09/673270

| Class | Subclass |
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ISSUE CLASSIFICATION

[illegible] UNDER 35 U.S.C. 371

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PATENT NUMBER

U.S. UTILITY Patent Application

O.I.P.E. 4Km 2 SCANNED [illegible] Q.A. [illegible]

PATENT DATE

| APPLICATION NO. | CONT/PRIOR | CLASS | SUBCLASS | ART UNIT | EXAMINER |
|---|---|---|---|---|---|
| 09/673270 | D | 375 | 332 | 2634 | CHIN, S. WARE |

APPLICANTS
Ernst Eberlein
Sabah Badri
Stefan Lipp
Stephan Buchholz

TITLE
Method and apparatus for fine frequency synchronization in multi-carrier demodulation systems

PTO-2040 12/99

## ISSUING CLASSIFICATION

| ORIGINAL | | CROSS REFERENCE(S) | | | | | |
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☐ **TERMINAL DISCLAIMER**

☐ The term of this patent subsequent to ____________ (date) has been disclaimed.

☐ The term of this patent shall not extend beyond the expiration date of U.S Patent. No. ____________

☐ The terminal ____months of this patent have been disclaimed.

**DRAWINGS**

| Sheets Drwg. | Figs. Drwg. | Print Fig. |
|---|---|---|
| | | |

(Assistant Examiner) (Date)

(Primary Examiner) (Date)

(Legal Instruments Examiner) (Date)

**CLAIMS ALLOWED**

| Total Claims | Print Claim for O.G. |
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**NOTICE OF ALLOWANCE MAILED**

**ISSUE FEE**

| Amount Due | Date Paid |
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**ISSUE BATCH NUMBER**

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## SEARCHED

| Class | Sub. | Date | Exmr. |
|---|---|---|---|
| 375 | 332 | 11/14 | cw |
| 370 | 203 | 11/14 | cw |
| 370 | 200 | 11/14 | cw |
| | ⋮ | ⋮ | ⋮ |
| | 207 | 11/14 | cw |
| 395 | 200 | 11/14 | cw |

## SEARCH NOTES
(INCLUDING SEARCH STRATEGY)

| | Date | Exmr. |
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| EAST | 11/14 | cw |
| IEEE | 11/14 | cw |

## INTERFERENCE SEARCHED

| Class | Sub. | Date | Exmr. |
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ISSUE SLIP STAPLE AREA (for additional cross references)

| POSITION | INITIALS | ID NO. | DATE |
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| FEE DETERMINATION | | | |
| O.I.P.E. CLASSIFIER | | 6 | 2-22-00 |
| FORMALITY REVIEW | | | |
| RESPONSE FORMALITY REVIEW | | | |
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## INDEX OF CLAIMS

✓ ............................ Rejected
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— (Through numeral)... Canceled
÷ ............................ Restricted
N ............................ Non-elected
I ............................ Interference
A ............................ Appeal
O ............................ Objected

| Claim Final | Claim Original | Date 5/24/04 | | | | | | | | |
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532 Rec'd PCT/PTO 13 OCT 2000

FORM PTO-1390 (REV 10-01-00)

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

# TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER: 41001 #5

U.S. APPLICATION NO. (If known, see 37 CFR 1.5): 09/673270

| INTERNATIONAL APPLICATION NO. | INTERNATIONAL FILING DATE | PRIORITY DATE CLAIMED |
| --- | --- | --- |
| PCT/EP98/02184 | 14 April 1998 | |

TITLE OF INVENTION
Method and Apparatus for Fine Frequency Synchronization in Multi-Carrier Demodulation Systems

APPLICANT(S) FOR DO/EO/US
Ernst Eberlein, Sabah Badri, Stefan Lipp, Stephan Buchholz, Albert Heuberger, Heinz Gerhaeuser

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☑ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☐ This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. ☑ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☑ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   - a. ☑ is transmitted herewith (required only if not transmitted by the International Bureau).
   - b. ☑ has been transmitted by the International Bureau.
   - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☐ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☑ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   - a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   - b. ☐ have been transmitted by the International Bureau.
   - c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   - d. ☑ have not been made and will not be made.
8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

**Items 11. to 16. below concern document(s) or information included:**

11. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☑ A FIRST preliminary amendment.
    ☐ A SECOND or SUBSEQUENT preliminary amendment.
14. ☑ A substitute specification.
15. ☐ A change of power of attorney and/or address letter.
16. ☑ Other items or information:

    (a) Copy of International Application as filed (14 April 1998).
    (b) Copy of International Search Report (12 January 1999).
    (c) Copy of Published International Application (21 October 1999).
    (d) Copy of International Preliminary Examination Report (19 July 2000).

529 Rec'd PCT/PTO 13 OCT 2000

| U.S. APPLICATION NO. (if known, see 37 CFR 1.5) | INTERNATIONAL APPLICATION NO. | ATTORNEY'S DOCKET NUMBER |
|---|---|---|
| 09/673270 | PCT/EP98/02184 | 41001 |

17. ☑ The following fees are subm[itted]:

| | CALCULATIONS | PTO USE ONLY |
|---|---|---|
| **BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)):** | | |
| Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO .......... **$1000.00** | | |
| International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO ....... **$860.00** | | |
| International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO .......... **$710.00** | | |
| International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provisions of PCT Article 33(1)-(4) ........... **$690.00** | | |
| International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4) ............... **$100.00** | | |
| **ENTER APPROPRIATE BASIC FEE AMOUNT =** | $ 860.00 | |
| Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☑ 30 months from the earliest claimed priority date (37 CFR 1.492(e)). | $ 130.00 | |

| CLAIMS | NUMBER FILED | NUMBER EXTRA | RATE | | |
|---|---|---|---|---|---|
| Total claims | 16 - 20 = | 0 | X **$18.00** | $ 0.00 | |
| Independent claims | 4 - 3 = | 1 | X **$80.00** | $ 80.00 | |
| MULTIPLE DEPENDENT CLAIM(S) (if applicable) | | | + **$270.00** | $ 0.00 | |

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| **TOTAL OF ABOVE CALCULATIONS =** | $ 1,070.00 | |
| Reduction of 1/2 for filing by small entity, if applicable. A Small Entity Statement must also by filed (Note 37 CFR 1.9, 1.27, 1.28). | $ (0.00) | |
| **SUBTOTAL =** | $ 1,070.00 | |
| Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)). + | $ 0.00 | |
| **TOTAL NATIONAL FEE =** | $ 1,070.00 | |
| Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property + | $ 0.00 | |
| **TOTAL FEES ENCLOSED =** | $ 1,070.00 | |
| | **Amount to be refunded:** | $ |
| | **charged:** | $ |

a. ☑ A check in the amount of $ 1,070.00 to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. ____________ in the amount of $____________ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☑ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 18-2220. A duplicate copy of this sheet is enclosed.

**NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.**

SEND ALL CORRESPONDENCE TO:

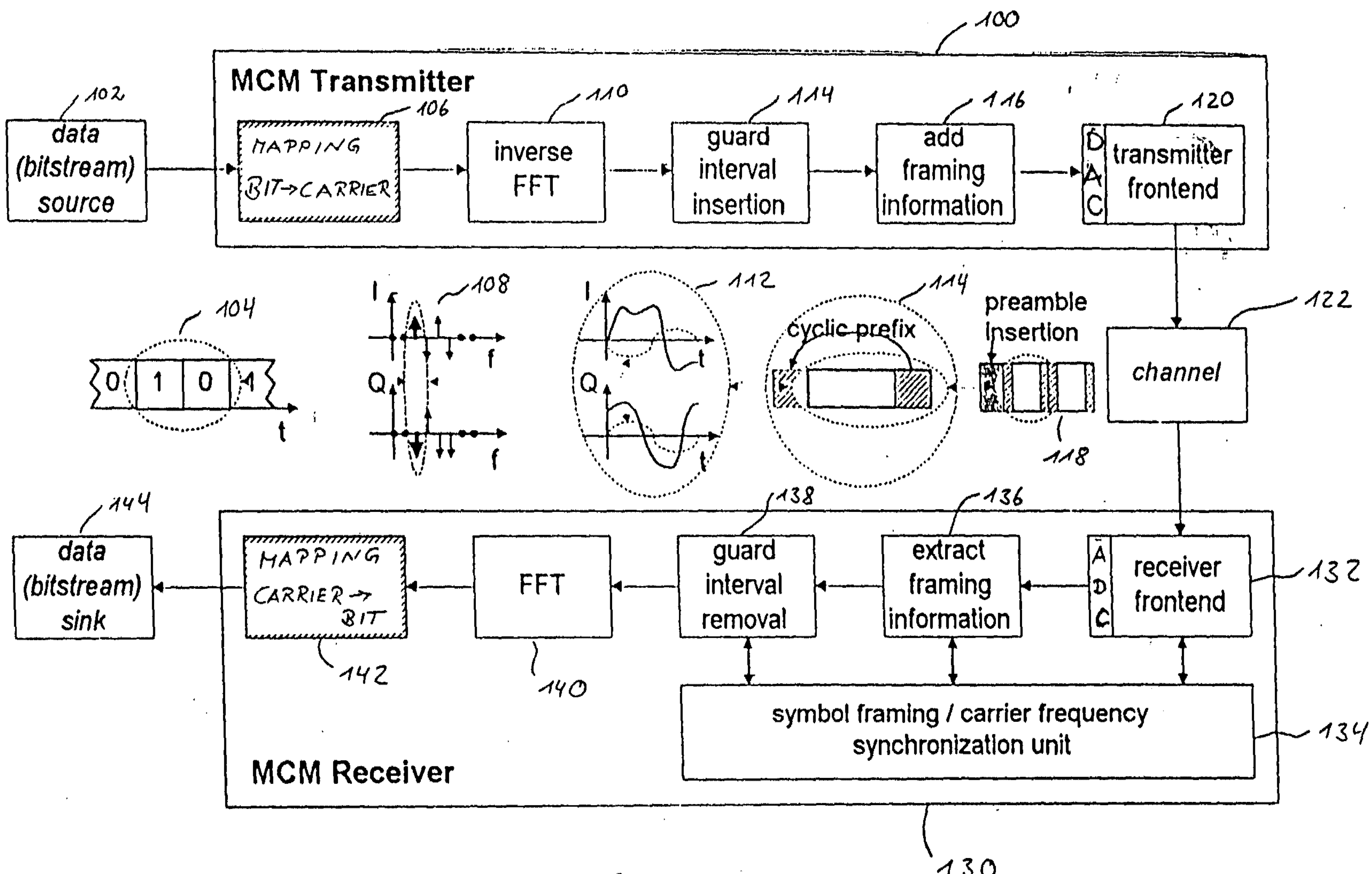
Roylance, Abrams, Berdo & Goodman, L.L.P.
1300 19th Street, N.W., Suite 600
Washington, DC 20036

John E. Holmes
SIGNATURE:

John E. Holmes
NAME

29,392
REGISTRATION NUMBER

Fraunhofer Ex 2018-5
Sirius XM v Fraunhofer, IPR2018-00681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MCM Transmitter
102
data (bitstream) source
106
MAPPING BIT→CARRIER
110
inverse FFT
114
guard interval insertion
116
add framing information
120
D A C
transmitter frontend
104
0 1 0 1
t
108
I f
Q f
112
I t
Q t
114
cyclic prefix
preamble insertion
118
122
channel
144
data (bitstream) sink
MAPPING CARRIER→BIT
142
FFT
140
138
guard interval removal
136
extract framing information
A D C
receiver frontend
132
symbol framing / carrier frequency synchronization unit
134
MCM Receiver
130

Fig. 1

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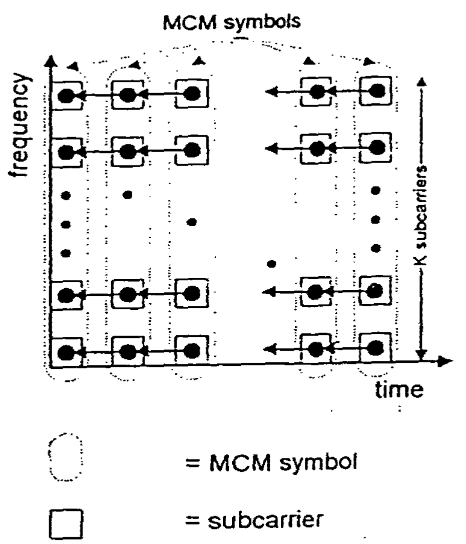


Fig. 2A

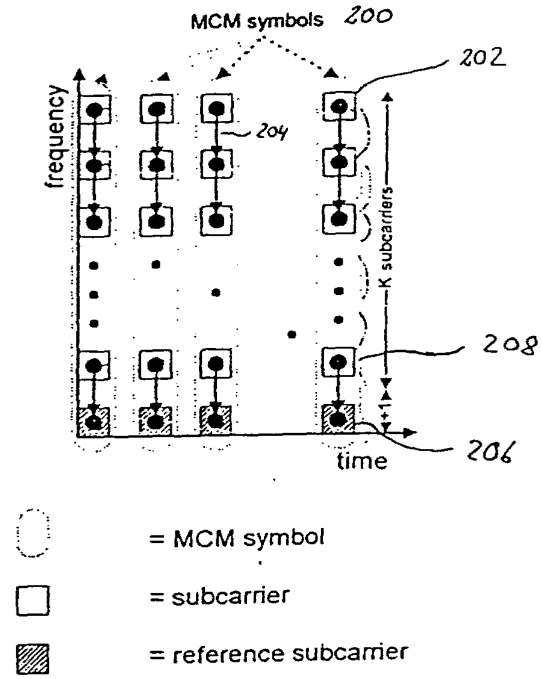


Fig. 2B

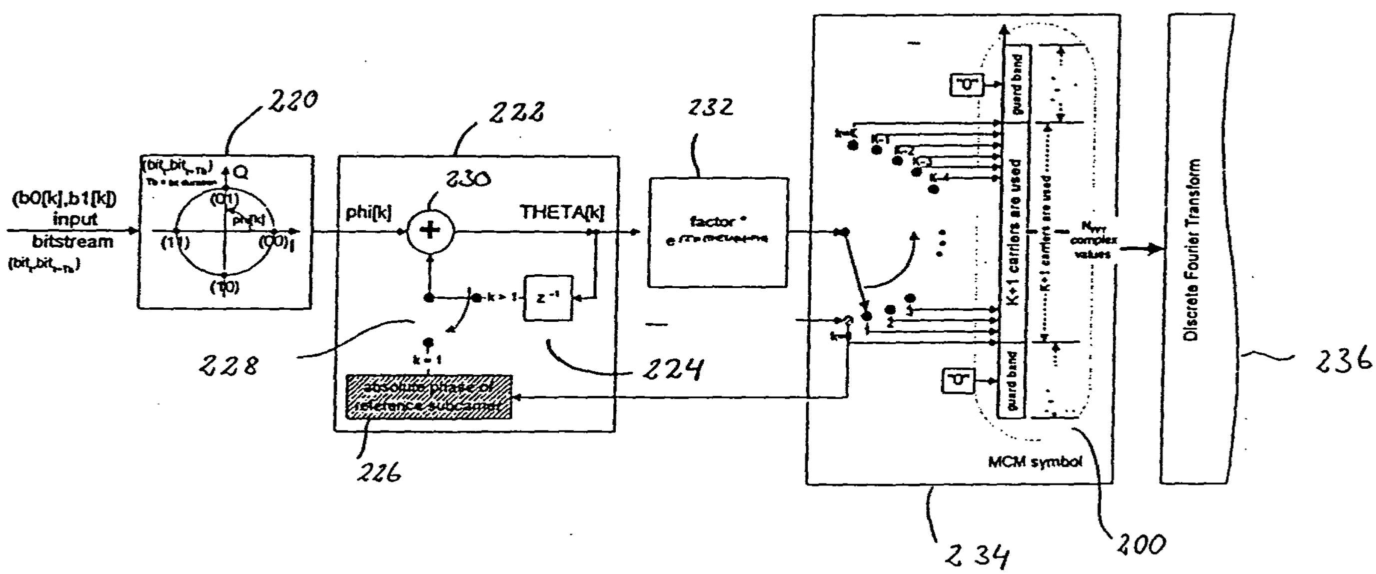


Fig. 3

09/673270

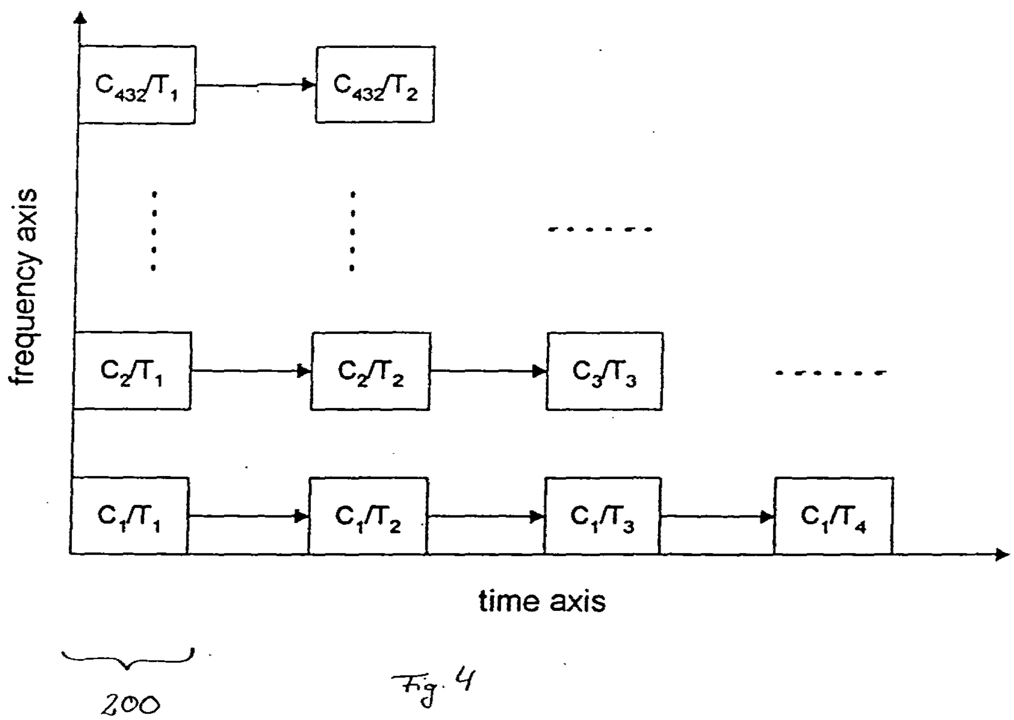


Fig. 4

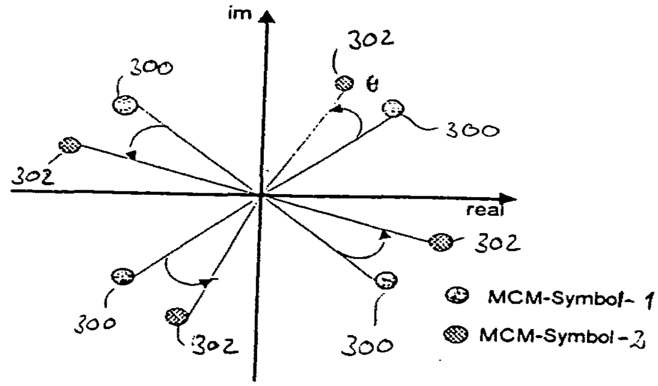
im
real
θ
300
302
MCM-Symbol-1
MCM-Symbol-2

Fig. 5

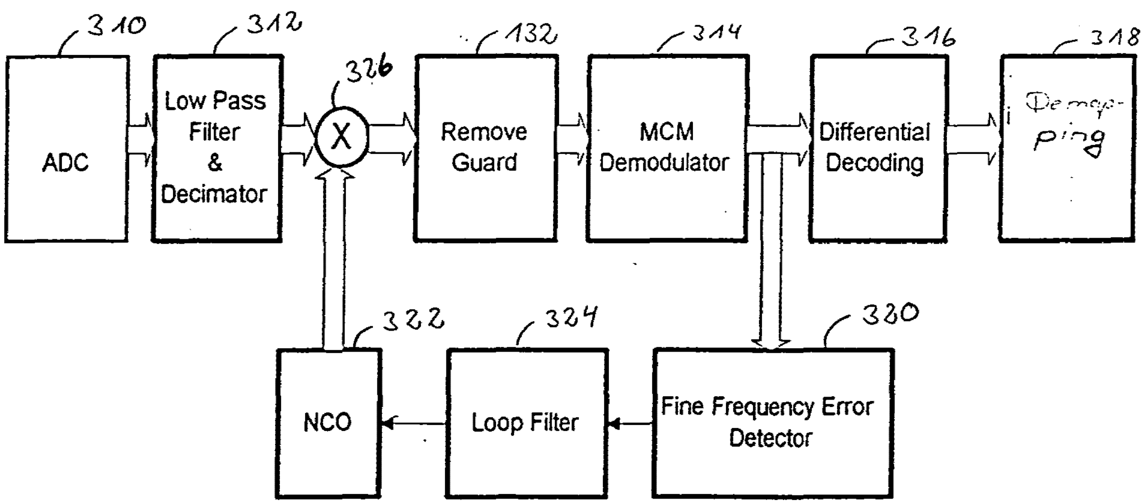
310
312
326
132
314
316
318
ADC
Low Pass Filter & Decimator
X
Remove Guard
MCM Demodulator
Differential Decoding
Demapping
322
324
320
NCO
Loop Filter
Fine Frequency Error Detector

Fig. 6

09/673270

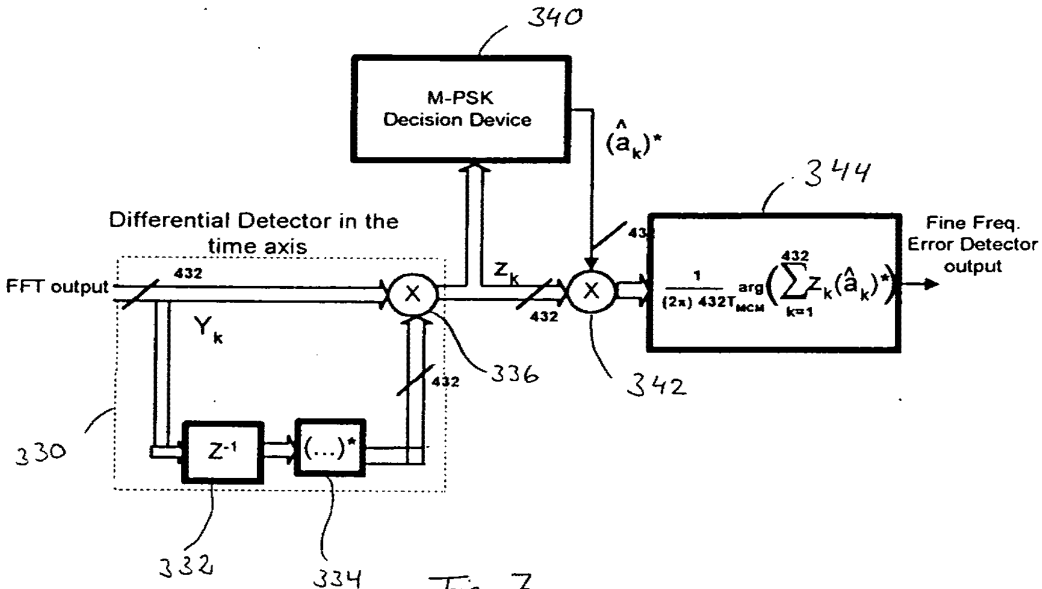


Fig. 7

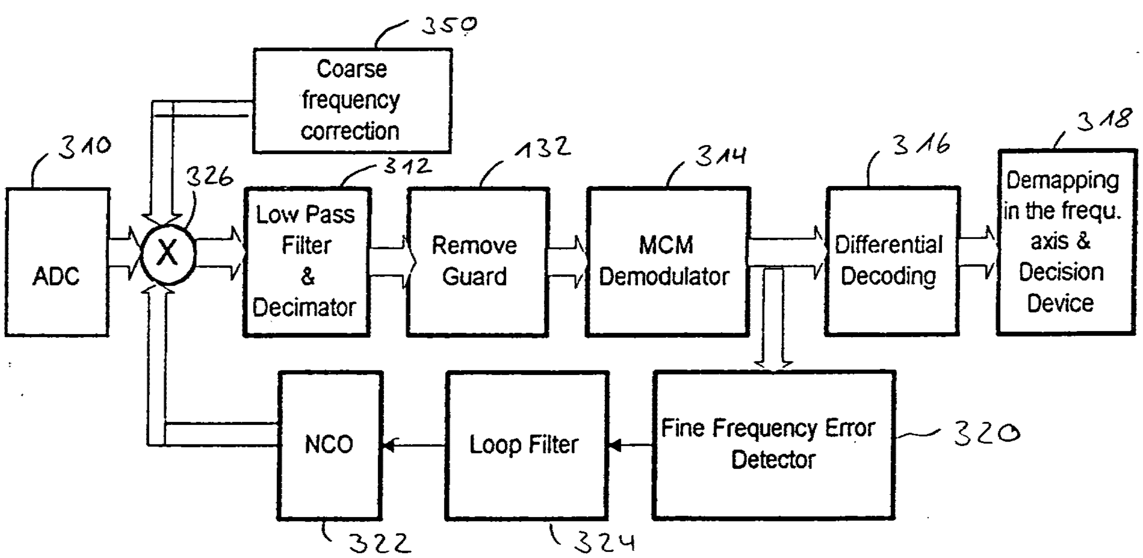


Fig. 8

09/673270

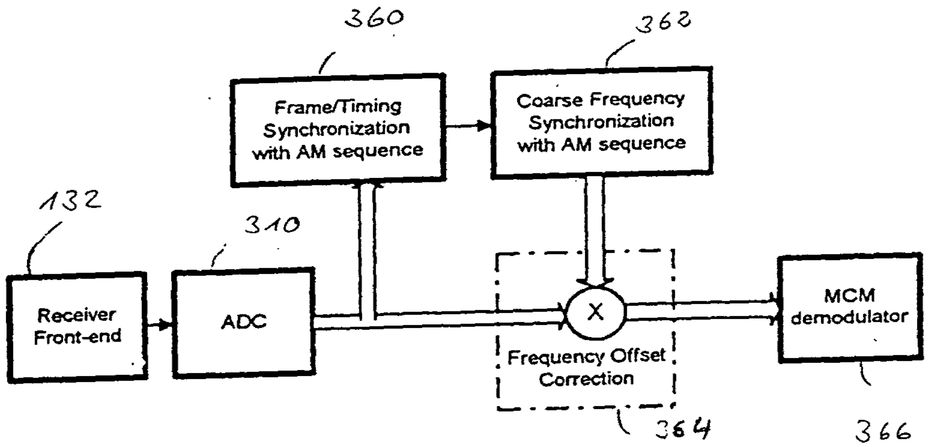


Fig. 9

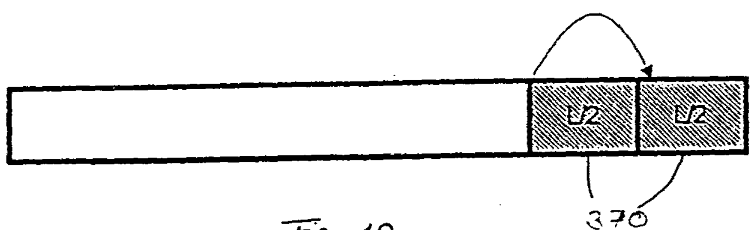


Fig. 10

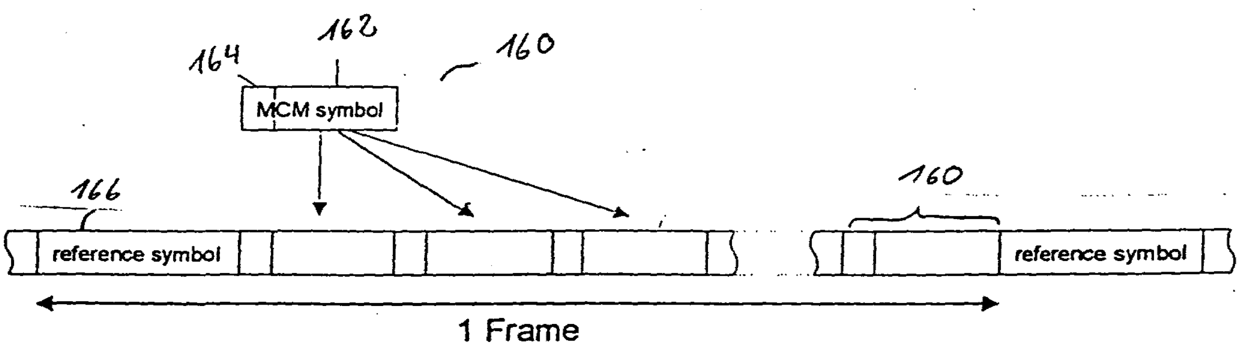


Fig. 11

09/673270

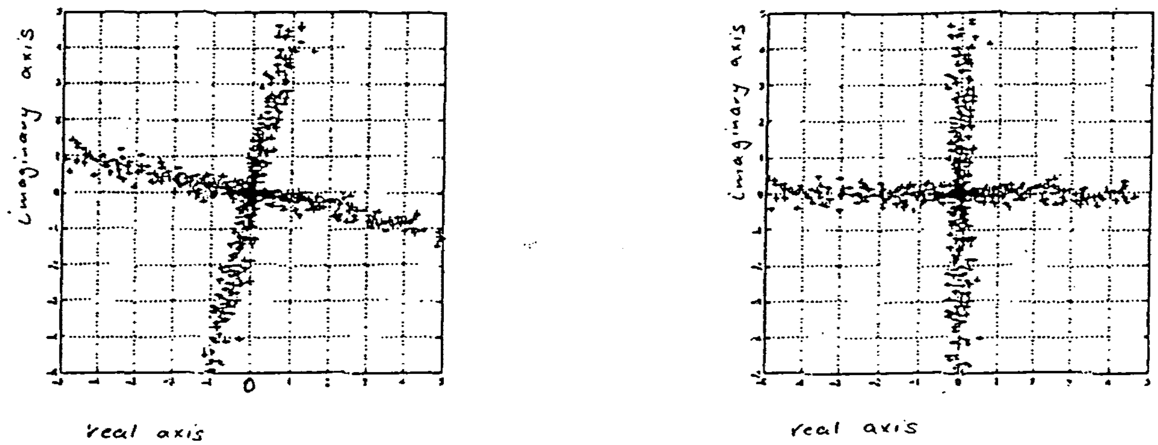


Fig. 12

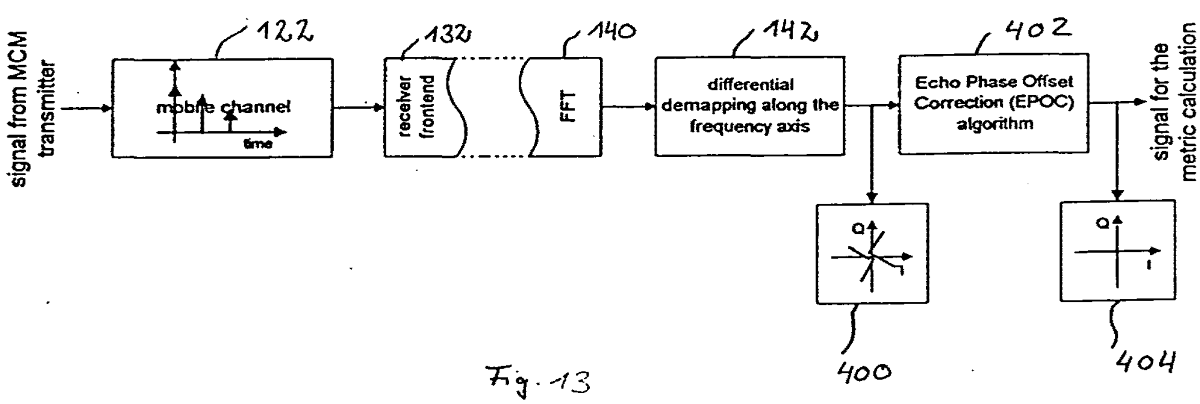


Fig. 13

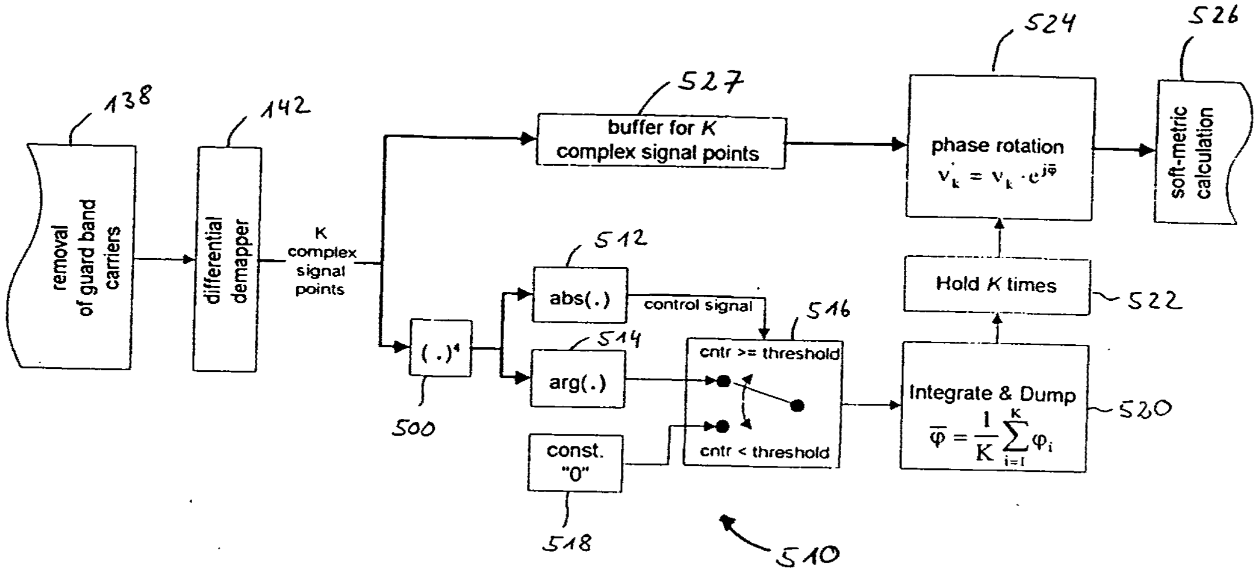
138
removal of guard band carriers
142
differential demapper
K complex signal points
527
buffer for K complex signal points
524
phase rotation
$v_k' = v_k \cdot e^{j\bar{\varphi}}$
526
soft-metric calculation
512
abs(.)
control signal
516
514
arg(.)
cntr >= threshold
cntr < threshold
500
$(.)^4$
const. "0"
518
510
Hold K times
522
Integrate & Dump
$\bar{\varphi} = \frac{1}{K}\sum_{i=1}^{K}\varphi_i$
520

Fig. 14

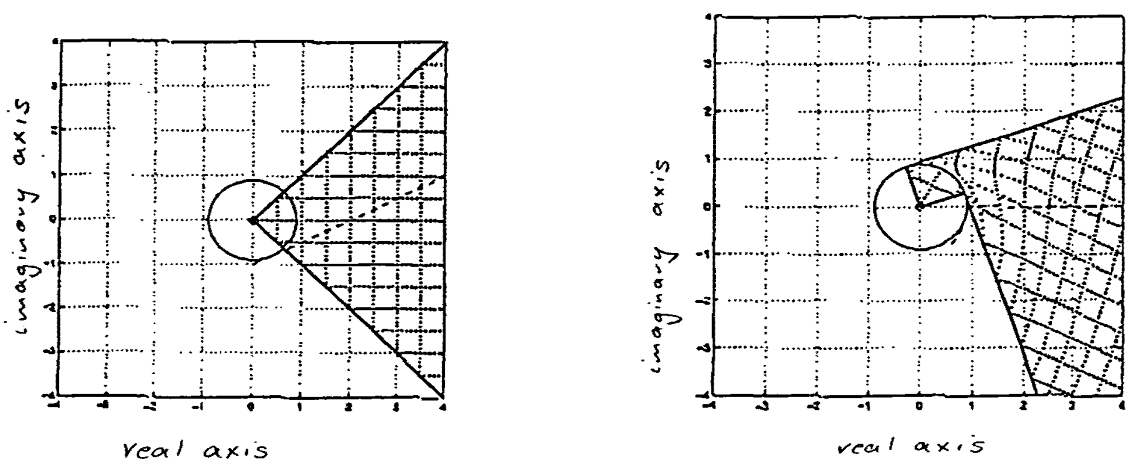
imaginary axis
real axis
imaginary axis
real axis

Fig. 15

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# METHOD AND APPARATUS FOR FINE FREQUENCY SYNCHRONIZATION IN MULTI-CARRIER DEMODULATION SYSTEMS

## FIELD OF THE INVENTION

The present invention relates to methods and apparatus for performing a fine frequency synchronization in multi-carrier demodulation systems, and in particular to methods and apparatus for performing a fine frequency synchronization compensating for a carrier frequency deviation from an oscillator frequency in a multi-carrier demodulation system of the type capable of carrying out a differential phase decoding of multi-carrier modulated signals, wherein the signals comprise a plurality of symbols, each symbol being defined by phase differences between simultaneous carriers having different frequencies.

Cancelled By Sub-Spec

## BACKGROUND OF THE INVENTION

In a multi carrier transmission system (MCM, OFDM), the effect of a carrier frequency offset is substantially more considerable than in a single carrier transmission system. MCM is more sensitive to phase noise and frequency offset which occurs as amplitude distortion and inter carrier interference (ICI). The inter carrier interference has the effect that the subcarriers are no longer orthogonal in relation to each other. Frequency offsets occur after power on or also later due to frequency deviation of the oscillators used for downconversion into baseband. Typical accuracies for the frequency of a free running oscillator are about ±50 ppm of the carrier frequency. With a carrier frequency in the S-band of 2.34 Ghz, for example, there will be a maximum local oscillator (LO) frequency deviation of above 100 kHz (117.25 kHz). The above named effects result in high requirements on the algorithm used for frequency offset correction.

## DESCRIPTION OF PRIOR ART

Most prior art algorithms for frequency synchronization divide frequency correction into two stages. In the first stage, a coarse synchronization is performed. In the second stage, a fine correction can be achieved. A frequently used algorithm for coarse synchronization of the carrier frequency uses a synchronization symbol which has a special spectral pattern in the frequency domain. Such a synchronization symbol is, for example, a CAZAC sequence (CAZAC = Constant Amplitude Zero Autocorrelation). Through comparison, i.e. the correlation, of the power spectrum of the received signal with that of the transmitted signal, the frequency carrier offset can be coarsely estimated. These prior art algorithms all work in the frequency domain. Reference is made, for example, to Ferdinand Claßen, Heinrich Meyr, "Synchronization Algorithms for an OFDM System for Mobile Communication", ITG-Fachtagung 130, Codierung für Quelle, Kanal und Übertragung, pp. 105 - 113, Oct. 26-28, 1994; and Timothy M. Schmidl, Donald C. Cox, "Low-Overhead, Low-Complexity [Burst] Synchronization for OFDM", in Proceedings of the IEEE International Conference on Communication ICC 1996, pp. 1301-1306 (1996).

For the coarse synchronization of the carrier frequency, Paul H. Moose, "A Technique for Orthogonal Frequency Division Multiplexing Frequency Offset Correction", IEEE Transaction On Communications, Vol. 42, No. 10, October 1994, suggest increasing the spacing between the subcarriers such that the subcarrier distance is greater than the maximum frequency difference between the received and transmitted carriers. The subcarrier distance is increased by reducing the number of sample values which are transformed by the Fast Fourier Transform. This corresponds to a reduction of the number of sampling values which are transformed by the Fast Fourier Transform.

## SUMMARY OF THE INVENTION

It is an object of the present invention to provide methods and apparatus for performing a fine frequency synchronization which allow a fine frequency synchronization compensating for a carrier frequency deviation from an oscillator frequency in a MCM transmission system which makes use of MCM signals in which information is differential phase encoded between simultaneous sub-carriers having different frequencies.

In accordance with a first aspect, the present invention provides a method of performing a fine frequency synchronization compensating for a carrier frequency deviation from an oscillator frequency in a multi-carrier demodulation system of the type capable of carrying out a differential phase decoding of multi-carrier modulated signals, the signals comprising a plurality of symbols, each symbol being defined by phase differences between simultaneous carriers having different frequencies, the method comprising the steps of:

determining a phase difference between phases of the same carrier in different symbols;

determining a frequency offset by eliminating phase shift uncertainties corresponding to codeable phase shifts from the phase difference; and

performing a feedback correction of the carrier frequency deviation based on the determined frequency offset.

In accordance with a second aspect, the present invention provides a method of performing a fine frequency synchronization compensating for a carrier frequency deviation from an oscillator frequency in a multi-carrier demodulation system of the type capable of carrying out a differential phase decoding of multi-carrier modulated signals, the signals comprising a plurality of symbols, each symbol being defined by phase differences between simultaneous carriers having different frequencies, the method comprising the steps of:

determining respective phases of the same carrier in different symbols;

eliminating phase shift uncertainties corresponding to codeable phase shifts from the phases to determine respective phase deviations;

determining a frequency offset by determining a phase difference between the phase deviations; and

performing a feedback correction of said carrier frequency deviation based on the determined frequency offset.

In accordance with a third aspect, the present invention provides a method of performing a fine frequency synchronization compensating for a carrier frequency deviation from an oscillator frequency in a multi-carrier demodulation system of the type capable of carrying out a differential phase decoding of multi-carrier modulated signals, the signals comprising a plurality of symbols, each symbol being defined by phase differences between simultaneous carriers having different frequencies, the method comprising the steps of:

for a plurality of carriers in the symbols:

determining a phase difference between phases of the same carrier in different symbols; and

determining a frequency offset by eliminating phase shift uncertainties corresponding to codeable phase shifts from the phase difference;

determining and averaged frequency offset by averaging the determined frequency offset of the plurality of carriers; and

performing a feedback correction of the frequency deviation based on the averaged frequency offset.

In accordance with a fourth aspect, the present invention provides a method of performing a fine frequency synchronization compensating for a carrier frequency deviation from an oscillator frequency in a multi-carrier demodulation system of the type capable of carrying out a differential phase decoding of multi-carrier modulated signals, the signals comprising a plurality of symbols, each symbol being defined by phase differences between simultaneous carriers having different frequencies, the method comprising the steps of:

for a plurality of carriers in the symbols:

determining respective phases of the same carrier in different symbols;

eliminating phase shift uncertainties corresponding to codeable phase shifts from said phases to determine respective phase deviations; and

determining a frequency offset by determining a phase difference between the phase deviations;

determining an averaged frequency offset by averaging the determined frequency offsets of the plurality of carriers; and

performing a feedback correction of the frequency deviation based on the averaged frequency offset.

In accordance with a fifth aspect, the present invention provides an apparatus for performing a fine frequency synchronization compensating for a carrier frequency deviation from an oscillator frequency, for a multi-carrier demodulation system of the type capable of carrying out a differential phase decoding of multi-carrier modulated signals, the signals comprising a plurality of symbols, each symbol being defined by phase differences between simultaneous carriers having different frequencies, the apparatus comprising:

means for determining a phase difference between phases of the same carrier in different symbols;

means for determining a frequency offset by eliminating phase shift uncertainties corresponding to codeable phase shifts from the phase difference; and

means for performing a feedback correction of the frequency deviation based on the determined frequency offset.

In accordance with a sixth aspect, the present invention provides an apparatus for performing a fine frequency synchronization compensating for a carrier frequency deviation from an oscillator frequency, for a multi-carrier demodulation system of the type capable of carrying out a differential phase decoding of multi-carrier modulated signals, said signals comprising a plurality of symbols, each symbol being defined by phase differences between simultaneous carriers having different frequencies, the apparatus comprising:

means for determining respective phases of the same carrier in different symbols;

means for eliminating phase shift uncertainties corresponding to codeable phase shifts from the phases to determine respective phase deviations;

means for determining a frequency offset by determining a phase difference between the phase deviations; and

means for performing a feedback correction of the frequency deviation based on the determined frequency offset.

In accordance with a seventh aspect, the present invention provides an apparatus for performing a fine frequency synchronization compensating for a carrier frequency deviation from an oscillator frequency, for a multi-carrier demodulation system of the type capable of carrying out a differential phase decoding of multi-carrier modulated signals, the signals comprising a plurality of symbols, each symbol being defined by phase differences between simultaneous carriers having different frequencies, the apparatus comprising:

means for determining a phase difference between phases of the same carrier in different symbols;

means for determining a frequency offset by eliminating phase shift uncertainties corresponding to codeable phase shifts from the phase difference;

means for determining an averaged frequency offset by averaging determined frequency offsets of a plurality of carriers; and

means for performing a feedback correction of the frequency deviation based on the averaged frequency offset.

In accordance with an eighth aspect, the present invention provides an apparatus for performing a fine frequency synchronization compensating for a carrier frequency deviation from an oscillator frequency, for a multi-carrier demodulation system of the type capable of carrying out a differential phase decoding of multi-carrier modulated signals, the signals comprising a plurality of symbols, each symbol being defined by phase differences between simultaneous carriers having different frequencies, the apparatus comprising:

means for determining respective phases of the same carrier in different symbols;

means for eliminating phase shift uncertainties corresponding to codeable phase shifts from the phases to determine respective phase deviations;

means for determining a frequency offset by determining a phase difference between the phase deviations;

means for determining an averaged frequency offset by averaging determined frequency offsets of a plurality of carriers; and

means for performing a feedback correction of the frequency deviation based on the averaged frequency offset.

The present invention relates to methods and apparatus for performing a fine frequency synchronization compensating for a carrier frequency deviation from an oscillator frequency. This fine frequency synchronization is preferably performed after completion of a coarse frequency synchronization, such that the frequency offsets after the coarse frequency synchronization are smaller than half the sub-carrier distance in the MCM signal. Since the frequency offsets which are to be corrected by the inventive fine frequency synchronization methods and apparatus, a correction of the frequency offsets by using a phase rotation with differential decoding and de-mapping in the time axis can be used. The frequency offsets are detected by determining the frequency differences between time contiguous sub-carrier symbols along the time axis. The frequency error is calculated by measuring the rotation of the I-Q cartesian coordinates of each sub-carrier and, in preferred embodiments, averaging them over all n sub-carriers of a MCM symbol.

Firstly, the phase ambiguity or uncertainty is eliminated by using a M-PSK decision device and correlating the output of the decision device with the input signal for a respective sub-carrier symbol. Thus, the phase offset for a sub-carrier symbol is determined and can be used for restructuring the frequency error in form of a feed-backward structure. Alternatively, the phase offsets of the sub-carrier symbols of one MCM symbol can be averaged over all of the active carriers of a MCM symbol, wherein the averaged phase offset is used to restructure the frequency error.

In accordance with the present invention, the determination of the frequency offset is performed in the frequency domain. The feedback correction in accordance with the inventive fine frequency synchronization is performed in the time domain. To this end, a differential decoder in the time domain is provided in order to detect frequency offsets of sub-carriers on the basis of the phases of timely successive sub-carrier symbols of different MCM symbols.

## BRIEF DESCRIPTION OF THE DRAWINGS

In the following, preferred embodiments of the present invention will be explained in detail on the basis of the drawings enclosed, in which:

Figure 1 shows a schematic overview of a MCM transmission system to which the present application can be applied;

Figures 2A and 2B show schematic views representing a scheme for differential mapping in the time axis and a scheme for differential mapping in the frequency axis;

Figure 3 shows a functional block diagram for performing a differential mapping in the frequency axis;

Figure 4 shows a representation of time variation of all sub-carriers in MCM symbols;

Figure 5 shows a QPSK-constellation for each sub-carrier with a frequency offset;

Figure 6 shows a general block diagram illustrating the position of the inventive fine frequency synchronization device in a MCM receiver;

Figure 7 shows a block diagram of the fine frequency error detector shown in Figure 6;

Figure 8 shows a block diagram of a MCM receiver comprising a coarse frequency synchronization unit and a fine frequency synchronization unit;

Figure 9 shows a block diagram of a unit for performing a coarse frequency synchronization;

Figure 10 shows a schematic view of a reference symbol used for performing a coarse frequency synchronization;

Figure 11 shows a schematic view of a typical MCM signal having a frame structure;

Figure 12 shows scatter diagrams of the output of an differential de-mapper of a MCM receiver for illustrating the effect of an echo phase offset correction;

Figure 13 shows a schematic block diagram for illustrating the position and the functionality of an echo phase offset correction unit;

Figure 14 shows a schematic block diagram of a preferred form of an echo phase offset correction device; and

Figure 15 shows schematic views for illustrating a projection performed by another echo phase offset correction algorithm.

## DETAILED DESCRIPTION OF THE EMBODIMENTS

Before discussing the present invention in detail, the mode of operation of a MCM transmission system is described referring to figure 1.

Referring to Figure 1, at 100 a MCM transmitter is shown that substantially corresponds to a prior art MCM transmitter. A description of such a MCM transmitter can be found, for example, in William Y. Zou, Yiyan Wu, "COFDM: AN OVERVIEW", IEEE Transactions on Broadcasting, vol. 41, No. 1, March 1995.

A data source 102 provides a serial bitstream 104 to the MCM transmitter. The incoming serial bitstream 104 is applied to a bit-carrier mapper 106 which produces a sequence of spectra 108 from the incoming serial bitstream 104. An inverse fast Fourier transform (IFFT) 110 is performed on the sequence of spectra 108 in order to produce a MCM time domain signal 112. The MCM time domain signal forms the useful MCM symbol of the MCM time signal. To avoid intersymbol interference (ISI) caused by multipath distortion, a unit 114 is provided for inserting a guard interval of fixed length between adjacent MCM symbols in time. In accordance with a preferred embodiment of the present invention, the last part of the useful MCM symbol is used as the guard interval by placing same in front of the useful symbol. The resulting MCM symbol is shown at 115 in Figure 1 and corresponds to a MCM symbol 160 depicted in Figure 11.

Figure 11 shows the construction of a typical MCM signal having a frame structure. One frame of the MCM time signal is composed of a plurality of MCM symbols 160. Each MCM symbol 160 is formed by an useful symbol 162 and a guard interval 164 associated therewith. As shown in Figure 11, each frame comprises one reference symbol 166. The present invention can advantageously be used with such a MCM signal, however, such a signal structure being not necessary for performing the present invention as long as the transmitted signal comprises a useful portion and at least one reference symbol.

In order to obtain the final frame structure shown in Figure 11, a unit 116 for adding a reference symbol for each predetermined number of MCM symbols is provided.

In accordance with the present invention, the reference symbol is an amplitude modulated bit sequence. Thus, an amplitude modulation of a bit sequence is performed such that the envelope of the amplitude modulated bit sequence defines a reference pattern of the reference symbol. This reference pattern defined by the envelope of the amplitude modulated bit sequence has to be detected when receiving the MCM signal at a MCM receiver. In a preferred embodiment of the present invention, a pseudo random bit sequence having good autocorrelation properties is used as the bit sequence that is amplitude modulated.

The choice of length and repetition rate of the reference symbol depends on the properties of the channel through which the MCM signal is transmitted, e.g. the coherence time of the channel. In addition, the repetition rate and the length of the reference symbol, in other words the number of useful symbols in each frame, depends on the receiver requirements concerning mean time for initial synchronization and mean time for resynchronization after synchronization loss due to a channel fade.

The resulting MCM signal having the structure shown at 118 in Figure 1 is applied to the transmitter front end 120. Roughly speaking, at the transmitter front end 120, a digital/analog conversion and an up-converting of the MCM signal is performed. Thereafter, the MCM signal is transmitted through a channel 122.

Following, the mode of operation of a MCM receiver 130 is shortly described referring to Figure 1. The MCM signal is received at the receiver front end 132. In the receiver front end 132, the MCM signal is down-converted and, furthermore, an analog/digital conversion of the down-converted signal is performed.

The down-converted MCM signal is provided to a symbol frame/carrier frequency synchronization unit 134.

A first object of the symbol frame/carrier frequency synchronization unit 134 is to perform a frame synchronization on the basis of the amplitude-modulated reference symbol. This frame synchronization is performed on the basis of a correlation between the amplitude-demodulated reference symbol an a predetermined reference pattern stored in the MCM receiver.

A second object of the symbol frame/carrier frequency synchronization unit is to perform a coarse frequency synchronization of the MCM signal. To this end, the symbol frame/carrier frequency synchronization unit 134 serves as a coarse frequency synchronization unit for determining a coarse frequency offset of the carrier frequence caused, for example, by a difference of the frequencies between the local oscillator of the transmitter and the local oscillator of the receiver. The determined frequency is used in order to perform a coarse frequency correction. The mode of operation of the coarse frequency synchronization unit is described in detail referring to Figures 9 and 10 hereinafter.

As described above, the frame synchronization unit 134 determines the location of the reference symbol in the MCM symbol. Based on the determination of the frame synchronization unit 134, a reference symbol extracting unit 136 extracts the framing information, i.e. the reference symbol, from the MCM symbol coming from the receiver front end 132. After the extraction of the reference symbol, the MCM signal is applied to a guard interval removal unit 138. The result of the signal processing performed hereherto in the MCM receiver are the useful MCM symbols.

The useful MCM symbols output from the guard interval removal unit 138 are provided to a fast Fourier transform unit 140 in order to provide a sequence of spectra from the useful symbols. Thereafter, the sequence of spectra is provided to a carrier-bit mapper 142 in which the serial bitstream is recovered. This serial bitstream is provided to a data sink 144.

Next, referring to Figures 2A and 2B, two modes for differential mapping are described. In Figure 2A, a first method of differential mapping along the time axis is shown. As can be seen from Figure 2A, a MCM symbol consists of K sub-carriers. The sub-carriers comprise different frequencies and are, in a preferred embodiment, equally spaced in the frequency axis direction. When using differential mapping along the time axis, one or more bits are encoded into phase and/or amplitude shifts between two sub-carriers of the same center frequency in adjacent MCM symbols. The arrows depicted between the sub-carrier symbols correspond to information encoded in amplitude and/or phase shifts between two sub-carrier symbols.

A second method of differential mapping is shown in Figure 2B. The present invention is adapted for MCM transmission system using the mapping scheme shown in Figure 2B. This mapping scheme is based on a differential mapping inside one MCM symbol along the frequency axis. A number of MCM symbols 200 is shown in Figure 2B. Each MCM symbol 200 comprises a number of sub-carrier symbols 202. The arrows 204 in Figure 2B illustrate information encoded between two sub-carrier symbols 202. As can be seen from the arrows 204, this mapping scheme is based on a differential mapping within one MCM symbol along the frequency axis direction.

In the embodiment shown in Figure 2B, the first sub-carrier (k=0) in an MCM symbol 200 is used as a reference sub-carrier 206 (shaded) such that information is encoded between the reference sub-carrier and the first active carrier 208. The other information of a MCM symbol 200 is encoded between active carriers, respectively.

Thus, for every MCM symbol an absolute phase reference exists. In accordance with Figure 2B, this absolute phase reference is supplied by a reference symbol inserted into every MCM symbol (k=0). The reference symbol can either have a constant phase for all MCM symbols or a phase that varies from MCM symbol to MCM symbol. A varying phase can be obtained by replicating the phase from the last subcarrier of the MCM symbol preceding in time.

In Figure 3 a preferred embodiment of a device for performing a differential mapping along the frequency axis is shown. Referring to Figure 3, assembly of MCM symbols in the frequency domain using differential mapping along the frequency axis according to the present invention is described.

Figure 3 shows the assembly of one MCM symbol with the following parameters:

$N_{FFT}$ designates the number of complex coefficients of the discrete Fourier transform, number of subcarriers respectively.

K designates the number of active carriers. The reference carrier is not included in the count for K.

According to Figure 3, a quadrature phase shift keying (QPSK) is used for mapping the bitstream onto the complex symbols. However, other M-ary mapping schemes (MPSK) like 2-PSK, 8-PSK, 16-QAM, 16-APSK, 64-APSK etc. are possible.

Furthermore, for ease of filtering and minimization of aliasing effects some subcarriers are not used for encoding information in the device shown in Figure 3. These sub-carriers, which are set to zero, constitute the so-called guard bands on the upper and lower edges of the MCM signal spectrum.

At the input of the mapping device shown in Figure 3, complex signal pairs b0[k], b1[k] of an input bitstream are received. K complex signal pairs are assembled in order to form one MCM symbol. The signal pairs are encoded into the K differential phase shifts phi[k] needed for assembly of one MCM symbol. In this embodiment, mapping from Bits to the 0, 90, 180 and 270 degrees phase shifts is performed using Gray Mapping in a quadrature phase shift keying device 220.

Gray mapping is used to prevent that differential detection phase errors smaller than 135 degrees cause double bit errors at the receiver.

Differential phase encoding of the K phases is performed in a differential phase encoder 222. At this stage of processing, the K phases phi[k] generated by the QPSK Gray mapper are differentially encoded. In principal, a feedback loop 224 calculates a cumulative sum over all K phases. As starting point for the first computation (k = 0) the phase of the reference carrier 226 is used. A switch 228 is provided in order to provide either the absolute phase of the reference subcarrier 226 or the phase information encoded onto the preceding (i.e. $z^{-1}$, where $z^{-1}$ denotes the unit delay operator) subcarrier to a summing point 230. At the output of the differential phase encoder 222, the phase information theta[k] with which the respective subcarriers are to be encoded is provided. In preferred embodiments of the present invention, the subcarriers of a MCM symbol are equally spaced in the frequency axis direction.

The output of the differential phase encoder 222 is connected to a unit 232 for generating complex subcarrier symbols using the phase information theta[k]. To this end, the K differentially encoded phases are converted to complex symbols by multiplication with

$$\text{factor} * e^{j*[2*pi*(theta[k] + PHI)]} \qquad \text{(Eq.1)}$$

wherein factor designates a scale factor and PHI designates an additional angle. The scale factor and the additional angle PHI are optional. By choosing PHI = 45° a rotated DQPSK signal constellation can be obtained.

Finally, assembly of a MCM symbol is effected in an assembling unit 234. One MCM symbol comprising $N_{FFT}$ subcarriers is assembled from $N_{FFT}$-K-1 guard band symbols which are "zero", one reference subcarrier symbol and K DQPSK subcarrier symbols. Thus, the assembled MCM symbol 200 is composed of K complex values containing the encoded information, two guard bands at both sides of the $N_{FFT}$ complex values and a reference subcarrier symbol.

The MCM symbol has been assembled in the frequency domain. For transformation into the time domain an inverse discrete Fourier transform (IDFT) of the output of the assembling unit 234 is performed by a transformator 236. In preferred embodiments of the present invention, the transformator 236 is adapted to perform a fast Fourier transform (FFT).

Further processing of the MCM signal in the transmitter as well as in the receiver is as described above referring to Figure 1.

At the receiver a de-mapping device 142 (Figure 1) is needed to reverse the operations of the mapping device described above referring to Figure 3. The implementation of the demapping device is straightforward and, therefore, need not be described herein in detail.

The differential mapping along the frequency axis direction is suitable for multi-carrier (OFCM) digital broadcasting over rapidly changing multi path channels. In accordance with this mapping scheme, there is no need for a channel stationarity exceeding one multi-carrier symbol. However, differential mapping into frequency axis direction may create a new problem. In multi path environments, path echoes succeeding or preceding the main path can lead to systematic phase offsets between sub-carriers in the same MCM symbol. Thus, it will be preferred to provide a correction unit in order to eliminate such phase offsets. Because the channel induced phase offsets between differential demodulated symbols are systematic errors, they can be corrected by an algorithm. In principle, such an algorithm must calculate the echo induced phase offset from the signal space constellation following the differential demodulation and subsequently correct this phase offset.

Examples for such echo phase correction algorithms are described at the end of this specification referring to Figures 12 to 15.

Next, the fine frequency synchronization in accordance with the present invention will be described referring to Figures

4 to 8. As mentioned above, the fine frequency synchronization in accordance with the present invention is performed after completion of the coarse frequency synchronization. Preferred embodiments of the coarse frequency synchronization which can be performed by the symbol frame/carrier frequency synchronization unit 134 are described hereinafter referring to Figures 9 and 10 after having described the fine frequency synchronization in accordance with the present invention.

With the fine frequency synchronization in accordance with the present invention frequency offsets which are smaller than half the sub-carrier distance can be corrected. Since the frequency offsets are low and equal for all sub-carriers the problem of fine frequency synchronization is reduced to sub-carrier level. Figure 4 is a schematical view of MCM symbols 200 in the time-frequency plane. Each MCM symbol 200 consists of 432 sub-carrier symbols $C_1$ to $C_{432}$. The MCM symbols are arranged along the time axis, the first MCM symbol 200 shown in Figure 4 having associated therewith a time $T_1$, the next MCM symbol having associated therewith a time $T_2$ and so on. In accordance with a preferred embodiment of the present invention, the fine frequency synchronization is based on a phase rotation which is derived from the same sub-carrier of two MCM symbols which are adjacent in the time axis direction, for example $C_1/T_1$ and $C_1/T_2$.

