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PTO/SB/01 (11_00)
Approved for use through 10/31/2002. OMB 0651-0032
U.S. Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE

UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 CFR 1.53(b))

Attorney Docket No.	BP4637
First Inventor	Joonsuk Kim
Title	REDUCED FEEDBACK FOR BEAMFORMING IN A WIRELESS COMMUNICATION
Express Mail Label No.	EV725285492US

APPLICATION ELEMENTS
See MPEP chapter 600 concerning utility patent application contents

ADDRESS TO: Assistant Commissioner for Patents
Box Patent Application
Washington, DC 20231

1. [X] Fee Transmittal Form (e.g. PTO/SB/17) *(submit an original and a duplicate for fee processing)*
2. [ ] Applicant claims small entity status. See 37 CFR 1.27.
3. [X] Specification [Total Pages 29]
   (preferred arrangement set forth below)
   - -Descriptive title of the invention
   - -Cross Reference to Related Applications
   - -Statement Regarding Fed sponsored R&D
   - -Reference to sequence listing, a table, or a computer program listing appendix
   - -Background of the Invention
   - -Brief Summary of the Invention
   - -Brief Description of the Drawings *(if filed)*
   - -Detailed Description
   - -Claim(s)
   - -Abstract of the Disclosure
4. [X] Drawing(s) (35 U.S.C. 113) [Total Pages 6]
5. Oath or Declaration [Total Pages 2]
   a. [X] Newly executed (original or copy)
   b. [ ] Copy from a prior application (37 CFR 1.63 (d)) *(for continuation/divisional with Box 18 completed)*
      i. [ ] DELETION OF INVENTOR(S)
      Signed statement attached deleting inventor(s) named in the prior application, see 37 CFR 1.63(d)(2) and 1.33(b).
6. [ ] Application Data Sheet. See 37 CFR 1.76
7. [ ] CD-ROM or CD-R in duplicate, large table or Computer Program *(Appendix)*
8. Nucleotide and/or Amino Acid Sequence Submission *(if applicable, all necessary)*
   a. [ ] Computer Readable Form (CRF)
   b. Specification Sequence Listing on:
      i. [ ] CD-ROM or CD-R (2 copies); or
      ii. [ ] paper
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ACCOMPANYING APPLICATION PARTS

9. [ ] Assignment Papers (cover sheet & documents(s))
10. [ ] 37 CFR 3.73(b) Statement *(when there is an ssignee)* [ ] Power of Attorney
11. [ ] English Translation Document *(if applicable)*
12. [X] Information Disclosure Statement (IDS)/PTO-1449 [ ] Copies of IDS Citations
13. [ ] Preliminary Amendment
14. [X] Return Receipt Postcard (MPEP 503) *(Should be specifically itemized)*
15. [ ] Certified Copy of Priority Document(s) *(if foreign priority is claimed)*
16. [ ] Request and Certification under 35 U.S.C. 122 (b)(2)(B)(i). Applicant must attach form PTO/SB/35 or its equivalent.
17. [ ] Other: ....

18. If a CONTINUING APPLICATION, check appropriate box, and supply the requisite information below and in a preliminary amendment, or in an Application Data Sheet under 37 CFR 1.76:
[ ] Continuation [ ] Divisional [ ] Continuation-in-part (CIP) of prior application No: ____________ ____________
Prior application information: Examiner_ Group Art Unit: ____________

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19. CORRESPONDENCE ADDRESS

[X] Customer Number or Bar Code Label 51,472 (insert customer no. or attach bar code label here) or [ ] Correspondence address below

Name	Timothy W. Markison				
Address	P.O. Box 160727				
City	Austin	State	TX	Zip Code	78716-0727
Country	USA	Telephone	(512) 342-0612	FAX	(512) 342-1674

Name (Print/Type)	Timothy W. Markison	Registration No. (Atty/Agent)	33,534
Signature	/Timothy W. Markison/	Date	6/28/2005

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062805 01789 U.S. PTO

FEE TRANSMITTAL for FY 2005

Complete if Known	
Application Number	
Filing Date	
First Named Inventor	Joonsuk Kim
Examiner Name	
Group Art Unit	
Atty Docket No.	BP4637

☐ Applicant claims small entity status

TOTAL AMOUNT OF PAYMENT ($) $1000.00

METHOD OF PAYMENT (check all that apply)

☐ Check ☒ Credit card ☐ Money Order ☐ None ☐ Other:

☒ Deposit Account Deposit Account Number 50-2126 Deposit Account Name Garlick, Harrison & Markison

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FEE CALCULATION

1. BASIC FILING, SEARCH, AND EXAMINATION FEES

Application Type	FILING FEE	SEARCH FEE	EXAMINATION FEE	TOTAL
Utility	300.00	500.00	200.00	1000.00
Design				
Plant				
Reissue				
Provisional				

2. EXCESS CLAIM FEES

	No. of Claims		Relavent # of Claims		Per Claim Fee		Total Fee
Total	16	-20 =	0	X	50	=	0.00
Independent	3	-3 =	0	X	200	=	0.00
Multiple Dependent				X	360	=	0.00

3. APPLICATION SIZE FEE

Total Sheets		Extra Sheets		Extra sheet multiplier	Fee	Size fee due
35	- 100 =	0	/50 =	0	250.00	0.00

4. OTHER FEE(S)

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Name *(Print Type)*	Timothy W. Markison	Registration No. *(Attorney Agent)*	33,534	Telephone	(512) 342-0612
Signature	/Timothy W. Markison/			Date	6/28/2005

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113261 U.S. PTO 11/168793 062805

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Signature	/Timothy W. Markison/			Date	6/28/2005

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DOCKET NO. BP 4637

TITLE OF THE INVENTION

REDUCED FEEDBACK FOR BEAMFORMING IN A WIRELESS COMMUNICATION

CROSS REFERENCE TO RELATED PATENTS

This invention is claiming priority under 35 USC § 119(e) to a provisionally filed patent application having the same title as the present patent application, a filing date of 4/21/2005, and an application number of 60/673,451.

BACKGROUND OF THE INVENTION

TECHNICAL FIELD OF THE INVENTION

This invention relates generally to wireless communication systems and more particularly to wireless communications using beamforming.

DESCRIPTION OF RELATED ART

Communication systems are known to support wireless and wire lined communications between wireless and/or wire lined communication devices. Such communication systems range from national and/or international cellular telephone systems to the Internet to point-to-point in-home wireless networks. Each type of communication system is constructed, and hence operates, in accordance with one or more communication standards. For instance, wireless communication systems may operate in accordance with one or more standards including, but not limited to, IEEE 802.11, Bluetooth, advanced mobile phone services (AMPS), digital AMPS, global system for mobile communications (GSM), code division multiple access (CDMA), local multi-point distribution systems (LMDS), multi-channel-multi-point distribution systems (MMDS), and/or variations thereof.

Depending on the type of wireless communication system, a wireless communication device, such as a cellular telephone, two-way radio, personal digital assistant (PDA), personal computer (PC), laptop computer, home entertainment equipment, et cetera communicates directly or indirectly with other wireless communication devices. For direct communications (also known as point-to-point communications), the participating wireless communication devices tune their receivers and transmitters to the same channel or channels (e.g., one of the plurality of radio frequency (RF) carriers of the wireless communication system) and communicate over that channel(s). For indirect wireless communications, each wireless communication device communicates directly with an associated base station (e.g., for cellular services) and/or an associated access point (e.g., for an in-home or in-building wireless network) via an assigned channel. To complete a communication connection between the wireless communication devices, the associated base stations and/or associated access points communicate with each other directly, via a system controller, via the public switch telephone network, via the Internet, and/or via some other wide area network.

For each wireless communication device to participate in wireless communications, it includes a built-in radio transceiver (i.e., receiver and transmitter) or is coupled to an associated radio transceiver (e.g., a station for in-home and/or in-building wireless communication networks, RF modem, etc.). As is known, the receiver is coupled to the antenna and includes a low noise amplifier, one or more intermediate frequency stages, a filtering stage, and a data recovery stage. The low noise amplifier receives inbound RF signals via the antenna and amplifies then. The one or more intermediate frequency stages mix the amplified RF signals with one or more local oscillations to convert the amplified RF signal into baseband signals or intermediate frequency (IF) signals. The filtering stage filters the baseband signals or the IF signals to attenuate unwanted out of band signals to produce filtered signals. The data recovery stage recovers raw data from the filtered signals in accordance with the particular wireless communication standard.

As is also known, the transmitter includes a data modulation stage, one or more intermediate frequency stages, and a power amplifier. The data modulation stage converts raw data into baseband signals in accordance with a particular wireless communication standard. The one or more intermediate frequency stages mix the baseband signals with one or more local oscillations to produce RF signals. The power amplifier amplifies the RF signals prior to transmission via an antenna.

In many systems, the transmitter will include one antenna for transmitting the RF signals, which are received by a single antenna, or multiple antennas, of a receiver. When the receiver includes two or more antennas, the receiver will select one of them to receive the incoming RF signals. In this instance, the wireless communication between the transmitter and receiver is a single-output-single-input (SISO) communication, even if the receiver includes multiple antennas that are used as diversity antennas (i.e., selecting one of them to receive the incoming RF signals). For SISO wireless communications, a transceiver includes one transmitter and one receiver. Currently, most wireless local area networks (WLAN) that are IEEE 802.11, 802.11a, 802,11b, or 802.11g employ SISO wireless communications.

Other types of wireless communications include single-input-multiple-output (SIMO), multiple-input-single-output (MISO), and multiple-input-multiple-output (MIMO). In a SIMO wireless communication, a single transmitter processes data into radio frequency signals that are transmitted to a receiver. The receiver includes two or more antennas and two or more receiver paths. Each of the antennas receives the RF signals and provides them to a corresponding receiver path (e.g., LNA, down conversion module, filters, and ADCs). Each of the receiver paths processes the received RF signals to produce digital signals, which are combined and then processed to recapture the transmitted data.

For a multiple-input-single-output (MISO) wireless communication, the transmitter includes two or more transmission paths (e.g., digital to analog converter, filters, up-conversion module, and a power amplifier) that each converts a corresponding portion of baseband signals into RF signals, which are transmitted via corresponding antennas to a receiver. The receiver includes a single receiver path that receives the multiple RF signals from the transmitter. In this instance, the receiver uses beam forming to combine the multiple RF signals into one signal for processing.

For a multiple-input-multiple-output (MIMO) wireless communication, the transmitter and receiver each include multiple paths. In such a communication, the transmitter parallel processes data using a spatial and time encoding function to produce two or more streams of data. The transmitter includes multiple transmission paths to convert each stream of data into multiple RF signals. The receiver receives the multiple RF signals via multiple receiver paths that recapture the streams of data utilizing a spatial and time decoding function. The recaptured streams of data are combined and subsequently processed to recover the original data.

To further improve wireless communications, transceivers may incorporate beamforming. In general, beamforming is a processing technique to create a focused antenna beam by shifting a signal in time or in phase to provide gain of the signal in a desired direction and to attenuate the signal in other directions. Prior art papers (1) Digital beamforming basics (antennas) by Steyskal, Hans, Journal of Electronic Defense, 7/1/1996; (2) Utilizing Digital Downconverters for Efficient Digital Beamforming, by Clint Schreiner, Red River Engineering, no publication date; and (3) Interpolation Based Transmit Beamforming for MIMO-OFMD with Partial Feedback, by Jihoon Choi and Robert W. Heath, University of Texas, Department of Electrical and Computer Engineering, Wireless Networking and Communications Group, September, 13, 2003 discuss beamforming concepts.

In order for a transmitter to properly implement beamforming (i.e., determine the beamforming matrix [V]), it needs to know properties of the channel over which the wireless communication is conveyed. Accordingly, the receiver must provide feedback information for the transmitter to determine the properties of the channel. One approach for sending feedback from the receiver to the transmitter is for the receiver to determine the channel response (H) and to provide it as the feedback information. An issue with this approach is the size of the feedback packet, which may be so large that, during the time it takes to send it to the transmitter, the response of the channel has changed.

To reduce the size of the feedback, the receiver may decompose the channel using singular value decomposition (SVD) and send information relating only to a calculated value of the transmitter's beamforming matrix (V) as the feedback information. In this approach, the receiver calculates (V) based on H = UDV*, where H is the channel response, D is a diagonal matrix, and U is a receiver unitary matrix. While this approach reduces the size of the feedback information, its size is still an issue for a MIMO wireless communication. For instance, in a 2x2 MIMO wireless communication, the feedback needs four elements that are all complex Cartesian coordinate values [V11 V12; V21 V22]. In general, Vik = aik + j*bik, where aik and bik are values between [-1, 1]. Thus, with 1 bit express per each element for each of the real and imaginary components, aik and bik can be either – ½ or ½, which requires 4x2x1 = 8 bits per tone. With 4 bit expressions per each element of V(f) in an orthogonal frequency division multiplexing (OFDM) 2 x 2 MIMO wireless communication, the number of bits required is 1728 per tone (e.g., 4*2*54*4 = 1728, 4 elements per tone, 2 bits for real and imaginary components per tone, 54 data tones per frame, and 4 bits per element), which requires overhead for a packet exchange that is too large for practical applications.

Therefore, a need exists for a method and apparatus for reducing beamforming feedback information for wireless communications.

BRIEF SUMMARY OF THE INVENTION

The present invention is directed to apparatus and methods of operation that are further described in the following Brief Description of the Drawings, the Detailed Description of the Invention, and the claims. Other features and advantages of the present invention will become apparent from the following detailed description of the invention made with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

Figure 1 is a schematic block diagram of a wireless communication system in accordance with the present invention;

Figure 2 is a schematic block diagram of a wireless communication device in accordance with the present invention;

Figure 3 is a schematic block diagram of another wireless communication device in accordance with the present invention;

Figure 4 is a schematic block diagram of baseband transmit processing in accordance with the present invention;

Figure 5 is a schematic block diagram of baseband receive processing in accordance with the present invention; and

Figure 6 is a schematic block diagram of a beamforming wireless communication in accordance with the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Figure 1 is a schematic block diagram illustrating a communication system 10 that includes a plurality of base stations and/or access points 12, 16, a plurality of wireless communication devices 18-32 and a network hardware component 34. Note that the network hardware 34, which may be a router, switch, bridge, modem, system controller, et cetera provides a wide area network connection 42 for the communication system 10. Further note that the wireless communication devices 18-32 may be laptop host computers 18 and 26, personal digital assistant hosts 20 and 30, personal computer hosts 24 and 32 and/or cellular telephone hosts 22 and 28. The details of the wireless communication devices will be described in greater detail with reference to Figure 2.

Wireless communication devices 22, 23, and 24 are located within an independent basic service set (IBSS) area and communicate directly (i.e., point to point). In this configuration, these devices 22, 23, and 24 may only communicate with each other. To communicate with other wireless communication devices within the system 10 or to communicate outside of the system 10, the devices 22, 23, and/or 24 need to affiliate with one of the base stations or access points 12 or 16.

The base stations or access points 12, 16 are located within basic service set (BSS) areas 11 and 13, respectively, and are operably coupled to the network hardware 34 via local area network connections 36, 38. Such a connection provides the base station or access point 12 16 with connectivity to other devices within the system 10 and provides connectivity to other networks via the WAN connection 42. To communicate with the wireless communication devices within its BSS 11 or 13, each of the base stations or access points 12-16 has an associated antenna or antenna array. For instance, base station or access point 12 wirelessly communicates with wireless communication devices 18 and 20 while base station or access point 16 wirelessly communicates with wireless communication devices 26 – 32. Typically, the wireless communication devices register with a particular base station or access point 12, 16 to receive services from the communication system 10.

Typically, base stations are used for cellular telephone systems and like-type systems, while access points are used for in-home or in-building wireless networks (e.g., IEEE 802.11 and versions thereof, Bluetooth, and/or any other type of radio frequency based network protocol). Regardless of the particular type of communication system, each wireless communication device includes a built-in radio and/or is coupled to a radio.

Figure 2 is a schematic block diagram illustrating a wireless communication device that includes the host device 18-32 and an associated radio 60. For cellular telephone hosts, the radio 60 is a built-in component. For personal digital assistants hosts, laptop hosts, and/or personal computer hosts, the radio 60 may be built-in or an externally coupled component.

As illustrated, the host device 18-32 includes a processing module 50, memory 52, a radio interface 54, an input interface 58, and an output interface 56. The processing module 50 and memory 52 execute the corresponding instructions that are typically done by the host device. For example, for a cellular telephone host device, the processing module 50 performs the corresponding communication functions in accordance with a particular cellular telephone standard.

The radio interface 54 allows data to be received from and sent to the radio 60. For data received from the radio 60 (e.g., inbound data), the radio interface 54 provides the data to the processing module 50 for further processing and/or routing to the output interface 56. The output interface 56 provides connectivity to an output display device such as a display, monitor, speakers, et cetera such that the received data may be displayed. The radio interface 54 also provides data from the processing module 50 to the radio 60. The processing module 50 may receive the outbound data from an input device such as a keyboard, keypad, microphone, et cetera via the input interface 58 or generate the data itself. For data received via the input interface 58, the processing module 50 may perform a corresponding host function on the data and/or route it to the radio 60 via the radio interface 54.

Radio 60 includes a host interface 62, digital receiver processing module 64, an analog-to-digital converter 66, a high pass and low pass filter module 68, an IF mixing down conversion stage 70, a receiver filter 71, a low noise amplifier 72, a transmitter/receiver switch 73, a local oscillation module 74, memory 75, a digital transmitter processing module 76, a digital-to-analog converter 78, a filtering/gain module 80, an IF mixing up conversion stage 82, a power amplifier 84, a transmitter filter module 85, a channel bandwidth adjust module 87, and an antenna 86. The antenna 86 may be a single antenna that is shared by the transmit and receive paths as regulated by the Tx/Rx switch 73, or may include separate antennas for the transmit path and receive path. The antenna implementation will depend on the particular standard to which the wireless communication device is compliant.

The digital receiver processing module 64 and the digital transmitter processing module 76, in combination with operational instructions stored in memory 75, execute digital receiver functions and digital transmitter functions, respectively. The digital receiver functions include, but are not limited to, digital intermediate frequency to baseband conversion, demodulation, constellation demapping, decoding, and/or descrambling. The digital transmitter functions include, but are not limited to, scrambling, encoding, constellation mapping, modulation, and/or digital baseband to IF conversion. The digital receiver and transmitter processing modules 64 and 76 may be implemented using a shared processing device, individual processing devices, or a plurality of processing devices. Such a processing device may be a microprocessor, micro-controller, digital signal processor, microcomputer, central processing unit, field programmable gate array, programmable logic device, state machine, logic circuitry, analog circuitry, digital circuitry, and/or any device that manipulates signals (analog and/or digital) based on operational instructions. The memory 75 may be a single memory device or a plurality of memory devices. Such a memory device may be a read-only memory, random access memory, volatile memory, non-volatile memory, static memory, dynamic memory, flash memory, and/or any device that stores digital information. Note that when the processing module 64 and/or 76 implements one or more of its functions via a state machine, analog circuitry, digital circuitry, and/or logic circuitry, the memory storing the corresponding operational instructions is embedded with the circuitry comprising the state machine, analog circuitry, digital circuitry, and/or logic circuitry.

In operation, the radio 60 receives outbound data 94 from the host device via the host interface 62. The host interface 62 routes the outbound data 94 to the digital transmitter processing module 76, which processes the outbound data 94 in accordance with a particular wireless communication standard (e.g., IEEE 802.11, Bluetooth, et cetera) to produce outbound baseband signals 96. The outbound baseband signals 96 will be digital base-band signals (e.g., have a zero IF) or a digital low IF signals, where the low IF typically will be in the frequency range of one hundred kilohertz to a few megahertz.

The digital-to-analog converter 78 converts the outbound baseband signals 96 from the digital domain to the analog domain. The filtering/gain module 80 filters and/or adjusts the gain of the analog signals prior to providing it to the IF mixing stage 82. The IF mixing stage 82 converts the analog baseband or low IF signals into RF signals based on a transmitter local oscillation 83 provided by local oscillation module 74. The power amplifier 84 amplifies the RF signals to produce outbound RF signals 98, which are filtered by the transmitter filter module 85. The antenna 86 transmits the outbound RF signals 98 to a targeted device such as a base station, an access point and/or another wireless communication device.

The radio 60 also receives inbound RF signals 88 via the antenna 86, which were transmitted by a base station, an access point, or another wireless communication device. The antenna 86 provides the inbound RF signals 88 to the receiver filter module 71 via the Tx/Rx switch 73, where the Rx filter 71 bandpass filters the inbound RF signals 88. The Rx filter 71 provides the filtered RF signals to low noise amplifier 72, which amplifies the signals 88 to produce an amplified inbound RF signals. The low noise amplifier 72 provides the amplified inbound RF signals to the IF mixing module 70, which directly converts the amplified inbound RF signals into an inbound low IF signals or baseband signals based on a receiver local oscillation 81 provided by local oscillation module 74. The down conversion module 70 provides the inbound low IF signals or baseband signals to the filtering/gain module 68. The high pass and low pass filter module 68 filters, based on settings provided by the channel bandwidth adjust module 87, the inbound low IF signals or the inbound baseband signals to produce filtered inbound signals.

The analog-to-digital converter 66 converts the filtered inbound signals from the analog domain to the digital domain to produce inbound baseband signals 90, where the inbound baseband signals 90 will be digital base-band signals or digital low IF signals, where the low IF typically will be in the frequency range of one hundred kilohertz to a few megahertz.. The digital receiver processing module 64, based on settings provided by the channel bandwidth adjust module 87, decodes, descrambles, demaps, and/or demodulates the inbound baseband signals 90 to recapture inbound data 92 in accordance with the particular wireless communication standard being implemented by radio 60. The host interface 62 provides the recaptured inbound data 92 to the host device 18-32 via the radio interface 54.

As one of average skill in the art will appreciate, the wireless communication device of figure 2 may be implemented using one or more integrated circuits. For example, the host device may be implemented on one integrated circuit, the digital receiver processing module 64, the digital transmitter processing module 76 and memory 75 may be implemented on a second integrated circuit, and the remaining components of the radio 60, less the antenna 86, may be implemented on a third integrated circuit. As an alternate example, the radio 60 may be implemented on a single integrated circuit. As yet another example, the processing module 50 of the host device and the digital receiver and transmitter processing modules 64 and 76 may be a common processing device implemented on a single integrated circuit. Further, the memory 52 and memory 75 may be implemented on a single integrated circuit and/or on the same integrated circuit as the common processing modules of processing module 50 and the digital receiver and transmitter processing module 64 and 76.

Figure 3 is a schematic block diagram illustrating a wireless communication device that includes the host device 18-32 and an associated radio 60. For cellular telephone hosts, the radio 60 is a built-in component. For personal digital assistants hosts, laptop hosts, and/or personal computer hosts, the radio 60 may be built-in or an externally coupled component.

As illustrated, the host device 18-32 includes a processing module 50, memory 52, radio interface 54, input interface 58 and output interface 56. The processing module 50 and memory 52 execute the corresponding instructions that are typically done by the host device. For example, for a cellular telephone host device, the processing module 50 performs the corresponding communication functions in accordance with a particular cellular telephone standard.

The radio interface 54 allows data to be received from and sent to the radio 60. For data received from the radio 60 (e.g., inbound data), the radio interface 54 provides the data to the processing module 50 for further processing and/or routing to the output interface 56. The output interface 56 provides connectivity to an output display device such as a display, monitor, speakers, et cetera such that the received data may be displayed. The radio interface 54 also provides data from the processing module 50 to the radio 60. The processing module 50 may receive the outbound data from an input device such as a keyboard, keypad, microphone, et cetera via the input interface 58 or generate the data itself. For data received via the input interface 58, the processing module 50 may perform a corresponding host function on the data and/or route it to the radio 60 via the radio interface 54.

Radio 60 includes a host interface 62, a baseband processing module 100, memory 65, a plurality of radio frequency (RF) transmitters 106 - 110, a transmit/receive (T/R) module 114, a plurality of antennas 81 - 85, a plurality of RF receivers 118 - 120, a channel bandwidth adjust module 87, and a local oscillation module 74. The baseband processing module 100, in combination with operational instructions stored in memory 65, executes digital receiver functions and digital transmitter functions, respectively. The digital receiver functions include, but are not limited to, digital intermediate frequency to baseband conversion, demodulation, constellation demapping, decoding, de-interleaving, fast Fourier transform, cyclic prefix removal, space and time decoding, and/or descrambling. The digital transmitter functions include, but are not limited to, scrambling, encoding, interleaving, constellation mapping, modulation, inverse fast Fourier transform, cyclic prefix addition, space and time encoding, and digital baseband to IF conversion. The baseband processing modules 100 may be implemented using one or more processing devices. Such a processing device may be a microprocessor, micro-controller, digital signal processor, microcomputer, central processing unit, field programmable gate array, programmable logic device, state machine, logic circuitry, analog circuitry, digital circuitry, and/or any device that manipulates signals (analog and/or digital) based on operational instructions. The memory 65 may be a single memory device or a plurality of memory devices. Such a memory device may be a read-only memory, random access memory, volatile memory, non-volatile memory, static memory, dynamic memory, flash memory, and/or any device that stores digital information. Note that when the processing module 100 implements one or more of its functions via a state machine, analog circuitry, digital circuitry, and/or logic circuitry, the memory storing the corresponding operational instructions is embedded with the circuitry comprising the state machine, analog circuitry, digital circuitry, and/or logic circuitry.

In operation, the radio 60 receives outbound data 94 from the host device via the host interface 62. The baseband processing module 64 receives the outbound data 88 and, based on a mode selection signal 102, produces one or more outbound symbol streams 90. The mode selection signal 102 will indicate a particular mode of operation that is compliant with one or more specific modes of the various IEEE 802.11 standards. For example, the mode selection signal 102 may indicate a frequency band of 2.4 GHz, a channel bandwidth of 20 or 22 MHz and a maximum bit rate of 54 megabits-per-second. In this general category, the mode selection signal will further indicate a particular rate ranging from 1 megabit-per-second to 54 megabits-per-second. In addition, the mode selection signal will indicate a particular type of modulation, which includes, but is not limited to, Barker Code Modulation, BPSK, QPSK, CCK, 16 QAM and/or 64 QAM. The mode select signal 102 may also include a code rate, a number of coded bits per subcarrier (NBPSC), coded bits per OFDM symbol (NCBPS), and/or data bits per OFDM symbol (NDBPS). The mode selection signal 102 may also indicate a particular channelization for the corresponding mode that provides a channel number and corresponding center frequency. The mode select signal 102 may further indicate a power spectral density mask value and a number of antennas to be initially used for a MIMO communication.

The baseband processing module 100, based on the mode selection signal 102 produces one or more outbound symbol streams 104 from the outbound data 94. For example, if the mode selection signal 102 indicates that a single transmit antenna is being utilized for the particular mode that has been selected, the baseband processing module 100 will produce a single outbound symbol stream 104. Alternatively, if the mode select signal 102 indicates 2, 3 or 4 antennas, the baseband processing module 100 will produce 2, 3 or 4 outbound symbol streams 104 from the outbound data 94.

Depending on the number of outbound streams 104 produced by the baseband module 10, a corresponding number of the RF transmitters 106 - 110 will be enabled to convert the outbound symbol streams 104 into outbound RF signals 112. In general, each of the RF transmitters 106 – 110 includes a digital filter and upsampling module, a digital to analog conversion module, an analog filter module, a frequency up conversion module, a power amplifier, and a radio frequency bandpass filter. The RF transmitters 106 – 110 provide the outbound RF signals 112 to the transmit/receive module 114, which provides each outbound RF signal to a corresponding antenna 81 - 85.

When the radio 60 is in the receive mode, the transmit/receive module 114 receives one or more inbound RF signals 116 via the antennas 81 – 85 and provides them to one or more RF receivers 118 - 122. The RF receiver 118 – 122, based on settings provided by the channel bandwidth adjust module 87, converts the inbound RF signals 116 into a corresponding number of inbound symbol streams 124. The number of inbound symbol streams 124 will correspond to the particular mode in which the data was received. The baseband processing module 100 converts the inbound symbol streams 124 into inbound data 92, which is provided to the host device 18-32 via the host interface 62.

As one of average skill in the art will appreciate, the wireless communication device of figure 3 may be implemented using one or more integrated circuits. For example, the host device may be implemented on one integrated circuit, the baseband processing module 100 and memory 65 may be implemented on a second integrated circuit, and the remaining components of the radio 60, less the antennas 81 - 85, may be implemented on a third integrated circuit. As an alternate example, the radio 60 may be implemented on a single integrated circuit. As yet another example, the processing module 50 of the host device and the baseband processing module 100 may be a common processing device implemented on a single integrated circuit. Further, the memory 52 and memory 65 may be implemented on a single integrated circuit and/or on the same integrated circuit as the common processing modules of processing module 50 and the baseband processing module 100.

Figure 4 is a schematic block diagram of baseband transmit processing 100-TX within the baseband processing module 100, which includes an encoding module 121, a puncture module 123, a switch, a plurality of interleaving modules 125, 126, a plurality of constellation encoding modules 128, 130, a beamforming module (V) 132, and a plurality of inverse fast Fourier transform (IFFT) modules 134, 136 for converting the outbound data 94 into the outbound symbol stream 104. As one of ordinary skill in the art will appreciate, the baseband transmit processing may include two or more of each of the interleaving modules 125, 126, the constellation mapping modules 128, 130, and the IFFT modules 134, 136. In addition, one of ordinary skill in art will further appreciate that the encoding module 121, puncture module 123, the interleaving modules 124, 126, the constellation mapping modules 128, 130, and the IFFT modules 134, 136 may be function in accordance with one or more wireless communication standards including, but not limited to, IEEE 802.11a, b, g, n.

In one embodiment, the encoding module 121 is operably coupled to convert outbound data 94 into encoded data in accordance with one or more wireless communication standards. The puncture module 123 punctures the encoded data to produce punctured encoded data. The plurality of interleaving modules 125, 126 is operably coupled to interleave the punctured encoded data into a plurality of interleaved streams of data. The plurality of constellation mapping modules 128, 130 is operably coupled to map the plurality of interleaved streams of data into a plurality of streams of data symbols. The beamforming module 132 is operably coupled to beamform, using a unitary matrix having polar coordinates, the plurality of streams of data symbols into a plurality of streams of beamformed symbols. The plurality of IFFT modules 134, 136 is operably coupled to convert the plurality of streams of beamformed symbols into a plurality of outbound symbol streams.

The beamforming module 132 is operably coupled to multiply a beamforming unitary matrix (V) with baseband signals provided by the plurality of constellation mapping modules 128, 130. The beamforming module 132 determines the beamforming unitary matrix V from feedback information from the receiver, wherein the feedback information includes a calculated expression of the beamforming matrix V having polar coordinates. The beamforming module 132 generates the beamforming unitary matrix V to satisfy the conditions of "V*V = VV* = "I", where "I" is an identity matrix of [1 0; 0 1] for 2x2 MIMO wireless communication, is [1 0 0 ;0 1 0; 0 0 1] for 3x3 MIMO wireless communication, or is [1 0 0 0; 0 1 0 0 ; 0 0 1 0; 0 0 0 1] for 4x4 MIMO wireless communication. In this equation, V*V means "conjugate (V) times V" and VV* means "V times conjugate (V)". Note that V may be a 2x2 unitary matrix for a 2x2 MIMO wireless communication, a 3x3 unitary matrix for a 3x3 MIMO wireless communication, and a 4x4 unitary matrix for a 4x4 MIMO wireless communication. Further note that for each column of V, a first row of polar coordinates including real values as references and a second row of polar coordinates including phase shift values.

In one embodiment, the constellation mapping modules 128, 130 function in accordance with one of the IEEE 802.11x standards to provide an OFDM (Orthogonal Frequency Domain Multiplexing) frequency domain baseband signals that includes a plurality of tones, or subcarriers, for carrying data. Each of the data carrying tones represents a symbol mapped to a point on a modulation dependent constellation map. For instance, a 16 QAM (Quadrature Amplitude Modulation) includes 16 constellation points, each corresponding to a different symbol. For an OFDM signal, the beamforming module 132 may regenerate the beamforming unitary matrix V for each tone from each constellation mapping module 128, 130, use the same beamforming unitary matrix for each tone from each constellation mapping module 128, 130, or a combination thereof.

The beamforming unitary matrix varies depending on the number of transmit paths (i.e., transmit antennas - M) and the number of receive paths (i.e., receiver antennas

$\lceil \cos\psi_1 \quad \cos\psi_2 \rceil$

– N) for an MxN MIMO communication. For instance, for a 2x2 MIMO communication, the beamforming unitary matrix may be:

In order to satisfy V*V = I, it needs to satisfy followings.

$$\cos\psi_1 \cos\psi_2 + \sin\psi_1 \sin\psi_2 e^{j(\phi_1-\phi_2)} = 0$$
$$\cos\psi_1 \cos\psi_2 + \sin\psi_1 \sin\psi_2 e^{j(\phi_2-\phi_1)} = 0$$

where i, j = 1, 2; ψ_1, Φ_1, ψ_2, and Φ_2 represent angles of the unit circle, wherein absolute value of $\psi_1 - \psi_2 = \pi/2$ and $\Phi_1 = \Phi_2$ or $\Phi_1 = \Phi_2 + \pi$ and $\psi_1 + \psi_2 = \pi/2$.

Therefore, with Φ_1 and ψ_1, the beamforming module 132 may regenerate V per each tone. For example, With 4-bits expression for angle Φ_1 and 3-bits for angle ψ_1, and 1-bit for the index for #1 or #2 in 54 tones, (i.e., 8-bits per tone) total feedback information may be 8x54/8 = 54bytes. (ψ in $[0, \pi]$, Φ in $[-\pi, \pi]$).

For a 3x3 MIMO communication, the beamforming unitary matrix may be:

$$V = (V)ij = \begin{bmatrix} \cos\psi_1 & \cos\psi_2 & \cos\psi_3 \\ \sin\psi_1 \cos\theta_1 e^{j\phi_{21}} & \sin\psi_2 \cos\theta_2 e^{j\phi_{22}} & \sin\psi_3 \cos\theta_3 e^{j\phi_{23}} \\ \sin\psi_1 \sin\theta_1 e^{j\phi_{31}} & \sin\psi_2 \sin\theta_2 e^{j\phi_{32}} & \sin\psi_3 \sin\theta_3 e^{j\phi_{33}} \end{bmatrix}$$

where i, j = 1, 2, 3; ψ_1, ψ_2, ψ_3, θ_1, θ_2, θ_3, Φ_{21}, Φ_{22}, Φ_{23}, Φ_{31}, Φ_{32}, Φ_{33} represent angles of the unit circle, wherein Diagonal (V*V) = 1s, and wherein:

$$\psi_i = \cos^{-1} V_{1i}, \theta_i = \cos^{-1}\left|\frac{V_{2i}}{\sin\psi_i}\right|$$
$$\phi_{2i} = \angle(V_{2i}), \phi_{3i} = \angle(V_{3i})$$

In this example, with 12 angles, the beamforming module 132 may regenerate V as a 3x3 matrix per tone. With 4-bits for expression for the angles, a 54 tone signal may have feedback information of 324 bytes (e.g., 4x12x54/8).

