットワークが相互に干渉を受ける位置に存在しても、干渉を受けるスロットと受けないスロットが存在し、干渉受けたスロットはでインターリーブ・符号化でエラー訂正され正しく伝送できる。

【図面の簡単な説明】

【図１】（Ａ）は、所定の長さを有するフレームを示す図であり、（Ｂ）は、１フレームがＮ個のスロットに分けられる様子を示す図であり、（Ｃ）は、１スロットの構成を示す図であり、（Ｄ）は、スロットに含まれる情報ビットを示す図であり、（Ｅ）は、１ビットを示すパルス列の例を示す図である。

【図２】実施の形態にかかる送信装置の構成例を示すブロック図である。

【図３】送信装置の送信手段の構成例を示すブロック図である。

【図４】実施の形態にかかる受信装置の構成例を示すブロック図である。

【図５】受信装置の受信手段の構成例を示すブロック図である。

【図６】２つの無線ネットワークの構成を示す図である。

【図７】（Ａ）は、本実施の形態におけるフレームのリソース割り当て状態を示す図であり、（Ｂ）は、ユーザ割当領域７０４のスロット化を示す図であり、（Ｃ）は、ユーザ割当領域７０４のスロット化データがスロット配列パターンに応じてフレームに配置された様子を示す図であり、（Ｄ）は全てのスロットがスロット配列パターンに応じてフレームに配置された様子を示す図である。

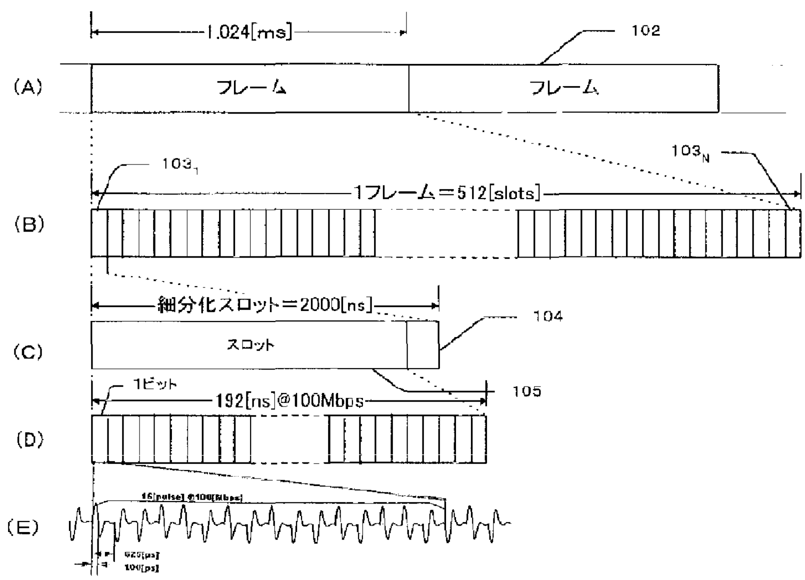
【図８】（Ａ）は、ＰＡＮＹに関するフレームを示す図であり、（Ｂ）は図７（Ｄ）に対応するＰＡＮＸに関するフレームを示す図であり、（Ｃ）は端末局Ｃが受信するスロット化データの状態を示す図である。

【図９】（Ａ）は、配列前のスロットを示す図であり、(B)はＮ個のスロットがランダムに配列される様子を示す図である。

【図１０】（Ａ）は，Ｎ個のスロットからなるフレームにおいて、Ｊ個の連続したスロットを一つのグループにする様子を示した図であり、（Ｂ）は、各グループから１のスロットを一つずつＪ個のスロット群に割り振りをした後の状態を示す図であり、（Ｃ）は、各スロット群においてＪ個のスロットをランダムに配列した後の状態を示している図である。

【図１１】（Ａ）は、同期パターンを含むフレームを示す図であり、（Ｂ）はフレーム内に同期用スロットがスロット配列パターンに応じて配列された状態を示す図であり、（Ｃ）は同期用スロットに対応する相関器の出力波形を示す図である。
【図１２】(A)は、あるフレームの位置部において同期用スロットが配置されている様子を示す図であり、同期ワードが繰り返し生成されている様子を示す図であり、(C)は、取り出された窓同期ワード１２０３が同期用スロットに対応するタイミングで送信される様子を示す図である。
【図１３】（Ａ）は、従来のＴＤＭＡフレームを示す図、（Ｂ）は従来のＴＤＭＡフレームの構成例を示す図である。
【図１４】２つのネットワークが近接して配置されている図である。
【図１５】（Ａ）は、図１４のネットワークＸにおけるフレーム構成を示す図であり、（Ｂ）は、図１４のネットワークＹにおけるフレーム構成を示す図である。
【符号の説明】
１０１、１０２ … フレーム
１０３ … 細分化スロット
１０４ … ガード・ピリオド
２０１ … 符号化（及びインターリーブ）手段
２０２ … スロット配列手段
２０３ … 送信タイミング制御手段
２０４ … 送信手段
２０６ … スロット配列制御手段
４０１ … 受信手段
４０２ … 受信タイミング制御手段
４０３ … スロット配列手段
４０４ … エラー訂正手段
４０５ … スロット配列制御手段