In the following, the present invention is described referring to QPSK mapping (QPSK = Quadrature Phase Shift Keying). However, it is obvious that the present invention can be applied to any MPSK mapping, wherein M designates the number of phase states used for encoding, for example 2, 4, 8, 16 ....

Figure 5 represents a complex coordinate system showing a QPSK constellation for each sub-carrier with frequency offset. The four possible phase positions of a first MCM symbol, MCM-symbol-1 are shown at 300. Changing from the sub-carrier (sub-carrier n) of this MCM symbol to the same sub-carrier of the next MCM symbol, MCM-symbol-2, the position in the QPSK constellation will be unchanged in case there is no frequency offset. If a frequency offset is present, which is smaller than half the distance between sub-carriers, as mentioned above, this frequency offset causes a phase rotation of the QPSK constellation of MCM-symbol-2 compared with MCM-symbol-1. The new QPSK constellation, that is the four possible phase positions for the subject sub-carrier of MCM-symbol-2 are shown at 302 in Figure 5. This phase rotation θ can be derived from the following equation:

$$C_n\left(kT_{MCM}\right) = e^{j2\pi f_{offset}T_{MCM}} C_n\left((k-1)T_{MCM}\right)$$

$$\theta = 2\pi f_{offset} T_{MCM} \qquad \text{(Eq.2)}$$

$C_n$ designates the QPSK constellation of a sub-carrier n in a MCM symbol. n is an index running from 1 to the number of active sub-carriers in the MCM symbol. Information regarding the frequency offset is contained in the term $e^{j2\pi f_{offset}T_{MCM}}$ of equation 2. This frequency offset is identical for all sub-carriers. Therefore, the phase rotation θ is identical for all sub-carriers as well. Thus, averaging overall sub-carrier of a MCM symbol can be performed.

Figure 6 shows a block diagram of a MCM receiver in which the present invention is implemented. An analog/digital converter 310 is provided in order to perform an analog/digital conversion of a down-converted signal received at the receiver front end 132 (Figure 1). The output of the analog/digital converter 310 is applied to a low path filter and decimator unit 312. The low path filter is an impulse forming filter which is identical to an impulse forming filter in the MCM transmitter. In the decimator, the signal is sampled at the MCM symbol frequency. As described above referring to Figure 1, guard intervals in the MCM signal are removed by a guard interval removal unit 132. Guard intervals are inserted between two

MCM symbols in the MCM transmitter in order to avoid intersymbol interference caused by channel memory.

The output of the guard interval removal unit 132 is applied to a MCM demodulator 314 which corresponds to the fast Fourier transformator 140 shown in Figure 1. Following the MCM demodulator 314 a differential decoding unit 316 and a demapping unit 318 are provided. In the differential decoding unit 316, phase information is recovered using differential decoding. In the demapping unit 318, demapping along the frequency axis direction is performed in order to reconstruct a binary signal from the complex signal input into the demapping unit 318.

The output of the MCM demodulator 314 is also applied to fine frequency error detector 320. The fine frequency error detector 320 produces an frequency error signal from the output of the MCM demodulator. In the depicted embodiment, the output of the fine frequency error detector 320 is applied to a numerical controlled oscillator 322 via a loop filter 324. The loop filter 324 is a low path filter for filtering superimposed interference portions of a higher frequency from the slowly varying error signal. The numerical controlled oscillator 322 produces a carrier signal on the basis of the filtered error signal. The carrier signal produced by the numerical controlled oscillator 322 is used for a frequency correction which is performed by making use of a complex multiplier 326. The inputs to the complex multiplier 326 are the output of the low path filter and decimator unit 312 and the output of the numerical controlled oscillator 322.

A description of a preferred embodiment of the fine frequency error detector 320 is given hereinafter referring to Figure 7.

The fine frequency error detector 320 comprises a differential detector in the time axis 330. The output of the MCM demodulator 314, i.e. the FFT output (FFT = Fast Fourier Transform) is applied to the input of the differential detector 330 which performs a differential detection in the time axis in order to derive information on a frequency offset from the same sub-carrier of two subsequently arriving MCM symbols. In the embodiment shown in Figure 7, the number of active sub-carriers is 432. Thus, the differential detector 330 performs a correlation between the first and the 433rd sample. The first sample is associated with MCM-symbol-1 (Figure 5), whereas the 433rd sample is associated with MCM-symbol-2 (Figure 5). However, both these samples are associated with the same sub-carrier.

To this end, the input signal $Y_k$ is applied to a $z^{-1}$-block 332 and thereafter to a unit 334 in order to form the complex conjugate of the output of the $z^{-1}$-block 332. A complex multiplier 336 is provided in order to multiply the output of the unit 334 by the input signal $Y_k$. The output of the multiplier 336 is a signal $Z_k$.

The function of the differential detector 330 can be expressed as follows:

$$Z_k = Y_{k+K} \cdot Y_k^* \qquad \text{(Eq.3)}$$

$$Y = \left[Y_1, Y_2 \ldots, Y_k \ldots\right] \qquad \text{(Eq.4)}$$

$$Y = \left[C_1 / T_1, C_2 / T_1, \ldots, C_{432} / T_1, C_1 / T_2 \ldots\right] \qquad \text{(Eq.5)}$$

$Y_k$ designates the output of the MCM modulator 314, i.e. the input to the differential detector 330, at a time k. $Z_k$ designates the output of the differential detector 330. K designates the number of active carriers.

The output $Z_k$ of the differential detector 330 contains a M-fold uncertainty corresponding to codeable phase shifts. In case of the QPSK this M-fold uncertainty is a 4-fold uncertainty, i.e. 0°, 90°, 180° and 270°. This phase shift uncertainty is eliminated from $Z_k$ making use of a M-PSK decision device 340. Such decision devices are known in the art and, therefore, have not to be described here in detail. The output of the decision device 340 $(\hat{a}_k)^*$ represents the complex conjugate of the codeable phase shift decided by the decision device 340. This output of the decision device 340 is correlated with the output of the differential detector 330 by performing a complex multiplication using a multiplier 342.

The output the multiplier 342 represents the phase offset for the respective sub-carriers. This phase offsets for the respective sub-carriers are averaged over one MCM symbol in an averaging unit 344 in accordance with a preferred embodiment of the present invention. The output of the averaging units 344 represent the output of the fine frequency error detector 320.

The mathematical description for this procedure is as follows:

$$f_{offset} = \frac{1}{2\pi K T_{MCM}} \arg\left\{ \sum_{n=1}^{K} Z_n \cdot \left(\hat{a}_n\right)^* \right\} \quad \text{(Eq.6)}$$

In accordance with preferred embodiments of the present invention, the frequency control loop has a backward structure. In the embodiment shown in Figure 6, the feedback loop is connected between the output of the MCM demodulator 314 and the input of the guard interval removal unit 132.

In Figure 8, a block diagram of a MCM receiver comprising a coarse frequency correction unit 350 and a fine frequency correction unit as described above is shown. As shown in Figure 8, a common complex multiplier 326 can be used in order to perform the coarse frequency correction and the fine frequency correction. As shown in Figure 8, the multiplier 326 can be provided preceding the low path filter and decimator unit 312. Depending on the position of the multiplier 326, a hold unit has to be provided in the fine frequency synchronization feedback loop. In an alternative embodiment, it is possible to use two separate multipliers for the coarse frequency correction and for the fine frequency correction. In such a case, the multiplier for the coarse frequency correction will be arranged preceding the low path filter and decimator unit, whereas the multiplier for the fine frequency correction will be arranged following the low path filter and decimator unit.

Following, preferred embodiments for implementing a coarse frequency synchronization will be described referring to Figures 9 and 10.

As it is shown in Figure 9, the output of the receiver front end 132 is connected to an analog/digital converter 310. The down-converted MCM signal is sampled at the output of the analog/digital converter 310 and is applied to a frame/timing synchronization unit 360. In a preferred embodiment, a fast running automatic gain control (AGC) (not shown) is provided preceding the frame/timing synchronization unit in order to eliminate fast channel fluctuations. The fast AGC is used in addition to the normally slow AGC in the signal path, in the case of transmission over a multipath channel with long channel impulse response and frequency selective fading. The fast AGC adjusts the average amplitude range of the signal to the known average amplitude of the reference symbol.

As described above, the frame/timing synchronization unit uses the amplitude-modulated sequence in the received signal in order to extract the framing information from the MCM signal and further to remove the guard intervals therefrom. After the frame/timing synchronization unit 360 it follows a coarse frequency synchronization unit 362 which estimates a coarse frequency offset based on the amplitude-modulated sequence of the reference symbol of the MCM signal. In the coarse frequency synchronization unit 362, a frequency offset of the carrier frequency with respect to the oscillator frequency in the MCM receiver is determined in oder to perform a frequency offset correction in a block 364. This frequency offset correction in block 364 is performed by a complex multiplication.

The output of the frequency offset correction block 364 is applied to the MCM demodulator 366 formed by the Fast Fourier Transformator 140 and the carrier-bit mapper 142 shown in Figure 1.

In order to perform the coarse frequency synchronization described herein, an amplitude-demodulation has to be performed on a preprocessed MCM signal. The preprocessing may be, for example, the down-conversion and the analog/digital conversion of the MCM signal. The result of the amplitude-demodulation of the preprocessed MCM signal is an envelope representing the amplitude of the MCM signal.

For the amplitude demodulation a simple $alpha_{max+}$ $beta_{min}$-method can be used. This method is described for example in Palachels A.: DSP-mP Routine Computes Magnitude, EDN, October 26, 1989; and Adams, W. T., and Bradley, J.: Magnitude Approximations for Microprocessor Implementation, IEEE Micro, Vol. 3, No. 5, October 1983.

It is clear that amplitude determining methods different from the described $alpha_{max+}$ $beta_{min}$- method can be used. For simplification, it is possible to reduce the amplitude calculation to a detection as to whether the current amplitude is above or below the average amplitude. The output signal then consists of a -1/+1 sequence which can be used to determine a coarse frequency offset by performing a correlation. This correlation can easily be performed using a simple integrated circuit (IC).

In addition, an oversampling of the signal received at the RF front end can be performed. For example, the received signal can be expressed with two times oversampling.

In accordance with a first embodiment, a carrier frequency offset of the MCM signal from an oscillator frequency in the MCM receiver is determined by correlating the envelope obtained by performing the amplitude-demodulation as described above with a predetermined reference pattern.

In case there is no frequency offset, the received reference symbol r(k) will be:

$$r(k) = S_{AM}(k) + n(k) \qquad \text{(Eq.7)}$$

wherein n(k) designates "additive Gaussian noise" and $S_{AM}$ denotes the AM sequence which has been sent. In order to simplify the calculation the additive Gaussian noise can be neglected. It follows:

$$r(k) \cong S_{AM}(k) \qquad \text{(Eq.8)}$$

In case a constant frequency offset $\Delta f$ is present, the received signal will be:

$$\tilde{r}(k) = S_{AM}(k) \cdot e^{j2\pi\Delta fkT_{MCM}} \qquad \text{(Eq.9)}$$

Information regarding the frequency offset is derived from the correlation of the received signal $\tilde{r}(k)$ with the AM sequence $S_{AM}$ which is known in the receiver:

$$\sum_{k=1}^{\frac{L}{2}} \tilde{r}(k) \cdot S_{AM}^{*}(k) = \sum_{k=1}^{\frac{L}{2}} \left|S_{AM}(k)\right|^2 e^{j2\pi\Delta fkT_{MCM}} \qquad \text{(Eq.10)}$$

Thus, the frequency offset is:

$$\Delta f = \frac{1}{2\pi T_{MCM}} \arg\left(\sum_{k=1}^{\frac{L}{2}} r(k) \cdot S_{AM}^{*}(k)\right) - \frac{1}{2\pi T_{MCM}} \arg\left(\sum_{k=1}^{\frac{L}{2}} \left|S_{AM}(k)\right|^2\right) \qquad \text{(Eq.11)}$$

Since the argument of $|S_{AM}(k)|^2$ is zero the frequency offset is:

$$\Delta f = \frac{1}{2\pi T_{MCM}} \arg\left( \sum_{k=1}^{\frac{L}{2}} \tilde{r}(k) \cdot S_{AM}^{*} \right) \qquad \text{(Eq.12)}$$

In accordance with a second embodiment of the coarse frequency synchronization algorithm, a reference symbol comprising at least two identical sequences 370 as shown in Figure 10 is used. Figure 10 shows the reference symbol of a MCM signal having two identical sequences 370 of a length of L/2 each. L designates the number of values of the two sequences 370 of the reference symbol.

As shown in Figure 10, within the amplitude-modulated sequence, there are at least two identical sections devoted to the coarse frequency synchronization. Two such sections, each containing L/2 samples, are shown at the end of the amplitude-modulated sequence in Figure 10. The amplitude-modulated sequence contains a large number of samples. For a non-ambiguous observation of the phase, only enough samples to contain a phase rotation of $2\pi$ should be used. This number is defined as L/2 in Figure 10.

Following, a mathematical derivation of the determination of a carrier frequency deviation is presented. In accordance with Figure 10, the following equation applies for the two identical sequences 370:

$$s\left(0 < k \le \frac{L}{2}\right) \equiv s\left(\frac{L}{2} < k \le L\right) \qquad \text{(Eq.13)}$$

If no frequency offset is present, the following equation 14 will be met by the received signal:

$$r\left(k + \frac{L}{2}\right) \equiv r(k) \qquad 0 < k \le \frac{L}{2} \qquad \text{(Eq.14)}$$

r(k) designates the values of the identical sequences. k is an index from one to L/2 for the respective samples.

If there is a frequency offset of, for example, $\Delta f$, the received signal is:

$$\tilde{r}(k) = r(k) \cdot e^{j2\pi\Delta f k T_{MCM}} \qquad \text{(Eq.15)}$$

$$\tilde{r}(k+\frac{L}{2}) = r(k) \cdot e^{j2\pi\Delta f\left(k+\frac{L}{2}\right)T_{MCM}} \qquad \text{(Eq.16)}$$

$\tilde{r}(k)$ designates sample values of the received portion which are based on the identical sequences. Information regarding the frequency offset is derived from the correlation of the received signal $\tilde{r}(k+L/2)$ with the received signal $\tilde{r}(k)$. This correlation is given by the following equation:

$$\sum_{k=1}^{\frac{L}{2}} \tilde{r}^*\left(k+\frac{L}{2}\right)\tilde{r}(k) = \sum_{k=1}^{\frac{L}{2}} |r(k)|^2 e^{-j2\pi\Delta f\frac{L}{2}T_{MCM}} \qquad \text{(Eq.17)}$$

$\tilde{r}^*$ designates the complex conjugate of the sample values of the portion mentioned above.

Thus, the frequency offset is

$$\Delta f = \frac{1}{2\pi\frac{L}{2}T_{MCM}} \arg\left(\sum_{k=1}^{\frac{L}{2}} \tilde{r}\left(k+\frac{L}{2}\right)\cdot\tilde{r}^*(k)\right) - \frac{1}{2\pi\frac{L}{2}T_{MCM}} \arg\left(\sum_{k=1}^{\frac{L}{2}} |\tilde{r}(k)|^2\right) \qquad \text{(Eq.18)}$$

Since the argument of $|\tilde{r}(k)|^2$ equals zero, the frequency offset becomes

$$\Delta f = \frac{1}{2\pi\frac{L}{2}T_{MCM}} \arg\left(\sum_{k=1}^{\frac{L}{2}} \tilde{r}\left(k+\frac{L}{2}\right)\cdot\tilde{r}^*(k)\right) \qquad \text{(Eq.19)}$$

Thus, it is clear that in both embodiments, described above, the frequency position of the maximum of the resulting output of the correlation determines the estimated value of the offset carrier. Furthermore, as it is also shown in Figure 9, the correction is performed in a feed forward structure.

In case of a channel with strong reflections, for example due to a high building density, the correlations described above might be insufficient for obtaining a suitable coarse frequency synchronization. Therefore, in accordance with a third embodiment of the present invention, corresponding values of the two portions which are correlated in accordance with a second embodiment, can be weighting with corresponding values of stored predetermined reference patterns corresponding to said two identical sequences of the reference symbol. This weighting can maximize the probability of correctly determining the frequency offset. The mathematical description of this weighting is as follows:

$$\Delta f = \frac{1}{2\pi \frac{L}{2} T_{MCM}} \arg\left( \sum_{k=1}^{\frac{L}{2}} \left[ \tilde{r}\left(k+\frac{L}{2}\right) \cdot \tilde{r}^{*}(k) \right] \cdot \left[ S_{AM}(k) S_{AM}^{*}\left(k+\frac{L}{2}\right) \right] \right) \qquad \text{(Eq.20)}$$

$S_{AM}$ designates the amplitude-modulated sequence which is known in the receiver, and $S^{*}_{AM}$ designates the complex conjugate thereof.

If the above correlations are calculated in the frequency domain, the amount of

$$\sum_{k=1}^{\frac{L}{2}} \left[ \tilde{r}\left(k+\frac{L}{2}\right) \cdot \tilde{r}^{*}(k) \right] \cdot \left[ S_{AM}(k) S_{AM}^{*}\left(k+\frac{L}{2}\right) \right] \qquad \text{(Eq.21)}$$

is used rather than the argument. This amount is maximized as a function of a frequency correction. The position of the maximum determines the estimation of the frequency deviation. As mentioned above, the correction is performed in a feed forward structure.

Preferred embodiments for performing an echo phase offset correction when using a differential mapping in the frequency axis will be described hereinafter referring to Figures 12 to 15.

Systematic phase shifts stemming from echoes in multipath environments may occur between subcarriers in the same MCM symbol. This phase offsets can cause bit errors when demodulating the MCM symbol at the receiver. Thus, it is preferred to make use of an algorithm to correct the systematic phase shifts stemming from echoes in multipath environments.

In Figure 12, scatter diagrams at the output of a differential demapper of a MCM receiver are shown. As can be seen from the left part of Figure 12, systematic phase shifts between subcarriers in the same MCM symbol cause a rotation of the demodulated phase shifts with respect to the axis of the complex coordinate system. In the right part of Figure 12, the demodulated phase shifts after having performed an echo phase offset correction are depicted. Now, the positions of the signal points are substantially on the axis of the complex coordinate system. These positions correspond to the modulated phase shifts of 0°, 90°, 180° and 270°, respectively.

An echo phase offset correction algorithm (EPOC algorithm) must calculate the echo induced phase offset from the signal space constellation following the differential demodulation and subsequently correct this phase offset.

For illustration purposes, one may think of the simplest algorithm possible which eliminates the symbol phase before computing the mean of all phases of the subcarriers. To illustrate the effect of such an EPOC algorithm, reference is made to the two scatter diagrams of subcarriers symbols contained in one MCM symbol in Figure 12. This scatter diagrams have been obtained as result of an MCM simulation. For the simulation a channel has been used which might typically show up in single frequency networks. The echoes of this channel stretched to the limits of the MCM guard interval. The guard interval was chosen to be 25% of the MCM symbol duration in this case.

Figure 13 represents a block diagram for illustrating the position and the functionality of an echo phase offset correction device in a MCM receiver. The signal of a MCM transmitter is transmitted through the channel 122 (Figures 1 and 13) and received at the receiver frontend 132 of the MCM receiver. The signal processing between the receiver frontend and the fast Fourier transformator 140 has been omitted in Figure 13. The output of the fast Fourier transformator is applied to the de-mapper, which performs a differential de-mapping along the frequency axis. The output of the de-mapper are the respective phase shifts for the subcarriers. The phase offsets of this phase shifts which are caused by echoes in multipath environments are visualized by a block 400 in Figure 13 which shows an example of a scatter diagram of the subcarrier symbols without an echo phase offset correction.

The output of the de-mapper 142 is applied to the input of an echo phase offset correction device 402. The echo phase offset correction device 402 uses an EPOC algorithm in order to eliminate echo phase offsets in the output of the de-mapper 142. The result is shown in block 404 of Figure 13, i.e. only the encoded phase shifts, 0°, 90°, 180° or 270° are present at the output of the correction device 402. The output of the correction device 402 forms the signal for the metric calculation which is performed in order to recover the bitstream representing the transmitted information.

A first embodiment of an EPOC algorithm and a device for performing same is now described referring to Figure 14.

The first embodiment of an EPOC algorithm starts from the assumption that every received differentially decoded complex symbol is rotated by an angle due to echoes in the multipath channel. For the subcarriers equal spacing in frequency is assumed since this represents a preferred embodiment. If the subcarriers were not equally spaced in frequency, a correction factor would have to be introduced into the EPOC algorithm.

Figure 14 shows the correction device 402 (Figure 13) for performing the first embodiment of an EPOC algorithm.

From the output of the de-mapper 142 which contains an echo phase offset as shown for example in the left part of Figure 12, the phase shifts related to transmitted information must first be discarded. To this end, the output of the de-mapper 142 is applied to a discarding unit 500. In case of a DQPSK mapping, the discarding unit can perform a "$(.)^4$" operation. The unit 500 projects all received symbols into the first quadrant. Therefore, the phase shifts related to transmitted information is eliminated from the phase shifts representing the subcarrier symbols. The same effect could be reached with a modulo-4 operation.

Having eliminated the information related symbol phases in unit 500, the first approach to obtain an estimation would be to simply compute the mean value over all symbol phases of one MCM symbol. However, it is preferred to perform a threshold decision before determining the mean value over all symbol phases of one MCM symbol. Due to Rayleigh fading some of the received symbols may contribute unreliable information to the determination of the echo phase offset. Therefore, depending on the absolute value of a symbol, a threshold decision is performed in order to determine whether the symbol should contribute to the estimate of the phase offset or not.

Thus, in the embodiment shown in Figure 14, a threshold decision unit 510 is included. Following the unit 500 the absolute value and the argument of a differentially decoded symbol is computed in respective computing units 512 and 514. Depending on the absolute value of a respective symbol, a control signal is derived. This control signal is compared with a threshold value in a decision circuit 516. If the absolute value, i.e. the control signal thereof, is smaller than a certain threshold, the decision circuit 516 replaces the angle value going into the averaging operation by a value equal to zero. To this end, a switch is provided in order to disconnect the output of the argument computing unit 514 from the input of the further processing stage and connects the input of the further processing stage with a unit 518 providing a constant output of "zero".

An averaging unit 520 is provided in order to calculate a mean value based on the phase offsets $\varphi_i$ determined for the individual subcarrier symbols of a MCM symbol as follows:

$$\overline{\varphi} = 1/K \sum_{i=1}^{K} \varphi_i \qquad \text{(Eq.22)}$$

In the averaging unit 520, summation over K summands is performed. The output of the averaging unit 520 is provided to a hold unit 522 which holds the output of the averaging unit 520 K times. The output of the hold unit 522 is connected with a phase rotation unit 524 which performs the correction of the phase offsets of the K complex signal points on the basis of the mean value $\overline{\varphi}$.

The phase rotation unit 524 performs the correction of the phase offsets by making use of the following equation:

$$v_k' = v_k \cdot e^{-j\overline{\varphi}} \qquad \text{(Eq.23)}$$

In this equation, $v_k'$ designates the K phase corrected differentially decoded symbols for input into the soft-metric calculation, whereas $v_k$ designates the input symbols. As long as a channel which is quasi stationary during the duration of one MCM symbols can be assumed, using the mean value over all subcarriers of one MCM symbol will provide correct results.

A buffer unit 527 may be provided in order to buffer the complex signal points until the mean value of the phase offsets for one MCM symbol is determined. The output of the phase rotation unit 524 is applied to the further processing stage 526 for performing the soft-metric calculation.

With respect to the results of the above echo phase offset correction, reference is made again to Figure 12. The two plots stem from a simulation which included the first embodiment of an echo phase offset correction algorithm described above. At the instant of the scatter diagram snapshot shown in the left part of Figure 12, the channel obviously distorted the constellation in such a way, that a simple angle rotation is a valid assumption. As shown in the right part of Figure 12, the signal constellation can be rotated back to the axis by applying the determined mean value for the rotation of the differentially detected symbols.

A second embodiment of an echo phase offset correction algorithm is described hereinafter. This second embodiment can be preferably used in connection with multipath channels that have up to two strong path echoes. The algorithm of the second embodiment is more complex than the algorithm of the first embodiment.

What follows is a mathematical derivation of the second embodiment of a method for echo phase offset correction. The following assumptions can be made in order to ease the explanation of the second embodiment of an EPOC algorithm.

In this embodiment, the guard interval of the MCM signal is assumed to be at least as long as the impulse response h[q], q = 0, 1, ..., Qh-1 of the multipath channel.

At the transmitter every MCM symbol is assembled using frequency axis mapping explained above. The symbol of the reference subcarrier equals 1, i.e. 0 degree phase shift. The optional phase shift PHI equals zero, i.e. the DQPSK signal constellation is not rotated.

Using an equation this can be expressed as

$$a_k = a_{k-1} a_k^{inc} \qquad \text{(Eq.24)}$$

with

k : index k = 1,2,...,K of the active subcarrier;

$a_k^{inc} = e^{j\frac{\pi}{2}m}$ : complex phase increment symbol; m=0,1,2,3 is the QPSK symbol number which is derived from Gray encoding pairs of 2 Bits;

$a_0 = 1$ : symbol of the reference subcarrier.

At the DFT output of the receiver the decision variables

$$e_k = a_k H_k \qquad \text{(Eq.25)}$$

are obtained with

$$H_k = \sum_{i=0}^{Q_h-1} h[i] \cdot e^{-j\frac{2\pi}{K}ki} \qquad \text{(Eq.26)}$$

being the DFT of the channel impulse response h[q] at position k.

With $|a_k|^2 = 1$ the differential demodulation yields

$$v_k = e_k \cdot e_{k-1}^* = a_k^{inc} H_k H_{k-1}^* \qquad \text{(Eq.27)}$$

For the receiver an additional phase term $\varphi_k$ is introduced, which shall be used to correct the systematic phase offset caused by the channel. Therefore, the final decision variable at the receiver is

$$v_k' = v_k \cdot e^{j\varphi_k} = a_k^{inc} \cdot e^{j\varphi_k} \cdot H_k \cdot H_{k-1}^* \qquad \text{(Eq.28)}$$

As can be seen from the Equation 28, the useful information

$a_k^{inc}$ is weighted with the product $e^{j\varphi_k} \cdot H_k \cdot H^*_{k-1}$ (rotation and effective transfer function of the channel). This product must be real-valued for an error free detection. Considering this, it is best to choose the rotation angle to equal the negative argument of $H_k \cdot H^*_{k-1}$. To derive the desired algorithm for 2-path channels, the nature of $H_k \cdot H^*_{k-1}$ is investigated in the next section.

It is assumed that the 2-path channel exhibits two echoes with energy content unequal zero, i.e. at least two dominant echoes. This assumption yields the impulse response

$$h[q] = c_1\delta_0[q] + c_2\delta_0[q - q_0] \qquad \text{(Eq.29)}$$

with

$c_1, c_2$ : complex coefficients representing the path echoes;

$q_0$ : delay of the second path echo with respect to the first path echo;

$\delta_0$ : Dirac pulse; $\delta_0[k] = 1$ for $k = 0$
$\delta_0[k] = 0$ else

The channel transfer function is obtained by applying a DFT to Equation 29:

$$H_k = H\left(e^{j\frac{2\pi}{K}k}\right) = c_1 + c_2 \cdot e^{-j\frac{2\pi}{K}kq_0} \qquad \text{(Eq.30)}$$

With Equation 30 the effective transfer function for differential demodulation along the frequency axis is:

$$\begin{aligned} H_k \cdot H^*_{k-1} &= \left(c_1 + c_2 e^{-j\frac{2\pi}{K}kq_0}\right) \cdot \left(c_1^* + c_2^* e^{+j\frac{2\pi}{K}(k-1)q_0}\right) \\ &= c_a + c_b \cos\left(\frac{\pi}{K}q_0(2k-1)\right) \end{aligned} \qquad \text{(Eq.31)}$$

Assuming a noise free 2-path channel, it can be observed from Equation 31 that the symbols on the receiver side are located on a straight line in case the symbol 1+j0 has been send (see above assumption). This straight line can be characterized by a point

$$c_a = |c_1|^2 + |c_2|^2 \cdot e^{-j\frac{2\pi}{K}q_0} \quad \text{(Eq.32)}$$

and the vector

$$c_b = 2c_1c_2^* \cdot e^{-j\frac{\pi}{K}q_0} \quad \text{(Eq.33)}$$

which determines its direction.

With the above assumptions, the following geometric derivation can be performed. A more suitable notation for the geometric derivation of the second embodiment of an EPOC algorithm is obtained if the real part of the complex plane is designated as x = Re{z}, the imaginary part as y = Im{z}, respectively, i.e. z = x+jy. With this new notation, the straight line, on which the received symbols will lie in case of a noise-free two-path channel, is

$$f(x) = a + b \cdot x \quad \text{(Eq.34)}$$

with

$$a = \mathrm{Im}\{c_a\} - \frac{\mathrm{Re}\{c_a\}}{\mathrm{Re}\{c_b\}} \cdot \mathrm{Im}\{c_b\} \quad \text{(Eq.35)}$$

and

$$b = -\frac{\mathrm{Im}\{c_a\} - \frac{\mathrm{Re}\{c_a\}}{\mathrm{Re}\{c_b\}} \cdot \mathrm{Im}\{c_b\}}{\mathrm{Re}\{c_a\} - \frac{\mathrm{Im}\{c_a\}}{\mathrm{Im}\{c_b\}} \cdot \mathrm{Re}\{c_b\}} \quad \text{(Eq.36)}$$

Additional noise will spread the symbols around the straight line given by Equations 34 to 36. In this case Equation 36 is the regression curve for the cluster of symbols.

For the geometric derivation of the second embodiment of an EPOC algorithm, the angle $\varphi_k$ from Equation 28 is chosen to be a function of the square distance of the considered symbol from the origin:

$$\varphi_k = f_K(|z|^2) \qquad \text{(Eq.37)}$$

Equation 37 shows that the complete signal space is distorted (torsion), however, with the distances from the origin being preserved.

For the derivation of the algorithm of the second embodiment, $f_K(\cdot)$ has to be determined such that all decision variables $v'_k$ (assuming no noise) will come to lie on the real axis:

$$\mathrm{Im}\left\{\left(x + jf(x)\right)\cdot e^{j f_K\left(|z|^2\right)}\right\} = 0 \qquad \text{(Eq.38)}$$

Further transformations of Equation 38 lead to a quadratic equation which has to be solved to obtain the solution for $\varphi_k$.

In case of a two-path channel, the echo phase offset correction for a given decision variable $v_k$ is

$$v'_k = v_k \cdot e^{j\varphi_k} \qquad \text{(Eq.39)}$$

with

$$\varphi_k = \begin{cases} -atan\left(\dfrac{a + b\sqrt{|v_k|^2(1+b^2) - a^2}}{-ab + \sqrt{|v_k|^2(1+b^2) - a^2}}\right) & \text{for } |v_k|^2 \geq \dfrac{a^2}{1+b^2} \\ atan\left(\dfrac{1}{b}\right) & \text{for } |v_k|^2 < \dfrac{a^2}{1+b^2} \end{cases} \qquad \text{(Eq.40)}$$

From the two possible solutions of the quadratic equation mentioned above, Equation 40 is the one solution that cannot cause an additional phase shift of 180 degrees.

The two plots in Figure 15 show the projection of the EPOC algorithm of the second embodiment for one quadrant of the complex plane. Depicted here is the quadratic grid in the sector $|\arg(z)| \leq \pi/4$ and the straight line $y = f(x) = a+b \cdot x$ with $a = -1.0$ and $b = 0.5$ (dotted line). In case of a noise-free channel, all received symbols will lie on this straight line if 1+j0 was send. The circle shown in the plots determines the boarder line for the two cases of Equation 40. In the left part, Figure 15 shows the situation before the projection, in the right part, Figure 15 shows the situation after applying the projection algorithm. By looking on the left part, one can see, that the straight line now lies on the real axis with 2+j0 being the fix point of the projection. Therefore, it can be concluded that the echo phase offset correction algorithm according to the second embodiment fulfills the design goal.

Before the second embodiment of an EPOC algorithm can be applied, the approximation line through the received symbols has to be determined, i.e. the parameters a and b must be estimated. For this purpose, it is assumed that the received symbols lie in sector $|\arg(z)| \leq \pi/4$, if 1+j0 was sent. If symbols other than 1+j0 have been sent, a modulo operation can be applied to project all symbols into the desired sector. Proceeding like this prevents the necessity of deciding on the symbols in an early stage and enables averaging over all signal points of one MCM symbol (instead of averaging over only ¼ of all signal points).

For the following computation rule for the EPOC algorithm of the second embodiment, $x_i$ is used to denote the real part of the i-th signal point and $y_i$ for its imaginary part, respectively ($i = 1, 2, \ldots, K$). Altogether, K values are available for the determination. By choosing the method of least squares, the straight line which has to be determined can be obtained by minimizing

$$(a,b) = \underset{(\tilde{a},\tilde{b})}{argmin} \sum_{i=1}^{K} \left(y_i - \left(\tilde{a} + \tilde{b} \cdot x_i\right)\right)^2 \qquad \text{(Eq.41)}$$

The solution for Equation 41 can be found in the laid open literature. It is

$$b = \frac{\sum_{i=1}^{K} \left(x_i - \overline{x}\right) \cdot y_i}{\sum_{i=1}^{K} \left(x_i - \overline{x}\right)^2}, \quad a = \overline{y} - \overline{x} \cdot b \qquad \text{(Eq.42)}$$

with mean values

$$\overline{x} = \frac{1}{N} \sum_{i=1}^{K} x_i, \quad \overline{y} = \frac{1}{N} \sum_{i=1}^{K} y_i \qquad \text{(Eq.43)}$$

If necessary, an estimation method with higher robustness can be applied. However, the trade-off will be a much higher computational complexity.

To avoid problems with the range in which the projection is applicable, the determination of the straight line should be separated into two parts. First, the cluster's centers of gravity are moved onto the axes, following, the signal space is distorted. Assuming that a and b are the original parameters of the straight line and $\alpha$ is the rotation angle, $f_{K(.)}$ has to be applied with the transformed parameters

$$b' = \frac{b \cdot \cos(\alpha) - \sin(\alpha)}{\cos(\alpha) + b \cdot \sin(\alpha)}, \qquad a' = a \cdot \left(\cos(\alpha) - b' \cdot \sin(\alpha)\right) \qquad \text{(Eq.44)}$$

Besides the two EPOC algorithms explained above section, different algorithms can be designed that will, however, most likely exhibit a higher degree of computational complexity.

Claims

1. A method of performing a fine frequency synchronization compensating for a carrier frequency deviation from an oscillator frequency in a multi-carrier demodulation system (130) of the type capable of carrying out a differential phase decoding of multi-carrier modulated signals, said signals comprising a plurality of symbols (200), each symbol being defined by phase differences between simultaneous carriers (202) having different frequencies, said method comprising the steps of:

determining a phase difference between phases of the same carrier in different symbols;

determining a frequency offset by eliminating phase shift uncertainties corresponding to codeable phase shifts from said phase difference; and

performing a feedback correction of said carrier frequency deviation based on said determined frequency offset.

2. A method of performing a fine frequency synchronization compensating for a carrier frequency deviation from an oscillator frequency in a multi-carrier demodulation system (130) of the type capable of carrying out a differential phase decoding of multi-carrier modulated signals, said signals comprising a plurality of symbols (200), each symbol being defined by phase differences between simultaneous carriers (202) having different frequencies, said method comprising the steps of:

determining respective phase of the same carrier in different symbols;

eliminating phase shift uncertainties corresponding to codeable phase shifts from said phases to determine respective phase deviations;

determining a frequency offset by determining a phase difference between said phase deviations;

performing a feedback correction of said carrier frequency deviation based on said determined frequency offset.

3. A method of performing a fine frequency synchronization compensating for a carrier frequency deviation from an oscillator frequency in a multi-carrier demodulation system (130) of the type capable of carrying out a differential phase decoding of multi-carrier modulated signals, said signals comprising a plurality of symbols (200), each symbol being defined by phase differences between simultaneous carriers (202) having different frequencies, said method comprising the steps of:

for a plurality of carriers (202) in said symbols (200):

determining a phase difference between phases of the same carrier in different symbols; and

determining a frequency offset by eliminating phase shift uncertainties corresponding to codeable phase shifts from said phase difference;

determining an averaged frequency offset ($f_{offset}$) by averaging said determined frequency offsets of said plurality of carriers (202); and

performing a feedback correction of said frequency deviation based on said averaged frequency offset ($f_{offset}$).

4. A method of performing a fine frequency synchronization

compensating for a carrier frequency deviation from an oscillator frequency in a multi-carrier demodulation system (130) of the type capable of carrying out a differential phase decoding of multi-carrier modulated signals, said signals comprising a plurality of symbols (200), each symbol being defined by phase differences between simultaneous carriers (202) having different frequencies, said method comprising the steps of:

for a plurality of carriers (202) in said symbols (200):

determining respective phases of the same carrier in different symbols;

eliminating phase shift uncertainties corresponding to codeable phase shifts from said phases to determine respective phase deviations; and

determining a frequency offset by determining a phase difference between said phase deviations;

determining an averaged frequency offset by averaging said determined frequency offsets of said plurality of carriers; and

performing a feedback correction of said frequency deviation based on said averaged frequency offset.

5. The method according to claims 1 or 3, wherein said step of determining a phase difference comprises the step of determining a phase difference between phases of the same carrier (202) in symbols (200) which are adjacent in the time axis direction.

6. The method according to claims 1 or 3, wherein said step of determining a frequency offset comprises the step of eliminating phase shift uncertainties corresponding to M-ary phase shifts.

7. The method according to claims 2 or 4, wherein said step of determining respective phases comprises the step of determining respective phases of the same carrier (202) in symbols (200) which are adjacent in the time axis direction.

8. The method according to claims 2 or 4, wherein said step of eliminating phase shift uncertainties comprises the step of eliminating M-ary phase shifts.

9. An apparatus for performing a fine frequency synchronization compensating for a carrier frequency deviation from an oscillator frequency, for a multi-carrier demodulation system (130) of the type capable of carrying out a differential phase decoding of multi-carrier modulated signals, said signals comprising a plurality of symbols (200), each symbol being defined by phase differences between simultaneous carriers (202) having different frequencies, said apparatus comprising:

means (330) for determining a phase difference between phases of the same carrier (202) in different symbols (200);

means (340, 342) for determining a frequency offset by eliminating phase shift uncertainties corresponding to codeable phase shifts from said phase difference; and

means for performing a feedback correction of said frequency deviation based on said determined frequency offset.

10. An apparatus for performing a fine frequency synchronization compensating for a carrier frequency deviation from an oscillator frequency, for a multi-carrier demodulation system (130) of the type capable of carrying out a differential phase decoding of

multi-carrier modulated signals, said signals comprising a plurality of symbols (200), each symbol being defined by phase differences between simultaneous carriers (202) having different frequencies, said apparatus comprising:

means for determining respective phases of the same carrier in different symbols;

means for eliminating phase shift uncertainties corresponding to codeable phase shifts from said phases to determine respective phase deviations;

means for determining a frequency offset by determining a phase difference between said phase deviations;

means for performing a feedback correction of said frequency deviation based on said determined frequency offset.

11. An apparatus for performing a fine frequency synchronization compensating for a carrier frequency deviation from an oscillator frequency, for a multi-carrier demodulation system (130) of the type capable of carrying out a differential phase decoding of multi-carrier modulated signals, said signals comprising a plurality of symbols (200), each symbol being defined by phase differences between simultaneous carriers (202) having different frequencies, said apparatus comprising:

means (330) for determining a phase difference between phases of the same carrier (202) in different symbols;

means (340, 342) for determining a frequency offset by eliminating phase shift uncertainties corresponding to codeable phase shifts from said phase difference;

means (344) for determining an averaged frequency offset ($f_{offset}$) by averaging determined frequency offsets of a plurality of carriers; and

means for performing a feedback correction of said frequency deviation based on said averaged frequency offset.

12. An apparatus for performing a fine frequency synchronization compensating for a carrier frequency deviation from an oscillator frequency, for a multi-carrier demodulation system (130) of the type capable of carrying out a differential phase decoding of multi-carrier modulated signals, said signals comprising a plurality of symbols (200), each symbol (200) being defined by phase differences between simultaneous carriers (202) having different frequencies, said apparatus comprising:

means for determining respective phases of the same carrier in different symbols;

means for eliminating phase shift uncertainties corresponding to codeable phase shifts from said phases to determine respective phase deviations;

means for determining a frequency offset by determining a phase difference between said phase deviations;

means for determining an averaged frequency offset by averaging determined frequency offsets of a plurality of carriers; and

means for performing a feedback correction of said frequency deviation based on said averaged frequency offset.

13. The apparatus according to claims 9 or 11, wherein said means (330) for determining a phase difference comprises means for determining a phase difference between phases

of the same carrier in symbols which are adjacent in the time axis direction.

14. The apparatus according to claims 10 or 12, wherein said means for determining respective phases comprises means for determining respective phases of the same carrier in symbols which are adjacent in the time axis direction.

15. The apparatus according to claims 9 or 11, wherein said means (340, 342) for determining a frequency offset comprises a M-ary phase shift keying decision device (340) and a complex multiplier (342).

16. The apparatus according to claims 10 or 12, wherein said means for eliminating phase shift uncertainties comprises a M-ary phase shift keying decision device and a complex multiplier.

17. The apparatus according to one of claims 9 to 16, wherein said means for performing a feedback correction of said frequency deviation comprises a numerical controlled oscillator (322) and a complex multiplier (326).

18. The apparatus according to claim 17, wherein said means for performing a feedback correction of said frequency deviation further comprises a low path filter (324) preceding said numerical controlled oscillator (322).

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**METHOD AND APPARATUS FOR FINE FREQUENCY SYNCHRONIZATION IN MULTI-CARRIER DEMODULATION SYSTEMS**

ABSTRACT

A method and an apparatus relate to a fine frequency synchronization compensating for a carrier frequency deviation from an oscillator frequency in a multi-carrier demodulation system 130 of the type capable of carrying out a differential phase decoding of multi-carrier modulated signals, the signals comprising a plurality of symbols 200, each symbol being defined by phase differences between simultaneous carriers 202 having different frequencies. A phase difference between phases of the same carrier 202 in different symbols 200 is determined. Thereafter, a frequency offset is determined by eliminating phase shift uncertainties corresponding to codeable phase shifts from the phase difference. Finally, a feedback correction of the carrier frequency deviation is performed based on the determined frequency offset. Alternatively, an averaged frequency offset can be determined by averaging determined frequency offsets of a plurality of carriers 202. Then, the feedback correction of the frequency deviation is performed based on the averaged frequency offset.

Cancel

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*patent application serial no.*

***Department of Commerce***
***Patent and Trademark Office***
***fee record***

10/17/2000 ERIMANDO 00000072 09673270

| | |
|---|---|
| 01 FC:970 | 860.00 OP |
| 02 FC:154 | 130.00 OP |
| 03 FC:964 | 80.00 OP |

## PATENT APPLICATION FEE DETERMINATION RECORD
Effective October 1, 2000

Application or Docket Number

### CLAIMS AS FILED - PART I

| | (Column 1) | (Column 2) |
|---|---|---|
| TOTAL CLAIMS | | |
| FOR | NUMBER FILED | NUMBER EXTRA |
| TOTAL CHARGEABLE CLAIMS | minus 20= | * |
| INDEPENDENT CLAIMS | minus 3 = | * |
| MULTIPLE DEPENDENT CLAIM PRESENT | | ☐ |

* If the difference in column 1 is less than zero, enter "0" in column 2

| SMALL ENTITY TYPE ☐ RATE | FEE | OR | OTHER THAN SMALL ENTITY RATE | FEE |
|---|---|---|---|---|
| BASIC FEE | | OR | BASIC FEE | 860 |
| X$ 9= | | OR | X$18= | |
| X40= | | OR | X80= | |
| +135= | | OR | +270= | |
| TOTAL | | OR | TOTAL | |

### CLAIMS AS AMENDED - PART II

**AMENDMENT A**

| | (Column 1) CLAIMS REMAINING AFTER AMENDMENT | | (Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR | (Column 3) PRESENT EXTRA |
|---|---|---|---|---|
| Total | * | Minus | ** | = |
| Independent | * | Minus | *** | = |
| FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM | | | | ☐ |

| SMALL ENTITY RATE | ADDITIONAL FEE | OR | OTHER THAN SMALL ENTITY RATE | ADDITIONAL FEE |
|---|---|---|---|---|
| X$ 9= | | OR | X$18= | |
| X40= | | OR | X80= | |
| +135= | | OR | +270= | |
| TOTAL ADDIT. FEE | | OR | TOTAL ADDIT. FEE | |

**AMENDMENT B**

| | (Column 1) CLAIMS REMAINING AFTER AMENDMENT | | (Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR | (Column 3) PRESENT EXTRA |
|---|---|---|---|---|
| Total | * | Minus | ** | = |
| Independent | * | Minus | *** | = |
| FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM | | | | ☐ |

| RATE | ADDITIONAL FEE | OR | RATE | ADDITIONAL FEE |
|---|---|---|---|---|
| X$ 9= | | OR | X$18= | |
| X40= | | OR | X80= | |
| +135= | | OR | +270= | |
| TOTAL ADDIT. FEE | | OR | TOTAL ADDIT. FEE | |

**AMENDMENT C**

| | (Column 1) CLAIMS REMAINING AFTER AMENDMENT | | (Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR | (Column 3) PRESENT EXTRA |
|---|---|---|---|---|
| Total | * | Minus | ** | = |
| Independent | * | Minus | *** | = |
| FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM | | | | ☐ |

| RATE | ADDITIONAL FEE | OR | RATE | ADDITIONAL FEE |
|---|---|---|---|---|
| X$ 9= | | OR | X$18= | |
| X40= | | OR | X80= | |
| +135= | | OR | +270= | |
| TOTAL ADDIT. FEE | | OR | TOTAL ADDIT. 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.



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09/673270
529[illegible]'d PCT/PTC 13 OCT 2000

41001 **PATENT**

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

#6/A

| | | |
|---|---|---|
| In re Application of: | : | |
| | : | |
| Ernst Eberlein et al. | : | Group Art Unit: |
| | : | |
| Serial No.: Not Assigned | : | Examiner: |
| | : | |
| Filed: Herewith | : | |
| | : | |
| For: Method and Apparatus for Fine Frequency Synchronization in Multi-Carrier Demodulation Systems | : | |

PRELIMINARY AMENDMENT

Assistant Commissioner for Patents
Washington, D.C. 20231

09673270.092600

Sir:

This Preliminary Amendment is being filed concurrently with the U.S. national stage entry under 35 U.S.C. § 371 of International Application No. PCT/EP98/02184, which has an International Filing Date of April 14, 1998. Prior to examination and calculation of the filing fees, please amend the national stage application as follows:

IN THE SPECIFICATION:

Please delete the current specification comprising pages 1-40 and 48 (as amended in the International Preliminary Examination Report dated July 19, 2000) and replace it with the accompanying substitute specification.

IN THE CLAIMS:

Please cancel claims 1-18 annexed to the International Preliminary Examination Report dated July 19, 2000, and substitute the following new claims 19-34:

19. A method of performing a fine frequency synchronization compensating for a carrier frequency deviation from an oscillator frequency in a multi-carrier demodulation system of the type capable of carrying out a differential phase

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decoding of multi-carrier modulated signals, said signals comprising a plurality of symbols, each symbol being defined by phase differences between simultaneous carriers having different frequencies, said method comprising the steps of:

a) determining a phase difference between phases of the same carrier in different symbols;

b) determining a frequency offset by eliminating phase shift uncertainties related to the transmitted information from said phase difference making use of a M-PSK decision device; and

c) performing a feedback correction of said carrier frequency deviation based on said determined frequency offset.

26. A method of performing a fine frequency synchronization compensating for a carrier frequency deviation from an oscillator frequency in a multi-carrier demodulation system of the type capable of carrying out a differential phase decoding of multi-carrier modulated signals, said signals comprising a plurality of symbols, each symbol being defined by phase differences between simultaneous carriers having different frequencies, said method comprising the steps of:

a) determining respective phase of the same carrier in different symbols;

b) eliminating phase shift uncertainties related to the transmitted information from said phases to determine respective phase deviations making use of a M-PSK decision device;

c) determining a frequency offset by determining a phase difference between said phase deviations; and

d) performing a feedback correction of said carrier frequency deviation based on said determined frequency offset.

21. The method according to claim 19, wherein

said steps a) and b) are performed for a plurality of carriers in said symbols,

an averaged frequency offset is determined by averaging said determined frequency offsets of said plurality of carriers, and

said feedback correction of said frequency deviation is performed based on said averaged frequency offset in said step c).

22. The method according to claim 20, wherein

said steps a), b) and c) are performed for a plurality of carriers in said symbols,

an averaged frequency offset is determined by averaging said determined frequency offsets of said plurality of carriers, and

said feedback correction of said frequency deviation is performed based on said averaged frequency offset.

23. The method according to claim 19, wherein said step a) comprises the step of determining a phase difference between phases of the same carrier in symbols which are adjacent in the time axis direction.

24. The method according to claim 19, wherein said step b) comprises the step of eliminating phase shift uncertainties corresponding to M-ary phase shifts.

25. The method according to claim 20, wherein said step a) comprises the step of determining respective phases of the same carrier in symbols which are adjacent in the time axis direction.

26. The method according to claim 20, wherein said step b) comprises the step of eliminating M-ary phase shifts.

27. An apparatus for performing a fine frequency synchronization compensating for a carrier frequency deviation from an oscillator frequency, for a multi-carrier demodulation system of the type capable of carrying out a differential phase decoding of multi-carrier modulated signals, said signals comprising a plurality of symbols, each symbol being defined by phase differences between simultaneous carriers having different frequencies, said apparatus comprising:

means for determining a phase difference between phases of the same carrier in different symbols;

M-PSK decision device for determining a frequency offset by eliminating phase shift uncertainties related to the transmitted information from said phase difference; and

means for performing a feedback correction of said frequency deviation based on said determined frequency offset.

28. An apparatus for performing a fine frequency synchronization compensating for a carrier frequency deviation from an oscillator frequency, for a multi-carrier demodulation system of the type capable of carrying out a differential phase decoding of multi-carrier modulated signals, said signals comprising a plurality of symbols, each symbol being defined by phase differences between simultaneous carriers having different frequencies, said apparatus comprising:

means for determining respective phases of the same carrier in different symbols;

M-PSK decision device for eliminating phase shift uncertainties related to the transmitted information from said phases to determine respective phase deviations;

means for determining a frequency offset by determining a phase difference between said phase deviations;

means for performing a feedback correction of said frequency deviation based on said determined frequency offset.

29. The apparatus according to claim 27, further comprising:

means for determining an averaged frequency offset by averaging determined frequency offsets of a plurality of carriers, wherein

said means for performing a feedback correction performs said feedback correction of said frequency deviation based on said averaged frequency offset.

30. The apparatus according to claim 28, further comprising:

means for determining an averaged frequency offset by averaging determined frequency offsets of a plurality of carriers, wherein

said means for performing a feedback correction performs said feedback correction of said frequency deviation based on said averaged frequency offset.

31. The apparatus according to claim 27, wherein said means for determining a phase difference comprises means for determining a phase difference between phases of the same carrier in symbols which are adjacent in the time axis direction.

32. The apparatus according to claim 28, wherein said means for determining respective phases comprises means for determining respective phases of the same carrier in symbols which are adjacent in the time axis direction.

33. The apparatus according to claim 27, wherein said means for performing a feedback correction of said frequency deviation comprises a numerical controlled oscillator and a complex multiplier.

34. The apparatus according to claim 33, wherein said means for performing a feedback correction of said frequency deviation further comprises a low path filter preceding said numerical controlled oscillator.

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REMARKS

By the present Preliminary Amendment, claims 1-18 annexed to the International Preliminary Examination Report dated July 19, 2000 are being cancelled and replaced with new claims 19-34. In the new claims, multiple dependencies and parenthetical reference numerals have been eliminated.

A substitute specification is being submitted to facilitate processing of this application. A marked-up copy of the substitute specification is also being provided to show the new changes which are beyond those previously made during the international stage. The substitute specification contains no new matter.

Early and favorable action on this application is respectfully requested. Should the Examiner have any questions, the Examiner is invited to contact the undersigned attorney at the local telephone number listed below.

Respectfully submitted,

John E. Holmes

John E. Holmes
Attorney for Applicant
Reg. No. 29,392

Roylance, Abrams, Berdo & Goodman
1300 19th Street, N.W., Suite 600
Washington, D.C. 20036-2680
(202) 659-9076

Dated: October 13, 2000

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# DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION (37 CFR 1.63)

☐ Declaration Submitted with Initial Filing OR ☑ Declaration Submitted after Initial Filing (surcharge (37 CFR 1.16 (e)) required)

| | |
|---|---|
| Attorney Docket Number | 41001 |
| First Named Inventor | Ernst Eberlein |
| *COMPLETE IF KNOWN* | |
| Application Number | / |
| Filing Date | |
| Group Art Unit | |
| Examiner Name | |

**As a below named inventor, I hereby declare that:**

My residence, post office address, and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

Method and Apparatus for Fine Frequency Synchronization in Multi-Carrier Demodulation Systems

*(Title of the Invention)*

the specification of which

☐ is attached hereto

OR

☑ was filed on (MM/DD/YYYY) 04/14/98 as United States Application Number or PCT International Application Number PCT/EP98/02184 and was amended on (MM/DD/YYYY) ______ (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56.

I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or of any PCT international application having a filing date before that of the application on which priority is claimed.

| Prior Foreign Application Number(s) | Country | Foreign Filing Date (MM/DD/YYYY) | Priority Not Claimed | Certified Copy Attached? YES | NO |
|---|---|---|---|---|---|
| | | | ☐ | ☐ | ☑ |
| | | | ☐ | ☐ | ☑ |
| | | | ☐ | ☐ | ☐ |
| | | | ☐ | ☐ | ☐ |

☐ Additional foreign application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto:

I hereby claim the benefit under 35 U.S.C. 119(e) of any United States provisional application(s) listed below.

| Application Number(s) | Filing Date (MM/DD/YYYY) |
|---|---|
| | |

☐ Additional provisional application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.



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# DECLARATION — Utility or Design Patent Application

I hereby claim the benefit under 35 U.S.C. 120 of any United States application(s), or 365(c) of any PCT international application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. 112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

| U.S. Parent Application or PCT Parent Number | Parent Filing Date (MM/DD/YYYY) | Parent Patent Number *(if applicable)* |
|---|---|---|
| | | |

☐ Additional U.S. or PCT international application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.

As a named inventor, I hereby appoint the following registered practitioner(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith: ☐ Customer Number [ ] → *Place Customer Number Bar Code Label here*
*OR*
☑ Registered practitioner(s) name/registration number listed below

| Name | Registration Number | Name | Registration Number |
|---|---|---|---|
| David S. Abrams | 22,576 | Stacey J. Longanecker | 33,952 |
| Robert H. Berdo | 19,415 | Joseph J. Buczynski | 35,084 |
| Alfred N. Goodman | 26.458 | Wayne C. Jaeschke, Jr. | 38,503 |
| Mark S. Bicks | 28,770 | Tara Laster Hoffman | P-46,510 |
| John E. Holmes | 29,392 | Jeffrey J. Howell | 46,402 |
| Garrett V. Davis | 32,023 | Marcus R. Mickney | 44,941 |
| Lance G. Johnson | 32,531 | Christian C. Michel | 46,300 |

☐ Additional registered practitioner(s) named on supplemental Registered Practitioner Information sheet PTO/SB/02C attached hereto.

Direct all correspondence to: ☐ Customer Number or Bar Code Label [ ] *OR* ☑ Correspondence address below

| | | | | | |
|---|---|---|---|---|---|
| Name | John E. Holmes | | | | |
| Address | Roylance, Abrams, Berdo & Goodman, L.L.P. | | | | |
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| City | Washington | State | D.C. | ZIP | 20036 |
| Country | USA | Telephone | (202)659-9076 | Fax | (202)659-9344 |

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

**Name of Sole or First Inventor:** ☐ A petition has been filed for this unsigned inventor

| Given Name (first and middle [if any]) | Family Name or Surname |
|---|---|
| Ernst | Eberlein |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Inventor's Signature | | | | | | Date | |
| Residence: City | Grossenseebach | State | | Country | Germany | Citizenship | German |
| Post Office Address | Waldstrasse 28 b | | | | | | |
| Post Office Address | | | | | | | |
| City | Grossenseebach | State | | ZIP | D-91091 | Country | Germany |

☐ Additional inventors are being named on the ____ supplemental Additional Inventor(s) sheet(s) PTO/SB/02A attached hereto

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**ADDITIONAL INVENTOR(S)**
**Supplemental Sheet**
Page 1 of 2

**Name of Additional Joint Inventor, if any:** ☐ A petition has been filed for this unsigned inventor

| Given Name (first and middle [if any]) | Family Name or Surname |
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| Sabah | Badri |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Inventor's Signature | | | | | | Date | |
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| Post Office Address | Sebaldusstrasse 8 | | | | | | |
| Post Office Address | | | | | | | |
| City | Erlangen | State | | ZIP | D-91058 | Country | Germany |

**Name of Additional Joint Inventor, if any:** ☐ A petition has been filed for this unsigned inventor

| Given Name (first and middle [if any]) | Family Name or Surname |
|---|---|
| Stefan | Lipp |

| | | | | | | | |
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| Inventor's Signature | | | | | | Date | |
| Residence: City | Erlangen | State | | Country | Germany | Citizenship | German |
| Post Office Address | Steinweg 9 a | | | | | | |
| Post Office Address | | | | | | | |
| City | Erlangen | State | | ZIP | D-91058 | Country | Germany |

**Name of Additional Joint Inventor, if any:** ☐ A petition has been filed for this unsigned inventor

| Given Name (first and middle [if any]) | Family Name or Surname |
|---|---|
| Stephan | Buchholz |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Inventor's Signature | Stephan Buchholz | | | | | Date | 11/20/00 |
| Residence: City | Muenchen | State | | Country | Germany | Citizenship | German |
| Post Office Address | Kerschlacher Strasse 8 | | | | | | |
| Post Office Address | | | | | | | |
| City | Muenchen | State | | ZIP | D-81447 | Country | Germany |

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# DECLARATION

**ADDITIONAL INVENTOR(S)**
**Supplemental Sheet**
Page 2 of 2

| Name of Additional Joint Inventor, if any: | | ☐ A petition has been filed for this unsigned inventor | | | |
|---|---|---|---|---|---|
| Given Name (first and middle [if any]) | Albert | Family Name or Surname | Heuberger | | |
| Inventor's Signature | | | | Date | |
| Residence: City | Erlangen | State | | Country | Germany |
| Citizenship | German | | | | |
| Post Office Address | Hausaeckerweg 18 | | | | |
| Post Office Address | | | | | |
| City | Erlangen | State | | ZIP | D-91056 |
| Country | Germany | | | | |

| Name of Additional Joint Inventor, if any: | | ☐ A petition has been filed for this unsigned inventor | | | |
|---|---|---|---|---|---|
| Given Name (first and middle [if any]) | Heinz | Family Name or Surname | Gerhaeuser | | |
| Inventor's Signature | | | | Date | |
| Residence: City | Waischenfeld | State | | Country | Germany |
| Citizenship | German | | | | |
| Post Office Address | Saugendorf 17 | | | | |
| Post Office Address | | | | | |
| City | Waischenfeld | State | | ZIP | D-91344 |
| Country | Germany | | | | |

| Name of Additional Joint Inventor, if any: | | ☐ A petition has been filed for this unsigned inventor | | | |
|---|---|---|---|---|---|
| Given Name (first and middle [if any]) | | Family Name or Surname | | | |
| Inventor's Signature | | | | Date | |
| Residence: City | | State | | Country | |
| Citizenship | | | | | |
| Post Office Address | | | | | |
| Post Office Address | | | | | |
| City | | State | | ZIP | |
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# DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION (37 CFR 1.63)

☐ Declaration Submitted with Initial Filing OR ☑ Declaration Submitted after Initial Filing (surcharge (37 CFR 1.16 (e)) required)

| | |
|---|---|
| Attorney Docket Number | 41001 |
| First Named Inventor | Ernst Eberlein |
| *COMPLETE IF KNOWN* | |
| Application Number | / |
| Filing Date | |
| Group Art Unit | |
| Examiner Name | |

**As a below named inventor, I hereby declare that:**

My residence, post office address, and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

Method and Apparatus for Fine Frequency Synchronization in Multi-Carrier Demodulation Systems

*(Title of the Invention)*

the specification of which
☐ is attached hereto
OR
☑ was filed on (MM/DD/YYYY) 04/14/98 as United States Application Number or PCT International Application Number PCT/EP98/02184 and was amended on (MM/DD/YYYY) ______ (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56.