For a 4x4 MIMO communication, the beamforming unitary matrix may be:

$$V = (V)ij = \begin{bmatrix} \cos\psi_1 \cos\varphi_1 & \cos\psi_2 \cos\varphi_2 & \cos\psi_3 \cos\varphi_3 & \cos\psi_4 \cos\varphi_4 \\ \cos\psi_1 \sin\varphi_1 e^{j\phi_{11}} & \cos\psi_2 \sin\varphi_2 e^{j\phi_{12}} & \cos\psi_3 \sin\varphi_3 e^{j\phi_{13}} & \cos\psi_4 \sin\varphi_4 e^{j\phi_{14}} \\ \sin\psi_1 \cos\theta_1 e^{j\phi_{21}} & \sin\psi_2 \cos\theta_2 e^{j\phi_{22}} & \sin\psi_3 \cos\theta_3 e^{j\phi_{23}} & \sin\psi_4 \cos\theta_4 e^{j\phi_{24}} \\ \sin\psi_1 \sin\theta_1 e^{j\phi_{31}} & \sin\psi_2 \sin\theta_2 e^{j\phi_{32}} & \sin\psi_3 \sin\theta_3 e^{j\phi_{33}} & \sin\psi_4 \sin\theta_4 e^{j\phi_{34}} \end{bmatrix}$$

= [cos(ψ_1) cos(ψ_2); sin(ψ_1)*$e^{j\,\Phi 1}$ sin(ψ_2)*$e^{j\,\Phi 2}$], where i, j = 1, 2, 3, 4; wherein ψ_1, ψ_2, ψ_3, ψ_4, θ_1, θ_2, θ_3, θ_4, φ_1, φ_2, φ_3, φ_4, Φ_{21}, Φ_{22}, Φ_{23}, Φ_{24}, Φ_{31}, Φ_{32}, Φ_{33}, Φ_{33}, Φ_{41}, Φ_{42}, Φ_{43}, Φ_{43} represent angles of the unit circle, wherein Diagonal (V*V) = 1s, and wherein:

$$\psi_i = \cos^{-1}\left(\sqrt{|V_{1i}|^2 + |V_{2i}|^2}\right), \varphi_i = \cos^{-1}\left(\frac{V_{1i}}{\cos\psi_i}\right), \theta_i = \cos^{-1}\left|\frac{V_{3i}}{\sin\psi_i}\right|$$
$$\phi_{1i} = \angle(V_{2i}), \phi_{2i} = \angle(V_{3i}), \phi_{3i} = \angle(V_{4i})$$

In this example, with 24 angles, the beamforming module 132 may regenerate V as a 4x4 matrix per tone. With 4-bits for expression for the angles, a 54 tone signal may have feedback information of 648 bytes (e.g., 4x24x54/8).

The baseband transmit processing 100-TX receives the polar coordinates Φ and ψ from the receiver as feedback information as will described in greater detail with reference to Figure 6.

Figure 5 is a schematic block diagram of baseband receive processing 100-RX that includes a plurality of fast Fourier transform (FFT) modules 140, 142, a beamforming (U) module 144, a plurality of constellation demapping modules 146, 148, a plurality of deinterleaving modules 150, 152, a switch, a depuncture module 154, and a decoding module 156 for converting a plurality of inbound symbol streams 124 into inbound data 92. As one of ordinary skill in the art will appreciate, the baseband receive processing 100-RX may include two or more of each of the deinterleaving modules 150, 152, the constellation demapping modules 146, 148, and the FFT modules 140, 142. In addition, one of ordinary skill in art will further appreciate that the decoding module 156, depuncture module 154, the deinterleaving modules 150, 152, the constellation decoding modules 146, 148, and the FFT modules 140, 142 may be function in accordance with one or more wireless communication standards including, but not limited to, IEEE 802.11a, b, g, n.

In one embodiment, a plurality of FFT modules 140, 142 is operably coupled to convert a plurality of inbound symbol streams 124 into a plurality of streams of beamformed symbols. The inverse beamforming module 144 is operably coupled to inverse beamform, using a unitary matrix having polar coordinates, the plurality of streams of beamformed symbols into a plurality of streams of data symbols. The plurality of constellation demapping modules is operably coupled to demap the plurality of streams of data symbols into a plurality of interleaved streams of data. The plurality of deinterleaving modules is operably coupled to deinterleave the plurality of interleaved streams of data into encoded data. The decoding module is operably coupled to convert the encoded data into inbound data 92.

The beamforming module 144 is operably coupled to multiply a beamforming unitary matrix (U) with baseband signals provided by the plurality of FFT modules 140, 142. The FFT modules 140, 142 function in accordance with one of the IEEE 802.11x standards to provide an OFDM (Orthogonal Frequency Domain Multiplexing) frequency domain baseband signals that includes a plurality of tones, or subcarriers, for carrying data. Each of the data carrying tones represents a symbol mapped to a point on a modulation dependent constellation map. The baseband receive processing 100-RX is further functional to produce feedback information for the transmitter as further described with reference to Figure 6.

Figure 6 is a schematic block diagram of a beamforming wireless communication where H=UDV* (H – represents the channel, U is the receiver beamforming unitary matrix, and V* is the conjugate of the transmitter beamforming unitary matrix. With H = UDV*, y (the received signal) = Hx + N, where x represents the transmitted signals and N represents noise. If z = Vx, then U*y = U*UDV*Vz + U*n = Dz + N.

From this expression, the baseband receive processing 100-RX may readily determine the feedback of V, where V includes polar coordinates. For instance, the receiver may decompose the channel using singular value decomposition (SVD) and send information relating only to a calculated value of the transmitter's beamforming matrix (V) as the feedback information. In this approach, the receiver calculates (V) based on H = UDV*, where H is the channel response, D is a diagonal matrix, and U is a receiver unitary matrix. This approach reduces the size of the feedback information with respect to SVD using Cartesian coordinates. For example, in a 2x2 MIMO wireless communication, the feedback needs four elements that are all complex values [V11 V12; V21 V22] with two angles (ψ and Φ). In general, Vik = aik + j*bik, where aik and bik are values between [-1, 1]. To cover [-1, 1], ψ is in [0, π] and Φ is in [0, 2π]. With π /2 resolutions for angles, ψ needs to be π /4 or 3π/4, i.e., cos(ψ) = 0.707 or -0.707, which requires 1 bit, where Φ needs to be either π/4, 3π/4, 5π/4, 7π/4, i.e., exp(j Φ) = 0.707(1+j), 0.707(1-j), 0.707(-1+j) or 0.707(-1-j), which requires 2 bits. With π/4 resolutions for angles, ψ needs to be π/8, 3π/8, 5π/8 or 7π/8, which requires 2 bits, where Φ needs to be either π/8, 3π/8, 5π/8, 7π/8, 9π/8, 11π/8, 13π/8 or 15π/8, which requires 4 bits. So, for an example of 2x2 system to use 4 bits per tone, it may have 1 bit for ψ, 2 bits for Φ and 1 index bit to determine the relationship between ψ and Φ, such as either ψ1 = ψ2+ π and Φ1+ Φ2 = π/2, or ψ1 = ψ2 and Φ1- Φ2 = π/2.

For the same resolution in Cartesian expression of 4 bits per each element for each of the real and imaginary components, aik and bik, can be within [- ½, ½], it requires 4*2*4 = 32 bits per tone. For OFDM MIMO wireless communications, the number of bits required is 1728 bits for the Cartesian expression. While an angle expression in accordance with the present invention requires 8 bits per tone, which for the same OFDM MIMO wireless communications would require 432 bits. This represents a significant reduction in the overhead needed for packet exchange.

The preceding discussion has presented a method and apparatus for reducing feedback information for beamforming in a wireless communication by using polar coordinates. As one of average skill in the art will appreciate, other embodiments may be derived from the present teachings without deviating from the scope of the claims.

CLAIMS

What is claimed is:

1. A method for reduced feedback for beamforming in a wireless communication, the method comprises:

receiving a baseband signal; and

digitally beamforming the baseband signal using a unitary matrix having polar coordinates.

2. The method of claim 1 comprises:

the baseband signal including a plurality of tones, wherein each of the plurality of tones corresponds to a symbol mapped to a constellation; and

digital beamforming each of the plurality of tones using the unitary matrix.

3. The method of claim 1 comprises:

receiving the baseband signal including:

encoding data to produce a stream of encoded data;

interleaving the stream of encoded data into a plurality of parallel streams of interleaved data;

constellation mapping symbols of each of the plurality of parallel streams of interleaved data to a plurality of parallel tones; and

digital beamforming each of the plurality of parallel tones using the unitary matrix.

4. The method of claim 1, wherein the unitary matrix comprises:

a plurality of polar coordinates as represented by V, wherein absolute value of each of the plurality of polar coordinates is a vector on a unit circle and each of the polar coordinates is orthogonal to at least one other of the polar coordinates such that V*V = I, where I represents an identity matrix.

5. The method of claim 4, wherein the unitary matrix further comprises:

for each column of V, a first row of polar coordinates including real values as references and a second row of polar coordinates including phase shift values.

6. The method of claim 5, wherein the unitary matrix further comprises for a 2xN multiple input multiple output (MIMO) wireless communication:

$$V = \begin{bmatrix} \cos\psi_1 & \cos\psi_2 \\ \sin\psi_1 e^{j\phi_1} & \sin\psi_2 e^{j\phi_2} \end{bmatrix}$$

wherein ψ_1, Φ_1, ψ_2, and Φ_2 represent angles of the unit circle, wherein absolute value of $\psi_1 - \psi_2 = \pi/2$ and $\Phi_1 = \Phi_2$ or $\Phi_1 = \Phi_2 + \pi$ and $\psi_1 + \psi_2 = \pi/2$.

7. The method of claim 5, wherein the unitary matrix further comprises for a 3xN multiple input multiple output (MIMO) wireless communication:

$$V = \begin{bmatrix} \cos\psi_1 & \cos\psi_2 & \cos\psi_3 \\ \sin\psi_1 \cos\theta_1 e^{j\phi_{21}} & \sin\psi_2 \cos\theta_2 e^{j\phi_{22}} & \sin\psi_3 \cos\theta_3 e^{j\phi_{23}} \\ \sin\psi_1 \sin\theta_1 e^{j\phi_{31}} & \sin\psi_2 \sin\theta_2 e^{j\phi_{32}} & \sin\psi_3 \sin\theta_3 e^{j\phi_{33}} \end{bmatrix}$$

wherein ψ_1, ψ_2, ψ_3, θ_1, θ_2, θ_3, Φ_{21}, Φ_{22}, Φ_{23}, Φ_{31}, Φ_{32}, Φ_{33} represent angles of the unit circle, wherein Diagonal (V*V) = 1s, and wherein:

$$\psi_i = \cos^{-1} V_{1i}, \theta_i = \cos^{-1}\left|\frac{V_{2i}}{\sin\psi_i}\right|$$

$$\phi_{2i} = \angle(V_{2i}), \phi_{3i} = \angle(V_{3i})$$

8. The method of claim 5, wherein the unitary matrix further comprises for a 4xN multiple input multiple output (MIMO) wireless communication:

$$V = \begin{bmatrix} \cos\psi_1 \cos\varphi_1 & \cos\psi_2 \cos\varphi_2 & \cos\psi_3 \cos\varphi_3 & \cos\psi_4 \cos\varphi_4 \\ \cos\psi_1 \sin\varphi_1 e^{j\phi_{11}} & \cos\psi_2 \sin\varphi_2 e^{j\phi_{12}} & \cos\psi_3 \sin\varphi_3 e^{j\phi_{13}} & \cos\psi_4 \sin\varphi_4 e^{j\phi_{14}} \\ \sin\psi_1 \cos\theta_1 e^{j\phi_{21}} & \sin\psi_2 \cos\theta_2 e^{j\phi_{22}} & \sin\psi_3 \cos\theta_3 e^{j\phi_{23}} & \sin\psi_4 \cos\theta_4 e^{j\phi_{24}} \\ \sin\psi_1 \sin\theta_1 e^{j\phi_{31}} & \sin\psi_2 \sin\theta_2 e^{j\phi_{32}} & \sin\psi_3 \sin\theta_3 e^{j\phi_{33}} & \sin\psi_4 \sin\theta_4 e^{j\phi_{34}} \end{bmatrix}$$

wherein ψ_1, ψ_2, ψ_3, ψ_4, θ_1, θ_2, θ_3, θ_4, φ_1, φ_2, φ_3, φ_4, Φ_{21}, Φ_{22}, Φ_{23}, Φ_{24}, Φ_{31}, Φ_{32}, Φ_{33}, Φ_{33}, Φ_{41}, Φ_{42}, Φ_{43}, Φ_{43} represent angles of the unit circle, wherein Diagonal (V*V) = 1s, and wherein:

$$\psi_i = \cos^{-1}\left(\sqrt{|V_{1i}|^2 + |V_{2i}|^2}\right), \varphi_i = \cos^{-1}\left(\frac{V_{1i}}{\cos\psi_i}\right), \theta_i = \cos^{-1}\left|\frac{V_{3i}}{\sin\psi_i}\right|$$

$$\phi_{1i} = \angle(V_{2i}), \phi_{2i} = \angle(V_{3i}), \phi_{3i} = \angle(V_{4i})$$

9. A transmit baseband processing module comprises:

an encoding module operably coupled to convert outbound data into encoded data;

a plurality of interleaving modules operably coupled to interleave the encoded data into a plurality of interleaved streams of data;

a plurality of constellation mapping modules operably coupled to map the plurality of interleaved streams of data into a plurality of streams of data symbols;

a beamforming module operably coupled to beamform, using a unitary matrix having polar coordinates, the plurality of streams of data symbols into a plurality of streams of beamformed symbols; and

a plurality of inverse fast Fourier transform modules operably coupled to convert the plurality of streams of beamformed symbols into a plurality of outbound symbol streams.

10. The transmit baseband processing module of claim 9, wherein the unitary matrix comprises:

a plurality of polar coordinates as represented by V, wherein absolute value of each of the plurality of polar coordinates is a vector on a unit circle and each of the polar coordinates is orthogonal to at least one other of the polar coordinates such that $V^*V = I$, where I represents an identity matrix.

11. The transmit baseband processing module of claim 11, wherein the unitary matrix further comprises:

for each column of V, a first row of polar coordinates including real values as references and a second row of polar coordinates including phase shift values.

12. The transmit baseband processing module of claim 11, wherein the unitary matrix further comprises for a 2xN multiple input multiple output (MIMO) wireless communication:

$$V = \begin{bmatrix} \cos\psi_1 & \cos\psi_2 \\ \sin\psi_1 e^{j\phi_1} & \sin\psi_2 e^{j\phi_2} \end{bmatrix}$$

wherein ψ_1, Φ_1, ψ_2, and Φ_2 represent angles of the unit circle, wherein absolute value of $\psi_1 - \psi_2 = \pi/2$ and $\Phi_1 = \Phi_2$ or $\Phi_1 = \Phi_2 + \pi$ and $\psi_1 + \psi_2 = \pi/2$.

13. The transmit baseband processing module of claim 11, wherein the unitary matrix further comprises for a 3xN multiple input multiple output (MIMO) wireless communication:

$$V = \begin{bmatrix} \cos\psi_1 & \cos\psi_2 & \cos\psi_3 \\ \sin\psi_1\cos\theta_1 e^{j\phi_{21}} & \sin\psi_2\cos\theta_2 e^{j\phi_{22}} & \sin\psi_3\cos\theta_3 e^{j\phi_{23}} \\ \sin\psi_1\sin\theta_1 e^{j\phi_{31}} & \sin\psi_2\sin\theta_2 e^{j\phi_{32}} & \sin\psi_3\sin\theta_3 e^{j\phi_{33}} \end{bmatrix}$$

wherein ψ_1, ψ_2, ψ_3, θ_1, θ_2, θ_3, Φ_{21}, Φ_{22}, Φ_{23}, Φ_{31}, Φ_{32}, Φ_{33} represent angles of the unit circle, wherein Diagonal (V*V) = 1s, and wherein:

$$\psi_i = \cos^{-1} V_{1i}, \theta_i = \cos^{-1}\left|\frac{V_{2i}}{\sin\psi_i}\right|$$
$$\phi_{2i} = \angle(V_{2i}), \phi_{3i} = \angle(V_{3i})$$

14. The transmit baseband processing module of claim 11, wherein the unitary matrix further comprises for a 4xN multiple input multiple output (MIMO) wireless communication:

$$V = \begin{bmatrix} \cos\psi_1\cos\varphi_1 & \cos\psi_2\cos\varphi_2 & \cos\psi_3\cos\varphi_3 & \cos\psi_4\cos\varphi_4 \\ \cos\psi_1\sin\varphi_1 e^{j\phi_{11}} & \cos\psi_2\sin\varphi_2 e^{j\phi_{12}} & \cos\psi_3\sin\varphi_3 e^{j\phi_{13}} & \cos\psi_4\sin\varphi_4 e^{j\phi_{14}} \\ \sin\psi_1\cos\theta_1 e^{j\phi_{21}} & \sin\psi_2\cos\theta_2 e^{j\phi_{22}} & \sin\psi_3\cos\theta_3 e^{j\phi_{23}} & \sin\psi_4\cos\theta_4 e^{j\phi_{24}} \\ \sin\psi_1\sin\theta_1 e^{j\phi_{31}} & \sin\psi_2\sin\theta_2 e^{j\phi_{32}} & \sin\psi_3\sin\theta_3 e^{j\phi_{33}} & \sin\psi_4\sin\theta_4 e^{j\phi_{34}} \end{bmatrix}$$

wherein ψ_1 , ψ_2 , ψ_3 , ψ_4 , θ_1, θ_2, θ_3, θ_4, φ_1, φ_2, φ_3, φ_4, Φ_{21}, Φ_{22} , Φ_{23} , Φ_{24} , Φ_{31}, Φ_{32} , Φ_{33} , Φ_{33} , Φ_{41}, Φ_{42} , Φ_{43} , Φ_{43} represent angles of the unit circle, wherein Diagonal (V*V) = 1s, and wherein:

$$\psi_i = \cos^{-1}\left(\sqrt{|V_{1i}|^2 + |V_{2i}|^2}\right), \varphi_i = \cos^{-1}\left(\frac{V_{1i}}{\cos\psi_i}\right), \theta_i = \cos^{-1}\left|\frac{V_{3i}}{\sin\psi_i}\right|$$

$$\phi_{1i} = \angle(V_{2i}), \phi_{2i} = \angle(V_{3i}), \phi_{3i} = \angle(V_{4i})$$

15. A receiver baseband processing module comprises:

a plurality of fast Fourier transform modules operably coupled to convert a plurality of inbound symbol streams into a plurality of streams of beamformed symbols;

an inverse beamforming module operably coupled to inverse beamform, using a unitary matrix having polar coordinates, the plurality of streams of beamformed symbols into a plurality of streams of data symbols;

a plurality of constellation demapping modules operably coupled to demap the plurality of streams of data symbols into a plurality of interleaved streams of data;

a plurality of deinterleaving modules operably coupled to deinterleave the plurality of interleaved streams of data into encoded data; and

a decoding module operably coupled to convert the encoded data into inbound data.

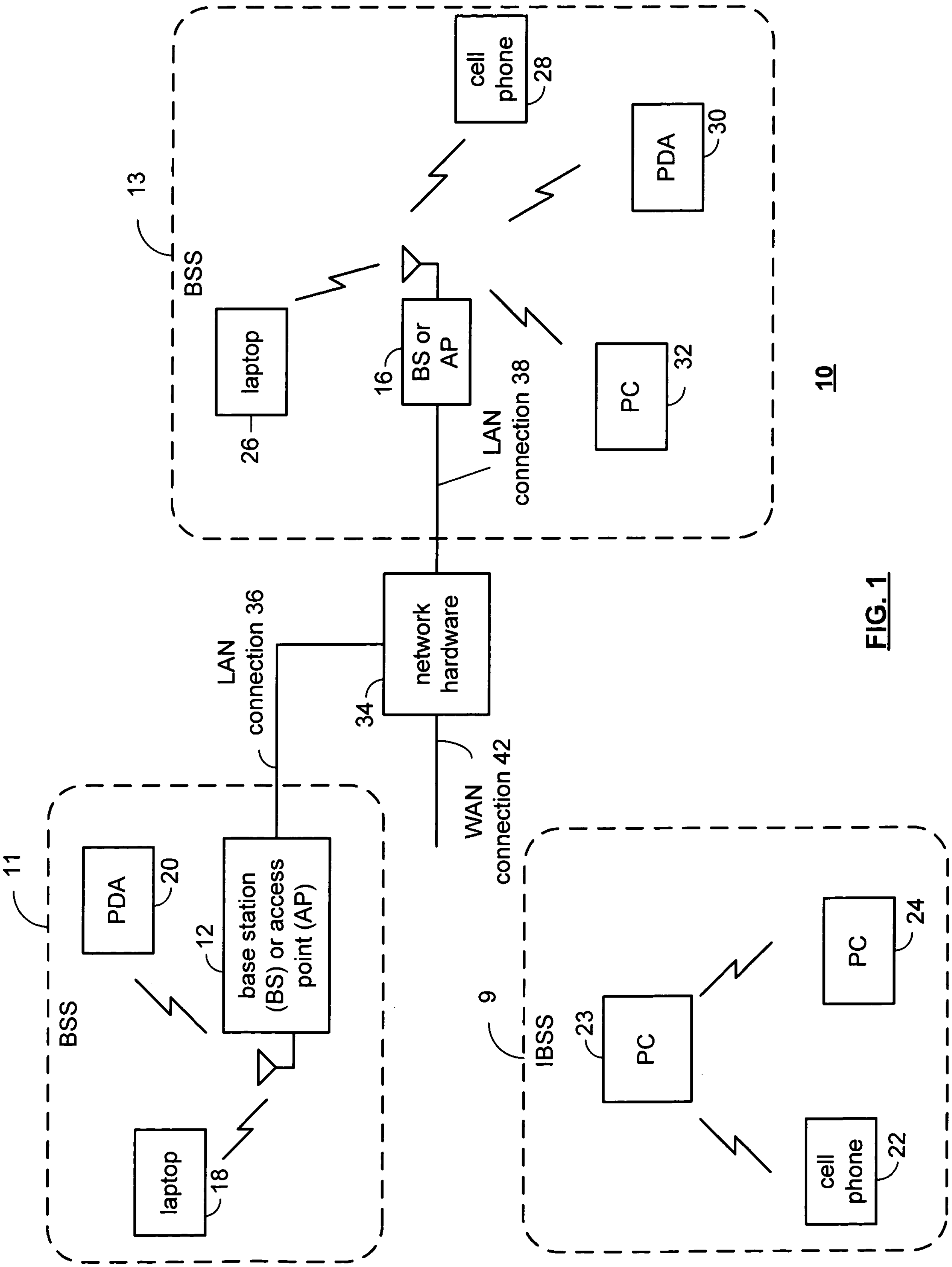
16. The receiver baseband processing module of claim 15, wherein the unitary matrix comprises:

a plurality of polar coordinates as represented by U, wherein absolute value of each of the plurality of polar coordinates is a vector on a unit circle and each of the polar coordinates is orthogonal to at least one other of the polar coordinates such that U*U = I, where I represents an identity matrix.

REDUCED FEEDBACK FOR BEAMFORMING IN A WIRELESS COMMUNICATION

ABSTRACT OF THE DISCLOSURE

A method for reduced feedback for beamforming in a wireless communication begins by receiving a baseband signal. The method continues by digitally beamforming the baseband signal using a unitary matrix having polar coordinates.



BSS
11
PDA
20
12
base station (BS) or access point (AP)
laptop
18
LAN connection 36
network hardware
34
WAN connection 42
IBSS
9
PC
23
PC
24
cell phone
22
BSS
13
laptop
26
BS or AP
16
LAN connection 38
cell phone
28
PDA
30
PC
32

10

FIG. 1

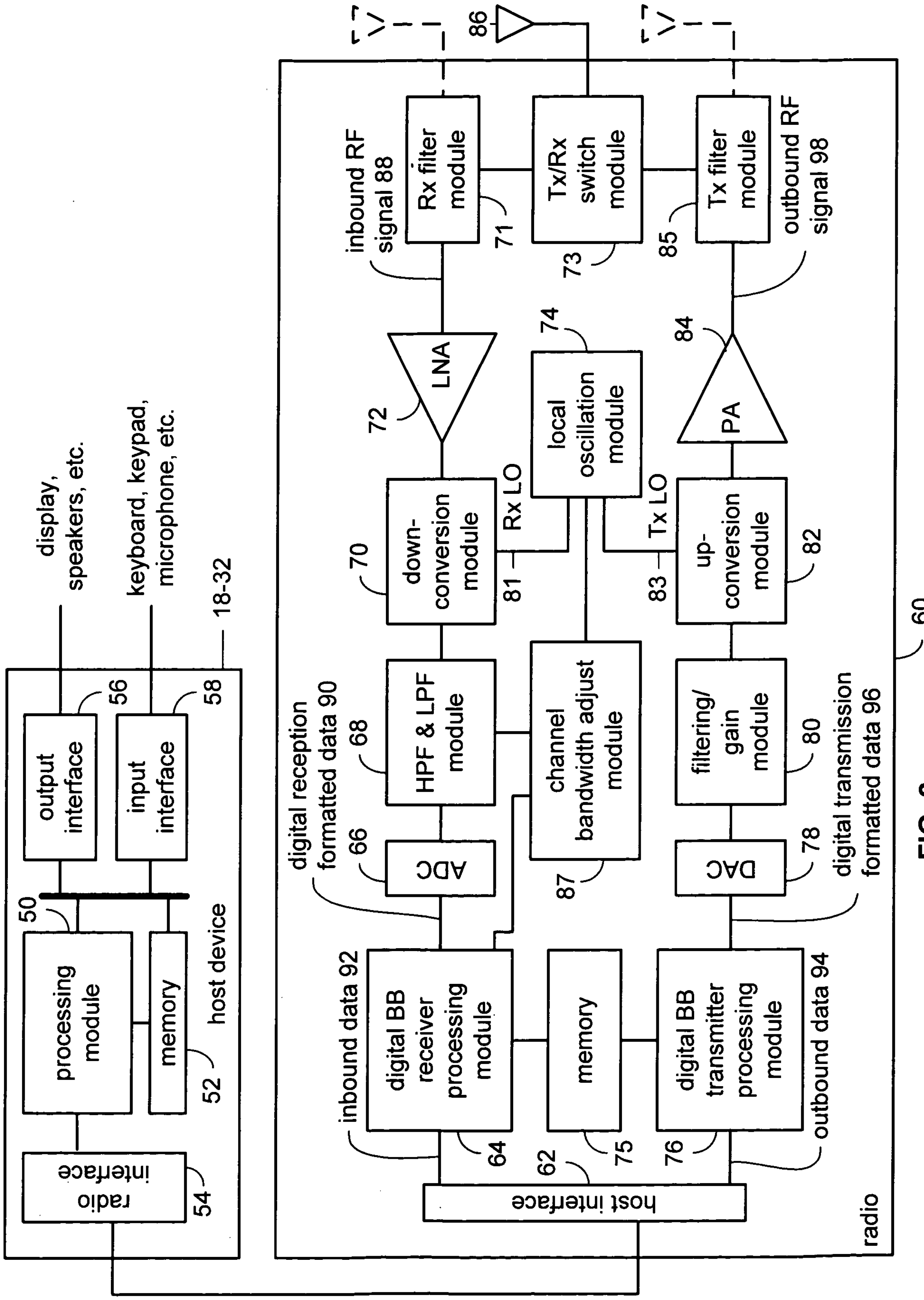
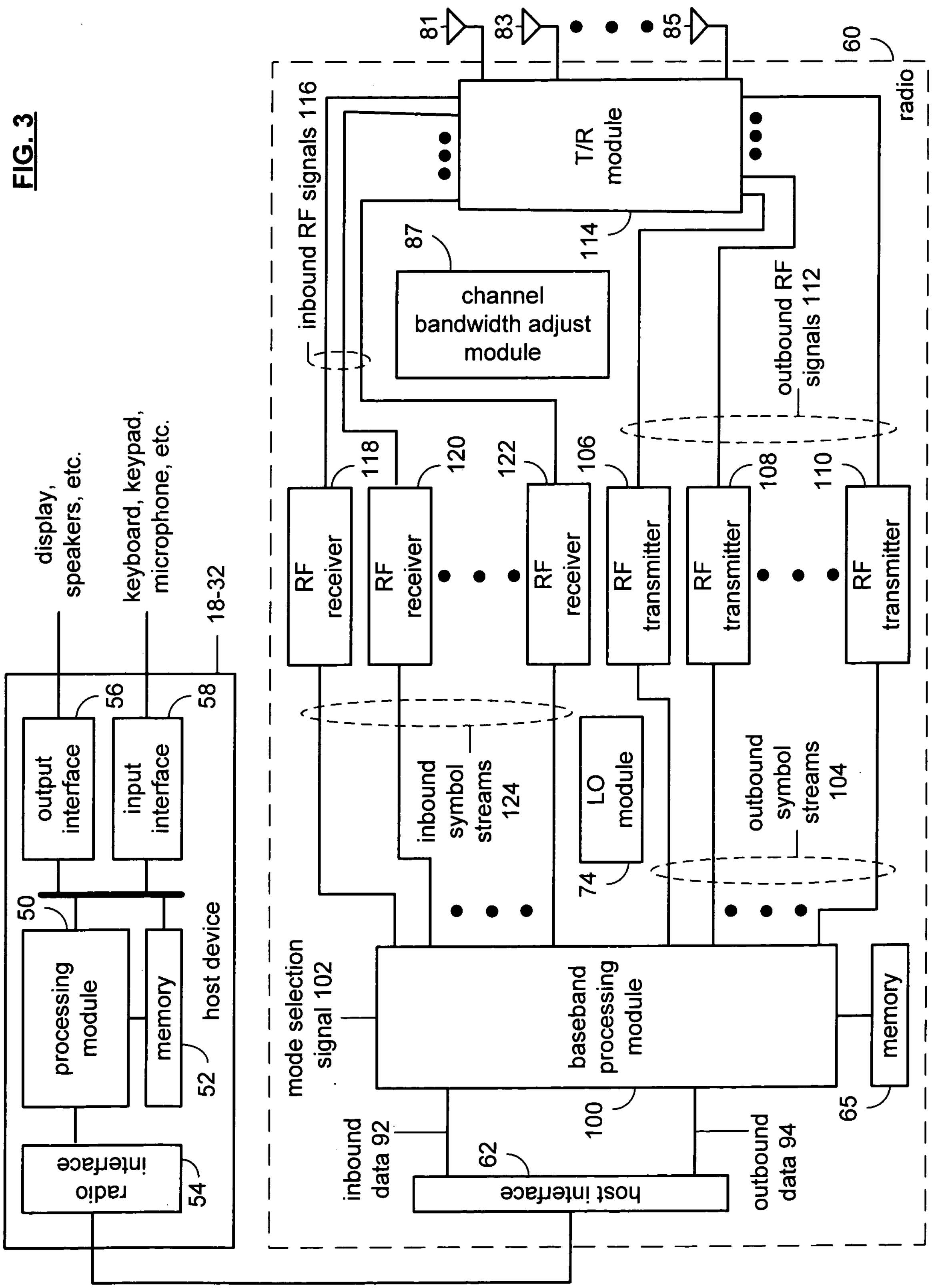

display, speakers, etc.
keyboard, keypad, microphone, etc.
18-32
output interface
56
input interface
58
50
processing module
memory
52
host device
radio interface
54
inbound RF signal 88
Rx filter module
71
Tx/Rx switch module
73
Tx filter module
85
outbound RF signal 98
86
LNA
72
local oscillation module
74
PA
84
down-conversion module
70
Rx LO
81
Tx LO
83
up-conversion module
82
HPF & LPF module
68
channel bandwidth adjust module
87
filtering/gain module
80
digital reception formatted data 90
ADC
66
DAC
78
digital transmission formatted data 96
60
inbound data 92
digital BB receiver processing module
64
memory
75
digital BB transmitter processing module
76
outbound data 94
62
host interface
radio

FIG. 2

FIG. 3


display, speakers, etc.
keyboard, keypad, microphone, etc.
18-32
output interface
56
input interface
58
processing module
50
memory
52
host device
radio interface
54
inbound RF signals 116
81
83
85
60
radio
T/R module
114
87
channel bandwidth adjust module
outbound RF signals 112
118
120
122
106
108
110
RF receiver
RF receiver
RF receiver
RF transmitter
RF transmitter
RF transmitter
inbound symbol streams 124
LO module
74
outbound symbol streams 104
mode selection signal 102
baseband processing module
memory
65
100
inbound data 92
62
host interface
outbound data 94

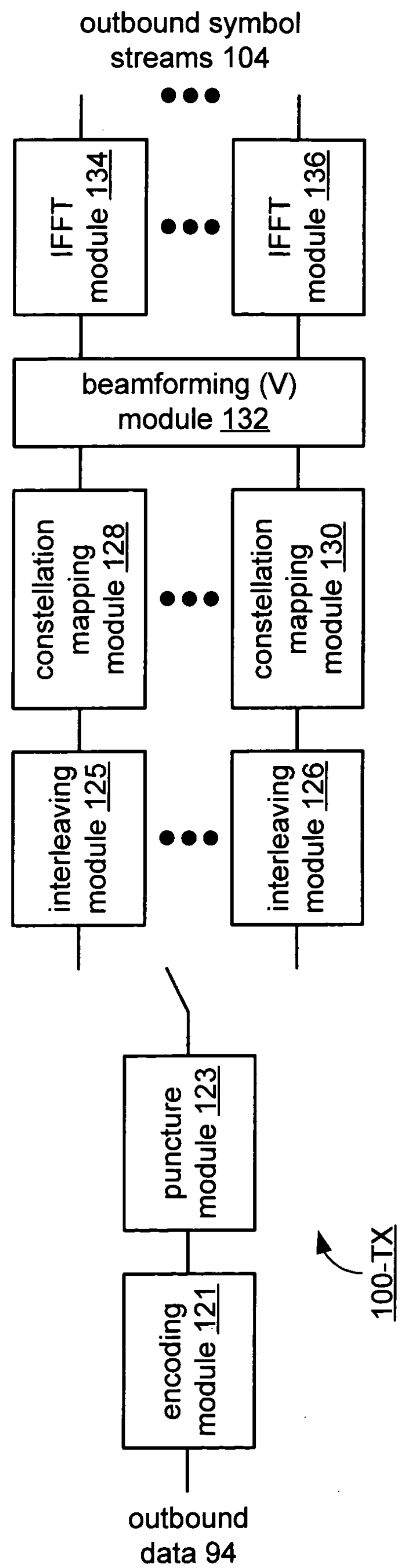

outbound symbol streams 104
IFFT module 134
IFFT module 136
beamforming (V) module 132
constellation mapping module 128
constellation mapping module 130
interleaving module 125
interleaving module 126
puncture module 123
encoding module 121
100-TX
outbound data 94