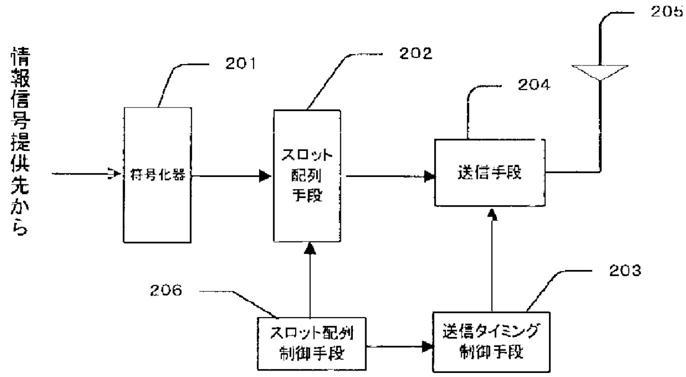
【図１】



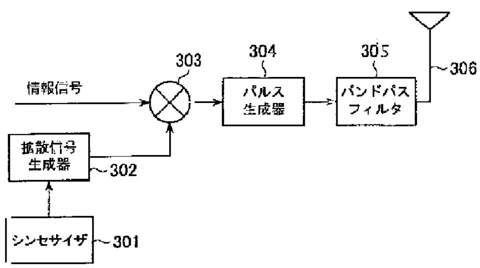

EVOLVED-0002451

ZTE/SAMSUNG 1005-0809

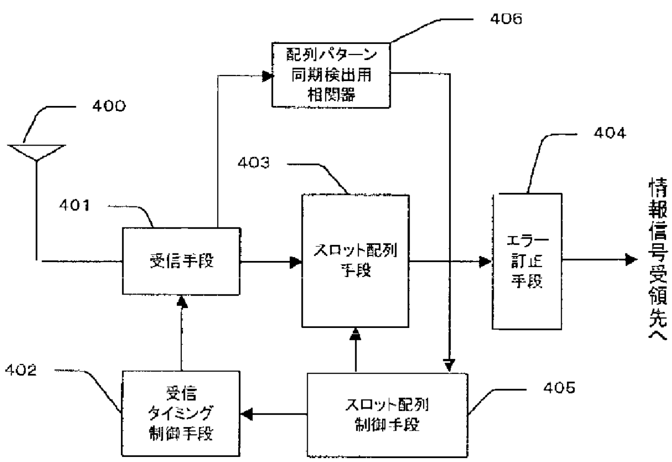
【図2】




【図3】



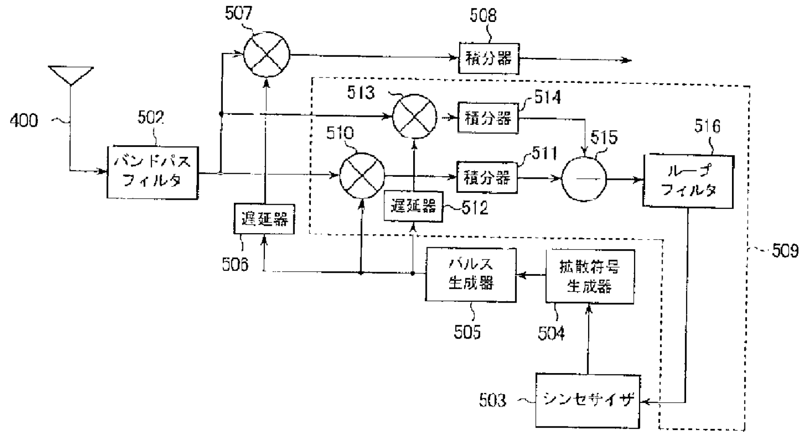

【図4】




EVOLVED-0002452

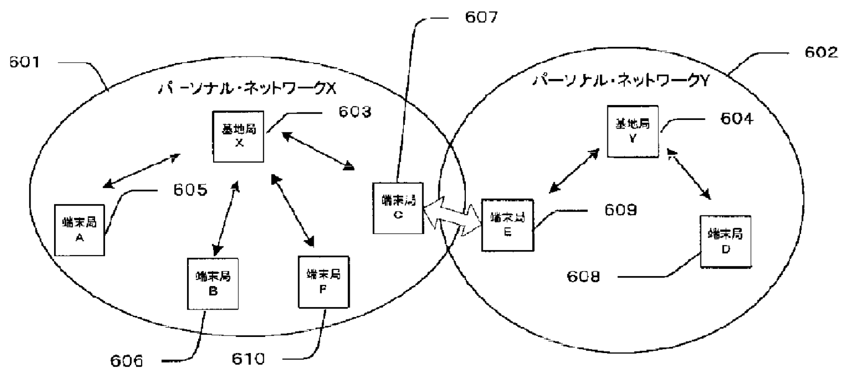
ZTE/SAMSUNG 1005-0810

【図5】



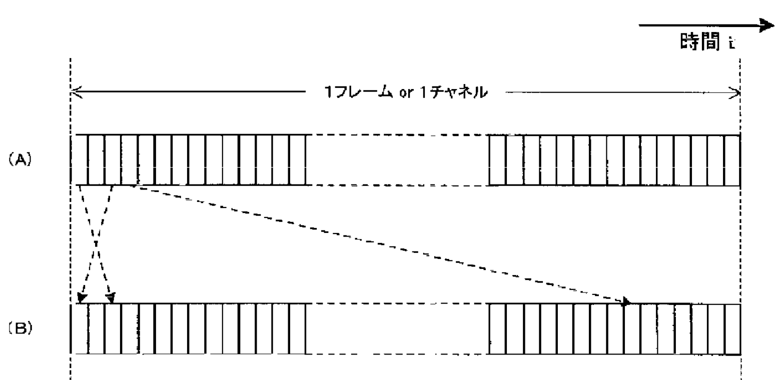
507
508
積分器
513
514
積分器
400
502
510
511
積分器
515
516
バンドパス
フィルタ
ループ
フィルタ
遅延器
512
遅延器
509
506
パルス
生成器
拡散符号
生成器
505
504
503
シンセサイザ


【図6】



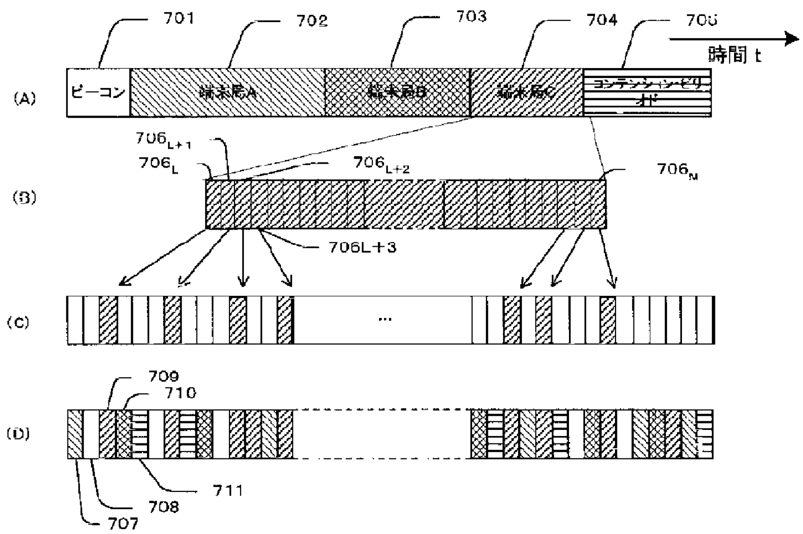
607
601
602
パーソナル・ネットワークX
パーソナル・ネットワークY
603
基地局
X
基地局
Y
604
605
端末局
A
端末局
C
端末局
E
609
端末局
D
608
端末局
B
端末局
F
606
610


【図9】

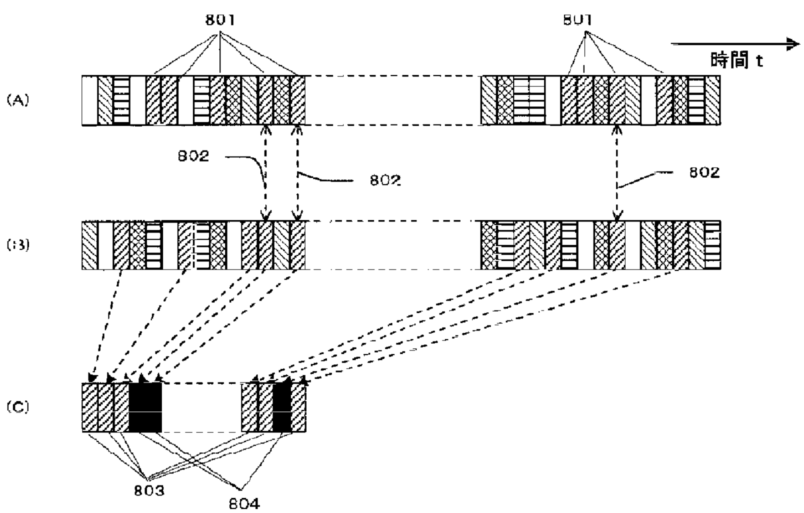


時間 t
1フレーム or 1チャネル
(A)
(B)