I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or of any PCT international application having a filing date before that of the application on which priority is claimed.

| Prior Foreign Application Number(s) | Country | Foreign Filing Date (MM/DD/YYYY) | Priority Not Claimed | Certified Copy Attached? YES | NO |
|---|---|---|---|---|---|
| | | | ☐ | ☐ | ☑ |
| | | | ☐ | ☐ | ☑ |
| | | | ☐ | ☐ | ☐ |
| | | | ☐ | ☐ | ☐ |

☐ Additional foreign application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto:

I hereby claim the benefit under 35 U.S.C. 119(e) of any United States provisional application(s) listed below.

| Application Number(s) | Filing Date (MM/DD/YYYY) | |
|---|---|---|
| | | ☐ Additional provisional application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto. |



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# DECLARATION

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**Supplemental Sheet**
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**Name of Additional Joint Inventor, if any:** ☐ A petition has been filed for this unsigned inventor

| Given Name (first and middle [if any]) | Family Name or Surname |
|---|---|
| Albert | Heuberger |

| | | | | | |
|---|---|---|---|---|---|
| Inventor's Signature | [signature] | | | Date | 11/21/00 |
| Residence: City | Erlangen | State | | Country | Germany | Citizenship | German |
| Post Office Address | Hausaeckerweg 18 | | | | |
| Post Office Address | | | | | |
| City | Erlangen | State | | ZIP | D-91056 | Country | Germany |

**Name of Additional Joint Inventor, if any:** ☐ A petition has been filed for this unsigned inventor

| Given Name (first and middle [if any]) | Family Name or Surname |
|---|---|
| Heinz | Gerhaeuser |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Inventor's Signature | [signature] | | | | | Date | 11/21/00 |
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**Name of Additional Joint Inventor, if any:** ☐ A petition has been filed for this unsigned inventor

| Given Name (first and middle [if any]) | Family Name or Surname |
|---|---|
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| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Inventor's Signature | | | | | | Date | |
| Residence: City | | State | | Country | | Citizenship | |
| Post Office Address | | | | | | | |
| Post Office Address | | | | | | | |
| City | | State | | ZIP | | Country | |

Burden Hour Statement: This form is estimated to take 0.4 hours to complete. Time will vary depending upon the needs of the individual case. Any comments on the amount of time you are required to complete this form should be sent to the Chief Information Officer, Patent and Trademark Office, Washington, DC 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Assistant Commissioner for Patents, Washington, DC 20231.

PTO/SB/02A (3-97)
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Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Please type a plus sign (+) inside this box → +





# DECLARATION

**ADDITIONAL INVENTOR(S)**
**Supplemental Sheet**
Page 1 of 2

**Name of Additional Joint Inventor, if any:** ☐ A petition has been filed for this unsigned inventor

| Given Name (first and middle [if any]) | Family Name or Surname |
|---|---|
| Sabah | Badri |

| | | | | | |
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| Inventor's Signature | S. Badri | | | Date | 11/22/00 |
| Residence: City | Erlangen | State | | Country | Germany | Citizenship | Moroccan |
| Post Office Address | Sebaldusstrasse 8 | | | | |
| Post Office Address | | | | | |
| City | Erlangen | State | | ZIP | D-91058 | Country | Germany |

**Name of Additional Joint Inventor, if any:** ☐ A petition has been filed for this unsigned inventor

| Given Name (first and middle [if any]) | Family Name or Surname |
|---|---|
| Stefan | Lipp |

| | | | | | | | |
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| Inventor's Signature | S. Lipp | | | | | Date | 11/22/00 |
| Residence: City | Erlangen | State | | Country | Germany | Citizenship | German |
| Post Office Address | Steinweg 9 a | | | | | | |
| Post Office Address | | | | | | | |
| City | Erlangen | State | | ZIP | D-91058 | Country | Germany |

**Name of Additional Joint Inventor, if any:** ☐ A petition has been filed for this unsigned inventor

| Given Name (first and middle [if any]) | Family Name or Surname |
|---|---|
| Stephan | ~~Buchholz~~ |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Inventor's Signature | | | | | | Date | |
| Residence: City | Muenchen | State | | Country | Germany | Citizenship | German |
| Post Office Address | Kerschlacher Strasse 8 | | | | | | |
| Post Office Address | | | | | | | |
| City | Muenchen | State | | ZIP | D-81447 | Country | Germany |

Please type a plus sign (+) inside this box → [+]

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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 contains a valid OMB control number.

# DECLARATION — Utility or Design Patent Application

I hereby claim the benefit under 35 U.S.C. 120 of any United States application(s), or 365(c) of any PCT international application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. 112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

| U.S. Parent Application or PCT Parent Number | Parent Filing Date (MM/DD/YYYY) | Parent Patent Number *(if applicable)* |
|---|---|---|
| | | |

☐ Additional U.S. or PCT international application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.

As a named inventor, I hereby appoint the following registered practitioner(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith: ☐ Customer Number [ ] → *Place Customer Number Bar Code Label here*
*OR*
☑ Registered practitioner(s) name/registration number listed below

| Name | Registration Number | Name | Registration Number |
|---|---|---|---|
| David S. Abrams | 22,576 | Stacey J. Longanecker | 33,952 |
| Robert H. Berdo | 19,415 | Joseph J. Buczynski | 35,084 |
| Alfred N. Goodman | 26,458 | Wayne C. Jaeschke, Jr. | 38,503 |
| Mark S. Bicks | 28,770 | Tara Laster Hoffman | P-46,510 |
| John E. Holmes | 29,392 | Jeffrey J. Howell | 46,402 |
| Garrett V. Davis | 32,023 | Marcus R. Mickney | 44,941 |
| Lance G. Johnson | 32,531 | Christian C. Michel | 46,300 |

14

☐ Additional registered practitioner(s) named on supplemental Registered Practitioner Information sheet PTO/SB/02C attached hereto.

Direct all correspondence to: ☐ Customer Number or Bar Code Label [ ] *OR* ☑ Correspondence address below

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| Name | John E. Holmes |
| Address | Roylance, Abrams, Berdo & Goodman, L.L.P. |
| Address | 1300 19th Street, N.W., Suite 600 |
| City | Washington — State D.C. — ZIP 20036 |
| Country | USA — Telephone (202)659-9076 — Fax (202)659-9344 |

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

**Name of Sole or First Inventor:** ☐ A petition has been filed for this unsigned inventor

| Given Name (first and middle [if any]) | Family Name or Surname |
|---|---|
| Ernst | Eberlein |

| | | | | | |
|---|---|---|---|---|---|
| Inventor's Signature | [signature] | | | Date | 11/21/00 |
| Residence: City | Grossenseebach | State | | Country Germany | Citizenship German |
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| City | Grossenseebach | State | | ZIP D-91091 | Country Germany |

1W

☐ Additional inventors are being named on the ____ supplemental Additional Inventor(s) sheet(s) PTO/SB/02A attached hereto

532 Rec'd PCT/PTO 13 OCT 2000

FORM PTO-1390 (REV 10-01-00) U S DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

ATTORNEY'S DOCKET NUMBER 41001

# TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

U.S. APPLICATION NO. (If known, see 37 CFR 1.5) 09/673270

| INTERNATIONAL APPLICATION NO. | INTERNATIONAL FILING DATE | PRIORITY DATE CLAIMED |
|---|---|---|
| PCT/EP98/02184 | 14 April 1998 | |

TITLE OF INVENTION
Method and Apparatus for Fine Frequency Synchronization in Multi-Carrier Demodulation Systems

APPLICANT(S) FOR DO/EO/US
Ernst Eberlein, Sabah Badri, Stefan Lipp, Stephan Buchholz, Albert Heuberger, Heinz Gerhaeuser

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☑ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☐ This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. ☑ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☑ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. ☑ is transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☑ has been transmitted by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☐ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☑ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ have been transmitted by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☑ have not been made and will not be made.
8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

**Items 11. to 16. below concern document(s) or information included:**

11. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☑ A FIRST preliminary amendment.
    ☐ A SECOND or SUBSEQUENT preliminary amendment.
14. ☑ A substitute specification.
15. ☐ A change of power of attorney and/or address letter.
16. ☑ Other items or information:

(a) Copy of International Application as filed (14 April 1998).
(b) Copy of International Search Report (12 January 1999).
(c) Copy of Published International Application (21 October 1999).
(d) Copy of International Preliminary Examination Report (19 July 2000).

Fraunhofer Ex 2018-78
Sirius XM v Fraunhofer, IPR2018-00681

529 Rec'd PCT/PTO 13 OCT 2000

| U.S. APPLICATION NO (if known, see 37 CFR 1 5) | INTERNATIONAL APPLICATION NO | ATTORNEY'S DOCKET NUMBER |
|---|---|---|
| 09/673270 | PCT/EP98/02184 | 41001 |

17. ☑ The following fees are submitted:

| | CALCULATIONS | PTO USE ONLY |
|---|---|---|
| **BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)):**<br>Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO ......... **$1000.00**<br>International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO ....... **$860.00**<br>International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO ........... **$710.00**<br>International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provisions of PCT Article 33(1)-(4) ........... **$690.00**<br>International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4) ................ **$100.00** | | |
| **ENTER APPROPRIATE BASIC FEE AMOUNT =** | $ 860.00 | |
| Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☑ 30 months from the earliest claimed priority date (37 CFR 1.492(e)). | $ 130.00 | |

| CLAIMS | NUMBER FILED | NUMBER EXTRA | RATE | | |
|---|---|---|---|---|---|
| Total claims | 16 - 20 = | 0 | X **$18.00** | $ 0.00 | |
| Independent claims | 4 - 3 = | 1 | X **$80.00** | $ 80.00 | |
| MULTIPLE DEPENDENT CLAIM(S) (if applicable) | | | + **$270.00** | $ 0.00 | |
| **TOTAL OF ABOVE CALCULATIONS =** | | | | $ 1,070.00 | |
| Reduction of 1/2 for filing by small entity, if applicable. A Small Entity Statement must also by filed (Note 37 CFR 1.9, 1.27, 1.28). | | | | $ (0.00) | |
| **SUBTOTAL =** | | | | $ 1,070.00 | |
| Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)). + | | | | $ 0.00 | |
| **TOTAL NATIONAL FEE =** | | | | $ 1,070.00 | |
| Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property + | | | | $ 0.00 | |
| **TOTAL FEES ENCLOSED =** | | | | $ 1,070.00 | |
| | | | | **Amount to be refunded:** | $ |
| | | | | **charged:** | $ |

a. ☑ A check in the amount of $ 1,070.00 to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. ________ in the amount of $________ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☑ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 18-2220. A duplicate copy of this sheet is enclosed.

**NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.**

SEND ALL CORRESPONDENCE TO:

Roylance, Abrams, Berdo & Goodman, L.L.P.
1300 19th Street, N.W., Suite 600
Washington, DC 20036

John E. Holmes (signature)
SIGNATURE

John E. Holmes
NAME

29,392
REGISTRATION NUMBER

09/673270

529 Rec'd PCT/PTC 13 OCT 2000

41001

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

| | | |
|---|---|---|
| In re Application of: | : | |
| | : | |
| Ernst Eberlein et al. | : | Group Art Unit: |
| | : | |
| Serial No.: Not Assigned | : | Examiner: |
| | : | |
| Filed: Herewith | : | |
| | : | |
| For: Method and Apparatus for Fine Frequency Synchronization in Multi-Carrier Demodulation Systems | : | |

PRELIMINARY AMENDMENT

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

This Preliminary Amendment is being filed concurrently with the U.S. national stage entry under 35 U.S.C. § 371 of International Application No. PCT/EP98/02184, which has an International Filing Date of April 14, 1998. Prior to examination and calculation of the filing fees, please amend the national stage application as follows:

IN THE SPECIFICATION:

Please delete the current specification comprising pages 1-40 and 48 (as amended in the International Preliminary Examination Report dated July 19, 2000) and replace it with the accompanying substitute specification.

IN THE CLAIMS:

Please cancel claims 1-18 annexed to the International Preliminary Examination Report dated July 19, 2000, and substitute the following new claims 19-34:

19. A method of performing a fine frequency synchronization compensating for a carrier frequency deviation from an oscillator frequency in a multi-carrier demodulation system of the type capable of carrying out a differential phase

decoding of multi-carrier modulated signals, said signals comprising a plurality of symbols, each symbol being defined by phase differences between simultaneous carriers having different frequencies, said method comprising the steps of:

a) determining a phase difference between phases of the same carrier in different symbols;

b) determining a frequency offset by eliminating phase shift uncertainties related to the transmitted information from said phase difference making use of a M-PSK decision device; and

c) performing a feedback correction of said carrier frequency deviation based on said determined frequency offset.

20. A method of performing a fine frequency synchronization compensating for a carrier frequency deviation from an oscillator frequency in a multi-carrier demodulation system of the type capable of carrying out a differential phase decoding of multi-carrier modulated signals, said signals comprising a plurality of symbols, each symbol being defined by phase differences between simultaneous carriers having different frequencies, said method comprising the steps of:

a) determining respective phase of the same carrier in different symbols;

b) eliminating phase shift uncertainties related to the transmitted information from said phases to determine respective phase deviations making use of a M-PSK decision device;

c) determining a frequency offset by determining a phase difference between said phase deviations; and

d) performing a feedback correction of said carrier frequency deviation based on said determined frequency offset.

21. The method according to claim 19, wherein

said steps a) and b) are performed for a plurality of carriers in said symbols,

an averaged frequency offset is determined by averaging said determined frequency offsets of said plurality of carriers, and

said feedback correction of said frequency deviation is performed based on said averaged frequency offset in said step c).

22. The method according to claim 20, wherein

said steps a), b) and c) are performed for a plurality of carriers in said symbols,

an averaged frequency offset is determined by averaging said determined frequency offsets of said plurality of carriers, and

said feedback correction of said frequency deviation is performed based on said averaged frequency offset.

23. The method according to claim 19, wherein said step a) comprises the step of determining a phase difference between phases of the same carrier in symbols which are adjacent in the time axis direction.

24. The method according to claim 19, wherein said step b) comprises the step of eliminating phase shift uncertainties corresponding to M-ary phase shifts.

25. The method according to claim 20, wherein said step a) comprises the step of determining respective phases of the same carrier in symbols which are adjacent in the time axis direction.

26. The method according to claim 20, wherein said step b) comprises the step of eliminating M-ary phase shifts.

27. An apparatus for performing a fine frequency synchronization compensating for a carrier frequency deviation from an oscillator frequency, for a multi-carrier demodulation system of the type capable of carrying out a differential phase decoding of multi-carrier modulated signals, said signals comprising a plurality of symbols, each symbol being defined by phase differences between simultaneous carriers having different frequencies, said apparatus comprising:

means for determining a phase difference between phases of the same carrier in different symbols;

M-PSK decision device for determining a frequency offset by eliminating phase shift uncertainties related to the transmitted information from said phase difference; and

means for performing a feedback correction of said frequency deviation based on said determined frequency offset.

28. An apparatus for performing a fine frequency synchronization compensating for a carrier frequency deviation from an oscillator frequency, for a multi-carrier demodulation system of the type capable of carrying out a differential phase decoding of multi-carrier modulated signals, said signals comprising a plurality of symbols, each symbol being defined by phase differences between simultaneous carriers having different frequencies, said apparatus comprising:

means for determining respective phases of the same carrier in different symbols;

M-PSK decision device for eliminating phase shift uncertainties related to the transmitted information from said phases to determine respective phase deviations;

means for determining a frequency offset by determining a phase difference between said phase deviations;

means for performing a feedback correction of said frequency deviation based on said determined frequency offset.

29. The apparatus according to claim 27, further comprising:

means for determining an averaged frequency offset by averaging determined frequency offsets of a plurality of carriers, wherein

said means for performing a feedback correction performs said feedback correction of said frequency deviation based on said averaged frequency offset.

30. The apparatus according to claim 28, further comprising:

means for determining an averaged frequency offset by averaging determined frequency offsets of a plurality of carriers, wherein

said means for performing a feedback correction performs said feedback correction of said frequency deviation based on said averaged frequency offset.

31. The apparatus according to claim 27, wherein said means for determining a phase difference comprises means for determining a phase difference between phases of the same carrier in symbols which are adjacent in the time axis direction.

32. The apparatus according to claim 28, wherein said means for determining respective phases comprises means for determining respective phases of the same carrier in symbols which are adjacent in the time axis direction.

33. The apparatus according to claim 27, wherein said means for performing a feedback correction of said frequency deviation comprises a numerical controlled oscillator and a complex multiplier.

34. The apparatus according to claim 33, wherein said means for performing a feedback correction of said frequency deviation further comprises a low path filter preceding said numerical controlled oscillator.

## REMARKS

By the present Preliminary Amendment, claims 1-18 annexed to the International Preliminary Examination Report dated July 19, 2000 are being cancelled and replaced with new claims 19-34. In the new claims, multiple dependencies and parenthetical reference numerals have been eliminated.

A substitute specification is being submitted to facilitate processing of this application. A marked-up copy of the substitute specification is also being provided to show the new changes which are beyond those previously made during the international stage. The substitute specification contains no new matter.

Early and favorable action on this application is respectfully requested. Should the Examiner have any questions, the Examiner is invited to contact the undersigned attorney at the local telephone number listed below.

Respectfully submitted,

John E. Holmes
Attorney for Applicant
Reg. No. 29,392

Roylance, Abrams, Berdo & Goodman
1300 19th Street, N.W., Suite 600
Washington, D.C. 20036-2680
(202) 659-9076

Dated: October 13, 2000

FH980409PUS

Please type a plus sign (+) inside this box → [+]

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OIPE NOV 29 2000 PATENT & TRADEMARK OFFICE

# DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION (37 CFR 1.63)

☐ Declaration Submitted with Initial Filing OR ☑ Declaration Submitted after Initial Filing (surcharge (37 CFR 1.16 (e)) required)

| | |
|---|---|
| Attorney Docket Number | 41001 |
| First Named Inventor | Ernst Eberlein |
| *COMPLETE IF KNOWN* | |
| Application Number | / |
| Filing Date | |
| Group Art Unit | |
| Examiner Name | |

**As a below named inventor, I hereby declare that:**

My residence, post office address, and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

Method and Apparatus for Fine Frequency Synchronization in Multi-Carrier Demodulation Systems

*(Title of the Invention)*

the specification of which

☐ is attached hereto

OR

☑ was filed on (MM/DD/YYYY) 04/14/98 as United States Application Number or PCT International Application Number PCT/EP98/02184 and was amended on (MM/DD/YYYY) ______ (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56.

I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or of any PCT international application having a filing date before that of the application on which priority is claimed.

| Prior Foreign Application Number(s) | Country | Foreign Filing Date (MM/DD/YYYY) | Priority Not Claimed | Certified Copy Attached? YES | NO |
|---|---|---|---|---|---|
| | | | ☐ | ☐ | ☑ |
| | | | ☐ | ☐ | ☑ |
| | | | ☐ | ☐ | ☐ |
| | | | ☐ | ☐ | ☐ |

☐ Additional foreign application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto:

I hereby claim the benefit under 35 U.S.C. 119(e) of any United States provisional application(s) listed below.

| Application Number(s) | Filing Date (MM/DD/YYYY) |
|---|---|
| | |

☐ Additional provisional application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.

Please type a plus sign (+) inside this box → [+]

PTO/SB/01 (12-97)
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I hereby claim the benefit under 35 U.S.C. 120 of any United States application(s), or 365(c) of any PCT international application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. 112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

| U.S. Parent Application or PCT Parent Number | Parent Filing Date (MM/DD/YYYY) | Parent Patent Number *(if applicable)* |
|---|---|---|
| | | |

☐ Additional U.S. or PCT international application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.

As a named inventor, I hereby appoint the following registered practitioner(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith: ☐ Customer Number [ ] → *Place Customer Number Bar Code Label here*
*OR*
☑ Registered practitioner(s) name/registration number listed below

| Name | Registration Number | Name | Registration Number |
|---|---|---|---|
| David S. Abrams | 22,576 | Stacey J. Longanecker | 33,952 |
| Robert H. Berdo | 19,415 | Joseph J. Buczynski | 35,084 |
| Alfred N. Goodman | 26,458 | Wayne C. Jaeschke, Jr. | 38,503 |
| Mark S. Bicks | 28,770 | Tara Laster Hoffman | P-46,510 |
| John E. Holmes | 29,392 | Jeffrey J. Howell | 46,402 |
| Garrett V. Davis | 32,023 | Marcus R. Mickney | 44,941 |
| Lance G. Johnson | 32,531 | Christian C. Michel | 46,300 |

☐ Additional registered practitioner(s) named on supplemental Registered Practitioner Information sheet PTO/SB/02C attached hereto.

Direct all correspondence to: ☐ Customer Number or Bar Code Label [ ] *OR* ☑ Correspondence address below

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| Name | John E. Holmes | | | | |
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| City | Washington | State | D.C. | ZIP | 20036 |
| Country | USA | Telephone | (202)659-9076 | Fax | (202)659-9344 |

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

**Name of Sole or First Inventor:** ☐ A petition has been filed for this unsigned inventor

| Given Name (first and middle [if any]) | Family Name or Surname |
|---|---|
| Ernst | Eberlein |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Inventor's Signature | | | | | | Date | |
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| Post Office Address | Waldstrasse 28 b | | | | | | |
| Post Office Address | | | | | | | |
| City | Grossenseebach | State | | ZIP | D-91091 | Country | Germany |

☐ Additional inventors are being named on the ____ supplemental Additional Inventor(s) sheet(s) PTO/SB/02A attached hereto

Please type a plus sign (+) inside this box → +

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# DECLARATION

**ADDITIONAL INVENTOR(S)**
**Supplemental Sheet**
Page 1 of 2

**Name of Additional Joint Inventor, if any:** ☐ A petition has been filed for this unsigned inventor

| Given Name (first and middle [if any]) | Family Name or Surname |
|---|---|
| Sabah | Badri |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Inventor's Signature | | | | | | Date | |
| Residence: City | Erlangen | State | | Country | Germany | Citizenship | Moroccan |
| Post Office Address | Sebaldusstrasse 8 | | | | | | |
| Post Office Address | | | | | | | |
| City | Erlangen | State | | ZIP | D-91058 | Country | Germany |

**Name of Additional Joint Inventor, if any:** ☐ A petition has been filed for this unsigned inventor

| Given Name (first and middle [if any]) | Family Name or Surname |
|---|---|
| Stefan | Lipp |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Inventor's Signature | | | | | | Date | |
| Residence: City | Erlangen | State | | Country | Germany | Citizenship | German |
| Post Office Address | Steinweg 9 a | | | | | | |
| Post Office Address | | | | | | | |
| City | Erlangen | State | | ZIP | D-91058 | Country | Germany |

**Name of Additional Joint Inventor, if any:** ☐ A petition has been filed for this unsigned inventor

| Given Name (first and middle [if any]) | Family Name or Surname |
|---|---|
| Stephan | Buchholz |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Inventor's Signature | Stephan Buchholz | | | | | Date | 11/20/00 |
| Residence: City | Muenchen | State | | Country | Germany | Citizenship | German |
| Post Office Address | Kerschlacher Strasse 8 | | | | | | |
| Post Office Address | | | | | | | |
| City | Muenchen | State | | ZIP | D-81447 | Country | Germany |

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Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

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# DECLARATION

**ADDITIONAL INVENTOR(S)**
**Supplemental Sheet**


**Name of Additional Joint Inventor, if any:** ☐ A petition has been filed for this unsigned inventor

| Given Name (first and middle [if any]) | Family Name or Surname |
|---|---|
| Albert | Heuberger |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Inventor's Signature | | | | | | Date | |
| Residence: City | Erlangen | State | | Country | Germany | Citizenship | German |
| Post Office Address | Hausaeckerweg 18 | | | | | | |
| Post Office Address | | | | | | | |
| City | Erlangen | State | | ZIP | D-91056 | Country | Germany |

**Name of Additional Joint Inventor, if any:** ☐ A petition has been filed for this unsigned inventor

| Given Name (first and middle [if any]) | Family Name or Surname |
|---|---|
| Heinz | Gerhaeuser |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Inventor's Signature | | | | | | Date | |
| Residence: City | Waischenfeld | State | | Country | Germany | Citizenship | German |
| Post Office Address | Saugendorf 17 | | | | | | |
| Post Office Address | | | | | | | |
| City | Waischenfeld | State | | ZIP | D-91344 | Country | Germany |

**Name of Additional Joint Inventor, if any:** ☐ A petition has been filed for this unsigned inventor

| Given Name (first and middle [if any]) | Family Name or Surname |
|---|---|
| | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Inventor's Signature | | | | | | Date | |
| Residence: City | | State | | Country | | Citizenship | |
| Post Office Address | | | | | | | |
| Post Office Address | | | | | | | |
| City | | State | | ZIP | | Country | |

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# DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION (37 CFR 1.63)

☐ Declaration Submitted with Initial Filing OR ☑ Declaration Submitted after Initial Filing (surcharge (37 CFR 1.16 (e)) required)

| | |
|---|---|
| Attorney Docket Number | 41001 |
| First Named Inventor | Ernst Eberlein |
| ***COMPLETE IF KNOWN*** | |
| Application Number | / |
| Filing Date | |
| Group Art Unit | |
| Examiner Name | |



**As a below named inventor, I hereby declare that:**

My residence, post office address, and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

Method and Apparatus for Fine Frequency Synchronization in Multi-Carrier Demodulation Systems

*(Title of the Invention)*

the specification of which

☐ is attached hereto

OR

☑ was filed on (MM/DD/YYYY) 04/14/98 as United States Application Number or PCT International Application Number PCT/EP98/02184 and was amended on (MM/DD/YYYY) ____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56.

I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or of any PCT international application having a filing date before that of the application on which priority is claimed.

| Prior Foreign Application Number(s) | Country | Foreign Filing Date (MM/DD/YYYY) | Priority Not Claimed | Certified Copy Attached? YES | NO |
|---|---|---|---|---|---|
| | | | ☐ | ☐ | ☑ |
| | | | ☐ | ☐ | ☑ |
| | | | ☐ | ☐ | ☐ |
| | | | ☐ | ☐ | ☐ |

☐ Additional foreign application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto:

I hereby claim the benefit under 35 U.S.C. 119(e) of any United States provisional application(s) listed below.

| Application Number(s) | Filing Date (MM/DD/YYYY) | |
|---|---|---|
| | | ☐ Additional provisional application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto. |



Burden Hour Statement: This form is estimated to take 0.4 hours to complete. Time will vary depending upon the needs of the individual case. Any comments on the amount of time you are required to complete this form should be sent to the Chief Information Officer, Patent and Trademark Office, Washington, DC 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Assistant Commissioner for Patents, Washington, DC 20231.

Please type a plus sign (+) inside this box → +

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Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE





# DECLARATION

**ADDITIONAL INVENTOR(S)**
**Supplemental Sheet**
Page 2 of 2

**Name of Additional Joint Inventor, if any:** ☐ A petition has been filed for this unsigned inventor

| Given Name (first and middle [if any]) | Family Name or Surname |
|---|---|
| Albert | Heuberger |

| | | | | | |
|---|---|---|---|---|---|
| **Inventor's Signature** | [signature] | | | **Date** | 11/21/00 |
| **Residence: City** | Erlangen | **State** | | **Country** Germany | **Citizenship** German |
| **Post Office Address** | Hausaeckerweg 18 | | | | |
| **Post Office Address** | | | | | |
| **City** | Erlangen | **State** | | **ZIP** D-91056 | **Country** Germany |

**Name of Additional Joint Inventor, if any:** ☐ A petition has been filed for this unsigned inventor

| Given Name (first and middle [if any]) | Family Name or Surname |
|---|---|
| Heinz | Gerhaeuser |

| | | | | | |
|---|---|---|---|---|---|
| **Inventor's Signature** | [signature] | | | **Date** | 11/21/00 |
| **Residence: City** | Waischenfeld | **State** | | **Country** Germany | **Citizenship** German |
| **Post Office Address** | Saugendorf 17 | | | | |
| **Post Office Address** | | | | | |
| **City** | Waischenfeld | **State** | | **ZIP** D-91344 | **Country** Germany |

**Name of Additional Joint Inventor, if any:** ☐ A petition has been filed for this unsigned inventor

| Given Name (first and middle [if any]) | Family Name or Surname |
|---|---|
| | |

| | | | | | |
|---|---|---|---|---|---|
| **Inventor's Signature** | | | | **Date** | |
| **Residence: City** | | **State** | | **Country** | **Citizenship** |
| **Post Office Address** | | | | | |
| **Post Office Address** | | | | | |
| **City** | | **State** | | **ZIP** | **Country** |

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# DECLARATION

**ADDITIONAL INVENTOR(S)**
**Supplemental Sheet**


**Name of Additional Joint Inventor, if any:** ☐ A petition has been filed for this unsigned inventor

| Given Name (first and middle [if any]) | Family Name or Surname |
|---|---|
| Sabah | Badri |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Inventor's Signature | S. Badri | | | | | Date | 11/22/00 |
| Residence: City | Erlangen | State | | Country | Germany | Citizenship | Moroccan |
| Post Office Address | Sebaldusstrasse 8 | | | | | | |
| Post Office Address | | | | | | | |
| City | Erlangen | State | | ZIP | D-91058 | Country | Germany |

**Name of Additional Joint Inventor, if any:** ☐ A petition has been filed for this unsigned inventor

| Given Name (first and middle [if any]) | Family Name or Surname |
|---|---|
| Stefan | Lipp |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Inventor's Signature | S. Lipp | | | | | Date | 11/22/00 |
| Residence: City | Erlangen | State | | Country | Germany | Citizenship | German |
| Post Office Address | Steinweg 9 a | | | | | | |
| Post Office Address | | | | | | | |
| City | Erlangen | State | | ZIP | D-91058 | Country | Germany |

**Name of Additional Joint Inventor, if any:** ☐ A petition has been filed for this unsigned inventor

| Given Name (first and middle [if any]) | Family Name or Surname |
|---|---|
| Stephan | ~~Buchholz~~ |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Inventor's Signature | | | | | | Date | |
| Residence: City | Muenchen | State | | Country | Germany | Citizenship | German |
| Post Office Address | Kerschlacher Strasse 8 | | | | | | |
| Post Office Address | | | | | | | |
| City | Muenchen | State | | ZIP | D-81447 | Country | Germany |



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# DECLARATION — Utility or Design Patent Application

I hereby claim the benefit under 35 U.S.C. 120 of any United States application(s), or 365(c) of any PCT international application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. 112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

| U.S. Parent Application or PCT Parent Number | Parent Filing Date (MM/DD/YYYY) | Parent Patent Number *(if applicable)* |
|---|---|---|
| | | |

☐ Additional U.S. or PCT international application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.

As a named inventor, I hereby appoint the following registered practitioner(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith: ☐ Customer Number [ ] → *Place Customer Number Bar Code Label here*
*OR*
☑ Registered practitioner(s) name/registration number listed below

| Name | Registration Number | Name | Registration Number |
|---|---|---|---|
| David S. Abrams | 22,576 | Stacey J. Longanecker | 33,952 |
| Robert H. Berdo | 19,415 | Joseph J. Buczynski | 35,084 |
| Alfred N. Goodman | 26,458 | Wayne C. Jaeschke, Jr. | 38,503 |
| Mark S. Bicks | 28,770 | Tara Laster Hoffman | P-46,510 |
| John E. Holmes | 29,392 | Jeffrey J. Howell | 46,402 |
| Garrett V. Davis | 32,023 | Marcus R. Mickney | 44,941 |
| Lance G. Johnson | 32,531 | Christian C. Michel | 46,300 |

☐ Additional registered practitioner(s) named on supplemental Registered Practitioner Information sheet PTO/SB/02C attached hereto.

Direct all correspondence to: ☐ Customer Number or Bar Code Label [ ] *OR* ☑ Correspondence address below

| | |
|---|---|
| Name | John E. Holmes |
| Address | Roylance, Abrams, Berdo & Goodman, L.L.P. |
| Address | 1300 19th Street, N.W., Suite 600 |
| City | Washington; State: D.C.; ZIP: 20036 |
| Country | USA; Telephone: (202)659-9076; Fax: (202)659-9344 |

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

**Name of Sole or First Inventor:** ☐ A petition has been filed for this unsigned inventor

| Given Name (first and middle [if any]) | Family Name or Surname |
|---|---|
| Ernst | Eberlein |

| | | | | | |
|---|---|---|---|---|---|
| Inventor's Signature | [signature] | | | Date | 11/21/00 |
| Residence: City | Grossenseebach | State | | Country: Germany | Citizenship: German |
| Post Office Address | Waldstrasse 28 b | | | | |
| Post Office Address | | | | | |
| City | Grossenseebach | State | | ZIP: D-91091 | Country: Germany |

☐ Additional inventors are being named on the ____ supplemental Additional Inventor(s) sheet(s) PTO/SB/02A attached hereto

UNITED STATES PATENT AND TRADEMARK OFFICE

COMMISSIONER FOR PATENTS
UNITED STATES PATENT AND TRADEMARK OFFICE
WASHINGTON, D.C. 20231
www.uspto.gov

Bib Data Sheet

| SERIAL NUMBER | FILING DATE | CLASS | GROUP ART UNIT | ATTORNEY DOCKET NO. |
|---|---|---|---|---|
| 09/673,270 | 11/29/2000<br>RULE – | 375 | 2631 | 41001 |

**APPLICANTS**

Ernst Eberlein, Grossenseebach, GERMANY;
Sabah Badri, Erlangen, GERMANY;
Stefan Lipp, Erlangen, GERMANY;
Stephan Buchholz, Muenchen, GERMANY;
Albert Heuberger, Erlangen, GERMANY;
Heinz Gerhaeuser, Waischenfeld, GERMANY;

** **CONTINUING DATA** *************************

THIS APPLICATION IS A 371 OF PCT/EP98/02184 04/14/1998

** **FOREIGN APPLICATIONS** ********************

**IF REQUIRED, FOREIGN FILING LICENSE GRANTED** ** 01/26/2001

| | STATE OR COUNTRY | SHEETS DRAWING | TOTAL CLAIMS | INDEPENDENT CLAIMS |
|---|---|---|---|---|
| Foreign Priority claimed ☐ yes ☑ no<br>35 USC 119 (a-d) conditions met ☐ yes ☑ no ☐ Met after Allowance<br>Verified and Acknowledged [signature] Examiner's Signature [initials] Initials | GERMANY | 13 | 1 | 1 |

**ADDRESS**

John E Holmes
Roylance Abrams Berdo & Goodman
Suite 600
1300 19th Street NW
Washington ,DC 20036

**TITLE**

Method and apparatus for fine frequency synchronization in multi-carrier demodulation systems

| FILING FEE RECEIVED | | |
|---|---|---|
| 1070 | FEES: Authority has been given in Paper No. _________ to charge/credit DEPOSIT ACCOUNT No. _________ for following: | ☐ All Fees<br>☐ 1.16 Fees ( Filing )<br>☐ 1.17 Fees ( Processing Ext. of time )<br>☐ 1.18 Fees ( Issue )<br>☐ Other ____________<br>☐ Credit |

527 Rec'd PCT/PTO 29 NOV 2000 PCT

41001

PATENT

#3

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

| | | |
|---|---|---|
| In re Application of: | : | |
| Ernst Eberlein et al. | : | Group Art Unit: |
| Serial No.: 09/673,270 | : | Examiner: |
| Filed: October 13, 2000 | : | |
| For: Method and Apparatus for Fine Frequency Synchronization in Multi-Carrier Demodulation Systems | : | |

OIPE JC99 NOV 29 2000 PATENT & TRADEMARK OFFICE

## TRANSMITTAL OF DECLARATION

Commissioner for Patents
Washington, D.C. 20231

Sir:

In response to the "Notification of Missing Requirements Under 35 U.S.C. 371 in the United States Designated/Elected Office (DO/EO/US)" mailed on November 13, 2000, the undersigned attorney herewith transmits two (2) declarations under 37 C.F.R. 1.63 executed by the inventors herein. The surcharge under 37 C.F.R. 1.492(e) was paid on October 13, 2000, simultaneously with the national stage entry under 35 U.S.C. 371, and hence is not being submitted herewith. However, the Office is authorized to charge any deficiency or credit any overpayment to Deposit Account number 18-2220.

Respectfully submitted,

John E. Holmes

John E. Holmes
Attorney for Applicants
Reg. No. 29,392

Roylance, Abrams, Berdo & Goodman
1300 19th Street, N.W., Suite 600
Washington, D.C. 20036-2680
(202) 659-9076

Dated: November 29, 2000

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Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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# DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION (37 CFR 1.63)

☐ Declaration Submitted with Initial Filing **OR** ☑ Declaration Submitted after Initial Filing (surcharge (37 CFR 1.16 (e)) required)

| | |
|---|---|
| **Attorney Docket Number** | 41001 |
| **First Named Inventor** | Ernst Eberlein |
| ***COMPLETE IF KNOWN*** | |
| Application Number | / |
| Filing Date | |
| Group Art Unit | |
| Examiner Name | |

**As a below named inventor, I hereby declare that:**

My residence, post office address, and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

Method and Apparatus for Fine Frequency Synchronization in Multi-Carrier Demodulation Systems

*(Title of the Invention)*

the specification of which

☐ is attached hereto

OR

☑ was filed on (MM/DD/YYYY) 04/14/98 as United States Application Number or PCT International Application Number PCT/EP98/02184 and was amended on (MM/DD/YYYY) ______ (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56.

I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or of any PCT international application having a filing date before that of the application on which priority is claimed.

| Prior Foreign Application Number(s) | Country | Foreign Filing Date (MM/DD/YYYY) | Priority Not Claimed | Certified Copy Attached? YES | NO |
|---|---|---|---|---|---|
| | | | ☐ | ☐ | ☑ |
| | | | ☐ | ☐ | ☑ |
| | | | ☐ | ☐ | ☐ |
| | | | ☐ | ☐ | ☐ |

☐ Additional foreign application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto:

I hereby claim the benefit under 35 U.S.C. 119(e) of any United States provisional application(s) listed below.

| Application Number(s) | Filing Date (MM/DD/YYYY) | |
|---|---|---|
| | | ☐ Additional provisional application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto. |

Please type a plus sign (+) inside this box → +





# DECLARATION

## ADDITIONAL INVENTOR(S) Supplemental Sheet



**Name of Additional Joint Inventor, if any:** ☐ A petition has been filed for this unsigned inventor

| Given Name (first and middle [if any]) | Family Name or Surname |
|---|---|
| Albert | Heuberger |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Inventor's Signature | [signature] | | | | | Date | 11/21/00 |
| Residence: City | Erlangen | State | | Country | Germany | Citizenship | German |
| Post Office Address | Hausaeckerweg 18 | | | | | | |
| Post Office Address | | | | | | | |
| City | Erlangen | State | | ZIP | D-91056 | Country | Germany |

**Name of Additional Joint Inventor, if any:** ☐ A petition has been filed for this unsigned inventor

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|---|---|
| Heinz | Gerhaeuser |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Inventor's Signature | [signature] | | | | | Date | 11/21/00 |
| Residence: City | Waischenfeld | State | | Country | Germany | Citizenship | German |
| Post Office Address | Saugendorf 17 | | | | | | |
| Post Office Address | | | | | | | |
| City | Waischenfeld | State | | ZIP | D-91344 | Country | Germany |

**Name of Additional Joint Inventor, if any:** ☐ A petition has been filed for this unsigned inventor

| Given Name (first and middle [if any]) | Family Name or Surname |
|---|---|
| | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Inventor's Signature | | | | | | Date | |
| Residence: City | | State | | Country | | Citizenship | |
| Post Office Address | | | | | | | |
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| City | | State | | ZIP | | Country | |

Please type a plus sign (+) inside this box → [+]

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| DECLARATION | ADDITIONAL INVENTOR(S) Supplemental Sheet Page 1 of 2 |
|---|---|

**Name of Additional Joint Inventor, if any:** ☐ A petition has been filed for this unsigned inventor

| Given Name (first and middle [if any]) | Family Name or Surname |
|---|---|
| Sabah | Badri |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Inventor's Signature | S. Badri | | | | | Date | 11/22/00 |
| Residence: City | Erlangen | State | | Country | Germany | Citizenship | Moroccan |
| Post Office Address | Sebaldusstrasse 8 | | | | | | |
| Post Office Address | | | | | | | |
| City | Erlangen | State | | ZIP | D-91058 | Country | Germany |

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| Stefan | Lipp |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Inventor's Signature | S. Lipp | | | | | Date | 11/22/00 |
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| Post Office Address | Steinweg 9 a | | | | | | |
| Post Office Address | | | | | | | |
| City | Erlangen | State | | ZIP | D-91058 | Country | Germany |

**Name of Additional Joint Inventor, if any:** ☐ A petition has been filed for this unsigned inventor

| Given Name (first and middle [if any]) | Family Name or Surname |
|---|---|
| Stephan | ~~Buchholz~~ |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Inventor's Signature | | | | | | Date | |
| Residence: City | Muenchen | State | | Country | Germany | Citizenship | German |
| Post Office Address | Kerschlacher Strasse 8 | | | | | | |
| Post Office Address | | | | | | | |
| City | Muenchen | State | | ZIP | D-81447 | Country | Germany |

Burden Hour Statement: This form is estimated to take 0.4 hours to complete. Time will vary depending upon the needs of the individual case. Any comments on the amount of time you are required to complete this form should be sent to the Chief Information Officer, Patent and Trademark Office, Washington, DC 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Assistant Commissioner for Patents, Washington, DC 20231.

TH980404 PUS

Please type a plus sign (+) inside this box → [+]

PTO/SB/01 (12-97)
Approved for use through 9/30/00. OMB 0651-0032
Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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# DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION (37 CFR 1.63)

☐ Declaration Submitted with Initial Filing OR ☑ Declaration Submitted after Initial Filing (surcharge (37 CFR 1.16 (e)) required)

| | |
|---|---|
| Attorney Docket Number | 41001 |
| First Named Inventor | Ernst Eberlein |
| *COMPLETE IF KNOWN* | |
| Application Number | / |
| Filing Date | |
| Group Art Unit | |
| Examiner Name | |

**As a below named inventor, I hereby declare that:**

My residence, post office address, and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

Method and Apparatus for Fine Frequency Synchronization in Multi-Carrier Demodulation Systems

*(Title of the Invention)*

the specification of which

☐ is attached hereto

OR

☑ was filed on (MM/DD/YYYY) 04/14/98 as United States Application Number or PCT International Application Number PCT/EP98/02184 and was amended on (MM/DD/YYYY) ________ (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56.

I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or of any PCT international application having a filing date before that of the application on which priority is claimed.

| Prior Foreign Application Number(s) | Country | Foreign Filing Date (MM/DD/YYYY) | Priority Not Claimed | Certified Copy Attached? YES | NO |
|---|---|---|---|---|---|
| | | | ☐ | ☐ | ☑ |
| | | | ☐ | ☐ | ☑ |
| | | | ☐ | ☐ | ☐ |
| | | | ☐ | ☐ | ☐ |

☐ Additional foreign application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto:

I hereby claim the benefit under 35 U.S.C. 119(e) of any United States provisional application(s) listed below.

| Application Number(s) | Filing Date (MM/DD/YYYY) |
|---|---|
| | |

☐ Additional provisional application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.

Please type a plus sign (+) inside this box → +

PTO/SB/02A (3-97)
Approved for use through 9/30/98. OMB 0651-0032
Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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OIPE NOV 2 9 2000 PATENT & TRADEMARK OFFICE

# DECLARATION

## ADDITIONAL INVENTOR(S) Supplemental Sheet

Page 1 of 2

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Name of Additional Joint Inventor, if any:** | | ☐ A petition has been filed for this unsigned inventor | | | | | |
| Given Name (first and middle [if any]) | | | | Family Name or Surname | | | |
| Sabah | | | | Badri | | | |
| Inventor's Signature | | | | | | Date | |
| Residence: City | Erlangen | State | | Country | Germany | Citizenship | Moroccan |
| Post Office Address | Sebaldusstrasse 8 | | | | | | |
| Post Office Address | | | | | | | |
| City | Erlangen | State | | ZIP | D-91058 | Country | Germany |
| **Name of Additional Joint Inventor, if any:** | | ☐ A petition has been filed for this unsigned inventor | | | | | |
| Given Name (first and middle [if any]) | | | | Family Name or Surname | | | |
| Stefan | | | | Lipp | | | |
| Inventor's Signature | | | | | | Date | |
| Residence: City | Erlangen | State | | Country | Germany | Citizenship | German |
| Post Office Address | Steinweg 9 a | | | | | | |
| Post Office Address | | | | | | | |
| City | Erlangen | State | | ZIP | D-91058 | Country | Germany |
| **Name of Additional Joint Inventor, if any:** | | ☐ A petition has been filed for this unsigned inventor | | | | | |
| Given Name (first and middle [if any]) | | | | Family Name or Surname | | | |
| Stephan | | | | Buchholz | | | |
| Inventor's Signature | Stephan Buchholz | | | | | Date | 11/20/00 |
| Residence: City | Muenchen | State | | Country | Germany | Citizenship | German |
| Post Office Address | Kerschlacher Strasse 8 | | | | | | |
| Post Office Address | | | | | | | |
| City | Muenchen | State | | ZIP | D-81447 | Country | Germany |

Burden Hour Statement: This form is estimated to take 0.4 hours to complete. Time will vary depending upon the needs of the individual case. Any comments on the amount of time you are required to complete this form should be sent to the Chief Information Officer, Patent and Trademark Office, Washington, DC 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Assistant Commissioner for Patents, Washington, DC 20231.

09725960 . 112900

Please type a plus sign (+) inside this box → +

PTO/SB/02A (3-97)
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# DECLARATION

**ADDITIONAL INVENTOR(S)**
**Supplemental Sheet**
Page 2 of 2

**Name of Additional Joint Inventor, if any:** ☐ A petition has been filed for this unsigned inventor

| Given Name (first and middle [if any]) | Family Name or Surname |
|---|---|
| Albert | Heuberger |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Inventor's Signature | | | | | | Date | |
| Residence: City | Erlangen | State | | Country | Germany | Citizenship | German |
| Post Office Address | Hausaeckerweg 18 | | | | | | |
| Post Office Address | | | | | | | |
| City | Erlangen | State | | ZIP | D-91056 | Country | Germany |

**Name of Additional Joint Inventor, if any:** ☐ A petition has been filed for this unsigned inventor

| Given Name (first and middle [if any]) | Family Name or Surname |
|---|---|
| Heinz | Gerhaeuser |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Inventor's Signature | | | | | | Date | |
| Residence: City | Waischenfeld | State | | Country | Germany | Citizenship | German |
| Post Office Address | Saugendorf 17 | | | | | | |
| Post Office Address | | | | | | | |
| City | Waischenfeld | State | | ZIP | D-91344 | Country | Germany |

**Name of Additional Joint Inventor, if any:** ☐ A petition has been filed for this unsigned inventor

| Given Name (first and middle [if any]) | Family Name or Surname |
|---|---|
| | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Inventor's Signature | | | | | | Date | |
| Residence: City | | State | | Country | | Citizenship | |
| Post Office Address | | | | | | | |
| Post Office Address | | | | | | | |
| City | | State | | ZIP | | Country | |

Burden Hour Statement: This form is estimated to take 0.4 hours to complete. Time will vary depending upon the needs of the individual case. Any comments on the amount of time you are required to complete this form should be sent to the Chief Information Officer, Patent and Trademark Office, Washington, DC 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Assistant Commissioner for Patents, Washington, DC 20231.

Please type a plus sign (+) inside this box → [+]

PTO/SB/01 (12-97)
Approved for use through 9/30/00. OMB 0651-0032
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 contains a valid OMB control number.

# DECLARATION — Utility or Design Patent Application

I hereby claim the benefit under 35 U.S.C. 120 of any United States application(s), or 365(c) of any PCT international application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. 112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

| U.S. Parent Application or PCT Parent Number | Parent Filing Date (MM/DD/YYYY) | Parent Patent Number *(if applicable)* |
|---|---|---|
| | | |

☐ Additional U.S. or PCT international application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.

As a named inventor, I hereby appoint the following registered practitioner(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith: ☐ Customer Number [ ] → *Place Customer Number Bar Code Label here*
*OR*
☑ Registered practitioner(s) name/registration number listed below

| Name | Registration Number | Name | Registration Number |
|---|---|---|---|
| David S. Abrams | 22,576 | Stacey J. Longanecker | 33,952 |
| Robert H. Berdo | 19,415 | Joseph J. Buczynski | 35,084 |
| Alfred N. Goodman | 26,458 | Wayne C. Jaeschke, Jr. | 38,503 |
| Mark S. Bicks | 28,770 | Tara Laster Hoffman | P-46,510 |
| John E. Holmes | 29,392 | Jeffrey J. Howell | 46,402 |
| Garrett V. Davis | 32,023 | Marcus R. Mickney | 44,941 |
| Lance G. Johnson | 32,531 | Christian C. Michel | 46,300 |

☐ Additional registered practitioner(s) named on supplemental Registered Practitioner Information sheet PTO/SB/02C attached hereto.

Direct all correspondence to: ☐ Customer Number or Bar Code Label [ ] *OR* ☑ Correspondence address below

| | | | | | |
|---|---|---|---|---|---|
| Name | John E. Holmes | | | | |
| Address | Roylance, Abrams, Berdo & Goodman, L.L.P. | | | | |
| Address | 1300 19th Street, N.W., Suite 600 | | | | |
| City | Washington | State | D.C. | ZIP | 20036 |
| Country | USA | Telephone | (202)659-9076 | Fax | (202)659-9344 |

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

**Name of Sole or First Inventor:** ☐ A petition has been filed for this unsigned inventor

| Given Name (first and middle [if any]) | Family Name or Surname |
|---|---|
| Ernst | Eberlein |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Inventor's Signature | | | | | | Date | |
| Residence: City | Grossenseebach | State | | Country | Germany | Citizenship | German |
| Post Office Address | Waldstrasse 28 b | | | | | | |
| Post Office Address | | | | | | | |
| City | Grossenseebach | State | | ZIP | D-91091 | Country | Germany |

☐ Additional inventors are being named on the ____ supplemental Additional Inventor(s) sheet(s) PTO/SB/02A attached hereto

Please type a plus sign (+) inside this box → [+]

PTO/SB/01 (12-97)
Approved for use through 9/30/00. OMB 0651-0032
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 contains a valid OMB control number.

# DECLARATION — Utility or Design Patent Application

I hereby claim the benefit under 35 U.S.C. 120 of any United States application(s), or 365(c) of any PCT international application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. 112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

| U.S. Parent Application or PCT Parent Number | Parent Filing Date (MM/DD/YYYY) | Parent Patent Number *(if applicable)* |
|---|---|---|
| | | |

☐ Additional U.S. or PCT international application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.

As a named inventor, I hereby appoint the following registered practitioner(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith: ☐ Customer Number [ ] → *Place Customer Number Bar Code Label here*
*OR*
☑ Registered practitioner(s) name/registration number listed below

| Name | Registration Number | Name | Registration Number |
|---|---|---|---|
| David S. Abrams | 22,576 | Stacey J. Longanecker | 33,952 |
| Robert H. Berdo | 19,415 | Joseph J. Buczynski | 35,084 |
| Alfred N. Goodman | 26,458 | Wayne C. Jaeschke, Jr. | 38,503 |
| Mark S. Bicks | 28,770 | Tara Laster Hoffman | P-46,510 |
| John E. Holmes | 29,392 | Jeffrey J. Howell | 46,402 |
| Garrett V. Davis | 32,023 | Marcus R. Mickney | 44,941 |
| Lance G. Johnson | 32,531 | Christian C. Michel | 46,300 |

☐ Additional registered practitioner(s) named on supplemental Registered Practitioner Information sheet PTO/SB/02C attached hereto.

Direct all correspondence to: ☐ Customer Number or Bar Code Label [ ] *OR* ☑ Correspondence address below

| | | | | | |
|---|---|---|---|---|---|
| Name | John E. Holmes | | | | |
| Address | Roylance, Abrams, Berdo & Goodman, L.L.P. | | | | |
| Address | 1300 19th Street, N.W., Suite 600 | | | | |
| City | Washington | State | D.C. | ZIP | 20036 |
| Country | USA | Telephone | (202)659-9076 | Fax | (202)659-9344 |

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

**Name of Sole or First Inventor:** ☐ A petition has been filed for this unsigned inventor

| Given Name (first and middle [if any]) | Family Name or Surname |
|---|---|
| Ernst | Eberlein |

| | | | | | |
|---|---|---|---|---|---|
| Inventor's Signature | [signature] | | | Date | 11/21/00 |
| Residence: City | Grossenseebach | State | | Country | Germany | 
| Citizenship | German | | | | |
| Post Office Address | Waldstrasse 28 b | | | | |
| Post Office Address | | | | | |
| City | Grossenseebach | State | | ZIP | D-91091 |
| Country | Germany | | | | |

☐ Additional inventors are being named on the ____ supplemental Additional Inventor(s) sheet(s) PTO/SB/02A attached hereto



14

1W

41001 PTO/PCT Rec'd 29 NOV 2000 PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

#1

| | | |
|---|---|---|
| In re Application of: | : | |
| | : | |
| Ernst Eberlein et al. | : | Group Art Unit: |
| | : | |
| Serial No.: 09/673,270 | : | Examiner: |
| | : | |
| Filed: October 13, 2000 | : | |
| | : | |
| For: Method and Apparatus for Fine Frequency Synchronization in Multi-Carrier Demodulation Systems | : | |

OIPE NOV 29 2000 PATENT & TRADEMARK OFFICE JC99

## INFORMATION DISCLOSURE STATEMENT

Commissioner for Patents
Washington, D.C. 20231

Sir:

In compliance with 37 C.F.R. §§ 1.56, 1.97 and 1.98, the Applicants herewith submit copies of the items listed in the attached Form PTO-1449. The Examiner's consideration and acknowledgement of these items is respectfully requested.

The Examiner is also advised of the existence of the following commonly-assigned U.S. national stage patent applications which disclose and claim related subject matter:

| Applicants | Serial No. | Title |
|---|---|---|
| Ernst Eberlein et al. | 09/673,265 | Coarse Frequency Synchronisation in Multicarrier Systems |
| Ernst Eberlein et al. | 09/673,271 | Frame Structure and Frame Synchronization for Multicarrier Systems |
| Ernst Eberlein et al. | 09/673,266 | Echo Phase Offset Correction in a Multi-Carrier Demodulation System (As Amended) |
| Ernst Eberlein et al. | 09/673,206 | Dual-Mode Receiver for Receiving Satellite and Terrestrial Signals in a Digital Broadcast System |

The Examiner is invited to review the art which has been made of record by the Applicants in the applications listed above, in addition to the documents submitted herewith.

Respectfully submitted,

John E. Holmes

John E. Holmes
Attorney for Applicants
Reg. No. 29,392

Roylance, Abrams, Berdo & Goodman
1300 19th Street, N.W., Suite 600
Washington, D.C. 20036-2680
(202) 659-9076

Dated: November 29, 2000

UNITED STATES DEPARTMENT OF COMMERCE
Patent and Trademark Office
Address: ASSISTANT COMMISSIONER FOR PATENTS
Washington, D.C. 20231

| U.S. APPLICATION NO. | FIRST NAMED APPLICANT | ATTY. DOCKET NO. |
|---|---|---|
| 09/673270 | EBERLEIN E | 41001 |

ROYLANCE ABRAMS BERDO & GOODMAN
SUITE 600
1300 19TH STREET NW
WASHINGTON, DC 20036

| INTERNATIONAL APPLICATION NO. | |
|---|---|
| PCT/EP98/02184 | |
| I.A. FILING DATE | PRIORITY DATE |
| 14 APR 98 | |

DATE MAILED: 19 JAN 2001

## NOTIFICATION OF ACCEPTANCE OF APPLICATION UNDER 35 U.S.C. 371 AND 37 CFR 1.494 OR 1.495

1. The applicant is hereby advised that the United States Patent and Trademark Office in its capacity as ☐ a Designated Office (37 CFR 1.494), ☒ an Elected Office (37 CFR 1.495), has determined that the above identified international application has met the requirements of 35 U.S.C. 371, and is **ACCEPTED** for national patentability examination in the United States Patent and Trademark Office.

2. The United States Application Number assigned to the application is shown above and the relevant dates are:

| 29 nov 2000 | 29 nov 2000 |
|---|---|
| 35 U.S.C. 102(e) DATE | DATE OF RECEIPT OF 35 U.S.C. 371 REQUIREMENTS |

A Filing Receipt (PTO-103X) will be issued for the present application in due course. **THE DATE APPEARING ON THE FILING RECEIPT AS THE "FILING DATE" IS THE DATE ON WHICH THE LAST OF THE 35 U.S.C. 371(C) REQUIREMENTS HAS BEEN RECEIVED IN THE OFFICE. THIS DATE IS SHOWN ABOVE.** *The filing date of the above identified application is the international filing date of the international application (Article 11(3) and 35 U.S.C. 363).* Once the Filing Receipt has been received, send all correspondence to the Group Art Unit designated thereon.

3. ☐ A request for immediate examination under 35 U.S.C. 371(f) was received on and the application will be examined in turn.

4. The following items have been received:
   - ☒ U.S. Basic National Fee.
   - ☒ Copy of the international application in:
     - ☐ a non-English language.
     - ☒ English.
   - ☒ Translation of the international application into English.
   - ☒ Oath or Declaration of inventors(s) for DO/EO/US.
   - ☐ Copy of Article 19 amendments. ☐ Translation of Article 19 amendments into English.
     - The Article 19 amendments ☐ have ☐ have not been entered.
   - ☐ The International Preliminary Examination Report in English and its Annexes, if any.
   - ☒ Copy of the Annexes to the International Preliminary Examination Report (IPER).
     - ☐ Translation of Annexes to the IPER into English.
     - The Annexes ☐ have ☒ have not been entered.
   - ☒ Preliminary amendment(s) filed 13 oct 2000 and ________.
   - ☐ Information Disclosure Statement(s) filed ________ and ________.
   - ☐ Assignment document.
   - ☐ Power of Attorney and/or Change of Address.
   - ☒ Substitute specification filed 13 oct 2000.
   - ☐ Verified Statement Claiming Small Entity Status.
   - ☐ Priority Document.
   - ☒ Copy of the International Search Report ☒ and copies of the references cited therein.
   - ☐ Other:

Applicant is reminded that any communication to the United States Patent and Trademark Office must be mailed to the address given in the heading and include the U.S. application no. shown above. (37 CFR 1.5)

Shelby J. Vigil

FORM PCT/DO/EO/903 (December 1997)

Telephone: 703-305-3653

2631



41001

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

#8

In re Application of:

Ernst Eberlein et al.

Group Art Unit: 2631

Serial No.: 09/673,270

Examiner:



Filed: October 13, 2000

For: Method and Apparatus for Fine Frequency Synchronization in Multi-Carrier Demodulation Systems

SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT



Commissioner for Patents
Washington, D.C. 20231

Sir:

In compliance with 37 C.F.R. §§ 1.56, 1.97 and 1.98, the Applicants herewith submit copies of the Japanese-language patent publications listed in the attached form PTO-1449, which were cited during foreign prosecution. English-language abstracts of these items are also included. The Examiner's consideration and acknowledgement of these items is respectfully requested.

The Examiner is advised that U.S. Patent No. 5,771,224 and European EP-A-0734132 are English-language counterparts of one of the two Japanese patent publications, No. JP-8-265293. A copy of the U.S. patent is also being submitted and is listed in the attached from PTO-1449. The undersigned does not have a copy of the European document but will be pleased to obtain and submit a copy at the Examiner's request.

Respectfully submitted,

John E. Holmes

John E. Holmes
Attorney for Applicants
Reg. No. 29,392

Roylance, Abrams, Berdo & Goodman
1300 19th Street, N.W., Suite 600
Washington, D.C. 20036-2680
(202) 659-9076

Dated: December 31, 2002

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. |
|---|---|---|---|---|
| 09/673,270 | 11/29/2000 | Ernst Eberlein | 41001 | 3590 |

7590 11/19/2003

John E Holmes
Roylance Abrams Berdo & Goodman
Suite 600
1300 19th Street NW
Washington, DC 20036

| EXAMINER | |
|---|---|
| WARE, CICELY Q | |
| **ART UNIT** | **PAPER NUMBER** |
| 2634 | 9 |

DATE MAILED: 11/19/2003

Please find below and/or attached an Office communication concerning this application or proceeding.

| Office Action Summary | Application No. | Applicant(s) | |
|---|---|---|---|
| | 09/673,270 | EBERLEIN ET AL. | |
| | Examiner | Art Unit | |
| | Cicely Ware | 2634 | |

*-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --*

**Period for Reply**

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

**Status**

1)☒ Responsive to communication(s) filed on *14 November 2003*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

**Disposition of Claims**

4)☒ Claim(s) *19-34* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *19-34* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

**Application Papers**

9)☒ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☒ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

**Priority under 35 U.S.C. §§ 119 and 120**

12)☐ 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:

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)).