FIG. 4

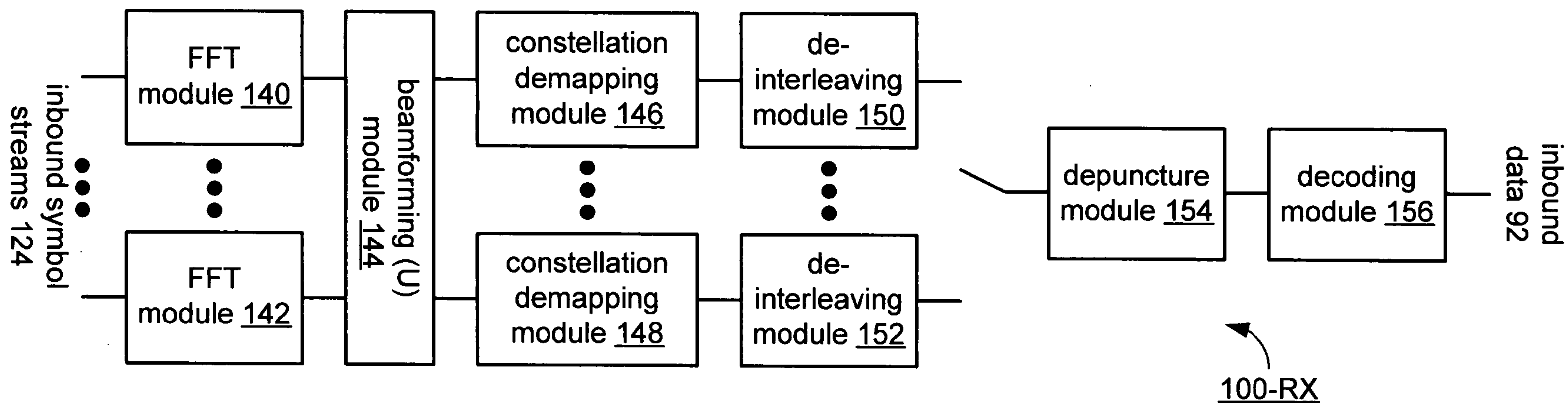

inbound symbol streams 124
FFT module 140
FFT module 142
beamforming (U) module 144
constellation demapping module 146
constellation demapping module 148
de-interleaving module 150
de-interleaving module 152
depuncture module 154
decoding module 156
inbound data 92
100-RX

FIG. 5

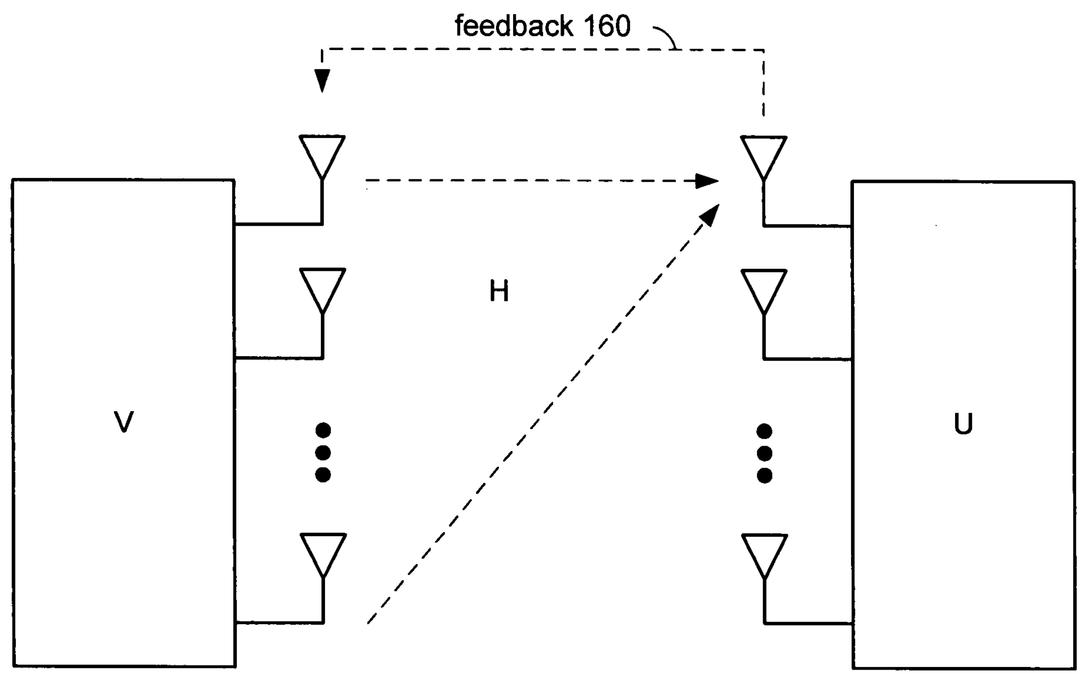


FIG. 6

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

[X] Declaration Submitted with Initial Filing OR [ ] Declaration Submitted after initial Filing (surcharge (37 CFR 1.16(e)) required)

Attorney Docket Number	BP4637
First Named Inventor	Joonsuk Kim
COMPLETE IF KNOWN	
Application Number	
Filing Date	
Group Art Unit	
Examiner Name	

As a below named inventor, I hereby declare that:

My residence, mailing 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:

REDUCED FEEDBACK FOR BEAMFORMING IN A WIRELESS COMMUNICATION

(Title of the Invention)

the specification of which

[X] is attached hereto

OR

[ ] was filed on (MM/DD/YYYY) [ ] as United States Application Number or PCT International Application Number [ ] 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, including for continuation-in-part applications, material information which became available between the filing date of the prior application and the national or PCT international filing date of the continuation-in-part application.

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 checkign the box, any foreign application for patent or inventor's certificate, or any PCT international application having a filing date before that of the application on which priority is claimed.

Prior Foreign Applications Numbers(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), 120, or 365 (c) of any U.S. or PCT application(s) listed below.

Application Numbers(s)	Filing Date (MM/DD/YYYY)	
60/673,451	4/21/2005	[ ] Additional application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.

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Name	Timothy W. Markison		
Address	P.O. Box 160727		
Address			
City	Austin	State TX	ZIP 78716-0727
Country	USA	Telephone (512) 342-0612	FAX (512) 342-1674

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 jeorpardize 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])	Joonsuk	Family Name or Surname	Kim
Inventor's Signature	[signature]	Date	6/27/05
Residence: City	San Jose	State CA	Country USA / Citizenship South Korea
Mailing Address	1046 Jacqueline Way		
Mailing Address			
City	San Jose	State CA	ZIP 95129 / Country USA

NAME OF SECOND INVENTOR: [ ] 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
Mailing Address			
Mailing Address			
City		State	ZIP / Country

[ ] Additional inventors are being named on the _____ supplemental Additional Inventor(s) sheets(s) PTO/SB/02A attached hereto.

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PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875 Effective December 8, 2004

Application or Docket Number: 11162795

APPLICATION AS FILED – PART I

FOR	NUMBER FILED (Column 1)	NUMBER EXTRA (Column 2)	SMALL ENTITY RATE ($)	SMALL ENTITY FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY FEE ($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	150.00		N/A	300.00
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	$250		N/A	$500
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	$100		N/A	$200
TOTAL CLAIMS (37 CFR 1.16(i))	16 minus 20 =	* 0	X$ 25 =		OR	X$50 =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	3 minus 3 =	* 0	X100 =			X200 =	
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))			+180=			+360=	
			TOTAL			TOTAL	1000

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

APPLICATION AS AMENDED – PART II

AMENDMENT A

	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	SMALL ENTITY RATE ($)	SMALL ENTITY ADDITIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	*	Minus	**	=	X$ 25 =		OR	X$50 =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	X100 =		OR	X200 =	
Application Size Fee (37 CFR 1.16(s))									
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))					+180=		OR	+360=	
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

AMENDMENT B

	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	SMALL ENTITY RATE ($)	SMALL ENTITY ADDITIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	*	Minus	**	=	X$ 25 =		OR	X$50 =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	X100 =		OR	X200 =	
Application Size Fee (37 CFR 1.16(s))									
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))					+180=		OR	+360=	
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

PATENT APPLICATION SERIAL NO ______________

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FEE RECORD SHEET

07/01/2005 DTESSEM1 00000027 11168793

01 FC:1011	300.00 OP
02 FC:1111	500.00 OP
03 FC:1311	200.00 OP

PTO-1556
(5/87)

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet 1 of 2

Complete if Known	
Application Number	
Filing Date	
First Named Inventor	Joonsuk Kim
Art Unit	
Examiner Name	
Attorney Docket Number	BP4637

U. S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		US-			
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Sheet 2 of 2

Complete if Known	
Application Number	
Filing Date	
First Named Inventor	Joonsuk Kim
Art Unit	
Examiner Name	
Attorney Docket Number	BP4637

NON PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
	1	"Interpolation Based Transmit Beamforming for MIMO-OFDM with Partial Feedback" by Jihoon Choi and Robert W. Heath, Jr. The University of Texas at Austin, Dept. of Electrical & Computer Engineering, Wireless Networking & Communications Group; Sept.16,2003; Pg. 1 - 14	
	2	"Digital Beamforming Basics (Antennas)" by Hans Steyskal; Journal of Electronic Defense; 07/01/1996 (7 pages)	
	3	"Utilizing Digital Downconverters for Efficient Digital Beamforming" by Clint Schreiner, Red River Engineering (5 pages)	

Examiner Signature		Date Considered	

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1 Applicant's unique citation designation number (optional). 2 Applicant is to place a check mark here if English language Translation is attached.

AUG 2 6 2005

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
(Attorney Docket No. BP4637)

In the Application of:
Joonsuk Kim

Serial No.: 11/168,793

Filed: 6/28/05

For: REDUCED FEEDBACK FOR BEAMFORMING IN A WIRELESS COMMUNICATION

§ Group Art Unit: Unknown
§ Examiner: Unknown

CERTIFICATE OF FIRST CLASS MAILING

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Diane Hudson
Diane Hudson

TRANSMITTAL OF CORPORATE DOCUMENTS

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

Enclosed herewith are (1) Certificate Under 37 C.F.R. 3.37(b) indicating reel & frame number of recorded assignment; (2) Power of Attorney; and, (3) Authorization letter from Broadcom Corporation. All of these documents are from Assignee for entry in the above-referenced application.

Respectfully submitted,

Date: August 24, 2005

By: /Timothy W. Markison/
Timothy W. Markison, Reg. 33,534

Garlick, Harrison & Markison, LLP
P.O. Box 160727
Austin, Texas 78716-0727
(512) 342-0612
(512) 342-1674 fax

OIPE AUG 2 6 2005 PATENT & TRADEMARK OFFICE

BP4637

Certificate Under 37 CFR 3.73(b)

Applicants: Joonsuk Kim

Entitled: **REDUCED FEEDBACK FOR BEAMFORMING IN A WIRELESS COMMUNICATION**

Application No. 11/168,793 Filing Date: 6/28/2005

Broadcom Corporation, a California Corporation
(Name and Type of Assignee)

states that it is :
1. [X] the assignee of the entire right, title, and interest; or
2. [ ] an assignee of an undivided part interest

in the patent application/patent identified above by virtue of either :

A. [X] An Assignment for the inventor(s) of the patent application/patent identified above. The assignment was recorded in the Patent and Trademark Office at Reel 016352, Frame 0720, or for which a copy thereof is attached.

OR

B. [ ] A chain of title for the inventor(s) of the patent application/patent identified above to the current assignee as shown below:

1. From ____________ To: ____________
The document was recorded in the Patent and Trademark Office at
Reel ______, Frame _______, or for which a copy thereof is attached.
2. From ____________ To: ____________
The document was recorded in the Patent and Trademark Office at
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The document was recorded in the Patent and Trademark Office at
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[ ] Additional documents in the chain of title are listed on a supplemental sheet.

[ ] Copies of assignments or other documents in the chain of title are attached.

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The undersigned (whose title is supplied below) is empowered to act on behalf of the assignee.

Date: 8-24-05

Name: Dee Henderson

Title: Sr. Manager, IP Admin. Broadcom Corporation

Signature: [signature]

OIPE
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Application Number	11/168,793
Filing Date	6/28/2005
First Named Inventor	Joonsuk Kim
Title	Reduced Feedback for Beamforming...
Art Unit	
Examiner Name	
Attorney Docket Number	BP4637

I hereby revoke all previous powers of attorney given in the above-identified application.

I hereby appoint:

☑ Practitioners associated with the Customer Number: 51,472

OR

☐ Practitioner(s) named below:

Name	Registration Number

as my/our attorney(s) or agent(s) to prosecute the application identified above, and to transact all business in the United States Patent and Trademark Office connected therewith.

Please recognize or change the correspondence address for the above-identified application to:

☑ The address associated with the above-mentioned Customer Number:

OR

☐ The address associated with Customer Number: 51,472

OR

☑ Firm or Individual Name	Timothy W. Markison				
Address	P. O. Box 160727				
City	Austin	State	Texas	Zip	78716
Country	USA				
Telephone	512-342-0612	Fax	512-301-3707		

I am the:

☐ Applicant/Inventor.

☑ Assignee of record of the entire interest. See 37 CFR 3.71.
Statement under 37 CFR 3.73(b) is enclosed. (Form PTO/SB/96)

SIGNATURE of Applicant or Assignee of Record

Signature	[signature]	Date	8-24-05
Name	Dee Henderson	Telephone	
Title and Company	Senior Manager, IP Administration Broadcom Corporation		

NOTE: Signatures of all the inventors or assignees of record of the entire interest or their representative(s) are required. Submit multiple forms if more than one signature is required, see below*.

☑ *Total of 1 forms are submitted.

This collection of information is required by 37 CFR 1.31, 1.32 and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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BP4637

BROADCOM.

BROADCOM CORPORATION
16215 Alton Parkway, P.O. Box 57013
Irvine, California 92619-7013

Phone: 949-450-8700
Fax: 949-450-8710

February 8, 2005

To whom it may concern:

I, Henry Samueli, hereby authorize Dee Henderson, Senior Manager, Intellectual Property Administration, to execute documents relating to US and foreign patent and trademark matters on behalf of Broadcom Corporation and/or its subsidiaries.

Henry Samueli, Ph.D.
Chief Technical Officer

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/168,793	06/28/2005	Joonsuk Kim	BP4637	9094

51472 7590 03/31/2008
GARLICK HARRISON & MARKISON
P.O. BOX 160727
AUSTIN, TX 78716-0727

EXAMINER	
NEFF, MICHAEL R	
ART UNIT	**PAPER NUMBER**
2611	
MAIL DATE	**DELIVERY MODE**
03/31/2008	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

PTOL-90A (Rev. 04/07)

Office Action Summary	**Application No.**	**Applicant(s)**	
	11/168,793	KIM, JOONSUK	
	Examiner	**Art Unit**	
	MICHAEL R. NEFF	2611	

-- 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) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, 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 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 *28 June 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) *1-16* 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) *1-16* 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 *28 June 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

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.

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/SB/08) Paper No(s)/Mail Date *6/28/2005*.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

Double Patenting

1. A rejection based on double patenting of the "same invention" type finds its support in the language of 35 U.S.C. 101 which states that "whoever invents or discovers any new and useful process ... may obtain a patent therefor ..." (Emphasis added). Thus, the term "same invention," in this context, means an invention drawn to identical subject matter. See *Miller v. Eagle Mfg. Co.*, 151 U.S. 186 (1894); *In re Ockert*, 245 F.2d 467, 114 USPQ 330 (CCPA 1957); and *In re Vogel*, 422 F.2d 438, 164 USPQ 619 (CCPA 1970).

A statutory type (35 U.S.C. 101) double patenting rejection can be overcome by canceling or amending the conflicting claims so they are no longer coextensive in scope. The filing of a terminal disclaimer cannot overcome a double patenting rejection based upon 35 U.S.C. 101.

2. Claims 1-14 are provisionally rejected under 35 U.S.C. 101 as claiming the same invention as that of claims 1-12 of copending Application No. 11/168,838. The scope of the invention claimed within the above mentioned co-pending application is equivalent to that of the scope of the limitations claimed in the above noted claims of the current application. This is a provisional double patenting rejection since the conflicting claims have not in fact been patented.

Claim Objections

3. Claim 11 is objected to because of the following informalities: Claim 11 has a dependency on itself rather than on a preceding claim; this is believed to be a typographical error. For the purpose of examining, claim 11 has been given dependency to claim 10. Appropriate correction is required.

Claim Rejections - 35 USC § 103

4. 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.

5. The factual inquiries set forth in *Graham* **v.** *John Deere Co.*, 383 U.S. 1, 148 USPQ 459 (1966), that are applied for establishing a background for determining obviousness under 35 U.S.C. 103(a) are summarized as follows:

1. Determining the scope and contents of the prior art.
2. Ascertaining the differences between the prior art and the claims at issue.
3. Resolving the level of ordinary skill in the pertinent art.
4. Considering objective evidence present in the application indicating obviousness or nonobviousness.

6. **Claims 1, 4-8 are rejected under 35 U.S.C. 103(a) as being unpatentable over Poon (US Publication 2005/0286663 A1) in view of Reinhardt (US Patent 5,541,607).**

Re Claim 1, Poon discloses a method for reduced feedback for beamforming in a wireless communication, the method comprises:

receiving a baseband signal (Figure 1, antenna elements); and

digitally beamforming the baseband signal using a unitary matrix (Paragraph 0018, 0025-26).

However Poon fails to explicitly disclose wherein the coordinates for the unitary matrix are polar coordinates. This design for a beamforming system is however disclosed by Reinhardt. Reinhardt discloses a beamforming system wherein polar coordinates are used for the purpose of beamforming (Figures 3 and 6; 78, 98; Col. 3 line 65-Col. 4 line 5; Col. 6 line 66- Col. 7 line 7).

Therefore it would have been obvious to one of ordinary skill in the art at the time the invention was made to incorporate the use of polar coordinates in the beamforming process as disclosed by Reinhardt within the beamforming system of Poon in order to gain the benefit increasing the system efficiency for a plurality of beams by replacing the power and bandwidth consuming rectangular coordinates.

Re Claims 4-8; the combined disclosures of Poon and Reinhardt as a whole disclose the method of claim 1, however these disclosures fail to explicitly disclose wherein the unitary matrix comprises: a plurality of polar coordinates as represented by V, wherein absolute value of each of the plurality of polar coordinates is a vector on a unit circle and each of the polar coordinates is orthogonal to at least one other of the polar coordinates such that V*V = I, where I represents an identity matrix as recited in claim 4; or wherein for each column of V, a first row of polar coordinates including real values as references and a second row of polar coordinates including phase shift values as recited in claim 5; or the unitary matrix limitations for a MIMO communication using a 2xn, 3xN, and 4xN matrix array as recited in claims 6-8.

However it would have been obvious to one of ordinary skill in the art at the time the invention was made that the above claim limitations would be obvious design choices for the system. The disclosure of Poon, as shown above in the citing by the Examiner, provides for a system of constructing beamforming matrices (paragraphs

0022-0024 and associated table 1). Previously in the disclosure the construction of the matrix array is discussed, (paragraph 0018) which the examiner reads as encompassing the limitations of the 2xN, 3xN, and 4xN matrices (claims 5-8), while the disclosure of the generation of the indices within these matrices as disclosed by Poon fully encompass the claimed limitations of the equations utilized to construct the various indices within the claimed matrices. In regards to claim 4, taking the disclosures of Poon and Reinhardt as a whole the Examiner reads this claim limitation as resulting from a design choice involving the polar coordinates being used, and based the features of a unitary matrix.

Therefore it would have been obvious to one of ordinary skill in the art at the time the invention was made to incorporate the design choices as provided within the limitations of claims 4-8 within the digital beamforming system as disclosed by Poon, Reinhardt and Poon_2 to gain the benefit of utilizing the beamforming aspect to address the specifications of the system design and desired functionality.

7. **Claims 2 and 3 are rejected under 35 U.S.C. 103(a) as being unpatentable over Poon and Reinhardt as applied to claim 1 above and further in view of Poon (herein after Poon_2) (US Publication 2006/0067428 A1).**

Re Claims 2 and 3; the combined disclosures of Poon and Reinhardt as a whole disclose the method of claim 1, Poon further discloses wherein the method comprises: digital beamforming each of the plurality (or parallel) of tones using the unitary matrix (Paragraph 0018, 0025-26; Figures 1 and 6 discloses the parallel signal I/O structure) and wherein receiving the baseband signal comprises: encoding data to produce a stream of encoded data (630, 640; Paragraphs 0045-46); but fails to explicitly disclose the limitation wherein the baseband signal including a plurality of tones, wherein each of the plurality of tones corresponds to a symbol mapped to a constellation as recited in claim 2, or wherein receiving the baseband signal comprises: encoding data to produce a stream of encoded data; interleaving the stream of encoded data into a plurality of parallel streams of interleaved data; constellation mapping symbols of each of the plurality of parallel streams of interleaved data to a plurality of parallel tones as recited in claim 3.

These system aspects are however disclosed by Poon_2. Poon_2 discloses a system wherein the baseband signal including a plurality of tones, wherein each of the plurality of tones corresponds to a symbol mapped to a constellation (14; Paragraph 0021-22 and the associated tables 3 and 4); and wherein receiving the baseband signal further comprises: interleaving the stream of encoded data into a plurality of parallel streams of interleaved data (12); constellation mapping symbols of each of the plurality of parallel streams of interleaved data to a plurality of parallel tones (14) as recited in claim 3.

Therefore it would have been obvious to one of ordinary skill in the art at the time the invention was made to incorporate the disclosure of Poon_2 within the beamforming system as disclosed by Poon and Reinhardt in order to obtain the benefit of more efficient signal manipulation prior to transmitting the signals post beamforming.

8. **Claims 9-16 are rejected under 35 U.S.C. 103(a) as being unpatentable over Poon in view of Reinhardt and Poon_2.**

Re Claims 9, Poon discloses a transmit baseband processing module comprises:

an encoding module operably coupled to convert outbound data into encoded data (630, 640; Paragraphs 0045-46);

a beamforming module operably coupled to:

obtain a feedback signal (Paragraph 0002, 0012, 0014) that includes a subset of angles, wherein a set of angles provide coordinates for a unitary matrix and wherein the subset of angles is a subset of the set of angles (Paragraph 0014, 0020-21);;

determine at least one remaining angle of the set of angles based on the subset of angles; determine the coordinates for the unitary matrix(paragraph 0022-24; Table 1); and digitally beamform, using the unitary matrix having coordinates, the plurality of streams of data symbols into a plurality of streams of beamformed symbols (Paragraph 0018, 0025-26).

However Poon fails to explicitly disclose the limitations wherein (1) the coordinates for the unitary matrix are polar coordinates or (2) a plurality of interleaving modules operably coupled to interleave the encoded data into a plurality of interleaved streams of data; a plurality of constellation mapping modules operably coupled to map the plurality of interleaved streams of data into a plurality of streams of data symbols; and a plurality of inverse fast Fourier transform modules operably coupled to convert the plurality of streams of beamformed symbols into a plurality of outbound symbol streams.

Regarding item (1) above, this design for a beamforming system is however disclosed by Reinhardt. Reinhardt discloses a beamforming system wherein polar coordinates are used for the purpose of beamforming (Figures 3 and 6; 78, 98; Col. 3 line 65-Col. 4 line 5; Col. 6 line 66- Col. 7 line 7).

Therefore it would have been obvious to one of ordinary skill in the art at the time the invention was made to incorporate the use of polar coordinates in the beamforming process as disclosed by Reinhardt within the beamforming system of Poon in order to gain the benefit increasing the system efficiency for a plurality of beams by replacing the power and bandwidth consuming rectangular coordinates.

Regarding item (2) above, Poon_2 discloses a plurality of interleaving modules (12; Figure 4 shows this system design implemented in a plurality) operably coupled to interleave the encoded data into a plurality of interleaved streams of data; a plurality of constellation mapping modules (14) operably coupled to map the plurality of interleaved streams of data into a plurality of streams of data symbols; and a plurality of inverse fast Fourier transform modules (16) operably coupled to convert the plurality of streams of beamformed symbols into a plurality of outbound symbol streams.

Therefore it would have been obvious to one of ordinary skill in the art at the time the invention was made to incorporate the disclosure of Poon_2 within the beamforming system as disclosed by Poon in order to obtain the benefit of more efficient signal manipulation prior to transmitting the signals post beamforming.

Claim 15 has been analyzed and rejected with regards to claim 9 as being the obvious receiver design to the claim limitations of the previously mentioned and currently rejected claim 9.

Re Claims 10-14 and 16; the combined disclosures of Poon, Reinhardt and Poon_2 as a whole disclose the communication device of claim 9, however these disclosures fail to explicitly disclose wherein the unitary matrix comprises: a plurality of polar coordinates as represented by V, wherein absolute value of each of the plurality of polar coordinates is a vector on a unit circle and each of the polar coordinates is orthogonal to at least one other of the polar coordinates such that V*V = I, where I represents an identity matrix as recited in claim 10 (with claim 16 being the obvious receiver counterpart; and the U matrix being the functional equivalent of the V matrix in the transmitter end); or wherein for each column of V, a first row of polar coordinates including real values as references and a second row of polar coordinates including phase shift values as recited in claim 11; or the unitary matrix limitations for a MIMO communication using a 2xn, 3xN, and 4xN matrix array as recited in claims 12-14.

However it would have been obvious to one of ordinary skill in the art at the time the invention was made that the above claim limitations would be obvious design choices for the system. The disclosure of Poon, as shown above in the citing by the Examiner, provides for a system of constructing beamforming matrices (paragraphs 0022-0024 and associated table 1). Previously in the disclosure the construction of the matrix array is discussed, (paragraph 0018) which the examiner reads as encompassing the limitations of the 2xN, 3xN, and 4xN matrices (claims 11-14), while the disclosure of the generation of the indices within these matrices as disclosed by Poon fully encompass the claimed limitations of the equations utilized to construct the various indices within the claimed matrices. In regards to claims 10 and 16, taking the disclosures of Poon and Reinhardt as a whole the Examiner reads this claim limitation as resulting from a design choice involving the polar coordinates being used, and based the features of a unitary matrix.

Therefore it would have been obvious to one of ordinary skill in the art at the time the invention was made to incorporate the design choices as provided within the limitations of claims 10-14 and 16 within the digital beamforming system as disclosed by Poon, Reinhardt and Poon_2 to gain the benefit of utilizing the beamforming aspect to address the specifications of the system design and desired functionality.

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to MICHAEL R. NEFF whose telephone number is (571)270-1848. The examiner can normally be reached on Monday - Friday 8:00am - 4:30pm EST ALT Fridays.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Shuwang Liu can be reached on (571)272-3036. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/MICHAEL R. NEFF/
Examiner, Art Unit 2611
/Shuwang Liu/
Supervisory Patent Examiner, Art Unit 2611

Notice of References Cited	Application/Control No. 11/168,793	Applicant(s)/Patent Under Reexamination KIM, JOONSUK	
	Examiner MICHAEL R. NEFF	Art Unit 2611	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-3,858,221 A	12-1974	Harrison et al.	343/815
*	B	US-3,916,533 A	11-1975	Kijesky, Michael M.	434/9
*	C	US-4,843,631 A	06-1989	Steinpichler et al.	382/280
*	D	US-5,541,607 A	07-1996	Reinhardt, Victor S.	342/372
*	E	US-2005/0286663 A1	12-2005	Poon, Ada S. Y.	375/347
*	F	US-2006/0067428 A1	03-2006	Poon, Ada S. Y.	375/299
*	G	US-2006/0155534 A1	07-2006	Lin et al.	704/223
*	H	US-2006/0234645 A1	10-2006	Lin et al.	455/069
	I	US-			
	J	US-			
	K	US-			
	L	US-			
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FOREIGN PATENT DOCUMENTS

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	P					
	Q					
	R					
	S					
	T					

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.

Index of Claims	Application/Control No. 11168793	Applicant(s)/Patent Under Reexamination KIM, JOONSUK
	Examiner MICHAEL R NEFF	Art Unit 2611

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE							
Final	Original	03/25/2008							
	1	✓							
	2	✓							
	3	✓							
	4	✓							
	5	✓							
	6	✓							
	7	✓							
	8	✓							
	9	✓							
	10	✓							
	11	✓							
	12	✓							
	13	✓							
	14	✓							
	15	✓							
	16	✓							

Search Notes	Application/Control No. 11168793	Applicant(s)/Patent Under Reexamination KIM, JOONSUK
	Examiner MICHAEL R NEFF	Art Unit 2611

SEARCHED

Class	Subclass	Date	Examiner
375	260, 267, 299	3/24/2008	MRN

SEARCH NOTES

Search Notes	Date	Examiner
Class/Subclass search performed using keyword limitations	3/24/2008	MRN
Inventor/Double patenting search performed in EAST database	3/24/2008	MRN

INTERFERENCE SEARCH

Class	Subclass	Date	Examiner

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CONFIRMATION NO. 9094

SERIAL NUMBER	FILING or 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
11/168,793	06/28/2005 **RULE**	375	2611	BP4637

APPLICANTS
Joonsuk Kim, San Jose, CA;

** **CONTINUING DATA** *************************
This appln claims benefit of 60/673,451 04/21/2005

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

** **IF REQUIRED, FOREIGN FILING LICENSE GRANTED** **
07/20/2005

Foreign Priority claimed ☐ Yes ☑ No 35 USC 119(a-d) conditions met ☐ Yes ☑ No Verified and Acknowledged /MICHAEL R NEFF/ Examiner's Signature	☐ Met after Allowance Initials	STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
		CA	6	16	3

ADDRESS

GARLICK HARRISON & MARKISON
P.O. BOX 160727
AUSTIN, TX 78716-0727
UNITED STATES

TITLE

Reduced feedback for beamforming in a wireless communication

FILING FEE RECEIVED		
1000	FEES: Authority has been given in Paper No.____________ to charge/credit DEPOSIT ACCOUNT No.____________ for following:	☐ All Fees ☐ 1.16 Fees (Filing) ☐ 1.17 Fees (Processing Ext. of time) ☐ 1.18 Fees (Issue) ☐ Other ________________ ☐ Credit

BIB (Rev. 05/07).

EAST Search History

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S1	43	kim-joonsuk.in.	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/24 12:38
S2	10	S1 and beam adj form$3	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/24 12:38
S3	26	S1 and ((beam adj form$3) or beamform$3 or beamstear$3 or (beam adj stear $3))	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/24 12:39
S4	1378	375/267.ccls.	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/24 12:53
S5	455	375/299.ccls.	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/24 12:53
S6	2436	375/260.ccls.	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/24 12:53
S7	3881	S4 or S5 or S6	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/24 12:53
S8	402	S7 and ((beam adj form$3) or beamform$3 or beamstear$3 or (beam adj stear $3))	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/24 12:53
S9	84	S8 and (unitary near matr$4)	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/24 12:54
S10	7	S9 and polar	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/24 12:54
S11	20	S8 and ((unitary near matr$4) same feedback)	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/24 14:09

S12	64728	((beam adj form $3) or beamform $3 or beamstear $3 or (beam adj stear$3))	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/24 14:17
S13	36	S12 and ((unitary near matr$4) same feedback)	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/24 14:17
S14	2	"7158759".pn.	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/24 14:29
S15	72464	((beam adj form $3) or beamform $3 or beamstear $3 or (beam adj stear$3) or beamsteer$3 or (beam adj steer $3))	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/24 14:39
S16	19	S15 and ((unitary near matr$4) same feedback) and interleav$3	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/24 14:39
S17	10	aldana-carlos.in.	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/24 15:08
S19	126	hansen-chris$6. in.	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/24 15:09
S20	10	S17 or S19 and S15	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/24 15:09
S21	3	(S17 or S19) and S15	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/24 15:09
S22	2	cartesean with polar with conver $5	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/24 17:28
S23	0	polar with rectangular with covner$5	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/24 17:38
S24	2507	polar with rectangular	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/24 17:38

S25	192	polar with coordinates with matrix	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/24 17:38
S26	8	S25 same unitary	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/24 17:39
S27	168	polar with S15	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/24 17:46
S28	12	matrix with real with polar	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/25 09:43

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PTO/SB/08A (08-03)
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet 1 of 2

Complete if Known	
Application Number	
Filing Date	
First Named Inventor	Joonsuk Kim
Art Unit	
Examiner Name	
Attorney Docket Number	BP4637

U. S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
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FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3]-Number[4]-Kind Code[5] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages Or Relevant Figures Appear	T[6]

Examiner Signature	/Michael Neff/	Date Considered	03/25/2008

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Sheet 2 of 2

NON PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
/M.N./	1	"Interpolation Based Transmit Beamforming for MIMO-OFDM with Partial Feedback" by Jihoon Choi and Robert W. Heath, Jr. The University of Texas at Austin, Dept. of Electrical & Computer Engineering, Wireless Networking & Communications Group; Sept.16,2003; Pg. 1 - 14	
/M.N./	2	"Digital Beamforming Basics (Antennas)" by Hans Steyskal; Journal of Electronic Defense; 07/01/1996 (7 pages)	
/M.N./	3	"Utilizing Digital Downconverters for Efficient Digital Beamforming" by Clint Schreiner, Red River Engineering (5 pages)	

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1 Applicant's unique citation designation number (optional). 2 Applicant is to place a check mark here if English language Translation is attached.

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PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: Kim
Examiner: Neff
Serial No: 11/168,793
Art Group: 2611
Filing Date: 6/28/05
Docket No: BP4637
Confirmation No. 9094
Title: REDUCED FEEDBACK FOR BEAMFORMING IN A WIRELESS COMMUNICATION

Date: 6/30/08

Mail Stop:
Commissioner for Patents,
PO Box 1450
Alexandria, Virginia 22313

In response to an Office Action mailed on 3/31/08 regarding the above-captioned patent application, the applicant respectfully submits the following amendment and response.

CLAIM AMENDMENTS

1. (currently amended) A method for reduced feedback for beamforming in a wireless communication, the method comprises:

receiving a baseband signal that includes a plurality of streams; and

digitally beamforming each of the plurality of streams of the baseband signal using a unitary matrix having polar coordinates to produce a plurality of beamformed symbols.

2. (original) The method of claim 1 comprises:

the baseband signal including a plurality of tones, wherein each of the plurality of tones corresponds to a symbol mapped to a constellation; and

digital beamforming each of the plurality of tones using the unitary matrix.

3. (original) The method of claim 1 comprises:

receiving the baseband signal including:

> encoding data to produce a stream of encoded data;
>
> interleaving the stream of encoded data into a plurality of parallel streams of interleaved data;
>
> constellation mapping symbols of each of the plurality of parallel streams of interleaved data to a plurality of parallel tones; and

digital beamforming each of the plurality of parallel tones using the unitary matrix.

4. (original) The method of claim 1, wherein the unitary matrix comprises:

a plurality of polar coordinates as represented by V, wherein absolute value of each of the plurality of polar coordinates is a vector on a unit circle and each of the polar coordinates is orthogonal to at least one other of the polar coordinates such that V*V = I, where I represents an identity matrix.

5. (original) The method of claim 4, wherein the unitary matrix further comprises:

for each column of V, a first row of polar coordinates including real values as references and a second row of polar coordinates including phase shift values.