【図7】



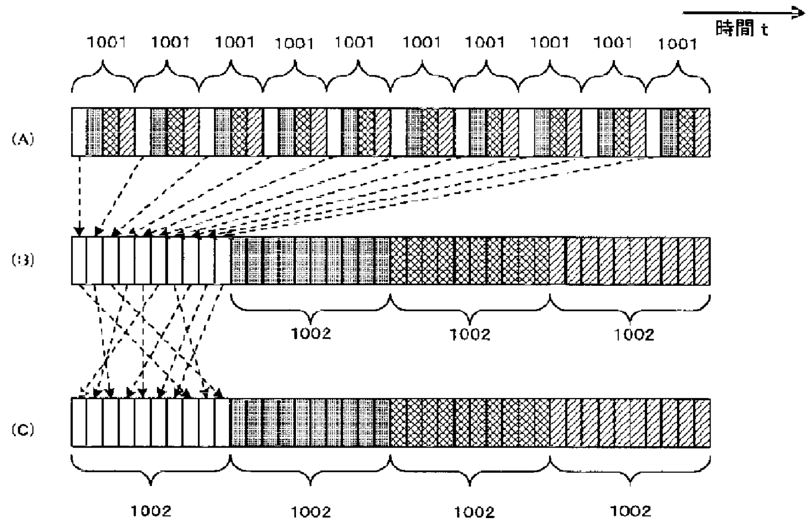

【図8】



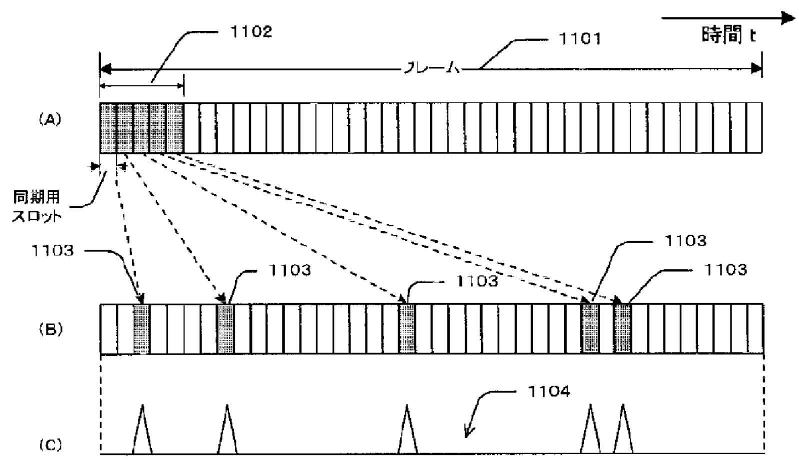

EVOLVED-0002454

ZTE/SAMSUNG 1005-0812

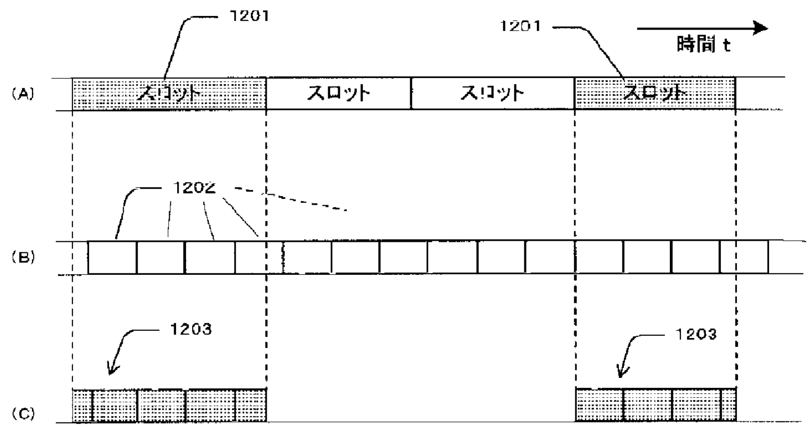
【図10】



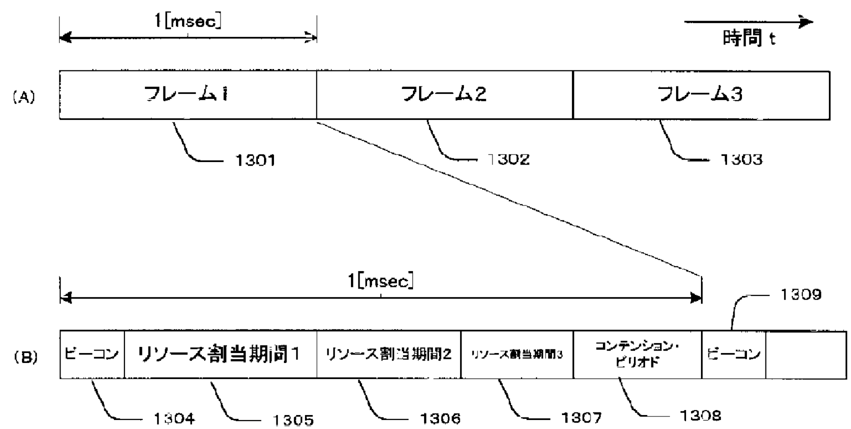

【図11】



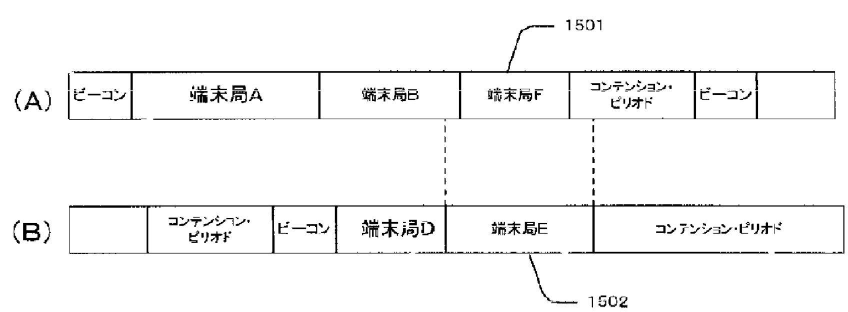
【図12】


1201
1201
時間 t
(A)
スロット
スロット
スロット
スロット
1202
(B)
1203
1203
(C)

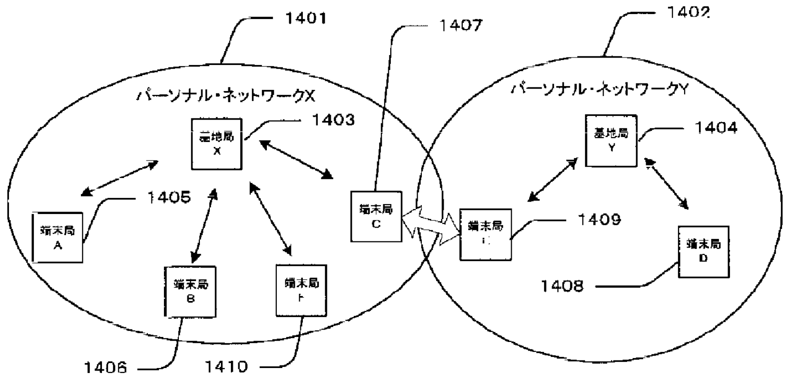
【図13】


1[msec]
時間 t
(A)
フレーム1
フレーム2
フレーム3
1301
1302
1303
1[msec]
1309
(B)
ビーコン
リソース割当期間1
リソース割当期間2
リソース割当期間3
コンテンション・ピリオド
ビーコン
1304
1305
1306
1307
1308

【図15】


1501
(A)
ビーコン
端末局A
端末局B
端末局F
コンテンション・ピリオド
ビーコン
(B)
コンテンション・ピリオド
ビーコン
端末局D
端末局E
コンテンション・ピリオド
1502

【図14】


1401
1407
1402
パーソナル・ネットワークX
パーソナル・ネットワークY
基地局
X
1403
基地局
Y
1404
1405
端末局
A
端末局
C
端末局
1409
端末局
D
1408
端末局
B
端末局
1406
1410

# Electronic Patent Application Fee Transmittal

| | |
|---|---|
| **Application Number:** | 12303947 |
| **Filing Date:** | 07-Jul-2010 |
| **Title of Invention:** | METHOD OF TRANSMITTING DATA IN A MOBILE COMMUNICATION SYSTEM |
| **First Named Inventor/Applicant Name:** | Yeong Hyeon Kwon |
| **Filer:** | David Gerard Majdali/Neeti Rajput |
| **Attorney Docket Number:** | 2101-3596 |

Filed as Large Entity

## U.S. National Stage under 35 USC 371 Filing Fees

| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
|---|---|---|---|---|
| **Basic Filing:** | | | | |
| **Pages:** | | | | |
| **Claims:** | | | | |
| **Miscellaneous-Filing:** | | | | |
| **Petition:** | | | | |
| **Patent-Appeals-and-Interference:** | | | | |
| **Post-Allowance-and-Post-Issuance:** | | | | |
| **Extension-of-Time:** | | | | |

| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
|---|---|---|---|---|
| **Miscellaneous:** | | | | |
| Submission- Information Disclosure Stmt | 1806 | 1 | 180 | 180 |
| | | **Total in USD ($)** | | **180** |

PTO/SB/08a (01-10)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE


| **INFORMATION DISCLOSURE STATEMENT BY APPLICANT** ( **Not for submission under 37 CFR 1.99)** | | |
|---|---|---|
| | Application Number | 12303947 |
| | Filing Date | 2010-07-07 |
| | First Named Inventor | Yeong Hyeon Kwon |
| | Art Unit | 2478 |
| | Examiner Name | KHAJURIA, SHRIPAL K |
| | Attorney Docket Number | 2101-3596 |