* See the attached detailed Office action for a list of the certified copies not received.

13)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application) since a specific reference was included in the first sentence of the specification or in an Application Data Sheet. 37 CFR 1.78.

a) ☐ The translation of the foreign language provisional application has been received.

14)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121 since a specific reference was included in the first sentence of the specification or in an Application Data Sheet. 37 CFR 1.78.

**Attachment(s)**

1) ☒ Notice of References Cited (PTO-892)

2) ☒ Notice of Draftsperson's Patent Drawing Review (PTO-948)

3) ☒ Information Disclosure Statement(s) (PTO-1449) Paper No(s) 3.

4) ☐ Interview Summary (PTO-413) Paper No(s). _____.

5) ☐ Notice of Informal Patent Application (PTO-152)

6) ☐ Other:

## DETAILED ACTION

### *Drawings*

1. This application has been filed with informal drawings, which are acceptable for examination purposes only. Formal drawings will be required when the application is allowed.

### *Specification*

2. The abstract of the disclosure is objected to because:

a. Line 1, applicant uses the phrase "relate to". Examiner suggests using "relating to" for clarification purposes.

Correction is required. See MPEP § 608.01(b).

3. The disclosure is objected to because of the following informalities:

a. Pg. 10, line 35, applicant uses the phrase "of a MCM receiver". Examiner suggests using "of an MCM receiver" for clarification purposes.

b. Pg. 14-15, line 8, applicant uses the phrase "symbols 200 is shown". Examiner suggests using "symbols 200 are shown" for clarification purposes.

c. Pg. 21, line 17, applicant uses the phrase "produces an frequency error". Examiner suggests using the phrase "produces a frequency error" for clarification purposes.

d. Pg. 22, line 12, examiner suggests inserting "of" between "both these samples" for clarification purposes.

e. Pg. 22, line 35-36, applicant uses the phrase “contains a M-fold uncertainty”. Examiner suggests using “contains an M-fold uncertainty”.

f. Pg. 22, line 37, examiner suggests re-writing this line for clarification purposes.

g. Pg. 23, line 3, examiner suggests re-writing this line for clarification purposes.

h. Pg. 23, line 12, examiner suggests replacing “This” with “The” for clarification purposes.

i. Pg. 25, line 3, applicant uses “oder”. Examiner suggests using “order” for clarification purposes.

j. Pg. 29, lines 7-10, examiner suggests re-writing these lines for clarification purposes.

k. Pg. 30, line 2, applicant uses “offsets”. Examiner suggests using “offset” for clarification purposes.

l. Pg. 30, line 9, applicant uses the phrase “demapper of a MCM receiver”. Examiner suggests using “demapper of an MCM receiver” for clarification purposes.

m. Pg. 30, line 30, examiner suggests using “subcarrier symbols” instead of “subcarriers symbols” for clarification purposes.

n. Pg. 30, lines 31-32, examiner suggests re-writing this line for clarification purposes.

o. Pg. 31, line 3, applicant uses the phrase “device in a MCM receiver”. Examiner suggests using “device in an MCM receiver” for clarification purposes.

p. Pg. 31, lines 10-16, examiner suggest re-writing these lines for clarification purposes.

q. Pg. 31, line 30, applicant uses the phrase "performing same is now". Examiner suggests using "performing the same is now" for clarification purposes.

r. Pg. 39, line 11, examiner suggests using "sent" instead of "send" for clarification purposes.

s. Pg. 40, line 31, applicant uses the phrase "explained above section". Examiner suggests using "explained in the above section".

Appropriate correction is required.

## *Claim Rejections - 35 USC § 102*

4. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (e) the invention was described in (1) an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent or (2) a patent granted on an application for patent by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in section 351(a) shall have the effects for purposes of this subsection of an application filed in the United States only if the international application designated the United States and was published under Article 21(2) of such treaty in the English language.

5. Claims 19-34 are rejected under 35 U.S.C. 102(e) as being anticipated by Ahn (US Patent 6,219,333).

(1) With regard to claim 19, Ahn discloses a method performing a fine frequency synchronization compensating for a carrier frequency deviation from an oscillator frequency in a multi-carrier demodulation system of the type capable of carrying out a

differential phase decoding of multi-carrier modulated signals, said signals comprising a plurality of symbols, each symbol being defined by phase differences between simultaneous carriers having different frequencies (col. 1, lines 25-33, 58-61, col. 2, lines 27-33), said method comprising the steps of: determining a phase difference between phases of the same carrier in different symbols (col. 2, lines 27-33, col. 7, lines 46-51), determining a frequency offset by eliminating phase shift uncertainties related to the transmitted information from said phase difference making use of a decision device (col. 2, lines 64-66, col. 5, lines 25-35, col. 7, lines 2-5, 45-51, col. 8, lines 1-7); performing a feedback correction of said carrier frequency deviation based on said determined frequency offset (Fig. 1, col. 3, lines 3-9).

(2) With regard to claim 20, inherits all the limitations of claim 19. Ahn further discloses determining respective phase of the same carrier in different symbols (col. 2, lines 27-30); eliminating phase shift uncertainties related to the transmitted information from said phases to determine respective phase deviations making use of a decision device (col. 7, lines 41-67); determining frequency offset by determining a phase difference between said phase deviations (col. 7, lines 41-67).

(3) With regard to claim 21, claim 21 inherits all the limitations of claim 19. Ahn further discloses wherein the method is performed for a plurality of carriers in said symbols (col. 1, lines 25-33, col. 2, lines 21-23); an averaged frequency offset is determined by averaging said determined frequency offsets of said plurality of carriers (col. 7, lines 37-54), and said feedback correction of said frequency deviation is

performed based on said averaged frequency offset (Fig. 1, col. 7, lines 41-67, col. 8, lines 1-7).

(4) With regard to claim 22, claim 22 inherits all the limitations of claims 20 and 21.

(5) With regard to claim 23, claim 23 inherits all the limitations of claim 19. Ahn further discloses the step of determining a phase difference between phases of the same carrier in symbols, which are adjacent in the time axis direction (col. 7, lines 46-49, col. 8, lines 9-11).

(6) With regard to claim 24, claim 24 inherits all the limitations of claim 19. Ahn further discloses the step of eliminating phase shift uncertainties corresponding to phase shifts (col. 1, lines 34-45, 5-57, col. 5, lines 58-61, col. 7, lines 31-63).

(7) With regard to claim 25, claim 25 inherits all the limitations of claim 20. Ahn further discloses the step of determining respective phases of the same carrier in symbols, which are adjacent in the time axis direction (col. 2, lines 27-33, col. 7, lines 46-49, col. 8, lines 9-11).

(8) With regard to claim 26, claim 26 inherits all the limitations of claim 20. Ahn further discloses the step of eliminating phase shifts (col. 7, lines 31-67).

(9) With regard to claim 27, claim 27 inherits all the limitations of claim 19.

(10) With regard to claim 28, claim 28 inherits all the limitations of claim 20.

(11) With regard to claim 29, claim 29 inherits all the limitations of claims 27 and 21.

(12) With regard to claim 30, claim 30 inherits all the limitations of claims 28 and 21.

(13) With regard to claim 31, claim 31 inherits all the limitations of claim 27 and 23.

(14) With regard to claim 32, claim 32 inherits all the limitations of claims 28 and 25.

(15) With regard to claim 33, claim 33 inherits all the limitations of claim 27. Ahn further discloses in (Fig. 1) means for performing a feedback correction of said frequency deviation comprises a numerical controlled oscillator and a complex multiplier (col. 3, lines 3-9, col. 4, lines 53-63, col. 8, lines 1-7).

(16) With regard to claim 34, claim 34 inherits all the limitations of claim 33. Ahn further discloses in (Fig. 1(106, 108)) performing a feedback correction of said frequency deviation further comprises a low path filter preceding said numerical controlled oscillator.

## *Conclusion*

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Cicely Ware whose telephone number is 703-305-8326. The examiner can normally be reached on Monday – Friday, 8-5.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Stephen Chin can be reached on 703-305-4714. The fax phone numbers for the organization where this application or proceeding is assigned are 703-872-9314 for regular communications and 703-872-9314 for After Final communications.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is 703-305-3900.

*Cicely Ware*

cqw
November 17, 2003

STEPHEN CHIN
SUPERVISORY PATENT EXAMINER
TECHNOLOGY CENTER 2600

| *Notice of References Cited* | Application/Control No. 09/673,270 | Applicant(s)/Patent Under Reexamination EBERLEIN ET AL. | |
|---|---|---|---|
| | Examiner Cicely Ware | Art Unit 2634 | Page 1 of 1 |

**U.S. PATENT DOCUMENTS**

| * | | Document Number Country Code-Number-Kind Code | Date MM-YYYY | Name | Classification |
|---|---|---|---|---|---|
| | A | US-6,219,333 | 04-2001 | Ahn, Myong-kyun | 370/203 |
| | B | US-5,345,440 | 09-1994 | Gledhill et al. | 370/210 |
| | C | US-5,267,273 | 11-1993 | Dartois et al. | 375/355 |
| | D | US-4,347,483 | 08-1982 | Flasza et al. | 331/12 |
| | E | US- | | | |
| | F | US- | | | |
| | G | US- | | | |
| | H | US- | | | |
| | I | US- | | | |
| | J | US- | | | |
| | K | US- | | | |
| | L | US- | | | |
| | M | US- | | | |

**FOREIGN PATENT DOCUMENTS**

| * | | Document Number Country Code-Number-Kind Code | Date MM-YYYY | Country | Name | Classification |
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**NON-PATENT DOCUMENTS**

| * | | Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages) |
|---|---|---|
| | U | |
| | V | |
| | W | |
| | X | |

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Form PTO-948 (Rev. 03/03)
Application No. [illegible]

U.S. DEPARTMENT OF COMMERCE
U.S. Patent and Trademark Office

# NOTICE OF DRAFTSPERSON'S PATENT DRAWING REVIEW

The drawing(s) filed (insert date) [illegible] are:

A. _____ approved by the Draftsperson under 37 CFR 1.84 or 1.152.

B. ✓ objected to by the Draftsperson under 37 CFR 1.84 or 1.152 for the reasons indicated below. Corrected drawings are required.

**1. DRAWINGS.** 37 CFR 1.84(a): Acceptable categories of drawings: Black ink or Color (3 sets required).
___ Color drawings are not acceptable until petition is granted. Fig(s)________
___ Pencil and non black ink not permitted Fig(s)____

**2. PHOTOGRAPHS.** 37 CFR 1.84(b)
___ 1 full-tone set is required. Fig(s)________
___ Photographs may not be mounted. 37 CFR 1.84(e)
___ Photographs must meet paper size requirements of of 37 CFR 1.84(f). Fig(s)________
___ Poor quality (half-tone). Fig(s)________

**3. TYPE OF PAPER.** 37 CFR 1.84(e)
___ Paper not flexible, strong, white, and durable. Fig(s)________
___ Erasures, alterations, overwritings, interlineations, folds, copy machine marks not accepted. Fig(s)________

**4. SIZE OF PAPER.** 37 CFR 1.84(f): Acceptable sizes:
21.0 cm by 29.7 cm (DIN size A4) or
21.6cm by 27.9cm (8 1/2x 11 inches)
___ All drawing sheets not the same size. Sheet(s)________
___ Drawings sheets not an acceptable size. Fig(s)____

**5. MARGINS.** 37 CFR 1.84(g): Acceptable margins:
Top 2.5 cm Left 2.5 cm Right 1.5 cm Bottom 1.0 cm
___ Margins not acceptable. Fig(s)________
______Top (T) ______ Left (L)
______Right (R) ______ Bottom (B)

**6. VIEWS.** 37 CFR 1.84(h)
REMINDER: Specification may require revision to correspond to drawing changes, e.g., if Fig. 1 is changed to Fig. 1A, Fig 1B and Fig. 1C, etc., the specification, at the Brief Description of the Drawings, must likewise be changed.
___Views not labeled separately or properly. Fig(s)________

**7. SECTIONAL VIEWS.** 37 CFR 1.84(h)(3)
____ Sectional designation should be noted with Arabic or Roman numbers. Fig(s)________

**8. ARRANGEMENT OF VIEWS.** 37 CFR 1.84(i)
___ Words do not appear on a horizontal, left-to-right fashion when page is either upright or turned so that the top becomes the right side, except for graphs. Fig(s)________

**9. SCALE.** 37 CFR 1.84(k)
___ Scale not large enough to show mechanism without crowding when drawing is reduced in size to two-thirds in reproduction. Fig(s)________

**10. CHARACTER OF LINES, NUMBERS, & LETTERS.** 37 CFR 1.84(l)
✓ Lines, numbers & letters not uniformly thick and well defined, clean, durable, and black (poor line quality). Fig(s) 1-5

**11. SHADING.** 37 CFR 1.84(m)
___ Solid black areas pale. Fig(s)________
___ Solid black shading not permitted. Fig(s)________

**12. NUMBERS, LETTERS, & REFERENCE CHARACTERS.** 37 CFR 1.84(p)
___ Numbers and reference characters not plain and legible. Fig(s)________
___ Figure legends are poor. Fig(s)________
___ Numbers and reference characters not oriented in the same direction as the view. 37 CFR 1.84(p)(1) Fig(s)________
___ English alphabet not used. 37 CFR 1.84(p)(2) Fig(s)________
___ Numbers, letters and reference characters must be at least 32 cm (1/8 inch) in height. 37 CFR 1.84(p)(3). Fig(s)________

**13. LEAD LINES.** 37 CFR 1.84(q)
___ Lead lines missing. Fig(s)________

**14. NUMBERING OF SHEETS OF DRAWINGS.** 37 CFR 1.84(t)
___ Sheets not numbered consecutively, and in Arabic numerals beginning with number 1. Sheet(s)_____

**15. NUMBERING OF VIEWS.** 37 CFR 1.84(u)
___ Views not numbered consecutively, and in Arabic numerals, beginning with number 1. Fig(s)______

**16. DESIGN DRAWINGS.** 37 CFR 1.152
___ Surface shading shown not appropriate. Fig(s)________
___ Solid black surface shading is not permitted except when used to represent the color black as well as color contrast. Fig(s)________

**COMMENTS:**

Reviewer [signature]

Date 11/17/03

If you have questions, call (703) 305-8404.

Attachment to Paper No. ________

| Form PTO-1449 U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE<br>INFORMATION DISCLOSURE CITATION<br>(Use several sheets if necessary) | ATTY. DOCKET NO.<br>41001 | SERIAL NO.<br>09/673,270 |
|---|---|---|
| | APPLICANT<br>Ernst Eberlein et al. | |
| | FILING DATE<br>October 13, 2000 | GROUP |



U.S. PATENT DOCUMENTS

| EXAMINER INITIAL | | DOCUMENT NUMBER | DATE | NAME | CLASS | SUBCLASS | FILING DATE IF APPROPRIATE |
|---|---|---|---|---|---|---|---|
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FOREIGN PATENT DOCUMENTS

| | | DOCUMENT NUMBER | DATE | COUNTRY | CLASS | SUBCLASS | TRANSLATION YES | NO |
|---|---|---|---|---|---|---|---|---|
| CW | | 9 2 0 5 6 4 6 | 04/1992 | WIPO | | | | |
| CW | | 0 8 2 2 6 8 2 | 02/1998 | European Pat. Off. | | | | |
| CW | | 9 8 0 0 9 4 6 | 01/1998 | WIPO | | | | |

OTHER DOCUMENTS (including Author, Title, Date, Pertinent Pages, Etc.)

| | | |
|---|---|---|
| CW | | Keller and Hanzo; "Orthogonal Frequency Division Multiplex Synchronisation Techniques for Wireless Local Area Networks", *IEEE International Symposium on Personal, Indoor and Mobile Radio Communications*, pp. 963-967 (October 1996). |
| CW | | Moose, "A Technique for Orthogonal Frequency Division Multiplexing Frequency Offset Correction", *IEEE Transactions on Communications*, Vol. 42, No. 10, pp. 2908-2914 (October 1994). |
| CW | | Classen and Meyr, "Synchronization Algorithms for an OFDM System for Mobile Communication", Condierung für Quelle, Kanal and Übertragung: ITG-Fachbericht, pp. 105-114 (October 1994). |
| CW | | Schmidl and Cox, "Low-Overhead, Low-Complexity [Burst] Synchronization for OFDM", *Proc. IEEE Int. Conf. on Commun.*, pp. 1301-1306 (1996). |
| CW | | Zou and Wu, "COFDM: An Overview", *IEEE Transactions on Broadcasting*, Vol. 41, No. 1, pp. 1-8 (March 1995). |
| CW | | Palacherla, "DSP-μP Routine Computes Magnitude", *EDN Electrical Design News*, Vol. 34, No. 22, pp. 225-226 (October 1989). |
| CW | | Adams and Brady, "Magnitude Approximations for Microprocessor Implementation", *IEEE Micro*, Vol. 3, No. 5, pp. 27-31 (October 1983). |

| EXAMINER | DATE CONSIDERED 11/13/03 |
|---|---|

*EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP 609; Draw Line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

| Form PTO-1449 U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE<br>INFORMATION DISCLOSURE CITATION<br>(Use several sheets if necessary) | ATTY. DOCKET NO.<br>41001 | SERIAL NO.<br>09/673,270 |
|---|---|---|
| | APPLICANT<br>Ernst Eberlein et al. | |
| | FILING DATE<br>October 13, 2000 | GROUP |



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OTHER DOCUMENTS (including Author, Title, Date, Pertinent Pages, Etc.)

| | | |
|---|---|---|
| *W* | | Luise and Regiannini, "Carrier Frequency Acquisition and Tracking for OFDM Systems", *IEEE Transactions on Communications*, Vol. 44, No. 11, pp. 1590-1598 (November 1996). |
| *W* | | Tuisel and Kammeyer, "Carrier-Recovery for Multicarrier-Transmission Over Mobile Radio Channels", *Int. Conf. on Acoustics, Speech and Signal Processing (ICASSP 92)*, San Francisco, Band 4, pp. 677-680 (1992). |
| *W* | | Moose, "Differentially Coded Multi-Frequency Modulation for Digital Communications", *Signal Processing V - Theories and Applications*, Proceedings of EUSIPCO-90 Fifth European Signal Processing Conference, Barcelona, Spain, Volume III, pp. 1807-1810 (September 1990). |
| | | |

| EXAMINER [signature] | DATE CONSIDERED 11/13/03 |
|---|---|

*EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP 609; Draw Line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

| Form PTO-1449 U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE | ATTY. DOCKET NO. 41001 | SERIAL NO. 09/673,270 |
|---|---|---|
| INFORMATION DISCLOSURE CITATION | APPLICANT Ernst Eberlein et al. | |
| (Use several sheets if necessary) | FILING DATE October 13, 2000 | GROUP 2631 |



U.S. PATENT DOCUMENTS

| EXAMINER INITIAL | | DOCUMENT NUMBER | | | | | | | DATE | NAME | CLASS | SUBCLASS | FILING DATE IF APPROPRIATE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CW | | 5 | 7 | 7 | 1 | 2 | 2 | 4 | 06/1998 | Seki et al. | 370 | 206 | |



FOREIGN PATENT DOCUMENTS

| | | DOCUMENT NUMBER | | | | | | | DATE | COUNTRY | CLASS | SUBCLASS | TRANSLATION YES | NO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CW | | 8 | 2 | 6 | 5 | 2 | 9 | 3 | 10/1996 | Japan | | | X | |
| CW | | 1 | 0 | 4 | 1 | 9 | 9 | 1 | 02/1998 | Japan | | | X | |

OTHER DOCUMENTS (including Author, Title, Date, Pertinent Pages, Etc.)

EXAMINER [signature] DATE CONSIDERED 1/13/03

*EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP 609; Draw Line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

Appl. No. 09/673,270
Amdt. dated February 19, 2004
Reply to Office Action of November 19, 2004

#11 xu
Amdt B
4-27-04

PATENT

41001

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

| | |
|---|---|
| In re Application of: | : |
| **Ernst Eberlein et al.** | : Group Art Unit: 2634 |
| Serial No.: **09/673,270** | : Examiner: C. Ware |
| Filed: **November 29, 2000** | : |
| For: **METHOD AND APPARATUS FOR FINE FREQUENCY SYNCHRONIZATION IN MULTI-CARRIER DEMODULATION SYSTEMS** | : |



AMENDMENT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

In response to the Office Action dated November 19, 2003, please amend the above-captioned application as indicated on the following pages.

Amendments to the specification, including abstract, begin on page 2 herein.

Remarks begin on page 10 herein.

2634

OIPE JC109 FEB 1 9 2004 PATENT & TRADEMARK OFFICE

PATENT

Case Docket No.: **41001**

| | |
|---|---|
| In re Application of: | |
| **Ernst Eberlein et al.** | Group Art Unit: 2634 |
| Serial No.: **09/673,270** | Examiner: C. Ware |
| Filed: **November 29, 2000** | |
| For: **METHOD AND APPARATUS FOR FINE FREQUENCY SYNCHRONIZATION IN MULTI-CARRIER DEMODULATION SYSTEMS** | |

RECEIVED
FEB 2 3 2004
Technology Center 2600

COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, VA 22313-1450

Transmitted herewith is an Amendment in the above-identified application:

☐ Small entity status of this application under 37 C.F.R. § 1.9 and 1.27 has been established by a verified statement previously submitted.

☐ A verified statement to establish small entity status under 37 C.F.R. § 1.9 and 1.27 is enclosed.

☐ No additional fee is required.

The fee has been calculated as shown below:

| | CLAIMS REMAINING AFTER AMENDMENT | HIGHEST NO. PREVIOUSLY PAID FOR | PRESENT EXTRA | SMALL ENTITY RATE | SMALL ENTITY ADDIT. FEE | OTHER THAN A SMALL ENTITY RATE | OTHER THAN A SMALL ENTITY ADDIT. FEE |
|---|---|---|---|---|---|---|---|
| TOTAL | | - = | | x 9 = | $ | x 18 = | $ |
| INDEP | | - = | | x 43 = | $ | x 86 = | $ |
| ☐ FIRST PRESENTATION OF MULT. DEP. CLAIM | | | | + 145 = | $ | + 290 = | $ |
| If the difference in Col. 1 is less than zero, enter "0" in Col. 2 | | | | TOTAL | $ | TOTAL | $ |

☐ Applicant(s) petition(s) for an extension of _____ month(s) to respond and submits herewith the fee of $_____.

☐ Please charge my Deposit Account No. 18-2220 in the amount of $_____. A duplicate copy of this sheet is attached.

☐ A check in the amount of $_____ is attached.

☒ The Commissioner is hereby authorized to charge payment of the following fees associated with this communication or credit any overpayment to Deposit Account No. 18-2220. A duplicate copy of this sheet is attached.

☒ Any additional excess claim fees under 37 C.F.R. § 1.16.

☒ Any additional patent application processing fees under 37 C.F.R. § 1.17.

Dated: 19 February, 2004

Roylance, Abrams, Berdo & Goodman, L.L.P.
1300 19th Street, N.W., Suite 600
Washington, D.C. 20036
(202) 659-9076

Stacey J. Longanecker
Attorney of Record
Reg. No. 33,952

AMENDMENTS TO THE SPECIFICATION:

Please amend the paragraph beginning on line 2 of page 8 as follows:

B1

Figure 12 shows scatter diagrams of the output of an differential de-mapper of [[a]] an MCM receiver for illustrating the effect of an echo phase offset correction;

Please amend the paragraph beginning on line 4 of page 12 as follows:

B2

A second method of differential mapping is shown in Figure 2B. The present invention is adapted for MCM transmission system using the mapping scheme shown in Figure 2B. This mapping scheme is based on a differential mapping inside one MCM symbol along the frequency axis. A number of MCM symbols 200 [[is]] are shown in Figure 2B. Each MCM symbol 200 comprises a number of sub-carrier symbols 202. The arrows 204 in Figure 2B illustrate information encoded between two sub-carrier symbols 202. As can be seen from the arrows 204, this mapping scheme is based on a differential mapping within one MCM symbol along the frequency axis direction.

Please amend the paragraph beginning on line 9 of page 18 as follows:

B3

The output of the MCM demodulator 314 is also applied to fine frequency error detector 320. The fine frequency error detector 320 produces [[an]] a frequency error signal from the output of the MCM demodulator. In the depicted embodiment, the output of the fine frequency error detector 320 is applied to a numerical controlled oscillator 322 via a loop filter 324. The loop filter 324 is a low pass filter for filtering superimposed interference portions of a higher frequency from the slowly varying error signal. The numerical controlled oscillator 322 produces a carrier signal on the basis of the filtered error signal. The carrier signal produced by the numerical controlled oscillator 322 is used for a frequency correction which is performed by making use of a complex multiplier 326. The inputs to the complex multiplier 326 are the output of the low pass filter and decimator unit 312 and the output of the numerical controlled oscillator 322.

Cont B3

Please amend the paragraph beginning on line 31 of page 18 as follows:

The fine frequency error detector 320 comprises a differential detector in the time axis 330. The output of the MCM demodulator 314, i.e. the FFT output (FFT = Fast Fourier Transform) is applied to the input of the differential detector 330 which performs a differential detection in the time axis in order to derive information on a frequency offset from the same sub-carrier of two subsequently arriving MCM symbols. In the embodiment shown in Figure 7, the number of active sub-carriers is 432. Thus, the differential detector 330 performs a correlation between the first and the 433rd sample. The first sample is associated with MCM-symbol-1 (Figure 5), whereas the 433rd sample is associated with MCM-symbol-2 (Figure 5). However, both of these samples are associated with the same sub-carrier.

B4

Please amend the paragraph beginning on line 28 of page 19 as follows:

The output $Z_k$ of the differential detector 330 contains [[a]] an M-fold uncertainty corresponding to codeable phase shifts. In case of the QPSK mapping, this M-fold uncertainty is a 4-fold uncertainty, i.e., in the 0°, 90°, 180° and 270°phase shifts. This phase shift uncertainty is eliminated from the output $Z_k$ [making use of a] by using an M-PSK decision device 340. Such decision devices are known in the art and, therefore, [[have]] are not [[to be]] described here in detail. The output of the decision device 340 $(\hat{a}_k)^*$ represents the complex conjugate of the codeable phase shift decided by the decision device 340. This output of the decision device 340 is correlated with the output of the differential detector 330 by performing a complex multiplication using a multiplier 342.

Please amend the paragraph beginning on line 5 of page 20 as follows:

The output the multiplier 342 represents the phase offset for the respective sub-carriers. [[This]] The phase offsets for the respective sub-carriers are averaged over one MCM symbol in an averaging unit 344 in accordance with a preferred embodiment of the present invention. The output of the averaging units 344 represent the output of the fine frequency error detector 320.

Please amend the paragraph beginning on line 24 of page 21 as follows:

As described above, the frame/timing synchronization unit uses the amplitude-modulated sequence in the received signal in order to extract the framing information from the MCM signal and further to remove the guard intervals

Cont B7

therefrom. After the frame/timing synchronization unit 360 it follows a coarse frequency synchronization unit 362 which estimates a coarse frequency offset based on the amplitude-modulated sequence of the reference symbol of the MCM signal. In the coarse frequency synchronization unit 362, a frequency offset of the carrier frequency with respect to the oscillator frequency in the MCM receiver is determined in [[oder]] order to perform a frequency offset correction in a block 364. This frequency offset correction in block 364 is performed by a complex multiplication.

Please amend the paragraph beginning on line 9 of page 26 as follows:

B8

In case of a channel with strong reflections, for example due to a high building density, the correlations described above might be insufficient for obtaining a suitable coarse frequency synchronization. Therefore, in accordance with a third embodiment of the present invention, corresponding values of the two portions (i.e., which are correlated in accordance with a second embodiment) [, can be weighting] can be weighted with corresponding values of stored predetermined reference patterns corresponding to said two identical sequences of the reference symbol. This weighting can maximize the probability of correctly determining the frequency offset. The mathematical description of this weighting is as follows:

Please amend the paragraph beginning on line 13 of page 27 as follows:

B9

Systematic phase shifts stemming from echoes in multipath environments may occur between subcarriers in the same MCM symbol. [[This]] These phase offsets can cause bit

Cont B9

errors when demodulating the MCM symbol at the receiver. Thus, it is preferred to make use of an algorithm to correct the systematic phase shifts stemming from echoes in multipath environments.

Please amend the paragraph beginning on line 20 of page 27 as follows:

B10

In Figure 12, scatter diagrams at the output of a differential demapper of [[a]] an MCM receiver are shown. As can be seen from the left part of Figure 12, systematic phase shifts between subcarriers in the same MCM symbol cause a rotation of the demodulated phase shifts with respect to the axis of the complex coordinate system. In the right part of Figure 12, the demodulated phase shifts after having performed an echo phase offset correction are depicted. Now, the positions of the signal points are substantially on the axis of the complex coordinate system. These positions correspond to the modulated phase shifts of 0°, 90°, 180° and 270°, respectively.

Please amend the paragraph beginning on line 38 of page 27 as follows:

B11

For illustration purposes, one may think of the simplest algorithm possible which eliminates the symbol phase before computing the mean of all phases of the subcarriers. To illustrate the effect of such an EPOC algorithm, reference is made to the two scatter diagrams of [[subcarriers]] subcarrier symbols contained in one MCM symbol in Figure 12. [[This]] These scatter diagrams have been obtained as result of an MCM simulation. For the simulation, a channel has been used which might typically show up in single frequency networks. The echoes of this channel stretched to the limits of the MCM

Cont B'11

guard interval. The guard interval was chosen to be 25% of the MCM symbol duration in this case.

Please amend the paragraph beginning on line 13 of page 28 as follows:

B'12

Figure 13 represents a block diagram for illustrating the position and the functionality of an echo phase offset correction device in [[a]] an MCM receiver. The signal of a MCM transmitter is transmitted through the channel 122 (Figures 1 and 13) and received at the receiver frontend 132 of the MCM receiver. The signal processing between the receiver frontend and the fast Fourier transformator 140 has been omitted in Figure 13. The output of the fast Fourier transformator is applied to the de-mapper, which performs a differential de-mapping along the frequency axis. The output of the de-mapper are the respective phase shifts for the subcarriers. The phase offsets of [[this]] these phase shifts, which are caused by echoes in multipath environments, are [[visualized]] illustrated by [[a]] block 400 in Figure 13, which shows an example of a scatter diagram of the subcarrier symbols without an echo phase offset correction.

Please amend the paragraph beginning on line 2 of page 29 as follows:

B'13

A first embodiment of an EPOC algorithm and a device for performing the same is now described referring to Figure 14.

Please amend the paragraph beginning on line 19 of page 36 as follows:

B'14

The two plots in Figure 15 show the projection of the EPOC algorithm of the second embodiment for one quadrant

B14

of the complex plane. Depicted here is the quadratic grid in the sector $|\arg(z)| \leq \pi / 4$ and the straight line $y = f(x) = a + b \cdot x$ with a = -1.0 and b = 0.5 (dotted line). In case of a noise-free channel, all received symbols will lie on this straight line if 1+j0 was [[send]]<u>sent</u>. The circle shown in the plots determines the boarder line for the two cases of Equation 40. In the left part, Figure 15 shows the situation before the projection, in the right part, Figure 15 shows the situation after applying the projection algorithm. By looking on the left part, one can see, that the straight line now lies on the real axis with 2+j0 being the fix point of the projection. Therefore, it can be concluded that the echo phase offset correction algorithm according to the second embodiment fulfills the design goal.

Please amend the paragraph beginning on line 16 of page 38 as follows:

B15

Besides the two EPOC algorithms explained <u>in the</u> above section, different algorithms can be designed that will, however, most likely exhibit a higher degree of computational complexity.

Please amend the "Abstract of the Disclosure" section of the specification following the claims as follows:

B16

A method and an apparatus [relate] <u>relating</u> to a fine frequency synchronization compensating for a carrier frequency deviation from an oscillator frequency in a multi-carrier demodulation system of the type capable of carrying out a differential phase decoding of multi-carrier modulated signals, the signals comprising a plurality of symbols, each symbol being defined by phase differences between simultaneous carriers having different frequencies. A phase difference between phases of the same carrier in different symbols is determined. Thereafter, a frequency offset is determined by eliminating phase shift uncertainties related to the transmitted information from the phase difference making use of a M-PSK decision device. Finally, a feedback correction of the carrier frequency deviation is performed based on the determined frequency offset. Alternatively, an averaged frequency offset can be determined by averaging determined frequency offsets of a plurality of carriers. Then, the feedback correction of the frequency deviation is performed based on the averaged frequency offset.

B16

## REMARKS

Claims 19-34 are pending. By the present Amendment, the specification has been amended to overcome the objections thereto set forth in sections 2 and 3 of the Office Action. Applicants note that the text references in sections 2 and 3 of the Office Action correspond to the version of the application text filed with the PCT Request on April 14, 1998. The page and line numbers used herein to refer to the amended, replacement text, however, correspond to the substitute specification submitted with the Preliminary Amendment on October 13, 2000.

In the Office Action, claims 19-34 are rejected under 35 U.S.C. § 102(e) as being anticipated by U.S. Patent No. 6,219,333, to Ahn. Applicants respectfully traverse this basis for rejecting the claims.

Applicants respectfully submit that the Ahn patent does not anticipate nor render obvious the subject matter of the independent claims 19, 20, 27 and 28 of the present application. The present application relates to a method and an apparatus for performing a fine frequency synchronization of multi-carrier modulated signals in which symbols are defined by phase differences between simultaneous carriers having different frequencies. This is recited in each of the independent claims 19, 20, 27 and 28 of the present application. Since, according to the invention, each symbol is defined by phase differences between simultaneous carriers having different frequencies, phase shift uncertainties related to the transmitted information have been eliminated.

According to claims 19 and 20 of the present application, phase shift uncertainties related to the transmitted information are eliminated from phase differences between phases of the same carrier in different symbols making use of a M-PSK decision device. According to claims 27 and 28 of the present application, respective phases of the same carrier in different symbols are determined, phase shift uncertainties are eliminated from the determined phases in order to determine respective phase deviations per claim 28, and a frequency offset is determined (e.g., by determining a phase difference between the phase deviations per claim 28).

The Ahn patent relates to a system for synchronizing a carrier frequency of an OFDM transmission system which uses one of the multiple carrier modulation methods (see column 1, lines 25 to 27 of the Ahn patent). The Ahn patent is silent regarding a differential coding in the direction of the frequency axis, that is, it is silent regarding signals having symbols being defined by phase differences between simultaneous carriers having different frequencies as defined in the independent claims of the present application.

Moreover, according to the Ahn patent, for fine frequency synchronization, a pilot signal is extracted from the carrier, a phase difference between the extracted pilot signal and a previously extracted pilot signal which is delayed for a duration of one symbol is calculated, and the prime part of the carrier frequency offset within a predetermined frequency is corrected by controlling a gain of the calculated phase difference (see column 2, lines 27 to 33 of the Ahn patent). The phase difference between the pilot signals which are transmitted in the same subchannel between the adjacent two symbols is proportional to the carrier frequency offset (see column 7, lines 46 to 49 of the Ahn patent).

Thus, according to the Ahn patent, pilot signals are used for deriving a phase difference based on which a carrier frequency offset is determined. Thus, it is not necessary to eliminate any phase shift uncertainties related to the transmitted information since pilot signals are not provided for transmitting information but have properties which are known at the transmitter's end and at the receiver's end. Accordingly, it is clear that the Ahn patent does not disclose or suggest an M-PSK decision device as claimed since such a device is not necessary in the system described in the Ahn patent. In particular, an M-PSK decision device is neither anticipated nor suggested by the text passages cited in the subject Office Action.

In view of the above considerations, it is clear that the claimed subject matter is not anticipated by the Ahn patent. Moreover, a man of ordinary skill would not take into consideration making use of an M-PSK decision device in a system as described in the Ahn patent which makes use of pilot signals for deriving frequency offsets, nor the above-described means recited in claims 27 and 28. Thus, the claimed subject matter is also not suggested by the Ahn patent. Accordingly, withdrawal of the 35 U.S.C. § 102(e) rejection of the independent claims 19, 20, 27 and 28 and their corresponding dependent claims 21-26 and 29-34 is respectfully requested.

Making use of information carrying symbols for determining a frequency offset is advantageous when compared to the system taught by the Ahn patent since additional pilot signals can be avoided. Thus, the available bandwidth can be utilized more efficiently. Moreover, the transmitter and the receiver can be implemented with a reduced complexity since pilot signals do not have to be generated at the transmitter's end and pilot signals do not have to be extracted at the receiver's end. Moreover, errors which are possible when extracting the pilot signals can be avoided according to the invention. In addition, a system for synchronizing as taught by the Ahn patent can be used only in connection with such signals which have pilot signals. By constrast, the claimed invention allows more flexibility since it is not restricted to such signals.

In view of the above, it is believed that the application is in condition for allowance and notice to this effect is respectfully requested. Should the Examiner have any questions, the Examiner is invited to contact the undersigned at the telephone number indicated below.

Respectfully Submitted,

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Dated: 19 February, 2004

Appl. No. 09/673,270
Amdt. dated February 19, 2004
Reply to Office Action of November 19, 2004

PATENT

41001

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

| | |
|---|---|
| In re Application of: | |
| **Ernst Eberlein et al.** | Group Art Unit: 2634 |
| Serial No.: **09/673,270** | Examiner: C. Ware |
| Filed: **November 29, 2000** | |
| For: **METHOD AND APPARATUS FOR FINE FREQUENCY SYNCHRONIZATION IN MULTI-CARRIER DEMODULATION SYSTEMS** | |

## AMENDMENT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

In response to the Office Action dated November 19, 2003, please amend the above-captioned application as indicated on the following pages.

Amendments to the specification, including abstract, begin on page 2 herein.

Remarks begin on page 10 herein.

PATENT

Case Docket No.: **41001**

In re Application of:

**Ernst Eberlein et al.**

Serial No.: **09/673,270**

Filed: **November 29, 2000**

For: **METHOD AND APPARATUS FOR FINE FREQUENCY SYNCHRONIZATION IN MULTI-CARRIER DEMODULATION SYSTEMS**

Group Art Unit: 2634

Examiner: C. Ware

COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, VA 22313-1450

Transmitted herewith is an Amendment in the above-identified application:

☐ Small entity status of this application under 37 C.F.R. § 1.9 and 1.27 has been established by a verified statement previously submitted.

☐ A verified statement to establish small entity status under 37 C.F.R. § 1.9 and 1.27 is enclosed.

☐ No additional fee is required.

The fee has been calculated as shown below:

| | CLAIMS REMAINING AFTER AMENDMENT | HIGHEST NO. PREVIOUSLY PAID FOR | PRESENT EXTRA | SMALL ENTITY RATE | SMALL ENTITY ADDIT. FEE | OTHER THAN A SMALL ENTITY RATE | OTHER THAN A SMALL ENTITY ADDIT. FEE |
|---|---|---|---|---|---|---|---|
| TOTAL | | - = | | x 9 = | $ | x 18 = | $ |
| INDEP | | - = | | x 43 = | $ | x 86 = | $ |
| ☐ FIRST PRESENTATION OF MULT. DEP. CLAIM | | | | + 145 = | $ | + 290 = | $ |
| | | | | TOTAL | $ | TOTAL | $ |

If the difference in Col. 1 is less than zero, enter "0" in Col. 2

☐ Applicant(s) petition(s) for an extension of _____ month(s) to respond and submits herewith the fee of $_____.

☐ Please charge my Deposit Account No. 18-2220 in the amount of $_____. A duplicate copy of this sheet is attached.

☐ A check in the amount of $_____ is attached.

☒ The Commissioner is hereby authorized to charge payment of the following fees associated with this communication or credit any overpayment to Deposit Account No. 18-2220. A duplicate copy of this sheet is attached.

☒ Any additional excess claim fees under 37 C.F.R. § 1.16.

☒ Any additional patent application processing fees under 37 C.F.R. § 1.17.

Dated: 19 February, 2004

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**Roylance, Abrams, Berdo & Goodman, L.L.P.**

# Fax

| | | | |
|---|---|---|---|
| **To:** | USPTO | **From:** | Stacey Longanecker |
| **Fax:** | 703 872 9306 | **Pages:** | 14 |
| **Phone:** | | **Date:** | February 26, 2004 |
| **Re:** | Amendment submitted for Serial No. 09/673,270 retransmitted per Examiner Ware's telephone request | **CC:** | |

☐ **Urgent** ☑ **For Review** ☐ **Please Comment** ☐ **Please Reply** ☐ **Please Recycle**

● **Comments:** Amendment originally submitted to USPTO on Feb. 19, 2004 but a portion of it was apparently mislocated within the Patent Office.

AMENDMENTS TO THE SPECIFICATION:

Please amend the paragraph beginning on line 2 of page 8 as follows:

Figure 12 shows scatter diagrams of the output of an differential de-mapper of [[a]] an MCM receiver for illustrating the effect of an echo phase offset correction;

Please amend the paragraph beginning on line 4 of page 12 as follows:

A second method of differential mapping is shown in Figure 2B. The present invention is adapted for MCM transmission system using the mapping scheme shown in Figure 2B. This mapping scheme is based on a differential mapping inside one MCM symbol along the frequency axis. A number of MCM symbols 200 [[is]] are shown in Figure 2B. Each MCM symbol 200 comprises a number of sub-carrier symbols 202. The arrows 204 in Figure 2B illustrate information encoded between two sub-carrier symbols 202. As can be seen from the arrows 204, this mapping scheme is based on a differential mapping within one MCM symbol along the frequency axis direction.

Please amend the paragraph beginning on line 9 of page 18 as follows:

The output of the MCM demodulator 314 is also applied to fine frequency error detector 320. The fine frequency error detector 320 produces [[an]] a frequency error signal from the output of the MCM demodulator. In the depicted embodiment, the output of the fine frequency error detector 320 is applied to a numerical controlled oscillator 322 via a loop filter 324. The loop filter 324 is a low pass filter for filtering superimposed interference portions of a higher frequency from the slowly varying error signal. The numerical controlled oscillator 322 produces a carrier signal on the basis of the filtered error signal. The carrier signal produced by the numerical controlled oscillator 322 is used for a frequency correction which is performed by making use of a complex multiplier 326. The inputs to the complex multiplier 326 are the output of the low pass filter and decimator unit 312 and the output of the numerical controlled oscillator 322.

Please amend the paragraph beginning on line 31 of page 18 as follows:

The fine frequency error detector 320 comprises a differential detector in the time axis 330. The output of the MCM demodulator 314, i.e. the FFT output (FFT = Fast Fourier Transform) is applied to the input of the differential detector 330 which performs a differential detection in the time axis in order to derive information on a frequency offset from the same sub-carrier of two subsequently arriving MCM symbols. In the embodiment shown in Figure 7, the number of active sub-carriers is 432. Thus, the differential detector 330 performs a correlation between the first and the 433rd sample. The first sample is associated with MCM-symbol-1 (Figure 5), whereas the 433rd sample is associated with MCM-symbol-2 (Figure 5). However, both <u>of</u> these samples are associated with the same sub-carrier.

Please amend the paragraph beginning on line 28 of page 19 as follows:

Appl. No. 09/988,001
Amdt. dated May 19, 2003
Reply to Office Action of February 19, 2003

The output $Z_k$ of the differential detector 330 contains [[a]] an M-fold uncertainty corresponding to codeable phase shifts. In case of the QPSK mapping, this M-fold uncertainty is a 4-fold uncertainty, i.e., in the 0°, 90°, 180° and 270°phase shifts. This phase shift uncertainty is eliminated from the output $Z_k$ [making use of a] by using an M-PSK decision device 340. Such decision devices are known in the art and, therefore, [[have]] are not [[to be]] described here in detail. The output of the decision device 340 $(\hat{a}_k)^*$ represents the complex conjugate of the codeable phase shift decided by the decision device 340. This output of the decision device 340 is correlated with the output of the differential detector 330 by performing a complex multiplication using a multiplier 342.

Please amend the paragraph beginning on line 5 of page 20 as follows:

The output the multiplier 342 represents the phase offset for the respective sub-carriers. [[This]] The phase offsets for the respective sub-carriers are averaged over one MCM symbol in an averaging unit 344 in accordance with a preferred embodiment of the present invention. The output of the averaging units 344 represent the output of the fine frequency error detector 320.

Please amend the paragraph beginning on line 24 of page 21 as follows:

As described above, the frame/timing synchronization unit uses the amplitude-modulated sequence in the received signal in order to extract the framing information from the MCM signal and further to remove the guard intervals therefrom. After the frame/timing synchronization unit 360 it follows a coarse frequency synchronization unit 362 which estimates a coarse frequency offset based on the amplitude-modulated sequence of the reference symbol of the MCM signal. In the coarse frequency synchronization unit 362, a frequency offset of the carrier frequency with respect to the oscillator frequency in the MCM receiver is determined in [[oder]] order to perform a frequency offset correction in a block 364. This frequency offset correction in block 364 is performed by a complex multiplication.

Please amend the paragraph beginning on line 9 of page 26 as follows:

In case of a channel with strong reflections, for example due to a high building density, the correlations described above might be insufficient for obtaining a suitable coarse frequency synchronization. Therefore, in accordance with a third embodiment of the present invention, corresponding values of the two portions (i.e., which are correlated in accordance with a second embodiment) [, can be weighting] can be weighted with corresponding values of stored predetermined reference patterns corresponding to said two identical sequences of the reference symbol. This weighting can maximize the probability of correctly determining the frequency offset. The mathematical description of this weighting is as follows:

Please amend the paragraph beginning on line 13 of page 27 as follows:

Systematic phase shifts stemming from echoes in multipath environments may occur between subcarriers in the same MCM symbol. [[This]] These phase offsets can cause bit errors when demodulating the MCM symbol at the receiver. Thus, it is preferred to make use of an algorithm to correct the systematic phase shifts stemming from echoes in multipath environments.

Please amend the paragraph beginning on line 20 of page 27 as follows:

In Figure 12, scatter diagrams at the output of a differential demapper of [[a]] an MCM receiver are shown. As can be seen from the left part of Figure 12, systematic phase shifts between subcarriers in the same MCM symbol cause a rotation of the demodulated phase shifts with respect to the axis of the complex coordinate system. In the right part of Figure 12, the demodulated phase shifts after having performed an echo phase offset correction are depicted. Now, the positions of the signal points are substantially on the axis of the complex coordinate system. These positions correspond to the modulated phase shifts of 0°, 90°, 180° and 270°, respectively.

Please amend the paragraph beginning on line 38 of page 27 as follows:

For illustration purposes, one may think of the simplest algorithm possible which eliminates the symbol phase before computing the mean of all phases of the subcarriers. To illustrate the effect of such an EPOC algorithm, reference is made to the two scatter diagrams of [[subcarriers]] subcarrier symbols contained in one MCM symbol in Figure 12. [[This]] These scatter diagrams have been obtained as result of an MCM simulation. For the simulation, a channel has been used which might typically show up in single frequency networks. The echoes of this channel stretched to the limits of the MCM guard interval. The guard interval was chosen to be 25% of the MCM symbol duration in this case.

Please amend the paragraph beginning on line 13 of page 28 as follows:

Figure 13 represents a block diagram for illustrating the position and the functionality of an echo phase offset correction device in [[a]] an MCM receiver. The signal of a MCM transmitter is transmitted through the channel 122 (Figures 1 and 13) and received at the receiver frontend 132 of the MCM receiver. The signal processing between the receiver frontend and the fast Fourier transformator 140 has been omitted in Figure 13. The output of the fast Fourier transformator is applied to the de-mapper, which performs a differential de-mapping along the frequency axis. The output of the de-mapper are the respective phase shifts for the subcarriers. The phase offsets of [[this]] these phase shifts, which are caused by echoes in multipath environments, are [[visualized]] illustrated by [[a]] block 400 in Figure 13, which shows an example of a scatter diagram of the subcarrier symbols without an echo phase offset correction.

Please amend the paragraph beginning on line 2 of page 29 as follows:

A first embodiment of an EPOC algorithm and a device for performing the same is now described referring to Figure 14.

Please amend the paragraph beginning on line 19 of page 36 as follows:
The two plots in Figure 15 show the projection of the EPOC algorithm of the second embodiment for one quadrant

of the complex plane. Depicted here is the quadratic grid in the sector $|\arg(z)| \leq \pi / 4$ and the straight line $y = f(x) = a + b \cdot x$ with a = -1.0 and b = 0.5 (dotted line). In case of a noise-free channel, all received symbols will lie on this straight line if 1+j0 was [[send]] sent. The circle shown in the plots determines the boarder line for the two cases of Equation 40. In the left part, Figure 15 shows the situation before the projection, in the right part, Figure 15 shows the situation after applying the projection algorithm. By looking on the left part, one can see, that the straight line now lies on the real axis with 2+j0 being the fix point of the projection. Therefore, it can be concluded that the echo phase offset correction algorithm according to the second embodiment fulfills the design goal.

Please amend the paragraph beginning on line 16 of page 38 as follows:

Besides the two EPOC algorithms explained in the above section, different algorithms can be designed that will, however, most likely exhibit a higher degree of computational complexity.

Please amend the "Abstract of the Disclosure" section of the specification following the claims as follows:

A method and an apparatus [relate] relating to a fine frequency synchronization compensating for a carrier frequency deviation from an oscillator frequency in a multi-carrier demodulation system of the type capable of carrying out a differential phase decoding of multi-carrier modulated signals, the signals comprising a plurality of symbols, each symbol being defined by phase differences between simultaneous carriers having different frequencies. A phase difference between phases of the same carrier in different symbols is determined. Thereafter, a frequency offset is determined by eliminating phase shift uncertainties related to the transmitted information from the phase difference making use of a M-PSK decision device. Finally, a feedback correction of the carrier frequency deviation is performed based on the determined frequency offset. Alternatively, an averaged frequency offset can be determined by averaging determined frequency offsets of a plurality of carriers. Then, the feedback correction of the frequency deviation is performed based on the averaged frequency offset.

## REMARKS

Claims 19-34 are pending. By the present Amendment, the specification has been amended to overcome the objections thereto set forth in sections 2 and 3 of the Office Action. Applicants note that the text references in sections 2 and 3 of the Office Action correspond to the version of the application text filed with the PCT Request on April 14, 1998. The page and line numbers used herein to refer to the amended, replacement text, however, correspond to the substitute specification submitted with the Preliminary Amendment on October 13, 2000.

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Applicants respectfully submit that the Ahn patent does not anticipate nor render obvious the subject matter of the independent claims 19, 20, 27 and 28 of the present application. The present application relates to a method and an apparatus for performing a fine frequency synchronization of multi-carrier modulated signals in which symbols are defined by phase differences between simultaneous carriers having different frequencies. This is recited in each of the independent claims 19, 20, 27 and 28 of the present application. Since, according to the invention, each symbol is defined by phase differences between simultaneous carriers having different frequencies, phase shift uncertainties related to the transmitted information have been eliminated.

According to claims 19 and 20 of the present application, phase shift uncertainties related to the transmitted information are eliminated from phase differences between phases of the same carrier in different symbols making use of a M-PSK decision device. According to claims 27 and 28 of the present application, respective phases of the same carrier in different symbols are determined, phase shift uncertainties are eliminated from the determined phases in order to determine respective phase deviations per claim 28, and a frequency offset is determined (e.g., by determining a phase difference between the phase deviations per claim 28).

The Ahn patent relates to a system for synchronizing a carrier frequency of an OFDM transmission system which uses one of the multiple carrier modulation methods (see column 1, lines 25 to 27 of the Ahn patent). The Ahn patent is silent regarding a differential coding in the direction of the frequency axis, that is, it is silent regarding signals having symbols being defined by phase differences between simultaneous carriers having different frequencies as defined in the independent claims of the present application.

Moreover, according to the Ahn patent, for fine frequency synchronization, a pilot signal is extracted from the carrier, a phase difference between the extracted pilot signal and a previously extracted pilot signal which is delayed for a duration of one symbol is calculated, and the prime part of the carrier frequency offset within a predetermined frequency is corrected by controlling a gain of the calculated phase difference (see column 2, lines 27 to 33 of the Ahn patent). The phase difference between the pilot signals which are transmitted in the same subchannel between the adjacent two symbols is proportional to the carrier frequency offset (see column 7, lines 46 to 49 of the Ahn patent).

Thus, according to the Ahn patent, pilot signals are used for deriving a phase difference based on which a carrier frequency offset is determined. Thus, it is not necessary to eliminate any phase shift uncertainties related to the transmitted information since pilot signals are not provided for transmitting information but have properties which are known at the transmitter's end and at the receiver's end. Accordingly, it is clear that the Ahn patent does not disclose or suggest an M-PSK decision device as claimed since such a device is not necessary in the system described in the Ahn patent. In particular, an M-PSK decision device is neither anticipated nor suggested by the text passages cited in the subject Office Action.

In view of the above considerations, it is clear that the claimed subject matter is not anticipated by the Ahn patent. Moreover, a man of ordinary skill would not take into consideration making use of an M-PSK decision device in a system as described in the Ahn patent which makes use of pilot signals for deriving frequency offsets, nor the above-described means recited in claims 27 and 28. Thus, the claimed subject matter is also not suggested by the Ahn patent. Accordingly, withdrawal of the 35 U.S.C. § 102(e) rejection of the independent claims 19, 20, 27 and 28 and their corresponding dependent claims 21-26 and 29-34 is respectfully requested.

Making use of information carrying symbols for determining a frequency offset is advantageous when compared to the system taught by the Ahn patent since additional pilot signals can be avoided. Thus, the available bandwidth can be utilized more efficiently. Moreover, the transmitter and the receiver can be implemented with a reduced complexity since pilot signals do not have to be generated at the transmitter's end and pilot signals do not have to be extracted at the receiver's end. Moreover, errors which are possible when extracting the pilot signals can be avoided according to the invention. In addition, a system for synchronizing as taught by the Ahn patent can be used only in connection with such signals which have pilot signals. By constrast, the claimed invention allows more flexibility since it is not restricted to such signals.

In view of the above, it is believed that the application is in condition for allowance and notice to this effect is respectfully requested. Should the Examiner have any questions, the Examiner is invited to contact the undersigned at the telephone number indicated below.

Respectfully Submitted,

Stacey J. Longanecker
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Dated: 18 February, 2004

UNITED STATES PATENT AND TRADEMARK OFFICE
UNDER SECRETARY OF COMMERCE FOR INTELLECTUAL PROPERTY AND DIRECTOR OF THE UNITED STATES PATENT AND TRADEMARK OFFICE
WASHINGTON, DC 20231
www.uspto.gov

Paper No.

# Notice of Non-Compliant Amendment (37 CFR 1.121)

The amendment document filed on 2/19/04 is considered non-compliant because it has failed to meet the requirements of 37 CFR 1.121, as amended on June 30, 2003 (see *68 Fed. Reg. 38611*, Jun. 30, 2003). In order for the amendment document to be compliant, correction of the following omission(s) or provision is required. **Only the section (1.121(h)) of the amendment document containing the omission or non-compliant provision must be resubmitted (in its entirety), e.g., the entire "Amendments to the claims" section of applicant's amendment document must be re-submitted.**

THE FOLLOWING CHECKED (X) ELEMENTS(S) CAUSE THE AMENDMENT DOCUMENT TO BE NON-COMPLIANT:

☑ 1. Amendments to the specification:
- ☐ A. Amended paragraph(s) do not include markings.
- ☐ B. New paragraph(s) should not be underlined.
- ☑ C. Other Amdt paragraph, pages, and lines doesn't coincide with the specification

☐ 2. Abstract:
- ☐ A. Not presented on a separate sheet. 37 CFR 1.72.
- ☐ B. Other

☐ 3. Amendments to the drawings:

☐ 4. Amendments to the claims:
- ☐ A. A complete listing of all of the claims is not present.
- ☐ B. The listing of claims does not include the text of all claims (incl. withdrawn claims)
- ☐ C. Each claim has not been provided with the proper status identifier, and as such, the individual status of each claim cannot be identified.
- ☐ D. The claims of this amendment paper have not been presented in ascending numerical order.
- ☐ E. Other:

For further explanation of the amendment format required by 37 CFR 1.121, see MPEP Sec. 714 and the USPTO website at http://www.uspto.gov/web/offices/pac/dapp/opla/preognotice/officeflyer.pdf.

If the non-compliant amendment is a **PRELIMINARY AMENDMENT,** applicant is given ONE MONTH from the mail date of this letter to supply the corrected section which complies with 37 CFR 1.121. Failure to comply with 37 CFR 1.121 will result in non-entry of the preliminary amendment and examination on the merits will commence without consideration of the proposed changes in the preliminary amendment(s). This notice is not an action under 35 U.S.C. 132, and **this ONE MONTH time limit is not extendable.**

If the non-compliant amendment is a reply to a **NON-FINAL OFFICE ACTION,** and since the amendment appears to be a *bona fide* attempt to be a reply (37 CFR 1.135(c)), applicant is given a TIME PERIOD of ONE MONTH from the mailing of this notice within which to re-submit the corrected section which complies with 37 CFR 1.121 in order to avoid abandonment. **EXTENSIONS OF THIS TIME PERIOD ARE AVAILABLE UNDER 37 CFR 1.136(a).**

If the amendment is a reply to a **FINAL REJECTION,** this form may be an attachment to an Advisory Action. **The period for response to a final rejection continues to run from the date set in the final rejection**, and is not affected by the non-compliant status of the amendment.

Antley Williams
Legal Instruments Examiner (LIE)

July 22, 2003 (rev.)

# United States Patent [19]

**Flasza et al.**

[11] **4,347,483**

[45] **Aug. 31, 1982**


[54] **FREQUENCY AND PHASE LOCK LOOP WITH SEPARATED AFC AND PHASE LOCKING**


[75] Inventors: **Michael D. Flasza**, Schaumburg; **Jouke N. Rypkema**, Lombard, both of Ill.

[73] Assignee: **Zenith Radio Corporation**, Glenview, Ill.