6. (original) The method of claim 5, wherein the unitary matrix further comprises for a 2xN multiple input multiple output (MIMO) wireless communication:

$$V = \begin{bmatrix} \cos\psi_1 & \cos\psi_2 \\ \sin\psi_1 e^{j\phi_1} & \sin\psi_2 e^{j\phi_2} \end{bmatrix}$$

wherein ψ_1 , Φ_1, ψ_2 , and Φ_2 represent angles of the unit circle, wherein absolute value of $\psi_1 - \psi_2 = \pi/2$ and $\Phi_1 = \Phi_2$ or $\Phi_1 = \Phi_2 + \pi$ and $\psi_1 + \psi_2 = \pi/2$.

7. (original) The method of claim 5, wherein the unitary matrix further comprises for a 3xN multiple input multiple output (MIMO) wireless communication:

$$V = \begin{bmatrix} \cos\psi_1 & \cos\psi_2 & \cos\psi_3 \\ \sin\psi_1 \cos\theta_1 e^{j\phi_{21}} & \sin\psi_2 \cos\theta_2 e^{j\phi_{22}} & \sin\psi_3 \cos\theta_3 e^{j\phi_{23}} \\ \sin\psi_1 \sin\theta_1 e^{j\phi_{31}} & \sin\psi_2 \sin\theta_2 e^{j\phi_{32}} & \sin\psi_3 \sin\theta_3 e^{j\phi_{33}} \end{bmatrix}$$

wherein ψ_1 , ψ_2 , ψ_3 , θ_1, θ_2, θ_3, Φ_{21}, Φ_{22} , Φ_{23} , Φ_{31}, Φ_{32} , Φ_{33} represent angles of the unit circle, wherein Diagonal (V*V) = 1s, and wherein:

$$\psi_i = \cos^{-1} V_{1i}, \theta_i = \cos^{-1}\left|\frac{V_{2i}}{\sin\psi_i}\right|$$
$$\phi_{2i} = \angle(V_{2i}), \phi_{3i} = \angle(V_{3i})$$

8. (original) The method of claim 5, wherein the unitary matrix further comprises for a 4xN multiple input multiple output (MIMO) wireless communication:

$$V = \begin{bmatrix} \cos\psi_1 \cos\varphi_1 & \cos\psi_2 \cos\varphi_2 & \cos\psi_3 \cos\varphi_3 & \cos\psi_4 \cos\varphi_4 \\ \cos\psi_1 \sin\varphi_1 e^{j\phi_{11}} & \cos\psi_2 \sin\varphi_2 e^{j\phi_{12}} & \cos\psi_3 \sin\varphi_3 e^{j\phi_{13}} & \cos\psi_4 \sin\varphi_4 e^{j\phi_{14}} \\ \sin\psi_1 \cos\theta_1 e^{j\phi_{21}} & \sin\psi_2 \cos\theta_2 e^{j\phi_{22}} & \sin\psi_3 \cos\theta_3 e^{j\phi_{23}} & \sin\psi_4 \cos\theta_4 e^{j\phi_{24}} \\ \sin\psi_1 \sin\theta_1 e^{j\phi_{31}} & \sin\psi_2 \sin\theta_2 e^{j\phi_{32}} & \sin\psi_3 \sin\theta_3 e^{j\phi_{33}} & \sin\psi_4 \sin\theta_4 e^{j\phi_{34}} \end{bmatrix}$$

wherein ψ_1, ψ_2, ψ_3, ψ_4, θ_1, θ_2, θ_3, θ_4, φ_1, φ_2, φ_3, φ_4, Φ_{21}, Φ_{22}, Φ_{23}, Φ_{24}, Φ_{31}, Φ_{32}, Φ_{33}, Φ_{33}, Φ_{41}, Φ_{42}, Φ_{43}, Φ_{43} represent angles of the unit circle, wherein Diagonal (V*V) = 1s, and wherein:

$$\psi_i = \cos^{-1}\left(\sqrt{|V_{1i}|^2 + |V_{2i}|^2}\right), \varphi_i = \cos^{-1}\left(\frac{V_{1i}}{\cos\psi_i}\right), \theta_i = \cos^{-1}\left|\frac{V_{3i}}{\sin\psi_i}\right|$$

$$\phi_{1i} = \angle(V_{2i}), \phi_{2i} = \angle(V_{3i}), \phi_{3i} = \angle(V_{4i})$$

9. (original) A transmit baseband processing module comprises:

an encoding module operably coupled to convert outbound data into encoded data;

a plurality of interleaving modules operably coupled to interleave the encoded data into a plurality of interleaved streams of data;

a plurality of constellation mapping modules operably coupled to map the plurality of interleaved streams of data into a plurality of streams of data symbols;

a beamforming module operably coupled to beamform, using a unitary matrix having polar coordinates, the plurality of streams of data symbols into a plurality of streams of beamformed symbols; and

a plurality of inverse fast Fourier transform modules operably coupled to convert the plurality of streams of beamformed symbols into a plurality of outbound symbol streams.

10. (original) The transmit baseband processing module of claim 9, wherein the unitary matrix comprises:

a plurality of polar coordinates as represented by V, wherein absolute value of each of the plurality of polar coordinates is a vector on a unit circle and each of the polar coordinates is orthogonal to at least one other of the polar coordinates such that V*V = I, where I represents an identity matrix.

11. (currently amended) The transmit baseband processing module of claim 10 ~~11~~, wherein the unitary matrix further comprises:

for each column of V, a first row of polar coordinates including real values as references and a second row of polar coordinates including phase shift values.

12. (original) The transmit baseband processing module of claim 11, wherein the unitary matrix further comprises for a 2xN multiple input multiple output (MIMO) wireless communication:

$$V = \begin{bmatrix} \cos\psi_1 & \cos\psi_2 \\ \sin\psi_1 e^{j\phi_1} & \sin\psi_2 e^{j\phi_2} \end{bmatrix}$$

wherein ψ_1 , Φ_1, ψ_2 , and Φ_2 represent angles of the unit circle, wherein absolute value of $\psi_1 - \psi_2 = \pi/2$ and $\Phi_1 = \Phi_2$ or $\Phi_1 = \Phi_2 + \pi$ and $\psi_1 + \psi_2 = \pi/2$.

13. (original) The transmit baseband processing module of claim 11, wherein the unitary matrix further comprises for a 3xN multiple input multiple output (MIMO) wireless communication:

$$V = \begin{bmatrix} \cos\psi_1 & \cos\psi_2 & \cos\psi_3 \\ \sin\psi_1 \cos\theta_1 e^{j\phi_{21}} & \sin\psi_2 \cos\theta_2 e^{j\phi_{22}} & \sin\psi_3 \cos\theta_3 e^{j\phi_{23}} \\ \sin\psi_1 \sin\theta_1 e^{j\phi_{31}} & \sin\psi_2 \sin\theta_2 e^{j\phi_{32}} & \sin\psi_3 \sin\theta_3 e^{j\phi_{33}} \end{bmatrix}$$

wherein ψ_1 , ψ_2 , ψ_3 , θ_1, θ_2, θ_3, Φ_{21}, Φ_{22} , Φ_{23} , Φ_{31}, Φ_{32} , Φ_{33} represent angles of the unit circle, wherein Diagonal (V*V) = 1s, and wherein:

$$\psi_i = \cos^{-1} V_{1i}, \theta_i = \cos^{-1}\left|\frac{V_{2i}}{\sin\psi_i}\right|$$
$$\phi_{2i} = \angle(V_{2i}), \phi_{3i} = \angle(V_{3i})$$

14. (original) The transmit baseband processing module of claim 11, wherein the unitary matrix further comprises for a 4xN multiple input multiple output (MIMO) wireless communication:

$$V = \begin{bmatrix} \cos\psi_1\cos\varphi_1 & \cos\psi_2\cos\varphi_2 & \cos\psi_3\cos\varphi_3 & \cos\psi_4\cos\varphi_4 \\ \cos\psi_1\sin\varphi_1 e^{j\phi_{11}} & \cos\psi_2\sin\varphi_2 e^{j\phi_{12}} & \cos\psi_3\sin\varphi_3 e^{j\phi_{13}} & \cos\psi_4\sin\varphi_4 e^{j\phi_{14}} \\ \sin\psi_1\cos\theta_1 e^{j\phi_{21}} & \sin\psi_2\cos\theta_2 e^{j\phi_{22}} & \sin\psi_3\cos\theta_3 e^{j\phi_{23}} & \sin\psi_4\cos\theta_4 e^{j\phi_{24}} \\ \sin\psi_1\sin\theta_1 e^{j\phi_{31}} & \sin\psi_2\sin\theta_2 e^{j\phi_{32}} & \sin\psi_3\sin\theta_3 e^{j\phi_{33}} & \sin\psi_4\sin\theta_4 e^{j\phi_{34}} \end{bmatrix}$$

wherein ψ_1 , ψ_2 , ψ_3 , ψ_4 , θ_1, θ_2, θ_3, θ_4, φ_1, φ_2, φ_3, φ_4, Φ_{21}, Φ_{22} , Φ_{23} , Φ_{24} , Φ_{31}, Φ_{32} , Φ_{33} , Φ_{33} , Φ_{41}, Φ_{42} , Φ_{43} , Φ_{43} represent angles of the unit circle, wherein Diagonal (V*V) = 1s, and wherein:

$$\psi_i = \cos^{-1}\left(\sqrt{|V_{1i}|^2 + |V_{2i}|^2}\right), \varphi_i = \cos^{-1}\left(\frac{V_{1i}}{\cos\psi_i}\right), \theta_i = \cos^{-1}\left|\frac{V_{3i}}{\sin\psi_i}\right|$$
$$\phi_{1i} = \angle(V_{2i}), \phi_{2i} = \angle(V_{3i}), \phi_{3i} = \angle(V_{4i})$$

15. (original) A receiver baseband processing module comprises:

a plurality of fast Fourier transform modules operably coupled to convert a plurality of inbound symbol streams into a plurality of streams of beamformed symbols;

an inverse beamforming module operably coupled to inverse beamform, using a unitary matrix having polar coordinates, the plurality of streams of beamformed symbols into a plurality of streams of data symbols;

a plurality of constellation demapping modules operably coupled to demap the plurality of streams of data symbols into a plurality of interleaved streams of data;

a plurality of deinterleaving modules operably coupled to deinterleave the plurality of interleaved streams of data into encoded data; and

a decoding module operably coupled to convert the encoded data into inbound data.

16. (original) The receiver baseband processing module of claim 15, wherein the unitary matrix comprises:

a plurality of polar coordinates as represented by U, wherein absolute value of each of the plurality of polar coordinates is a vector on a unit circle and each of the polar coordinates is orthogonal to at least one other of the polar coordinates such that U*U = I, where I represents an identity matrix.

REMARKS/ARGUMENTS

1. In the above referenced Office Action, the Examiner provisionally rejected claims 1-14 under 35 USC § 101 as claiming the same invention as that of claims 1-12 of copending U.S. Patent No. 11/168,838; claims 1, 4-8 under 35 USC § 103 (a) as being unpatentable over Poon (U.S. Patent Publication No. 2005/0286663) in view of Reinhardt (U.S. Patent No. 5,541,607); claims 2 and 3 under 35 USC § 103 (a) as being unpatentable over Poon (U.S. Patent Publication No. 2005/0286663) in view of Reinhardt (U.S. Patent No. 5,541,607) and Poon (U.S. Patent Publication No. 2006/0067428) [Poon_2]; and claims 9-16 under 35 USC § 103 (a) as being unpatentable over Poon (U.S. Patent Publication No. 2005/0286663) in view of Reinhardt (U.S. Patent No. 5,541,607) and Poon (U.S. Patent Publication No. 2006/0067428). In addition, the Examiner has objected to claim 11 for an informality. The rejections and objections have been traversed and, as such, the applicant respectfully requests reconsideration of the allowability of claims 1-16.

2. Claim 11 has been amended in accordance with the Examiner's suggestion to overcome an informality.

3. Claims 1-14 have been rejected under 35 USC § 101 as claiming the same invention as that of claims 1-12 of copending U.S. Patent No. 11/168,838. The applicant respectfully disagrees with this rejection and the reasoning thereof.

Claims 1-5 of Present Application	Claim 1 of the 11/168,838 application as of the date of this response
1. A method for reduced feedback for beamforming in a wireless communication, the method comprises: receiving a baseband signal; and digitally beamforming the baseband signal using a unitary matrix having polar coordinates.	1. A method for beamforming in a wireless communication, the method comprises: receiving a baseband signal; <u>receiving a feedback signal that includes a subset of angles, wherein a set of angles provide polar coordinates for a unitary matrix and wherein the subset of angles is a subset of the set of angles;</u>

2. The method of claim 1 comprises: the baseband signal including a plurality of tones, wherein each of the plurality of tones corresponds to a symbol mapped to a constellation; and digital beamforming each of the plurality of tones using the unitary matrix. 3. The method of claim 1 comprises: receiving the baseband signal including: encoding data to produce a stream of encoded data; interleaving the stream of encoded data into a plurality of parallel streams of interleaved data; constellation mapping symbols of each of the plurality of parallel streams of interleaved data to a plurality of parallel tones; and digital beamforming each of the plurality of parallel tones using the unitary matrix. 4. The method of claim 1, wherein the unitary matrix comprises: a plurality of polar coordinates as represented by V, wherein absolute value of each of the plurality of polar coordinates is a vector on a unit circle and each of the polar coordinates is orthogonal to at least one other of the polar coordinates such that V*V = I, where I represents an identity matrix. 5. The method of claim 4, wherein the unitary matrix further comprises: for each column of V, a first row of polar coordinates including real values as	determining at least one remaining angle of the set of angles based on the subset of angles; determining the polar coordinates for the unitary matrix; and digitally beamforming the baseband signal using the unitary matrix. [emphasis added]

references and a second row of polar coordinates including phase shift values.	

Claims 9-11 of Present Application	Claim 8 of the 11/168,838 application as of the date of this response
9. A transmit baseband processing module comprises: an encoding module operably coupled to convert outbound data into encoded data; a plurality of interleaving modules operably coupled to interleave the encoded data into a plurality of interleaved streams of data; a plurality of constellation mapping modules operably coupled to map the plurality of interleaved streams of data into a plurality of streams of data symbols; a beamforming module operably coupled to beamform, using a unitary matrix having polar coordinates, the plurality of streams of data symbols into a plurality of streams of beamformed symbols; and a plurality of inverse fast Fourier transform modules operably coupled to convert the plurality of streams of beamformed symbols into a plurality of outbound symbol streams. 10. The transmit baseband processing module of claim 9, wherein the unitary matrix comprises: a plurality of polar coordinates as represented by V, wherein absolute value of each of the plurality of polar coordinates is a vector on a unit circle and each of the polar coordinates is orthogonal to at least one other of the polar coordinates such that V*V = I, where I represents an identity	8. A transmit baseband processing module comprises: an encoding module operably coupled to convert outbound data into encoded data; a plurality of interleaving modules operably coupled to interleave the encoded data into a plurality of interleaved streams of data; a plurality of constellation mapping modules operably coupled to map the plurality of interleaved streams of data into a plurality of streams of data symbols; a beamforming module operably coupled to: obtain a feedback signal that includes a subset of angles, wherein a set of angles provide polar coordinates for a unitary matrix and wherein the subset of angles is a subset of the set of angles; determine at least one remaining angle of the set of angles based on the subset of angles; determine the polar coordinates for the unitary matrix; and digitally beamform, using the unitary matrix having polar coordinates, the plurality of streams of data symbols into a plurality of streams of beamformed symbols; and

matrix. 11. The transmit baseband processing module of claim 10, wherein the unitary matrix further comprises: for each column of V, a first row of polar coordinates including real values as references and a second row of polar coordinates including phase shift values.	a plurality of inverse fast Fourier transform modules operably coupled to convert the plurality of streams of beamformed symbols into a plurality of outbound symbol streams. [emphasis added]

The above tabular comparison demonstrates that the invention of the present case is not the same invention as that of copending application 11/168,838. In particular, copending application includes the limitations of receiving or obtaining a feedback signals that is utilized to determine polar coordinates for a unitary matrix. The claims of the present patent application have no such limitation. As such, the claims of the present patent application are not claiming the same invention as the claims of copending patent application 11/168,838.

4. Claims 1, 4-8 have been rejected under 35 USC § 103 (a) as being unpatentable over Poon (U.S. Patent Publication No. 2005/0286663) in view of Reinhardt (U.S. Patent No. 5,541,607). The applicant respectfully disagrees with this rejection and the reasoning thereof.

Poon teaches a compact feedback for closed loop MIMO systems that utilizes codebooks know to both the transmitter and receiver. The codebooks hold pre-coding information that a transmitter may use for beamforming. A receiver identifies the codebook elements for the transmitter to use by transmitting indices identifying the codebook elements. [paragraph 14] Poon further teaches that an input/output model can be expressed as y = Hx + z, where where x_i is the signal on the ith transmit antenna, y_i is the signal received at the ith receive antenna, H_{ij} is the channel gain from the jth transmit antenna to the ith receive antenna, and z_i is the noise on the ith receive antenna. In closed-loop MIMO, the transmitter may apply a pre-coding matrix P to the signal for beamforming and the I/O model becomes y=HPx+z. [paragraphs 15 and 16] Poon further teaches in paragraph 18 that U and V are Nx.N unitary matrices, and that Matrix V may be used as the transmit beamforming matrix, in which case P=V.

Poon teaches that the pre-coding Matrix P may be a unitary matrix that is applied to a radio frequency (RF) signal (i.e., x) to produce the resulting beamformed signal of Px. [emphasis added]

Reinhardt teaches a polar digital beamforming method and system that includes a polar digital beamforming (PDBF) array module 32, which, as shown in Figure 3, includes a plurality of subarrays 1-N. Each subarray includes a subarray controller a phasor 50, an attenuator 52, a power amplifier 54, and an antenna 56. With reference to Figures 4 and 5, Reinhardt teaches that a subarray controller 48 of one of the subarrays receives digital modulation information (e.g., $S_m(t)$) and pointing weights (e.g., P_{mn}) from the computer 40. The subarray controller 48 processes the digital modulation information, $S_m(t)$, and the pointing weights, P_{mn}, to produce a polar attenuation A_n and a phase Φ_n. These signals are corrected and provided to the attenuators 50 and phasors 52. (column 5, line 46, through column 6, line 10.

As such, Reinhardt is teaches that a computer 40 generates digital modulation information, Sm(t), and different pointing weights, P_{mn}, for each of the subarrays. As such, each subarray processes the same signal using different pointing weights.

Combining the teachings of Poon, which teaches that the pre-coding Matrix P may be a unitary matrix that is applied to a radio frequency (RF) signal (i.e., x) to produce the resulting beamformed signal of Px, with the teachings of Reinhardt, which teaches that each subarray processes the same signal using different pointing weights, does not render claim 1, as amended, obvious. As amended, claim 1 claims, in part, digitally beamforming each of the plurality of streams of the baseband signal using a unitary matrix having polar coordinates to produce a plurality of beamformed symbols.

As such, the baseband beamforming of claim 1 is done a plurality of signals using the same matrix. As such, the applicant believes that clam 1 overcomes the present rejection.

Claims 4-8 are dependent upon claim 1 and introduce additional patentable subject matter. The applicant believes that the reasons that distinguish claim 1 over the present rejection are applicable in distinguishing claims 4-8 over the same rejection.

5. Claims 2 and 3 have been rejected under 35 USC § 103 (a) as being unpatentable over Poon (U.S. Patent Publication No. 2005/0286663) in view of Reinhardt (U.S. Patent No. 5,541,607) and Poon (U.S. Patent Publication No. 2006/0067428) [Poon_2]. The applicant respectfully disagrees with this rejection and the reasoning thereof.

As discussed above, the combined teaches of Poon and Reinhardt fail to render claim 1 obvious. Since claims 2 and 3 are dependent upon claim 1 and introduce additional patentable subject matter, combining the teachings of Poon and Reinhardt with Poon_2 fails to render claims 2 and 3 obvious. As such, the applicant believes that claims 2 and 3 over the present rejection.

6. Claims 9-16 have been rejected under 35 USC § 103 (a) as being unpatentable over Poon (U.S. Patent Publication No. 2005/0286663) in view of Reinhardt (U.S. Patent No. 5,541,607) and Poon (U.S. Patent Publication No. 2006/0067428). The applicant respectfully disagrees with this rejection and the reasoning thereof.

Claim 9 claims, in part, that a beamforming module is operably coupled to beamform, <u>using a unitary matrix having polar coordinates</u>, <u>the plurality of streams of data symbols</u> into a plurality of streams of beamformed symbols. [emphasis added] The applicant believes that the combined teachings of Poon, which teaches that the pre-coding Matrix P may be a unitary matrix that <u>is applied to a radio frequency (RF) signal (i.e., x)</u> to produce the resulting beamformed signal of Px, Reinhardt, which teaches that <u>each subarray processes the same signal using different pointing weights</u>, and Poon_2, as referenced by the Examiner, does not render claim 9 obvious. Thus, the applicant believes that claim 9 overcomes the present rejection.

Claims 10-14 are dependent upon claim 9 and introduce additional patentable subject matter. The applicant believes that the reasons that distinguish claim 9 over the present rejection are applicable in distinguishing claims 10-14 over the same rejection.

Claim 15 claims, in part, an inverse beamforming module operably coupled to inverse beamform, using a unitary matrix having polar coordinates, the plurality of streams of beamformed symbols into a plurality of streams of data symbols. The applicant believes that the same reasons that distinguish claim 9 over the present rejection are applicable in distinguishing claim 15 over the same rejection.

Claim 16 is dependent upon claim 15 and introduces additional patentable subject matter. The applicant believes that the reasons that distinguish claim 15 over the present rejection are applicable in distinguishing claim 16over the same rejection.

For the foregoing reasons, the applicant believes that claims 1-16 are in condition for allowance and respectfully request that they be passed to allowance.

The Applicant hereby rescinds any disclaimer of claim scope made in the parent application or any predecessor application in relation to the instant application. The Examiner is advised that any such previous disclaimer and the prior art that it was made to avoid, may need to be revisited. Further, the claims in the instant application may be broader than those of a parent application. Moreover, the Examiner should also be advised that any disclaimer made in the instant application should not be read into or against the parent application.

The Examiner is invited to contact the undersigned by telephone or facsimile if the Examiner believes that such a communication would advance the prosecution of the present invention.

RESPECTFULLY SUBMITTED,

By: /Timothy W. Markison reg. 33,534/
Timothy W. Markison
Phone: (808) 665-1725
Fax No. (808) 665-1728

CERTIFICATE OF MAILING
37 C.F.R 1.8

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Date Signature

Electronic Acknowledgement Receipt

EFS ID:	3538523
Application Number:	11168793
International Application Number:	
Confirmation Number:	9094
Title of Invention:	Reduced feedback for beamforming in a wireless communication
First Named Inventor/Applicant Name:	Joonsuk Kim
Customer Number:	51472
Filer:	Timothy W. Markison/Barbara Adkins
Filer Authorized By:	Timothy W. Markison
Attorney Docket Number:	BP4637
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Document Number	Document Description	File Name	File Size(Bytes) /Message Digest	Multi Part /.zip	Pages (if appl.)
1	Amendment - After Non-Final Rejection	BP4637_Response_to_033108_OA_063008.pdf	97911 0cf3525e5c2c398e16aef5ff379c1face887c3fe	no	15

Warnings:

Information:

Total Files Size (in bytes):	97911

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New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/SB/06 (07-06)
Approved for use through 1/31/2007. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 11/168,793	Filing Date 06/28/2005	☐ To be Mailed

APPLICATION AS FILED – PART I

FOR	NUMBER FILED (Column 1)	NUMBER EXTRA (Column 2)	SMALL ENTITY ☐ RATE ($)	SMALL ENTITY FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =		OR	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =			X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							
			TOTAL			TOTAL	

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

APPLICATION AS AMENDED – PART II

AMENDMENT 06/30/2008	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	SMALL ENTITY RATE ($)	SMALL ENTITY ADDITIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	* 16	Minus	** 20	= 0	X $ =		OR	X $50=	0
Independent (37 CFR 1.16(h))	* 3	Minus	***3	= 0	X $ =		OR	X $210=	0
☐ Application Size Fee (37 CFR 1.16(s))									
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	0

AMENDMENT	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	RATE ($)	ADDITIONAL FEE ($)	OR	RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =		OR	X $ =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =		OR	X $ =	
☐ Application Size Fee (37 CFR 1.16(s))									
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

Legal Instrument Examiner:
/MOLIKI I. MAY/

UNITED STATES PATENT AND TRADEMARK OFFICE

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/168,793	06/28/2005	Joonsuk Kim	BP4637	9094

51472 7590 10/06/2008
GARLICK HARRISON & MARKISON
P.O. BOX 160727
AUSTIN, TX 78716-0727

EXAMINER	
NEFF, MICHAEL R	
ART UNIT	**PAPER NUMBER**
2611	
MAIL DATE	**DELIVERY MODE**
10/06/2008	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

PTOL-90A (Rev. 04/07)

Office Action Summary	Application No.	Applicant(s)	
	11/168,793	KIM, JOONSUK	
	Examiner	Art Unit	
	MICHAEL R. NEFF	2611	

-- 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) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, 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 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 _30 June 2008_.

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) _1-16_ 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) _1-16_ 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

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.

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/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

Response to Arguments

1. Applicant's arguments filed 6/30/2008 have been fully considered but they are not persuasive. The examiner thoroughly reviewed the applicant's arguments but firmly believes that the cited reference reasonably and properly meets the claimed limitation as rejected.

(1) Applicant's arguments: Re Double Patenting rejection: "In particular, copending application includes the limitations of receiving or obtaining a feedback signals that is utilized to determine polar coordinates for a unitary matrix. The claims of the present patent application have no such limitation. As such, the claims of the present patent application are not claiming the same invention as the claims of copending patent application 11/168,838."

Examiner's response: The Examiner maintains the grounds of a double patenting rejection. While the independent reference of the '838 reference may have more limitations than that of the current application, this does not effect the fact that the limitations of the current application are contained within the limitations of the '838 reference. The examiner notes for the applicant that this is a one way double patenting that has not been applied in the reverse manner of the current application reading on '838. Due to the cancellation of claim 2 in the '838 reference, the double patenting rejection been modified to account for this, but is nonetheless maintained as previously presented.

(2) Applicant's arguments: Re Claims 9, 15, and now amended claim 1; "Claim 9 claims, in part, that a beamforming module is operably coupled to beamform, using a unitary matrix having polar coordinates, the plurality of streams of data symbols into a plurality of streams of beamformed symbols. [emphasis added] The applicant believes that the combined teachings of Poon, which teaches that the pre-coding Matrix P may be a unitary matrix that is applied to a radio frequency (RF) signal (i.e., x) to produce the resulting beamformed signal of Px, Reinhardt, which teaches that each subarray processes the same signal using different pointing weights, and Poon_2, as referenced by the Examiner, does not render claim 9 obvious. Thus, the applicant believes that claim 9 overcomes the present rejection.

Examiner's response: Applicant's arguments fail to comply with 37 CFR 1.111(b) because they amount to a general allegation that the claims define a patentable invention without specifically pointing out how the language of the claims patentably distinguishes them from the references.

Applicant's arguments do not comply with 37 CFR 1.111(c) because they do not clearly point out the patentable novelty which he or she thinks the claims present in view of the state of the art disclosed by the references cited or the objections made. Further, they do not show how the amendments avoid such references or objections.

Regarding the argument above, the applicant has failed to even discuss beyond mentioning the prior art of Poon_2, which is the prior art utilized to disclose the argued limitations. Further, the disclosure of Poon discusses MIMO and multi channel functionality (Abstract, 0019, for example). The disclosure of Poon_2 further establishes the prior knowledge of the functionality of the system of the current application in a MIMO system wherein a plurality of streams (signals) are present.

The Examiner therefore retains the previous grounds of rejection for the claims. Claim 1 has been amended and thus the office action provided below has been revised to provide new grounds of rejection for said amendment as well as to provide the revised double patenting rejection in light of the cancelling of claims within the co-pending application.

Double Patenting

2. A rejection based on double patenting of the "same invention" type finds its support in the language of 35 U.S.C. 101 which states that "whoever invents or discovers any new and useful process ... may obtain a patent therefor ..." (Emphasis added). Thus, the term "same invention," in this context, means an invention drawn to identical subject matter. See *Miller v. Eagle Mfg. Co.*, 151 U.S. 186 (1894); *In re Ockert*, 245 F.2d 467, 114 USPQ 330 (CCPA 1957); and *In re Vogel*, 422 F.2d 438, 164 USPQ 619 (CCPA 1970).

A statutory type (35 U.S.C. 101) double patenting rejection can be overcome by canceling or amending the conflicting claims so they are no longer coextensive in scope. The filing of a terminal disclaimer cannot overcome a double patenting rejection based upon 35 U.S.C. 101.

3. Claims 1, 3-14 are provisionally rejected under 35 U.S.C. 101 as claiming the same invention as that of claims 1, 3-12 of copending Application No. 11/168,838. The scope of the invention claimed within the above mentioned co-pending application is

equivalent to that of the scope of the limitations claimed in the above noted claims of the current application. This is a provisional double patenting rejection since the conflicting claims have not in fact been patented.

Claim Rejections - 35 USC § 103

4. The text of those sections of Title 35, U.S. Code not included in this action can be found in a prior Office action.

5. **Claims 1, 4-8 are rejected under 35 U.S.C. 103(a) as being unpatentable over Poon (US Publication 2005/0286663 A1) in view of Reinhardt (US Patent 5,541,607).**

Re Claim 1, Poon discloses a method for reduced feedback for beamforming in a wireless communication, the method comprises:

receiving a baseband signal (Figure 1, antenna elements) that includes a plurality of streams (Paragraphs 0019, 0034-0039, 0042-0048); and

digitally beamforming each of the plurality of streams of (Paragraphs 0019, 0034-0039, 0042-0048) the baseband signal using a unitary matrix (Paragraph 0018, 0025-26).

However Poon fails to explicitly disclose wherein the coordinates for the unitary matrix are polar coordinates to produce a plurality of streams. This design for a beamforming system is however disclosed by Reinhardt. Reinhardt discloses a beamforming system wherein polar coordinates are used for the purpose of beamforming (Figures 3 and 6; 78, 98; Col. 3 line 65-Col. 4 line 5; Col. 6 line 66- Col. 7 line 7).

Therefore it would have been obvious to one of ordinary skill in the art at the time the invention was made to incorporate the use of polar coordinates in the beamforming process as disclosed by Reinhardt within the MIMO beamforming system of Poon in order to gain the benefit increasing the system efficiency for a plurality of beams by replacing the power and bandwidth consuming rectangular coordinates.

Re Claims 4-8; the combined disclosures of Poon and Reinhardt as a whole disclose the method of claim 1, however these disclosures fail to explicitly disclose wherein the unitary matrix comprises: a plurality of polar coordinates as represented by V, wherein absolute value of each of the plurality of polar coordinates is a vector on a unit circle and each of the polar coordinates is orthogonal to at least one other of the polar coordinates such that V*V = I, where I represents an identity matrix as recited in claim 4; or wherein for each column of V, a first row of polar coordinates including real values as references and a second row of polar coordinates including phase shift values as recited in claim 5; or the unitary matrix limitations for a MIMO communication using a 2xn, 3xN, and 4xN matrix array as recited in claims 6-8.

However it would have been obvious to one of ordinary skill in the art at the time the invention was made that the above claim limitations would be obvious design choices for the system. The disclosure of Poon, as shown above in the citing by the Examiner, provides for a system of constructing beamforming matrices (paragraphs 0022-0024 and associated table 1). Previously in the disclosure the construction of the matrix array is discussed, (paragraph 0018) which the examiner reads as encompassing the limitations of the 2xN, 3xN, and 4xN matrices (claims 5-8), while the disclosure of the generation of the indices within these matrices as disclosed by Poon fully encompass the claimed limitations of the equations utilized to construct the various indices within the claimed matrices. In regards to claim 4, taking the disclosures of Poon and Reinhardt as a whole the Examiner reads this claim limitation as resulting from a design choice involving the polar coordinates being used, and based the features of a unitary matrix.

Therefore it would have been obvious to one of ordinary skill in the art at the time the invention was made to incorporate the design choices as provided within the limitations of claims 4-8 within the digital beamforming system as disclosed by Poon, Reinhardt and Poon_2 to gain the benefit of utilizing the beamforming aspect to address the specifications of the system design and desired functionality.

6. **Claims 2 and 3 are rejected under 35 U.S.C. 103(a) as being unpatentable over Poon and Reinhardt as applied to claim 1 above and further in view of Poon (herein after Poon_2) (US Publication 2006/0067428 A1).**

Re Claims 2 and 3; the combined disclosures of Poon and Reinhardt as a whole disclose the method of claim 1, Poon further discloses wherein the method comprises: digital beamforming each of the plurality (or parallel) of tones using the unitary matrix (Paragraph 0018, 0025-26; Figures 1 and 6 discloses the parallel signal I/O structure) and wherein receiving the baseband signal comprises: encoding data to produce a stream of encoded data (630, 640; Paragraphs 0045-46); but fails to explicitly disclose the limitation wherein the baseband signal including a plurality of tones, wherein each of the plurality of tones corresponds to a symbol mapped to a constellation as recited in claim 2, or wherein receiving the baseband signal comprises: encoding data to produce a stream of encoded data; interleaving the stream of encoded data into a plurality of parallel streams of interleaved data; constellation mapping symbols of each of the plurality of parallel streams of interleaved data to a plurality of parallel tones as recited in claim 3.

These system aspects are however disclosed by Poon_2. Poon_2 discloses a system wherein the baseband signal including a plurality of tones, wherein each of the plurality of tones corresponds to a symbol mapped to a constellation (14; Paragraph 0021-22 and the associated tables 3 and 4); and wherein receiving the baseband signal further comprises: interleaving the stream of encoded data into a plurality of parallel streams of interleaved data (12); constellation mapping symbols of each of the plurality of parallel streams of interleaved data to a plurality of parallel tones (14) as recited in claim 3.

Therefore it would have been obvious to one of ordinary skill in the art at the time the invention was made to incorporate the disclosure of Poon_2 within the beamforming system as disclosed by Poon and Reinhardt in order to obtain the benefit of more efficient signal manipulation prior to transmitting the signals post beamforming.

7. **Claims 9-16 are rejected under 35 U.S.C. 103(a) as being unpatentable over Poon in view of Reinhardt and Poon_2.**

Re Claims 9, Poon discloses a transmit baseband processing module comprises:

an encoding module operably coupled to convert outbound data into encoded data (630, 640; Paragraphs 0045-46);

a beamforming module operably coupled to beamform, using a unitary matrix having coordinates (paragraph 0022-24; Table 1), the plurality of streams of data symbols into a plurality of streams of beamformed symbols (Paragraph 0018, 0025-26).

However Poon fails to explicitly disclose the limitations wherein (1) the coordinates for the unitary matrix are polar coordinates or (2) a plurality of interleaving modules operably coupled to interleave the encoded data into a plurality of interleaved streams of data; a plurality of constellation mapping modules operably coupled to map the plurality of interleaved streams of data into a plurality of streams of data symbols; and a plurality of inverse fast Fourier transform modules operably coupled to convert the plurality of streams of beamformed symbols into a plurality of outbound symbol streams.