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|---|---|---|---|---|---|---|---|---|
| | 1 | 2000102067 | JP | | 2000-04-07 | MITSUBISHI ELECTRIC CORP | | ☐ |
| | 2 | 2001268051 | JP | | 2001-09-28 | NTT DOCOMO INC | | ☐ |
| | 3 | 2003179576 | JP | | 2003-06-27 | SONY CORP | | ☐ |

| INFORMATION DISCLOSURE STATEMENT BY APPLICANT ( Not for submission under 37 CFR 1.99) | Application Number | 12303947 |
|---|---|---|
| | Filing Date | 2010-07-07 |
| | First Named Inventor | Yeong Hyeon Kwon |
| | Art Unit | 2478 |
| | Examiner Name | KHAJURIA, SHRIPAL K |
| | Attorney Docket Number | 2101-3596 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 4 | 2005/055527 | WO | | 2005-06-16 | QUALCOMM INC | | ☐ |

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| Examiner Initials* | Cite No | Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published. | T[5] |
|---|---|---|---|
| | 1 | | ☐ |

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**EXAMINER SIGNATURE**

| Examiner Signature | | Date Considered | |
|---|---|---|---|

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

| **INFORMATION DISCLOSURE STATEMENT BY APPLICANT** ( Not for submission under 37 CFR 1.99) | Application Number | 12303947 |
|---|---|---|
| | Filing Date | 2010-07-07 |
| | First Named Inventor | Yeong Hyeon Kwon |
| | Art Unit | 2478 |
| | Examiner Name | KHAJURIA, SHRIPAL K |
| | Attorney Docket Number | 2101-3596 |

**CERTIFICATION STATEMENT**

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

**OR**

☒ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☒ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☐ A certification statement is not submitted herewith.

**SIGNATURE**

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

| Signature | /David Majdali/ | Date (YYYY-MM-DD) | 2012-04-18 |
|---|---|---|---|
| Name/Print | David Majdali | Registration Number | 53,257 |

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5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

# Electronic Acknowledgement Receipt

| | |
|---|---|
| **EFS ID:** | 12576106 |
| **Application Number:** | 12303947 |
| **International Application Number:** | |
| **Confirmation Number:** | 1730 |
| **Title of Invention:** | METHOD OF TRANSMITTING DATA IN A MOBILE COMMUNICATION SYSTEM |
| **First Named Inventor/Applicant Name:** | Yeong Hyeon Kwon |
| **Customer Number:** | 35884 |
| **Filer:** | David Gerard Majdali/Neeti Rajput |
| **Filer Authorized By:** | David Gerard Majdali |
| **Attorney Docket Number:** | 2101-3596 |
| **Receipt Date:** | 18-APR-2012 |
| **Filing Date:** | 07-JUL-2010 |
| **Time Stamp:** | 21:20:17 |
| **Application Type:** | U.S. National Stage under 35 USC 371 |

## Payment information:

| | |
|---|---|
| Submitted with Payment | yes |
| Payment Type | Deposit Account |
| Payment was successfully received in RAM | $180 |
| RAM confirmation Number | 9583 |
| Deposit Account | 502290 |
| Authorized User | |

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

Charge any Additional Fees required under 37 C.F.R. Section 1.21 (Miscellaneous fees and charges)

## File Listing:

| Document Number | Document Description | File Name | File Size(Bytes)/ Message Digest | Multi Part /.zip | Pages (if appl.) |
|---|---|---|---|---|---|
| 1 | Information Disclosure Statement (IDS) Form (SB08) | 2101-3596_41812_IDSform.pdf | 612340<br>b9528ae1ec3c82a35848e04e21816f51ce2d3311 | no | 4 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| A U.S. Patent Number Citation or a U.S. Publication Number Citation is required in the Information Disclosure Statement (IDS) form for autoloading of data into USPTO systems. You may remove the form to add the required data in order to correct the Informational Message if you are citing U.S. References. If you chose not to include U.S. References, the image of the form will be processed and be made available within the Image File Wrapper (IFW) system. However, no data will be extracted from this form. Any additional data such as Foreign Patent Documents or Non Patent Literature will be manually reviewed and keyed into USPTO systems. | | | | | |
| 2 | Foreign Reference | JP2000-102067.pdf | 773765<br>209f729cdc8011ef4636f7b902cc103d300df036 | no | 9 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 3 | Foreign Reference | JP2001-268051.pdf | 1963524<br>d2b0ef62f7e495eba21ddb750195bd45dc94bcc9 | no | 24 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 4 | Foreign Reference | JP2003-179576.pdf | 1870793<br>51772502832c3b251b1d808d950b011d69aceaa6 | no | 20 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 5 | Foreign Reference | WO2005-055527.pdf | 6926599<br>9052ceb9b6ce3d8a50d2838b330cf12daafbc7a3 | no | 56 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 6 | Fee Worksheet (SB06) | fee-info.pdf | 30788<br>f31749793a85a3e27a2195ab87425522573da4a4 | no | 2 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| | | **Total Files Size (in bytes):** | 12177809 | | |

**This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.**

**New Applications Under 35 U.S.C. 111**
**If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.**

**National Stage of an International Application under 35 U.S.C. 371**
**If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.**

**New International Application Filed with the USPTO as a Receiving Office**
**If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.**

| **INFORMATION DISCLOSURE STATEMENT BY APPLICANT** ( **Not for submission under 37 CFR 1.99)** | | |
|---|---|---|
| | Application Number | 12303947 |
| | Filing Date | 2010-07-07 |
| | First Named Inventor | Yeong Hyeon Kwon |
| | Art Unit | 2478 |
| | Examiner Name | KHAJURIA, SHRIPAL K |
| | Attorney Docket Number | 2101-3596 |

**U.S.PATENTS** Remove

| Examiner Initial* | Cite No | Patent Number | Kind Code[1] | Issue Date | Name of Patentee or Applicant of cited Document | Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear |
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| | 1 | | | | | |

If you wish to add additional U.S. Patent citation information please click the Add button. Add

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| Examiner Initial* | Cite No | Publication Number | Kind Code[1] | Publication Date | Name of Patentee or Applicant of cited Document | Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear |
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**FOREIGN PATENT DOCUMENTS** Remove

| Examiner Initial* | Cite No | Foreign Document Number[3] | Country Code[2] i | Kind Code[4] | Publication Date | Name of Patentee or Applicant of cited Document | Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear | T[5] |
|---|---|---|---|---|---|---|---|---|
| /S.K./ | 1 | 2000102067 | JP | | 2000-04-07 | MITSUBISHI ELECTRIC CORP | | ☐ |
| /S.K./ | 2 | 2001268051 | JP | | 2001-09-28 | NTT DOCOMO INC | | ☐ |
| /S.K./ | 3 | 2003179576 | JP | | 2003-06-27 | SONY CORP | | ☐ |

| | | |
|---|---|---|
| **INFORMATION DISCLOSURE STATEMENT BY APPLICANT** ( **Not for submission under 37 CFR 1.99)** | Application Number | 12303947 |
| | Filing Date | 2010-07-07 |
| | First Named Inventor | Yeong Hyeon Kwon |
| | Art Unit | 2478 |
| | Examiner Name | KHAJURIA, SHRIPAL K |
| | Attorney Docket Number | 2101-3596 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| /S.K./ | 4 | 2005/055527 | WO | | 2005-06-16 | QUALCOMM INC | | ☐ |

If you wish to add additional Foreign Patent Document citation information please click the Add button Add

**NON-PATENT LITERATURE DOCUMENTS** Remove

| Examiner Initials* | Cite No | Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published. | T5 |
|---|---|---|---|
| | 1 | | ☐ |

If you wish to add additional non-patent literature document citation information please click the Add button Add

**EXAMINER SIGNATURE**

| | | | |
|---|---|---|---|
| Examiner Signature | /Shripal Khajuria/ | Date Considered | 04/24/2012 |

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

| INFORMATION DISCLOSURE STATEMENT BY APPLICANT ( Not for submission under 37 CFR 1.99) | | |
|---|---|---|
| | Application Number | 12303947 |
| | Filing Date | 2010-07-07 |
| | First Named Inventor | Yeong Hyeon Kwon |
| | Art Unit | 2478 |
| | Examiner Name | KHAJURIA, SHRIPAL K |
| | Attorney Docket Number | 2101-3596 |

**CERTIFICATION STATEMENT**

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

**OR**

☒ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☒ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☐ A certification statement is not submitted herewith.