[21] Appl. No.: **172,920**

[22] Filed: **Jul. 28, 1980**

[51] **Int. Cl.**³ .......... **H03L 7/10**

[52] **U.S. Cl.** .......... **331/12**; 331/25; 331/31

[58] **Field of Search** .......... 331/10-12, 331/17, 18, 25, 30-32



[56] **References Cited**

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| | | | |
|---|---|---|---|
| 4,072,909 | 2/1978 | Citta | 331/12 |
| 4,156,204 | 5/1979 | Hargis | 331/12 |
| 4,188,589 | 2/1980 | Brown et al. | 331/12 |



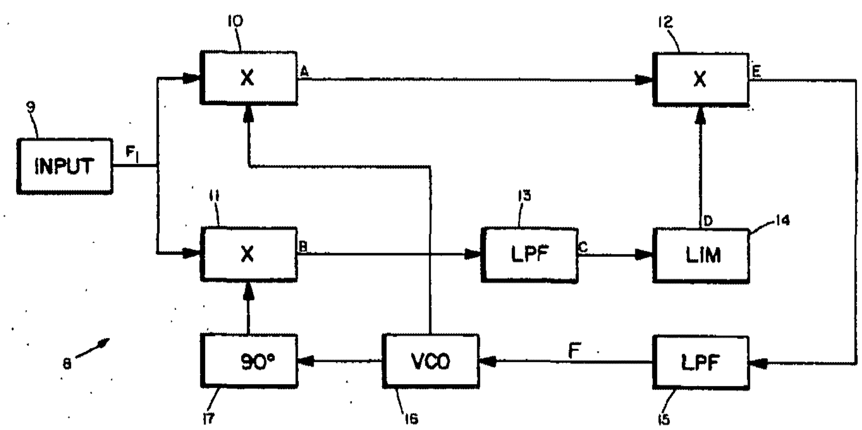
*Primary Examiner*—Siegfried H. Grimm
*Assistant Examiner*—Edward P. Westin

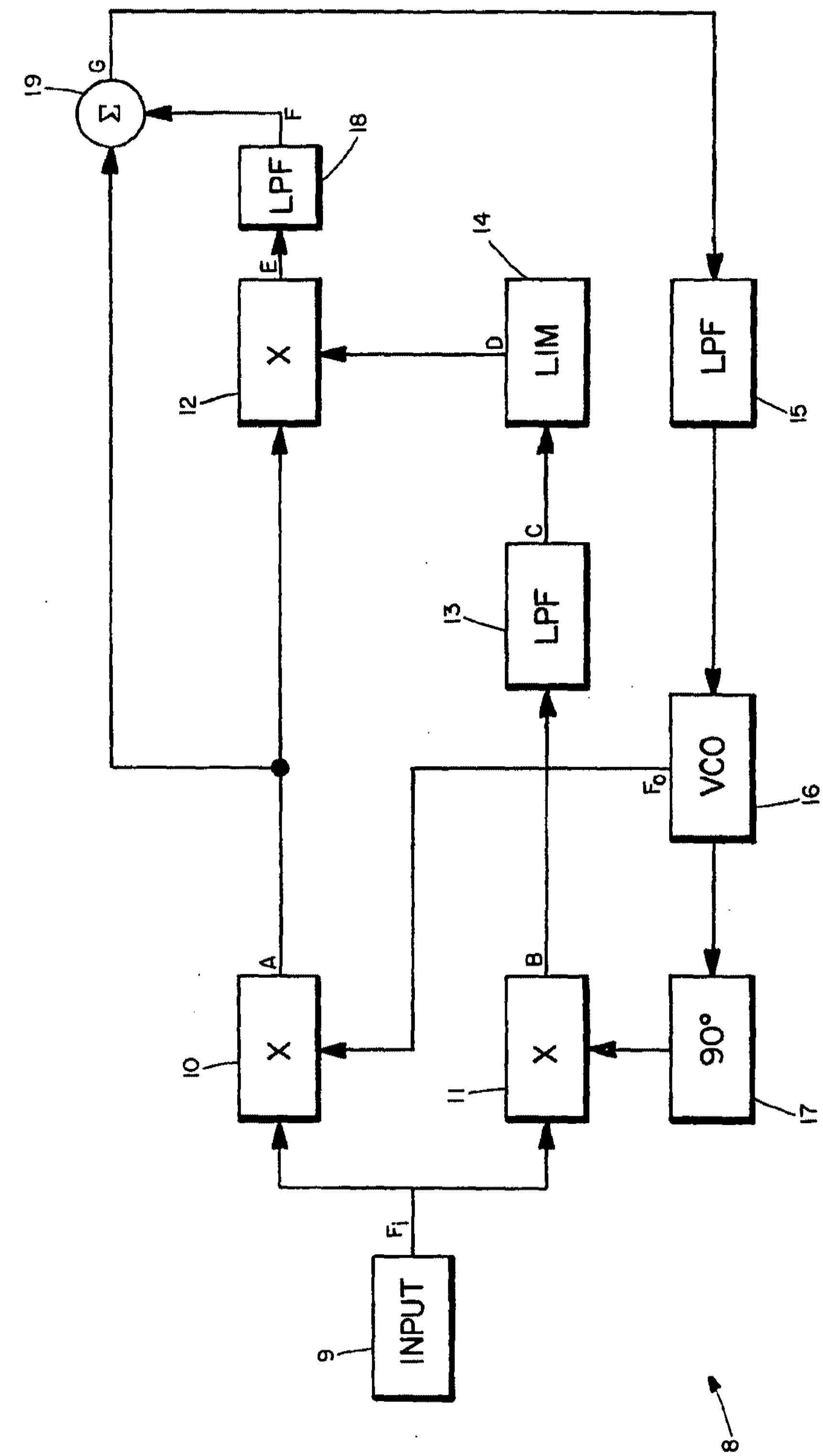


[57] **ABSTRACT**

A frequency and phase lock loop is disclosed in which AFC and phase locking functions are completely separated thus permitting signal acquisition range and closed loop bandwidth parameters to be independently established. Interference between phase lock loop (PLL) and automatic frequency control (AFC) signals resulting in the loss of a beat frequency signal for matching VCO and reference signal frequencies is eliminated thus affording enhanced PLL frequency pull-in range.


**1 Claim, 24 Drawing Figures**




INPUT
X
X
X
LPF
LPF
LPF
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VCO
90°
Σ
A
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E
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$F_i$
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Fig. 1

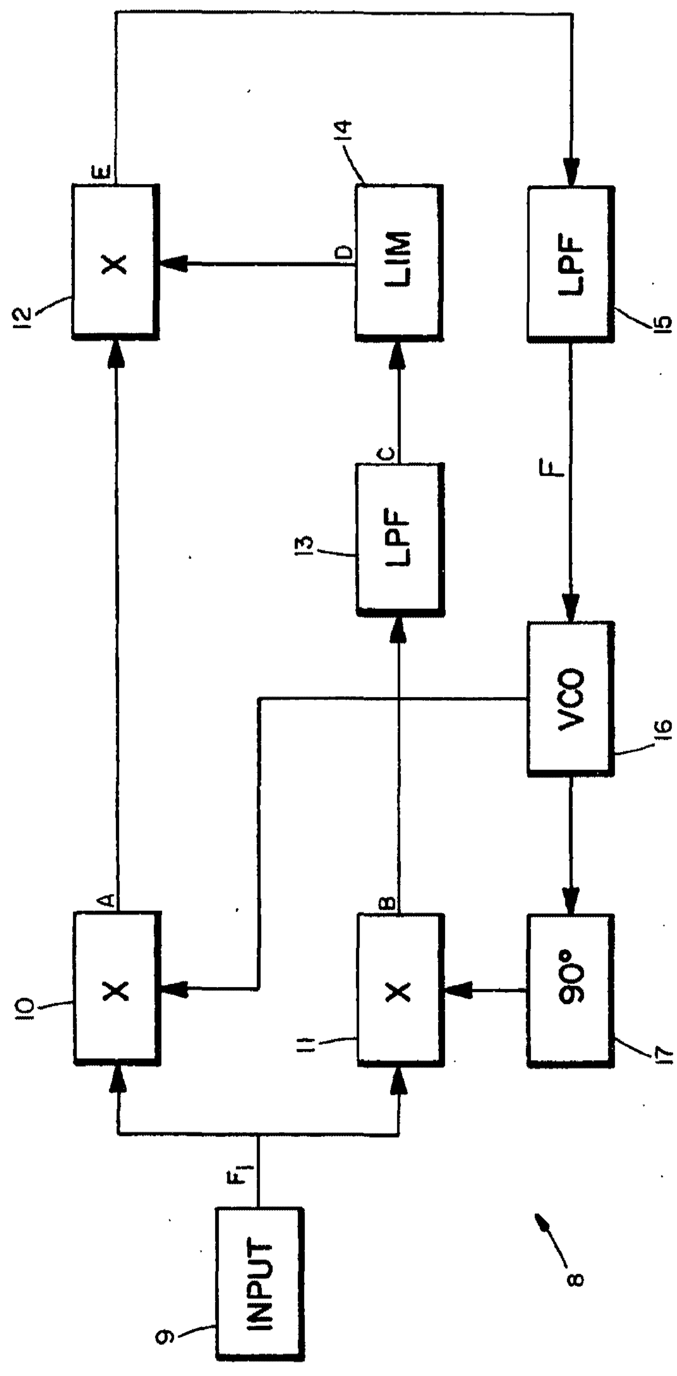



Fig. 2

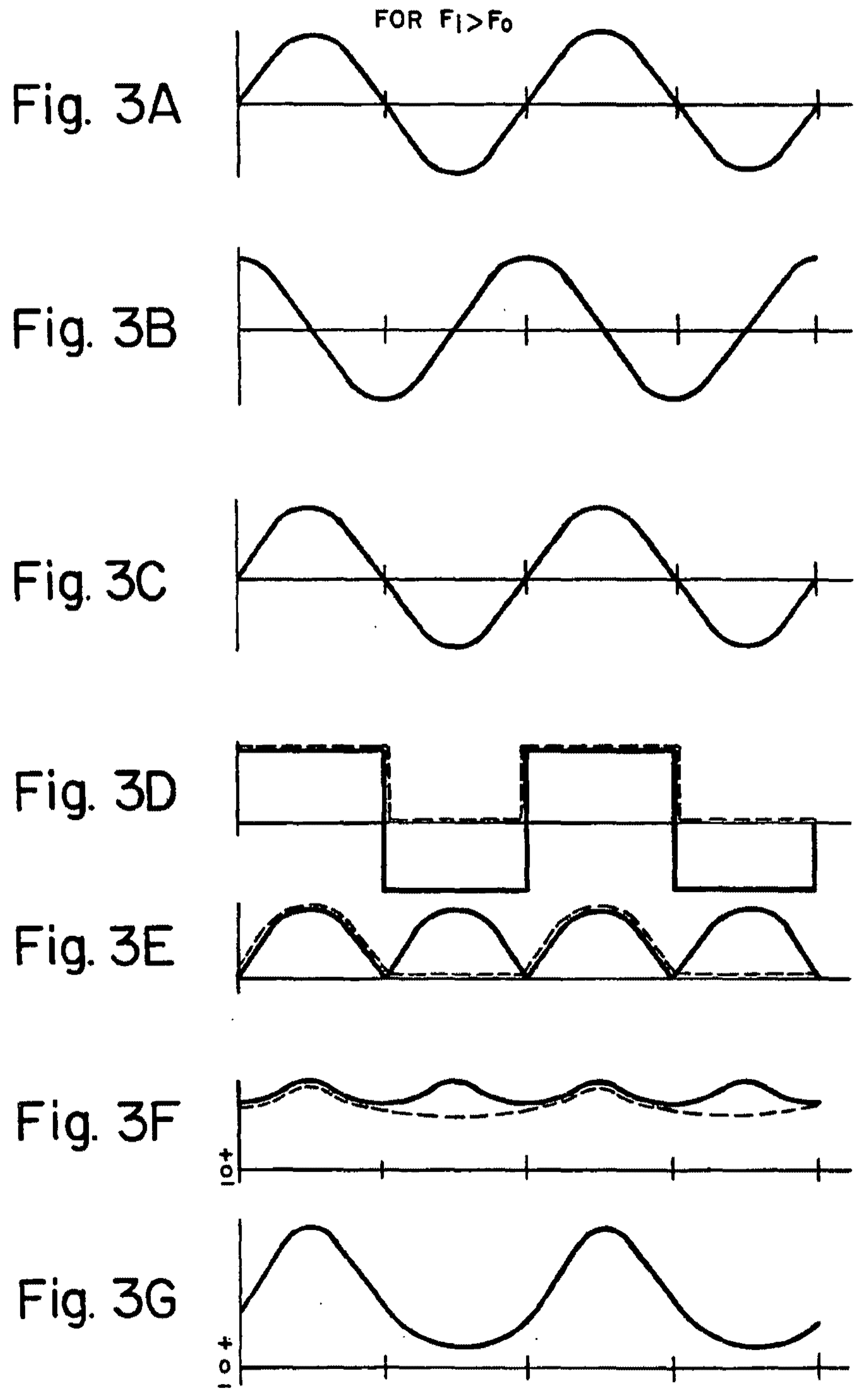

FOR F1>F0
Fig. 3A
Fig. 3B
Fig. 3C
Fig. 3D
Fig. 3E
Fig. 3F
+
0
-
Fig. 3G
+
0
-

Fig. 4A

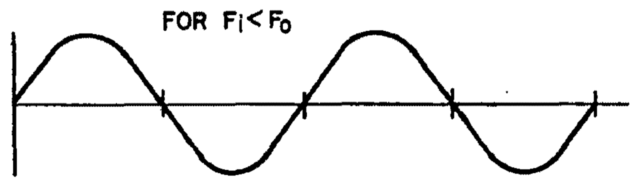



Fig. 4B

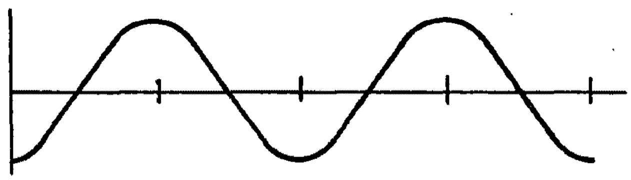


Fig. 4C

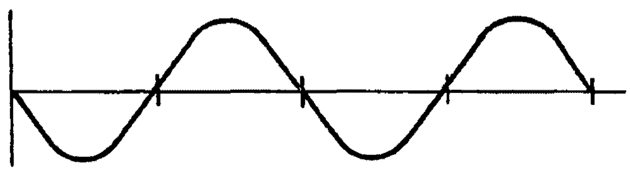


Fig. 4D

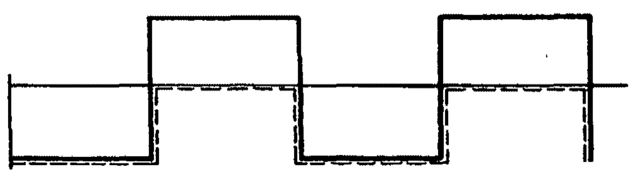


Fig. 4E

Fig. 4F

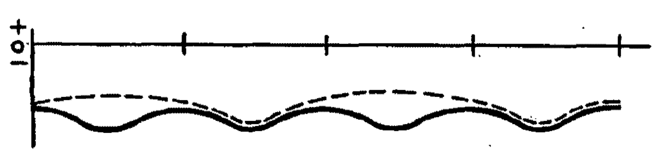
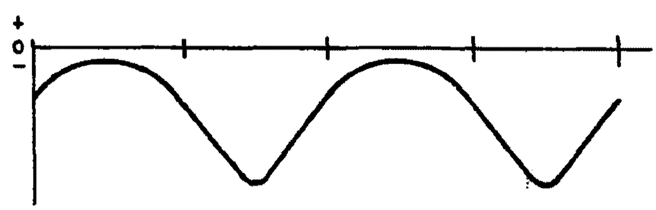
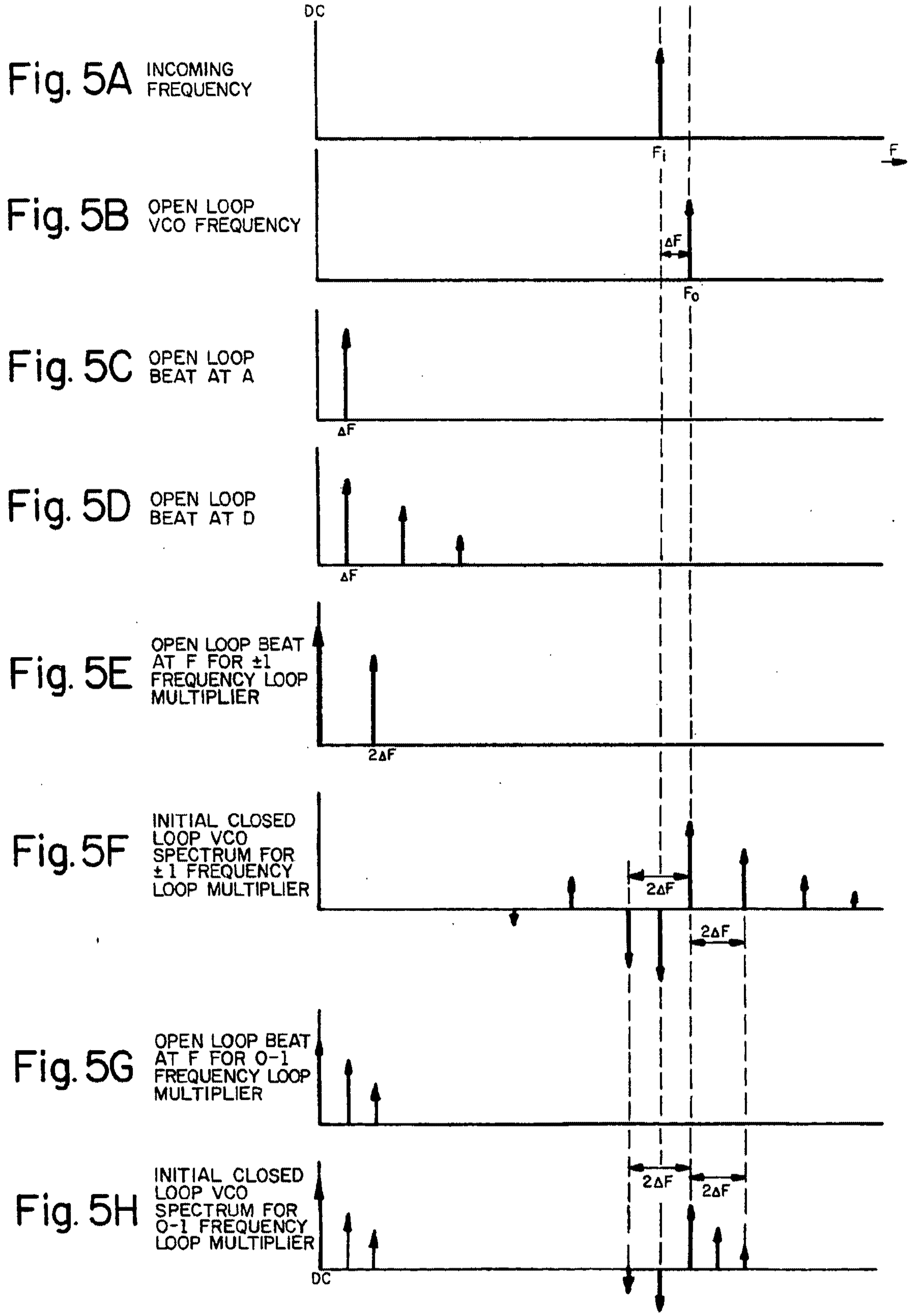



Fig. 4G




DC
Fig. 5A INCOMING FREQUENCY
Fi
F
Fig. 5B OPEN LOOP VCO FREQUENCY
ΔF
Fo
Fig. 5C OPEN LOOP BEAT AT A
ΔF
Fig. 5D OPEN LOOP BEAT AT D
ΔF
Fig. 5E OPEN LOOP BEAT AT F FOR ±1 FREQUENCY LOOP MULTIPLIER
2ΔF
Fig. 5F INITIAL CLOSED LOOP VCO SPECTRUM FOR ±1 FREQUENCY LOOP MULTIPLIER
2ΔF
2ΔF
Fig. 5G OPEN LOOP BEAT AT F FOR 0-1 FREQUENCY LOOP MULTIPLIER
Fig. 5H INITIAL CLOSED LOOP VCO SPECTRUM FOR 0-1 FREQUENCY LOOP MULTIPLIER
2ΔF
2ΔF
DC

# FREQUENCY AND PHASE LOCK LOOP WITH SEPARATED AFC AND PHASE LOCKING

## BACKGROUND OF THE INVENTION

This invention relates generally to signal acquisition and lock-on systems, and more particularly to a frequency and phase lock loop system for receiving RF signals.

A phase lock loop (PLL) is a feed back system typically comprising a phase detector or phase comparator, a PLL filter, and a voltage controlled oscillator (VCO). The VCO output signal is applied to one input terminal of a phase or frequency comparator, with an input reference signal being provided to the other input terminal of the phase or frequency comparator. The comparator generates an error signal, in response to phase or frequency differences between the VCO output signal and the reference signal. The error signal is applied to the PLL filter, the output signals of this filter being, in turn, applied to the control input of the VCO. By means of this feedback system the oscillator frequency approaches more closely and eventually locks onto the phase of the reference input signal by virtue of the correction signal fed back to the VCO.

The typical PLL has two modes of operation: signal acquisition, or frequency pull-in, and phase lock. In the acquisition mode the VCO's frequency is not equal to the input signal frequency and the loop generates a voltage which pulls the VCO frequency toward the input signal's frequency until it locks. The level of this stage of performance of the PLL is measured in terms of the maximum frequency acquisition range and the time required for signal pull-in. The second mode of PLL operation is termed phase lock which occurs when the VCO frequency and the input signal frequency are equal. Phase lock mode of operation is measured, or evaluated, in terms of PLL performance in the presence of noise. PLL performance in the presence of noise is determined by the closed loop noise bandwidth. Increased closed loop noise bandwidth results in increased PLL susceptibility to noise perturbation. To increase the PLL's frequency acquisition range, the cutoff frequency of the low pass loop filter is increased. However, this has the simultaneous undesirable effect of increasing the closed loop noise bandwidth thus decreasing PLL performance in the phase lock mode of operation. Thus, in prior art PLL systems a compromise between acquisition range and loop noise performance was required in optimizing PLL performance in a particular application.

Various approaches generally classified as either multiple loop systems or multiple mode systems have been proposed to improve performance of PLL systems. Quadricorrelators, swept or dithered VCO systems and frequency phase lock loops with frequency difference discriminators are some examples. These systems frequently do not lend themselves to integration, are often burdened with transitory discontinuities when changing modes, and do not fully achieve the goal of independent control over frequency acquisition and PLL performance characteristics.

A specific approach to improving FPLL performance is disclosed in U.S. Pat. No. 4,072,909 to Citta which discloses an automative phase and frequency control system. Briefly, this system includes two multipliers coupled to the input, or received, signal and to quadrature phase shifting means for phase shifting the output of the VCO to the multiplier combination thus producing a pair of quadrature phase related beat signals together with sum signals. The sum signals are filtered out while the beat signal output of one multiplier is coupled to one input of a third multiplier with the quadrature beat signal of the other multiplier converted by limiter circuitry and a low pass filter to a constant amplitude signal which is provided to the other input terminal of the third multiplier. With the low pass filter possessing a predetermined phase versus frequency characteristic, the filter (and also the limiter) output signal undergoes a phase delay which is a function of the signal frequency. Multiplication of the squared output signal of the limiter and the sinusoidal-like beat signal output of the first multiplier produces an error signal of constant amplitude having a DC component which varies with beat signal frequency. This DC component is then filtered and fed back to the VCO permitting input signal acquisition and normal phase lock operation when the frequencies of the VCO and the input signal are equal resulting in a DC output voltage signal from the limiter. This system represents a substantial improvement in automatic phase and frequency control systems in that substantial independence between signal acquisition and phase lock parameters is achieved.

While a large signal acquisition range and stable phase lock loop operation is attainable in the automatic phase and frequency control system described and claimed in the referenced patent, the degree to which independent control over the frequency acquisition and loop noise performance can be exercised is limited. The feedback signal in this system includes AC components which include harmonics of the beat frequency. As the difference frequency between the input and VCO signals become smaller, the AC loop gain increases with these harmonics increasing in strength. Not only do these beat frequency harmonics increase in amplitude thus producing unwanted sidebands around the VCO center frequency, but the fundamental beat frequency is lost from the VCO control signal. The absence of the fundamental beat frequency is due to the "chopping" effect of the frequency loop multiplier on the beat note signal and limits PLL performance. More specifically, the restriction on the independent control of frequency acquisition and PLL parameters results in the requirement that the residual frequency error of the frequency acquisition part of the system must be less than the lock-in range of the PLL in order for phase lock to occur within one beat cycle.

These and other problems experienced in the above-discussed Citta patent are eliminated in the present invention which is not only capable of being implemented as an IC, but also is capable of improved signal pull-in range and possesses an infinite figure of merit. This is accomplished by the total separation of acquisition and phase lock functions in the frequency and phase lock loop with separated AFC and phase locking of the present invention.

## OBJECTS OF THE INVENTION

Accordingly, it is an object of the present invention to provide an improved system for acquiring and locking on to a transmitted RF signal.

Another object of the present invention is to provide an improved signal acquisition and lock-on system with enhanced signal pull-in range.

Still another object of the present invention is to provide an improved frequency and phase lock loop system for acquiring and locking on to a transmitted RF signal.

Still another object of the present invention is to provide an improved frequency and phase lock loop system in which AFC and PLL functions are carried out completely independently.

A further object of the present invention is to provide an improved frequency and phase lock loop system capable of being produced in a single integrated circuit (IC).

A still further object of the present invention is to provide an improved frequency and phase lock loop system in which signal acquisition and pull-in ranges are independent and may be established separately.

## BRIEF DESCRIPTION OF THE DRAWINGS

The appended claims set forth those novel features believed characteristic of the invention. However, the invention itself, as well as further objects and advantages thereof will best be understood by reference to the following detailed description of a preferred embodiment taken in conjunction with the accompanying drawings, where like reference characters identify like elements throughout the various figures, in which:

FIG. 1 is a simplified block diagram of one embodiment of a frequency and phase lock loop system with separated AFC and phase locking in accordance with the present invention;

FIG. 2 is a simplified block diagram of another embodiment of a frequency and phase lock loop system with separated AFC and phase locking in accordance with the present invention;

FIGS. 3A-3G and 4A-4G show wave forms of signals at various points within the present invention as shown in FIG. 1 for $f_i > f_o$ and for $f_i < f_o$, respectively, where $f_i$ is the input signal frequency and $f_o$ is the open loop oscillator signal frequency; and

FIGS. 5A-5H show the frequency spectrum of signals at various points in the frequency and phase lock loop system with separated AFC and phase locking in accordance with the present invention.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

A frequency and phase lock loop system with separated AFC and phase locking in accordance with the present invention is shown in FIG. 1. An input signal with a frequency $f_i$ is coupled to a pair of multipliers 10 and 11. Input stage 9 is comprised of any of the more conventional components typically included in the front end of an RF receiver. For example, included in input stage 9 would be an antenna, a received signal amplifier, a tuner, a mixer, and an IF amplifier. The output signal $f_o$ of a voltage control oscillator (VCO) 16 is coupled to the remaining input terminals of multipliers 10 and 11. A 90° phase shift network 17 is provided between oscillator 16 and multiplier 11. The output of multiplier 10 is coupled to one input of a multiplier 12 while the output of multiplier 11 is coupled to a low pass filter 13 which in turn is coupled to a symmetrical limiter 14. The output of limiter 14 is coupled to the remaining input terminal of multiplier 12. The output of multiplier 12 is coupled via a low pass filter 18 to a signal adder with the output of multiplier 10 provided to the other input terminal of adder 19. The output of adder 19 is coupled via a low pass filter 15 to the control input terminal of voltage control oscillator 16 the output of which is a signal with an open loop output frequency $f_o$.

With the exception of filter 13 and limiter 14 the components of the preferred embodiment of the frequency and phase lock loop system with separated AFC and phase locking as shown in FIG. 1 do not require a detailed explanation. Details of filter 13 and limiter 14 utilized in the preferred embodiment of this invention can be found in U.S. Pat. No. 4,072,909 to Citta. However, it should be obvious that numerous filter and limiter circuits which perform the functions described later can be used without departing from the spirit of the present invention. The operation of the frequency and phase control system 8 shown in FIG. 1 is best understood if discussed in conjunction with FIGS. 3A through 3G and FIGS. 4A through 4G. It is to be noted here that FIGS. 3A-3G and 4A-4G show the situation resulting in a maximum error signal for a 90° phase shift occurring in filter 13. This is done simply for illustrative purposes. Signal multipliers 10 and 11 in response to the input signal $f_i$ and quadrature sample of the output of VCO 16 produce a pair of quadrature phase related frequency difference signal together with sum signals which are removed by filters 13 and 15. While these quadrature beat signals are obtained by inducing a phase shift in an oscillator output it should be obvious that any phase shift in either the oscillator or input signals may be used to produce quadrature beat signals without departing from the spirit of the present invention. The beat signal output of multiplier 10 is directly coupled to one input of multiplier 12 while the quadrature beat signal from multiplier 11 is converted by limiter circuit 14 and low pass filter 13 to a constant amplitude signal. With low pass filter 13 possessing a predetermined phase versus frequency characteristic, the phase delay which occurs within filter 13 (and therefore the phase of the output signal of limiter 14) is a function of the difference frequency.

Multiplication of the "squared" output signal of limiter 14 and the beat signal output of multiplier 10 produces an error signal having a DC component which varies with the beat signal of FIG. 3A. This error signal is provided by multiplier 12 to low pass filter 18 which converts the full wave rectified signal to a DC voltage which is applied to one input of adder 19. Full wave rectification occurs only for the case where a 90° phase shift occurs in LPF 13. To the other input of adder 19 is provided the beat signal output of multiplier 10. Signal adder 19 has the effect of providing the DC level of the AFC loop from multiplier 12 to the beat note frequency of phase lock loop multiplier 10. This permits the DC level acquisition signal to be added to the beat note phase locking signal to provide a correction signal to VCO 16 having acquisition and phase locking characteristics which are completely independent. The output of adder 19 is coupled by filter 15 to VCO 16 to produce both signal acquisition and phase lock of the input signal. Once the VCO frequency $f_o$ and the input signal frequency $f_i$ are equal, the output of limiter 14 becomes a DC voltage while the output of phase detector multiplier 10 maintains phase lock with its output signal being a function of the phase difference between the input signal and the VCO output signal.

A more detailed description of the operation of the present invention is provided by reference to the block diagram of FIG. 1 in combination with the signal waveforms shown in FIGS. 3A-3G and FIGS. 4A-4G. For convenience the individual curves of the figures will be referred to by the figure number in conjunction with the letter of the curve. In addition, the location of the signal waveform of each of the curves is shown by a corresponding letter in the block diagram of FIG. 1 of the frequency and phase lock loop system with separated AFC and phase locking of the present invention. FIGS. 3A-3G depict the signals present within the circuit during acquisition when the input signal, $f_i$, is at a higher frequency than the output signal, $f_o$, of VCO 16. FIGS. 4A-4G depict the signals present within the circuit during acquisition when the output signal, $f_o$, of VCO 16 is at a higher frequency than the input signal, $f_i$. As can be seen from a brief review of the respective figures, this relative difference in frequency results in 180° phase differences and change in sign between the waveforms at various locations in the system for each of the enumerated conditions. Because the principles involved in the basic operation of the system remain the same for both frequency conditions, only FIGS. 3A-3G will be described in detail with that discussion equally applicable to the opposite condition of $f_i < f_o$.

The beat signal outputs of multipliers 10 and 11 are shown in FIGS. 3A and 3B, respectively. It should be noted that a quadrature relationship exists in which the output of multiplier 11 leads that of multiplier 10 by 90°. The signal shown in FIG. 3A is coupled directly to one input of multiplier 12 and that shown in FIG. 3B is applied to low pass filter 13. The output of filter 13, presented in FIG. 3C, shows a 90° lagging phase shift to have occurred within the filter. Similarly, as can be seen in FIG. 4C, because $f_i$ is less than $f_0$ the phase of the output signal of multipler 10 leads the phase of the signal provided to filter 13 by frequency loop multiplier 11. Limiter 14 converts the phase shifted sinusoidal beat signal of FIG. 3C to a substantially amplitude limited periodic signal having the same phase as the waveform in FIG. 3C as depicted in FIG. 3D.

Because $f_i > f_o$ and there is a 90° phase shift lag caused by low pass filter 13, the square wave of FIG. 3D is in phase with the beat signal output of phase lock multiplier 10 shown in FIG. 3A. This phase relationship is due to the phase shift produced by the frequency-dependent phase shift characteristics of low pass filter 13. The conditions shown are of special interest because they represent the maximum error voltage output of the system. The frequency corresponding to this phase condition is determined by the phase shift characteristics of filter 13 and is largely a matter of design choice.

The application of the square wave signal shown in FIG. 3D and the sinusoidal beat signal of FIG. 3A to the inputs of multiplier 12 produces an output signal which is essentially the full wave rectification of the beat signal in FIG. 3A. This waveform, which is shown in FIG. 3E, is then filtered by low pass filter 18 to provide the waveform shown in FIG. 3F which is essentially a DC voltage. The DC voltage signal shown in FIG. 3F is then applied to one input terminal of signal adder 19 while to the other input terminal of adder 19 is applied the phase lock loop beat signal output of multiplier 10. The resultant signal is shown in FIG. 3G in which a sinusoidal variation has been imposed on a DC level signal. The result is that a periodic signal superimposed upon a DC level is provided to VCO 16. This control signal thus includes a large DC level for signal acquisition and a sinusoidal beat signal variation necessary for signal phase lock. This input signal provided to VCO 16 is in contrast to the control signal of the referenced Citta patent in which the sinusoidal beat frequency is "chopped" by the action of the limiter output signal on the beat signal output of the phase lock multiplier. This signal "chopping" results in a loss of the fundamental beat frequency from the output of the phase lock multiplier which limits the Citta system's phase locking capability to the extent the residual frequency error of the AFC has to be less than the lock-in range of the PLL. By retaining the fundamental beat frequency and superimposing it upon the DC signal acquisition level, the present invention provides the phase lock loop with the capability to pull the signal in from its full frequency acquisition range.

Thus, in the present invention the fundamental beat frequency at multiplier 10 is passed to adder 19 and transmitted to VCO 16 producing a sideband which is coherent with the input frequency $f_o$. This sideband output of VCO 16 is, in turn, provided to multiplier 10 which produces a DC component at the output of multiplier 10 which results in the continuation of the frequency acquisition process until phase lock occurs. The PLL portion of the present invention assists frequency acquisition by pulling the VCO during and/or after the AFC portion has pulled it to within its finite residual frequency error. The output of multiplier 12 is filtered by low pass filter 18 and provided to signal adder 19 where it is combined with the beat signal output of phase lock multiplier 10. The resultant waveform is shown in FIG. 3G and it is this signal which is provided to low pass filter 15 in order to produce a DC voltage and the fundamental of the low frequency beat signal suitable for application to the control circuitry within VCO 16.

FIGS. 4A-4G show a set of curves similar to those shown in FIGS. 3A-3G but depicting system performance when the reference frequency is less than that of VCO 16 under maximum error voltage conditions. As expected, system operation remains essentially the same. The primary difference is in the quadrature relationship between the outputs of multipliers 10 and 11 which is reversed to that shown in FIGS. 3A and 3B. The waveforms presented in FIGS. 4A-4G indicate that when the oscillator frequency is greater than that of the input signal, the beat signal produced by a pair of quadrature multipliers is 180° out of phase with the beat signal produced when the frequency relationships are reversed.

Because low pass filter 13 responds only to the frequency of the beat signal and does not respond to the relationship between beat signals, low pass filter 13 again produces a lagging phase shift of 90° yielding the signal shown in FIG. 4C. FIG. 4D shows the constant amplitude signal in phase with that of FIG. 4C produced by the action of limiter 14. Due to the opposite phase relationship between the beat signals of FIGS. 4A-4G and those of FIG. 3A-3G, the constant amplitude signal (shown in FIG. 4D) is 180° out of phase with the beat signal of FIG. 4A and signal multiplication in multiplier 12 results in a similar, but reversed polarity, full wave rectified output signal (shown in FIG. 4E) which when filtered by low pass filter 18 produces the negative voltage "maximum" shown in FIG. 4F. Again, full wave rectification occurs here because of the 90° phase difference between the input and outputs of low pass filter 13. The output of LPF18 is then provided to one input of signal adder 19 to which is also provided the beat signal output of phase lock multiplier 10 shown in FIG. 4A to produce the periodic signal superimposed upon the voltage signal of FIG. 4G. This negative voltage represents the opposite maximum acquisition voltage of the system and possesses a large DC component for signal acquisition in combination with the fundamental beat frequency signal for phase locking.

The frequency difference detection portion of the system, or the AFC system, is made up of frequency difference multiplier 11, low pass filter 13, limiter 14, signal multiplier 12, low pass filter 18, signal adder 19, low pass filter 15, VCO 16, and quadrature phase shifting circuit 17. The output of multiplier 12 is not diminished as frequency lock is obtained but rather becomes a very low frequency signal having a near 0 DC average. This facilitates the phase lock function of the present invention because the point to which the frequency loop pulls the signal to is now within the frequency acquisition range of the phase lock loop due to the presence of the fundamental beat frequency in the control signal provided to VCO 16.

In the phase lock mode of operation the output signals of multipliers 10 and 11 become DC voltages porportional to the phase differences between their respective input signals. Since the signals applied to multiplier 10 are substantially in quadrature, a near 0 DC output signal results while the in-phase inputs of multiplier 11 (due to the action of phase shifter 17) cause a near maximum positive or negative output voltage. The output of multiplier 11 is passed by low pass filter 13 causing limiter 14 to apply a positive or negative voltage to one input of multiplier 12. The near 0 output voltage of multiplier 10 is coupled directly to multiplier 12 which couples it substantially unchanged via low pass filter 18 to signal adder 19. Thus, the actions of multiplier 11, low pass filter 13, and signal limiter 14 produce no effect upon the error signal developed by multiplier 10 once acquisition, as evidence by DC output signals from multipliers 10 and 11, is obtained. Multiplier 10, signal adder 19, low pass filter 15, and VCO 16 comprise the phase lock loop portion of the present invention and perform standard APC functions to maintain phase synchronization.

In the present invention the error signal which reflects the difference in phase between the input signal and the VCO 16 is provided by multiplier 10 directly to signal adder 19. The DC voltage level required for signal acquisition from initial frequency errors greater than the PLL pull-in range is provided to signal adder 19 via the AFC loop in which undesirable AC components transmitted by frequency loop multiplier 11, LPF 13 and limiter 14 in conjunction with multiplier 12 are extracted by low pass filter 18. This signal processing arrangement provides for the complete separation of frequency and phase locking functions with signal acquisition performance established primarily by low pass filter 13 and phase lock loop characteristics established by low pass filter 15. The AC beat note is thus passed through adder 19 and low pass filter 15 directly to VCO 18. In addition, in the present system phase detector multiplier 10 performs a multiple function in providing an output signal which represents the phase difference between the input and VCO signals after phase locking occurs, while providing the beat note signal during signal acquisition to frequency multiplier 12 to generate the DC level which represents the frequency difference between the input and VCO signals as well as providing the fundamental of the beat note to adder 19 to further aid in the frequency acquisition process.

The present invention has thus far been described in terms of using a ±1 frequency loop, or baseband multiplier, 12. The operation of this type of signal multiplier is unrestricted as to the sign of both of the input variables. Thus, the waveforms of FIGS. 3A-3G and 4A-4G reflect the operating characteristics of a ±1 baseband multiplier 12. The output of limiter 14 shown in FIG. 3D therefore has both plus and minus components producing a full rectified waveform shown in FIG. 3E as the output of multiplier 12 when combined with the beat signal output of phase lock multiplier 10. FIGS. 4D and 4E similarly show the waveforms for a system incorporating a ±1 frequency loop multiplier 12 for the case of $f_i<f_o$. By differentially weighting the inputs to adder 19 two stable signal acquisition states are possible. If the output of adder 19 depends equally upon the phase loop signal and the frequency loop signal, only one stable acquisition state is possible. In this manner, the loop gains of the phase and frequency loop may be independently varied.

The dotted waveforms shown in FIGS. 3D and 3E, and 4D and 4E show the signal format at corresponding points in the present invention when a 0-1 baseband balanced (i.e. single-balanced) multiplier 12 is utilized in the present invention. FIG. 2 shows a simplified block diagram of the present invention when a 0-1 baseband balanced multiplier 12 is used. Except for effecting AFC loop gain and there being only one stable state, the end result and system performance is unchanged whether a ±1 or 0-1 multiplier is employed. The type of frequency loop multiplier used effects the waveform only at points D and E in the present invention and has no influence on the correction signal provided to VCO 16. The use of a 0-1 frequency loop multiplier thus represents another embodiment of the present invention. The 0-1 multiplier is balanced for the input from limiter 14 but not for the input from phase detector multiplier 10. As the fundamental of the beat frequency is now in the feedback error signal, the pull-in mechanism of the APC loop aides the pull-in of the AFC loop and the system exhibits an increased frequency pull-in range.

Shown in FIGS. 5A-5H is the frequency spectrum at various points in the preferred embodiment of the frequency and phase lock loop system with separated AFC and phase locking. The incoming frequency $f_i$ is shown in FIG. 5A while the open loop VCO frequency $f_o$ is shown in FIG. 5B. FIG. 5C shows the fundamental beat frequency Δf of $f_o-f_i$. The open loop beat frequency spectrum at point D is shown in FIG. 5D. This represents the output of ideal limiter 14 to baseband multiplier 12. Only odd harmonics of the beat frequency are present here. The open loop beat frequency spectrum at point E, or at the output of baseband multiplier 12, is shown in FIG. 5E. This represents the frequency spectrum of the fundamental beat frequency multiplied by the output of limiter 14. The fundamental of the original beat frequency is absent here. The open loop beat frequency at point F, following passage of the signal through low pass filter 18, is shown in FIG. 5F and consists essentially of a DC signal provided to signal adder 19. This DC signal represents the frequency acquisition component of the correction signal provided to VCO 16. Adder 19 combines the output of phase detector multiplier 10 and low pass filter 18 to produce the frequency spectrum shown in FIG. 5G. It can be seen that the spectrum includes not only the fundamental beat frequency Δf but also a DC frequency acquisition component. FIG. 5H shows the initial closed loop VCO spectrum from which it can be seen that a DC component will be generated at the output of multiplier 10 due to the presence of a spectral component at $f_i$ at both of its inputs. The generation of this DC signal is due to the presence of the fundamental beat frequency Δf in the open loop beat frequency signal provided by signal adder 19 to VCO 16. The referenced prior art Citta patent provides a correction signal to the VCO which consists of the frequency spectrum shown in FIG. 5F. It can be seen that the fundamental beat frequency Δf is absent from this output signal and because of the absence of the fundamental beat frequency the initial closed loop VCO spectrum of the Citta system also is without a Δf component and a DC correction signal for VCO 16. Consequently, the spectrum in the Citta system lacks a component at $f_i$ and, without the fundamental beat frequency present in the feedback loop, the output of multiplier 10 is without a DC correction signal for VCO 16. The absence of the fundamental beat frequency component is due to the chopping effect of the frequency loop multiplier in the Citta system and results in an AC signal feedback to the VCO which limits system phase lock performance due to instabilities caused by the AC feedback signal.

There has thus been shown a frequency and phase lock loop system and method with separated AFC and phase locking which provides for the independent establishment of signal acquisition range and close loop bandwidth performance parameters. This system and method also offers increased signal acquisition range and the advantages of an integrated circuit design.

While particular embodiments of the invention have been shown and described, it will be obvious to those skilled in the art that changes and modifications may be made without departing from the invention in its broader aspects and, therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of the invention.

The matter set forth in the foregoing description and accompanying drawings is offered by way of illustration only and not as a limitation. The actual scope of the invention is intended to be defined in the following claims when viewed in their proper perspective against the prior art.

We claim:

1. An automatic phase and frequency control system for producing phase and frequency synchronization between a locally generated signal and an input signal comprising;

voltage controlled oscillator means producing said locally generated signal having a frequency responsive to a control signal;

signal generating means producing first and second beat signals between said input signal and said locally generated signal, said beat signals having a substantially quadrature relationship;

translating means converting said first beat signal to a constant amplitude signal having a phase relative to said second beat signal which varies in a predetermined relationship to the frequency of said first beat signal, said translating means being capable of coupling a DC signal;

multiplying means multiplying said second beat signal from said signal generating means and the output signal of said translating means to develop a composite correction signal, said multiplying means including a single-balanced signal multiplier capable of receiving signals of a single sign from said signal generating means and said translating means; and

low pass filter means coupling said composite correction signal to the control signal input of said voltage controlled oscillator, said composite correction signal including the fundamental beat note frequency of said input signal and said locally generated signal.

* * * * *

US005267273A

# United States Patent [19]

**Dartois et al.**

[11] **Patent Number: 5,267,273**

[45] **Date of Patent: Nov. 30, 1993**

[54] **CLOCK SIGNAL GENERATOR USING FRACTIONAL FREQUENCY DIVISION AND CONTROL THEREOF**

[75] Inventors: **Luc Dartois**, Carrieres S/Poissy, France; **Peter Reusens**, Laarne; **Etienne Vanzieleghen**, Anvers, both of Belgium

[73] Assignee: **Alcatel Radiotelephone**, Paris, France

[21] Appl. No.: **750,171**

[22] Filed: **Aug. 26, 1991**

[30] **Foreign Application Priority Data**

Aug. 24, 1990 [FR] France ............................ 90 10616

[51] **Int. Cl.**[5] ............................ **H04L 7/00**

[52] **U.S. Cl.** ............................ **375/106**; 377/48; 377/50; 377/51

[58] **Field of Search** ............................ 375/106, 110; 328/15, 328/30; 377/47-50, 51-54

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*Primary Examiner*—Curtis Kuntz

*Assistant Examiner*—Don N. Vo

*Attorney, Agent, or Firm*—Sughrue, Mion, Zinn, Macpeak & Seas

[57] **ABSTRACT**

A clock signal generator using fractional frequency division is provided comprising a division circuit that produces a clock signal starting from a timing rhythm signal. The frequencies of the two signals are in a division ratio which is the sum of a whole part and a fractional part. A pulse subtractor is provided for receiving the rhythm signal and transmitting it to the division circuit while deleting at least one pulse from this signal upon a command. An accumulator commands a pulse subtractor on each occasion when the product of the number of pulses of the clock signal counted, starting from a time of origin and of the fractional part, changes by unity.

**15 Claims, 2 Drawing Sheets**

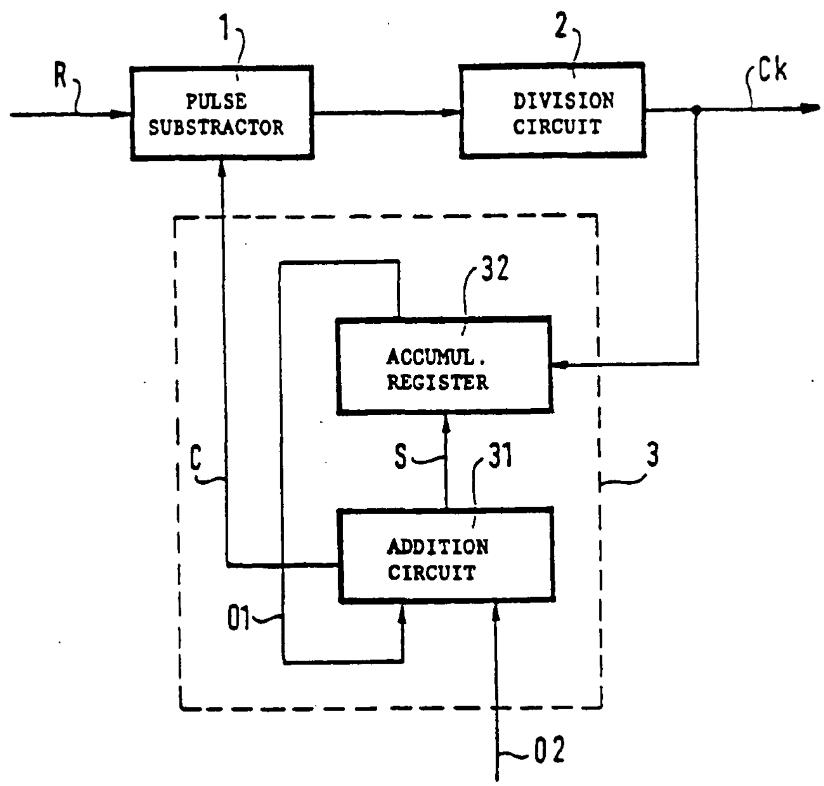


FIG.1

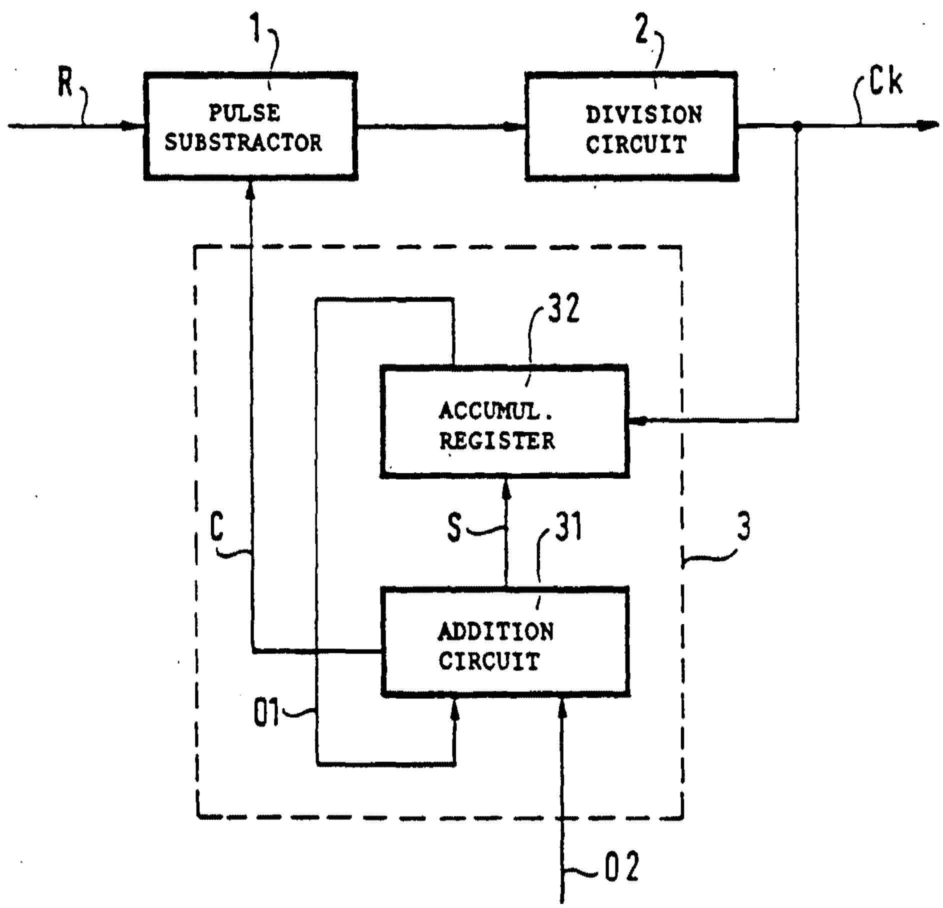
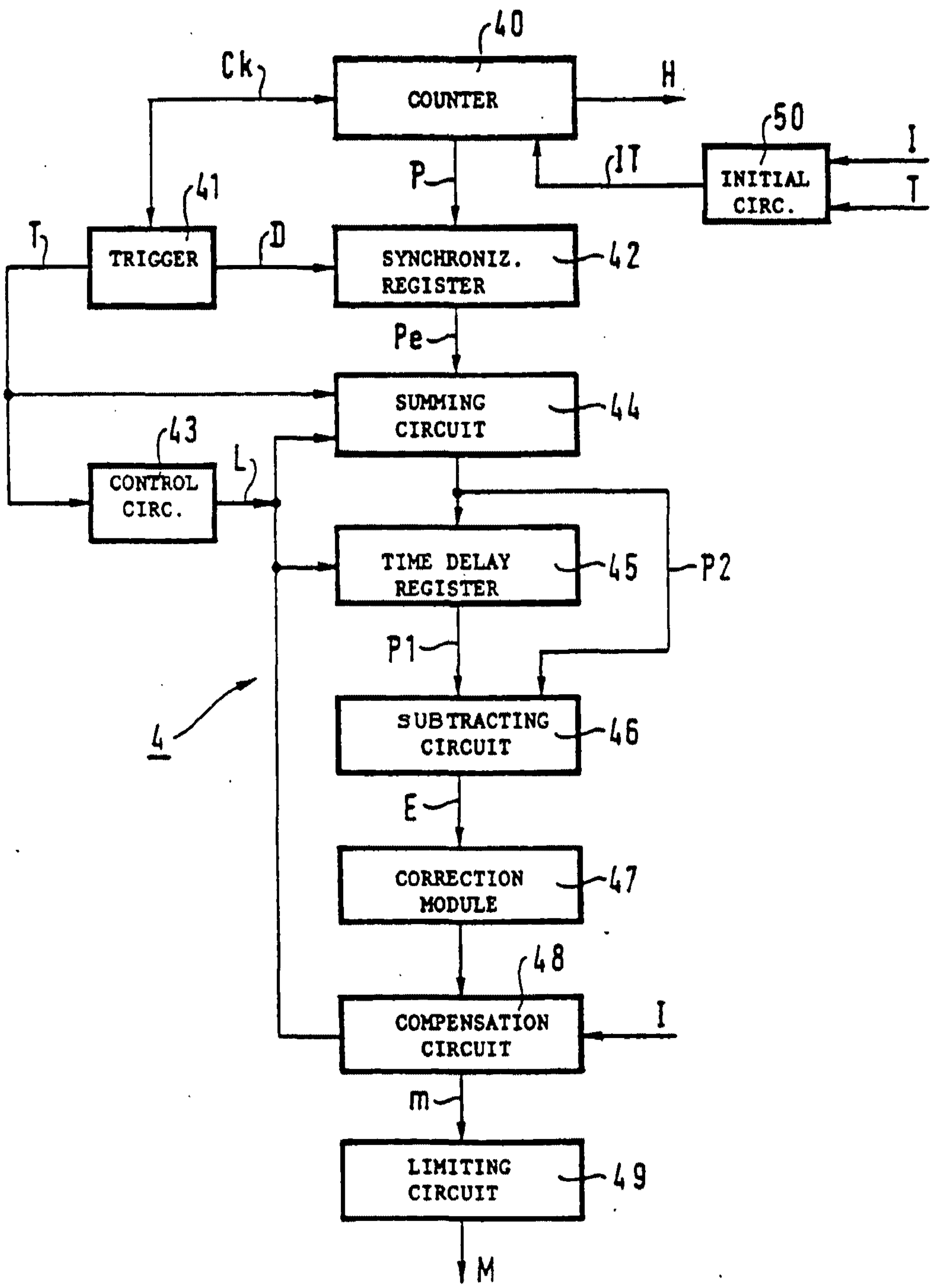

R
1
PULSE
SUBSTRACTOR
2
DIVISION
CIRCUIT
Ck
32
ACCUMUL.
REGISTER
C
S
31
3
ADDITION
CIRCUIT
01
02

FIG. 2



40
Ck
COUNTER
H
50
I
P
IT
INITIAL CIRC.
T
41
T
TRIGGER
D
SYNCHRONIZ. REGISTER
42
Pe
SUMMING CIRCUIT
44
43
L
CONTROL CIRC.
TIME DELAY REGISTER
45
P2
P1
4
SUBTRACTING CIRCUIT
46
E
CORRECTION MODULE
47
48
COMPENSATION CIRCUIT
I
m
LIMITING CIRCUIT
49
M

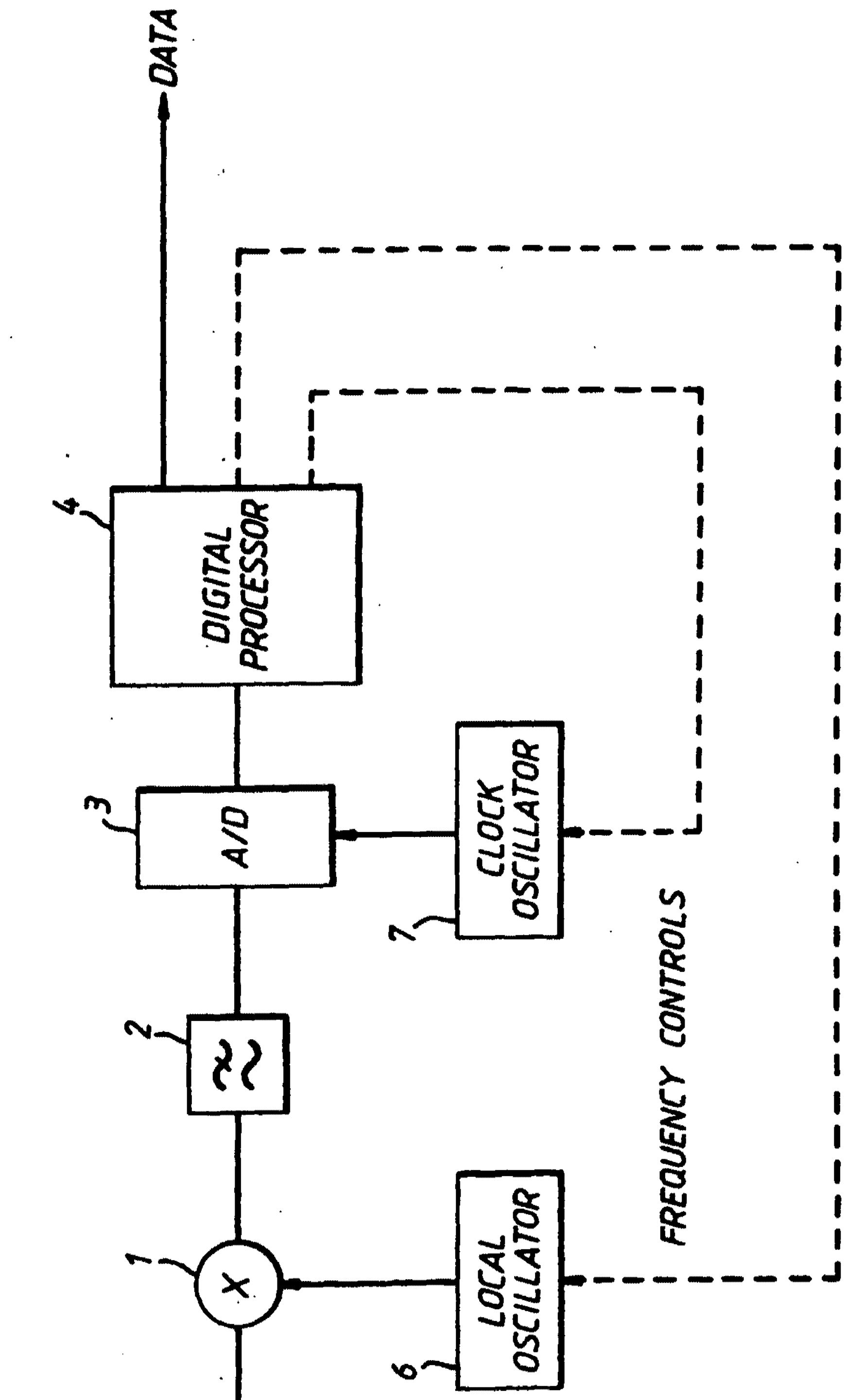

DATA
4
DIGITAL PROCESSOR
3
A/D
CLOCK OSCILLATOR
7
2
FREQUENCY CONTROLS
1
LOCAL OSCILLATOR
6
UHF TUNER

Fig. 4.

# CLOCK SIGNAL GENERATOR USING FRACTIONAL FREQUENCY DIVISION AND CONTROL THEREOF

## BACKGROUND OF THE INVENTION

The present invention relates to a clock signal generator using fractional division of frequency and to means for keeping said clock signal generator under the control of a synchronization signal.

The majority of electronic circuits are now designed to operate using a determined frequency clock signal produced by an oscillator. When a piece of equipment includes circuits that are designed to operate on different clock signals, a first solution consists in using a specific oscillator circuit for each clock signal. This solution is clearly not an economical way of solving the problem. Use is often made, when the frequency of a first clock signal is not a multiple of the frequency of a second one, of a clock signal generator employing fractional division of its frequency. Such a clock signal generator, when it is fully implemented in digital technology produces a signal the average frequency of which over one full period is the frequency of the signal it is receiving divided by a division ratio.

The use is known of a programmable counter receiving a signal at a steady rhythm and adapted to periodically output, depending on the period of recurrency, a successive first and second series of pulses the frequencies of repetition of which are submultiples of the frequency of the steady rhythm signal. Such a device, apart from the programmable counter, requires two additional counters in order to determine the number of pulses in each series, together with control means. It hence occupies, where it is implemented in integrated form, a fairly large substrate surface area which is an obstacle to the miniaturization of the equipment in which it is incorporated.

European Patent 0 019 412 disclosed the use of a counter that is preceded by a pulse absorber or subtractor for fulfilling the function of a programmable counter. The pulse subtractor in effect eliminates pulses from the rhythm signal when commanded so to do thus modifying the frequency of the output signal from the counter.

Nevertheless, the phase shift between the output signal and a signal the frequency of which is exactly at the division ratio of the rhythm signal frequency is highly variable and can have an appreciable amplitude.

A first object of the present invention is to provide a clock signal generator using fractional division of frequency of reduced size made possible by the use of individual circuits that are more simple and the output signal of which only suffers from limited phase shifting relative to the desired frequency. This phase shift, in a preferred embodiment, is less than one period of the steady rhythm signal.

In certain fields of application, particularly in telecommunications systems receiving equipment, it is necessary to set the output signal from the clock signal generator under the control of a synchronization signal.

The present invention hence also has the object of providing control means that are specially suitable for this type of clock signal generator using fractional division of frequency.

Although one should not attempt to see a limitation of the invention in this, the provisions of the invention can advantageously be used in the Pan-European digital cellular radiocommunications system. In this system, a mobile terminal comprises a speech coding and decoding unit which can be implemented using a standard component working with 8 kHz and 2048 kHz clock signals. The terminal further includes an internal clock signal generator producing a 13 MHz steady rhythm signal, and produces a 50 Hz synchronization signal onto which the coding and decoding units require to be synchronized. The invention hence makes it possible, starting from this steady rhythm signal, to produce clock signals that are synchronized onto this synchronization signal.

## SUMMARY OF THE INVENTION

The invention provides a clock signal generator using fractional frequency division comprising a division circuit that produces a clock signal starting from a timing rhythm signal, the frequencies of the two said signals being in a division ratio which is the sum of a whole part and a fractional part, the generator including a pulse subtractor receiving said rhythm signal and transmitting it to said division circuit while deleting at least one pulse from said signal upon a command, and accumulator means for commanding said pulse subtractor on each occasion when the product of the number of pulses of the clock signal counted starting from a time of origin and of said fractional part changes by unity.