Regarding item (1) above, this design for a beamforming system is however disclosed by Reinhardt. Reinhardt discloses a beamforming system wherein polar coordinates are used for the purpose of beamforming (Figures 3 and 6; 78, 98; Col. 3 line 65-Col. 4 line 5; Col. 6 line 66- Col. 7 line 7).

Therefore it would have been obvious to one of ordinary skill in the art at the time the invention was made to incorporate the use of polar coordinates in the beamforming process as disclosed by Reinhardt within the beamforming system of Poon in order to gain the benefit increasing the system efficiency for a plurality of beams by replacing the power and bandwidth consuming rectangular coordinates.

Regarding item (2) above, Poon_2 discloses a plurality of interleaving modules (12; Figure 4 shows this system design implemented in a plurality) operably coupled to interleave the encoded data into a plurality of interleaved streams of data; a plurality of constellation mapping modules (14) operably coupled to map the plurality of interleaved streams of data into a plurality of streams of data symbols; and a plurality of inverse fast Fourier transform modules (16) operably coupled to convert the plurality of streams of beamformed symbols into a plurality of outbound symbol streams.

Therefore it would have been obvious to one of ordinary skill in the art at the time the invention was made to incorporate the disclosure of Poon_2 within the beamforming system as disclosed by Poon in order to obtain the benefit of more efficient signal manipulation prior to transmitting the signals post beamforming.

Claim 15 has been analyzed and rejected with regards to claim 9 as being the obvious receiver design to the claim limitations of the previously mentioned and currently rejected claim 9.

Re Claims 10-14 and 16; the combined disclosures of Poon, Reinhardt and Poon_2 as a whole disclose the communication device of claim 9, however these disclosures fail to explicitly disclose wherein the unitary matrix comprises: a plurality of polar coordinates as represented by V, wherein absolute value of each of the plurality of polar coordinates is a vector on a unit circle and each of the polar coordinates is orthogonal to at least one other of the polar coordinates such that V*V = I, where I represents an identity matrix as recited in claim 10 (with claim 16 being the obvious receiver counterpart; and the U matrix being the functional equivalent of the V matrix in the transmitter end); or wherein for each column of V, a first row of polar coordinates including real values as references and a second row of polar coordinates including phase shift values as recited in claim 11; or the unitary matrix limitations for a MIMO communication using a 2xn, 3xN, and 4xN matrix array as recited in claims 12-14.

However it would have been obvious to one of ordinary skill in the art at the time the invention was made that the above claim limitations would be obvious design choices for the system. The disclosure of Poon, as shown above in the citing by the Examiner, provides for a system of constructing beamforming matrices (paragraphs 0022-0024 and associated table 1). Previously in the disclosure the construction of the matrix array is discussed, (paragraph 0018) which the examiner reads as encompassing the limitations of the 2xN, 3xN, and 4xN matrices (claims 11-14), while the disclosure of the generation of the indices within these matrices as disclosed by Poon fully encompass the claimed limitations of the equations utilized to construct the various indices within the claimed matrices. In regards to claims 10 and 16, taking the disclosures of Poon and Reinhardt as a whole the Examiner reads this claim limitation as resulting from a design choice involving the polar coordinates being used, and based the features of a unitary matrix.

Therefore it would have been obvious to one of ordinary skill in the art at the time the invention was made to incorporate the design choices as provided within the limitations of claims 10-14 and 16 within the digital beamforming system as disclosed by

Poon, Reinhardt and Poon_2 to gain the benefit of utilizing the beamforming aspect to address the specifications of the system design and desired functionality.

Conclusion

8. Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). 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 date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to MICHAEL R. NEFF whose telephone number is (571)270-1848. The examiner can normally be reached on Monday - Friday 8:00am - 4:30pm EST ALT Fridays.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Shuwang Liu can be reached on (571)272-3036. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/MICHAEL R. NEFF/
Examiner, Art Unit 2611
/Shuwang Liu/
Supervisory Patent Examiner, Art Unit 2611

Index of Claims	**Application/Control No.** 11168793	**Applicant(s)/Patent Under Reexamination** KIM, JOONSUK
	Examiner MICHAEL R NEFF	**Art Unit** 2611

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ **Claims renumbered in the same order as presented by applicant** ☐ **CPA** ☐ **T.D.** ☐ **R.1.47**

CLAIM		DATE								
Final	Original	03/25/2008	09/29/2008							
	1	✓	✓							
	2	✓	✓							
	3	✓	✓							
	4	✓	✓							
	5	✓	✓							
	6	✓	✓							
	7	✓	✓							
	8	✓	✓							
	9	✓	✓							
	10	✓	✓							
	11	✓	✓							
	12	✓	✓							
	13	✓	✓							
	14	✓	✓							
	15	✓	✓							
	16	✓	✓							

Search Notes	Application/Control No. 11168793	Applicant(s)/Patent Under Reexamination KIM, JOONSUK
	Examiner MICHAEL R NEFF	Art Unit 2611

SEARCHED

Class	Subclass	Date	Examiner
375	260, 267, 299	3/24/2008	MRN

SEARCH NOTES

Search Notes	Date	Examiner
Class/Subclass search performed using keyword limitations	3/24/2008	MRN
Inventor/Double patenting search performed in EAST database	3/24/2008	MRN
Prior art revisited per amendments and arguments from applicant	9/29/2008	MRN

INTERFERENCE SEARCH

Class	Subclass	Date	Examiner

/MICHAEL R NEFF/
Examiner.Art Unit 2611

Doc code: RCEX
Doc description: Request for Continued Examination (RCE)

PTO/SB/30EFS (12-08)
Approved for use through 01/31/2009. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

REQUEST FOR CONTINUED EXAMINATION(RCE)TRANSMITTAL
(Submitted Only via EFS-Web)

Application Number	11168793	Filing Date	2005-06-28	Docket Number (if applicable)	BP4637	Art Unit	2611
First Named Inventor	Joonsuk Kim			Examiner Name	Michael R. Neff		

This is a Request for Continued Examination (RCE) under 37 CFR 1.114 of the above-identified application.
Request for Continued Examination (RCE) practice under 37 CFR 1.114 does not apply to any utility or plant application filed prior to June 8, 1995, or to any design application. The Instruction Sheet for this form is located at WWW.USPTO.GOV

SUBMISSION REQUIRED UNDER 37 CFR 1.114

Note: If the RCE is proper, any previously filed unentered amendments and amendments enclosed with the RCE will be entered in the order in which they were filed unless applicant instructs otherwise. If applicant does not wish to have any previously filed unentered amendment(s) entered, applicant must request non-entry of such amendment(s).

☐ Previously submitted. If a final Office action is outstanding, any amendments filed after the final Office action may be considered as a submission even if this box is not checked.

- ☐ Consider the arguments in the Appeal Brief or Reply Brief previously filed on ____________
- ☐ Other ____________

☒ Enclosed

- ☒ Amendment/Reply
- ☐ Information Disclosure Statement (IDS)
- ☐ Affidavit(s)/ Declaration(s)
- ☐ Other ____________

MISCELLANEOUS

☐ Suspension of action on the above-identified application is requested under 37 CFR 1.103(c) for a period of months ____________
(Period of suspension shall not exceed 3 months; Fee under 37 CFR 1.17(i) required)

☐ Other ____________

FEES

☒ **The RCE fee under 37 CFR 1.17(e) is required by 37 CFR 1.114 when the RCE is filed.**
The Director is hereby authorized to charge any underpayment of fees, or credit any overpayments, to Deposit Account No 502126

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT REQUIRED

☒ Patent Practitioner Signature
☐ Applicant Signature

PTO/SB/30EFS (12-08)
Approved for use through 01/31/2009. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Signature of Registered U.S. Patent Practitioner			
Signature	/Jessica W. Smith/	Date (YYYY-MM-DD)	2009-01-29
Name	Jessica W. Smith	Registration Number	39884

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Electronic Patent Application Fee Transmittal

Application Number:	11168793
Filing Date:	28-Jun-2005
Title of Invention:	Reduced feedback for beamforming in a wireless communication
First Named Inventor/Applicant Name:	Joonsuk Kim
Filer:	Jessica Smith/Melanie Murdock
Attorney Docket Number:	BP4637

Filed as Large Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Extension - 1 month with $0 paid	1251	1	130	130

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
Request for continued examination	1801	1	810	810
		Total in USD ($)		**940**

Electronic Acknowledgement Receipt

EFS ID:	4701221
Application Number:	11168793
International Application Number:	
Confirmation Number:	9094
Title of Invention:	Reduced feedback for beamforming in a wireless communication
First Named Inventor/Applicant Name:	Joonsuk Kim
Customer Number:	51472
Filer:	Jessica Smith/Melanie Murdock
Filer Authorized By:	Jessica Smith
Attorney Docket Number:	BP4637
Receipt Date:	29-JAN-2009
Filing Date:	28-JUN-2005
Time Stamp:	17:08:46
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Credit Card
Payment was successfully received in RAM	$940
RAM confirmation Number	2682
Deposit Account	502126
Authorized User	MURDOCK,MELANIE

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

Charge any Additional Fees required under 37 C.F.R. Section 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		BP4637_Amendment_01062009.pdf	174911 68ec16d55174f5379832db28f3484506d81070c3	yes	19

Multipart Description/PDF files in .zip description

Document Description	Start	End
Amendment Submitted/Entered with Filing of CPA/RCE	1	1
Claims	2	8
Applicant Arguments/Remarks Made in an Amendment	9	19

Warnings:

Information:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
2	Request for Continued Examination (RCE)	BP4637_RCE_01292009.pdf	697277 b9a9fe7bd6062904bbb42e76cea5a5c2d29082d7	no	3

Warnings:

Information:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
3	Fee Worksheet (PTO-06)	fee-info.pdf	32003 18e038004afc0b1d6f2aba7d67fb184e317f7d50	no	2

Warnings:

Information:

Total Files Size (in bytes): 904191

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New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor:	Joonsuk Kim	**Docket:**	BP4637
Serial No.:	11/168,793	**Art Unit:**	2611
Filed:	June 28, 2005	**Examiner:**	Micheal R. Neff
Title:	Reduced Feedback for Beamforming in a Wireless Communication		

RESPONSE TO FINAL OFFICE ACTION

M/S Amendment
Commissioner for Patents
P. O. Box 1450
Alexandria, VA 22313-1450

Dear Commissioner:

In response to the Office Action dated October 6, 2008, please consider the following amendment and response.

Amendment to the Claims

1. (currently amended) A method for reduced feedback for beamforming in a wireless communication, the method comprises:

receiving a baseband signal that includes a plurality of streams;

determining a unitary matrix having polar coordinates in response to feedback information, wherein the feedback information includes angles of a unit circle; and

digitally beamforming each of the plurality of streams of the baseband signal using the ~~a~~ unitary matrix ~~having polar coordinates~~ to produce a plurality of beamformed symbols.

2. (original) The method of claim 1 comprises:

the baseband signal including a plurality of tones, wherein each of the plurality of tones corresponds to a symbol mapped to a constellation; and

digital beamforming each of the plurality of tones using the unitary matrix.

3. (original) The method of claim 1 comprises:

receiving the baseband signal including:

encoding data to produce a stream of encoded data;

interleaving the stream of encoded data into a plurality of parallel streams of interleaved data;

constellation mapping symbols of each of the plurality of parallel streams of interleaved data to a plurality of parallel tones; and

digital beamforming each of the plurality of parallel tones using the unitary matrix.

4. (currently amended) The method of claim 1, wherein the unitary matrix comprises:

a plurality of polar coordinates as represented by V, wherein absolute value of each of the plurality of polar coordinates is a vector on the ~~a~~ unit circle and each of the polar coordinates is orthogonal to at least one other of the polar coordinates such that V*V = I, where I represents an identity matrix.

5. (original) The method of claim 4, wherein the unitary matrix further comprises:

for each column of V, a first row of polar coordinates including real values as references and a second row of polar coordinates including phase shift values.

6. (original) The method of claim 5, wherein the unitary matrix further comprises for a 2xN multiple input multiple output (MIMO) wireless communication:

$$V = \begin{bmatrix} \cos\psi_1 & \cos\psi_2 \\ \sin\psi_1 e^{j\phi_1} & \sin\psi_2 e^{j\phi_2} \end{bmatrix}$$

wherein ψ_1, Φ_1, ψ_2, and Φ_2 represent angles of the unit circle, wherein absolute value of $\psi_1 - \psi_2 = \pi/2$ and $\Phi_1 = \Phi_2$ or $\Phi_1 = \Phi_2 + \pi$ and $\psi_1 + \psi_2 = \pi/2$.

7. (original) The method of claim 5, wherein the unitary matrix further comprises for a 3xN multiple input multiple output (MIMO) wireless communication:

$$V = \begin{bmatrix} \cos\psi_1 & \cos\psi_2 & \cos\psi_3 \\ \sin\psi_1\cos\theta_1 e^{j\phi_{21}} & \sin\psi_2\cos\theta_2 e^{j\phi_{22}} & \sin\psi_3\cos\theta_3 e^{j\phi_{23}} \\ \sin\psi_1\sin\theta_1 e^{j\phi_{31}} & \sin\psi_2\sin\theta_2 e^{j\phi_{32}} & \sin\psi_3\sin\theta_3 e^{j\phi_{33}} \end{bmatrix}$$

wherein ψ_1, ψ_2, ψ_3, θ_1, θ_2, θ_3, Φ_{21}, Φ_{22}, Φ_{23}, Φ_{31}, Φ_{32}, Φ_{33} represent angles of the unit circle, wherein Diagonal (V*V) = 1s, and wherein:

$$\psi_i = \cos^{-1} V_{1i}, \theta_i = \cos^{-1}\left|\frac{V_{2i}}{\sin\psi_i}\right|$$
$$\phi_{2i} = \angle(V_{2i}), \phi_{3i} = \angle(V_{3i})$$

8. (original) The method of claim 5, wherein the unitary matrix further comprises for a 4xN multiple input multiple output (MIMO) wireless communication:

$$V = \begin{bmatrix} \cos\psi_1\cos\varphi_1 & \cos\psi_2\cos\varphi_2 & \cos\psi_3\cos\varphi_3 & \cos\psi_4\cos\varphi_4 \\ \cos\psi_1\sin\varphi_1 e^{j\phi_{11}} & \cos\psi_2\sin\varphi_2 e^{j\phi_{12}} & \cos\psi_3\sin\varphi_3 e^{j\phi_{13}} & \cos\psi_4\sin\varphi_4 e^{j\phi_{14}} \\ \sin\psi_1\cos\theta_1 e^{j\phi_{21}} & \sin\psi_2\cos\theta_2 e^{j\phi_{22}} & \sin\psi_3\cos\theta_3 e^{j\phi_{23}} & \sin\psi_4\cos\theta_4 e^{j\phi_{24}} \\ \sin\psi_1\sin\theta_1 e^{j\phi_{31}} & \sin\psi_2\sin\theta_2 e^{j\phi_{32}} & \sin\psi_3\sin\theta_3 e^{j\phi_{33}} & \sin\psi_4\sin\theta_4 e^{j\phi_{34}} \end{bmatrix}$$

wherein ψ_1, ψ_2, ψ_3, ψ_4, θ_1, θ_2, θ_3, θ_4, φ_1, φ_2, φ_3, φ_4, Φ_{21}, Φ_{22}, Φ_{23}, Φ_{24}, Φ_{31}, Φ_{32} , Φ_{33}, Φ_{33}, Φ_{41}, Φ_{42}, Φ_{43}, Φ_{43} represent angles of the unit circle, wherein Diagonal (V*V) = 1s, and wherein:

$$\psi_i = \cos^{-1}\left(\sqrt{|V_{1i}|^2 + |V_{2i}|^2}\right), \varphi_i = \cos^{-1}\left(\frac{V_{1i}}{\cos\psi_i}\right), \theta_i = \cos^{-1}\left|\frac{V_{3i}}{\sin\psi_i}\right|$$
$$\phi_{1i} = \angle(V_{2i}), \phi_{2i} = \angle(V_{3i}), \phi_{3i} = \angle(V_{4i})$$

9. (currently amended) A transmit baseband processing module comprises:

an encoding module operably coupled to convert outbound data into encoded data;

a plurality of interleaving modules operably coupled to interleave the encoded data into a plurality of interleaved streams of data;

a plurality of constellation mapping modules operably coupled to map the plurality of interleaved streams of data into a plurality of streams of data symbols;

a beamforming module operably coupled to beamform, using a unitary matrix having polar coordinates, the plurality of streams of data symbols into a plurality of streams of beamformed symbols, wherein the polar coordinates of the unitary matrix are based on feedback information that includes angles of a unit circle; and

a plurality of inverse fast Fourier transform modules operably coupled to convert the plurality of streams of beamformed symbols into a plurality of outbound symbol streams.

10. (currently amended) The transmit baseband processing module of claim 9, wherein the unitary matrix comprises:

a plurality of polar coordinates as represented by V, wherein absolute value of each of the plurality of polar coordinates is a vector on the ~~a~~ unit circle and each of the polar coordinates is orthogonal to at least one other of the polar coordinates such that V*V = I, where I represents an identity matrix.

11. (currently amended) The transmit baseband processing module of claim 10 ~~11~~, wherein the unitary matrix further comprises:

for each column of V, a first row of polar coordinates including real values as references and a second row of polar coordinates including phase shift values.

12. (currently amended) The transmit baseband processing module of claim 11, wherein the unitary matrix further comprises for a 2xN multiple input multiple output (MIMO) wireless communication:

$$V = \begin{bmatrix} \cos\psi_1 & \cos\psi_2 \\ \sin\psi_1 e^{j\phi_1} & \sin\psi_2 e^{j\phi_2} \end{bmatrix}$$

wherein ψ_1, Φ_1, ψ_2, and Φ_2 represent angles of the unit circle, wherein absolute value of $\psi_1 - \psi_2 = \pi/2$ and $\Phi_1 = \Phi_2$ or $\Phi_1 = \Phi_2 + \pi$ and $\psi_1 + \psi_2 = \pi/2$; and

wherein the feedback information includes ψ_1, Φ_1 and an index bit to determine the relationship between ψ_1 and Φ_1.

13. (original) The transmit baseband processing module of claim 11, wherein the unitary matrix further comprises for a 3xN multiple input multiple output (MIMO) wireless communication:

$$V = \begin{bmatrix} \cos\psi_1 & \cos\psi_2 & \cos\psi_3 \\ \sin\psi_1 \cos\theta_1 e^{j\phi_{21}} & \sin\psi_2 \cos\theta_2 e^{j\phi_{22}} & \sin\psi_3 \cos\theta_3 e^{j\phi_{23}} \\ \sin\psi_1 \sin\theta_1 e^{j\phi_{31}} & \sin\psi_2 \sin\theta_2 e^{j\phi_{32}} & \sin\psi_3 \sin\theta_3 e^{j\phi_{33}} \end{bmatrix}$$

wherein ψ_1, ψ_2, ψ_3, θ_1, θ_2, θ_3, Φ_{21}, Φ_{22}, Φ_{23}, Φ_{31}, Φ_{32}, Φ_{33} represent angles of the unit circle, wherein Diagonal (V*V) = 1s, and wherein:

$$\psi_i = \cos^{-1} V_{1i}, \theta_i = \cos^{-1}\left|\frac{V_{2i}}{\sin\psi_i}\right|$$
$$\phi_{2i} = \angle(V_{2i}), \phi_{3i} = \angle(V_{3i})$$

14. (original) The transmit baseband processing module of claim 11, wherein the unitary matrix further comprises for a 4xN multiple input multiple output (MIMO) wireless communication:

$$V = \begin{bmatrix} \cos\psi_1 \cos\varphi_1 & \cos\psi_2 \cos\varphi_2 & \cos\psi_3 \cos\varphi_3 & \cos\psi_4 \cos\varphi_4 \\ \cos\psi_1 \sin\varphi_1 e^{j\phi_{11}} & \cos\psi_2 \sin\varphi_2 e^{j\phi_{12}} & \cos\psi_3 \sin\varphi_3 e^{j\phi_{13}} & \cos\psi_4 \sin\varphi_4 e^{j\phi_{14}} \\ \sin\psi_1 \cos\theta_1 e^{j\phi_{21}} & \sin\psi_2 \cos\theta_2 e^{j\phi_{22}} & \sin\psi_3 \cos\theta_3 e^{j\phi_{23}} & \sin\psi_4 \cos\theta_4 e^{j\phi_{24}} \\ \sin\psi_1 \sin\theta_1 e^{j\phi_{31}} & \sin\psi_2 \sin\theta_2 e^{j\phi_{32}} & \sin\psi_3 \sin\theta_3 e^{j\phi_{33}} & \sin\psi_4 \sin\theta_4 e^{j\phi_{34}} \end{bmatrix}$$

wherein ψ_1, ψ_2, ψ_3, ψ_4, θ_1, θ_2, θ_3, θ_4, φ_1, φ_2, φ_3, φ_4, Φ_{21}, Φ_{22}, Φ_{23}, Φ_{24}, Φ_{31}, Φ_{32}, Φ_{33}, Φ_{33}, Φ_{41}, Φ_{42}, Φ_{43}, Φ_{43} represent angles of the unit circle, wherein Diagonal (V*V) = 1s, and wherein:

$$\psi_i = \cos^{-1}\left(\sqrt{|V_{1i}|^2 + |V_{2i}|^2}\right), \varphi_i = \cos^{-1}\left(\frac{V_{1i}}{\cos\psi_i}\right), \theta_i = \cos^{-1}\left|\frac{V_{3i}}{\sin\psi_i}\right|$$

$$\phi_{1i} = \angle(V_{2i}), \phi_{2i} = \angle(V_{3i}), \phi_{3i} = \angle(V_{4i})$$

15. (currently amended) A receiver baseband processing module comprises:

a plurality of fast Fourier transform modules operably coupled to convert a plurality of inbound symbol streams into a plurality of streams of beamformed symbols;

an inverse beamforming module operably coupled to inverse beamform, using a unitary matrix having polar coordinates, the plurality of streams of beamformed symbols into a plurality of streams of data symbols, wherein the polar coordinates of the unitary matrix are based on feedback information that includes angles of a unit circle;

a plurality of constellation demapping modules operably coupled to demap the plurality of streams of data symbols into a plurality of interleaved streams of data;

a plurality of deinterleaving modules operably coupled to deinterleave the plurality of interleaved streams of data into encoded data; and

a decoding module operably coupled to convert the encoded data into inbound data.

16. (currently amended) The receiver baseband processing module of claim 15, wherein the unitary matrix comprises:

a plurality of polar coordinates as represented by U, wherein absolute value of each of the plurality of polar coordinates is a vector on the ~~a~~ unit circle and each of the polar coordinates is orthogonal to at least one other of the polar coordinates such that U*U = I, where I represents an identity matrix.

REMARKS

Claims 1 and 3 through 12 remain in this application. Claims 1, 4, 9, 10, 11, 12, 15 and 16 are amended.

Claim Rejections under 35 U.S.C. § 101

In the above referenced Office Action, claims 1, 3-14 in this application were rejected under 35 USC § 101 as claiming the same invention as that of claims 1, 3-12 of co-pending U.S. Patent No. 11/168,838. However, the claims in this application are not identical to the claims in co-pending U.S. Patent No. 11/168, 838. M.P.E.P. §804 states that:

> "In determining whether a statutory basis for a double patenting rejection exists, the question to be asked is: Is the same invention being claimed twice? 35 U.S.C. 101 prevents two patents from issuing on the same invention. "Same invention" means identical subject matter. *Miller v. Eagle Mfg. Co.*, 151 U.S. 186 (1984); *In re Vogel,* 422 F.2d 438, 164 USPQ 619 (CCPA 1970); and *In re Ockert*, 245 F.2d 467, 114 USPQ 330 (CCPA 1957).
>
> A reliable test for double patenting under 35 U.S.C. 101 is whether a claim in the application could be literally infringed without literally infringing a corresponding claim in the patent. *In re Vogel*, 422 F.2d 438, 164 USPQ 619 (CCPA 1970). Is there an embodiment of the invention that falls within the scope of one claim, but not the other? If there is such an embodiment, then identical subject matter is not defined by both claims and statutory double patenting would not exist. For example, the invention defined by a claim reciting a compound having a "halogen" substituent is not identical to or substantively the same as a claim reciting the same compound except having a "chlorine" substituent in place of the halogen because "halogen" is broader than "chlorine." On the other hand, claims may be differently worded and still define the same invention. Thus, a claim reciting a widget having a length of "36 inches" defines the same invention as a claim reciting the same widget having a length of '3 feet.'"

As stated in M.P.E.P. §804, claims must include identical subject matter to support a statutory basis for a double patenting rejection. The claims 1, 3-14 in this application are not identical to the claims 1, 3-12 of copending U.S. Patent No. 11/168,838. Below is a chart of Claim 1 of the present application in comparison to claim 1 of the copending U.S. Patent No. 11/168,838.

Claim 1 of Present Application	Claim 1 of the 11/168,838 application as of the date of this response
1. A method for reduced feedback for beamforming in a wireless communication, the method comprises: receiving a baseband signal that includes a plurality of streams; determining a unitary matrix having polar coordinates in response to feedback information, wherein the feedback information includes angles of a unit circle; and digitally beamforming each of the plurality of streams of the baseband signal using the ~~a~~ unitary matrix to produce a plurality of beamformed symbols.	1. A method for beamforming in a wireless communication, the method comprises: receiving a baseband signal that includes a plurality of streams; receiving a feedback signal that includes a subset of angles, wherein a set of angles provide polar coordinates for a unitary matrix and wherein the subset of angles is a subset of the set of angles; determining at least one remaining angle of the set of angles based on the subset of angles; determining the polar coordinates for the unitary matrix; and digitally beamforming the plurality of streams of the baseband signal using the unitary matrix to produce a plurality of beamformed symbols.

Claim 9 of Present Application	Claim 8 of the 11/168,838 application as of the date of this response
9. A transmit baseband processing module comprises: an encoding module operably coupled to convert outbound data into encoded data; a plurality of interleaving modules operably coupled to interleave the encoded data into a plurality of interleaved streams of data; a plurality of constellation mapping modules operably coupled to map the plurality of interleaved streams of data into a plurality of streams of data symbols; a beamforming module operably coupled to beamform, using a unitary matrix having polar coordinates, the plurality of streams of data symbols into a plurality of streams of beamformed symbols, wherein the polar coordinates of the unitary matrix are based on feedback information that includes angles of a unit circle; and a plurality of inverse fast Fourier transform modules operably coupled to convert the plurality of streams of beamformed symbols into a plurality of outbound symbol streams.	8. A transmit baseband processing module comprises: an encoding module operably coupled to convert outbound data into encoded data; a plurality of interleaving modules operably coupled to interleave the encoded data into a plurality of interleaved streams of data; a plurality of constellation mapping modules operably coupled to map the plurality of interleaved streams of data into a plurality of streams of data symbols; a beamforming module operably coupled to: obtain a feedback signal that includes a subset of angles, wherein a set of angles provide polar coordinates for a unitary matrix and wherein the subset of angles is a subset of the set of angles; determine at least one remaining angle of the set of angles based on the subset of angles; determine the polar coordinates for the unitary matrix; and digitally beamform, using the unitary matrix having polar coordinates, the plurality of streams of data symbols into a plurality of streams of beamformed symbols; and a plurality of inverse fast Fourier transform modules operably coupled to convert the plurality of streams of beamformed symbols into a plurality of outbound symbol streams. [emphasis added]

The above tabular comparison demonstrates that the independent claims 1 and 9 of the present case are not the same as that of copending application 11/168,838. As such, the rejection of claims 1, 3 through 14 under 35 USC § 101 is not proper and should be withdrawn.

Claim Rejections under 35 U.S.C. 103(a)

The Office Action rejected claims 1 and 4-7 under 35 USC § 103 (a) as being unpatentable over U.S. Patent Publication No. 2005/0286663 (the Poon reference) in view of U.S. Patent No. 5,541,607 (the Reinhardt reference); claims 2 and 3 under 35 USC § 103 (a) as being unpatentable over the Poon reference in view of the Reinhardt reference and U.S. Patent Publication No. 2006/0067428 (the Poon_2 reference); and claims 9 through 16 under 35 USC § 103 (a) as being unpatentable over the Poon reference in view of the Reinhardt reference and the Poon_2 reference. The rejections are traversed for the reasons below and, as such, reconsideration of the allowability of claims 1-16 is respectfully requested.

Independent Claim 1 and dependent claims 2 through 8

The Office Action has failed to prove a prima facie case of obviousness of Independent Claim 1 and dependent claims 2-8 under 35 USC § 103(a). The rejection under 35 USC § 103(a) is not proper and without basis because the Poon reference and the Reinhardt reference teach away from the elements of the claims.

Independent claim 1 states, "receiving a baseband signal that includes a plurality of streams; determining a unitary matrix having polar coordinates in response to feedback information, wherein the feedback information includes angles of a unit circle; and digitally beamforming each of the plurality of streams of the baseband signal using the unitary matrix to produce a plurality of beamformed symbols." The specification of this application states on page 4, line 27 to page 5, line 11:

> "To reduce the size of the feedback, the receiver may decompose the channel using singular value decomposition (SVD) and send information relating only to a calculated value of the transmitter's beamforming matrix (V) as the feedback information. In this approach, the receiver calculates (V) based on H=UDV*, where H is the channel response, D is a diagonal matrix, and U is a receiver

unitary matrix. While this approach reduces the size of the feedback information, its size is still an issue for a MIMO wireless communication. For instance, in a 2.times.2 MIMO wireless communication, the feedback needs four elements that are all complex Cartesian coordinate values [V11 V12; V21 V22]. In general, Vik=aik+j*bik, where aik and bik are values between[-1, 1]. Thus, with 1 bit express per each element for each of the real and imaginary components, aik and bik can be either-1/2 or 1/2, which requires 4.times.2.times.1=8 bits per tone. With 4 bit expressions per each element of V(f) in an orthogonal frequency division multiplexing (OFDM) 2.times.2 MIMO wireless communication, the number of bits required is 1728 per tone (e.g., 4*2*54*4=1728, 4 elements per tone, 2 bits for real and imaginary components per tone, 54 data tones per frame, and 4 bits per element), which requires overhead for a packet exchange that is too large for practical applications."

In an embodiment, the specification of this application states on page 19, line 28 to page 20, line 15 that:

"From this expression, the baseband receive processing 100-RX may readily determine the feedback of V, where V includes polar coordinates. For instance, the receiver may decompose the channel using singular value decomposition (SVD) and send information relating only to a calculated value of the transmitter's beamforming matrix (V) as the feedback information. In this approach, the receiver calculates (V) based on H = UDV*, where H is the channel response, D is a diagonal matrix, and U is a receiver unitary matrix. This approach reduces the size of the feedback information with respect to SVD using Cartesian coordinates. For example, in a 2x2 MIMO wireless communication, the feedback needs four elements that are all complex values [V11 V12; V21 V22] with two angles (ψ and Φ). In general, Vik = aik + j*bik, where aik and bik are values between [-1, 1]. To cover [-1, 1], ψ is in [0, π] and Φ is in [0, 2π]. With π /2 resolutions for angles, ψ needs to be π /4 or 3π/4, i.e., cos(ψ) = 0.707 or -0.707, which requires 1 bit, where Φ needs to be either π/4, 3π/4, 5π/4, 7π/4, i.e., exp(j

> Φ) = 0.707(1+j), 0.707(1-j), 0.707(-1+j) or 0.707(-1-j), which requires 2 bits. With $\pi/4$ resolutions for angles, ψ needs to be $\pi/8$, $3\pi/8$, $5\pi/8$ or $7\pi/8$, which requires 2 bits, where Φ needs to be either $\pi/8$, $3\pi/8$, $5\pi/8$, $7\pi/8$, $9\pi/8$, $11\pi/8$, $13\pi/8$ or $15\pi/8$, which requires 4 bits. So, for an example of 2x2 system to use 4 bits per tone, it may have 1 bit for ψ, 2 bits for Φ and 1 index bit to determine the relationship between ψ and Φ, such as either $\psi 1 = \psi 2 + \pi$ and $\Phi 1 + \Phi 2 = \pi/2$, or $\psi 1 = \psi 2$ and $\Phi 1 - \Phi 2 = \pi/2$."

The Office Action has failed to show how the Poon reference and the Reinhardt reference disclose or make obvious the elements of claim 1, *inter alia*, of "determining a unitary matrix having polar coordinates in response to feedback information, wherein the feedback information includes angles of a unit circle; and digitally beamforming each of the plurality of streams of the baseband signal using the unitary matrix to produce a plurality of beamformed symbols." First, with respect to the Poon reference, it states in paragraph 14 that:

> "[0014] To approach the performance of ML receivers with the complexity of linear receivers, and to reduce the feedback bandwidth, the various embodiments of the present invention utilize codebooks known to both the transmitter and receiver. The codebooks hold pre-coding information that a transmitter may use for beamforming. A receiver identifies the codebook elements for the transmitter to use by transmitting indices identifying the codebook elements. In some embodiments, codebooks are found searched using geometric techniques involving differentiable manifolds, such as Grassmann manifolds."

In paragraph 21, the Poon reference further states that:

> "[0021] Suppose the desired pre-coding matrix P is the first M columns of V. The desired pre-coding matrix P may be viewed as a point on the Grassmann manifold, G(N,M), which is a set of M-dimensional hyper-planes in an N-dimensional space. The dimensionality of the set G(N,M) is only M(N-M) which is less than the number of real coefficients in P, 2N.sup.2. The Grassmann manifold G(N,M) may be quantized into equal portions. The different portions

> may be searched to determine in which portion P is located and the corresponding index may then be sent back to the transmitter. This quantization scheme requires the receiver to compare P with a codebook of N.times.M unitary matrices and the complexity is on the order of 2.sup.QN.sup.3 where 2.sup.Q is the number of elements in the codebook. The transmitter then uses the codebook element identified by the transmitted index as the pre-coding matrix for beamforming."

Thus, the Poon reference is describing use of codebooks known to both the transmitter and receiver. The Poon reference describes that the transmitter uses the codebook element identified by the transmitted index as the pre-coding matrix for beamforming.

The Poon reference nowhere describes or suggests using a unitary matrix with polar coordinates. Further, it does not describe that angles of a unit circle, such as Φ_1 and ψ_1, need to be transmitted in a feedback signal, or that a beamforming module in the transmitter may then calculate the polar coordinates in the matrix from the angles of the unit circle. As such, it fails to disclose or suggest the elements of claim 1, *inter alia*, of "determining a unitary matrix having polar coordinates in response to feedback information, wherein the feedback information includes angles of a unit circle; and digitally beamforming each of the plurality of streams of the baseband signal using the unitary matrix to produce a plurality of beamformed symbols."

Furthermore, the Office Action has failed to show how the Reinhardt reference adds to the teachings of the Poon reference to suggest the elements of the claims. In fact the Reinhardt reference teaches away from the elements of claim 1. The Reinhardt reference states at column 4, lines 45 through 51:

> "In the preferred embodiment, a distributed computing approach is utilized to determine the necessary complex subarray weights from data or modulation information and the desired pointing angles or weights for each beam. Thus, each subarray controller 48 determines a corresponding complex weighting value and switches its associated phasor 50 and attenuator 52."