**SIGNATURE**

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

| Signature | /David Majdali/ | Date (YYYY-MM-DD) | 2012-04-18 |
|---|---|---|---|
| Name/Print | David Majdali | Registration Number | 53,257 |

## Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

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9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Customer No. 035884 Docket No. 2101-3596

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

| | |
|---|---|
| In re application of: Yeong Hyeon KWON et al. | Art Unit: 2478 |
| Serial No.: 12/303,947 | Examiner: Khajuria, Shripal K. |
| Filed: July 7, 2010 | Conf. No. 1730 |
| For: METHOD OF TRANSMITTING DATA IN A MOBILE COMMUNICATION SYSTEM | |

**AMENDMENT AFTER NOTICE OF ALLOWANCE (NOA) PURSUANT TO 37 CFR 1.312**

Mail Stop Issue Fee
Commissioner for Patents
P. O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

In response to the Notice of Allowance dated March 6, 2012, for which the Issue Fee is due June 6, 2012, this paper is submitted prior to payment of the Issue Fee. Applicant respectfully requests that the Examiner amend the above-identified application as follows prior to issuance:

IN THE SPECIFICATION:

Please amend the first paragraph at line 1 on page 1 as follows:

This application is the National Stage filing under 35 U.S.C. § 371 of International Application No. PCT/KR07/02784, filed on ~~January~~ June 8, 2007, which claims the benefit of earlier filing date and right of priority to Korean Application Nos. 10-2006-0052167, filed on June 9, 2006, and 10-2006-0057488, filed on June 26, 2006.

## REMARKS

Claims 31-46, which are all the claims in the application, have been allowed. Applicant respectfully submits that the amendments to the specification are intended to correct formal matters and do not change the scope of the claims.

The foregoing amendment to the specification corrects a typographical error in the filing date of PCT Application No. PCT/KR07/02784. It is respectfully noted that the filing date of June 8, 2007 was correctly listed on PCT Publication No. WO 2007/042492, and on the Declaration/Power of Attorney filed on July 7, 2010.

The specification has been amended to reflect the issued status of the parent application. No new matter has been added to the specification. In view of the allowance of claims 31-46, which have not been amended with this paper, it is respectfully submitted that claims 31-46 are still in condition for allowance. The Examiner is requested to issue a Response to Rule 312 Communication (PTO-271) as soon as possible.

If for any reason the Examiner finds the proposed amendments not in condition for entry or if further changes are deemed necessary, the Examiner is requested to call the undersigned attorney at the Los Angeles, California, telephone number (213) 623-2221.

Respectfully Submitted,
LEE, HONG, DEGERMAN, KANG & WAIMEY

Date: May 3, 2012

By: /Ali Atefi/
Ali Atefi
Registration No. 63,960
Attorney for Applicant(s)

Customer No. 035884

# Electronic Acknowledgement Receipt

| | |
|---|---|
| **EFS ID:** | 12700958 |
| **Application Number:** | 12303947 |
| **International Application Number:** | |
| **Confirmation Number:** | 1730 |
| **Title of Invention:** | METHOD OF TRANSMITTING DATA IN A MOBILE COMMUNICATION SYSTEM |
| **First Named Inventor/Applicant Name:** | Yeong Hyeon Kwon |
| **Customer Number:** | 35884 |
| **Filer:** | Ali. Atefi/Anna Tounian |
| **Filer Authorized By:** | Ali. Atefi |
| **Attorney Docket Number:** | 2101-3596 |
| **Receipt Date:** | 03-MAY-2012 |
| **Filing Date:** | 07-JUL-2010 |
| **Time Stamp:** | 19:13:05 |
| **Application Type:** | U.S. National Stage under 35 USC 371 |

## Payment information:

| | |
|---|---|
| Submitted with Payment | no |

## File Listing:

| Document Number | Document Description | File Name | File Size(Bytes)/ Message Digest | Multi Part /.zip | Pages (if appl.) |
|---|---|---|---|---|---|
| 1 | | 2101-3596-312Amendment.pdf | 82611<br>32c07c3c8627f173b08d1939ff6f909c084e280a | yes | 3 |

| | Multipart Description/PDF files in .zip description | | |
|---|---|---|---|
| | **Document Description** | **Start** | **End** |
| | Amendment after Notice of Allowance (Rule 312) | 1 | 1 |
| | Specification | 2 | 2 |
| | Applicant Arguments/Remarks Made in an Amendment | 3 | 3 |

**Warnings:**

**Information:**

| | |
|---|---|
| **Total Files Size (in bytes):** | 82611 |

**This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.**

**New Applications Under 35 U.S.C. 111**
**If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.**

**National Stage of an International Application under 35 U.S.C. 371**
**If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.**

**New International Application Filed with the USPTO as a Receiving Office**
**If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.**

## PART B - FEE(S) TRANSMITTAL

**Complete and send this form, together with applicable fee(s), to: Mail** **Mail Stop ISSUE FEE**
**Commissioner for Patents**
**P.O. Box 1450**
**Alexandria, Virginia 22313-1450**
**or Fax (571)-273-2885**

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

35884 7590 03/06/2012

LEE, HONG, DEGERMAN, KANG & WAIMEY
660 S. FIGUEROA STREET
Suite 2300
LOS ANGELES, CA 90017

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

**Certificate of Mailing or Transmission**

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

| |
|---|
| (Depositor's name) |
| (Signature) |
| (Date) |

| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 12/303,947 | 07/07/2010 | Yeong Hyeon Kwon | 2101-3596 | 1730 |

TITLE OF INVENTION: METHOD OF TRANSMITTING DATA IN A MOBILE COMMUNICATION SYSTEM

| APPLN. TYPE | SMALL ENTITY | ISSUE FEE DUE | PUBLICATION FEE DUE | PREV. PAID ISSUE FEE | TOTAL FEE(S) DUE | DATE DUE |
|---|---|---|---|---|---|---|
| nonprovisional | NO | $1740 | $300 | $0 | $2040 | 06/06/2012 |

| EXAMINER | ART UNIT | CLASS-SUBCLASS |
|---|---|---|
| KHAJURIA, SHRIPAL K | 2478 | 370-328000 |

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list

(1) the names of up to 3 registered patent attorneys or agents OR, alternatively,

(2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 LEE, HONG, DEGERMAN, KANG & WAIMEY
2
3

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE: LG ELECTRONICS INC.

(B) RESIDENCE: (CITY and STATE OR COUNTRY): SEOUL, REPUBLIC OF KOREA

Please check the appropriate assignee category or categories (will not be printed on the patent) : ☐ Individual ☑ Corporation or other private group entity ☐ Government

4a. The following fee(s) are submitted:
- ☑ Issue Fee
- ☑ Publication Fee (No small entity discount permitted)
- ☐ Advance Order - # of Copies ____

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**
- ☐ A check is enclosed.
- ☑ Payment by credit card. Form PTO-2038 is attached.
- ☑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number 50-2290 (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)
- ☐ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.
- ☐ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature /Ali Atefi/ Date June 5, 2012

Typed or printed name Ali Atefi Registration No. 63,960

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

## Electronic Patent Application Fee Transmittal

| | |
|---|---|
| **Application Number:** | 12303947 |
| **Filing Date:** | 07-Jul-2010 |
| **Title of Invention:** | METHOD OF TRANSMITTING DATA IN A MOBILE COMMUNICATION SYSTEM |
| **First Named Inventor/Applicant Name:** | Yeong Hyeon Kwon |
| **Filer:** | Ali. Atefi/Anna Tounian |
| **Attorney Docket Number:** | 2101-3596 |