The phase shift between the clock signal generator signal and the steady rhythm signal is thus minimized. Moreover, in the clock signal generator using fractional division of frequency, with the division ratio taking the form of the sum of the product of a first division factor and of the fractional part and of the product of a second division factor and the ones-complement of said fractional part, the accumulator means include an accumulation register producing a first operand which adopts the value of an addition signal in response to said clock signal, and an addition circuit producing said addition signal as the sum modulo the denominator of said fractional part of said first operand and of a second operand comprising at least the numerator of said fractional part and producing a carry-over signal, the pulse subtractor being adapted to absorb a number of pulses equal to the difference between said two division factors in response to this carry-over signal.

Moreover, with the clock signal generator adapted to be controlled by a synchronization signal, it includes a closed loop feedback control module receiving said synchronization signal and said clock signal and producing a correction signal, the abovesaid second operand being the sum of said numerator and said correction signal.

Thus, with the frequency of the clock signal being a multiple of the frequency of the synchronization signal, the control module includes means for producing a counting value corresponding to the number of pulses of said clock signal that have appeared during a fixed duration measurement period, means for producing a correction value that is proportional to the difference of a second and a first counting value and inversely proportional to the duration separating the mid-point of the second and the first corresponding measuring periods, said correction signal which usually is zero, being assigned said correction value during a correction period that is expressed as a number of periods of the clock signal.

Moreover, in the clock signal generator using fractional frequency division with the measurement period being a multiple of the period of the synchronization signal, and the first and second corresponding measuring periods being consecutive, the control module includes a counter receiving said clock signal and producing a phase signal, the capacity of this counter being a sub-multiple of the frequency ratio of said clock signal and said synchronization signal, and includes a summing circuit producing said second counting value as the sum of the values adopted by said phase signal at the rhythm of said synchronization signal, a time-delay register producing said first counting value in the same way as said second counting value with a delay of said measurement period, a subtraction circuit producing a phase deviation signal as the difference of said second and first counting values, and a correction module producing said correction value in proportion to the phase deviation signal.

Advantageously in the clock signal generator using fractional division of frequency, an individual output from said counter is employed for producing an auxiliary clock signal.

In one embodiment, the clock signal generator using fractional frequency division further includes a compensation circuit for immediately producing this correction value as the sum of the values of the output signal of said correction module during the previous measuring period and the current measuring period.

Moreover in the clock signal generator using fractional division of frequency, the compensation circuit includes a saturation adder limiting said correction value to a determined maximum value.

In one particular embodiment, the generator includes a limiting circuit that affects this correction signal for the correction value during the first appearance of a determined state on an individual output of said counter subsequent to the start of a period of said synchronization signal, said correction signal being zero during the remainder of this period.

Moreover, it can include a synchronization register producing, as a measurement signal, this phase signal in response to a triggering signal originating from a triggering circuit the output of which adopts the value of said synchronization signal upon command from the clock signal, said measurement signal being addressed to the summing circuit.

According to one further feature, the generator can include a command circuit producing a command signal the period of which is equal to the measurement period, said command signal resetting said summing circuit, transferring the input to the output of said time-delay register and modifying the output signal from the compensating circuit. Advantageously, the clock signal generator using fractional frequency division receives an initialization signal adapted to initialize the compensation circuit.

Moreover, the generator can include an initialization circuit which imposes a starting value on the counter in response to the initialization signal.

In one particular case of the clock signal generator using fractional division of frequency, the whole number part of the division ratio is zero.

It is also possible to make provision so that the difference in the two division factors is equal to unity, the pulse subtractor deleting one single pulse upon command.



The various objects and features of the present invention will become more clear from the description of several embodiments provided by way of non-limiting examples with reference to the attached drawings.

## BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. 1 is a block diagram of a clock signal generator using fractional division of frequency according to the invention.

FIG. 2 is the schematic of a control module for the clock signal generator.

## DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Clock signal generators using fractional division of frequency receive a steady rhythm signal and produce a clock signal and are adapted so that the frequencies of these signals are in a division ratio equal to Q. This ratio can always be expressed as the sum of the product of a first division factor A and of a fractional part F and of the product of a second division factor B and the ones-complement of this fractional part, where the division factors are whole numbers and the fractional part is a number comprised between zero and one:

$$Q = A.F + B.(1-F)$$

The various numbers can moreover be chosen so that the difference between the two division factors is equal to unity:

$$A = B + 1$$

Moreover, the fractional part can be represented in the form of a fraction comprising a numerator N and a denominator D:

$$F = N/D$$

The invention described below is valid regardless of the value of these various numbers.

By way of example, and in order to clarify the description, the invention will be explained with regard to a concrete case of its application in the Pan-European digital cellular radiocommunications system. In this case, a mobile terminal is fitted with an internal oscillator which produces the rhythm signal at a frequency of 13 MHz. Starting from this signal, it is necessary to produce the clock signal which is notably made use of by the speech processing circuits, at a frequency of 2.048 MHz. The division ratio is hence:

$$Q = 6.34765625$$
$$Q = 6 + 89/256$$
$$= 6\,\frac{(256-89)}{256} + 7\cdot\frac{(89)}{256}$$

By using the notation discussed above:

$$A = 7 \quad B = 6 \quad F = \frac{89}{256}$$
$$N = 89 \quad D = 256$$

The clock signal generator using fractional division of frequency according to the invention and illustrated in FIG. 1 comprises a pulse absorber or subtractor 1 which receives the rhythm signal R and the output of which is connected to the input of a division circuit 2 which produces the clock signal Ck. It also includes accumulation means 3 which receive this clock signal and control the pulse subtractor by means of a carry-over signal C, these means being provided for limiting the phase shift in the clock signal as will become more clear below.

The pulse subtractor 1 transmits the steady rhythm signal R directly to its output except when it receives the carry-over signal C. In this latter case, it deletes one pulse from the steady rhythm signal. The division circuit 2 produces the clock signal Ck the frequency of which is a sub-multiple of the frequency of the signal that is applied to its input. This sub-multiple is equal to the second division factor B which in the present case is 6. This circuit can be a counter for example, and when it is dividing by an even number this can advantageously be a ring counter also known as a Johnson counter. A counter of this type takes the form of a series of a flip-flops the first of which receives the output signal from the last which is the clock signal Ck. The sub-multiple is here twice the number of flip-flops.

Accumulation means 3 are provided for triggering the pulse subtractor 1 each time that the product of the fractional part F and of a number of clock signal pulses counted starting from an origin point in time changes by unity, in other words when the whole number part increases by a unity value. The point in time of the origin is arbitrarily fixed and only constitutes a time reference. It can for example be the time when the clock signal generator was first started.

These accumulation means 3, in one particular embodiment which should not be considered as limiting the invention, comprise an addition circuit 31 and an accumulation register 32.

The accumulation register 32 produces a first operand $O_1$ which has the value that the addition signal S had when the most recent pulse in clock signal Ck occurred.

Addition circuit 31 produces this addition signal S as the sum of the first operand and of a second operand $O_2$ modulo the denominator D of the fractional part F. The second operand, in this first part of the invention, adopts the value of the numerator N of this fractional part F. This circuit is moreover designed to supply the carry-over signal C for the pulse subtractor 1, when this sum is greater than the denominator.

Thus, every time that the product of the numerator and of the number of pulses in the clock signal becomes greater than a multiple of the denominator, and below which value it previously was, one clock signal pulse is deleted which comes down to carrying out division by the first division factor A.

In the numerical example being considered, the denominator is equal 256. The addition circuit can hence consist of a single adder supplying an output signal on 8 bits and a carry-over signal.

The invention applies if the division ratio is reduced to the fractional part, in other words if the first and second division factor, A and B respectively, are respectively 1 and 0. In this case, the division circuit 2 is reduced to a simple link, the clock signal Ck being the output signal from the pulse subtractor 1.

The invention also applies if the division factors differ by more than unity. Here, it is sufficient to adapt the pulse subtractor 1 to delete a number of pulses that is equal to the difference between these two factors. This operation which is within the abilities of those skilled in the art, will not be described in more detail.

According to one further feature of the invention, the clock signal generator using fractional divisional frequency is designed to be kept under the control of a synchronization signal via a control module, the frequency of this synchronization signal being a sub-multiple of the frequency of the clock signal.

This control module is adapted to register the number of pulses in the clock signal Ck during a fixed value measurement period. It produces a first counting value during a first measurement period, and then a second counting value during a second measurement period. It then calculates a correction value that is proportional to the difference between these two counting values and inversely proportional to the duration of the time that separates the mid-points of the two corresponding measurement periods. It finally produces a correction signal which adopts this correction value during a correction period and which for the rest of the time is zero. This correction signal is added to the numerator N of the fractional part F in order to form the second operand $O_2$ of addition circuit 31.

This control module 4 appears in an embodiment that is provided solely for indicative purposes in FIG. 2. It includes several units which will now be described in detail.

A counter 40 receives the clock signal Ck and produces a phase signal P which corresponds to the number of pulses that have appeared since it was reset. The capacity of this counter is a sub-multiple of the frequency ratio between clock signal Ck and synchronization signal T. A trigger circuit 41 produces a trigger signal D that adopts the value that synchronization signal T had at the time the second pulse of clock signal Ck appeared. This can for example be a flip-flop of the type known as a D-type flip-flop.

A synchronization register 42 produces a measurement signal Pe the value of which is the value that phase signal P had at the moment the last pulse of trigger signal D appeared.

A control circuit 43 produces a periodic command signal L the value of which is equal to the measurement period. Advantageously, this measurement period is a multiple of the synchronization signal period.

A summing circuit 44 supplies the second counting value $P_2$ which is the sum of the values adopted by measurement signal Pe at the time of each pulse of synchronization signal T. This circuit is reset by command signal L. It can now be seen more clearly why the output signal from this circuit is the second counting value.

A time delay register 45 produces the first counting value $P_1$ as the second counting value delayed by one measurement period, in other words one period of command signal L. This hence justifies its name since at any given instant, the output signal from this register has the value that the output signal from summing circuit 44 had during the preceding measurement period.

A subtracting circuit 46 produces a phase deviation or shift signal E as the difference between the two counting values: $P_2-P_1$.

A correction module 47 produces an output signal the value of which is equal to the value of phase deviation signal E divided by the ratio between the measurement period and the period of synchronization signal T, multiplied by a constant which is often referred to as the stiffness coefficient of closed-loop control.

A compensation circuit **48** produces a correction value m which is the sum of the values of the output signal from correction module **47** during the preceding measurement period and during the current period. This circuit is designed to limit the correction value to a maximum value. It for example comprises a saturation adder which produces either the sum of the two values or the said maximum value if the actual sum is higher. This circuit is also designed to be initialized by an initializing signal I.

A limiting circuit **49** produces the correction signal M having the correction value m during a correction period, it being zero for the rest of the time. This correction period can have any value whatsoever and will be determined by the person skilled in the art.

This correction signal M is added by means of an adding circuit not shown in the figure, to the numerator N of the fractional part F in order to provide the second operand $O_2$.

Finally, as an accessory provision, counter **40** is adapted to be initialized to a starting value $I_T$ by means of an initializing circuit **50** commanded by initializing signal I upon the appearance of synchronization signal T.

In one embodiment of the clock signal generator, the counter **40** is moreover adapted to supply an auxiliary clock signal H at the output of one of its counting cells. This auxiliary clock signal is synchronized with the clock signal and just like the latter, is under the control of synchronization signal T.

This variant can be advantageously applied in the case of the mobile terminal referred to previously. In fact, certain components designed for speech processing operate with a 2.048 MHz signal and a 8 kHz signal which is the speech sampling frequency. Moreover, the signals need to be slaved to the 50 Hz synchronizing signal produced by the terminal and which corresponds to the communication frame rate.

In this case, the capacity of counter **40** will be chosen to be equal to 256, the most significant bits corresponding to auxiliary clock signal H at a frequency of 8 kHz.

It will be noted that the counting values $P_1$, $P_2$ in this case are not equal to the number of pulses in clock signal Ck produced during the corresponding measurement period, because counter **40** will have gone through several cycles (160 in this case) during a synchronization signal period. These counting values correspond, however, to the numbers of pulses since they are congruous therewith (modulo 256 in this case). Given the low frequency deviation that exists between the clock signal when it is being slaved and when it is not, the counter capacity is sufficient. If this were not the case, it would always be possible to increase the capacity of this counter in order to widen the possible range of correction, its capacity being limited to the ratio between the frequencies of the clock signal generator signals and of the synchronization signal.

One advantageous solution consists in designing limiting circuit **49** in such a way that the correction period is the period of auxiliary clock signal H. The correction signal is assigned the correction value during this period and is zero over the remainder of the period of synchronization signal T. This operation is periodically repeated at the synchronization signal rate, for example.

In this case, if closed loop control requires to make it possible to obtain a relative frequency deviation between the auxiliary clock signal and the synchronization signal that is less than 5 parts per million, the correction value could take one of the values −2, −1, 0, 1 or 2.

In effect, during a synchronization period for which the correction value is 2, during one period of the auxiliary clock signal, the division ratio is equal to $Qc=6+91/256$, while over the other 159 periods, it is equal to $Qo=6+89/256$. The frequency deviation is hence equal to:

$$\frac{Qc-Qo}{160\,Qo}=7.68\cdot10^{-6}$$

The second operand $O_2$ which is the sum of the correction value and of the numerator will hence be a whole number comprised between 87 and 91. The adder which produces this second operand can be reduced to a simple combination logic circuit which produces the 4 least significant bits of this operand, its 3 most significant bits being invariable. In effect, the 5 decimal values that this operator can adopt are expressed as follows in binary notation:

87 = 101 0111
88 = 101 1000
89 = 101 1001
90 = 101 1010
91 = 101 1011

Moreover, it will be noted that the carry-over signal C from addition circuit **31** is periodic. Its period corresponds to 256 pulses of clock signal Ck. The result is that the auxiliary clock signal which has the same period presents the special feature that all of its pulses have the same phase shift or deviation since they are separated by the same number of periods of the regular rhythm signal R. Thus, when the auxiliary clock signal is employed as a sampling signal, it does not introduce spurious modulation into the signal being sampled.

A further advantage of the invention resides in the fact that the distribution in time between divisions by the first factor A and the second factor B is as uniform as possible. In the numerical example selected (A=7, B=6), the maximum phase deviation, also called phase jitter, between clock signal Ck and the regular rhythm signal is equal to one period of this rhythm signal, in other words 76.9 ns.

The embodiment of a closed-loop control module that has just been described has a very comprehensive structure which provides the required performance. The invention also applies if certain components are deleted.

In effect, trigger circuit **41** is not strictly necessary, its role being limited to synchronizing synchronization register **42** onto clock signal Ck. It can be eliminated by directly controlling this register with synchronization signal T in the place of trigger signal D.

It is also not indispensable to take counting values $P_1$, $P_2$ over several periods of synchronization signal T, although this does increase the accuracy of closed-loop control. In this case, the control circuit **43** has no more purpose and nor has summing circuit **44**. The second counting value $P_2$ is equal to the measurement signal $P_1$ which is directly applied to the input of time delay register **45** instead of the output signal from summing circuit **44**. This synchronization register is commanded by synchronization signal T instead of command signal L, and this also applies to compensating circuit **48**.

Moreover, this compensating circuit can also be deleted, the output from correction module 47 being directly linked to the input of limiting circuit 49.

What is claimed is:

1. The clock signal generator using fractional frequency division comprising a division circuit that produces a clock signal starting from a timing rhythm signal, wherein frequencies of said clock and timing rhythm signals are in a division ratio which is a sum of a whole part and a fractional part, said generator including a pulse subtractor for receiving said rhythm signal and for transmitting it to said division circuit while deleting at least one pulse from said rhythm signal upon a command, accumulator means, connected to said division circuit, for commanding said pulse subtractor on each occasion when a product of a number of pulses of said clock signal and of said fractional part changes by unity, and means for determining said product and for counting said number of pulses starting at a time of origin.

2. The clock signal generator using fractional frequency division according to claim 1, wherein with said division ratio forms a sum of a first product of a first division factor and of said fractional part and of a second product of a second division factor and an ones-complement of said fractional part, said accumulator means include an accumulation register producing a first operand which adopts a value of an addition signal in response to said clock signal, and an addition circuit producing said addition signal as a sum modulo a denominator of said fractional part of said first operand and of a second operand comprising at least a numerator of said fractional part and producing a carry-out signal, said pulse subtractor being adapted to absorb a number of pulses equal to a difference between said two division factors in response to this carry-over signal.

3. The clock signal generator using fractional frequency division according to claim 2, wherein with said clock signal generator adapted to be controlled by a synchronization signal, it includes a closed loop feedback control module receiving said synchronization signal and said clock signal and producing a correction signal, said second operand being a sum of said numerator and said correction signal.

4. The clock signal generator using fractional frequency division according to claim 3, wherein the frequency of said clock signal is a multiple of the frequency of said synchronization signal and wherein said control module includes:

means, connected to said division circuit, for producing a counting value corresponding to the number of pulses of said clock signal that have appeared during a fixed duration measurement period, means for receiving said clock signal and for producing a correction value, which is proportional to a difference between second and first counting values and inversely proportional to a duration separating mid-points of second and first corresponding measuring periods, said correction signal which usually is zero, being assigned the correction value during a correction period that is expressed as a number of periods of said clock signal, said control module calculating said difference and said duration separating said mid-points.

5. The clock signal generator using fractional frequency division according to claim 4, wherein a measurement period is a multiple of the period of said synchronization signal, said first and second corresponding measuring periods being consecutive, said control module including:

a counter for receiving said clock signal and for producing a phase signal, a capacity of said counter being a sub-multiple of a frequency ratio of said clock signal and said synchronization signal,

a summing circuit for producing said first and second counting values as sums of values adopted by said phase signal at a rhythm of said synchronization signal,

a time-delay register for delaying and producing said first counting value at a same time as said summing circuit outputs said second counting value after a delay equaling said measurement period, a subtraction circuit producing a phase deviation signal as the difference of said second and first counting values, and a correction module producing said correction value in proportion to said phase deviation signal.

6. The clock signal generator using fractional frequency division according to claim 5, wherein an individual output from said counter is employed for producing an auxiliary clock signal.

7. The clock signal generator using fractional frequency division according to claim 5, further including a compensation circuit for immediately producing said correction value as a sum of values of an output signal of said correction module during a previous measuring period and a current measuring period.

8. The clock signal generator using fractional frequency division according to claim 7, wherein said compensation circuit includes a saturation adder limiting said correction value to a predetermined maximum value.

9. The clock signal generator using fractional frequency division according to claim 5, further including a limiting circuit that affects said correction signal for said correction value during a first appearance of a predetermined state on an individual output of said counter subsequent to a start for a period of said synchronization signal, said correction signal being zero during a remainder of said period.

10. The clock signal generator using fractional frequency division according to claim 5, wherein said control module further includes a synchronization register for receiving said phase signal from said counter and for producing a measurement signal based on said phase signal in response to a triggering single originating from a triggering circuit, an output of which adopts the value of said synchronization signal upon command from said clock signal, said measurement signal being addressed to said summing circuit.

11. The clock signal generator using fractional frequency division according to claim 10, wherein said control module further includes a command circuit for receiving the synchronization signal and for producing based thereon a command signal, a period of which is equal to said measurement period, said command signal resetting said summing circuit, transferring an input to an output of said time-delay register and modifying an output signal from said compensating circuit.

12. The clock signal generator using fractional frequency division according to claim 5, wherein it receives an initialization signal adapted to initialize said compensation circuit.

13. The clock signal generator using fractional frequency division according to claim 12, wherein it includes an initialization circuit which imposes a starting

value on said counter in response to said initialization signal.

14. The clock signal generator using fractional division according to claim 1, wherein the whole number part of said division ratio is zero.

15. The clock signal generator using fractional frequency division according to claim 2, wherein the difference in the two division factors is equal to unity, said pulse subtractor deleting one single pulse upon command.

* * * * *

B7

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| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 09/673,270 | 11/29/2000 | Ernst Eberlein | 41001 | 3590 |

7590 06/23/2004

John E Holmes
Roylance Abrams Berdo & Goodman
Suite 600
1300 19th Street NW
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| EXAMINER | |
|---|---|
| WARE, CICELY Q | |
| **ART UNIT** | **PAPER NUMBER** |
| 2634 | 12 |

DATE MAILED: 06/23/2004

Please find below and/or attached an Office communication concerning this application or proceeding.



PTO 90C (Rev 10/03)

| Office Action Summary | Application No. | Applicant(s) |
|---|---|---|
| | 09/673,270 | EBERLEIN ET AL. |
| | Examiner | Art Unit |
| | Cicely Ware | 2634 |

*-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --*

**Period for Reply**

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

**Status**

1)☒ Responsive to communication(s) filed on *23 February 2004*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

**Disposition of Claims**

4)☒ Claim(s) *19-34* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *19-34* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

**Application Papers**

9)☐ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☒ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

**Priority under 35 U.S.C. §§ 119 and 120**

12)☐ 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:

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)).

* See the attached detailed Office action for a list of the certified copies not received.

13)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application) since a specific reference was included in the first sentence of the specification or in an Application Data Sheet. 37 CFR 1.78.

a) ☐ The translation of the foreign language provisional application has been received.

14)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121 since a specific reference was included in the first sentence of the specification or in an Application Data Sheet. 37 CFR 1.78.

**Attachment(s)**

1) ☒ Notice of References Cited (PTO-892)

2) ☒ Notice of Draftsperson's Patent Drawing Review (PTO-948)

3) ☐ Information Disclosure Statement(s) (PTO-1449) Paper No(s) _____ .

4) ☐ Interview Summary (PTO-413) Paper No(s). _____ .

5) ☐ Notice of Informal Patent Application (PTO-152)

6) ☐ Other: .

## DETAILED ACTION

### *Claim Rejections - 35 USC § 112*

1. The following is a quotation of the second paragraph of 35 U.S.C. 112:

> The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

2. Regarding claims 19-34, the phrase "of the type" renders the claim indefinite because it is unclear whether the limitation(s) following the phrase are part of the claimed invention. See MPEP § 2173.05(d).

a. **2173.05(b) Relative Terminology**

> E. "Type"
>
> The addition of the word "type" to an otherwise definite expression (e.g., Friedel-Crafts catalyst) extends the scope of the expression so as to render it indefinite. *Ex parte Copenhaver*, 109 USPQ 118 (Bd. App. 1955). Likewise, the phrase "ZSM-5-type aluminosilicate zeolites" was held to be indefinite because it was unclear what "type" was intended to convey. The interpretation was made more difficult by the fact that the zeolites defined in the dependent claims were not within the genus of the type of zeolites defined in the independent claim. *Ex parte Attig*, 7 USPQ2d 1092 (Bd. Pat. App. & Inter. 1986).

### *Drawings*

3. This application has been filed with informal drawings, which are acceptable for examination purposes only. Formal drawings will be required when the application is allowed.

### ***Claim Rejections - 35 USC § 102***

4. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

5. Claims 19-32 are rejected under 35 U.S.C. 102(e) as being anticipated by Gledhill et al. (US Patent 5,345,440).

(1) With regard to claim 19, Gledhill et al. discloses a method performing a fine frequency synchronization compensating for a carrier frequency deviation from an oscillator frequency in a multi-carrier demodulation system of the type capable of carrying out a differential phase decoding of multi-carrier modulated signals, said signals comprising a plurality of symbols, each symbol being defined by phase differences between simultaneous carriers having different frequencies, said method comprising the steps of: determining a phase difference between phases of the same carrier in different symbols, determining a frequency offset by eliminating phase shift uncertainties related to the transmitted information from said phase difference making use of a decision device; performing a feedback correction (Fig. 4) of said carrier frequency deviation based on said determined frequency offset (abstract, col. 2, lines 36-43, col. 3, lines 47-49, col. 4, lines 30-36, 64-68, col. 5, lines 1-7, 16-22, 30-35, 37-41, col. 6, lines 54-56, 66-67, col. 8, lines 53-64, col. 9, lines 8-26, 56-62, col. 11, lines 41-49, 55-56, co. 14, lines 54-58, 64-66, col. 15, lines 3-7, 17-24).

(2) With regard to claim 20, claim 20 inherits all the limitations of claim 19. Gledhill et al. further discloses determining respective phase of the same carrier in different symbols; eliminating phase shift uncertainties related to the transmitted information from said phases to determine respective phase deviations making use of a decision device; determining frequency offset by determining a phase difference between said phase deviations (abstract, col. 2, lines 36-43, col. 3, lines 47-49, col. 6, lines 54-56, col. 8, lines 1-5, col. 11, lines 3-6, 41-49, 55-56).

(3) With regard to claim 21, claim 21 inherits all the limitations of claim 19. Gledhill et al. further discloses wherein the method is performed for a plurality of carriers in said symbols; an averaged frequency offset is determined by averaging said determined frequency offsets of said plurality of carriers, and said feedback correction of said frequency deviation is performed based on said averaged frequency offset (col. 15, lines 27-29, 36-42, 62-68, col. 16,lines 1-6).

(4) With regard to claim 22, claim 22 inherits all the limitations of claims 20 and 21.

(5) With regard to claim 23, claim 23 inherits all the limitations of claim 19. Gledhill et al. further discloses the step of determining a phase difference between phases of the same carrier in symbols, which are adjacent in the time axis direction (col. 10, lines 33-34, 54-56, col. 11, lines 3-6).

(6) With regard to claim 24, claim 24 inherits all the limitations of claim 19. Gledhill et al. further discloses the step of eliminating phase shift uncertainties corresponding to M-ary phase shifts (col. 2, lines 51-68, 1-5, col. 4, lines 30-36).

(7) With regard to claim 25, claim 25 inherits all the limitations of claim 20. Gledhill et al. further discloses the step of determining respective phases of the same carrier in symbols, which are adjacent in the time axis direction (col. 3, lines 47-49, col. 8, lines 1-5, col. 10, lines 33-34, 54-56, col. 11, lines 3-6).

(8) With regard to claim 26, claim 26 inherits all the limitations of claim 20. Gledhill et al. further discloses the step of eliminating M-ary phase shifts (col. 2, lines 51-68, 1-5, col. 4, lines 30-36).

(9) With regard to claim 27, claim 27 inherits all the limitations of claim 19.

(10) With regard to claim 28, claim 28 inherits all the limitations of claim 20.

(11) With regard to claim 29, claim 29 inherits all the limitations of claims 27 and 21.

(12) With regard to claim 30, claim 30 inherits all the limitations of claims 28 and 21.

(13) With regard to claim 31, claim 31 inherits all the limitations of claim 27 and 23.

(14) With regard to claim 32, claim 32 inherits all the limitations of claims 28 and 25.

## *Claim Rejections - 35 USC § 103*

6. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the

> invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

7. Claims 33 and 34 are rejected under 35 U.S.C. 103(a) as being unpatentable over Gledhill et al. (US Patent 5,345,440) as applied to claim 27 above, in view of Ahn (US Patent 6,219,333).

(1) With regard to claim 33, claim 33 inherits all the limitations of claim 27. However Gledhill et al. does not disclose discloses in means for performing a feedback correction of said frequency deviation comprises a numerical controlled oscillator and a complex multiplier.

However Ahn discloses in (Fig. 1) means for performing a feedback correction of said frequency deviation comprises a numerical controlled oscillator and a complex multiplier (col. 3, lines 3-9, col. 4, lines 53-63, col. 8, lines 1-7).

Therefore it would have been obvious to one of ordinary skill in the art to modify Gledhill et al. to incorporate means for performing a feedback correction of said frequency deviation comprises a numerical controlled oscillator and a complex multiplier in order to successfully synchronize the carrier frequency even when the offset of the carrier frequency is above the bandwidth of one sub-channel (Ahn, col. 2, lines 5-8

(2 With regard to claim 34, claim 34 inherits all the limitations of claim 33. Ahn further discloses in (Fig. 1(106, 108)) performing a feedback correction of said frequency deviation further comprises a low path filter preceding said numerical controlled oscillator.

**_Conclusion_**

8. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Cicely Ware whose telephone number is 703-305-8326. The examiner can normally be reached on Monday – Friday, 8-5.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Stephen Chin can be reached on 703-305-4714. The fax phone numbers for the organization where this application or proceeding is assigned are 703-872-9314 for regular communications and 703-872-9314 for After Final communications.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is 703-305-3900.

*Cicely Ware*

cqw
June 3, 2004

STEPHEN CHIN
SUPERVISORY PATENT EXAMINE
TECHNOLOGY CENTER 2600

| **Notice of References Cited** | Application/Control No. 09/673,270 | Applicant(s)/Patent Under Reexamination EBERLEIN ET AL. | |
|---|---|---|---|
| | Examiner Cicely Ware | Art Unit 2634 | Page 1 of 1 |

## U.S. PATENT DOCUMENTS

| * | | Document Number Country Code-Number-Kind Code | Date MM-YYYY | Name | Classification |
|---|---|---|---|---|---|
| | A | US-6,219,333 | 04-2001 | Ahn, Myong-kyun | 370/203 |
| | B | US-5,694,389 | 12-1997 | Seki et al. | 370/208 |
| | C | US-6,226,337 | 05-2001 | Klank et al. | 375/367 |
| | D | US-6,192,068 | 02-2001 | Fattouche et al. | 375/130 |
| | E | US- | | | |
| | F | US- | | | |
| | G | US- | | | |
| | H | US- | | | |
| | I | US- | | | |
| | J | US- | | | |
| | K | US- | | | |
| | L | US- | | | |
| | M | US- | | | |

## FOREIGN PATENT DOCUMENTS

| * | | Document Number Country Code-Number-Kind Code | Date MM-YYYY | Country | Name | Classification |
|---|---|---|---|---|---|---|
| | N | | | | | |
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## NON-PATENT DOCUMENTS

| * | | Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages) |
|---|---|---|
| | U | |
| | V | |
| | W | |
| | X | |

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.



Fraunhofer Ex 2018-179
Sirius XM v Fraunhofer, IPR2018-00681

Appl. No. 09/673,270
Amdt. dated September 23, 2004
Reply to Office Action of June 23, 2004



41

PATENT

41001

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

| | |
|---|---|
| In re Application of: | : |
| **Ernst Eberlein et al.** | : Group Art Unit: 2634 |
| Serial No.: **09/673,270** | : Examiner: C. Ware |
| Filed: **November 29, 2000** | : |
| For: **METHOD AND APPARATUS FOR FINE FREQUENCY SYNCHRONIZATION IN MULTI-CARRIER DEMODULATION SYSTEMS** | : |

AMENDMENT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

In response to the Office Action dated June 23, 2004, please amend the above-captioned application as indicated on the following pages.

Amendments to the claims begin on page 2 herein.

Remarks begin on page 7 herein.

AMENDMENTS TO THE CLAIMS:

19. (Amended) A method of performing a fine frequency synchronization compensating for a carrier frequency deviation from an oscillator frequency in a multi-carrier demodulation system [of the type ]capable of carrying out a differential phase decoding of multi-carrier modulated signals, said signals comprising a plurality of symbols, each symbol being defined by phase differences between simultaneous carriers having different frequencies, said method comprising the steps of:

a) determining a phase difference between phases of the same carrier in different symbols;

b) determining a frequency offset by eliminating phase shift uncertainties related to the transmitted information from said phase difference making use of a M-PSK decision device; and

c) performing a feedback correction of said carrier frequency deviation based on said determined frequency offset.

20. (Amended) A method of performing a fine frequency synchronization compensating for a carrier frequency deviation from an oscillator frequency in a multi-carrier demodulation system [of the type ]capable of carrying out a differential phase decoding of multi-carrier modulated signals, said signals comprising a plurality of symbols, each symbol being defined by phase differences between simultaneous carriers having different frequencies, said method comprising the steps of:

a) determining respective phase of the same carrier in different symbols;

b) eliminating phase shift uncertainties related to the transmitted information from said phases to determine respective phase deviations making use of a M-PSK decision device;

c) determining a frequency offset by determining a phase difference between said phase deviations; and

d) performing a feedback correction of said carrier frequency deviation based on said determined frequency offset.

21. (Previously Presented) The method according to claim 19, wherein

said steps a) and b) are performed for a plurality of carriers in said symbols,

an averaged frequency offset is determined by averaging said determined frequency offsets of said plurality of carriers, and

said feedback correction of said frequency deviation is performed based on said averaged frequency offset in said step c).

22. (Previously Presented) The method according to claim 20, wherein

said steps a), b) and c) are performed for a plurality of carriers in said symbols,

an averaged frequency offset is determined by averaging said determined frequency offsets of said plurality of carriers, and

said feedback correction of said frequency deviation is performed based on said averaged frequency offset.

23. (Previously Presented) The method according to claim 19, wherein said step a) comprises the step of determining a phase difference between phases of the same carrier in symbols which are adjacent in the time axis direction.

24. (Previously Presented) The method according to claim 19, wherein said step b) comprises the step of eliminating phase shift uncertainties corresponding to M-ary phase shifts.

25. (Previously Presented) The method according to claim 20, wherein said step a) comprises the step of determining respective phases of the same carrier in symbols which are adjacent in the time axis direction.

26. (Previously Presented) The method according to claim 20, wherein said step b) comprises the step of eliminating M-ary phase shifts.

27. (Amended) An apparatus for performing a fine frequency synchronization compensating for a carrier frequency deviation from an oscillator frequency, for a multi-carrier demodulation system [of the type ]capable of carrying out a differential phase decoding of multi-carrier modulated signals, said signals comprising a plurality of symbols, each symbol being defined by phase differences between simultaneous carriers having different frequencies, said apparatus comprising:

means for determining a phase difference between phases of the same carrier in different symbols;

M-PSK decision device for determining a frequency offset by eliminating phase shift uncertainties related to the transmitted information from said phase difference; and

means for performing a feedback correction of said frequency deviation based on said determined frequency offset.

28. (Amended) An apparatus for performing a fine frequency synchronization compensating for a carrier frequency deviation from an oscillator frequency, for a multi-carrier demodulation system [of the type ]capable of carrying out a differential phase decoding of multi-carrier modulated signals, said signals comprising a plurality of symbols, each symbol being defined by phase differences between simultaneous carriers having different frequencies, said apparatus comprising:

means for determining respective phases of the same carrier in different symbols;

M-PSK decision device for eliminating phase shift uncertainties related to the transmitted information from said phases to determine respective phase deviations;

means for determining a frequency offset by determining a phase difference between said phase deviations;

means for performing a feedback correction of said frequency deviation based on said determined frequency offset.

29. (Previously Presented) The apparatus according to claim 27, further comprising:

means for determining an averaged frequency offset by averaging determined frequency offsets of a plurality of carriers, wherein said means for performing a feedback correction performs said feedback correction of said frequency deviation based on said averaged frequency offset.

30. (Previously Presented) The apparatus according to claim 28, further comprising:

means for determining an averaged frequency offset by averaging determined frequency offsets of a plurality of carriers, wherein

said means for performing a feedback correction performs said feedback correction of said frequency deviation based on said averaged frequency offset.

31. (Previously Presented) The apparatus according to claim 27, wherein said means for determining a phase difference comprises means for determining a phase difference between phases of the same carrier in symbols which are adjacent in the time axis direction.

32. (Previously Presented) The apparatus according to claim 28, wherein said means for determining respective phases comprises means for determining respective phases of the same carrier in symbols which are adjacent in the time axis direction.

33. (Previously Presented) The apparatus according to claim 27, wherein said means for performing a feedback correction of said frequency deviation comprises a numerical controlled oscillator and a complex multiplier.

34. (Previously Presented) The apparatus according to claim 33, wherein said means for performing a feedback correction of said frequency deviation further comprises a low path filter preceding said numerical controlled oscillator.

REMARKS

Claims 19-34 are pending. By the present Amendment, claims 19, 20, 27 and 28 have been amended to delete the text "of the type" and, accordingly, to overcome the objection under 35 U.S.C. § 112, second paragraph, set forth in the Office Action. A Transmittal of Formal Drawings is being filed concurrently herewith.

In the Office Action, claims 19-32 are rejected under 35 U.S.C. § 102(e) [sic] as being anticipated by U.S. Patent No. 5,345,440, to Gledhill et al (hereinafter referred to as the Gledhill et al patent). Applicants respectfully traverse this basis for rejecting the claims.

The Applicants wish to point out that the Gledhill et al patent is based on an International PCT application no. WO 9205646 which was cited in the International Preliminary Examination Report (IPER), copy attached, provided in the International PCT application corresponding to the present application. The IPER acknowledged the patentability of the subject matter claimed in the corresponding International PCT application (e.g., using "a phase difference modulation in the frequency axis rather than the time axis") over the Gledhill et al patent.

The Gledhill et al patent discloses a method for receiving orthogonal frequency division multiplex (OFDM) signals. As stated in column 2, lines 42 to 47 of the Gledhill et al patent, data are preferably differentially coded. Unlike the present invention, however, the Gledhill et al patent teaches a differential coding in the direction of the time axis rather than a differential coding in the direction of the frequency axis. The differential coding in the time axis is also described in column 6, lines 54 to 61 of the Gledhill et al patent, which state that the transitions between successive phase states define two data bits being coded. Moreover, column 9, lines 21 to 23 state that, for differentially coded data, it is the transitions between successive values of the data which define the desired data to be demodulated.

The independent claims 19, 20, 27 and 28 each recite that each symbol is defined by phase differences between simultaneous carriers having different frequencies. This is specific for differential coding in the direction of the frequency axis. Thus, the subject matter of the independent claims of the present invention is clearly not anticipated by the Gledhill et al patent, which discloses OFDM signals differentially coded in the direction of the time axis as discussed above. Withdrawal of the rejection of claims 19-32 as being anticipated by the Gledhill et patent under 35 U.S.C. § 102 is respectfully requested.

In the Office Action, claims 33 and 34 are rejected under 35 U.S.C. § 103(a) as being obvious over the Gledhill et al patent in view of U.S. Patent No. 6,219,333, to Ahn et al (hereinafter referred as the Ahn et al patent). The Gledhill et al patent does not disclose or suggest providing an OFDM signal in which each symbol is defined by phase differences between simultaneous carriers having different frequencies, as recited in the independent claims 19, 20, 27 and 28. Further, there is no motivation to modify the system disclosed in the Gledhill et al patent to make use of a differential coding in the direction of the frequency axis, since the apparatus for receiving OFDM signals as taught by the Gledhill et al patent is developed for OFDM signals differentially coded in the direction of the time axis. Using OFDM signals differentially coded in the direction of the frequency axis would require a different receiver that is not disclosed or suggested by the Gledhill et al patent. Such a receiver requires means for performing a de-mapping in the frequency axis, as well as a means for performing a de-mapping in the time axis. The Gledhill et al patent merely teaches recovery of the encoded data and fine-frequency synchronization by performing a de-mapping in the time axis.

The Ahn et al patent does not overcome the deficiencies of the Gledhill et al patent. The Ahn patent relates to a system for synchronizing a carrier frequency of an OFDM transmission system which uses one of the multiple carrier modulation methods (see column 1, lines 25 to 27 of the Ahn patent). The Ahn patent is silent regarding a differential coding in the direction of the frequency axis, that is, it is silent regarding signals having symbols being defined by phase differences between simultaneous carriers having different frequencies as defined in the independent claims of the present application. Moreover, according to the Ahn patent, for fine frequency synchronization, a pilot signal is extracted from the carrier, a phase difference between the extracted pilot signal and a previously extracted pilot signal which is delayed for a duration of one symbol is calculated, and the prime part of the carrier frequency offset within a predetermined frequency is corrected by controlling a gain of the calculated phase difference (see column 2, lines 27 to 33 of the Ahn patent). The phase difference between the pilot signals which are transmitted in the same subchannel between the adjacent two symbols is proportional to the carrier frequency offset (see column 7, lines 46 to 49 of the Ahn patent).

According to the Ahn patent, pilot signals are used for deriving a phase difference based on which a carrier frequency offset is determined. As stated in the Amendment dated February 23, 2004, it is not necessary to eliminate any phase shift uncertainties related to the transmitted information since pilot signals are not provided for transmitting information but have properties which are known at the transmitter's end and at the receiver's end. Accordingly, it is clear that the Ahn patent does not disclose or suggest an M-PSK decision device as claimed since such a device is not necessary in the system described in the Ahn patent. Thus, the claimed subject matter is also not suggested by the Ahn patent. Accordingly, withdrawal of the rejection of claims 33 and 34 as being obvious under 35 U.S.C. § 103(a) over the Gledhill et patent in view of the Ahn et al patent is respectfully requested.

In view of the above, it is believed that the application is in condition for allowance and notice to this effect is respectfully requested. Should the Examiner have any questions, the Examiner is invited to contact the undersigned at the telephone number indicated below.

Respectfully Submitted,

Stacey J. Longanecker
Attorney for Applicant
Reg. No. 33,952

Roylance, Abrams, Berdo & Goodman, L.L.P.
1300 19th Street, N.W., Suite 600
Washington, D.C. 20036
(202) 659-9076

Dated: 23 September, 2004

41001

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

| | |
|---|---|
| In re Application of: | : |
| **Ernst Eberlein et al.** | : Group Art Unit: 2634 |
| Serial No.: **09/673,270** | : Examiner: C. Ware |
| Filed: **November 29, 2000** | : |
| For: **METHOD AND APPARATUS FOR FINE FREQUENCY SYNCHRONIZATION IN MULTI-CARRIER DEMODULATION SYSTEMS** | : |

## SUBMISSION OF FORMAL DRAWINGS

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Transmitted herewith are thirteen (13) sheets of formal drawings. Kindly substitute the attached formal drawings for the informal drawings submitted with the originally-filed application.

Respectfully Submitted,

Stacey J. Longanecker
Attorney for Applicant
Reg. No. 33,952

Roylance, Abrams, Berdo & Goodman, L.L.P.
1300 19th Street, N.W., Suite 600
Washington, D.C. 20036
(202) 659-9076

Dated: September 23, 2004

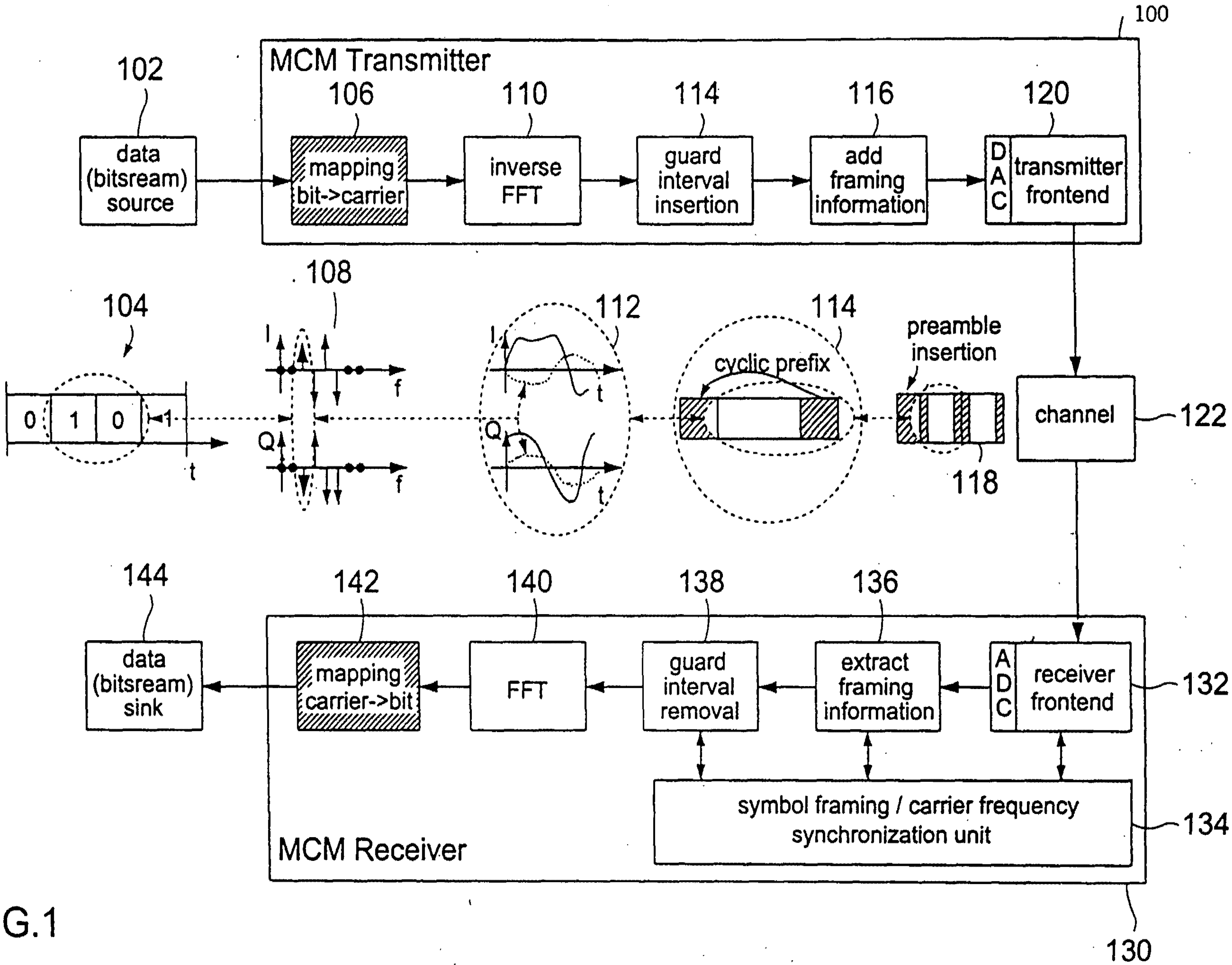


FIG.1



REPLACEMENT SHEET

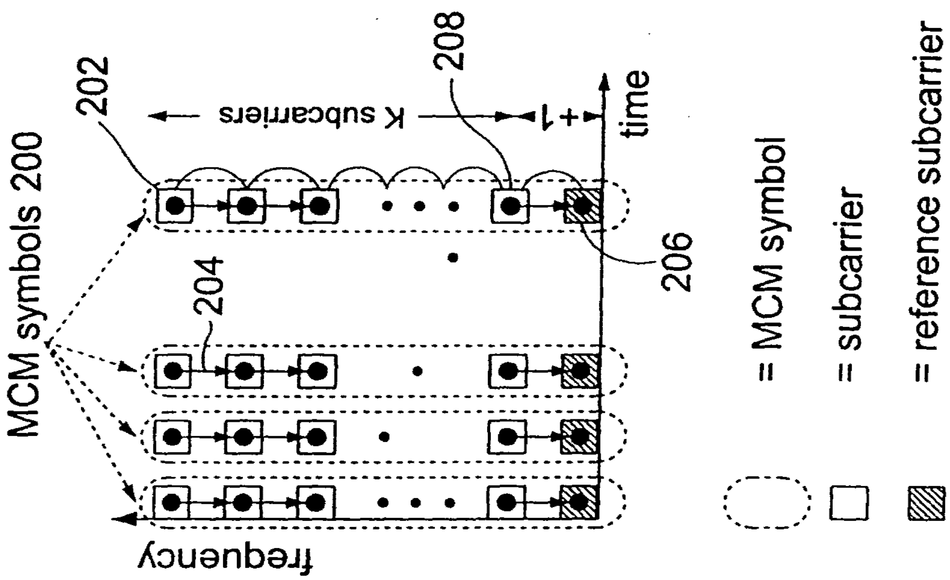
MCM symbols 200
202
208
204
206
K subcarriers
+1
time
frequency
= MCM symbol
= subcarrier
= reference subcarrier

FIG.2B

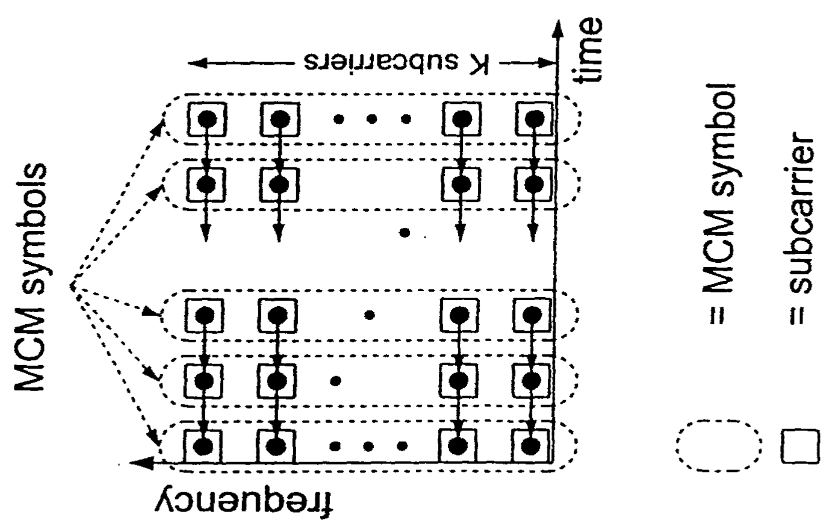
MCM symbols
K subcarriers
time
frequency
= MCM symbol
= subcarrier