The Reinhardt reference also states at column 4, lines 16 through 21:

> "As also illustrated in FIG. 3, computer 40 communicates via digital data communication lines 46 with subarrays S.sub.1 to S.sub.n. Typical communications include data streams or digitized modulation information, as well as beam pointing angles or complex weighting circuit values."

At column 5, line 46, through column 6, line 10 with reference to Figures 4 and 5, the Reihardt reference describes that computer 40 transmits digital modulation information (e.g., $S_m(t)$) and pointing weights (e.g., P_{mn}) to a subarray controller 48 of one of the subarrays. The subarray controller 48 processes the digital modulation information, $S_m(t)$, and the pointing weights, P_{mn}, to produce a polar attenuation A_n and a phase Φ_n. The Reinhardt reference describes that the computer 40 provides beam pointing angles or complex weighting circuit values to subarrays, and that the subarrays then produce a polar attenuation A_n and a phase Φ_n. As such, the Reinhardt reference fails to disclose feedback information from a receiver that includes angles of a unit circle, such as Φ_1 and ψ_1 or that the angles may be used to calculate the polar coordinates for a unitary matrix. As such, it fails to disclose or suggest the elements of claim 1, *inter alia*, of "determining a unitary matrix having polar coordinates in response to feedback information, wherein the feedback information includes angles of a unit circle; and digitally beamforming each of the plurality of streams of the baseband signal using the unitary matrix to produce a plurality of beamformed symbols."

Since neither the Poon reference or the Reinhardt reference disclose or suggest the requirements of claim 1, a prima facie case of obviousness under 35 U.S.C. 103 has not been shown with respect to claim 1 in the Office Action. Dependent claims 2 through 8 add further patentable matter to claim 1 and thus, are further patentable over the cited references.

<u>Independent Claim 9 and dependent claims 10 through 14</u>

The Office Action has failed to prove a prima facie case of obviousness of Claims 9 through 14 under 35 USC § 103(a). The rejection under 35 USC § 103(a) is not proper and without basis because the Poon reference and the Reinhardt reference and the Poon_2 teach away from the elements of the claims.

Independent claim 9 states, “an encoding module operably coupled to convert outbound data into encoded data; a plurality of interleaving modules operably coupled to interleave the encoded data into a plurality of interleaved streams of data; a plurality of constellation mapping modules operably coupled to map the plurality of interleaved streams of data into a plurality of streams of data symbols; a beamforming module operably coupled to beamform, using a unitary matrix having polar coordinates, the plurality of streams of data symbols into a plurality of streams of beamformed symbols, wherein the polar coordinates of the unitary matrix are based on feedback information that includes angles of a unit circle; and a plurality of inverse fast Fourier transform modules operably coupled to convert the plurality of streams of beamformed symbols into a plurality of outbound symbol streams.”

The Poon reference is describing use of codebooks known to both the transmitter and receiver. The Poon reference describes that the transmitter uses the codebook element identified by the transmitted index as the pre-coding matrix for beamforming. The Poon reference nowhere describes or suggests or realizes how the angles, such as Φ_1 and ψ_1, may be received in a feedback signal and used to determine polar coordinates in a unitary matrix. As such, the Poon reference fails to disclose or suggest the elements of claim 9, *inter alia* of, “a beamforming module operably coupled to beamform, using a unitary matrix having polar coordinates, the plurality of streams of data symbols into a plurality of streams of beamformed symbols, wherein the polar coordinates of the unitary matrix are based on feedback information that includes angles of a unit circle.”

The Reinhardt reference describes that the computer 40 provides beam pointing angles or complex weighting circuit values to subarrays, and that the subarrays then produce a polar attenuation A_n and a phase Φ_n. As such, the Reinhardt reference fails to disclose a feedback signal from a receiver with angles from a unit circle, such as Φ_1 and ψ_1, or that the angles may be used to calculate the other angles, such as Φ_2 and ψ_2, to determine polar coordinates in a unitary matrix for a unitary matrix. As such, the Reinhardt reference fails to disclose or suggest the elements of claim 9, *inter alia* of, “a beamforming module operably coupled to beamform, using a unitary matrix having polar coordinates, the plurality of streams of data symbols into a plurality of streams of beamformed symbols, wherein the polar coordinates of the unitary matrix are based on feedback information that includes angles of a unit circle."

Furthermore, the Poon_2 teaches away from the elements of claim 9, *inter alia* of, "a beamforming module operably coupled to beamform, using a unitary matrix having polar coordinates, the plurality of streams of data symbols into a plurality of streams of beamformed symbols, wherein the polar coordinates of the unitary matrix are based on feedback information that includes angles of a unit circle." The Poon_2 reference states in paragraph 13 that:

> "This beam forming matrix V may be determined in the receiver 34 by first determining the channel matrix H (using, for example, received training signals) and then decomposing the matrix H using SVD techniques (or other similar techniques). The beam forming matrix V may then be transmitted back to the transmitter 32 to be used in the generation of a subsequent transmit signal. In a multicarrier system, a separate matrix V may be required for each subcarrier in the system."

This description states that the entire beam forming matrix V is transmitted back to the transmitter. As such, the Poon_2 reference teaches away from a feedback signal from a receiver with angles from a unit circle, such as Φ_1 and ψ_1, or that the angles may be used to calculate the other angles, such as Φ_2 and ψ_2, to determine polar coordinates in a unitary matrix for a unitary matrix. The Poon_2 reference thus teaches away from the elements of claim 9.

Since neither the Poon reference or the Reinhardt reference or the Poon_2 reference disclose or suggest the requirements of the claim, a prima facie case of obviousness under 35 U.S.C. 103 has not been shown with respect to claim 9 in the Office Action. Dependent claims 10 through 14 add further patentable matter to claim 9 and thus, are further patentable over the cited references.

<u>Independent Claim 15 and dependent claim 16</u>

The Office Action has failed to prove a prima facie case of obviousness of claims 15 and 16 under 35 USC § 103(a). The rejection under 35 USC § 103(a) is not proper and without basis because the Poon reference and the Reinhardt reference and the Poon_2 teach away from the elements of the claims for the reasons stated above with respect to claim 9.

For the above reasons, the Application is in condition for allowance. Therefore, it is respectfully requested that the rejection of the claims be withdrawn and full allowance granted. Should the Examiner have any further comments or suggestions, please contact Jessica Smith at (972) 240-5324.

Respectfully submitted,
GARLICK HARRISON & MARKISON

Dated: January 29, 2009

/Jessica Smith/

Jessica W. Smith
Reg. No. 39,884

Garlick Harrison & Markison
P. O. Box 160727
Austin, TX 78716-0727
Phone: (972) 240-5324
Fax: (888) 456-7824

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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 11/168,793	Filing Date 06/28/2005	☐ To be Mailed

APPLICATION AS FILED – PART I

FOR	NUMBER FILED (Column 1)	NUMBER EXTRA (Column 2)	SMALL ENTITY ☐ RATE ($)	SMALL ENTITY FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =		OR	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =			X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							
			TOTAL			TOTAL	

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

APPLICATION AS AMENDED – PART II

AMENDMENT 01/29/2009	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	SMALL ENTITY RATE ($)	SMALL ENTITY ADDITIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	* 16	Minus	** 20	= 0	X $ =		OR	X $52=	0
Independent (37 CFR 1.16(h))	* 3	Minus	***3	= 0	X $ =		OR	X $220=	0
☐ Application Size Fee (37 CFR 1.16(s))									
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	0

AMENDMENT	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	RATE ($)	ADDITIONAL FEE ($)	OR	RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =		OR	X $ =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =		OR	X $ =	
☐ Application Size Fee (37 CFR 1.16(s))									
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

Legal Instrument Examiner:
/VINCENT BUTLER/

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/168,793	06/28/2005	Joonsuk Kim	BP4637	9094

51472 7590 04/15/2009

GARLICK HARRISON & MARKISON
P.O. BOX 160727
AUSTIN, TX 78716-0727

EXAMINER	
NEFF, MICHAEL R	

ART UNIT	PAPER NUMBER
2611	

MAIL DATE	DELIVERY MODE
04/15/2009	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

PTOL-90A (Rev. 04/07)

Office Action Summary	Application No.	Applicant(s)
	11/168,793	KIM, JOONSUK
	Examiner	Art Unit
	MICHAEL R. NEFF	2611

-- 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) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, 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 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 *29 January 2009*.

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) *1-16* 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) *1-4,9,10,15 and 16* is/are rejected.

7)☒ Claim(s) *5-8, 11-14* 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

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.

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/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

Request for Continued Examination

1. The request filed on 1/29/2009, for a Request for Continued Examination (RCE) under 37 CFR 1.114 based on the Parent Application No. 11/168793 is acceptable and a RCE has been established. An action on the RCE follows.

Response to Arguments

2. Applicant's arguments with respect to the claims have been considered but are moot in view of the new ground(s) of rejection.

Double Patenting

3. The nonstatutory double patenting rejection is based on a judicially created doctrine grounded in public policy (a policy reflected in the statute) so as to prevent the unjustified or improper timewise extension of the "right to exclude" granted by a patent and to prevent possible harassment by multiple assignees. A nonstatutory obviousness-type double patenting rejection is appropriate where the conflicting claims are not identical, but at least one examined application claim is not patentably distinct from the reference claim(s) because the examined application claim is either anticipated by, or would have been obvious over, the reference claim(s). See, e.g., *In re Berg*, 140 F.3d 1428, 46 USPQ2d 1226 (Fed. Cir. 1998); *In re Goodman*, 11 F.3d 1046, 29 USPQ2d 2010 (Fed. Cir. 1993); *In re Longi*, 759 F.2d 887, 225 USPQ 645 (Fed. Cir. 1985); *In re Van Ornum*, 686 F.2d 937, 214 USPQ 761 (CCPA 1982); *In re Vogel*, 422 F.2d 438, 164 USPQ 619 (CCPA 1970); and *In re Thorington*, 418 F.2d 528, 163 USPQ 644 (CCPA 1969).

A timely filed terminal disclaimer in compliance with 37 CFR 1.321(c) or 1.321(d) may be used to overcome an actual or provisional rejection based on a nonstatutory double patenting ground provided the conflicting application or patent either is shown to be commonly owned with this application, or claims an invention made as a result of activities undertaken within the scope of a joint research agreement.

Effective January 1, 1994, a registered attorney or agent of record may sign a terminal disclaimer. A terminal disclaimer signed by the assignee must fully comply with 37 CFR 3.73(b).

4. Claims 1, 3-14 are provisionally rejected on the ground of nonstatutory obviousness-type double patenting as being unpatentable over claims 1, 3-12 of copending Application No. 11/168,838. Although the conflicting claims are not identical,

they are not patentably distinct from each other because while the current application provides the limitation of determining the unitary matrix the basis of the ‘838 reference is the determination of the unitary matrix through the received feedback signal; rendering it obvious that the limitations of the current application are encompassed in the ‘838 copending application.

This is a provisional obviousness-type double patenting rejection because the conflicting claims have not in fact been patented.

Claim Rejections - 35 USC § 112

5. 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.

6. Claim 3 is rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

7. Re Claim 3, the claim is directed towards the receiving method, however the following limitations are all aspects of the transmission aspects of the system. For example, the method is claimed as encoding, rather than decoding. The grounds for this rejection are further supported in Figures 4 and 5 of the current application. For the purpose of examination the claim will be considered as a method for transmitting the baseband signal.

Claim Rejections - 35 USC § 102

8. 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.

9. **Claim 1 is rejected under 35 U.S.C. 102(e) as being anticipated by Li et al. (herein after Li) (US Publication 2006/0068738 A1).**

Re claim 1, Li discloses a method for reduced feedback for beamforming in a wireless communication, the method comprises: receiving a baseband signal that includes a plurality of streams (Figure 1 antenna arrays; Figure 2 element 210; Paragraphs 0001, 0002 and 0043);

determining a unitary matrix having polar coordinates in response to feedback information (paragraphs 0012-0013; Figure 2), wherein the feedback information includes angles of a unit circle (paragraphs 0012-0013, 0015-0017; Figure 2);

and digitally beamforming each of the plurality of streams of the baseband signal using the unitary matrix to produce a plurality of beamformed symbols (paragraph 0015).

Claim Rejections - 35 USC § 103

10. The text of those sections of Title 35, U.S. Code not included in this action can be found in a prior Office action.

11. **Claims 2 and 4 are rejected under 35 U.S.C. 103(a) as being unpatentable over Li.**

Re claim 2, Li discloses wherein the method of claim 1 comprises: the baseband signal including a plurality of tones (Paragraph 0010), wherein each of the plurality of tones corresponds to a symbol mapped to a constellation (Paragraph 0010); and digital beamforming each of the plurality of tones using the unitary matrix (Paragraph 0015).

The disclosure of Li does not specifically disclose 'tones' the examiner interprets the disclosure of sub channels within the spatial channels as disclosure that would be obvious to one of ordinary skill in the art to disclosing a functionally equivalent process to the tone manipulation.

Re claim 4, Li discloses the method of claim 1, wherein the unitary matrix comprises: a plurality of polar coordinates as represented by V, such that V*V = I, where I represents an identity matrix (Paragraph 0015-0016). However Li fails to explicitly disclose wherein absolute value of each of the plurality of polar coordinates is a vector on the unit circle and each of the polar coordinates is orthogonal to at least one other of the polar coordinates.

However, as this limitation is disclosed as the factor resulting in the V*V=I relationship, it would be obvious to one of ordinary skill in the art that as Li provided the disclosure of the computation of the identity matrix that the process steps are inclusive of this disclosure despite not being explicitly spelled out in the disclosure of Li.

12. **Claims 3, 9, 10, 15 and 16 are rejected under 35 U.S.C. 103(a) as being unpatentable over Li as applied to claim 1 above, and further in view of Poon (US publication 2006/0067428 A1).**

Re claim 3, Li discloses the method of claim 1 comprises: receiving (per 112 above transmitting) the baseband signal including: encoding data to produce a stream of encoded data (Paragraph 0015); and digital beamforming each of the plurality of parallel tones using the unitary matrix (Paragraph 0015); however Li fails to explicitly disclose interleaving the stream of encoded data into a plurality of parallel streams of interleaved data; constellation mapping symbols of each of the plurality of parallel streams of interleaved data to a plurality of parallel tones.

This method is however disclosed by Poon. Poon discloses the transmitting method comprising interleaving the stream of encoded data into a plurality of parallel streams of interleaved data (Figure 1 element 12); constellation mapping symbols of each of the plurality of parallel streams of interleaved data to a plurality of parallel tones (Figure 1 element 14).

Therefore it would have been obvious to one of ordinary skill in the art at the time the invention was made to incorporate the closed loop MIMO transceiver design as disclosed by Poon within the closed loop MIMO transceiver design of Li in order to gain the benefit of the application of well known transmission and receiving design structures utilized within the closed loop design.

Re claim 9, Li discloses a transmit baseband processing module comprises: an encoding module operably coupled to convert outbound data into encoded data (Paragraph 0015); a beamforming module operably coupled to beamform, using a unitary matrix having polar coordinates (paragraphs 0012-0013, 0015; Figure 2), the plurality of streams of data symbols into a plurality of streams of beamformed symbols (paragraphs 0012-0013, 0015-0017; Figure 2), wherein the polar coordinates of the unitary matrix are based on feedback information that includes angles of a unit circle (paragraphs 0012-0013, 0015-0017; Figure 2); however Li fails to explicitly disclose a plurality of interleaving modules operably coupled to interleave the encoded data into a plurality of interleaved streams of data; a plurality of constellation mapping modules operably coupled to map the plurality of interleaved streams of data into a plurality of streams of data symbols; and a plurality of inverse fast Fourier transform modules operably coupled to convert the plurality of streams of beamformed symbols into a plurality of outbound symbol streams.

This design is however disclosed by Poon. Poon discloses a plurality of interleaving modules (12; Figure 4 shows the system design implemented in a plurality) operably coupled to interleave the encoded data into a plurality of interleaved streams of data; a plurality of constellation mapping modules operably coupled to map the plurality of interleaved streams of data into a plurality of streams of data symbols (14;

Figure 4 shows the system design implemented in a plurality); and a plurality of inverse fast Fourier transform modules operably coupled to convert the plurality of streams of beamformed symbols into a plurality of outbound symbol streams (16; Figure 4 shows the system design implemented in a plurality).

Therefore it would have been obvious to one of ordinary skill in the art at the time the invention was made to incorporate the closed loop MIMO transceiver design as disclosed by Poon within the closed loop MIMO transceiver design of Li in order to gain the benefit of the application of well known transmission and receiving design structures utilized within the closed loop design.

Re claim 10, the combined disclosures of Li and Poon as a whole disclose the transmit module of claim 9, Li further discloses wherein the unitary matrix comprises: a plurality of polar coordinates as represented by V, such that V*V = I, where I represents an identity matrix (Paragraph 0015-0016). However Li fails to explicitly disclose wherein absolute value of each of the plurality of polar coordinates is a vector on the unit circle and each of the polar coordinates is orthogonal to at least one other of the polar coordinates.

However, as this limitation is disclosed as the factor resulting in the V*V=I relationship, it would be obvious to one of ordinary skill in the art that as Li provided the disclosure of the computation of the identity matrix that the process steps are inclusive of this disclosure despite not being explicitly spelled out in the disclosure of Li.

Claim 15 has been analyzed and rejected with regards to claim 9 as being the obvious receiver design to the claim limitations of the previously mentioned and currently rejected claim 9.

Claim 16 has been analyzed and rejected with regards to claim 9 as being the obvious receiver design to the claim limitations of the previously mentioned and currently rejected claim 10.

Allowable Subject Matter

13. Claims 5-8 and 11-14 are 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.

14. The following is a statement of reasons for the indication of allowable subject matter: The prior art of record fails to render obvious or anticipate the specifics of the matrix composition for the various cases as provided for in the limitations of the above mentioned claims.

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to MICHAEL R. NEFF whose telephone number is (571)270-1848. The examiner can normally be reached on Monday - Friday 8:00am - 4:30pm EST ALT Fridays.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Shuwang Liu can be reached on (571)272-3036. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/MICHAEL R. NEFF/
Examiner, Art Unit 2611
/Shuwang Liu/
Supervisory Patent Examiner, Art Unit 2611

Notice of References Cited	Application/Control No. 11/168,793	Applicant(s)/Patent Under Reexamination KIM, JOONSUK	
	Examiner MICHAEL R. NEFF	Art Unit 2611	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-2006/0068738 A1	03-2006	Li et al.	455/277.1
	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
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

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.

Index of Claims	Application/Control No. 11168793	Applicant(s)/Patent Under Reexamination KIM, JOONSUK
	Examiner MICHAEL R NEFF	Art Unit 2611

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	03/25/2008	09/29/2008	04/09/2009						
	1	✓	✓	✓						
	2	✓	✓	✓						
	3	✓	✓	✓						
	4	✓	✓	✓						
	5	✓	✓	O						
	6	✓	✓	O						
	7	✓	✓	O						
	8	✓	✓	O						
	9	✓	✓	✓						
	10	✓	✓	✓						
	11	✓	✓	O						
	12	✓	✓	O						
	13	✓	✓	O						
	14	✓	✓	O						
	15	✓	✓	✓						
	16	✓	✓	✓						

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	11168793	KIM, JOONSUK
	Examiner	**Art Unit**
	MICHAEL R NEFF	2611

SEARCHED

Class	Subclass	Date	Examiner
375	260, 267, 299	3/24/2008	MRN

SEARCH NOTES

Search Notes	Date	Examiner
Class/Subclass search performed using keyword limitations	3/24/2008	MRN
Inventor/Double patenting search performed in EAST database	3/24/2008	MRN
Prior art revisited per amendments and arguments from applicant	9/29/2008	MRN
Updated search per amendments and arguments	4/9/2009	MRN

INTERFERENCE SEARCH

Class	Subclass	Date	Examiner

/MICHAEL R NEFF/
Examiner.Art Unit 2611

EAST Search History

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S1	136	(feedback$3) same angle same circle	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/04/07 09:41
S2	8	S1 and baseband	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/04/07 09:41
S3	0	S1 and beamform$4	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/04/07 09:41
S4	2040	baseband and beamform$4	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/04/07 09:42
S5	176	S4 and unitary	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/04/07 09:42
S6	4	S5 and (unit with circle)	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/04/07 09:42
S7	2157	feedback and (unit with circle)	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/04/07 09:43
S8	30	S4 and S7	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/04/07 09:43
S9	15113	polar same angle	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/04/07 10:15
S10	62	S9 and S4	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/04/07 10:15
S11	34	S10 and feedback$3	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/04/07 10:16
S12	2	"20060067428"	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/04/08 10:08

4/ 9/ 2009 11:02:36 AM
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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor:	Joonsuk Kim	**Docket:**	BP4637
Serial No.:	11/168,793	**Art Unit:**	2611
Filed:	June 28, 2005	**Examiner:**	Micheal R. Neff
Title:	Reduced Feedback for Beamforming in a Wireless Communication		

RESPONSE TO NON-FINAL OFFICE ACTION

M/S Amendment
Commissioner for Patents
P. O. Box 1450
Alexandria, VA 22313-1450

Dear Commissioner:

In response to the Office Action dated April 15, 2009, please consider the following amendment and response.

Amendment to the Claims

1 (Currently Amended). A method for reduced feedback for beamforming in a wireless communication, the method comprises:

receiving a baseband signal that includes a plurality of streams;

determining a unitary matrix ~~having polar coordinates~~ in response to feedback information, wherein the feedback information includes angles of a unit circle and wherein the unitary matrix includes:

a plurality of polar coordinates represented by V, wherein absolute value of each of the plurality of polar coordinates is a vector on a unit circle and each of the polar coordinates is orthogonal to at least one other of the polar coordinates such that V*V = I, where I represents an identity matrix; and

for each column of V, a first row of polar coordinates includes real values as references and a second row of polar coordinates includes phase shift values; and

digitally beamforming each of the plurality of streams of the baseband signal using the unitary matrix to produce a plurality of beamformed symbols.

2 (Original). The method of claim 1 comprises:

the baseband signal including a plurality of tones, wherein each of the plurality of tones corresponds to a symbol mapped to a constellation; and

digital beamforming each of the plurality of tones using the unitary matrix.

3 (Currently Amended). The method of claim 1 comprises:

receiving outbound data; ~~the baseband signal including:~~

encoding the outbound data to produce a stream of encoded data;

interleaving the stream of encoded data into a plurality of parallel streams of interleaved data;

constellation mapping symbols of each of the plurality of parallel streams of interleaved data to a plurality of parallel tones; and

digital beamforming each of the plurality of parallel tones using the unitary matrix.

4 (Canceled). Please cancel claim 4.

5 (Canceled). Please cancel claim 5.

6 (Currently Amended). The method of claim 1 ~~5~~, wherein the unitary matrix further comprises for a 2xN multiple input multiple output (MIMO) wireless communication:

$$V = \begin{bmatrix} \cos\psi_1 & \cos\psi_2 \\ \sin\psi_1 e^{j\phi_1} & \sin\psi_2 e^{j\phi_2} \end{bmatrix}$$

wherein ψ_1, Φ_1, ψ_2, and Φ_2 represent angles of the unit circle, wherein absolute value of $\psi_1 - \psi_2 = \pi/2$ and $\Phi_1 = \Phi_2$ or $\Phi_1 = \Phi_2 + \pi$ and $\psi_1 + \psi_2 = \pi/2$.

7 (Currently Amended). The method of claim 1 ~~5~~, wherein the unitary matrix further comprises for a 3xN multiple input multiple output (MIMO) wireless communication:

$$V = \begin{bmatrix} \cos\psi_1 & \cos\psi_2 & \cos\psi_3 \\ \sin\psi_1 \cos\theta_1 e^{j\phi_{21}} & \sin\psi_2 \cos\theta_2 e^{j\phi_{22}} & \sin\psi_3 \cos\theta_3 e^{j\phi_{23}} \\ \sin\psi_1 \sin\theta_1 e^{j\phi_{31}} & \sin\psi_2 \sin\theta_2 e^{j\phi_{32}} & \sin\psi_3 \sin\theta_3 e^{j\phi_{33}} \end{bmatrix}$$

wherein ψ_1, ψ_2, ψ_3, θ_1, θ_2, θ_3, Φ_{21}, Φ_{22}, Φ_{23}, Φ_{31}, Φ_{32}, Φ_{33} represent angles of the unit circle, wherein Diagonal (V*V) = 1s, and wherein:

$$\psi_i = \cos^{-1} V_{1i}, \theta_i = \cos^{-1}\left|\frac{V_{2i}}{\sin\psi_i}\right|$$
$$\phi_{2i} = \angle(V_{2i}), \phi_{3i} = \angle(V_{3i})$$

8 (Currently Amended). The method of claim 1 ~~5~~, wherein the unitary matrix further comprises for a 4xN multiple input multiple output (MIMO) wireless communication:

$$V = \begin{bmatrix} \cos\psi_1 \cos\varphi_1 & \cos\psi_2 \cos\varphi_2 & \cos\psi_3 \cos\varphi_3 & \cos\psi_4 \cos\varphi_4 \\ \cos\psi_1 \sin\varphi_1 e^{j\phi_{11}} & \cos\psi_2 \sin\varphi_2 e^{j\phi_{12}} & \cos\psi_3 \sin\varphi_3 e^{j\phi_{13}} & \cos\psi_4 \sin\varphi_4 e^{j\phi_{14}} \\ \sin\psi_1 \cos\theta_1 e^{j\phi_{21}} & \sin\psi_2 \cos\theta_2 e^{j\phi_{22}} & \sin\psi_3 \cos\theta_3 e^{j\phi_{23}} & \sin\psi_4 \cos\theta_4 e^{j\phi_{24}} \\ \sin\psi_1 \sin\theta_1 e^{j\phi_{31}} & \sin\psi_2 \sin\theta_2 e^{j\phi_{32}} & \sin\psi_3 \sin\theta_3 e^{j\phi_{33}} & \sin\psi_4 \sin\theta_4 e^{j\phi_{34}} \end{bmatrix}$$

wherein ψ_1, ψ_2, ψ_3, ψ_4, θ_1, θ_2, θ_3, θ_4, φ_1, φ_2, φ_3, φ_4, Φ_{21}, Φ_{22}, Φ_{23}, Φ_{24}, Φ_{31}, Φ_{32} , Φ_{33}, Φ_{33}, Φ_{41}, Φ_{42}, Φ_{43}, Φ_{43} represent angles of the unit circle, wherein Diagonal (V*V) = 1s, and wherein:

$$\psi_i = \cos^{-1}\left(\sqrt{|V_{1i}|^2 + |V_{2i}|^2}\right), \varphi_i = \cos^{-1}\left(\frac{V_{1i}}{\cos\psi_i}\right), \theta_i = \cos^{-1}\left|\frac{V_{3i}}{\sin\psi_i}\right|$$
$$\phi_{1i} = \angle(V_{2i}), \phi_{2i} = \angle(V_{3i}), \phi_{3i} = \angle(V_{4i})$$

9 (Currently Amended). A transmit baseband processing module comprises:

an encoding module operably coupled to convert outbound data into encoded data;

a plurality of interleaving modules operably coupled to interleave the encoded data into a plurality of interleaved streams of data;

a plurality of constellation mapping modules operably coupled to map the plurality of interleaved streams of data into a plurality of streams of data symbols;

a beamforming module operably coupled to beamform, using a unitary matrix ~~having polar coordinates~~, the plurality of streams of data symbols into a plurality of streams of beamformed symbols, ~~wherein the polar coordinates of the unitary matrix are based on feedback information that includes angles of a unit~~ wherein the unitary matrix includes:

a plurality of polar coordinates represented by V, wherein absolute value of each of the plurality of polar coordinates is a vector on a unit circle and each of the polar coordinates is orthogonal to at least one other of the polar coordinates such that V*V = I, where I represents an identity matrix; and

for each column of V, a first row of polar coordinates includes real values as references and a second row of polar coordinates includes phase shift values; and

a plurality of inverse fast Fourier transform modules operably coupled to convert the plurality of streams of beamformed symbols into a plurality of outbound symbol streams.

10 (Canceled). Please cancel claim 10.

11 (Canceled). Please cancel claim 11.

12 (Currently Amended). The transmit baseband processing module of claim 9 ~~11~~, wherein the unitary matrix further comprises for a 2xN multiple input multiple output (MIMO) wireless communication:

$$V = \begin{bmatrix} \cos\psi_1 & \cos\psi_2 \\ \sin\psi_1 e^{j\phi_1} & \sin\psi_2 e^{j\phi_2} \end{bmatrix}$$

wherein ψ_1 , Φ_1, ψ_2 , and Φ_2 represent angles of the unit circle, wherein absolute value of $\psi_1 - \psi_2 = \pi/2$ and $\Phi_1 = \Phi_2$ or $\Phi_1 = \Phi_2 + \pi$ and $\psi_1 + \psi_2 = \pi/2$; and

wherein the feedback information includes ψ_1 , Φ_1 and an index bit to determine the relationship between ψ_1 and Φ_1.

13 (Currently Amended). The transmit baseband processing module of claim 9 ~~11~~, wherein the unitary matrix further comprises for a 3xN multiple input multiple output (MIMO) wireless communication:

$$V = \begin{bmatrix} \cos\psi_1 & \cos\psi_2 & \cos\psi_3 \\ \sin\psi_1 \cos\theta_1 e^{j\phi_{21}} & \sin\psi_2 \cos\theta_2 e^{j\phi_{22}} & \sin\psi_3 \cos\theta_3 e^{j\phi_{23}} \\ \sin\psi_1 \sin\theta_1 e^{j\phi_{31}} & \sin\psi_2 \sin\theta_2 e^{j\phi_{32}} & \sin\psi_3 \sin\theta_3 e^{j\phi_{33}} \end{bmatrix}$$

wherein ψ_1, ψ_2, ψ_3, θ_1, θ_2, θ_3, Φ_{21}, Φ_{22}, Φ_{23}, Φ_{31}, Φ_{32}, Φ_{33} represent angles of the unit circle, wherein Diagonal (V*V) = 1s, and wherein:

$$\psi_i = \cos^{-1} V_{1i}, \theta_i = \cos^{-1}\left|\frac{V_{2i}}{\sin\psi_i}\right|$$
$$\phi_{2i} = \angle(V_{2i}), \phi_{3i} = \angle(V_{3i})$$

14 (Currently Amended). The transmit baseband processing module of claim 9 ~~11~~, wherein the unitary matrix further comprises for a 4xN multiple input multiple output (MIMO) wireless communication:

$$V = \begin{bmatrix} \cos\psi_1 \cos\varphi_1 & \cos\psi_2 \cos\varphi_2 & \cos\psi_3 \cos\varphi_3 & \cos\psi_4 \cos\varphi_4 \\ \cos\psi_1 \sin\varphi_1 e^{j\phi_{11}} & \cos\psi_2 \sin\varphi_2 e^{j\phi_{12}} & \cos\psi_3 \sin\varphi_3 e^{j\phi_{13}} & \cos\psi_4 \sin\varphi_4 e^{j\phi_{14}} \\ \sin\psi_1 \cos\theta_1 e^{j\phi_{21}} & \sin\psi_2 \cos\theta_2 e^{j\phi_{22}} & \sin\psi_3 \cos\theta_3 e^{j\phi_{23}} & \sin\psi_4 \cos\theta_4 e^{j\phi_{24}} \\ \sin\psi_1 \sin\theta_1 e^{j\phi_{31}} & \sin\psi_2 \sin\theta_2 e^{j\phi_{32}} & \sin\psi_3 \sin\theta_3 e^{j\phi_{33}} & \sin\psi_4 \sin\theta_4 e^{j\phi_{34}} \end{bmatrix}$$

wherein ψ_1, ψ_2, ψ_3, ψ_4, θ_1, θ_2, θ_3, θ_4, φ_1, φ_2, φ_3, φ_4, Φ_{21}, Φ_{22}, Φ_{23}, Φ_{24}, Φ_{31}, Φ_{32}, Φ_{33}, Φ_{33}, Φ_{41}, Φ_{42}, Φ_{43}, Φ_{43} represent angles of the unit circle, wherein Diagonal (V*V) = 1s, and wherein:

$$\psi_i = \cos^{-1}\left(\sqrt{|V_{1i}|^2 + |V_{2i}|^2}\right), \varphi_i = \cos^{-1}\left(\frac{V_{1i}}{\cos\psi_i}\right), \theta_i = \cos^{-1}\left|\frac{V_{3i}}{\sin\psi_i}\right|$$
$$\phi_{1i} = \angle(V_{2i}), \phi_{2i} = \angle(V_{3i}), \phi_{3i} = \angle(V_{4i})$$

15 (Currently Amended). A receiver baseband processing module comprises:

a plurality of fast Fourier transform modules operably coupled to convert a plurality of inbound symbol streams into a plurality of streams of beamformed symbols;

an inverse beamforming module operably coupled to inverse beamform, using a unitary matrix having polar coordinates, the plurality of streams of beamformed symbols into a plurality of streams of data symbols, wherein the polar coordinates of the unitary matrix are based on feedback information that includes angles of a unit circle and wherein the unitary matrix includes:

a plurality of polar coordinates represented by U, wherein absolute value of each of the plurality of polar coordinates is a vector on a unit circle and each of the polar coordinates is orthogonal to at least one other of the polar coordinates U*U = I, where I represents an identity matrix; and

for each column of U, a first row of polar coordinates includes real values as references and a second row of polar coordinates includes phase shift values;

a plurality of constellation demapping modules operably coupled to demap the plurality of streams of data symbols into a plurality of interleaved streams of data;

a plurality of deinterleaving modules operably coupled to deinterleave the plurality of interleaved streams of data into encoded data; and

a decoding module operably coupled to convert the encoded data into inbound data.

16 (Canceled). Please cancel claim 16.

REMARKS

Claims 1, 2, 3, 6 through 9, 12 through 15 remain in this application. Claims 4, 5, 10, 11 and 16 are canceled.

Claim Rejections for Double Patenting

In the above referenced Office Action, claims 1, 3-14 are provisionally rejected provisionally rejected on the ground of nonstatutory obviousness-type double patenting as being unpatentable over claims 1, 3-12 of copending Application No. 11/168,838. The Office Action states that it is a provisional obviousness-type double patenting rejection because the conflicting claims have not in fact been patented.

As of this time, the Application No. 11/168,838 is still pending. Applicants respectfully request deferral of filing a terminal disclaimer in this application until such time that a Notice of Allowance has occurred in Application No. 11/168,838.

Claim Rejections under 35 U.S.C. §112

The Office Action rejected claim 3 under 35 U.S.C. §112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. Claim 3 has been amended above for clarification.

Claim Rejections under 35 U.S.C. §102 and 103

The Office Action rejected claim 1 under 35 USC § 102 as being anticipated by US Publication 2006/0068738 to Li et al. (the Li reference). The Office Action rejected claims 2 and 4 are rejected under 35 U.S.C. 103(a) as being unpatentable over the Li reference. The Office Action rejected Claims 3, 9,10,15 and 16 under 35 U.S.C. 103(a) as being unpatentable over the Li reference as applied to claim 1 above, and further in view of U.S. Patent Publication No. 2006/0067428 (the Poon reference).