Filed as Large Entity

### U.S. National Stage under 35 USC 371 Filing Fees

| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
|---|---|---|---|---|
| **Basic Filing:** | | | | |
| **Pages:** | | | | |
| **Claims:** | | | | |
| **Miscellaneous-Filing:** | | | | |
| **Petition:** | | | | |
| **Patent-Appeals-and-Interference:** | | | | |
| **Post-Allowance-and-Post-Issuance:** | | | | |
| Utility Appl issue fee | 1501 | 1 | 1740 | 1740 |
| Publ. Fee- early, voluntary, or normal | 1504 | 1 | 300 | 300 |

| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
|---|---|---|---|---|
| **Extension-of-Time:** | | | | |
| **Miscellaneous:** | | | | |
| | **Total in USD ($)** | | | **2040** |

# Electronic Acknowledgement Receipt

| | |
|---|---|
| **EFS ID:** | 12943035 |
| **Application Number:** | 12303947 |
| **International Application Number:** | |
| **Confirmation Number:** | 1730 |
| **Title of Invention:** | METHOD OF TRANSMITTING DATA IN A MOBILE COMMUNICATION SYSTEM |
| **First Named Inventor/Applicant Name:** | Yeong Hyeon Kwon |
| **Customer Number:** | 35884 |
| **Filer:** | Ali. Atefi/Anna Tounian |
| **Filer Authorized By:** | Ali. Atefi |
| **Attorney Docket Number:** | 2101-3596 |
| **Receipt Date:** | 05-JUN-2012 |
| **Filing Date:** | 07-JUL-2010 |
| **Time Stamp:** | 21:43:17 |
| **Application Type:** | U.S. National Stage under 35 USC 371 |

## Payment information:

| | |
|---|---|
| Submitted with Payment | yes |
| Payment Type | Credit Card |
| Payment was successfully received in RAM | $2040 |
| RAM confirmation Number | 7133 |
| Deposit Account | 502290 |
| Authorized User | LEE, HONG, DEGERMAN, KANG & WAIMEY |

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

Charge any Additional Fees required under 37 C.F.R. Section 1.21 (Miscellaneous fees and charges)

## File Listing:

| Document Number | Document Description | File Name | File Size(Bytes)/ Message Digest | Multi Part /.zip | Pages (if appl.) |
|---|---|---|---|---|---|
| 1 | Transmittal Letter | 2101-3596-Transmittal-IssueFee.pdf | 71729<br>9d19c73a415a8c2b0c626b2d5fae41f2cbd317d7 | no | 1 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 2 | Issue Fee Payment (PTO-85B) | 2101-3596-IssueFeeForm.pdf | 340824<br>2c05cdaff912f14d9e01bf499ce687525dc6a2ac | no | 1 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 3 | Fee Worksheet (SB06) | fee-info.pdf | 32110<br>d9b4c521d5b0c937c5d9da11ea1f4ac40511ba14 | no | 2 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| | | | **Total Files Size (in bytes):** | 444663 | |

**This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.**

**New Applications Under 35 U.S.C. 111**
**If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.**

**National Stage of an International Application under 35 U.S.C. 371**
**If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.**

**New International Application Filed with the USPTO as a Receiving Office**
**If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.**

**Customer No. 035884** **Docket No. 2101-3596**

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

| | |
|---|---|
| In re application of: Yeong Hyeon KWON et al. | Art Unit: 2478 |
| Serial No.: 12/303,947 | Examiner: Khajuria, Shripal K. |
| Filed: July 7, 2010 | Conf. No. 1730 |
| For: METHOD OF TRANSMITTING DATA IN A MOBILE COMMUNICATION SYSTEM | |

**TRANSMITTAL OF ISSUE FEE**

Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

In response to the Notice of Allowance dated March 6, 2012, enclosed are the following:

☒ Form Part B - Issue Fee Transmittal.

☒ Inventor(s) or Assignee(s) is entitled to **LARGE** entity.

☒ The Commissioner is hereby authorized to charge the Issue Fee in the amount of $2,040 to the credit card and any deficiency in payment or credit any overpayment to **Deposit Account No. 502290.**

Respectfully submitted,

Lee, Hong, Degerman, Kang & Waimey

Date: June 5, 2012

By: /Ali Atefi/
Ali Atefi
Registration No. 63,960
Attorney for Applicant(s)

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

| APPLICATION NO. | ISSUE DATE | PATENT NO. | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 12/303,947 | 07/10/2012 | 8218481 | 2101-3596 | 1730 |

35884 7590 06/20/2012

LEE, HONG, DEGERMAN, KANG & WAIMEY
660 S. FIGUEROA STREET
Suite 2300
LOS ANGELES, CA 90017

# ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

**Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)**
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 135 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Data Management (ODM) at (571)-272-4200.

APPLICANT(s) (Please see PAIR WEB site http://pair.uspto.gov for additional applicants):

Yeong Hyeon Kwon, Gyeonggi-do, KOREA, REPUBLIC OF;
Seung Hee Han, Gyeonggi-do, KOREA, REPUBLIC OF;
Hyun Hwa Park, Gyeonggi-do, KOREA, REPUBLIC OF;
Dong Cheol Kim, Gyeonggi-do, KOREA, REPUBLIC OF;
Hyun Woo Lee, Gyeonggi-do, KOREA, REPUBLIC OF;
Min Seok Noh, Gyeonggi-do, KOREA, REPUBLIC OF;

IR103 (Rev. 10/09)

PTO/AIA/80 (07-12)
Approved for use through 11/30/2014. OMB 0651-0035
U.S. Patent and Trademark Office; U.S DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

# POWER OF ATTORNEY TO PROSECUTE APPLICATIONS BEFORE THE USPTO

I hereby revoke all previous powers of attorney given in the application identified in the attached statement under 37 CFR 3.73(c).

I hereby appoint:

[■] Practitioners associated with Customer Number: 62574

**OR**

[ ] Practitioner(s) named below (if more than ten patent practitioners are to be named, then a customer number must be used):

| Name | Registration Number | Name | Registration Number |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

As attorney(s) or agent(s) to represent the undersigned before the United States Patent and Trademark Office (USPTO) in connection with any and all patent applications assigned only to the undersigned according to the USPTO assignment records or assignments documents attached to this form in accordance with 37 CFR 3.73(c).

Please change the correspondence address for the application identified in the attached statement under 37 CFR 3.73(c) to:

[■] The address associated with Customer Number: 62574

**OR**

[ ]

| | | | |
|---|---|---|---|
| Firm or Individual Name | | | |
| Address | | | |
| City | | State | Zip |
| Country | | | |
| Telephone | | Email | |

Assignee Name and Address: TQ LAMBDA, LLC
805 Las Cimas Parkway, Suite 240
Austin, TX 78746

**A copy of this form, together with a statement under 37 CFR 3.73(c) (Form PTO/AIA/96 or equivalent) is required to be Filed in each application in which this form is used. The statement under 37 CFR 3.73(c) may be completed by one of The practitioners appointed in this form, and must identify the application in which this Power of Attorney is to be filed.**

**SIGNATURE of Assignee of Record**
The individual whose signature and title is supplied below is authorized to act on behalf of the assignee

| | | | |
|---|---|---|---|
| Signature | Abha S. Divine | Date | 2/27/14 |
| Name | Abha S. Divine | Telephone | (512) 609-1820 |
| Title | Managing Director | | |

PTO/SB/47 (03-09)
Approved for use through 05/31/2015. OMB 0651-0016
U.S. Patent and Trademark Office; U. S. DEPARTMENT OF COMMERCE


# "FEE ADDRESS" INDICATION FORM

**Address to:**
**Mail Stop M Correspondence**
**Commissioner for Patents**
**P.O. Box 1450**
**Alexandria, VA 22313-1450**

**- OR -**

**Fax to:**
**571-273-6500**

**INSTRUCTIONS:** The issue fee must have been paid for application(s) listed on this form. In addition, only an address represented by a Customer Number can be established as the fee address for maintenance fee purposes (hereafter, fee address). A fee address should be established when correspondence related to maintenance fees should be mailed to a different address than the correspondence address for the application. **When to check the first box below**: If you have a Customer Number to represent the fee address. **When to check the second box below**: If you have no Customer Number representing the desired fee address, in which case a completed Request for Customer Number (PTO/SB/125) must be attached to this form. For more information on Customer Numbers, see the Manual of Patent Examining Procedure (MPEP) § 403.