FIG.2A

REPLACEMENT SHEET

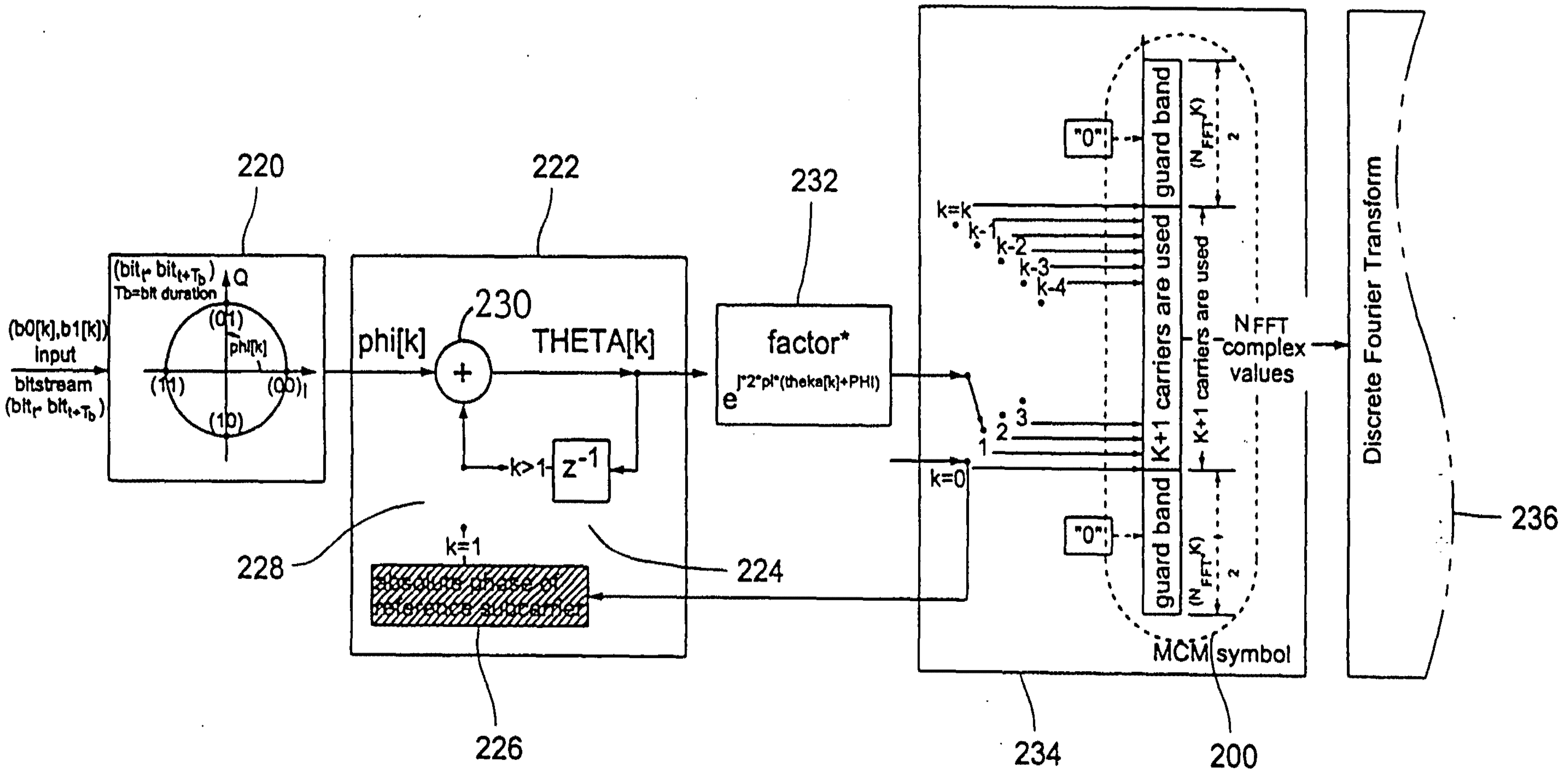


FIG.3

REPLACEMENT SHEET

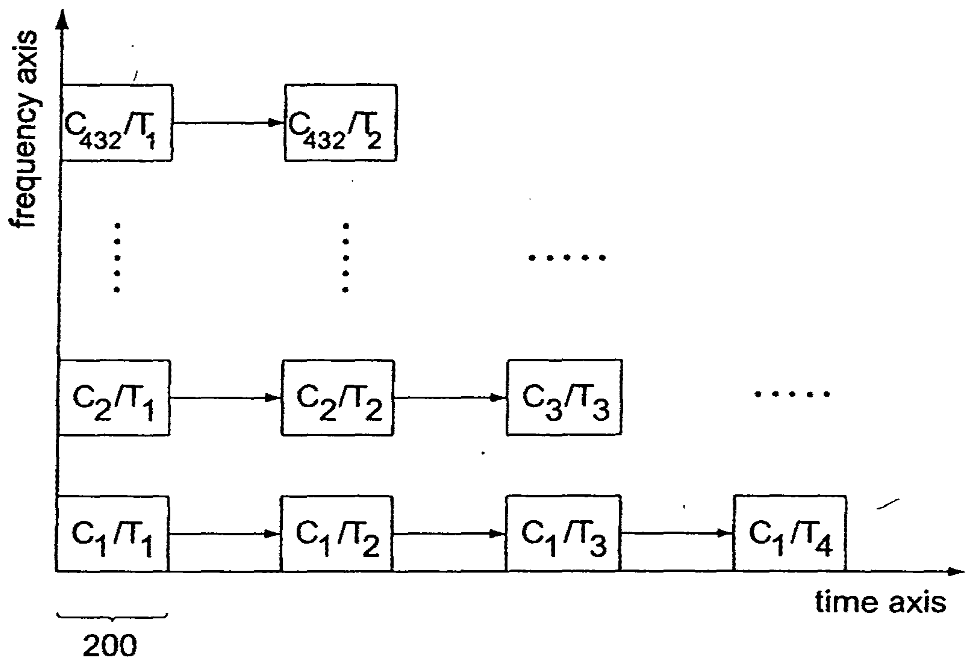


FIG.4

REPLACEMENT SHEET

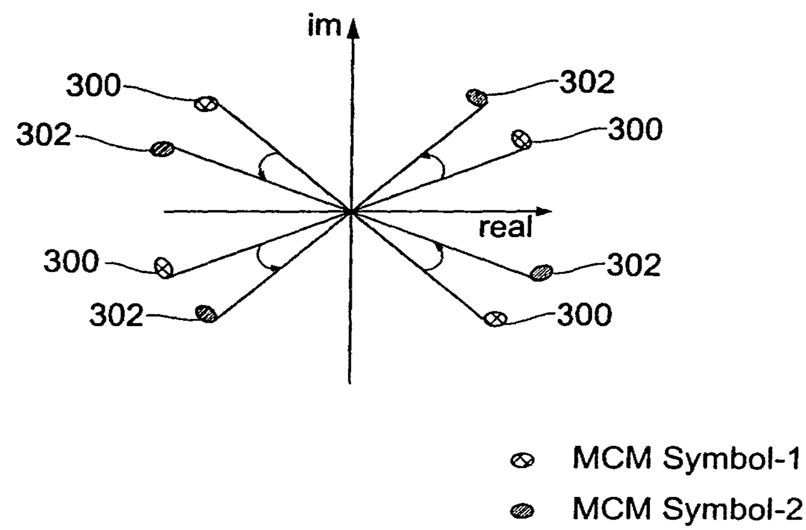


FIG.5

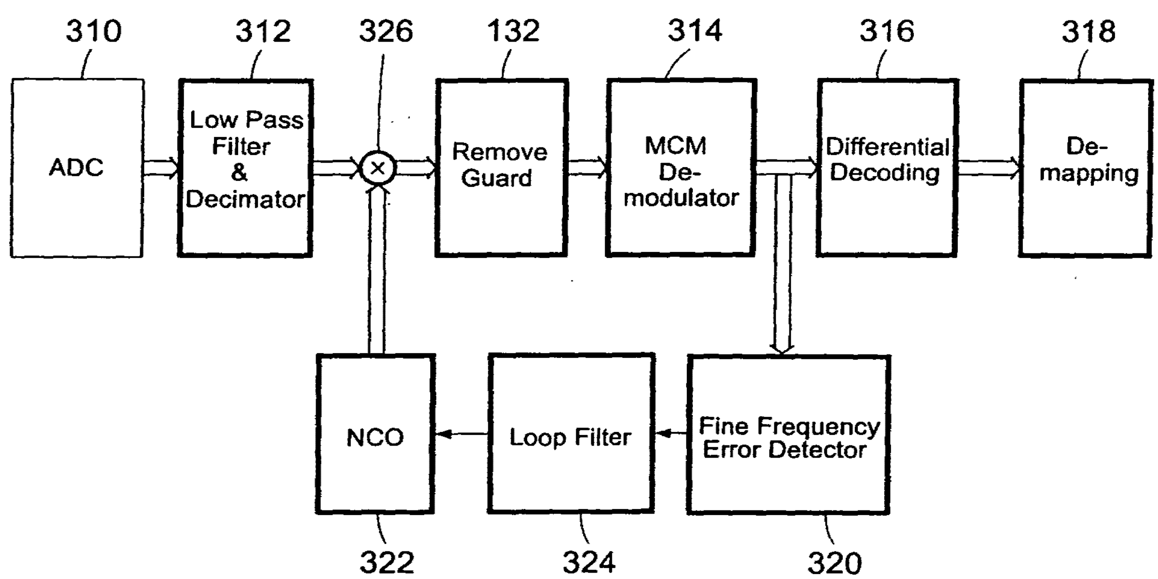


FIG.6

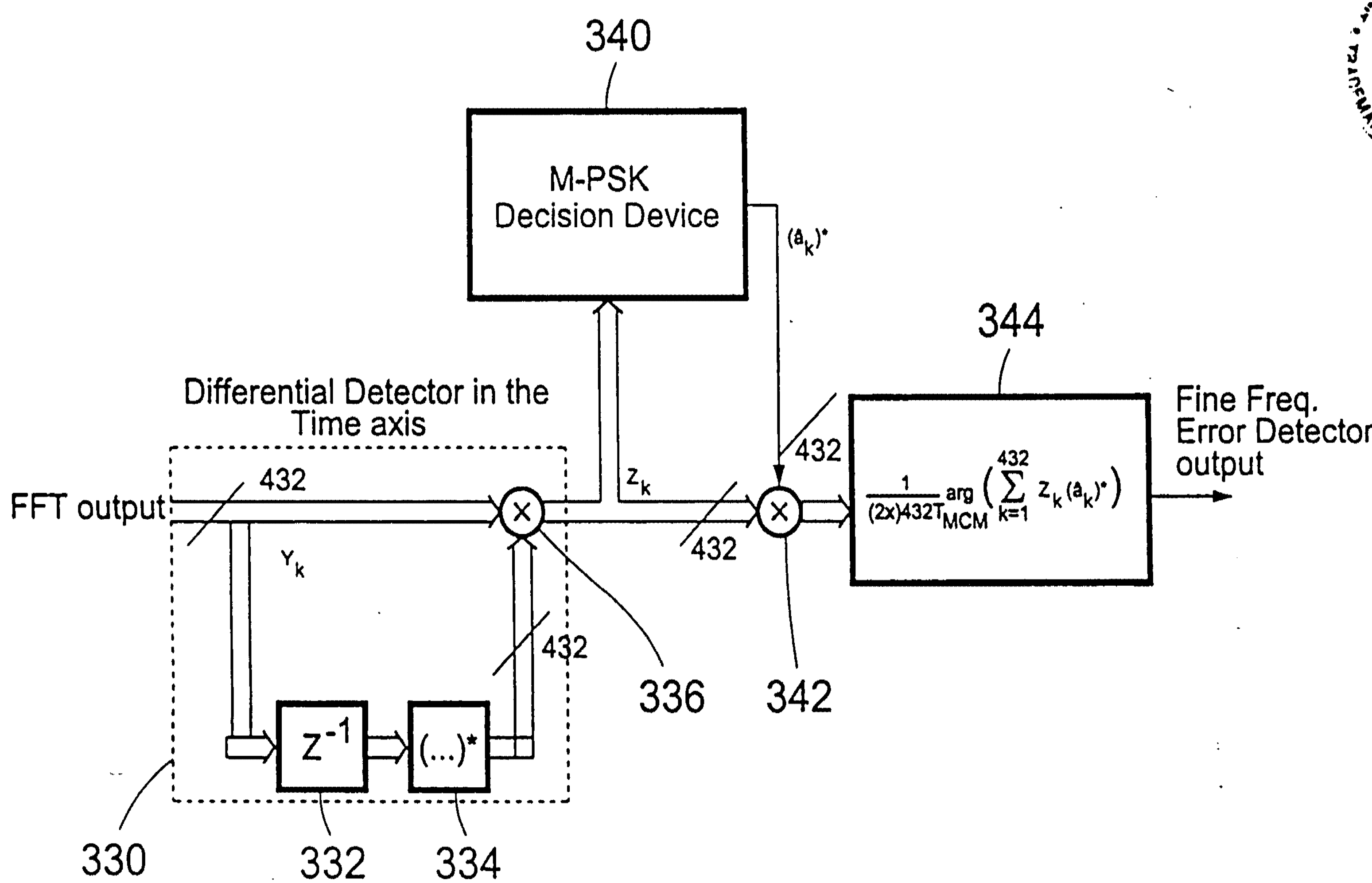


FIG.7

REPLACEMENT SHEET

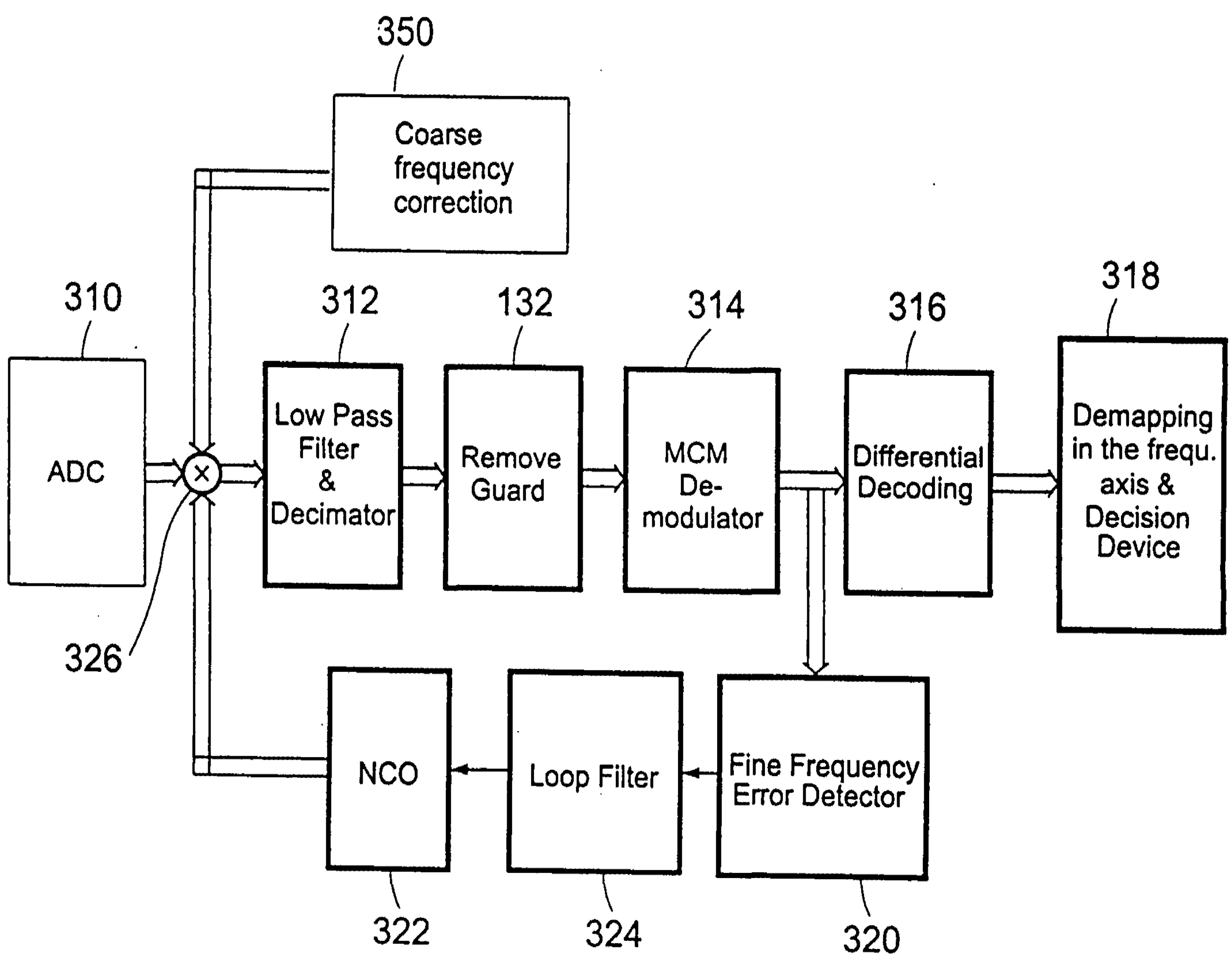


FIG.8



REPLACEMENT SHEET

REPLACEMENT SHEET

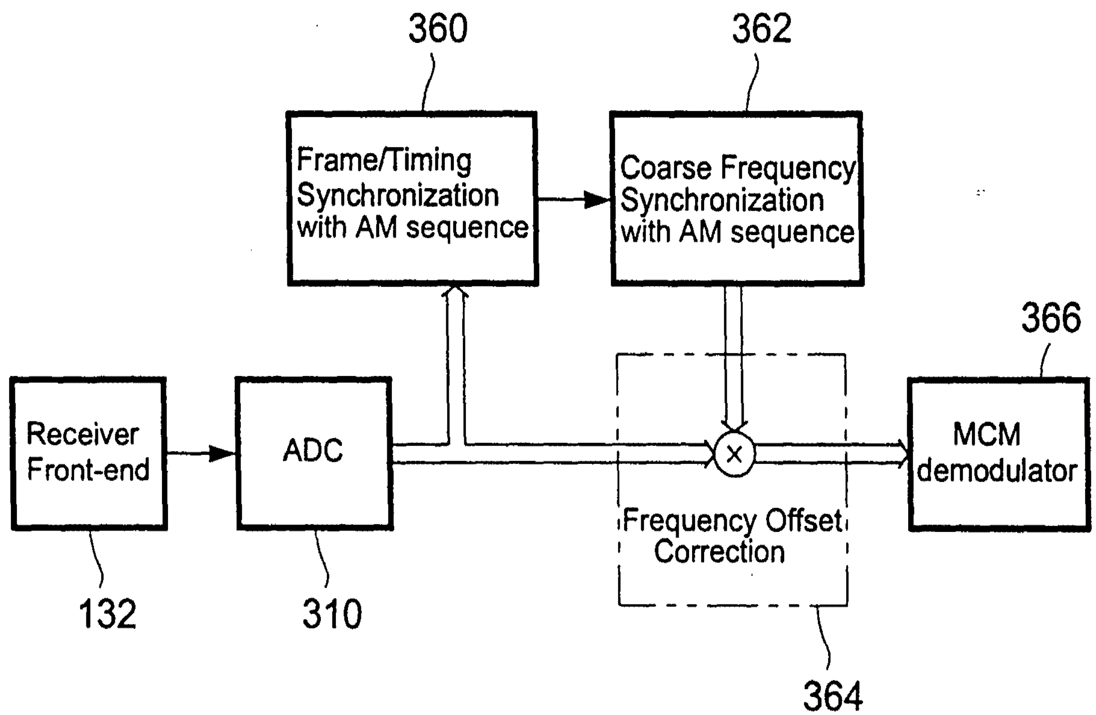


FIG.9

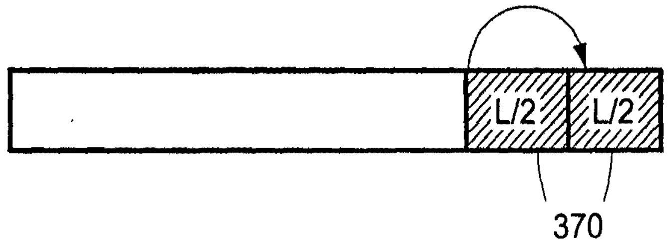


FIG.10

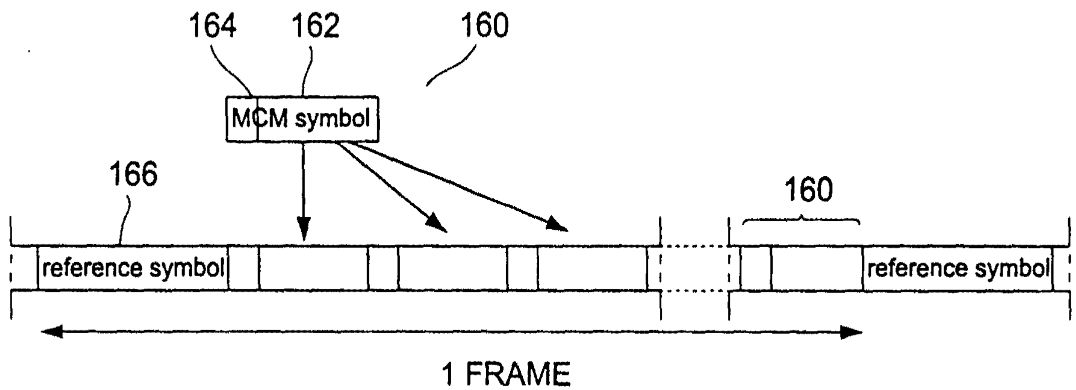


FIG.11



REPLACEMENT SHEET

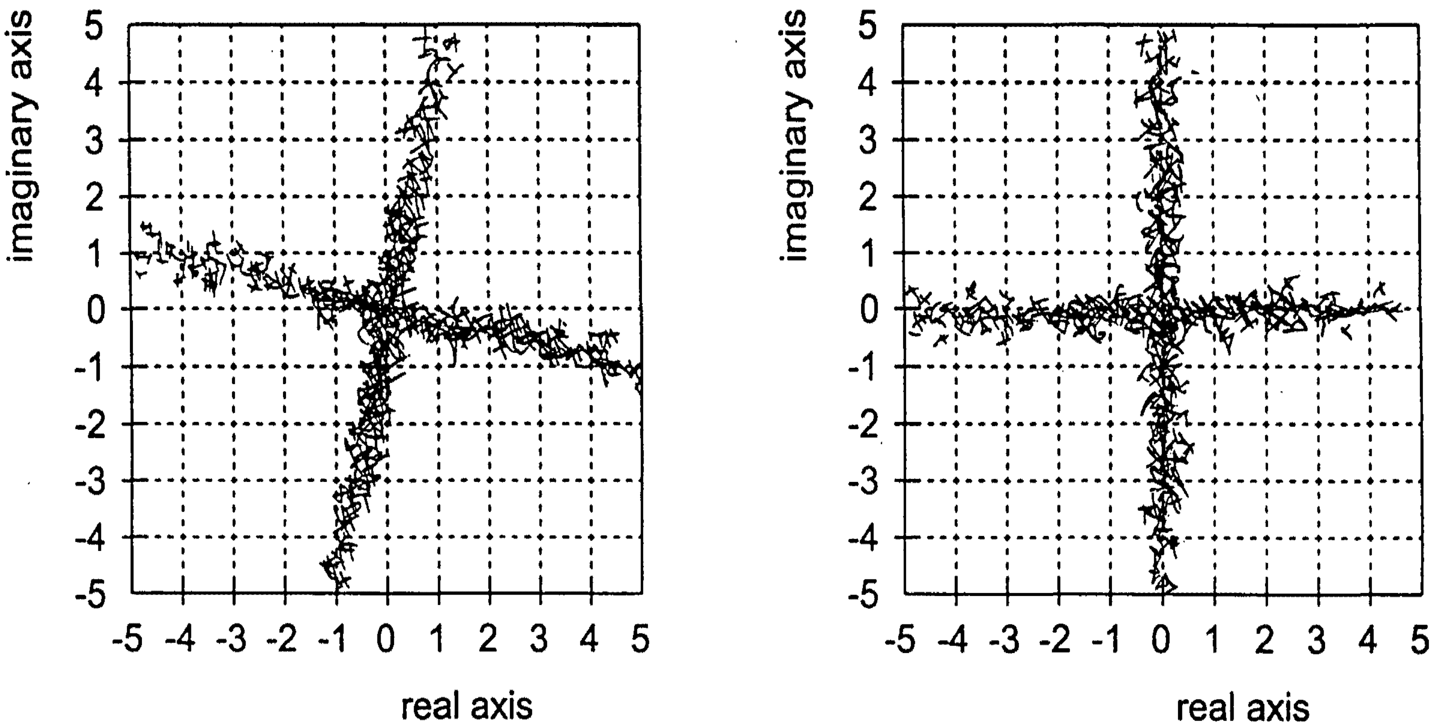
imaginary axis
5
4
3
2
1
0
-1
-2
-3
-4
-5
-5 -4 -3 -2 -1 0 1 2 3 4 5
real axis
imaginary axis
5
4
3
2
1
0
-1
-2
-3
-4
-5
-5 -4 -3 -2 -1 0 1 2 3 4 5
real axis

FIG.12

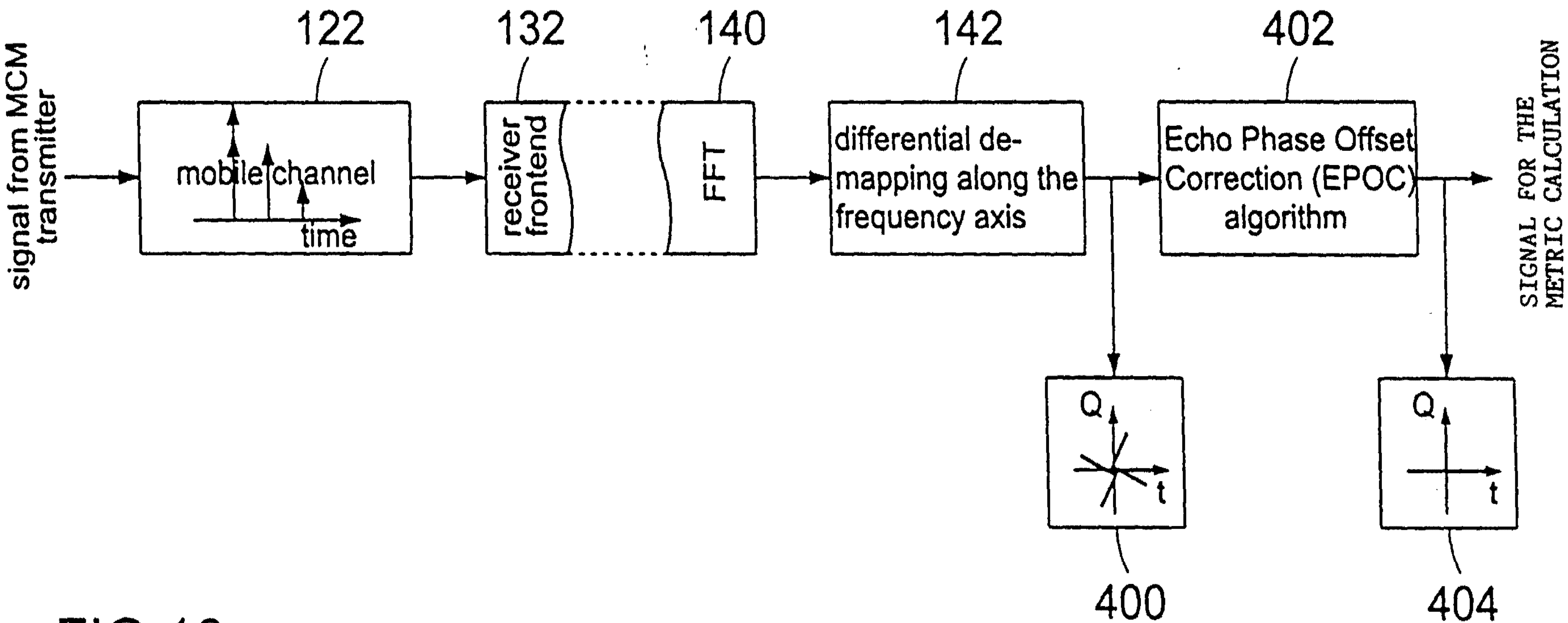


FIG.13

REPLACEMENT SHEET

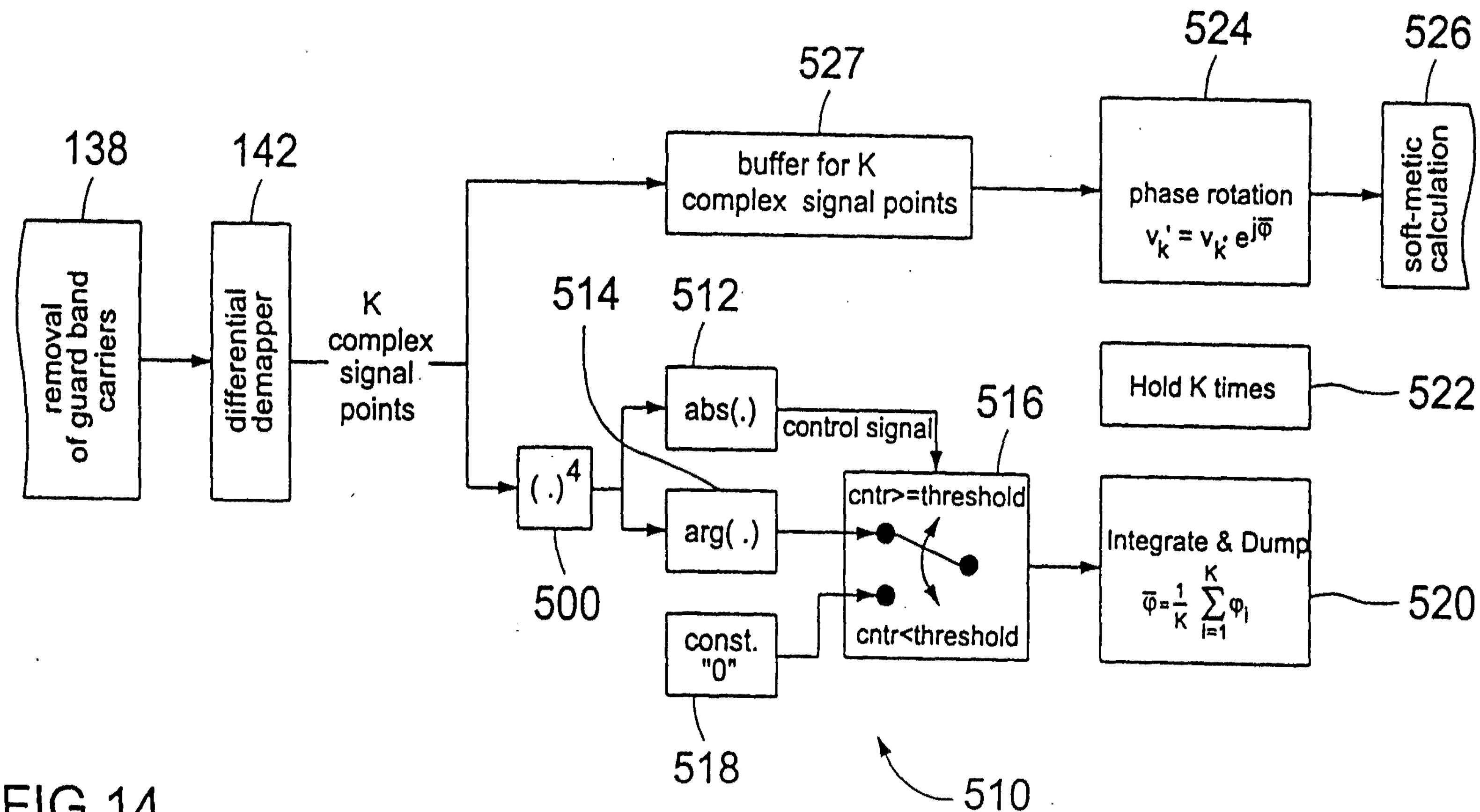


FIG.14

REPLACEMENT SHEET

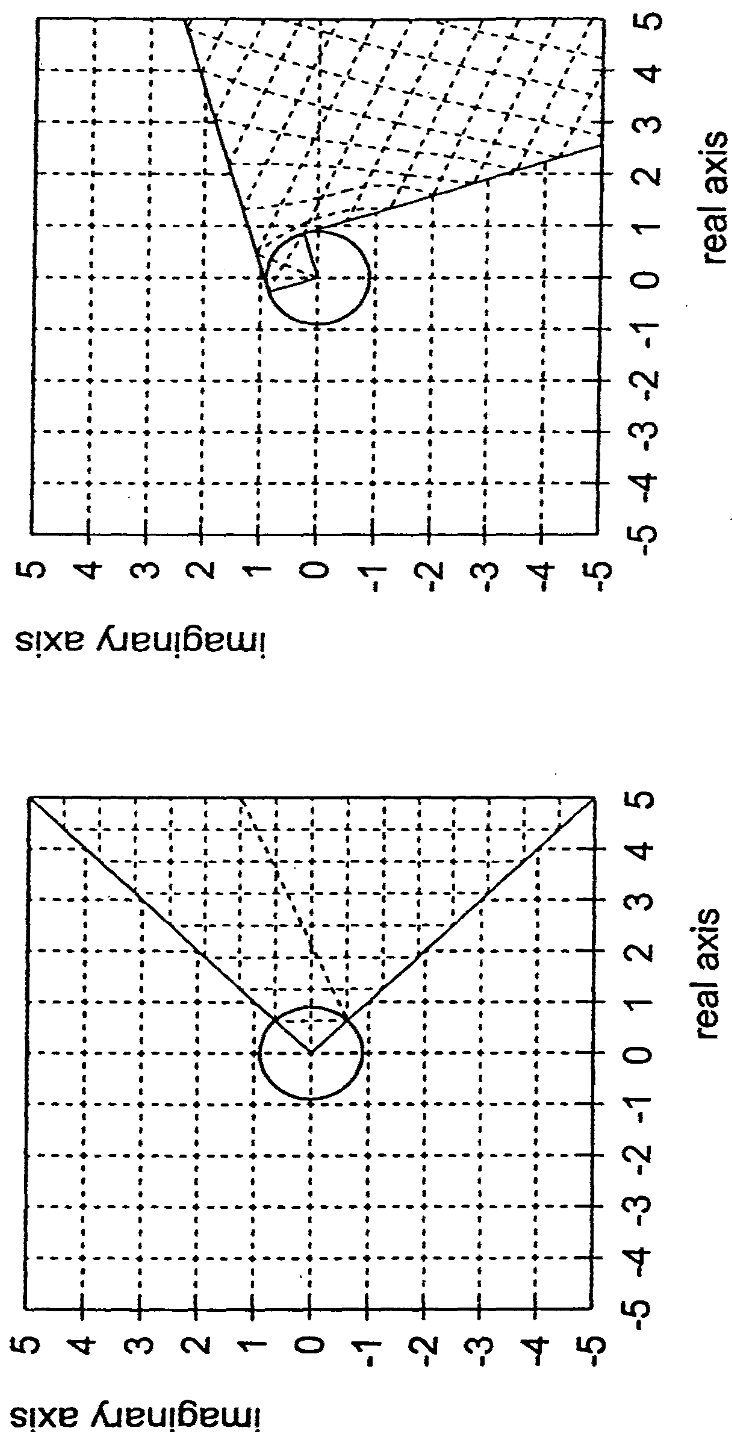
imaginary axis
real axis
5 4 3 2 1 0 -1 -2 -3 -4 -5
imaginary axis
real axis
5 4 3 2 1 0 -1 -2 -3 -4 -5

FIG.15

| **PATENT APPLICATION FEE DETERMINATION RECORD**<br>Effective October 1, 2000 | Application or Docket Number<br>09/673270 |
|---|---|

## CLAIMS AS FILED - PART I

| | (Column 1) | (Column 2) |
|---|---|---|
| TOTAL CLAIMS | | |
| FOR | NUMBER FILED | NUMBER EXTRA |
| TOTAL CHARGEABLE CLAIMS | 1 minus 20= | * |
| INDEPENDENT CLAIMS | 1 minus 3 = | * |
| MULTIPLE DEPENDENT CLAIM PRESENT ☐ | | |

* If the difference in column 1 is less than zero, enter "0" in column 2

| SMALL ENTITY TYPE ☐ RATE | FEE | OR | OTHER THAN SMALL ENTITY RATE | FEE |
|---|---|---|---|---|
| BASIC FEE | | OR | BASIC FEE | 860 |
| X$ 9= | | OR | X$18= | |
| X40= | | OR | X80= | |
| +135= | | OR | +270= | |
| TOTAL | | OR | TOTAL | |

## CLAIMS AS AMENDED - PART II

**AMENDMENT A**

| | (Column 1) CLAIMS REMAINING AFTER AMENDMENT | | (Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR | (Column 3) PRESENT EXTRA |
|---|---|---|---|---|
| Total | * 14 | Minus | ** 20 | = — |
| Independent | * 4 | Minus | *** 3 | = 1 |
| FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM ☐ | | | | |

| SMALL ENTITY RATE | ADDITIONAL FEE | OR | OTHER THAN SMALL ENTITY RATE | ADDITIONAL FEE |
|---|---|---|---|---|
| X$ 9= | | OR | X$18= | |
| X40= | | OR | X80= | 80 |
| +135= | | OR | +270= | |
| TOTAL ADDIT. FEE | | OR | TOTAL ADDIT. FEE | 80 paid |

**AMENDMENT B**

| | (Column 1) CLAIMS REMAINING AFTER AMENDMENT | | (Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR | (Column 3) PRESENT EXTRA |
|---|---|---|---|---|
| Total | * 16 | Minus | ** 20 | = — |
| Independent | * 4 | Minus | *** 4 | = — |
| FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM ☐ | | | | |

| RATE | ADDITIONAL FEE | OR | RATE | ADDITIONAL FEE |
|---|---|---|---|---|
| X$ 9= | | OR | X$18= | |
| X40= | | OR | X80= | |
| +135= | | OR | +270= | |
| TOTAL ADDIT. FEE | | OR | TOTAL ADDIT. FEE | |

**AMENDMENT C**

| | (Column 1) CLAIMS REMAINING AFTER AMENDMENT | | (Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR | (Column 3) PRESENT EXTRA |
|---|---|---|---|---|
| Total | * | Minus | ** | = |
| Independent | * | Minus | *** | = |
| FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM ☐ | | | | |

| RATE | ADDITIONAL FEE | OR | RATE | ADDITIONAL FEE |
|---|---|---|---|---|
| X$ 9= | | OR | X$18= | |
| X40= | | OR | X80= | |
| +135= | | OR | +270= | |
| TOTAL ADDIT. FEE | | OR | TOTAL ADDIT. 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.

FORM PTO-875 (Rev. 8/00)

Patent and Trademark Office, U.S. DEPARTMENT OF COMMERCE

BEST AVAILABLE COPY

| Ref # | Hits | Search Query | DBs | Default Operator | Plurals | Time Stamp |
|---|---|---|---|---|---|---|
| L1 | 1 | wo92/05646.ptpn. | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 11:06 |
| L2 | 0 | 1 and (numerical adj2 oscillator) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 11:07 |
| S1 | 142 | fraunhofer adj2 gesellschaft adj zur adj foerderung adj der adj angewandten | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2003/11/13 10:42 |
| S2 | 3 | (fraunhofer adj2 gesellschaft adj zur adj foerderung adj der adj angewandten) and (mcm or ofdm) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2003/11/13 10:43 |
| S3 | 1 | ((fraunhofer adj2 gesellschaft adj zur adj foerderung adj der adj angewandten) and (mcm or ofdm)) and @ad<="19980414" | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2003/11/13 10:43 |
| S4 | 38 | (fraunhofer adj2 gesellschaft adj zur adj foerderung adj der adj angewandten) and ((multi adj2 carrier transmission) or ofdm) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2003/11/13 10:43 |
| S5 | 12 | ((fraunhofer adj2 gesellschaft adj zur adj foerderung adj der adj angewandten) and ((multi adj2 carrier transmission) or ofdm)) and @ad<="19980414" | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2003/11/13 10:44 |
| S6 | 0 | (((fraunhofer adj2 gesellschaft adj zur adj foerderung adj der adj angewandten) and ((multi adj2 carrier transmission) or ofdm)) and @ad<="19980414") and (fine adj frequency adj synchroniz$5) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 09:26 |
| S7 | 0 | (ebehlim adj2 ernst) and (fine adj frequency adj synchroniz$5) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 09:25 |
| S8 | 1 | (lipp adj2 stefan) and (fine adj frequency adj synchroniz$5) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 09:24 |
| S9 | 0 | (buchholz adj2 albert) and (fine adj frequency adj synchroniz$5) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 09:25 |

| | | | | | | |
|---|---|---|---|---|---|---|
| S10 | 0 | (gerhaeuser adj2 heing) and (fine adj frequency adj synchroniz$5) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 09:25 |
| S11 | 1 | (badri adj2 sabah) and (fine adj frequency adj synchroniz$5) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 09:26 |
| S12 | 0 | 375/332.ccls. and (fine adj frequency adj synchroniz$5) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2003/11/13 10:49 |
| S13 | 18 | fine adj frequency adj synchroniz$5 | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2003/11/13 10:50 |
| S14 | 14 | (fine adj frequency adj synchroniz$5) and carrier | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2003/11/13 10:49 |
| S15 | 1 | (fine adj frequency adj synchroniz$5) and (multi adj2 carrier adj2 demodulation) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2003/11/13 10:51 |
| S16 | 1 | (fine adj frequency adj synchroniz$5) and (multi adj2 carrier adj demodulation) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2003/11/14 12:18 |
| S17 | 24 | ((multi adj2 carrier adj transmission) or ofdm) and (multi adj2 carrier adj2 demodulation) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2003/11/13 11:13 |
| S18 | 2 | (((multi adj2 carrier adj transmission) or ofdm) and (multi adj2 carrier adj2 demodulation)) and @ad<"19980414" | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2003/11/13 11:16 |
| S19 | 0 | ((((multi adj2 carrier adj transmission) or ofdm) and (multi adj2 carrier adj2 demodulation)) and @ad<"19980414") and (fine adj frequency adj synchroniz$5) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2003/11/13 11:12 |
| S20 | 0 | (((multi adj2 carrier adj transmission) or ofdm) and (multi adj2 carrier adj2 demodulation)) and (fine adj frequency adj synchroniz$5) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2003/11/13 11:12 |
| S21 | 16 | ((multi adj2 carrier adj transmission) or ofdm) and ((multi adj2 carrier) and (frequency adj offset or deviation) and ((plurality or multiple) adj symbol$1)) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2003/11/13 11:28 |

| | | | | | | |
|---|---|---|---|---|---|---|
| S213 | 0 | ((cancel$4 or suppress$3 or mitigat$3 or eliminat$3) adj2 (electromagnetic adj (interference or wave$1)) same (circuit or (printed adj board))) and ((inverse adj2 phase) near antenna) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2004/05/25 11:25 |
| S214 | 0 | 333/12.ccls. and (((inverse adj2 phase) and antenna) and ((printed or circuit) adj board)) and @ad<"19991130" | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2004/05/25 13:30 |
| S215 | 1 | "375"/.ccls. and (((inverse adj2 phase) and antenna) and ((printed or circuit) adj board)) and @ad<"19991130" | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2004/05/25 13:31 |
| S216 | 1 | (lipp-stefan.in.) and (fine adj frequency adj synchroniz$5) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 09:24 |
| S217 | 0 | (ebehlim-ernst.in.) and (fine adj frequency adj synchroniz$5) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 09:25 |
| S218 | 0 | (buchholz-albert.in.) and (fine adj frequency adj synchroniz$5) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 09:25 |
| S219 | 0 | (gerhaeuser-heing.in.) and (fine adj frequency adj synchroniz$5) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 09:25 |
| S220 | 1 | (badri-sabah.in.) and (fine adj frequency adj synchroniz$5) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 09:26 |
| S221 | 0 | ((fraunhofer adj2 gesellschaft adj zur adj foerderung adj der adj angewandten.as.) and ((multi adj2 carrier transmission) or ofdm)) and (fine adj frequency adj synchroniz$5) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 09:34 |
| S222 | 27 | ((multi adj2 carrier transmission) or mcm or ofdm) and (fine adj frequency adj synchroniz$5) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 09:41 |
| S223 | 7 | S222 and ((frequency adj2 (offset or deviation)) adj2 (correct$3 or compensat$3 or mitigat$3)) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 09:43 |

| | | | | | | |
|---|---|---|---|---|---|---|
| S224 | 7 | S223 and ad@<"19980414" | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 10:07 |
| S225 | 27 | ((multi adj2 carrier transmission) or mcm or ofdm) and (fine adj frequency adj synchroniz$5) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 10:06 |
| S226 | 7 | S225 and ((frequency adj2 (offset or deviation)) adj2 (correct$3 or compensat$3 or mitigat$3)) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 10:08 |
| S227 | 0 | S226 and @ad<"19980414" | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 10:07 |
| S228 | 0 | S226 and @ad<"19980414" | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 10:08 |
| S229 | 1188 | ((frequency adj2 (offset or deviation)) adj2 (correct$3 or compensat$3 or mitigat$3)) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 10:08 |
| S230 | 22 | S229 and (fine adj2 synchroniz$5) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 10:09 |
| S231 | 1 | S230 and (differential adj2 decod$3) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 11:36 |
| S232 | 1 | S231 and phase | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 10:11 |
| S233 | 1191 | ((frequency adj2 (offset or deviation)) adj2 (correct$3 or compensat$3 or mitigat$3)) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 12:40 |
| S234 | 22 | S233 and (fine adj2 synchroniz$5) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 12:42 |
| S235 | 0 | S234 and (differential adj2 phase adj2 decod$3) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 11:41 |

| | | | | | | |
|---|---|---|---|---|---|---|
| S236 | 0 | S233 and (differential adj2 phase adj2 decod$3) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 11:41 |
| S237 | 1 | S234 and (differential adj2 decod$3) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 12:41 |
| S238 | 1 | S237 and phase | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 11:51 |
| S239 | 0 | S238 and (feedback and (m adj2 psk)) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 11:51 |
| S240 | 0 | S238 and (feedback ) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 12:31 |
| S241 | 39 | differential adj2 phase adj2 decod$3 | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 12:31 |
| S242 | 0 | S233 and (differential adj2 phase adj2 decod$3) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 12:46 |
| S243 | 3 | S241 and (fine adj2 synchroniz$5) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 12:31 |
| S244 | 2 | S243 and @ad<"19980414" | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 12:32 |
| S245 | 1 | 370/480.ccls. and (differential adj2 phase adj2 decod$3) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 12:36 |
| S246 | 0 | S245 and (feedback and (m adj2 psk)) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 12:35 |
| S247 | 1 | 375/332.ccls. and (differential adj2 phase adj2 decod$3) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 12:35 |

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|---|---|---|---|---|---|---|
| S248 | 1 | (differential adj2 phase adj2 decod$3) and feedback and (m adj2 psk) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 12:38 |
| S249 | 0 | S248 and ((frequency adj2 (offset or deviation)) adj2 (correct$3 or compensat$3 or mitigat$3)) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 12:37 |
| S250 | 0 | S233 and ((differential adj2 phase adj2 decod$3) and feedback and (m adj2 psk)) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 12:41 |
| S251 | 0 | S241 and ((frequency adj2 (offset or deviation)) adj2 (correct$3 or compensat$3 or mitigat$3)) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 12:40 |
| S252 | 7 | S233 and ((phase adj2 (offset or difference or deviation)) and feedback and (m adj2 psk)) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 12:41 |
| S253 | 6 | S252 and @ad<"19980414" | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 12:41 |
| S254 | 0 | S253 and (fine adj2 synchroniz$5) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 07:26 |
| S255 | 1 | S253 and (differential adj2 decod$3) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 12:59 |
| S256 | 0 | (fine adj2 synchroniz$5) and (phase adj2 (shift$3 or offset or deviation)) and (m adj2 psk) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 07:28 |
| S257 | 41 | (frequency adj2 synchroniz$5) and (phase adj2 (shift$3 or offset or deviation)) and (m adj2 psk) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 07:28 |
| S258 | 17 | S257 and (fine and course) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 07:30 |
| S262 | 41 | (frequency adj2 synchroniz$5) and (phase adj2 (shift$3 or offset or deviation)) and (m adj2 psk) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 07:36 |

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| S263 | 17 | S262 and (fine and course) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 07:31 |
| S264 | 6 | S263 and (differential adj2 cod$3) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 07:31 |
| S265 | 4 | S264 and @ad<"19980414" | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 07:37 |
| S266 | 1 | 370/480.ccls. and (phase adj2 (shift$3 or offset or deviation)) and (m adj2 psk) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 07:36 |
| S267 | 29 | (fine adj2 synchroniz$5) same (phase adj2 (shift$3 or offset or deviation)) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 07:38 |
| S268 | 0 | S267 and (m adj2 psk) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 08:48 |
| S269 | 5 | S267 and ( psk) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 07:37 |
| S270 | 5 | S269 and @ad<"19980414" | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 08:49 |
| S271 | 199 | (fine adj2 synchroniz$5) and (phase adj2 (shift$3 or offset or deviation)) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 07:40 |
| S272 | 0 | S271 and (m adj2 psk) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 07:39 |
| S273 | 103 | (frequency adj2 (offset or deviation)) and (m adj2 psk) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 07:40 |
| S274 | 18 | S273 and (frequency adj2 synchroniz$5) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 07:40 |

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| S27 5 | 14 | S274 and (phase adj2 (shift$3 or offset or deviation)) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 07:40 |
| S27 6 | 5 | S275 and @ad<"19980414" | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 07:46 |
| S27 7 | 2 | synchroniz$5 with (differential adj2 phase adj2 decod$3) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 08:46 |
| S27 8 | 1 | wo92/05646.ptpn. | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 11:06 |
| S27 9 | 127 | fine adj2 frequency adj2 estimat$3 | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 08:47 |
| S28 0 | 83 | S279 and (phase adj2 (shift$3 or difference or deviation or drift$1)) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 08:48 |
| S28 1 | 5 | S280 and (m adj2 psk) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 08:48 |
| S28 2 | 1 | S281 and @ad<"19980414" | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 08:49 |

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| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 09/673,270 | 11/29/2000 | Ernst Eberlein | 41001 | 3590 |

7590 01/26/2005

John E Holmes
Roylance Abrams Berdo & Goodman
Suite 600
1300 19th Street NW
Washington, DC 20036

| EXAMINER | |
|---|---|
| WARE, CICELY Q | |
| **ART UNIT** | **PAPER NUMBER** |
| 2634 | |

DATE MAILED: 01/26/2005

Please find below and/or attached an Office communication concerning this application or proceeding.



PTO-90C (Rev. 10/03)

| Office Action Summary | Application No. 09/673,270 | Applicant(s) EBERLEIN ET AL. |
| --- | --- | --- |
| | Examiner Cicely Ware | Art Unit 2634 |

*-- The MAILING DATE of this communication appears on th cover sheet with th correspond nc address --*

**Period for Reply**

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

**Status**

1)☒ Responsive to communication(s) filed on 23 September 2004.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

**Disposition of Claims**

4)☒ Claim(s) 19-34 is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) 19-31,33 and 34 is/are rejected.

7)☒ Claim(s) 32 is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

**Application Papers**

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

**Priority under 35 U.S.C. §§ 119 and 120**

12)☐ 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:

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)).

* See the attached detailed Office action for a list of the certified copies not received.

13)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application) since a specific reference was included in the first sentence of the specification or in an Application Data Sheet. 37 CFR 1.78.

a) ☐ The translation of the foreign language provisional application has been received.

14)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121 since a specific reference was included in the first sentence of the specification or in an Application Data Sheet. 37 CFR 1.78.

**Attachment(s)**

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO-1449) Paper No(s) _____ .
4) ☐ Interview Summary (PTO-413) Paper No(s). _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: .

## DETAILED ACTION

### *Claim Rejections - 35 USC § 112*

1. Claim 21 recites the limitation "said averaged frequency offset in said step c)" in line 6. There is insufficient antecedent basis for this limitation in the claim.

### *Claim Rejections - 35 USC § 102*

2. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

3. Claims 19, 20, 22-31, 33, 34 are rejected under 35 U.S.C. 102(b) as being anticipated by Gledhill et al. (US Patent 5,345,440).

(1) With regard to claim 19, Gledhill et al. discloses in (Fig. 1A, 1B) a method performing a fine frequency synchronization compensating for a carrier frequency deviation from an oscillator frequency in a multi-carrier demodulation system of the type capable of carrying out a differential phase decoding of multi-carrier modulated signals, said signals comprising a plurality of symbols, each symbol being defined by phase differences between simultaneous carriers having different frequencies, said method comprising the steps of: determining a phase difference between phases of the same carrier in different symbols, determining a frequency offset by eliminating phase shift uncertainties related to the transmitted information from said phase difference making

use of a decision device; performing a feedback correction (Fig. 4) of said carrier frequency deviation based on said determined frequency offset (abstract, col. 1, lines 21-26, col. 2, lines 30-39, 41-43, col. 3, lines 2-5, col. 4, lines 30-46, col. 5, lines 1-9, 16-22, 30-41, col. 6, lines 43-46, 54-56, 62-64, col. 8, lines 53-62, col. 9, lines, 59-63, col. 12, lines 51-55, col. 15, lines 3-18).

(2) With regard to claim 20, claim 20 inherits all the limitations of claim 19. Gledhill et al. further discloses determining respective phase of the same carrier in different symbols; eliminating phase shift uncertainties related to the transmitted information from said phases to determine respective phase deviations making use of a decision device; determining frequency offset by determining a phase difference between said phase deviations (abstract, col. 3, lines 47-59, col. 9, lines 26-30, 59-63, col. 11, lines 3-20, 41-48, col. 12, lines 51-55).

(3) With regard to claim 22, claim 22 inherits all the limitations of claim 20. Gledhill et al. further discloses wherein steps a, b and c are performed for a plurality of carriers in said symbols, an averaged frequency offset is determined by averaging said determined frequency offsets of said plurality of carriers, and said feedback correction of said frequency deviation is performed based on said averaged frequency offset (col. 4, lines 64-68, col. 8, lines 15-32, col. 9, lines 58-63).

(4) With regard to claim 23, claim 23 inherits all the limitations of claim 19. Gledhill et al. further discloses the step of determining a phase difference between phases of the same carrier in symbols, which are adjacent in the time axis direction (col. 10, lines 33-34, 54-56, col. 11, lines 3-6).

(5) With regard to claim 24, claim 24 inherits all the limitations of claim 19. Gledhill et al. further discloses the step of eliminating phase shift uncertainties corresponding to M-ary phase shifts (col. 2, lines 51-68, col. 3, lines 1-5, col. 4, lines 30-36).

(6) With regard to claim 25, claim 25 inherits all the limitations of claim 20. Gledhill et al. further discloses the step of determining respective phases of the same carrier in symbols, which are adjacent in the time axis direction (col. 3, lines 47-49, col. 8, lines 1-5, col. 10, lines 33-34, 54-56, col. 11, lines 3-6).

(7) With regard to claim 26, claim 26 inherits all the limitations of claim 20. Gledhill et al. further discloses the step of eliminating M-ary phase shifts (col. 2, lines 51-68, 1-5, col. 4, lines 30-46).

(8) With regard to claim 27, claim 27 inherits all the limitations of claim 19.

(9) With regard to claim 28, claim 28 inherits all the limitations of claim 20.

(10) With regard to claim 29, claim 29 inherits all the limitations of claims 27 and 22.

(11) With regard to claim 30, claim 30 inherits all the limitations of claims 28 and 22.

(12) With regard to claim 31, claim 31 inherits all the limitations of claim 27 and 23.

(13) With regard to claim 33, claim 33 inherits all the limitations of claim 27. Gledhill et al. further discloses in (Fig. 4 (4, 7) wherein said means for performing a

feedback correction of said frequency deviation comprises a numerical controlled oscillator and complex multiplier (col. 7, lines 58-68).

(14) With regard to claim 34, claim 34 inherits all the limitations of claim 33. Gledhill et al. further discloses in (Fig. 4 (2, 7) wherein said means for performing a feedback correction of said frequency deviation further comprises a low path filter preceding said controlled oscillator (col. 7, lines 58-68).

### ***Response to Arguments***

***4.*** Applicant's arguments filed 23, September 2004 have been fully considered but they are not persuasive. In response to applicant's argument **"that the references fail to show certain features of applicant's invention, it is noted that the features upon which applicant relies (i.e., differential coding in the direction of the frequency axis) are not recited in the rejected claim(s)"**. Although the claims are interpreted in light of the specification, limitations from the specification are not read into the claims. See *In re Van Geuns*, 988 F.2d 1181, 26 USPQ2d 1057 (Fed. Cir. 1993). Applicant discloses on Pg. 7 of the Remarks, "that each symbol is defined by phase differences between simultaneous carriers having different frequencies, is specific for differential coding in the direction of the frequency frequencies". Examiner maintains the rejection "that each symbol is defined by phase differences between simultaneous carriers having different frequencies", however this does not lead toward operating in the time axis or the frequency axis. Therefore the previous rejection in regards to claim 1-34 is maintained.

### ***Allowable Subject Matter***

5. Claim 32 is objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims. The following is a statement of reasons for the indication of allowable subject matter: The instant application discloses a method of performing a fine frequency synchronization compensating for a carrier frequency deviation form an oscillator frequency in a multi-carrier demodulation system. Prior art references show similar methods but fail to teach: **"means for determining respective phases comprises means for determining respective phases of the same carrier in symbols which are adjacent in the time axis direction"**, as in claim 32.

### ***Conclusion***

6. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Cicely Ware whose telephone number is 703-305-8326. The examiner can normally be reached on Monday – Friday, 8-5.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Stephen Chin can be reached on 703-305-4714. The fax phone numbers for the organization where this application or proceeding is assigned are 703-872-9314 for regular communications and 703-872-9314 for After Final communications.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is 703-305-3900.

***Cicely Ware***

cqw
January 12, 2005

Amanda Le

AMANDA T. LE
PRIMARY EXAMINER

| Notice of References Cited | Application/Control No. 09/673,270 | Applicant(s)/Patent Under Re xamination EBERLEIN ET AL. | |
|---|---|---|---|
| | Examiner Cicely Ware | Art Unit 2634 | Page 1 of 1 |

**U.S. PATENT DOCUMENTS**

| * | | Document Number Country Code-Number-Kind Code | Date MM-YYYY | Name | Classification |
|---|---|---|---|---|---|
| | A | US-5,345,440 | 09-1994 | Gledhill et al. | 370/210 |
| | B | US- | | | |
| | C | US- | | | |
| | D | US- | | | |
| | E | US- | | | |
| | F | US- | | | |
| | G | US- | | | |
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| | I | US- | | | |
| | J | US- | | | |
| | K | US- | | | |
| | L | US- | | | |
| | M | US- | | | |

**FOREIGN PATENT DOCUMENTS**

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**NON-PATENT DOCUMENTS**

| * | | Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages) |
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*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

# *Index of Claims*

| Application No. | Applicant(s) |
|---|---|
| 09/673,270 | EBERLEIN ET AL. |
| **Examiner** | **Art Unit** |
| Cicely Ware | 2634 |

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| = | Allowed | | ÷ | Restricted | | I | Interference | | O | Objected | |

| Claim Final | Claim Original | Date 1/5/04 | Claim Final | Claim Original | Date | Claim Final | Claim Original | Date |
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| Search Notes | Application No. 09/673,270 | Applicant(s) EBERLEIN ET AL. |
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| | Examiner Cicely Ware | Art Unit 2634 |

**SEARCHED**

| Class | Subclass | Date | Examiner |
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| 370 | 480 | 1/5 | CW |
| 375 | 332 | 1/5 | CW |
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**SEARCH NOTES (INCLUDING SEARCH STRATEGY)**

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PATENT

OIPE JC104 APR 26 2005 PATENT & TRADEMARK OFFICE

Case Docket No.: **41001**

In re Application of:

**Ernst Eberlein et al.**

Serial No.: **09/673,270**

Filed: **November 29, 2000**

For: **METHOD AND APPARATUS FOR FINE FREQUENCY SYNCHRONIZATION IN MULTI-CARRIER DEMODULATION SYSTEMS**

Group Art Unit: 2634

Examiner: C. Ware

COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, VA 22313-1450

Transmitted herewith is an Amendment in the above-identified application:

☐ Small entity status of this application under 37 C.F.R. § 1.9 and 1.27 has been established by a verified statement previously submitted.

☐ A verified statement to establish small entity status under 37 C.F.R. § 1.9 and 1.27 is enclosed.

☐ No additional fee is required.

The fee has been calculated as shown below:

| | CLAIMS REMAINING AFTER AMENDMENT | HIGHEST NO. PREVIOUSLY PAID FOR | PRESENT EXTRA | SMALL ENTITY RATE | SMALL ENTITY ADDIT. FEE | OTHER THAN A SMALL ENTITY RATE | OTHER THAN A SMALL ENTITY ADDIT. FEE |
|---|---|---|---|---|---|---|---|
| TOTAL | 16 | 20 - = | 0 | x 25 = | $ | x 50 = | $ |
| INDEP | 5 | 4 = | 1 | x 100 = | $ | x 200 = | $200.00 |
| ☐FIRST PRESENTATION OF MULT. DEP. CLAIM | | | | + 180 = | $ | + 360 = | $ |
| If the difference in Col. 1 is less than zero, enter "0" in Col. 2 | | | | TOTAL | $ | TOTAL | $200.00 |

☐ Applicant(s) petition(s) for an extension of _____ month(s) to respond and submits herewith the fee of $_____.

☐ Please charge my Deposit Account No. 18-2220 in the amount of $_____. A duplicate copy of this sheet is attached.

☒ A check in the amount of $ 200.00 is attached.

☒ The Commissioner is hereby authorized to charge payment of the following fees associated with this communication or credit any overpayment to Deposit Account No. 18-2220. A duplicate copy of this sheet is attached.

- ☒ Any additional excess claim fees under 37 C.F.R. § 1.16.
- ☒ Any additional patent application processing fees under 37 C.F.R. § 1.17.

Dated: April 26, 2004

Stacey J. Longanecker
Attorney of Record
Reg. No. 33,952

Roylance, Abrams, Berdo & Goodman, L.L.P.
1300 19th Street, N.W., Suite 600
Washington, D.C. 20036
(202) 659-9076

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| In re Application of: | : |
| | : |
| **Ernst Eberlein et al.** | : Group Art Unit: 2634 |
| | : |
| Serial No.: **09/673,270** | : Examiner: C. Ware |
| | : |
| Filed: **November 29, 2000** | : Confirmation No.: 3590 |
| | : |
| For: **METHOD AND APPARATUS FOR FINE FREQUENCY SYNCHRONIZATION IN MULTI-CARRIER DEMODULATION SYSTEMS** | : |

AMENDMENT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

In response to the Office Action dated January 26, 2005, please amend the above-captioned application as indicated on the following pages.

Amendments to the claims begin on page 2 herein.

Remarks begin on page 8 herein.

AMENDMENTS TO THE CLAIMS:

19. (Amended) A method of performing a fine frequency synchronization compensating for a carrier frequency deviation from an oscillator frequency in a multi-carrier demodulation system capable of carrying out a differential phase decoding of multi-carrier modulated signals, said signals comprising a plurality of symbols, each symbol being [defined by phase differences between simultaneous carriers having different frequencies]differentially coded in the direction of the frequency axis, said method comprising the steps of:

a) determining a phase difference between phases of the same carrier in different symbols;

b) determining a frequency offset by eliminating phase shift uncertainties related to the transmitted information from said phase difference making use of a M-PSK decision device; and

c) performing a feedback correction of said carrier frequency deviation based on said determined frequency offset.

20. (Amended) A method of performing a fine frequency synchronization compensating for a carrier frequency deviation from an oscillator frequency in a multi-carrier demodulation system capable of carrying out a differential phase decoding of multi-carrier modulated signals, said signals comprising a plurality of symbols, each symbol being [defined by phase differences between simultaneous carriers having different frequencies]differentially coded in the direction of the frequency axis, said method comprising the steps of:

a) determining respective phase of the same carrier in different symbols;

b) eliminating phase shift uncertainties related to the transmitted information from said phases to determine respective phase deviations making use of a M-PSK decision device;

c) determining a frequency offset by determining a phase difference between said phase deviations; and

d) performing a feedback correction of said carrier frequency deviation based on said determined frequency offset.

21. (Amended) The method according to claim 19, wherein

said steps a) and b) are performed for a plurality of carriers in said symbols,

an averaged frequency offset is determined by averaging said determined frequency offsets of said plurality of carriers, and

said feedback correction of said frequency deviation is performed based on said averaged frequency offset[ in said step c)].

22. (Previously Presented) The method according to claim 20, wherein

said steps a), b) and c) are performed for a plurality of carriers in said symbols,

an averaged frequency offset is determined by averaging said determined frequency offsets of said plurality of carriers, and

said feedback correction of said frequency deviation is performed based on said averaged frequency offset.

23. (Previously Presented) The method according to claim 19, wherein said step a) comprises the step of determining a phase difference between phases of the same carrier in symbols which are adjacent in the time axis direction.

24. (Previously Presented) The method according to claim 19, wherein said step b) comprises the step of eliminating phase shift uncertainties corresponding to M-ary phase shifts.

25. (Previously Presented) The method according to claim 20, wherein said step a) comprises the step of determining respective phases of the same carrier in symbols which are adjacent in the time axis direction.

26. (Previously Presented) The method according to claim 20, wherein said step b) comprises the step of eliminating M-ary phase shifts.

27. (Amended) An apparatus for performing a fine frequency synchronization compensating for a carrier frequency deviation from an oscillator frequency, for a multi-carrier demodulation system capable of carrying out a differential phase decoding of multi-carrier modulated signals, said signals comprising a plurality of symbols, each symbol being [defined by phase differences between simultaneous carriers having different frequencies]differentially coded in the direction of the frequency axis, said apparatus comprising:

means for determining a phase difference between phases of the same carrier in different symbols;

M-PSK decision device for determining a frequency offset by eliminating phase shift uncertainties related to the transmitted information from said phase difference; and

means for performing a feedback correction of said frequency deviation based on said determined frequency offset.

28. (Amended) An apparatus for performing a fine frequency synchronization compensating for a carrier frequency deviation from an oscillator frequency, for a multi-carrier demodulation system capable of carrying out a differential phase decoding of multi-carrier modulated signals, said signals comprising a plurality of symbols, each symbol being [defined by phase differences between simultaneous carriers having different frequencies]differentially coded in the direction of the frequency axis, said apparatus comprising:

means for determining respective phases of the same carrier in different symbols;

M-PSK decision device for eliminating phase shift uncertainties related to the transmitted information from said phases to determine respective phase deviations;

means for determining a frequency offset by determining a phase difference between said phase deviations;

means for performing a feedback correction of said frequency deviation based on said determined frequency offset.

29. (Previously Presented) The apparatus according to claim 27, further comprising:

means for determining an averaged frequency offset by averaging determined frequency offsets of a plurality of carriers, wherein said means for performing a feedback correction performs said feedback correction of said frequency deviation based on said averaged frequency offset.

30. (Previously Presented) The apparatus according to claim 28, further comprising:

means for determining an averaged frequency offset by averaging determined frequency offsets of a plurality of carriers, wherein

said means for performing a feedback correction performs said feedback correction of said frequency deviation based on said averaged frequency offset.

31. (Previously Presented) The apparatus according to claim 27, wherein said means for determining a phase difference comprises means for determining a phase difference between phases of the same carrier in symbols which are adjacent in the time axis direction.

32. (Amended) [The apparatus according to claim 28,] An apparatus for performing a fine frequency synchronization compensating for a carrier frequency deviation from an oscillator frequency, for a multi-carrier demodulation system capable of carrying out a differential phase decoding of multi-carrier modulated signals, said signals comprising a plurality of symbols, each symbol being defined by phase differences between simultaneous carriers having different frequencies, said apparatus comprising:

means for determining respective phases of the same carrier in different symbols;

M-PSK decision device for eliminating phase shift uncertainties related to the transmitted information from said phases to determine respective phase deviations;

means for determining a frequency offset by determining a phase difference between said phase deviations;

means for performing a feedback correction of said frequency deviation based on said determined frequency offset;

wherein said means for determining respective phases comprises means for determining respective phases of the same carrier in symbols which are adjacent in the time axis direction.

33. (Previously Presented) The apparatus according to claim 27, wherein said means for performing a feedback correction of said frequency deviation comprises a numerical controlled oscillator and a complex multiplier.

34. (Previously Presented) The apparatus according to claim 33, wherein said means for performing a feedback correction of said frequency deviation further comprises a low path filter preceding said numerical controlled oscillator.

REMARKS

Claims 19-34 are pending. By the present Amendment, claim 21 has been amended to delete the text "in said step c)" and, accordingly, to overcome the objection under 35 U.S.C. § 112 set forth in the Office Action. The independent claims 19, 20, 27 and 28 have also been amended to more clearly recite an aspect of the present invention as discussed below. Applicants note with appreciation the allowance of claim 32 if rewritten in independent form to include the limitations of the base claim and any intervening claims. Accordingly, claim 32 as been amended to include the limitations of independent claim 28.

In the Office Action, claims 19, 20, 22-31, 33 and 34 are rejected under 35 U.S.C. § 102(b) as being anticipated by U.S. Patent No. 5,345,440, to Gledhill et al (hereinafter referred to as the Gledhill et al patent). In response to the Amendment dated 23 September 2004, the Office Action states that the features of the present invention relied on by the Applicant to distinguish the present invention over the applied references are not recited in the rejected claims. Accordingly, the independent claims 19, 20, 27 and 28 have each been amended to recite each symbol being "differentially coded in the direction of the frequency axis." Thus, the subject matter of the independent claims of the present invention is clearly not anticipated by the Gledhill et al patent, which discloses OFDM signals differentially coded in the direction of the time axis as discussed in the Amendment dated 23 September 2004. Support for these claim amendments is provided on pages 12-14 and Figs. 2B and 3 of the substitute specification submitted with the Preliminary Amendment on October 13, 2000. Withdrawal of the rejection of claims 19, 20, 22-31, 33 and 34 as being anticipated by the Gledhill et patent under 35 U.S.C. § 102 is therefore respectfully requested.

In view of the above, it is believed that the application is in condition for allowance and notice to this effect is respectfully requested. Should the Examiner have any questions, the Examiner is invited to contact the undersigned at the telephone number indicated below.

Respectfully Submitted,

Stacey J. Longanecker
Attorney for Applicant
Reg. No. 33,952

Roylance, Abrams, Berdo & Goodman, L.L.P.
1300 19th Street, N.W., Suite 600
Washington, D.C. 20036
(202) 659-9076

Dated: 26 April, 2005

**PATENT APPLICATION FEE DETERMINATION RECORD**
Effective December 8, 2004

09/673210

## CLAIMS AS FILED - PART I

| | (Column 1) | (Column 2) |
|---|---|---|
| TOTAL CLAIMS | | |
| FOR | NUMBER FILED | NUMBER EXTRA |
| TOTAL CHARGEABLE CLAIMS | minus 20= | |
| INDEPENDENT CLAIMS | minus 3 = | |
| MULTIPLE DEPENDENT CLAIM PRESENT | | ☐ |

* If the difference in column 1 is less than zero, enter "0" in column 2

| SMALL ENTITY TYPE ☐ RATE | FEE | OR | OTHER THAN SMALL ENTITY RATE | FEE |
|---|---|---|---|---|
| BASIC FEE | | OR | BASIC FEE | |
| X$ 25= | | OR | X$50= | |
| X100= | | OR | X200= | |
| +180= | | OR | +360= | |
| TOTAL | | OR | TOTAL | |

## CLAIMS AS AMENDED - PART II

4/26/05

AMENDMENT A

| | (Column 1) CLAIMS REMAINING AFTER AMENDMENT | | (Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR | (Column 3) PRESENT EXTRA |
|---|---|---|---|---|
| Total | * 16 | Minus | ** 20 | = 0 |
| Independent | * 5 | Minus | *** 4 | = 1 |
| FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM | | | | ☐ |

| SMALL ENTITY RATE | ADDITIONAL FEE | OR | OTHER THAN SMALL ENTITY RATE | ADDITIONAL FEE |
|---|---|---|---|---|
| X$ 25= | | OR | X$50= | 0 |
| X100= | | OR | X200= | 200 |
| +180= | | OR | +360= | |
| TOTAL ADDIT. FEE | | OR | TOTAL ADDIT. FEE | 200 |

AMENDMENT B

| | (Column 1) CLAIMS REMAINING AFTER AMENDMENT | | (Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR | (Column 3) PRESENT EXTRA |
|---|---|---|---|---|
| Total | * | Minus | ** | = |
| Independent | * | Minus | *** | = |
| FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM | | | | ☐ |

| RATE | ADDITIONAL FEE | OR | RATE | ADDITIONAL FEE |
|---|---|---|---|---|
| X$ 25= | | OR | X$50= | |
| X100= | | OR | X200= | |
| +180= | | OR | +360= | |
| TOTAL ADDIT. FEE | | OR | TOTAL ADDIT. FEE | |

AMENDMENT C

| | (Column 1) CLAIMS REMAINING AFTER AMENDMENT | | (Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR | (Column 3) PRESENT EXTRA |
|---|---|---|---|---|
| Total | * | Minus | ** | = |
| Independent | * | Minus | *** | = |
| FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM | | | | ☐ |

| RATE | ADDITIONAL FEE | OR | RATE | ADDITIONAL FEE |
|---|---|---|---|---|
| X$ 25= | | OR | X$50= | |
| X100= | | OR | X200= | |
| +180= | | OR | +360= | |

UNITED STATES PATENT AND TRADEMARK OFFICE

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www.uspto.gov

| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 09/673,270 | 11/29/2000 | Ernst Eberlein | 41001 | 3590 |

7590 05/12/2005

John E Holmes
Roylance Abrams Berdo & Goodman
Suite 600
1300 19th Street NW
Washington, DC 20036

| EXAMINER | |
|---|---|
| WARE, CICELY Q | |
| **ART UNIT** | **PAPER NUMBER** |
| 2634 | |

DATE MAILED: 05/12/2005

Please find below and/or attached an Office communication concerning this application or proceeding.