However, the Office Action stated that Claims 5-8 and 11-14 would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims. Claim 1 has been amended to include elements of claims 4 and 5. Claim 9 have been amended to include elements of claims 10 and 11. Claim 15 has been amended similarly.

For the above reasons, the Application is in condition for allowance. Therefore, it is respectfully requested that the rejection of the claims be withdrawn and full allowance granted. Should the Examiner have any further comments or suggestions, please contact Jessica Smith at (972) 240-5324.

Respectfully submitted,
GARLICK HARRISON & MARKISON

Dated: June 29, 2009

/Jessica Smith/

Jessica W. Smith
Reg. No. 39,884

Garlick Harrison & Markison
P. O. Box 160727
Austin, TX 78716-0727
Phone: (972) 240-5324
Fax: (888) 456-7824

Electronic Acknowledgement Receipt

EFS ID:	5609975
Application Number:	11168793
International Application Number:	
Confirmation Number:	9094
Title of Invention:	Reduced feedback for beamforming in a wireless communication
First Named Inventor/Applicant Name:	Joonsuk Kim
Customer Number:	51472
Filer:	Jessica Smith/Melanie Murdock
Filer Authorized By:	Jessica Smith
Attorney Docket Number:	BP4637
Receipt Date:	29-JUN-2009
Filing Date:	28-JUN-2005
Time Stamp:	19:44:06
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		BP4637_Amendment_07152009.pdf	127195 b06e8f9e36344424f13e4a68cb5d6fb7ca9bbc9e	yes	10

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Amendment/Req. Reconsideration-After Non-Final Reject	1	1
	Claims	2	8
	Applicant Arguments/Remarks Made in an Amendment	9	10
Warnings:			
Information:			
	Total Files Size (in bytes):	127195	

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New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/SB/06 (07-06)
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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 11/168,793	Filing Date 06/28/2005	☐ To be Mailed

APPLICATION AS FILED – PART I

FOR	NUMBER FILED (Column 1)	NUMBER EXTRA (Column 2)	SMALL ENTITY ☐ RATE ($)	FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =		OR	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =			X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							
			TOTAL			TOTAL	

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

APPLICATION AS AMENDED – PART II

AMENDMENT 06/29/2009	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	SMALL ENTITY RATE ($)	ADDITIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	* 12	Minus	** 20	= 0	X $ =		OR	X $52=	0
Independent (37 CFR 1.16(h))	* 3	Minus	***3	= 0	X $ =		OR	X $220=	0
☐ Application Size Fee (37 CFR 1.16(s))									
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	0

AMENDMENT	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	RATE ($)	ADDITIONAL FEE ($)		RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =		OR	X $ =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =		OR	X $ =	
☐ Application Size Fee (37 CFR 1.16(s))									
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

Legal Instrument Examiner:
/ROSS W. BROWN/

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/168,793	06/28/2005	Joonsuk Kim	BP4637	9094

51472 7590 10/27/2009
GARLICK HARRISON & MARKISON
P.O. BOX 160727
AUSTIN, TX 78716-0727

EXAMINER	
NEFF, MICHAEL R	
ART UNIT	**PAPER NUMBER**
2611	
NOTIFICATION DATE	**DELIVERY MODE**
10/27/2009	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

MMURDOCK@TEXASPATENTS.COM
JIVY@TEXASPATENTS.COM
SMCWHINNIE@TEXASPATENTS.COM

PTOL-90A (Rev. 04/07)

Office Action Summary	Application No.	Applicant(s)
	11/168,793	KIM, JOONSUK
	Examiner	**Art Unit**
	MICHAEL R. NEFF	2611

-- 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) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, 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 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 *29 June 2009*.

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) *1-3,6-9 and 12-15* 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) *1-3, 6-9, 12-15* 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

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.

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/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

Response to Arguments

1. Applicant's arguments with respect to claims 1-3, 6-9, and 12-15 have been considered but are moot in view of the new ground(s) of rejection.

Allowable Subject Matter

2. The indicated allowability of claims 5-8 and 11-14 of the claims submitted 1/29/2209 is withdrawn in view of the newly discovered reference(s) to Malik et al.. Rejections based on the newly cited reference(s) follow.

Double Patenting

3. The nonstatutory double patenting rejection is based on a judicially created doctrine grounded in public policy (a policy reflected in the statute) so as to prevent the unjustified or improper timewise extension of the “right to exclude” granted by a patent and to prevent possible harassment by multiple assignees. A nonstatutory obviousness-type double patenting rejection is appropriate where the conflicting claims are not identical, but at least one examined application claim is not patentably distinct from the reference claim(s) because the examined application claim is either anticipated by, or would have been obvious over, the reference claim(s). See, e.g., *In re Berg*, 140 F.3d 1428, 46 USPQ2d 1226 (Fed. Cir. 1998); *In re Goodman*, 11 F.3d 1046, 29 USPQ2d 2010 (Fed. Cir. 1993); *In re Longi*, 759 F.2d 887, 225 USPQ 645 (Fed. Cir. 1985); *In re Van Ornum*, 686 F.2d 937, 214 USPQ 761 (CCPA 1982); *In re Vogel*, 422 F.2d 438, 164 USPQ 619 (CCPA 1970); and *In re Thorington*, 418 F.2d 528, 163 USPQ 644 (CCPA 1969).

A timely filed terminal disclaimer in compliance with 37 CFR 1.321(c) or 1.321(d) may be used to overcome an actual or provisional rejection based on a nonstatutory double patenting ground provided the conflicting application or patent either is shown to be commonly owned with this application, or claims an invention made as a result of activities undertaken within the scope of a joint research agreement.

Effective January 1, 1994, a registered attorney or agent of record may sign a terminal disclaimer. A terminal disclaimer signed by the assignee must fully comply with 37 CFR 3.73(b).

4. Claims 1, 3, 6-9 and 12-14 are provisionally rejected on the ground of nonstatutory obviousness-type double patenting as being unpatentable over claims 1, 3-

12 of copending Application No. 11/168,838. Although the conflicting claims are not identical, they are not patentably distinct from each other because while the current application provides the limitation of determining the unitary matrix the basis of the ‘838 reference is the determination of the unitary matrix through the received feedback signal; rendering it obvious that the limitations of the current application are encompassed in the ‘838 copending application.

This is a provisional obviousness-type double patenting rejection because the conflicting claims have not in fact been patented.

Claim Rejections - 35 USC § 112

5. Claim 3, via the amendments filed on 6/29/2009 no longer contains a 112 issue.

6. 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.

7. Claims 1-3, 6-9, 12-15 are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

8. Re claims 1, 9 and 15 these claims recite the limitation ‘first row…includes real values as references”. The term ‘references’ is not clearly defined within the claim language, or the specification in a way that provided evidence towards the intention of the use of these reference values. All other claims are indefinite due to dependency.

Claim Rejections - 35 USC § 103

9. The text of those sections of Title 35, U.S. Code not included in this action can be found in a prior Office action.

10. Claims 1 and 2 are rejected under 35 U.S.C. 103(a) as being unpatentable over Li et al. (herein after Li) (US Publication 2006/0068738 A1) in view of Malik et al. (herein after Malik) (US Publication 2009/0061786 A1).

Re claim 1, Li discloses a method for reduced feedback for beamforming in a wireless communication, the method comprises: receiving a baseband signal that includes a plurality of streams (Figure 1 antenna arrays; Figure 2 element 210; Paragraphs 0001, 0002 and 0043);

determining a unitary matrix having polar coordinates in response to feedback information (paragraphs 0012-0013; Figure 2), wherein the feedback information includes angles of a unit circle (paragraphs 0012-0013, 0015-0017; Figure 2); wherein the unitary matrix includes: a plurality of polar coordinates as represented by V, such that V*V = I, where I represents an identity matrix (Paragraph 0015-0016),

and digitally beamforming each of the plurality of streams of the baseband signal using the unitary matrix to produce a plurality of beamformed symbols (paragraph 0015); however Li fails to explicitly disclose wherein (1) the absolute value of each of the plurality of polar coordinates is a vector on the unit circle and each of the polar coordinates is orthogonal to at least one other of the polar coordinates and (2) wherein for each column of V, a first row of polar coordinates includes real values as references and a second row of polar coordinates includes phase shift values.

Regarding item (1) above however, as this limitation is disclosed as the factor resulting in the V*V=I relationship, it would be obvious to one of ordinary skill in the art that as Li provided the disclosure of the computation of the identity matrix that the process steps are inclusive of this disclosure despite not being explicitly spelled out in the disclosure of Li.

Regarding item (2) this limitation is however disclosed by Malik. Malik discloses where for each column of V, a first row of polar coordinates includes real values as references and a second row of polar coordinates includes phase shift values (Paragraph 0063).

Therefore it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the disclosure of Li to disclose the detail of Malik as the two disclosures are focal on the application of beamforming matrix construction for MIMO communications.

Re claim 2, Li and Malik as a whole disclose the method of claim 1; Li further discloses wherein the method comprises: the baseband signal including a plurality of tones (Paragraph 0010), wherein each of the plurality of tones corresponds to a symbol mapped to a constellation (Paragraph 0010); and digital beamforming each of the plurality of tones using the unitary matrix (Paragraph 0015).

The disclosure of Li does not specifically disclose 'tones' the examiner interprets the disclosure of sub channels within the spatial channels as disclosure that would be obvious to one of ordinary skill in the art to disclosing a functionally equivalent process to the tone manipulation.

11. **Claims 3, 9, and 15 are rejected under 35 U.S.C. 103(a) as being unpatentable over Li and Malik as applied to claim 1 above, and further in view of Poon (US publication 2006/0067428 A1).**

Re claim 3, the combined disclosure of Li and Malik as a whole discloses the method of claim 1; Li further disclosure wherein the method comprises: receiving outbound data; encoding the outbound data to produce a stream of encoded data (Paragraph 0015); and digital beamforming each of the plurality of parallel tones using the unitary matrix (Paragraph 0015); however Li fails to explicitly disclose interleaving the stream of encoded data into a plurality of parallel streams of interleaved data; constellation mapping symbols of each of the plurality of parallel streams of interleaved data to a plurality of parallel tones.

This method is however disclosed by Poon. Poon discloses the transmitting method comprising interleaving the stream of encoded data into a plurality of parallel streams of interleaved data (Figure 1 element 12); constellation mapping symbols of each of the plurality of parallel streams of interleaved data to a plurality of parallel tones (Figure 1 element 14).

Therefore it would have been obvious to one of ordinary skill in the art at the time the invention was made to incorporate the closed loop MIMO transceiver design as disclosed by Poon within the closed loop MIMO transceiver design of Li and Malik in order to gain the benefit of the application of well known transmission and receiving design structures utilized within the closed loop design.

Re claim 9, Li discloses a transmit baseband processing module comprises: an encoding module operably coupled to convert outbound data into encoded data (Paragraph 0015); a beamforming module operably coupled to beamform, using a unitary matrix (paragraphs 0012-0013, 0015; Figure 2), the plurality of streams of data symbols into a plurality of streams of beamformed symbols (paragraphs 0012-0013, 0015-0017; Figure 2), wherein the unitary matrix comprises: a plurality of polar coordinates as represented by V, such that V*V = I, where I represents an identity matrix (Paragraph 0012-0013, 0015-0017; Figure 2); however Li fails to explicitly disclose wherein (1) absolute value of each of the plurality of polar coordinates is a vector on the unit circle and each of the polar coordinates is orthogonal to at least one other of the polar coordinates; (2) wherein for each column of V, a first row of polar coordinates includes real values as references and a second row of polar coordinates includes phase shift values; and (3) a plurality of interleaving modules operably coupled to interleave the encoded data into a plurality of interleaved streams of data; a plurality of constellation mapping modules operably coupled to map the plurality of interleaved streams of data into a plurality of streams of data symbols; and a plurality of inverse fast Fourier transform modules operably coupled to convert the plurality of streams of beamformed symbols into a plurality of outbound symbol streams.

Regarding item (1) above, however, as this limitation is disclosed as the factor resulting in the V*V=I relationship, it would be obvious to one of ordinary skill in the art that as Li provided the disclosure of the computation of the identity matrix that the process steps are inclusive of this disclosure despite not being explicitly spelled out in the disclosure of Li.

Regarding item (2) this limitation is however disclosed by Malik. Malik discloses where for each column of V, a first row of polar coordinates includes real values as references and a second row of polar coordinates includes phase shift values (Paragraph 0063).

Therefore it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the disclosure of Li to disclose the detail of Malik as the two disclosures are focal on the application of beamforming matrix construction for MIMO communications.

Regarding item (3) this design is however disclosed by Poon. Poon discloses a plurality of interleaving modules (12; Figure 4 shows the system design implemented in a plurality) operably coupled to interleave the encoded data into a plurality of interleaved streams of data; a plurality of constellation mapping modules operably coupled to map the plurality of interleaved streams of data into a plurality of streams of data symbols (14; Figure 4 shows the system design implemented in a plurality); and a plurality of inverse fast Fourier transform modules operably coupled to convert the plurality of streams of beamformed symbols into a plurality of outbound symbol streams (16; Figure 4 shows the system design implemented in a plurality).

Therefore it would have been obvious to one of ordinary skill in the art at the time the invention was made to incorporate the closed loop MIMO transceiver design as disclosed by Poon within the closed loop MIMO transceiver design of Li in order to gain the benefit of the application of well known transmission and receiving design structures utilized within the closed loop design.

Claim 15 has been analyzed and rejected with regards to claim 9 as being the obvious receiver design to the claim limitations of the previously mentioned and currently rejected claim 9.

Allowable Subject Matter

12. Claims 6-8 and 12-14 are 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, and to overcome the pending double patenting rejections as well as the pending 112 second paragraph issues.

The following is a statement of reasons for the indication of allowable subject matter: The prior art of record fails to render obvious or anticipate the specifics of the matrix composition, regarding the polar application of the unit circle angles, for the various cases as provided for in the limitations of the above mentioned claims.

13. As allowable subject matter has been indicated, applicant's reply must either comply with all formal requirements or specifically traverse each requirement not complied with. See 37 CFR 1.111(b) and MPEP § 707.07(a).

(See Double patenting/112 rejection above)

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to MICHAEL R. NEFF whose telephone number is (571)270-1848. The examiner can normally be reached on Monday - Friday 8:00am - 4:30pm EST ALT Fridays.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Shuwang Liu can be reached on (571)272-3036. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/MICHAEL R. NEFF/
Examiner, Art Unit 2611
/Shuwang Liu/
Supervisory Patent Examiner, Art Unit 2611

Notice of References Cited	Application/Control No. 11/168,793	Applicant(s)/Patent Under Reexamination KIM, JOONSUK	
	Examiner MICHAEL R. NEFF	Art Unit 2611	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-2009/0061786 A1	03-2009	Malik et al.	455/69
	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
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

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.

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	11168793	KIM, JOONSUK
	Examiner	**Art Unit**
	MICHAEL R NEFF	2611

SEARCHED

Class	Subclass	Date	Examiner
375	260, 267, 299	3/24/2008	MRN

SEARCH NOTES

Search Notes	Date	Examiner
Class/Subclass search performed using keyword limitations	3/24/2008	MRN
Inventor/Double patenting search performed in EAST database	3/24/2008	MRN
Prior art revisited per amendments and arguments from applicant	9/29/2008	MRN
Updated search per amendments and arguments	4/9/2009	MRN
Discussed merits of claim language with spe Shuwang Liu	10/13/2009	MRN

INTERFERENCE SEARCH

Class	Subclass	Date	Examiner
375	267,299	10/9/2009	MRN

/MICHAEL R NEFF/
Examiner.Art Unit 2611

Index of Claims	Application/Control No. 11168793	Applicant(s)/Patent Under Reexamination KIM, JOONSUK
	Examiner MICHAEL R NEFF	Art Unit 2611

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	03/25/2008	09/29/2008	04/09/2009	10/22/2009					
	1	✓	✓	✓	✓					
	2	✓	✓	✓	✓					
	3	✓	✓	✓	✓					
	4	✓	✓	✓	-					
	5	✓	✓	O	-					
	6	✓	✓	O	✓					
	7	✓	✓	O	✓					
	8	✓	✓	O	✓					
	9	✓	✓	✓	✓					
	10	✓	✓	✓	-					
	11	✓	✓	O	-					
	12	✓	✓	O	✓					
	13	✓	✓	O	✓					
	14	✓	✓	O	✓					
	15	✓	✓	✓	✓					
	16	✓	✓	✓	-					

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S1	136	(feedback$3) same angle same circle	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/04/07 09:41
S2	8	S1 and baseband	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/04/07 09:41
S3	0	S1 and beamform$4	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/04/07 09:41
S4	2040	baseband and beamform$4	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/04/07 09:42
S5	176	S4 and unitary	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/04/07 09:42
S6	4	S5 and (unit with circle)	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/04/07 09:42
S7	2157	feedback and (unit with circle)	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/04/07 09:43
S8	30	S4 and S7	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/04/07 09:43
S9	15113	polar same angle	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/04/07 10:15
S10	62	S9 and S4	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/04/07 10:15
S11	34	S10 and feedback$3	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/04/07 10:16
S12	2	"20060067428"	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/04/08 10:08
S13	2	"US 20060239372"	US-PGPUB; USPAT; USOCR; DERWENT	OR	ON	2009/09/29 15:10

S19	2	us-20060039489-$. did.	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/10/14 13:13
S20	2	us-20090147881-$. did.	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/10/14 13:13
S21	2	us-20090106619-$. did.	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/10/14 13:13
S22	2	us-20090061786-$. did.	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/10/14 13:14
S24	2	us-20090031184-$. did.	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/10/14 13:16
S25	9	S19 or S20 or S21 or S22 or S24	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/10/14 13:22
S26	5	S25 and reference	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/10/14 13:22
S27	2	us-20060039489-$. did.	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/10/21 17:25
S28	2	us-20090147881-$. did.	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/10/21 17:25
S29	2	us-20090106619-$. did.	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/10/21 17:25
S30	2	us-20090061786-$. did.	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/10/21 17:25
S31	2	us-20090031184-$. did.	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/10/21 17:25
S32	9	S27 or S28 or S29 or S30 or S31	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/10/21 17:25

EAST Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S14	7	references.clm. and unitary.clm. and polar.clm.	USPAT; UPAD	OR	ON	2009/10/09 08:34
S15	427	375/299.ccls.	USPAT; UPAD	OR	ON	2009/10/09 08:34

S16	0	S14 and S15	USPAT; UPAD	OR	ON	2009/10/09 08:34
S17	1049	375/267.ccls.	USPAT; UPAD	OR	ON	2009/10/09 08:49
S18	0	S17 and S14	USPAT; UPAD	OR	ON	2009/10/09 08:49

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor:	Joonsuk Kim	**Docket:**	BP4637
Serial No.:	11/168,793	**Art Unit:**	2611
Filed:	June 28, 2005	**Examiner:**	Micheal R. Neff
Title:	Reduced Feedback for Beamforming in a Wireless Communication		

RESPONSE TO NON-FINAL OFFICE ACTION

M/S Amendment
Commissioner for Patents
P. O. Box 1450
Alexandria, VA 22313-1450

Dear Commissioner:

In response to the Office Action dated October 27, 2009, please consider the following amendment and response.

Amendment to the Claims

1 (Currently Amended). A method for reduced feedback for beamforming in a wireless communication, the method comprises:

receiving a baseband signal by a transmitter that includes a plurality of streams;

determining a unitary matrix V by the transmitter in response to feedback information received from a receiver, wherein the feedback information for a 2xN unitary matrix V includes angles of a unit circle ψ_1, Φ_1 and an index bit that defines a relationship between ψ_1 and Φ_1 and wherein determining the 2xN unitary matrix includes:

determining the set of angles ψ_1 and Φ_1, ψ_2, and Φ_2 in response to the feedback information;

determining a plurality of polar coordinates represented by the 2xN unitary matrix V based on the set of angles ψ_1 and Φ_1, ψ_2, and Φ_2, wherein absolute value of each of the plurality of polar coordinates is a vector on a unit circle and each of the polar coordinates is orthogonal to at least one other of the polar coordinates such that $VV^*=V^*V = I$, where I represents an identity matrix; and

for each column of V, a first row of polar coordinates includes real values as references and a second row of polar coordinates includes phase shift values; and

digitally beamforming each of the plurality of streams of the baseband signal using the unitary matrix to produce a plurality of beamformed symbols.

2 (Original). The method of claim 1 comprises:

the baseband signal including a plurality of tones, wherein each of the plurality of tones corresponds to a symbol mapped to a constellation; and

digital beamforming each of the plurality of tones using the unitary matrix.

3 (Previously Presented). The method of claim 1 comprises:

receiving outbound data;

encoding the outbound data to produce a stream of encoded data;

interleaving the stream of encoded data into a plurality of parallel streams of interleaved data;

constellation mapping symbols of each of the plurality of parallel streams of interleaved data to a plurality of parallel tones; and

digital beamforming each of the plurality of parallel tones using the unitary matrix.

4 (Canceled). Please cancel claim 4.

5 (Canceled). Please cancel claim 5.

6 (Currently Amended). The method of claim 1, wherein the 2xN unitary matrix ~~further~~ comprises for a 2xN multiple input multiple output (MIMO) wireless communication:

$$V = \begin{bmatrix} \cos\psi_1 & \cos\psi_2 \\ \sin\psi_1 e^{j\phi_1} & \sin\psi_2 e^{j\phi_2} \end{bmatrix}$$

wherein ψ_1, Φ_1, ψ_2, and Φ_2 represent angles of the unit circle, wherein absolute value of $\psi_1 - \psi_2 = \pi/2$ and $\Phi_1 = \Phi_2$ or $\Phi_1 = \Phi_2 + \pi$ and $\psi_1 + \psi_2 = \pi/2$; and

wherein the index bit in the feedback information defines whether $\psi_1 - \psi_2 = \pi/2$ and $\Phi_1 = \Phi_2$ or $\Phi_1 = \Phi_2 + \pi$ and $\psi_1 + \psi_2 = \pi/2$.

7 (Previously Presented). The method of claim 1, wherein the unitary matrix further comprises for a 3xN multiple input multiple output (MIMO) wireless communication:

$$V = \begin{bmatrix} \cos\psi_1 & \cos\psi_2 & \cos\psi_3 \\ \sin\psi_1 \cos\theta_1 e^{j\phi_{21}} & \sin\psi_2 \cos\theta_2 e^{j\phi_{22}} & \sin\psi_3 \cos\theta_3 e^{j\phi_{23}} \\ \sin\psi_1 \sin\theta_1 e^{j\phi_{31}} & \sin\psi_2 \sin\theta_2 e^{j\phi_{32}} & \sin\psi_3 \sin\theta_3 e^{j\phi_{33}} \end{bmatrix}$$

wherein ψ_1, ψ_2, ψ_3, θ_1, θ_2, θ_3, Φ_{21}, Φ_{22}, Φ_{23}, Φ_{31}, Φ_{32}, Φ_{33} represent angles of the unit circle, wherein Diagonal (V*V) = 1s, and wherein:

$$\psi_i = \cos^{-1} V_{1i}, \theta_i = \cos^{-1}\left|\frac{V_{2i}}{\sin\psi_i}\right|$$
$$\phi_{2i} = \angle(V_{2i}), \phi_{3i} = \angle(V_{3i})$$

8 (Previously Presented). The method of claim 1, wherein the unitary matrix further comprises for a 4xN multiple input multiple output (MIMO) wireless communication:

$$V = \begin{bmatrix} \cos\psi_1\cos\varphi_1 & \cos\psi_2\cos\varphi_2 & \cos\psi_3\cos\varphi_3 & \cos\psi_4\cos\varphi_4 \\ \cos\psi_1\sin\varphi_1 e^{j\phi_{11}} & \cos\psi_2\sin\varphi_2 e^{j\phi_{12}} & \cos\psi_3\sin\varphi_3 e^{j\phi_{13}} & \cos\psi_4\sin\varphi_4 e^{j\phi_{14}} \\ \sin\psi_1\cos\theta_1 e^{j\phi_{21}} & \sin\psi_2\cos\theta_2 e^{j\phi_{22}} & \sin\psi_3\cos\theta_3 e^{j\phi_{23}} & \sin\psi_4\cos\theta_4 e^{j\phi_{24}} \\ \sin\psi_1\sin\theta_1 e^{j\phi_{31}} & \sin\psi_2\sin\theta_2 e^{j\phi_{32}} & \sin\psi_3\sin\theta_3 e^{j\phi_{33}} & \sin\psi_4\sin\theta_4 e^{j\phi_{34}} \end{bmatrix}$$

wherein ψ_1, ψ_2, ψ_3, ψ_4, θ_1, θ_2, θ_3, θ_4, φ_1, φ_2, φ_3, φ_4, Φ_{21}, Φ_{22}, Φ_{23}, Φ_{24}, Φ_{31}, Φ_{32} , Φ_{33}, Φ_{33}, Φ_{41}, Φ_{42}, Φ_{43}, Φ_{43} represent angles of the unit circle, wherein Diagonal (V*V) = 1s, and wherein:

$$\psi_i = \cos^{-1}\left(\sqrt{|V_{1i}|^2 + |V_{2i}|^2}\right), \varphi_i = \cos^{-1}\left(\frac{V_{1i}}{\cos\psi_i}\right), \theta_i = \cos^{-1}\left|\frac{V_{3i}}{\sin\psi_i}\right|$$
$$\phi_{1i} = \angle(V_{2i}), \phi_{2i} = \angle(V_{3i}), \phi_{3i} = \angle(V_{4i})$$

9 (Currently Amended). A transmit baseband processing module comprises:

an encoding module operably coupled to convert outbound data into encoded data;

a plurality of interleaving modules operably coupled to interleave the encoded data into a plurality of interleaved streams of data;

a plurality of constellation mapping modules operably coupled to map the plurality of interleaved streams of data into a plurality of streams of data symbols;

a beamforming module operably coupled to beamform, using a unitary matrix, the plurality of streams of data symbols into a plurality of streams of beamformed symbols, wherein the unitary matrix is based on feedback information from a receiver, wherein a 2xN unitary matrix V includes:

a plurality of polar coordinates ~~represented by V~~, wherein the plurality of polar coordinates are determined in response to the feedback information, wherein the feedback information includes angles of a unit circle ψ_1, Φ_1 and an index bit that defines a relationship between ψ_1 and Φ_1 and wherein absolute value of each of the plurality of polar coordinates is a vector on a unit circle and each of the polar coordinates is orthogonal to at least one other of the polar coordinates such that $VV^*=V^*V = I$, where I represents an identity matrix; and

for each column of V, a first row of polar coordinates includes real values as references and a second row of polar coordinates includes phase shift values; and

a plurality of inverse fast Fourier transform modules operably coupled to convert the plurality of streams of beamformed symbols into a plurality of outbound symbol streams.

10 (Canceled). Please cancel claim 10.

11 (Canceled). Please cancel claim 11.

12 (Previously Presented). The transmit baseband processing module of claim 9, wherein the unitary matrix further comprises for a 2xN multiple input multiple output (MIMO) wireless communication:

$$V = \begin{bmatrix} \cos\psi_1 & \cos\psi_2 \\ \sin\psi_1 e^{j\phi_1} & \sin\psi_2 e^{j\phi_2} \end{bmatrix}$$

wherein ψ_1 , Φ_1, ψ_2 , and Φ_2 represent angles of the unit circle, wherein absolute value of $\psi_1 - \psi_2 = \pi/2$ and $\Phi_1 = \Phi_2$ or $\Phi_1 = \Phi_2 + \pi$ and $\psi_1 + \psi_2 = \pi/2$; and

wherein the feedback information includes ψ_1 , Φ_1 and an index bit to determine the relationship between ψ_1 and Φ_1.

13 (Previously Presented). The transmit baseband processing module of claim 9, wherein the unitary matrix further comprises for a 3xN multiple input multiple output (MIMO) wireless communication:

$$V = \begin{bmatrix} \cos\psi_1 & \cos\psi_2 & \cos\psi_3 \\ \sin\psi_1 \cos\theta_1 e^{j\phi_{21}} & \sin\psi_2 \cos\theta_2 e^{j\phi_{22}} & \sin\psi_3 \cos\theta_3 e^{j\phi_{23}} \\ \sin\psi_1 \sin\theta_1 e^{j\phi_{31}} & \sin\psi_2 \sin\theta_2 e^{j\phi_{32}} & \sin\psi_3 \sin\theta_3 e^{j\phi_{33}} \end{bmatrix}$$

wherein ψ_1, ψ_2, ψ_3, θ_1, θ_2, θ_3, Φ_{21}, Φ_{22}, Φ_{23}, Φ_{31}, Φ_{32}, Φ_{33} represent angles of the unit circle, wherein Diagonal (V*V) = 1s, and wherein:

$$\psi_i = \cos^{-1} V_{1i}, \theta_i = \cos^{-1}\left|\frac{V_{2i}}{\sin\psi_i}\right|$$
$$\phi_{2i} = \angle(V_{2i}), \phi_{3i} = \angle(V_{3i})$$

14 (Previously Presented). The transmit baseband processing module of claim 9, wherein the unitary matrix further comprises for a 4xN multiple input multiple output (MIMO) wireless communication:

$$V=\begin{bmatrix} \cos\psi_1\cos\varphi_1 & \cos\psi_2\cos\varphi_2 & \cos\psi_3\cos\varphi_3 & \cos\psi_4\cos\varphi_4 \\ \cos\psi_1\sin\varphi_1 e^{j\phi_{11}} & \cos\psi_2\sin\varphi_2 e^{j\phi_{12}} & \cos\psi_3\sin\varphi_3 e^{j\phi_{13}} & \cos\psi_4\sin\varphi_4 e^{j\phi_{14}} \\ \sin\psi_1\cos\theta_1 e^{j\phi_{21}} & \sin\psi_2\cos\theta_2 e^{j\phi_{22}} & \sin\psi_3\cos\theta_3 e^{j\phi_{23}} & \sin\psi_4\cos\theta_4 e^{j\phi_{24}} \\ \sin\psi_1\sin\theta_1 e^{j\phi_{31}} & \sin\psi_2\sin\theta_2 e^{j\phi_{32}} & \sin\psi_3\sin\theta_3 e^{j\phi_{33}} & \sin\psi_4\sin\theta_4 e^{j\phi_{34}} \end{bmatrix}$$

wherein ψ_1, ψ_2, ψ_3, ψ_4, θ_1, θ_2, θ_3, θ_4, φ_1, φ_2, φ_3, φ_4, Φ_{21}, Φ_{22}, Φ_{23}, Φ_{24}, Φ_{31}, Φ_{32}, Φ_{33}, Φ_{33}, Φ_{41}, Φ_{42}, Φ_{43}, Φ_{43} represent angles of the unit circle, wherein Diagonal (V*V) = 1s, and wherein:

$$\psi_i=\cos^{-1}\left(\sqrt{|V_{1i}|^2+|V_{2i}|^2}\right), \varphi_i=\cos^{-1}\left(\frac{V_{1i}}{\cos\psi_i}\right), \theta_i=\cos^{-1}\left|\frac{V_{3i}}{\sin\psi_i}\right|$$

$$\phi_{1i}=\angle(V_{2i}), \phi_{2i}=\angle(V_{3i}), \phi_{3i}=\angle(V_{4i})$$

15 (Currently Amended). A receiver baseband processing module comprises:

a plurality of fast Fourier transform modules operably coupled to convert a plurality of inbound symbol streams into a plurality of streams of beamformed symbols;

an inverse beamforming module operably coupled to inverse beamform, using a unitary matrix having polar coordinates, the plurality of streams of beamformed symbols into a plurality of streams of data symbols, wherein the polar coordinates of the unitary matrix are based on feedback information that includes angles of a unit circle ψ_1, Φ_1 and an index bit that defines a relationship between ψ_1 and Φ_1 and wherein the unitary matrix includes:

a plurality of polar coordinates represented by U, wherein the plurality of polar coordinates are determined in response to the feedback information and wherein absolute value of each of the plurality of polar coordinates is a vector on a unit circle and each of the polar coordinates is orthogonal to at least one other of the polar coordinates $U^*U = I$, where I represents an identity matrix; and

for each column of U, a first row of polar coordinates includes real values as references and a second row of polar coordinates includes phase shift values;

a plurality of constellation demapping modules operably coupled to demap the plurality of streams of data symbols into a plurality of interleaved streams of data;

a plurality of deinterleaving modules operably coupled to deinterleave the plurality of interleaved streams of data into encoded data; and

a decoding module operably coupled to convert the encoded data into inbound data.

16 (Canceled). Please cancel claim 16.

REMARKS

Claims 1, 2, 3, 6 through 9, 12 through 15 remain in this application. Claims 4, 5, 10, 11 and 16 are canceled. Claims 1, 6, 9 and 15 are currently amended.

Claim Rejections for Double Patenting

In the above referenced Office Action, claims 1, 3-14 are provisionally rejected provisionally rejected on the ground of nonstatutory obviousness-type double patenting as being unpatentable over claims 1, 3-12 of copending Application No. 11/168,838. The Office Action states that it is a provisional obviousness-type double patenting rejection because the conflicting claims have not in fact been patented.

Applicants submit herewith a terminal disclaimer to obviate the provisional obviousness-type double patenting rejection in the event of a Notice of Allowance in Application No. 11/168,838.

Claim Rejections under 35 U.S.C. §112

The Office Action rejected claims 1-3, 6-9 and 12-15 under 35 U.S.C. §112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. The Office Action states that the limitation 'first row ... includes real values as references" is not clearly defined within the claim language, or the specification in a way that provided evidence towards the intention of the use of these reference values.

This rejection is respectfully traversed because the specification clearly defines the intention of the use of the reference values in the unitary matrix V. With reference to the corresponding US Published Application 2006/0239372, paragraphs 49 and 50 state:

> [0049] The beamforming module 132 is operably coupled to multiply a beamforming unitary matrix (V) with baseband signals provided by the plurality of constellation mapping modules 128, 130. The beamforming module 132 determines the beamforming unitary matrix V from feedback information from the receiver, wherein the feedback information includes a calculated expression of the beamforming matrix V having polar coordinates. The beamforming module

132 generates the beamforming unitary matrix V to satisfy the conditions of "V*V=VV*="I", where "I" is an identity matrix of [1 0; 0 1] for 2.times.2 MIMO wireless communication, is [1 0 0 ;0 1 0; 0 0 1] for 3.times.3 MIMO wireless communication, or is [1 0 0 0; 0 1 0 0 ; 0 0 1 0; 0 0 0 1] for 4.times.4 MIMO wireless communication. In this equation, V*V means "conjugate (V) times V" and VV* means "V times conjugate (V)". Note that V may be a 2.times.2 unitary matrix for a 2.times.2 MIMO wireless communication, a 3.times.3 unitary matrix for a 3.times.3 MIMO wireless communication, and a 4.times.4 unitary matrix for a 4.times.4 MIMO wireless communication. Further note that for each column of V, a first row of polar coordinates including real values as references and a second row of polar coordinates including phase shift values.