For the following listed application(s), please recognize as the "Fee Address" under the provisions of 37 CFR 1.363 the address associated with:

☑ Customer Number: 62574

*OR*

☐ The attached Request for Customer Number (PTO/SB/125) form.

| PATENT NUMBER (if known) | APPLICATION NUMBER |
|---|---|
| 8,218,481 | 12/303,947 |

Completed by (check one):

☐ Applicant/Inventor

Signature

☑ Attorney or Agent of record 45285 (Reg. No.)

Jason H. Vick
Typed or printed name

☐ Assignee of record of the entire interest. See 37 CFR 3.71. Statement under 37 CFR 3.73(b) is enclosed. (Form PTO/SB/96)

303-863-9700
Requester's telephone number

☐ Assignee recorded at Reel ________ Frame________

March 11, 2014
Date

NOTE: Signatures of all the inventors or assignees of record of the entire interest or their representative(s) are required. Submit multiple forms if more that one signature is required, see below*.

☑ *** Total of 1 forms are submitted.**

# Electronic Acknowledgement Receipt

| | |
|---|---|
| **EFS ID:** | 18437805 |
| **Application Number:** | 12303947 |
| **International Application Number:** | |
| **Confirmation Number:** | 1730 |
| **Title of Invention:** | METHOD OF TRANSMITTING DATA IN A MOBILE COMMUNICATION SYSTEM |
| **First Named Inventor/Applicant Name:** | Yeong Hyeon Kwon |
| **Customer Number:** | 35884 |
| **Filer:** | Jason Vick/Joanne Vos |
| **Filer Authorized By:** | Jason Vick |
| **Attorney Docket Number:** | 2101-3596 |
| **Receipt Date:** | 11-MAR-2014 |
| **Filing Date:** | 07-JUL-2010 |
| **Time Stamp:** | 17:43:35 |
| **Application Type:** | U.S. National Stage under 35 USC 371 |

## Payment information:

| | |
|---|---|
| Submitted with Payment | no |

## File Listing:

| Document Number | Document Description | File Name | File Size(Bytes)/ Message Digest | Multi Part /.zip | Pages (if appl.) |
|---|---|---|---|---|---|
| 1 | | Statement_Under_373c_w_POA.pdf | 522421<br>fb15c26549ae785ebd7ce35ccb851a2f22cfcae9 | yes | 3 |

| | Multipart Description/PDF files in .zip description | | | | |
|---|---|---|---|---|---|
| | **Document Description** | | | **Start** | **End** |
| | Assignee showing of ownership per 37 CFR 3.73. | | | 1 | 2 |
| | Power of Attorney | | | 3 | 3 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 2 | Change of Address | Fee_Address.pdf | 205392<br>aeb3dec5f5992513cf06fc1359b4e8e9658b503f | no | 1 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| | | **Total Files Size (in bytes):** | 727813 | | |

**This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.**

**<u>New Applications Under 35 U.S.C. 111</u>**
**If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.**

**<u>National Stage of an International Application under 35 U.S.C. 371</u>**
**If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.**

**<u>New International Application Filed with the USPTO as a Receiving Office</u>**
**If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.**

PTO/AIA/96 (08-12)
Approved for use through 01/31/2013. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

## STATEMENT UNDER 37 CFR 3.73(c)

Applicant/Patent Owner: TQ LAMBDA LLC

Application No./Patent No.: 8,218,481 Filed/Issue Date: July 10, 2012

Titled: METHOD OF TRANSMITTING DATA IN A MOBILE COMMUNICATION SYSTEM

TQ LAMBDA LLC, a Corporation

(Name of Assignee) (Type of Assignee, e.g., corporation, partnership, university, government agency, etc.)

states that, for the patent application/patent identified above, it is (choose **one** of options 1, 2, 3 or 4 below):

1. [✓] The assignee of the entire right, title, and interest.

2. [ ] An assignee of less than the entire right, title, and interest (check applicable box):

   [ ] The extent (by percentage) of its ownership interest is ____________%. Additional Statement(s) by the owners holding the balance of the interest must be submitted to account for 100% of the ownership interest.

   [ ] There are unspecified percentages of ownership. The other parties, including inventors, who together own the entire right, title and interest are:

   Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

3. [ ] The assignee of an undivided interest in the entirety (a complete assignment from one of the joint inventors was made). The other parties, including inventors, who together own the entire right, title, and interest are:

   Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

4. [ ] The recipient, via a court proceeding or the like (*e.g.*, bankruptcy, probate), of an undivided interest in the entirety (a complete transfer of ownership interest was made). The certified document(s) showing the transfer is attached.

The interest identified in option 1, 2 or 3 above (not option 4) is evidenced by either (choose **one** of options A or B below):

A. [ ] An assignment from the inventor(s) of the patent application/patent identified above. The assignment was recorded in the United States Patent and Trademark Office at Reel ____________, Frame ____________, or for which a copy thereof is attached.

B. [✓] A chain of title from the inventor(s), of the patent application/patent identified above, to the current assignee as follows:

1. From: YEONG HYEON KWON et al. To: LG ELECTRONICS INC.

   The document was recorded in the United States Patent and Trademark Office at Reel 024647, Frame 0517, or for which a copy thereof is attached.

2. From: LG ELECTRONICS INC. To: TQ LAMBDA LLC

   The document was recorded in the United States Patent and Trademark Office at Reel 032343, Frame 0761, or for which a copy thereof is attached.

## STATEMENT UNDER 37 CFR 3.73(c)

3. From: ____________________ To: ____________________

The document was recorded in the United States Patent and Trademark Office at

Reel ________, Frame ________, or for which a copy thereof is attached.

4. From: ____________________ To: ____________________

The document was recorded in the United States Patent and Trademark Office at

Reel ________, Frame ________, or for which a copy thereof is attached.

5. From: ____________________ To: ____________________

The document was recorded in the United States Patent and Trademark Office at

Reel ________, Frame ________, or for which a copy thereof is attached.

6. From: ____________________ To: ____________________

The document was recorded in the United States Patent and Trademark Office at

Reel ________, Frame ________, or for which a copy thereof is attached.

☐ Additional documents in the chain of title are listed on a supplemental sheet(s).

☑ As required by 37 CFR 3.73(c)(1)(i), the documentary evidence of the chain of title from the original owner to the assignee was, or concurrently is being, submitted for recordation pursuant to 37 CFR 3.11.

[NOTE: A separate copy (i.e., a true copy of the original assignment document(s)) must be submitted to Assignment Division in accordance with 37 CFR Part 3, to record the assignment in the records of the USPTO. See MPEP 302.08]

The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.

| | |
|---|---|
| [signature] | March 11, 2014 |
| Signature | Date |
| Jason H. Vick | 45,285 |
| Printed or Typed Name | Title or Registration Number |

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

| APPLICATION NUMBER | FILING OR 371(C) DATE | FIRST NAMED APPLICANT | ATTY. DOCKET NO./TITLE |
|---|---|---|---|
| 12/303,947 | 07/07/2010 | Yeong Hyeon Kwon | |

**CONFIRMATION NO. 1730**

**POA ACCEPTANCE LETTER**

*OC000000067468470*

62574
Jason H. Vick
Sheridan Ross, PC
Suite # 1200
1560 Broadway
Denver, CO 80202

Date Mailed: 04/01/2014

## NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 03/11/2014.

The Power of Attorney in this application is accepted. Correspondence in this application will be mailed to the above address as provided by 37 CFR 1.33.

/jtfitzhugh sr/

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

UNITED STATES PATENT AND TRADEMARK OFFICE
UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

| APPLICATION NUMBER | FILING OR 371(C) DATE | FIRST NAMED APPLICANT | ATTY. DOCKET NO./TITLE |
|---|---|---|---|
| 12/303,947 | 07/07/2010 | Yeong Hyeon Kwon | 2101-3596 |

**CONFIRMATION NO. 1730**

**POWER OF ATTORNEY NOTICE**

*OC000000067468359*

35884
LEE, HONG, DEGERMAN, KANG & WAIMEY
660 S. FIGUEROA STREET
Suite 2300
LOS ANGELES, CA 90017

Date Mailed: 04/01/2014

## NOTICE REGARDING CHANGE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 03/11/2014.

- The Power of Attorney to you in this application has been revoked by the assignee who has intervened as provided by 37 CFR 3.71. Future correspondence will be mailed to the new address of record(37 CFR 1.33).