PTO-90C (Rev. 10/03)

NTC, A. NONCPL

UNITED STATES PATENT AND TRADEMARK OFFICE

09/673270

COMMISSIONER FOR PATENTS
UNITED STATES PATENT AND TRADEMARK OFFICE
P.O. BOX 1450
ALEXANDRIA, VA 22313-1450
www.uspto.gov

**Notice of Non-Compliant Amendment** (37 CFR 1.121)

The amendment document filed on 4/26/05 is considered non-compliant because it has failed to meet the requirements of 37 CFR 1.121. In order for the amendment document to be compliant, correction of the following item(s) is required. **Only the corrected section of the non-compliant amendment document must be resubmitted (in its entirety), e.g., the entire "Amendments to the claims" section of applicant's amendment document must be re-submitted.** 37 CFR 1.121(h).

THE FOLLOWING CHECKED (X) ITEM(S) CAUSE THE AMENDMENT DOCUMENT TO BE NON-COMPLIANT:

☐ 1. Amendments to the specification:
- ☐ A. Amended paragraph(s) do not include markings.
- ☐ B. New paragraph(s) should not be underlined.
- ☐ C. Other ______

☐ 2. Abstract:
- ☐ A. Not presented on a separate sheet. 37 CFR 1.72.
- ☐ B. Other ______

☐ 3. Amendments to the drawings: ______

☑ 4. Amendments to the claims:
- ☑ A. A complete listing of <u>all</u> of the claims is not present.
- ☑ B. The listing of claims does not include the text of all pending claims (including withdrawn claims)
- ☑ C. Each claim has not been provided with the proper status identifier, and as such, the individual status of each claim cannot be identified. Note: the status of every claim must be indicated after its claim number by using one of the following 7 status identifiers: (Original), (Currently amended), (Canceled), (Withdrawn), (Previously presented), (New) and (Not entered).
- ☐ D. The claims of this amendment paper have not been presented in ascending numerical order.
- ☐ E. Other: ______

For further explanation of the amendment format required by 37 CFR 1.121, see MPEP Sec. 714 and the USPTO website at http://www.uspto.gov/web/offices/pac/dapp/opla/preognotice/officeflyer.pdf.

If the non-compliant amendment is a **PRELIMINARY AMENDMENT,** applicant is given ONE MONTH from the mail date of this letter to supply the corrected section which complies with 37 CFR 1.121. Failure to comply with 37 CFR 1.121 will result in non-entry of the preliminary amendment and examination on the merits will commence without consideration of the proposed changes in the preliminary amendment(s). This notice is not an action under 35 U.S.C. 132, and **this ONE MONTH time limit is not extendable.**

If the non-compliant amendment is a reply to a **NON-FINAL OFFICE ACTION (including a submission for an RCE),** and since the amendment appears to be a *bona fide* attempt to be a reply (37 CFR 1.135(c)), applicant is given a TIME PERIOD of ONE MONTH from the mailing of this notice within which to re-submit the corrected section which complies with 37 CFR 1.121 in order to avoid abandonment. **EXTENSIONS OF THIS TIME PERIOD ARE AVAILABLE UNDER 37 CFR 1.136(a).**

If the amendment is a reply to a **FINAL REJECTION,** this form may be an attachment to an Advisory Action. **<u>The period for response to a final rejection continues to run from the date set in the final rejection</u>**, and is not affected by the non-compliant status of the amendment.

Laticia Tyson
Legal Instruments Examiner (LIE)

571-272-7285
Telephone No.

Fraunhofer Ex 2018-235
Sirius XM v Fraunhofer, IPR2018-00681

Rev. 6/04

Appl. No. 09/673,270
Response to Notice of Non-Compliant Amdt. dated May 18, 2005
Reply to Notice of Non-Compliant Amdt. of May 12, 2005



PATENT

41001

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

| | |
|---|---|
| In re Application of: | : |
| **Ernst Eberlein et al.** | : Group Art Unit: 2634 |
| Serial No.: **09/673,270** | : Examiner: C. Ware |
| Filed: **November 29, 2000** | : Confirmation No.: 3590 |
| For: **METHOD AND APPARATUS FOR FINE FREQUENCY SYNCHRONIZATION IN MULTI-CARRIER DEMODULATION SYSTEMS** | : |

**RESPONSE TO NON-COMPLIANT AMENDMENT**

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

In response to the Notice of Non-Compliant Amendment dated May 12, 2005, the Applicants hereby resubmit below the previously non-compliant section of the Amendment filed on April 26, 2005, that is, the "AMENDMENTS TO THE CLAIMS" section, which has now been modified to overcome the objections set forth in the Notice.

AMENDMENTS TO THE CLAIMS:

Claims 1-18 (Cancelled)

19. (Currently Amended) A method of performing a fine frequency synchronization compensating for a carrier frequency deviation from an oscillator frequency in a multi-carrier demodulation system capable of carrying out a differential phase decoding of multi-carrier modulated signals, said signals comprising a plurality of symbols, each symbol being [defined by phase differences between simultaneous carriers having different frequencies]differentially coded in the direction of the frequency axis, said method comprising the steps of:

a) determining a phase difference between phases of the same carrier in different symbols;

b) determining a frequency offset by eliminating phase shift uncertainties related to the transmitted information from said phase difference making use of a M-PSK decision device; and

c) performing a feedback correction of said carrier frequency deviation based on said determined frequency offset.

20. (Currently Amended) A method of performing a fine frequency synchronization compensating for a carrier frequency deviation from an oscillator frequency in a multi-carrier demodulation system capable of carrying out a differential phase decoding of multi-carrier modulated signals, said signals comprising a plurality of symbols, each symbol being [defined by phase differences between simultaneous carriers having different

frequencies]differentially coded in the direction of the frequency axis, said method comprising the steps of:

a) determining respective phase of the same carrier in different symbols;

b) eliminating phase shift uncertainties related to the transmitted information from said phases to determine respective phase deviations making use of a M-PSK decision device;

c) determining a frequency offset by determining a phase difference between said phase deviations; and

d) performing a feedback correction of said carrier frequency deviation based on said determined frequency offset.

21. (Currently Amended) The method according to claim 19, wherein

said steps a) and b) are performed for a plurality of carriers in said symbols,

an averaged frequency offset is determined by averaging said determined frequency offsets of said plurality of carriers, and

said feedback correction of said frequency deviation is performed based on said averaged frequency offset[ in said step c)].

22. (Previously Presented) The method according to claim 20, wherein

said steps a), b) and c) are performed for a plurality of carriers in said symbols, an averaged frequency offset is determined by averaging said determined frequency offsets of said plurality of carriers, and

said feedback correction of said frequency deviation is performed based on said averaged frequency offset.

23. (Previously Presented) The method according to claim 19, wherein said step a) comprises the step of determining a phase difference between phases of the same carrier in symbols which are adjacent in the time axis direction.

24. (Previously Presented) The method according to claim 19, wherein said step b) comprises the step of eliminating phase shift uncertainties corresponding to M-ary phase shifts.

25. (Previously Presented) The method according to claim 20, wherein said step a) comprises the step of determining respective phases of the same carrier in symbols which are adjacent in the time axis direction.

26. (Previously Presented) The method according to claim 20, wherein said step b) comprises the step of eliminating M-ary phase shifts.

27. (Currently Amended) An apparatus for performing a fine frequency synchronization compensating for a carrier frequency deviation from an oscillator frequency, for a multi-carrier demodulation system capable of carrying out a differential phase decoding of multi-carrier modulated signals, said signals comprising a plurality of symbols, each symbol being [defined by phase differences between simultaneous carriers having different frequencies]differentially coded in the direction of the frequency axis, said apparatus comprising:

means for determining a phase difference between phases of the same carrier in different symbols;

M-PSK decision device for determining a frequency offset by eliminating phase shift uncertainties related to the transmitted information from said phase difference; and

means for performing a feedback correction of said frequency deviation based on said determined frequency offset.

28. (Currently Amended) An apparatus for performing a fine frequency synchronization compensating for a carrier frequency deviation from an oscillator frequency, for a multi-carrier demodulation system capable of carrying out a differential phase decoding of multi-carrier modulated signals, said signals comprising a plurality of symbols, each symbol being [defined by phase differences between simultaneous carriers having different frequencies]differentially coded in the direction of the frequency axis, said apparatus comprising:

means for determining respective phases of the same carrier in different symbols;

M-PSK decision device for eliminating phase shift uncertainties related to the transmitted information from said phases to determine respective phase deviations;

means for determining a frequency offset by determining a phase difference between said phase deviations;

means for performing a feedback correction of said frequency deviation based on said determined frequency offset.

29. (Previously Presented) The apparatus according to claim 27, further comprising:

means for determining an averaged frequency offset by averaging determined frequency offsets of a plurality of carriers, wherein

said means for performing a feedback correction performs said feedback correction of said frequency deviation based on said averaged frequency offset.

30. (Previously Presented) The apparatus according to claim 28, further comprising:

means for determining an averaged frequency offset by averaging determined frequency offsets of a plurality of carriers, wherein

said means for performing a feedback correction performs said feedback correction of said frequency deviation based on said averaged frequency offset.

31. (Previously Presented) The apparatus according to claim 27, wherein said means for determining a phase difference comprises means for determining a phase difference between phases of the same carrier in symbols which are adjacent in the time axis direction.

32. (Currently Amended) [The apparatus according to claim 28,] <u>An apparatus for performing a fine frequency synchronization compensating for a carrier frequency deviation from an oscillator frequency, for a multi-carrier demodulation system capable of carrying out a differential phase decoding of</u>

multi-carrier modulated signals, said signals comprising a plurality of symbols, each symbol being defined by phase differences between simultaneous carriers having different frequencies, said apparatus comprising:

means for determining respective phases of the same carrier in different symbols;

M-PSK decision device for eliminating phase shift uncertainties related to the transmitted information from said phases to determine respective phase deviations;

means for determining a frequency offset by determining a phase difference between said phase deviations;.

means for performing a feedback correction of said frequency deviation based on said determined frequency offset;

wherein said means for determining respective phases comprises means for determining respective phases of the same carrier in symbols which are adjacent in the time axis direction.

33. (Previously Presented) The apparatus according to claim 27, wherein said means for performing a feedback correction of said frequency deviation comprises a numerical controlled oscillator and a complex multiplier.

34. (Previously Presented) The apparatus according to claim 33, wherein said means for performing a feedback correction of said frequency deviation further comprises a low path filter preceding said numerical controlled oscillator.

## REMARKS

Should the Examiner have any questions, the Examiner is invited to contact the undersigned at the telephone number indicated below.

Respectfully Submitted,

Stacey J. Longanecker
Attorney for Applicant
Reg. No. 33,952

Roylance, Abrams, Berdo & Goodman, L.L.P.
1300 19th Street, N.W., Suite 600
Washington, D.C. 20036
(202) 659-9076

Dated: 18 May, 2005

**PATENT APPLICATION FEE DETERMINATION RECORD**
Effective December 8, 2004

09/673210

## CLAIMS AS FILED - PART I

| | (Column 1) | (Column 2) |
|---|---|---|
| TOTAL CLAIMS | | |
| FOR | NUMBER FILED | NUMBER EXTRA |
| TOTAL CHARGEABLE CLAIMS | minus 20= | |
| INDEPENDENT CLAIMS | minus 3 = | |
| MULTIPLE DEPENDENT CLAIM PRESENT | | ☐ |

* If the difference in column 1 is less than zero, enter "0" in column 2

SMALL ENTITY TYPE ☐ OR OTHER THAN SMALL ENTITY

| SMALL ENTITY RATE | FEE | OR | OTHER THAN SMALL ENTITY RATE | FEE |
|---|---|---|---|---|
| BASIC FEE | | OR | BASIC FEE | |
| X$ 25= | | OR | X$50= | |
| X100= | | OR | X200= | |
| +180= | | OR | +360= | |
| TOTAL | | OR | TOTAL | |

## CLAIMS AS AMENDED - PART II

4/26/05

| AMENDMENT A | (Column 1) CLAIMS REMAINING AFTER AMENDMENT | | (Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR | (Column 3) PRESENT EXTRA |
|---|---|---|---|---|
| Total | * 16 | Minus | ** 20 | = 0 |
| Independent | * 5 | Minus | *** 4 | = 1 |
| FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM | | | | ☐ |

| SMALL ENTITY RATE | ADDITIONAL FEE | OR | OTHER THAN SMALL ENTITY RATE | ADDITIONAL FEE |
|---|---|---|---|---|
| X$ 25= | | OR | X$50= | 0 |
| X100= | | OR | X200= | 200 |
| +180= | | OR | +360= | |
| TOTAL ADDIT. FEE | | OR | TOTAL ADDIT. FEE | 200 |

5/18/05

| AMENDMENT B | (Column 1) CLAIMS REMAINING AFTER AMENDMENT | | (Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR | (Column 3) PRESENT EXTRA |
|---|---|---|---|---|
| Total | * 16 | Minus | ** 20 | = |
| Independent | * 5 | Minus | *** 5 | = |
| FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM | | | | ☐ |

| SMALL ENTITY RATE | ADDITIONAL FEE | OR | OTHER THAN SMALL ENTITY RATE | ADDITIONAL FEE |
|---|---|---|---|---|
| X$ 25= | | OR | X$50= | |
| X100= | | OR | X200= | |
| +180= | | OR | +360= | |
| TOTAL ADDIT. FEE | | OR | TOTAL ADDIT. FEE | |

| AMENDMENT C | (Column 1) CLAIMS REMAINING AFTER AMENDMENT | | (Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR | (Column 3) PRESENT EXTRA |
|---|---|---|---|---|
| Total | * | Minus | ** | = |
| Independent | * | Minus | *** | = |
| FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM | | | | ☐ |

| SMALL ENTITY RATE | ADDITIONAL FEE | OR | OTHER THAN SMALL ENTITY RATE | ADDITIONAL FEE |
|---|---|---|---|---|
| X$ 25= | | OR | X$50= | |
| X100= | | OR | X200= | |
| +180= | | OR | +360= | |

| | | | | | | |
|---|---|---|---|---|---|---|
| S215 | 1 | "375"/.ccls. and (((inverse adj2 phase) and antenna) and ((printed or circuit) adj board)) and @ad<"19991130" | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2004/05/25 13:31 |
| S216 | 1 | (lipp-stefan.in.) and (fine adj frequency adj synchroniz$5) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 09:24 |
| S217 | 0 | (ebehlim-ernst.in.) and (fine adj frequency adj synchroniz$5) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 09:25 |
| S218 | 0 | (buchholz-albert.in.) and (fine adj frequency adj synchroniz$5) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 09:25 |
| S219 | 0 | (gerhaeuser-heing.in.) and (fine adj frequency adj synchroniz$5) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 09:25 |
| S220 | 1 | (badri-sabah.in.) and (fine adj frequency adj synchroniz$5) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 09:26 |
| S221 | 0 | ((fraunhofer adj2 gesellschaft adj zur adj foerderung adj der adj angewandten.as.) and ((multi adj2 carrier transmission) or ofdm)) and (fine adj frequency adj synchroniz$5) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 09:34 |
| S222 | 27 | ((multi adj2 carrier transmission) or mcm or ofdm) and (fine adj frequency adj synchroniz$5) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 09:41 |
| S223 | 7 | S222 and ((frequency adj2 (offset or deviation)) adj2 (correct$3 or compensat$3 or mitigat$3)) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 09:43 |
| S224 | 7 | S223 and ad@<"19980414" | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 10:07 |
| S225 | 27 | ((multi adj2 carrier transmission) or mcm or ofdm) and (fine adj frequency adj synchroniz$5) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 10:06 |
| S226 | 7 | S225 and ((frequency adj2 (offset or deviation)) adj2 (correct$3 or compensat$3 or mitigat$3)) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 10:08 |

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|---|---|---|---|---|---|---|
| S227 | 0 | S226 and @ad<"19980414" | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 10:07 |
| S228 | 0 | S226 and @ad<"19980414" | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 10:08 |
| S229 | 1188 | ((frequency adj2 (offset or deviation)) adj2 (correct$3 or compensat$3 or mitigat$3)) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 10:08 |
| S230 | 22 | S229 and (fine adj2 synchroniz$5) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 10:09 |
| S231 | 1 | S230 and (differential adj2 decod$3) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 11:36 |
| S232 | 1 | S231 and phase | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 10:11 |
| S233 | 1191 | ((frequency adj2 (offset or deviation)) adj2 (correct$3 or compensat$3 or mitigat$3)) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 12:40 |
| S234 | 22 | S233 and (fine adj2 synchroniz$5) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 12:42 |
| S235 | 0 | S234 and (differential adj2 phase adj2 decod$3) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 11:41 |
| S236 | 0 | S233 and (differential adj2 phase adj2 decod$3) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 11:41 |
| S237 | 1 | S234 and (differential adj2 decod$3) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 12:41 |
| S238 | 1 | S237 and phase | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 11:51 |

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|---|---|---|---|---|---|---|
| S239 | 0 | S238 and (feedback and (m adj2 psk)) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 11:51 |
| S240 | 0 | S238 and (feedback ) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 12:31 |
| S241 | 39 | differential adj2 phase adj2 decod$3 | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 12:31 |
| S242 | 0 | S233 and (differential adj2 phase adj2 decod$3) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 12:46 |
| S243 | 3 | S241 and (fine adj2 synchroniz$5) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 12:31 |
| S244 | 2 | S243 and @ad<"19980414" | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 12:32 |
| S245 | 1 | 370/480.ccls. and (differential adj2 phase adj2 decod$3) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 12:36 |
| S246 | 0 | S245 and (feedback and (m adj2 psk)) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 12:35 |
| S247 | 1 | 375/332.ccls. and (differential adj2 phase adj2 decod$3) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 12:35 |
| S248 | 1 | (differential adj2 phase adj2 decod$3) and feedback and (m adj2 psk) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 12:38 |
| S249 | 0 | S248 and ((frequency adj2 (offset or deviation)) adj2 (correct$3 or compensat$3 or mitigat$3)) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 12:37 |
| S250 | 0 | S233 and ((differential adj2 phase adj2 decod$3) and feedback and (m adj2 psk)) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 12:41 |

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|---|---|---|---|---|---|---|
| S251 | 0 | S241 and ((frequency adj2 (offset or deviation)) adj2 (correct$3 or compensat$3 or mitigat$3)) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 12:40 |
| S252 | 7 | S233 and ((phase adj2 (offset or difference or deviation)) and feedback and (m adj2 psk)) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 12:41 |
| S253 | 6 | S252 and @ad<"19980414" | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 12:41 |
| S254 | 0 | S253 and (fine adj2 synchroniz$5) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 07:26 |
| S255 | 1 | S253 and (differential adj2 decod$3) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/04 12:59 |
| S256 | 0 | (fine adj2 synchroniz$5) and (phase adj2 (shift$3 or offset or deviation)) and (m adj2 psk) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 07:28 |
| S257 | 41 | (frequency adj2 synchroniz$5) and (phase adj2 (shift$3 or offset or deviation)) and (m adj2 psk) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 07:28 |
| S258 | 17 | S257 and (fine and course) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 07:30 |
| S262 | 41 | (frequency adj2 synchroniz$5) and (phase adj2 (shift$3 or offset or deviation)) and (m adj2 psk) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 07:36 |
| S263 | 17 | S262 and (fine and course) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 07:31 |
| S264 | 6 | S263 and (differential adj2 cod$3) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 07:31 |
| S265 | 4 | S264 and @ad<"19980414" | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 07:37 |

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|---|---|---|---|---|---|---|
| S266 | 1 | 370/480.ccls. and (phase adj2 (shift$3 or offset or deviation)) and (m adj2 psk) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 07:36 |
| S267 | 29 | (fine adj2 synchroniz$5) same (phase adj2 (shift$3 or offset or deviation)) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 07:38 |
| S268 | 0 | S267 and (m adj2 psk) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 08:48 |
| S269 | 5 | S267 and ( psk) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 07:37 |
| S270 | 5 | S269 and @ad<"19980414" | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 08:49 |
| S271 | 199 | (fine adj2 synchroniz$5) and (phase adj2 (shift$3 or offset or deviation)) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 07:40 |
| S272 | 0 | S271 and (m adj2 psk) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 07:39 |
| S273 | 103 | (frequency adj2 (offset or deviation)) and (m adj2 psk) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 07:40 |
| S274 | 18 | S273 and (frequency adj2 synchroniz$5) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 07:40 |
| S275 | 14 | S274 and (phase adj2 (shift$3 or offset or deviation)) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 07:40 |
| S276 | 5 | S275 and @ad<"19980414" | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 07:46 |
| S277 | 2 | synchroniz$5 with (differential adj2 phase adj2 decod$3) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 08:46 |

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|---|---|---|---|---|---|---|
| S278 | 1 | wo92/05646.ptpn. | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 11:06 |
| S279 | 127 | fine adj2 frequency adj2 estimat$3 | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 11:42 |
| S280 | 83 | S279 and (phase adj2 (shift$3 or difference or deviation or drift$1)) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 08:48 |
| S281 | 5 | S280 and (m adj2 psk) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 08:48 |
| S282 | 1 | S281 and @ad<"19980414" | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 08:49 |
| S284 | 0 | S283 and (numerical adj2 oscillator) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/01/05 11:07 |
| S286 | 3 | (fraunhofer adj2 gesellschaft adj zur adj foerderung adj der adj angewandten) and (mcm or ofdm) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/07/20 16:43 |
| S287 | 0 | S286 and (multi adj2 carrier adj2 demodulat$3) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/07/20 16:43 |
| S288 | 0 | (ebehlim adj2 ernst.in.) and (fine adj frequency adj synchroniz$5) and (multi adj2 carrier adj2 demodulat$3) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/07/20 16:43 |
| S289 | 1 | (lipp adj2 stefan) and (fine adj frequency adj synchroniz$5) and (multi adj2 carrier adj2 demodulat$3) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/07/20 16:46 |
| S290 | 15 | "9205646" | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/07/20 16:46 |
| S291 | 0 | (buchholz adj2 albert.in.) and (fine adj frequency adj synchroniz$5) and (multi adj2 carrier adj2 demodulat$3) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/07/20 17:52 |

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|---|---|---|---|---|---|---|
| S29 2 | 0 | (gerhaeuser adj2 heing.in.) and (fine adj frequency adj synchroniz$5) and (multi adj2 carrier adj2 demodulat$3) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/07/20 17:52 |
| S29 3 | 1 | (badri adj2 sabah) and (fine adj frequency adj synchroniz$5) and (multi adj2 carrier adj2 demodulat$3) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/07/20 17:53 |
| S29 4 | 1 | (badri adj2 sabah) and (fine adj frequency adj synchroniz$5) and ((multi adj2 carrier adj2 demodulat$3) or (mcm)) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/07/20 17:53 |
| S29 5 | 1 | (badri adj2 sabah.in.) and (fine adj frequency adj synchroniz$5) and ((multi adj2 carrier adj2 demodulat$3) or (mcm)) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/07/20 17:53 |
| S29 6 | 0 | 375/332.ccls. and (fine adj frequency adj synchroniz$5) and (multi adj2 carrier adj2 demodulat$3) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/07/20 17:54 |
| S29 7 | 0 | 370/210.ccls. and (fine adj frequency adj synchroniz$5) and (multi adj2 carrier adj2 demodulat$3) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/07/20 17:55 |
| S29 8 | 6 | 370/210.ccls. and (multi adj2 carrier adj2 demodulat$3) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/07/20 17:55 |
| S29 9 | 0 | S298 and ((differential$3 adj2 cod$3) with frequency) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/07/20 17:55 |
| S30 0 | 0 | S298 and ((differential$3 adj2 cod$3) near3 frequency) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/07/20 17:56 |
| S30 1 | 0 | "375332".ccls. and ((differential$3 adj2 cod$3) near3 frequency) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/07/20 17:56 |
| S30 2 | 0 | "375/332".ccls. and ((differential$3 adj2 cod$3) near3 frequency) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/07/20 17:56 |
| S30 3 | 2 | "370/210".ccls. and ((differential$3 adj2 cod$3) near3 frequency) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/07/20 17:58 |

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|---|---|---|---|---|---|---|
| S30 4 | 0 | "370".ccls. and ((differential$3 adj2 cod$3) near3 frequency) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/07/20 17:59 |
| S30 5 | 47 | ((differential$3 adj2 cod$3) near3 frequency) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/07/20 17:59 |
| S30 6 | 0 | S305 and (multi adj2 carrier adj2 demodulat$3) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/07/20 18:00 |
| S30 7 | 2 | S305 and (multi adj2 carrier ) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/07/20 18:00 |

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|---|---|---|---|---|---|---|
| S12 0 | 0 | 375/200.ccls. and mpsk | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2003/11/14 17:19 |
| S12 1 | 21 | fine adj frequency adj synchroniz$5 same ((mcm) or multi adj2 carrier or frequency or channel$1 or bin$1) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2004/05/23 13:45 |
| S12 2 | 21 | (fine adj frequency adj synchroniz$5) same ((mcm) or multi adj2 carrier or frequency or channel$1 or bin$1) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2004/05/23 13:22 |
| S12 3 | 1 | ((fine adj frequency adj synchroniz$5) same ((mcm) or multi adj2 carrier or frequency or channel$1 or bin$1)) and (differential adj phase adj decod$3) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2004/05/23 13:25 |
| S12 4 | 1 | wo92/05646.ptpn. | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2004/05/23 13:26 |
| S12 5 | 9 | ((fine adj frequency adj synchroniz$5) same ((mcm) or multi adj2 carrier or frequency or channel$1 or bin$1)) and (phase adj (difference or offset)) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2004/05/23 13:26 |
| S12 6 | 9 | ((fine adj frequency adj synchroniz$5) same ((mcm) or multi adj2 carrier or frequency or channel$1 or bin$1)) and (phase adj (difference or offset$1 or deviation$1)) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2004/05/23 13:26 |
| S12 7 | 8 | (((fine adj frequency adj synchroniz$5) same ((mcm) or multi adj2 carrier or frequency or channel$1 or bin$1)) and (phase adj (difference or offset$1 or deviation$1))) and (frequency adj (difference or offset$1 or deviation$1)) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2004/05/23 13:27 |
| S12 8 | 1 | ((((fine adj frequency adj synchroniz$5) same ((mcm) or multi adj2 carrier or frequency or channel$1 or bin$1)) and (phase adj (difference or offset$1 or deviation$1))) and (frequency adj (difference or offset$1 or deviation$1))) and (feedback adj correct$3) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2004/05/23 13:27 |

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| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 09/673,270 | 11/29/2000 | Ernst Eberlein | 41001 | 3590 |

7590 08/10/2005

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| EXAMINER | |
|---|---|
| WARE, CICELY Q | |
| **ART UNIT** | **PAPER NUMBER** |
| 2634 | |

DATE MAILED: 08/10/2005

Please find below and/or attached an Office communication concerning this application or proceeding.

| Office Action Summary | Application No. | Applicant(s) |
| --- | --- | --- |
| | 09/673,270 | EBERLEIN ET AL. |
| | **Examiner** | **Art Unit** |
| | Cicely Ware | 2634 |

*-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --*

**Period for Reply**

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

**Status**

1)☒ Responsive to communication(s) filed on *26 April 2005*.

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

**Disposition of Claims**

4)☒ Claim(s) *19-34* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) *32* is/are allowed.

6)☒ Claim(s) *19,20,22-31,33 and 34* is/are rejected.

7)☒ Claim(s) *21* is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

**Application Papers**

9)☐ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *26 April 2005* is/are: a)☒ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

**Priority under 35 U.S.C. §§ 119 and 120**

12)☐ 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:

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)).

* See the attached detailed Office action for a list of the certified copies not received.

13)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application) since a specific reference was included in the first sentence of the specification or in an Application Data Sheet. 37 CFR 1.78.

a) ☐ The translation of the foreign language provisional application has been received.

14)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121 since a specific reference was included in the first sentence of the specification or in an Application Data Sheet. 37 CFR 1.78.

**Attachment(s)**

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO-1449) Paper No(s) _____.
4) ☐ Interview Summary (PTO-413) Paper No(s). _____.
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other:

## DETAILED ACTION

### *Response to Arguments*

1. Applicant's arguments filed 4/26/2005 have been fully considered but they are not persuasive. Applicant asserts on Pg. 8 of REMARKS that Gledhill et al. discloses OFDM signals differentially coded in the direction of the time axis. However Examiner asserts that in Table 1 Gledhill et al. in fact discloses the signals differentially coded in the frequency domain.. Therefore examiner maintains the original rejection.

### *Claim Rejections - 35 USC § 102*

2. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

3. Claims 19, 20, 22-31, 33, 34 are rejected under 35 U.S.C. 102(b) as being anticipated by Gledhill et al. (previously cited).

(1) With regard to claim 19, Gledhill et al. discloses in (Fig. 1A, 1B) a method performing a fine frequency synchronization compensating for a carrier frequency deviation from an oscillator frequency in a multi-carrier demodulation system of the type capable of carrying out a differential phase decoding of multi-carrier modulated signals, said signals comprising a plurality of symbols, each symbol being differentially coded in the direction of the frequency axis (Table 1), said method comprising the steps of:

determining a phase difference between phases of the same carrier in different symbols, determining a frequency offset by eliminating phase shift uncertainties related to the transmitted information from said phase difference making use of a decision device; performing a feedback correction (Fig. 4) of said carrier frequency deviation based on said determined frequency offset (abstract, col. 1, lines 21-26, col. 2, lines 30-39, 41-43, col. 3, lines 2-5, col. 4, lines 30-46, col. 5, lines 1-9, 16-22, 30-41, col. 6, lines 43-46, 54-56, 62-64, col. 8, lines 53-62, col. 9, lines, 59-63, col. 12, lines 51-55, col. 15, lines 3-18).

(2) With regard to claim 20, claim 20 inherits all the limitations of claim 19. Gledhill et al. further discloses determining respective phase of the same carrier in different symbols; eliminating phase shift uncertainties related to the transmitted information from said phases to determine respective phase deviations making use of a decision device; determining frequency offset by determining a phase difference between said phase deviations (abstract, col. 3, lines 47-59, col. 9, lines 26-30, 59-63, col. 11, lines 3-20, 41-48, col. 12, lines 51-55).

(3) With regard to claim 22, claim 22 inherits all the limitations of claim 20. Gledhill et al. further discloses wherein steps a, b and c are performed for a plurality of carriers in said symbols, an averaged frequency offset is determined by averaging said determined frequency offsets of said plurality of carriers, and said feedback correction of said frequency deviation is performed based on said averaged frequency offset (col. 4, lines 64-68, col. 8, lines 15-32, col. 9, lines 58-63).

(4) With regard to claim 23, claim 23 inherits all the limitations of claim 19. Gledhill et al. further discloses the step of determining a phase difference between phases of the same carrier in symbols, which are adjacent in the time axis direction (col. 10, lines 33-34, 54-56, col. 11, lines 3-6).

(5) With regard to claim 24, claim 24 inherits all the limitations of claim 19. Gledhill et al. further discloses the step of eliminating phase shift uncertainties corresponding to M-ary phase shifts (col. 2, lines 51-68, col. 3, lines 1-5, col. 4, lines 30-36).

(6) With regard to claim 25, claim 25 inherits all the limitations of claim 20. Gledhill et al. further discloses the step of determining respective phases of the same carrier in symbols, which are adjacent in the time axis direction (col. 3, lines 47-49, col. 8, lines 1-5, col. 10, lines 33-34, 54-56, col. 11, lines 3-6).

(7) With regard to claim 26, claim 26 inherits all the limitations of claim 20. Gledhill et al. further discloses the step of eliminating M-ary phase shifts (col. 2, lines 51-68, 1-5, col. 4, lines 30-46).

(8) With regard to claim 27, claim 27 inherits all the limitations of claim 19.

(9) With regard to claim 28, claim 28 inherits all the limitations of claim 20.

(10) With regard to claim 29, claim 29 inherits all the limitations of claims 27 and 22.

(11) With regard to claim 30, claim 30 inherits all the limitations of claims 28 and 22.

(12) With regard to claim 31, claim 31 inherits all the limitations of claim 27 and 23.

(13) With regard to claim 33, claim 33 inherits all the limitations of claim 27. Gledhill et al. further discloses in (Fig. 4 (4, 7) wherein said means for performing a feedback correction of said frequency deviation comprises a numerical controlled oscillator and complex multiplier (col. 7, lines 58-68).

(14) With regard to claim 34, claim 34 inherits all the limitations of claim 33. Gledhill et al. further discloses in (Fig. 4 (2, 7) wherein said means for performing a feedback correction of said frequency deviation further comprises a low path filter preceding said controlled oscillator (col. 7, lines 58-68).

## ***Allowable Subject Matter***

4. Claim 21 is objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims. The following is a statement of reasons for the indication of allowable subject matter: The instant application discloses a method of performing a fine frequency synchronization compensating for a carrier frequency deviation form an oscillator frequency in a multi-carrier demodulation system. Prior art references show similar methods but fail to teach: **"an averaged frequency offset is determined by averaging said determined frequency offsets of said plurality of carriers, and said feedback correction of said frequency deviation is performed based on said averaged frequency offset**", as in claim 21

5. Claim 32 is allowed.

6. The following is a statement of reasons for the indication of allowable subject matter: The instant application discloses a method of performing a fine frequency synchronization compensating for a carrier frequency deviation form an oscillator frequency in a multi-carrier demodulation system. Prior art references show similar methods but fail to teach: **"means for determining respective phases comprises means for determining respective phases of the same carrier in symbols which are adjacent in the time axis direction"**, as in claim 32.

***Conclusion***

7. **THIS ACTION IS MADE FINAL.** Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Cicely Ware whose telephone number is 703-305-8326. The examiner can normally be reached on Monday – Friday, 8-5.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Stephen Chin can be reached on 703-305-4714. The fax phone numbers for the organization where this application or proceeding is assigned are 703-872-9314 for regular communications and 703-872-9314 for After Final communications.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is 703-305-3900.

*Cicely Ware*

cqw
August 6, 2005

STEPHEN CHIN
SUPERVISORY PATENT EXAMINER
TECHNOLOGY CENTER 2600

| *Notice of References Cited* | Application/Control No. 09/673,270 | Applicant(s)/Patent Under Reexamination EBERLEIN ET AL. | |
|---|---|---|---|
| | Examiner Cicely Ware | Art Unit 2634 | Page 1 of 1 |

**U.S. PATENT DOCUMENTS**

| * | | Document Number Country Code-Number-Kind Code | Date MM-YYYY | Name | Classification |
|---|---|---|---|---|---|
| | A | US-5,345,440 | 09-1994 | Gledhill et al. | 370/210 |
| | B | US- | | | |
| | C | US- | | | |
| | D | US- | | | |
| | E | US- | | | |
| | F | US- | | | |
| | G | US- | | | |
| | H | US- | | | |
| | I | US- | | | |
| | J | US- | | | |
| | K | US- | | | |
| | L | US- | | | |
| | M | US- | | | |

**FOREIGN PATENT DOCUMENTS**

| * | | Document Number Country Code-Number-Kind Code | Date MM-YYYY | Country | Name | Classification |
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**NON-PATENT DOCUMENTS**

| * | | Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages) |
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*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

## Search Notes

| Application No. | Applicant(s) |
|---|---|
| 09/673,270 | EBERLEIN ET AL. |
| **Examiner** | **Art Unit** |
| Cicely Ware | 2634 |

### SEARCHED

| Class | Subclass | Date | Examiner |
|---|---|---|---|
| 370 | 480 | 7/20 | CW |
| 375 | 332 | 7/20 | CW |
| 370 | 210 | 7/20 | CW |
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### SEARCH NOTES (INCLUDING SEARCH STRATEGY)

| | DATE | EXMR |
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U.S. Patent and Trademark Office

Part of Paper No. 2

## *Index of Claims*

| Application No. | Applicant(s) |
|---|---|
| 09/673,270 | EBERLEIN ET AL. |
| **Examiner** | **Art Unit** |
| Cicely Ware | 2634 |

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Appl. No. 09/673,270
Amdt. dated November 10, 2005
Reply to final Office Action mailed August 10, 2005

41001

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

| | |
|---|---|
| In re Application of: | : |
| **Ernst Eberlein et al.** | : Group Art Unit: 2634 |
| Serial No.: **09/673,270** | : Examiner: C. Ware |
| Filed: **November 29, 2000** | : Confirmation No.: 3590 |
| For: **METHOD AND APPARATUS FOR FINE FREQUENCY SYNCHRONIZATION IN MULTI-CARRIER DEMODULATION SYSTEMS** | : |

**AMENDMENT**

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

In response to the final office action dated August 10, 2005, please amend the above-captioned application as indicated on the following pages.

Amendments to the claims begin on page 2 herein.

Remarks begin on page 5 herein.

AMENDMENTS TO THE CLAIMS:

Claims 1-18 (Cancelled)

19. (Currently Amended) A method of performing a fine frequency synchronization compensating for a carrier frequency deviation from an oscillator frequency in a multi-carrier demodulation system capable of carrying out a differential phase decoding of multi-carrier modulated signals, said signals comprising a plurality of symbols, each symbol being differentially coded in the direction of the frequency axis, said method comprising the steps of:

a) determining a phase difference between phases of the same carrier in different symbols;

b) determining a frequency offset by eliminating phase shift uncertainties related to the transmitted information from said phase difference making use of a M-PSK decision device; and

c) performing a feedback correction of said carrier frequency deviation based on said determined frequency offset, wherein

said steps a) and b) are performed for a plurality of carriers in said symbols,

an averaged frequency offset is determined by averaging said determined frequency offsets of said plurality of carriers, and

said feedback correction of said frequency deviation is performed based on said averaged frequency offset.

Claims 20 -22.(Cancelled)

23. (Previously Presented) The method according to claim 19, wherein said step a) comprises the step of determining a phase difference between phases of the same carrier in symbols which are adjacent in the time axis direction.

24. (Previously Presented) The method according to claim 19, wherein said step b) comprises the step of eliminating phase shift uncertainties corresponding to M-ary phase shifts.

Claim 25 - 29 (Cancelled)

30. (Currently Amended) The apparatus according to claim [[28]]32, further comprising:

means for determining an averaged frequency offset by averaging determined frequency offsets of a plurality of carriers, wherein

said means for performing a feedback correction performs said feedback correction of said frequency deviation based on said averaged frequency offset.

31. (Cancelled)

32. (Currently Amended) An apparatus for performing a fine frequency synchronization compensating for a carrier frequency deviation from an oscillator frequency, for a multi-carrier demodulation system capable of carrying out a differential phase decoding of multi-carrier modulated signals, said signals comprising a plurality of symbols, each symbol being defined by

phase differences between simultaneous carriers having different frequencies, said apparatus comprising:

means for determining respective phases of the same carrier in different symbols;

M-PSK decision device for eliminating phase shift uncertainties related to the transmitted information from said phases to determine respective phase deviations;

means for determining a frequency offset by determining a phase difference between said phase deviations; and

means for performing a feedback correction of said frequency deviation based on said determined frequency offset;

wherein said means for determining respective phases comprises means for determining respective phases of the same carrier in symbols which are adjacent in the time axis direction.

33. (Currently Amended) The apparatus according to claim [[27]]32, wherein said means for performing a feedback correction of said frequency deviation comprises a numerical controlled oscillator and a complex multiplier.

34. (Previously Presented) The apparatus according to claim 33, wherein said means for performing a feedback correction of said frequency deviation further comprises a low path filter preceding said numerical controlled oscillator.

## REMARKS

By the present amendment, claims 19-34 are pending. In the Office Action, claim 21 is indicated as being allowable if rewritten in independent form. Accordingly, independent claim 19 has been amended to include the limitations of claim 21. Applicants also note with appreciation the allowance of claim 32, which has been amended to correct a typographical error. Claims 30 and 33 have been amended to depend from allowed claim 32. Claims 20-22, 25-29 and 31 are cancelled.

In view of the above, it is believed that the application, including claims 19, 23-24, 30 and 32-34, is in condition for allowance and notice to this effect is respectfully requested. Should the Examiner have any questions, the Examiner is invited to contact the undersigned at the telephone number indicated below.

Respectfully Submitted,

Stacey J. Longanecker
Attorney for Applicant
Reg. No. 33,952

Roylance, Abrams, Berdo & Goodman, L.L.P.
1300 19th Street, N.W., Suite 600
Washington, D.C. 20036
(202) 659-9076

Dated: 10 November, 2005

**PATENT APPLICATION FEE DETERMINATION RECORD**
Effective December 8, 2004

09/673 270

## CLAIMS AS FILED - PART I

| | (Column 1) | (Column 2) |
|---|---|---|
| TOTAL CLAIMS | | |
| FOR | NUMBER FILED | NUMBER EXTRA |
| TOTAL CHARGEABLE CLAIMS | minus 20= | |
| INDEPENDENT CLAIMS | minus 3 = | |
| MULTIPLE DEPENDENT CLAIM PRESENT | | ☐ |

* If the difference in column 1 is less than zero, enter "0" in column 2

| SMALL ENTITY TYPE ☐ RATE | FEE | OR | OTHER THAN SMALL ENTITY RATE | FEE |
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| BASIC FEE | | OR | BASIC FEE | |
| X$ 25= | | OR | X$50= | |
| X100= | | OR | X200= | |
| +180= | | OR | +360= | |
| TOTAL | | OR | TOTAL | |

## CLAIMS AS AMENDED - PART II

**AMENDMENT A** 4/26/05

| | (Column 1) CLAIMS REMAINING AFTER AMENDMENT | | (Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR | (Column 3) PRESENT EXTRA |
|---|---|---|---|---|
| Total | * 16 | Minus | ** 20 | = 0 |
| Independent | * 5 | Minus | *** 4 | = 1 |
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| SMALL ENTITY RATE | ADDITIONAL FEE | OR | OTHER THAN SMALL ENTITY RATE | ADDITIONAL FEE |
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| X$ 25= | | OR | X$50= | 0 |
| X100= | | OR | X200= | 200 |
| +180= | | OR | +360= | |
| TOTAL ADDIT. FEE | | OR | TOTAL ADDIT. FEE | 200 |

**AMENDMENT B** 5/18/05

| | (Column 1) CLAIMS REMAINING AFTER AMENDMENT | | (Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR | (Column 3) PRESENT EXTRA |
|---|---|---|---|---|
| Total | * 16 | Minus | ** 20 | = — |
| Independent | * 5 | Minus | *** 5 | = — |
| FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM | | | | ☐ |

| RATE | ADDITIONAL FEE | OR | RATE | ADDITIONAL FEE |
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| X$ 25= | | OR | X$50= | |
| X100= | | OR | X200= | |
| +180= | | OR | +360= | |
| TOTAL ADDIT. FEE | | OR | TOTAL ADDIT. FEE | |

**AMENDMENT C** 11/10/05

| | (Column 1) CLAIMS REMAINING AFTER AMENDMENT | | (Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR | (Column 3) PRESENT EXTRA |
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| Total | * 7 | Minus | ** 16 | = — |
| Independent | * 2 | Minus | *** 5 | = — |
| FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM | | | | ☐ |

| RATE | ADDITIONAL FEE | OR | RATE | ADDITIONAL FEE |
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| X$ 25= | | OR | X$50= | |
| X100= | | OR | X200= | |
| +180= | | OR | +360= | |

| Ref # | Hits | Search Query | DBs | Default Operator | Plurals | Time Stamp |
|---|---|---|---|---|---|---|
| L1 | 257 | 370/210.ccls. and (mcm or (multi adj2 carrier adj2 transmission) or ofdm) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/11/21 13:22 |
| L2 | 4 | 1 and ((mean or averag$3) near3 (frequency adj2 (offset or delay$3))) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/11/21 13:22 |
| L3 | 22317 | (mcm or (multi adj2 carrier adj2 transmission) or ofdm) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/11/21 13:23 |
| L4 | 49 | 3 and ((mean or averag$3) near3 (frequency adj2 (offset or delay$3))) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/11/21 13:22 |
| L5 | 55 | 3 and ((mean or averag$3) near3 (frequency adj2 (offset or delay$3 or deviat$3))) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/11/21 13:23 |
| L6 | 0 | 5 and (feedback near3 (frequency adj2 (offset or delay$3 or deviat$3))) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/11/21 13:24 |
| L7 | 10 | 375/332.ccls. and (mcm or (multi adj2 carrier adj2 transmission) or ofdm) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/11/21 13:23 |
| L8 | 1 | 7 and ((mean or averag$3) near3 (frequency adj2 (offset or delay$3 or deviat$3))) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/11/21 13:24 |
| L9 | 0 | 8 and (feedback near3 (frequency adj2 (offset or delay$3 or deviat$3))) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/11/21 13:24 |
| L10 | 0 | 7 and (feedback near3 ((mean or averag$3) near3 (frequency adj2 (offset or delay$3 or deviat$3)))) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/11/21 13:24 |
| L11 | 0 | 1 and (feedback near3 ((mean or averag$3) near3 (frequency adj2 (offset or delay$3 or deviat$3)))) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/11/21 13:24 |
| L12 | 0 | 3 and (feedback near3 ((mean or averag$3) near3 (frequency adj2 (offset or delay$3 or deviat$3)))) | US-PGPUB; USPAT; EPO; JPO; DERWENT | OR | OFF | 2005/11/21 13:24 |

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United States Patent and Trademark Office
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# NOTICE OF ALLOWANCE AND FEE(S) DUE

7590 01/23/2006

John E Holmes
Roylance Abrams Berdo & Goodman
Suite 600
1300 19th Street NW
Washington, DC 20036

| EXAMINER | |
|---|---|
| WARE, CICELY Q | |
| ART UNIT | PAPER NUMBER |
| 2634 | |

DATE MAILED: 01/23/2006

| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 09/673,270 | 11/29/2000 | Ernst Eberlein | 41001 | 3590 |

TITLE OF INVENTION: METHOD AND APPARATUS FOR FINE FREQUENCY SYNCHRONIZATION IN MULTI-CARRIER DEMODULATION SYSTEMS

| APPLN. TYPE | SMALL ENTITY | ISSUE FEE | PUBLICATION FEE | TOTAL FEE(S) DUE | DATE DUE |
|---|---|---|---|---|---|
| nonprovisional | NO | $1400 | $0 | $1400 | 04/24/2006 |

**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 REFLECTS A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE APPLIED IN THIS APPLICATION. THE PTOL-85B (OR AN EQUIVALENT) MUST BE RETURNED WITHIN THIS PERIOD EVEN IF NO FEE IS DUE OR THE APPLICATION WILL BE REGARDED AS ABANDONED.**

**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 should be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). Even if the fee(s) have already been paid, Part B - Fee(s) Transmittal should be completed and returned. 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.

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)

7590 01/23/2006

John E Holmes
Roylance Abrams Berdo & Goodman
Suite 600
1300 19th Street NW
Washington, DC 20036

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. |
|---|---|---|---|---|
| 09/673,270 | 11/29/2000 | Ernst Eberlein | 41001 | 3590 |

TITLE OF INVENTION: METHOD AND APPARATUS FOR FINE FREQUENCY SYNCHRONIZATION IN MULTI-CARRIER DEMODULATION SYSTEMS

| APPLN. TYPE | SMALL ENTITY | ISSUE FEE | PUBLICATION FEE | TOTAL FEE(S) DUE | DATE DUE |
|---|---|---|---|---|---|
| nonprovisional | NO | $1400 | $0 | $1400 | 04/24/2006 |

| EXAMINER | ART UNIT | CLASS-SUBCLASS |
|---|---|---|
| WARE, CICELY Q | 2634 | 375-332000 |

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 enclosed:

☐ Issue Fee
☐ Publication Fee (No small entity discount permitted)
☐ Advance Order - # of Copies __________

4b. Payment of Fee(s):

☐ A check in the amount of the fee(s) is enclosed.
☐ Payment by credit card. Form PTO-2038 is attached.
☐ The Director is hereby authorized by charge the required fee(s), 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).

The Director of the USPTO is requested to apply the Issue Fee and Publication Fee (if any) or to re-apply any previously paid issue fee to the application identified above.
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
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www.uspto.gov

| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 09/673,270 | 11/29/2000 | Ernst Eberlein | 41001 | 3590 |

7590 01/23/2006

John E Holmes
Roylance Abrams Berdo & Goodman
Suite 600
1300 19th Street NW
Washington, DC 20036

| EXAMINER | |
|---|---|
| WARE, CICELY Q | |
| **ART UNIT** | **PAPER NUMBER** |
| 2634 | |

DATE MAILED: 01/23/2006

**Determination of Patent Term Extension under 35 U.S.C. 154 (b)**
(application filed after June 7, 1995 but prior to May 29, 2000)

The Patent Term Extension is 0 day(s). Any patent to issue from the above-identified application will include an indication of the 0 day extension on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Extension 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 (703) 305-8283.

| Notice of Allowability | Application No. 09/673,270 | Applicant(s) EBERLEIN ET AL. | |
|---|---|---|---|
| | Examiner Cicely Ware | Art Unit 2634 | |

***-- 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 *Amendment filed 11/10/2005*.

2. ☒ The allowed claim(s) is/are *19, 23, 24, 30, 32, 33, 34, renumbered as 1-3, 5, 4, 7, 6 respectively*.

3. ☐ 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.**

4. ☐ 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.

5. ☐ 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).**

6. ☐ 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-1449 or PTO/SB/08), Paper No./Mail Date _____
4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
5. ☐ Notice of Informal Patent Application (PTO-152)
6. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
7. ☒ Examiner's Amendment/Comment
8. ☒ Examiner's Statement of Reasons for Allowance
9. ☐ Other _____.

## EXAMINER'S AMENDMENT

1. An examiner's amendment to the record appears below. Should the changes and/or additions be unacceptable to applicant, an amendment may be filed as provided by 37 CFR 1.312. To ensure consideration of such an amendment, it MUST be submitted no later than the payment of the issue fee.

The application has been amended as follows:

**I. SPECIFICATION**

a. Pg. 1, line 6, insert "This application is a 371 of PCT/EP98/02184 04/14/1998"

## REASONS FOR ALLOWANCE

1. The following is an examiner's statement of reasons for allowance: The following is a statement of reasons for the indication of allowable subject matter: The instant application discloses a method of performing a fine frequency synchronization compensating for a carrier frequency deviation form an oscillator frequency in a multi-carrier demodulation system. Prior art references show similar methods but fail to teach: **"feedback correction of said frequency deviation is performed based on said averaged frequency offset"**, as in claim 19; **"means for determining respective phases comprises means for determining respective phases of the same carrier in symbols which are adjacent in the time axis direction"**, as in claim 32.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

### *Conclusion*

2. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Cicely Ware whose telephone number is 571-272-3047. The examiner can normally be reached on Monday – Friday, 8-5.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Stephen Chin can be reached on 571-272-3056. The fax phone numbers for the organization where this application or proceeding is assigned are 703-872-9314 for regular communications and 703-872-9314 for After Final communications.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is 703-305-3900.

*Cicely Ware*

cqw
December 9, 2005

STEPHEN CHIN
SUPERVISORY PATENT EXAMINER
TECHNOLOGY CENTER 2600

Sheet 1 of 1

| Form PTO-1449 U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE<br>INFORMATION DISCLOSURE CITATION<br>(Use several sheets if necessary) | ATTY. DOCKET NO.<br>41001 | SERIAL NO.<br>09/673,270 |
|---|---|---|
| | APPLICANT<br>Ernst Eberlein et al. | |
| | FILING DATE<br>October 13, 2000 | GROUP<br>2631 |

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U.S. PATENT DOCUMENTS

| EXAMINER INITIAL | | DOCUMENT NUMBER | DATE | NAME | CLASS | SUBCLASS | FILING DATE IF APPROPRIATE |
|---|---|---|---|---|---|---|---|
| lw | | 5 7 7 1 2 2 4 | 06/1998 | Seki et al. | 370 | 206 | |
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FOREIGN PATENT DOCUMENTS

| | | DOCUMENT NUMBER | DATE | COUNTRY | CLASS | SUBCLASS | TRANSLATION YES | TRANSLATION NO |
|---|---|---|---|---|---|---|---|---|
| lw | | 8 2 6 5 2 9 3 | 10/1996 | Japan | — | — | X | |
| lw | | 1 0 4 1 9 9 1 | 02/1998 | Japan | — | — | X | |
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OTHER DOCUMENTS (including Author, Title, Date, Pertinent Pages, Etc.)

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| EXAMINER [signature] | DATE CONSIDERED 1/13/03 |
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*EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP 609; Draw Line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

| Form PTO-1449 U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE<br>INFORMATION DISCLOSURE CITATION<br>(Use several sheets if necessary) | ATTY. DOCKET NO. 41001 | SERIAL NO. 09/673,270 |
|---|---|---|
| | APPLICANT Ernst Eberlein et al. | |
| | FILING DATE October 13, 2000 | GROUP |

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U.S. PATENT DOCUMENTS

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FOREIGN PATENT DOCUMENTS

| | | DOCUMENT NUMBER | DATE | COUNTRY | CLASS | SUBCLASS | TRANSLATION YES | NO |
|---|---|---|---|---|---|---|---|---|
| CW | | 9 2 0 5 6 4 6 | 04/1992 | WIPO | — | — | | |
| CW | | 0 8 2 2 6 8 2 | 02/1998 | European Pat. Off. | — | — | | |
| CW | | 9 8 0 0 9 4 6 | 01/1998 | WIPO | — | — | | |

OTHER DOCUMENTS (including Author, Title, Date, Pertinent Pages, Etc.)

| | | |
|---|---|---|
| CW | | Keller and Hanzo; "Orthogonal Frequency Division Multiplex Synchronisation Techniques for Wireless Local Area Networks", *IEEE International Symposium on Personal, Indoor and Mobile Radio Communications*, pp. 963-967 (October 1996). |
| CW | | Moose, "A Technique for Orthogonal Frequency Division Multiplexing Frequency Offset Correction", *IEEE Transactions on Communications*, Vol. 42, No. 10, pp. 2908-2914 (October 1994). |
| CW | | Classen and Meyr, "Synchronization Algorithms for an OFDM System for Mobile Communication", Condierung für Quelle, Kanal and Übertragung: ITG-Fachbericht, pp. 105-114 (October 1994). |
| CW | | Schmidl and Cox, "Low-Overhead, Low-Complexity [Burst] Synchronization for OFDM", *Proc. IEEE Int. Conf. on Commun.*, pp. 1301-1306 (1996). |
| CW | | Zou and Wu, "COFDM: An Overview", *IEEE Transactions on Broadcasting*, Vol. 41, No. 1, pp. 1-8 (March 1995). |
| CW | | Palacherla, "DSP-µP Routine Computes Magnitude", *EDN Electrical Design News*, Vol. 34, No. 22, pp. 225-226 (October 1989). |
| CW | | Adams and Brady, "Magnitude Approximations for Microprocessor Implementation", *IEEE Micro*, Vol. 3, No. 5, pp. 27-31 (October 1983). |

| EXAMINER [signature] | DATE CONSIDERED 11/13/03 |
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*EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP 609; Draw Line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

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PATENT & TRADEMARK OFFICE

Appl. No. 09/673,270
Amdt. dated November 10, 2005
Reply to final Office Action mailed August 10, 2005

41001

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

| | |
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| In re Application of: | : |
| | : |
| **Ernst Eberlein et al.** | : Group Art Unit: 2634 |
| | : |
| Serial No.: **09/673,270** | : Examiner: C. Ware |
| | : |
| Filed: **November 29, 2000** | : Confirmation No.: 3590 |
| | : |
| For: **METHOD AND APPARATUS FOR FINE FREQUENCY SYNCHRONIZATION IN MULTI-CARRIER DEMODULATION SYSTEMS** | : |

## AMENDMENT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

In response to the final office action dated August 10, 2005, please amend the above-captioned application as indicated on the following pages.

Amendments to the claims begin on page 2 herein.

Remarks begin on page 5 herein.

| **Issue Classification** | Application/Control No.<br>09/673,270 | Applicant(s)/Patent under Reexamination<br>EBERLEIN ET AL. | |
|---|---|---|---|
| | Examiner<br>Cicely Ware | Art Unit<br>2634 | |

# ISSUE CLASSIFICATION

| ORIGINAL | | CROSS REFERENCE(S) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| CLASS | SUBCLASS | CLASS | SUBCLASS (ONE SUBCLASS PER BLOCK) | | | | | | |
| 375 | 332 | 370 | 210 | | | | | | |
| INTERNATIONAL CLASSIFICATION | | | | | | | | | |
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| Cicely Ware 11/21/2005<br>(Assistant Examiner) (Date) | [signature] 2634 12/10/05<br>STEPHEN CHIN<br>SUPERVISORY PATENT EXAMINER<br>TECHNOLOGY CENTER 2600<br>(Primary Examiner) (Date) | Total Claims Allowed: 7 |
| [signature] 1/19/06<br>(Legal Instruments Examiner) (Date) | | O.G. Print Claim(s): 1 — O.G. Print Fig.: 1 |

☐ 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 |
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| 5 | 30 | | 60 | | 90 | | 120 | | 150 | | 180 | | 210 |

| *Search Notes* | Application/Control No. 09/673,270 | Applicant(s)/Patent under Reexamination EBERLEIN ET AL. | |
|---|---|---|---|
| | Examiner Cicely Ware | Art Unit 2634 | |

**SEARCHED**

| Class | Subclass | Date | Examiner |
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**INTERFERENCE SEARCHED**

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**SEARCH NOTES (INCLUDING SEARCH STRATEGY)**

| | DATE | EXMR |
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| 375/332 | 11/21 | CW |
| 370/210 | 11/21 | CW |
| EAST | 11/21 | CW |
| Inventor Search | 11/21 | CW |
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| *Index of Claims* | Application/Control No. 09/673,270 | Applicant(s)/Patent under Reexamination EBERLEIN ET AL. |
|---|---|---|
| | Examiner Cicely Ware | Art Unit 2634 |

| √ | Rejected | – | (Through numeral) Cancelled | N | Non-Elected | A | Appeal |
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| Claim | | Date | | | | | | | | |
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## 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)

7590 01/23/2006

John E Holmes
Roylance Abrams Berdo & Goodman
Suite 600
1300 19th Street NW
Washington, DC 20036

OIPE IAP34 APR 21 2006 PATENT & TRADEMARK OFFICE

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.

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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. |
|---|---|---|---|---|
| 09/673,270 | 11/29/2000 | Ernst Eberlein | 41001 | 3590 |

TITLE OF INVENTION: METHOD AND APPARATUS FOR FINE FREQUENCY SYNCHRONIZATION IN MULTI-CARRIER DEMODULATION SYSTEMS

04/24/2006 CNGUYEN1 00000033 09673270

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| APPLN. TYPE | SMALL ENTITY | ISSUE FEE | PUBLICATION FEE | TOTAL FEE(S) DUE | DATE DUE |
|---|---|---|---|---|---|
| nonprovisional | NO | $1400 | $0 | $1400 | 04/24/2006 |

| EXAMINER | ART UNIT | CLASS-SUBCLASS |
|---|---|---|
| WARE, CICELY Q | 2634 | 375-332000 |

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 Roylance, Abrams, Berdo &
   2 Goodman, L.L.P.
   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: Fraunhofer-Gesellschaft zur Foerderung der angewandten Forschung e.V.,

(B) RESIDENCE: (CITY and STATE OR COUNTRY): Muenchen, Germany

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 enclosed:
- ☒ Issue Fee
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- ☒ A check in the amount of the fee(s) is enclosed.
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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).

The Director of the USPTO is requested to apply the Issue Fee and Publication Fee (if any) or to re-apply any previously paid issue fee to the application identified above.
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Authorized Signature: Stacey J Longanecker Date: April 21, 2006

Typed or printed name: Stacey J. Longanecker Registration No. 33,952