/jtfitzhugh sr/

---

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

# POWER OF ATTORNEY TO PROSECUTE APPLICATIONS BEFORE THE USPTO

I hereby revoke all previous powers of attorney given in the application identified in the attached statement under 37 CFR 3.73(c).

I hereby appoint:

☒ Practitioners associated with Customer Number: 62574

**OR**

☐ Practitioner(s) named below (if more than ten patent practitioners are to be named, then a customer number must be used):

| Name | Registration Number | Name | Registration Number |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

As attorney(s) or agent(s) to represent the undersigned before the United States Patent and Trademark Office (USPTO) in connection with any and all patent applications assigned only to the undersigned according to the USPTO assignment records or assignments documents attached to this form in accordance with 37 CFR 3.73(c).

Please change the correspondence address for the application identified in the attached statement under 37 CFR 3.73(c) to:

☒ The address associated with Customer Number: 62574

**OR**

☐

| | | | |
|---|---|---|---|
| Firm or Individual Name | | | |
| Address | | | |
| City | | State | Zip |
| Country | | | |
| Telephone | | Email | |

Assignee Name and Address: EVOLVED WIRELESS LLC
805 Las Cimas Parkway, Suite 240
Austin, TX 78746

**A copy of this form, together with a statement under 37 CFR 3.73(c) (Form PTO/AIA/96 or equivalent) is required to be Filed in each application in which this form is used. The statement under 37 CFR 3.73(c) may be completed by one of The practitioners appointed in this form, and must identify the application in which this Power of Attorney is to be filed.**

**SIGNATURE of Assignee of Record**

The individual whose signature and title is supplied below is authorized to act on behalf of the assignee

| | | | |
|---|---|---|---|
| Signature | Abha S Divine | Date | October 22, 2014 |
| Name | Abha Divine | Telephone | |
| Title | Managing Director | | |

# Electronic Acknowledgement Receipt

| | |
|---|---|
| **EFS ID:** | 20565718 |
| **Application Number:** | 12303947 |
| **International Application Number:** | |
| **Confirmation Number:** | 1730 |
| **Title of Invention:** | METHOD OF TRANSMITTING DATA IN A MOBILE COMMUNICATION SYSTEM |
| **First Named Inventor/Applicant Name:** | Yeong Hyeon Kwon |
| **Customer Number:** | 62574 |
| **Filer:** | Jason Vick/Joanne Vos |
| **Filer Authorized By:** | Jason Vick |
| **Attorney Docket Number:** | 7836-4-PUS |
| **Receipt Date:** | 30-OCT-2014 |
| **Filing Date:** | 07-JUL-2010 |
| **Time Stamp:** | 16:39:49 |
| **Application Type:** | U.S. National Stage under 35 USC 371 |

## Payment information:

| | |
|---|---|
| Submitted with Payment | no |

## File Listing:

| Document Number | Document Description | File Name | File Size(Bytes)/ Message Digest | Multi Part /.zip | Pages (if appl.) |
|---|---|---|---|---|---|
| 1 | | Statement_Under_373c_w_POA_EWL.pdf | 2526383<br>87718370323572db1f4146ac00d6bd038aec64be | yes | 3 |

| | Multipart Description/PDF files in .zip description | | |
|---|---|---|---|
| | **Document Description** | **Start** | **End** |
| | Assignee showing of ownership per 37 CFR 3.73. | 1 | 2 |
| | Power of Attorney | 3 | 3 |
| **Warnings:** | | | |
| **Information:** | | | |
| | **Total Files Size (in bytes):** | 2526383 | |

**This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.**

**New Applications Under 35 U.S.C. 111**
**If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.**

**National Stage of an International Application under 35 U.S.C. 371**
**If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.**

**New International Application Filed with the USPTO as a Receiving Office**
**If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.**

PTO/AIA/96 (08-12)
Approved for use through 01/31/2013. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

## STATEMENT UNDER 37 CFR 3.73(c)

Applicant/Patent Owner: EVOLVED WIRELESS LLC

Application No./Patent No.: 8,218,481 Filed/Issue Date: July 10, 2012

Titled: METHOD OF TRANSMITTING DATA IN A MOBILE COMMUNICATION SYSTEM

EVOLVED WIRELESS LLC, a Corporation

(Name of Assignee) (Type of Assignee, e.g., corporation, partnership, university, government agency, etc.)

states that, for the patent application/patent identified above, it is (choose **one** of options 1, 2, 3 or 4 below):

1. [✓] The assignee of the entire right, title, and interest.

2. [ ] An assignee of less than the entire right, title, and interest (check applicable box):

   [ ] The extent (by percentage) of its ownership interest is ______%. Additional Statement(s) by the owners holding the balance of the interest must be submitted to account for 100% of the ownership interest.

   [ ] There are unspecified percentages of ownership. The other parties, including inventors, who together own the entire right, title and interest are:

   Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

3. [ ] The assignee of an undivided interest in the entirety (a complete assignment from one of the joint inventors was made). The other parties, including inventors, who together own the entire right, title, and interest are:

   Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

4. [ ] The recipient, via a court proceeding or the like (*e.g.*, bankruptcy, probate), of an undivided interest in the entirety (a complete transfer of ownership interest was made). The certified document(s) showing the transfer is attached.

The interest identified in option 1, 2 or 3 above (not option 4) is evidenced by either (choose **one** of options A or B below):

A. [ ] An assignment from the inventor(s) of the patent application/patent identified above. The assignment was recorded in the United States Patent and Trademark Office at Reel ______, Frame ______, or for which a copy thereof is attached.

B. [✓] A chain of title from the inventor(s), of the patent application/patent identified above, to the current assignee as follows:

1. From: YEONG HYEON KWON et al. To: LG ELECTRONICS INC.

   The document was recorded in the United States Patent and Trademark Office at Reel 024647, Frame 0517, or for which a copy thereof is attached.

2. From: LG ELECTRONICS INC. To: TQ LAMBDA LLC

   The document was recorded in the United States Patent and Trademark Office at Reel 032343, Frame 0761, or for which a copy thereof is attached.

## STATEMENT UNDER 37 CFR 3.73(c)

3. From: TQ LAMBDA LLC To: EVOLVED WIRELESS LLC

The document was recorded in the United States Patent and Trademark Office at Reel 034039, Frame 0403, or for which a copy thereof is attached.

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6. From: ______ To: ______

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☐ Additional documents in the chain of title are listed on a supplemental sheet(s).

☑ As required by 37 CFR 3.73(c)(1)(i), the documentary evidence of the chain of title from the original owner to the assignee was, or concurrently is being, submitted for recordation pursuant to 37 CFR 3.11.

[NOTE: A separate copy (i.e., a true copy of the original assignment document(s)) must be submitted to Assignment Division in accordance with 37 CFR Part 3, to record the assignment in the records of the USPTO. See MPEP 302.08]

The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.

| | |
|---|---|
| /Jason H. Vick/ | October 30, 2014 |
| Signature | Date |
| Jason H. Vick | 45,285 |
| Printed or Typed Name | Title or Registration Number |

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| APPLICATION NUMBER | FILING OR 371(C) DATE | FIRST NAMED APPLICANT | ATTY. DOCKET NO./TITLE |
|---|---|---|---|
| 12/303,947 | 07/07/2010 | Yeong Hyeon Kwon | 7836-4-PUS |

**CONFIRMATION NO. 1730**

**POA ACCEPTANCE LETTER**

*OC000000071715188*

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1560 Broadway
Denver, CO 80202

Date Mailed: 11/07/2014

## NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 10/30/2014.

The Power of Attorney in this application is accepted. Correspondence in this application will be mailed to the above address as provided by 37 CFR 1.33.

/ttkim/

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101