[0050] In one embodiment, the constellation mapping modules 128, 130 function in accordance with one of the IEEE 802.11x standards to provide an OFDM (Orthogonal Frequency Domain Multiplexing) frequency domain baseband signals that includes a plurality of tones, or subcarriers, for carrying data. Each of the data carrying tones represents a symbol mapped to a point on a modulation dependent constellation map. For instance, a 16 QAM (Quadrature Amplitude Modulation) includes 16 constellation points, each corresponding to a different symbol. For an OFDM signal, the beamforming module 132 may regenerate the beamforming unitary matrix V for each tone from each constellation mapping module 128, 130, use the same beamforming unitary matrix for each tone from each constellation mapping module 128, 130, or a combination thereof.

The specification describes that the unitary matrix V includes a first row of polar coordinates including real values as references and a second row of polar coordinates including phase shift values. In addition, the specification describes that the baseband processing module multiplies the beamforming unitary matrix (V) with baseband signals provided by the plurality of constellation mapping modules 128, 130. Further, the specification specifically defines the mathematical equations defining the first row of polar coordinates of the unitary matrix including real values for a 2x2 matrix, 3x3 matrix and 4x4 matrix in paragraphs 50, 53 and 55. Thus, the specification clearly defines the intention of the use of the real values as references in the unitary matrix V.

As such, the claims meet all the requirements of 35 U.S.C. 112. "Determining whether a claim is definite requires an analysis of 'whether one skilled in the art would understand the bounds of the claim when read in light of the specification . . . . If the claims read in light of the specification reasonably apprise those skilled in the art of the scope of the invention, § 112 demands no more.' " *Personalized Media Communications, LLC v. U.S. Int'l Trade Comm'n*, 161 F.3d 696, 48 USPQ2d 1880 (Fed. Cir. 1998) (citing *Miles Lab., Inc. v. Shandon, Inc.*, 997 F.2d 870, 875, 27 USPQ2d 1123, 1126 (Fed. Cir. 1993) and finding that term digital detector is definite because the written description of the specification was sufficient to inform one skilled in the art of the meaning of the claim language).

Claim Rejections under 35 U.S.C. §103

Claims 1 and 2 are rejected under 35 U.S.C. 103(a) as being unpatentable over Li et al. (hereinafter Li) (US Publication 2006/0068738 A1) in view of Malik et al. (hereinafter Malik) (US Publication 2009/0061786 A1). Claims 3, 9, and 15 are rejected under 35 U.S.C. 103(a) as being unpatentable over Li and Malik as applied to claim 1 above, and further in view of Poon (US publication 2006/0067428 A1).

The Office Action stated that Claims 6-8 and 12-14 would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims. Claims 1, 9 and 15 have been amended to include elements of claims 6 and 8 respectively. The amended claims are patentable over the cited references for the following reasons.

Independent Claim 1 and dependent claims 2-3 and 6-8

The Office Action has failed to prove a prima facie case of obviousness of Independent Claim 1 and dependent claims 2-3 and 6-8 under 35 USC § 103(a). The rejection under 35 USC § 103(a) is not proper and without basis because the Li reference and the Malik reference teach away from the elements of the claims. The specification of this application states on page 4, line 27 to page 5, line 11:

> "To reduce the size of the feedback, the receiver may decompose the channel using singular value decomposition (SVD) and send information relating only to a calculated value of the transmitter's beamforming matrix (V) as the feedback information. In this approach, the receiver calculates (V) based on H=UDV*, where H is the channel response, D is a diagonal matrix, and U is a receiver unitary matrix. While this approach reduces the size of the feedback information, its size is still an issue for a MIMO wireless communication. For instance, in a 2x2 MIMO wireless communication, the feedback needs four elements that are all complex Cartesian coordinate values [V11 V12; V21 V22]. In general, Vik=aik+j*bik, where aik and bik are values between[-1, 1]. Thus, with 1 bit express per each element for each of the real and imaginary components, aik and bik can be either-1/2 or 1/2, which requires 4.times.2.times.1=8 bits per tone. With 4 bit expressions per each element of V(f) in an orthogonal frequency division multiplexing (OFDM) 2x2 MIMO wireless communication, the number of bits required is 1728 per tone (e.g., 4*2*54*4=1728, 4 elements per tone, 2 bits for real and imaginary components per tone, 54 data tones per frame, and 4 bits per element), which requires overhead for a packet exchange that is too large for practical applications."

In an embodiment, the specification of this application states on page 19, line 28 to page 20, line 15 that:

> "From this expression, the baseband receive processing 100-RX may readily determine the feedback of V, where V includes polar coordinates. For instance, the receiver may decompose the channel using singular value decomposition (SVD) and send information relating only to a calculated value of the transmitter's beamforming matrix (V) as the feedback information. In this approach, the receiver calculates (V) based on H = UDV*, where H is the channel response, D is a diagonal matrix, and U is a receiver unitary matrix. This approach reduces the size of the feedback information with respect to SVD using Cartesian coordinates. For example, in a 2x2 MIMO wireless communication, the

feedback needs four elements that are all complex values [V11 V12; V21 V22] with two angles (ψ and Φ). In general, Vik = aik + j*bik, where aik and bik are values between [-1, 1]. To cover [-1, 1], ψ is in $[0, \pi]$ and Φ is in $[0, 2\pi]$. With $\pi/2$ resolutions for angles, ψ needs to be $\pi/4$ or $3\pi/4$, i.e., $\cos(\psi) = 0.707$ or -0.707, which requires 1 bit, where Φ needs to be either $\pi/4$, $3\pi/4$, $5\pi/4$, $7\pi/4$, i.e., $\exp(j\Phi) = 0.707(1+j)$, $0.707(1-j)$, $0.707(-1+j)$ or $0.707(-1-j)$, which requires 2 bits. With $\pi/4$ resolutions for angles, ψ needs to be $\pi/8$, $3\pi/8$, $5\pi/8$ or $7\pi/8$, which requires 2 bits, where Φ needs to be either $\pi/8$, $3\pi/8$, $5\pi/8$, $7\pi/8$, $9\pi/8$, $11\pi/8$, $13\pi/8$ or $15\pi/8$, which requires 4 bits. So, for an example of 2x2 system to use 4 bits per tone, it may have 1 bit for ψ, 2 bits for Φ and 1 index bit to determine the relationship between ψ and Φ, such as either $\psi1 = \psi2 + \pi$ and $\Phi1 + \Phi2 = \pi/2$, or $\psi1 = \psi2$ and $\Phi1 - \Phi2 = \pi/2$."

As described above, by using polar coordinates, for an example of 2x2 system, the feedback information includes 1 bit for ψ, 2 bits for Φ and 1 index bit to determine the relationship between ψ and Φ. This reduces the number of bits of feedback information needed when the feedback information includes Cartesian coordinates.

The Office Action has failed to show how the Li reference and the Malik reference disclose or make obvious the elements of claim 1, *inter alia*, of "determining a unitary matrix V by the transmitter in response to feedback information received from a receiver, wherein the feedback information for a 2xN unitary matrix V includes angles of a unit circle ψ_1, Φ_1 and an index bit that defines a relationship between ψ_1 and Φ_1 and wherein determining the 2xN unitary matrix includes: determining the set of angles ψ_1 and Φ_1, ψ_2, and Φ_2 in response to the feedback information; determining a plurality of polar coordinates represented by the 2xN unitary matrix V based on the set of angles ψ_1 and Φ_1, ψ_2, and Φ_2, wherein absolute value of each of the plurality of polar coordinates is a vector on a unit circle and each of the polar coordinates is orthogonal to at least one other of the polar coordinates such that $\underline{VV^*=}V^*V = I$, where I represents an identity matrix; and for each column of V, a first row of polar coordinates includes real values as references and a second row of polar coordinates includes phase shift values." First, with respect to the Li reference, the Li reference describes in paragraph 57 that:

> 5) Receiver quantizes and feeds back Φ, θ and ϕ
> The transmitter may then reconstruct $\overline{V}$ using Φ, θ and ϕ
>
> $$n_1=\sin(\theta)\cos(\phi) \quad (33)$$
>
> $$n_2=\sin(\theta)\sin(\phi)n_3=\cos(\theta) \quad (34)$$
>
> $$\overline{V}=\cos(\Phi)G_4+i\sin(\Phi)(n_1G_1+n_2G_2+n_3G_3) \quad (35)$$

The Li reference fails to describe a feedback signal includes a subset of angles ψ_1 and Φ_1 and that the angles ψ_2 , and Φ_2 can be determined based on the subset of angles ψ_1 and Φ_1, and then determining the polar coordinates for the unitary matrix based on the set of angles ψ_1 and Φ_1, ψ_2 , and Φ_2.

With respect to the Malik reference, it teaches using Cartesian coordinates as feedback information in a MIMO system. The Malik reference states in paragraph 59 through 61 that:

> [0059]Representing, the coefficient $[Tx_{filt}]_{2,1}$ in the Cartesian coordinate system (which is the most common form of representing complex numbers in digital electronic systems), the feedback information is determined to be:
> Feedback_Info_Set={a_{21},b_{21}} (17)
>
> [0060]where, $v_{21}ej^{(.phi_{21}-.phi_{11})}=a_{21}+jb_{21}$
>
> [0061]According to the method of the present invention, instead of feeding back the right-handed singular-vector matrix [V], the receiver feeds back the information identified in equation (17) to the transmitter.

As described above, the Malik reference describes that the receiver feedback information from the coefficient $[Tx_{filt}]_{2,1}$ in the Cartesian coordinate system. This teaches away from the elements of claim 1 that the feedback information for a 2xN unitary matrix V includes angles of a unit circle ψ_1, Φ_1 and an index bit that defines a relationship between ψ_1 and Φ_1.

In conclusion, the Office Action has failed to show how the Li reference and the Malik reference make obvious the elements of the independent claim 1. Claims 2, 3, 6 through 8 add further patentable matter to Claim 1 and thus are further differentiated and patentable under 35 U.S.C. §102 over the Li and Malik references.

Independent Claim 9 and dependent claims 12 -14

For similar reasons with respect to claim 1, the Office Action has failed to show how the Li reference and the Malik reference make obvious the elements of the independent claim 9. Claims 12-14 add further patentable matter to Claim 9 and thus are further differentiated and patentable under 35 U.S.C. §102 over the Li and Malik references.

Independent Claim 15

For similar reasons with respect to claim 1, the Office Action has failed to show how the Li reference and the Malik reference make obvious the elements of the independent claim 15.

CONCLUSION

For the above reasons, the Application is in condition for allowance. Therefore, it is respectfully requested that the rejection of the claims be withdrawn and full allowance granted. Should the Examiner have any further comments or suggestions, please contact Jessica Smith at (972) 240-5324.

Respectfully submitted,
GARLICK HARRISON & MARKISON

Dated: January 27, 2010

/Jessica Smith/

Jessica W. Smith
Reg. No. 39,884

Garlick Harrison & Markison
P. O. Box 160727
Austin, TX 78716-0727
Phone: (972) 240-5324
Fax: (888) 456-7824

TERMINAL DISCLAIMER TO OBVIATE A PROVISIONAL DOUBLE PATENTING REJECTION OVER A PENDING "REFERENCE" APPLICATION	Docket Number (Optional) BP4637

In re Application of: Joonsuk Kim

Application No.: 11/168,793

Filed: June 28, 2005

For: Reduced Feedback for Beamforming in a Wireless Communication

The owner*, Broadcom Corporation, of 100 percent interest in the instant application hereby disclaims, except as provided below, the terminal part of the statutory term of any patent granted on the instant application which would extend beyond the expiration date of the full statutory term of any patent granted on pending **reference** Application Number 11/168,838, filed on June 28, 2005, as such term is defined in 35 U.S.C. 154 and 173, and as the term of any patent granted on said **reference** application may be shortened by any terminal disclaimer filed prior to the grant of any patent on the pending **reference** application. The owner hereby agrees that any patent so granted on the instant application shall be enforceable only for and during such period that it and any patent granted on the **reference** application are commonly owned. This agreement runs with any patent granted on the instant application and is binding upon the grantee, its successors or assigns.

In making the above disclaimer, the owner does not disclaim the terminal part of any patent granted on the instant application that would extend to the expiration date of the full statutory term as defined in 35 U.S.C. 154 and 173 of any patent granted on said **reference** application, "as the term of any patent granted on said **reference** application may be shortened by any terminal disclaimer filed prior to the grant of any patent on the pending **reference** application," in the event that: any such patent: granted on the pending **reference** application: expires for failure to pay a maintenance fee, is held unenforceable, is found invalid by a court of competent jurisdiction, is statutorily disclaimed in whole or terminally disclaimed under 37 CFR 1.321, has all claims canceled by a reexamination certificate, is reissued, or is in any manner terminated prior to the expiration of its full statutory term as shortened by any terminal disclaimer filed prior to its grant.

Check either box 1 or 2 below, if appropriate.

1. ☐ For submissions on behalf of a business/organization (e.g., corporation, partnership, university, government agency, etc.), the undersigned is empowered to act on behalf of the business/organization.

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 Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

2. ☑ The undersigned is an attorney or agent of record. Reg. No. 39,884

/Jessica W.Smith, Reg. No. 39884/ — 1/27/2010
Signature — Date

Jessica W. Smith, Reg. No. 39,884
Typed or printed name

972-240-5324
Telephone Number

☑ Terminal disclaimer fee under 37 CFR 1.20(d) is included.

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

*Statement under 37 CFR 3.73(b) is required if terminal disclaimer is signed by the assignee (owner). Form PTO/SB/96 may be used for making this statement. See MPEP § 324.

Electronic Patent Application Fee Transmittal

Application Number:	11168793
Filing Date:	28-Jun-2005
Title of Invention:	Reduced feedback for beamforming in a wireless communication
First Named Inventor/Applicant Name:	Joonsuk Kim
Filer:	Jessica Smith/Melanie Murdock
Attorney Docket Number:	BP4637

Filed as Large Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
Statutory disclaimer	1814	1	140	140
		Total in USD ($)		**140**

Electronic Acknowledgement Receipt

EFS ID:	6895713
Application Number:	11168793
International Application Number:	
Confirmation Number:	9094
Title of Invention:	Reduced feedback for beamforming in a wireless communication
First Named Inventor/Applicant Name:	Joonsuk Kim
Customer Number:	51472
Filer:	Jessica Smith/Melanie Murdock
Filer Authorized By:	Jessica Smith
Attorney Docket Number:	BP4637
Receipt Date:	27-JAN-2010
Filing Date:	28-JUN-2005
Time Stamp:	19:35:56
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Credit Card
Payment was successfully received in RAM	$140
RAM confirmation Number	6084
Deposit Account	502126
Authorized User	MURDOCK,MELANIE

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

Charge any Additional Fees required under 37 C.F.R. Section 1.16 (National application filing, search, and examination fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.17 (Patent application and reexamination processing fees)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		BP4637_Amendment_01272010.pdf	163404 e47bb5550fde736a34dbe1d3ba1e1470d4fa9564	yes	15

Multipart Description/PDF files in .zip description

Document Description	Start	End
Amendment/Req. Reconsideration-After Non-Final Reject	1	1
Claims	2	8
Applicant Arguments/Remarks Made in an Amendment	9	15

Warnings:

Information:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
2	Terminal Disclaimer Filed	BP4637_Terminal_Disclaimer_01272010.pdf	35553 6f968b3e7c195db441f4fcea68410c9e7087e29f	no	1

Warnings:

Information:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
3	Fee Worksheet (PTO-875)	fee-info.pdf	29876 ef4b3d0b1f6cf1dd9951f2be6ea150ad7e39136a	no	2

Warnings:

Information:

Total Files Size (in bytes): 228833

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/SB/06 (07-06)
Approved for use through 1/31/2007. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 11/168,793	Filing Date 06/28/2005	☐ To be Mailed

APPLICATION AS FILED – PART I

FOR	NUMBER FILED (Column 1)	NUMBER EXTRA (Column 2)	SMALL ENTITY ☐ RATE ($)	SMALL ENTITY FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =		OR	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =			X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT 01/27/2010	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	SMALL ENTITY RATE ($)	SMALL ENTITY ADDITIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	* 15	Minus	** 20	=	X $ =		OR	X $ =	
Independent (37 CFR 1.16(h))	* 3	Minus	***3	=	X $ =		OR	X $ =	
☐ Application Size Fee (37 CFR 1.16(s))									
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

AMENDMENT	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	RATE ($)	ADDITIONAL FEE ($)		RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =		OR	X $ =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =		OR	X $ =	
☐ Application Size Fee (37 CFR 1.16(s))									
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

Legal Instrument Examiner:
/JACQUELINE M. WEIR/

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

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

NOTICE OF ALLOWANCE AND FEE(S) DUE

51472 7590 03/01/2010

GARLICK HARRISON & MARKISON
P.O. BOX 160727
AUSTIN, TX 78716-0727

EXAMINER	
NEFF, MICHAEL R	
ART UNIT	PAPER NUMBER
2611	

DATE MAILED: 03/01/2010

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/168,793	06/28/2005	Joonsuk Kim	BP4637	9094

TITLE OF INVENTION: REDUCED FEEDBACK FOR BEAMFORMING IN A WIRELESS COMMUNICATION

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	$1510	$300	$0	$1810	06/01/2010

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the SMALL ENTITY status shown above.

If the SMALL ENTITY is shown as YES, verify your current SMALL ENTITY status:

A. If the status is the same, pay the TOTAL FEE(S) DUE shown above.

B. If the status above is to be removed, check box 5b on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and twice the amount of the ISSUE FEE shown above, or

If the SMALL ENTITY is shown as NO:

A. Pay TOTAL FEE(S) DUE shown above, or

B. If applicant claimed SMALL ENTITY status before, or is now claiming SMALL ENTITY status, check box 5a on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and 1/2 the ISSUE FEE shown above.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

PTOL-85 (Rev. 08/07) Approved for use through 08/31/2010.

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)

51472 7590 03/01/2010

GARLICK HARRISON & MARKISON
P.O. BOX 160727
AUSTIN, TX 78716-0727

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.
11/168,793	06/28/2005	Joonsuk Kim	BP4637	9094

TITLE OF INVENTION: REDUCED FEEDBACK FOR BEAMFORMING IN A WIRELESS COMMUNICATION

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	$1510	$300	$0	$1810	06/01/2010

EXAMINER	ART UNIT	CLASS-SUBCLASS
NEFF, MICHAEL R	2611	375-299000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list

(1) the names of up to 3 registered patent attorneys or agents OR, alternatively,

(2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 ______________________

2 ______________________

3 ______________________

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE

(B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. The following fee(s) are submitted:

❑ Issue Fee

❑ Publication Fee (No small entity discount permitted)

❑ Advance Order - # of Copies ______________

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**

❑ A check is enclosed.

❑ Payment by credit card. Form PTO-2038 is attached.

❑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number __________ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)

❑ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.

❑ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature ______________________ Date ______________________

Typed or printed name ______________________ Registration No. ______________________

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

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.
11/168,793	06/28/2005	Joonsuk Kim	BP4637	9094

51472 7590 03/01/2010

GARLICK HARRISON & MARKISON
P.O. BOX 160727
AUSTIN, TX 78716-0727

EXAMINER	
NEFF, MICHAEL R	
ART UNIT	PAPER NUMBER
2611	

DATE MAILED: 03/01/2010

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)

(application filed on or after May 29, 2000)

The Patent Term Adjustment to date is 558 day(s). If the issue fee is paid on the date that is three months after the mailing date of this notice and the patent issues on the Tuesday before the date that is 28 weeks (six and a half months) after the mailing date of this notice, the Patent Term Adjustment will be 558 day(s).

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

PTOL-85 (Rev. 08/07) Approved for use through 08/31/2010.

Notice of Allowability	Application No. 11/168,793	Applicant(s) KIM, JOONSUK	
	Examiner MICHAEL R. NEFF	Art Unit 2611	

-- 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 remarks and amendments filed 1/27/2010.
2. ☒ The allowed claim(s) is/are 1-3, 6-9, 12-15.
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/SB/08), Paper No./Mail Date _____
4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
5. ☐ Notice of Informal Patent Application
6. ☒ Interview Summary (PTO-413), Paper No./Mail Date 2/23/2010 .
7. ☒ Examiner's Amendment/Comment
8. ☒ Examiner's Statement of Reasons for Allowance
9. ☐ Other _____.

/MICHAEL R. NEFF/
Examiner, Art Unit 2611

Examiner-Initiated Interview Summary	Application No.	Applicant(s)	
	11/168,793	KIM, JOONSUK	
	Examiner	Art Unit	
	MICHAEL R. NEFF	2611	

All Participants:

(1) *MICHAEL R. NEFF*.

(2) *Jessica Smith*.

Status of Application: *allowable*

(3) _____.

(4) _____.

Date of Interview: *23 February 2010*

Time: *2:15 pm*

Type of Interview:

☒ Telephonic
☐ Video Conference
☐ Personal (Copy given to: ☐ Applicant ☐ Applicant's representative)

Exhibit Shown or Demonstrated: ☐ Yes ☒ No

If Yes, provide a brief description: .

Part I.

Rejection(s) discussed:

n/a

Claims discussed:

1, 15

Prior art documents discussed:

n/a

Part II.

SUBSTANCE OF INTERVIEW DESCRIBING THE GENERAL NATURE OF WHAT WAS DISCUSSED:

Discussed proposed examiner's amendment to the claims and appropiate placement of said amendments.

Part III.

☒ It is not necessary for applicant to provide a separate record of the substance of the interview, since the interview directly resulted in the allowance of the application. The examiner will provide a written summary of the substance of the interview in the Notice of Allowability.

☐ It is not necessary for applicant to provide a separate record of the substance of the interview, since the interview did not result in resolution of all issues. A brief summary by the examiner appears in Part II above.

/MICHAEL R. NEFF/
Examiner, Art Unit 2611

(Applicant/Applicant's Representative Signature – if appropriate)

DETAILED ACTION

EXAMINER'S AMENDMENT

1. An Examiner's amendment to the record appears below. Should the changes and/or additions be unacceptable to the 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.

Authorization for this Examiner's amendment was given in a telephonic interview with Jessica Smith on 2/23/2010.

Please make the following amendments to the claims:

1) In claim 1, in line 5; please change **'unitary matrix V includes'** to read **"unitary matrix V, wherein N is a number of receiver antennas, includes"**

2) In claim 9, in lines 9-10; please change **'unitary matrix V includes:'** to read **"unitary matrix V, wherein N is a number of receiver antennas, includes:"**

3) In claim 15, line 12; please change **'U*U=I'** to read **"UU*=U*U=I"**

Terminal Disclaimer

2. The terminal disclaimer filed on 1/27/2010 disclaiming the terminal portion of any patent granted on this application which would extend beyond the expiration date of 11/168,838 has been reviewed and is accepted. The terminal disclaimer has been recorded.

Allowable Subject Matter

3. Claims 1-3, 6-9, 12-15 are allowed.

4. The following is an examiner's statement of reasons for allowance: The prior art of record fails to anticipate or render obvious the specific limitations of the feedback information and the determination of the angle sets within the parameters of polar coordinates.

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

Any inquiry concerning this communication or earlier communications from the examiner should be directed to MICHAEL R. NEFF whose telephone number is (571)270-1848. The examiner can normally be reached on Monday - Friday 8:00am - 4:30pm EST ALT Fridays.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Shuwang Liu can be reached on (571)272-3036. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/MICHAEL R. NEFF/
Examiner, Art Unit 2611
/Shuwang Liu/
Supervisory Patent Examiner, Art Unit 2611

Index of Claims	Application/Control No. 11168793	Applicant(s)/Patent Under Reexamination KIM, JOONSUK
	Examiner MICHAEL R NEFF	Art Unit 2611

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☒ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	03/25/2008	09/29/2008	04/09/2009	10/22/2009	02/23/2010				
1	1	✓	✓	✓	✓	=				
2	2	✓	✓	✓	✓	=				
3	3	✓	✓	✓	✓	=				
	4	✓	✓	✓	-	-				
	5	✓	✓	O	-	-				
4	6	✓	✓	O	✓	=				
5	7	✓	✓	O	✓	=				
6	8	✓	✓	O	✓	=				
7	9	✓	✓	✓	✓	=				
	10	✓	✓	✓	-	-				
	11	✓	✓	O	-	-				
8	12	✓	✓	O	✓	=				
9	13	✓	✓	O	✓	=				
10	14	✓	✓	O	✓	=				
11	15	✓	✓	✓	✓	=				
	16	✓	✓	✓	-	-				

Issue Classification

Application/Control No.	Applicant(s)/Patent Under Reexamination
11168793	KIM, JOONSUK
Examiner	**Art Unit**
MICHAEL R NEFF	2611

ORIGINAL		INTERNATIONAL CLASSIFICATION					
CLASS	SUBCLASS	CLAIMED					NON-CLAIMED
375	267	H	0	4	B	7 / 02 (2006.0)	

CROSS REFERENCE(S)

CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)				
375	299	260			

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☒ T.D. ☐ R.1.47

Final	Original
1	1
2	2
3	3
	4
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4	6
5	7
6	8
7	9
	10
	11
8	12
9	13
10	14
11	15
	16

/MICHAEL R NEFF/ Examiner.Art Unit 2611 (Assistant Examiner)	02/23/2010 (Date)	Total Claims Allowed: 11
/SHUWANG LIU/ Supervisory Patent Examiner.Art Unit 2611 (Primary Examiner)	02/24/2010 (Date)	O.G. Print Claim(s): 11 O.G. Print Figure: 2

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	11168793	KIM, JOONSUK
	Examiner	**Art Unit**
	MICHAEL R NEFF	2611

SEARCHED

Class	Subclass	Date	Examiner
375	260, 267, 299	3/24/2008	MRN

SEARCH NOTES

Search Notes	Date	Examiner
Class/Subclass search performed using keyword limitations	3/24/2008	MRN
Inventor/Double patenting search performed in EAST database	3/24/2008	MRN
Prior art revisited per amendments and arguments from applicant	9/29/2008	MRN
Updated search per amendments and arguments	4/9/2009	MRN
Discussed merits of claim language with spe Shuwang Liu	10/13/2009	MRN

INTERFERENCE SEARCH

Class	Subclass	Date	Examiner
375	267,299	10/9/2009	MRN
375	267	2/23/2010	MRN

/MICHAEL R NEFF/ Examiner.Art Unit 2611	

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S1	43	kim-joonsuk.in.	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/24 12:38
S2	10	S1 and beam adj form $3	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/24 12:38
S3	26	S1 and ((beam adj form$3) or beamform $3 or beamstear$3 or (beam adj stear$3))	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/24 12:39
S4	1378	375/267.ccls.	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/24 12:53
S5	455	375/299.ccls.	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/24 12:53
S6	2436	375/260.ccls.	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/24 12:53
S7	3881	S4 or S5 or S6	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/24 12:53
S8	402	S7 and ((beam adj form$3) or beamform $3 or beamstear$3 or (beam adj stear$3))	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/24 12:53
S9	84	S8 and (unitary near matr$4)	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/24 12:54
S10	7	S9 and polar	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/24 12:54
S11	20	S8 and ((unitary near matr$4) same feedback)	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/24 14:09
S12	64728	((beam adj form$3) or beamform$3 or beamstear$3 or (beam adj stear$3))	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/24 14:17

S13	36	S12 and ((unitary near matr$4) same feedback)	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/24 14:17
S14	2	"7158759".pn.	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/24 14:29
S15	72464	((beam adj form$3) or beamform$3 or beamstear$3 or (beam adj stear$3) or beamsteer$3 or (beam adj steer$3))	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/24 14:39
S16	19	S15 and ((unitary near matr$4) same feedback) and interleav $3	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/24 14:39
S17	10	aldana-carlos.in.	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/24 15:08
S19	126	hansen-chris$6.in.	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/24 15:09
S20	10	S17 or S19 and S15	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/24 15:09
S21	3	(S17 or S19) and S15	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/24 15:09
S22	2	cartesean with polar with conver$5	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/24 17:28
S23	0	polar with rectangular with covner$5	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/24 17:38
S24	2507	polar with rectangular	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/24 17:38
S25	192	polar with coordinates with matrix	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/24 17:38
S26	8	S25 same unitary	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/24 17:39
S27	168	polar with S15	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/24 17:46
S28	12	matrix with real with polar	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/03/25 09:43

S29	2	"US 20060239372"	US-PGPUB; USPAT; USOCR; DERWENT	OR	ON	2008/09/29 13:16
S30	2	"20050286663"	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2008/09/29 13:23
S31	2	"US 20060239373"	US-PGPUB; USPAT; USOCR; DERWENT	OR	ON	2009/06/20 13:29

EAST Search History (Interference)

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2/23/2010 3:41:13 PM
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EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S1	136	(feedback$3) same angle same circle	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/04/07 09:41
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S3	0	S1 and beamform$4	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/04/07 09:41
S4	2040	baseband and beamform$4	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/04/07 09:42
S5	176	S4 and unitary	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/04/07 09:42
S6	4	S5 and (unit with circle)	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/04/07 09:42
S7	2157	feedback and (unit with circle)	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/04/07 09:43
S8	30	S4 and S7	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/04/07 09:43
S9	15113	polar same angle	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/04/07 10:15
S10	62	S9 and S4	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/04/07 10:15
S11	34	S10 and feedback$3	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/04/07 10:16
S12	2	"20060067428"	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/04/08 10:08
S13	2	"US 20060239372"	US-PGPUB; USPAT; USOCR; DERWENT	OR	ON	2009/09/29 15:10

S19	2	us-20060039489-$.did.	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/10/14 13:13
S20	2	us-20090147881-$.did.	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/10/14 13:13
S21	2	us-20090106619-$.did.	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/10/14 13:13
S22	2	us-20090061786-$.did.	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/10/14 13:14
S24	2	us-20090031184-$.did.	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/10/14 13:16
S25	9	S19 or S20 or S21 or S22 or S24	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/10/14 13:22
S26	5	S25 and reference	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/10/14 13:22
S27	2	us-20060039489-$.did.	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/10/21 17:25
S28	2	us-20090147881-$.did.	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/10/21 17:25
S29	2	us-20090106619-$.did.	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/10/21 17:25
S30	2	us-20090061786-$.did.	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/10/21 17:25
S31	2	us-20090031184-$.did.	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/10/21 17:25
S32	9	S27 or S28 or S29 or S30 or S31	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2009/10/21 17:25

EAST Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	1125	375/267.ccls.	USPAT; UPAD	OR	ON	2010/02/23 15:44
L2	1125	L1	USPAT; UPAD	OR	ON	2010/02/23 15:44
L3	852	references.clm. and polar.clm.	USPAT; UPAD	OR	ON	2010/02/23 15:44

L4	1	2 and 3	USPAT; UPAD	OR	ON	2010/02/23 15:44
S14	7	references.clm. and unitary.clm. and polar.clm.	USPAT; UPAD	OR	ON	2009/10/09 08:34
S15	427	375/299.ccls.	USPAT; UPAD	OR	ON	2009/10/09 08:34
S16	0	S14 and S15	USPAT; UPAD	OR	ON	2009/10/09 08:34
S17	1049	375/267.ccls.	USPAT; UPAD	OR	ON	2009/10/09 08:49
S18	0	S17 and S14	USPAT; UPAD	OR	ON	2009/10/09 08:49

2/23/2010 3:44:38 PM
C:\ Documents and Settings\ mneff\ My Documents\ EAST\ Workspaces\ 11168793 rce.wsp

Application Number	Application/Control No.	Applicant(s)/Patent under Reexamination	
	11/168,793	KIM, JOONSUK	

Document Code - DISQ	Internal Document – DO NOT MAIL

TERMINAL DISCLAIMER	☒ APPROVED	☐ DISAPPROVED
Date Filed : 1/27/10	**This patent is subject to a Terminal Disclaimer**	

Approved/Disapproved by:
ANDRE ROBINSON

U.S. Patent and Trademark Office

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.
11/168,793	06/28/2005	Joonsuk Kim	BP4637	9094

51472 7590 04/28/2010
GARLICK HARRISON & MARKISON
P.O. BOX 160727
AUSTIN, TX 78716-0727

EXAMINER	
NEFF, MICHAEL R	

ART UNIT	PAPER NUMBER
2611	

NOTIFICATION DATE	DELIVERY MODE
04/28/2010	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

MMURDOCK@TEXASPATENTS.COM
SMCWHINNIE@TEXASPATENTS.COM

PTOL-90A (Rev. 04/07)

Supplemental Notice of Allowability	Application No. 11/168,793	Applicant(s) KIM, JOONSUK
	Examiner MICHAEL R. NEFF	Art Unit 2611

-- 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 *remarks and amendments filed 1/27/2010*.

2. ☒ The allowed claim(s) is/are *1-3,6-9 and 12-15*.

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/SB/08), Paper No./Mail Date _____
4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
5. ☐ Notice of Informal Patent Application
6. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
7. ☒ Examiner's Amendment/Comment
8. ☐ Examiner's Statement of Reasons for Allowance
9. ☐ Other _____.

/MICHAEL R. NEFF/
Examiner, Art Unit 2611

DETAILED ACTION

EXAMINER'S AMENDMENT

1. An Examiner's amendment to the record appears below. Should the changes and/or additions be unacceptable to the 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.

Please make the following amendment to the Specification:

On page 16, please delete the cut off equation.

On page 17, in the space following line 2, please enter the following:

$$V = \begin{bmatrix} \cos\psi_1 & \cos\psi_2 \\ \sin\psi_1 e^{j\phi_1} & \sin\psi_2 e^{j\phi_2} \end{bmatrix}$$

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to MICHAEL R. NEFF whose telephone number is (571)270-1848. The examiner can normally be reached on Monday - Friday 8:00am - 4:30pm EST ALT Fridays.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Shuwang Liu can be reached on (571)272-3036. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/MICHAEL R. NEFF/
Examiner, Art Unit 2611
/Shuwang Liu/
Supervisory Patent Examiner, Art Unit 2611

Search Notes	**Application/Control No.** 11168793	**Applicant(s)/Patent Under Reexamination** KIM, JOONSUK
	Examiner MICHAEL R NEFF	**Art Unit** 2611

SEARCHED

Class	Subclass	Date	Examiner
375	260, 267, 299	3/24/2008	MRN

SEARCH NOTES

Search Notes	Date	Examiner
Class/Subclass search performed using keyword limitations	3/24/2008	MRN
Inventor/Double patenting search performed in EAST database	3/24/2008	MRN
Prior art revisited per amendments and arguments from applicant	9/29/2008	MRN
Updated search per amendments and arguments	4/9/2009	MRN
Discussed merits of claim language with spe Shuwang Liu	10/13/2009	MRN

INTERFERENCE SEARCH

Class	Subclass	Date	Examiner
375	267,299	10/9/2009	MRN
375	267	2/23/2010	MRN

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)

51472 7590 03/01/2010

GARLICK HARRISON & MARKISON
P.O. BOX 160727
AUSTIN, TX 78716-0727

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.
11/168,793	06/28/2005	Joonsuk Kim	BP4637	9094

TITLE OF INVENTION: REDUCED FEEDBACK FOR BEAMFORMING IN A WIRELESS COMMUNICATION

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	$1510	$300	$0	$1810	06/01/2010

EXAMINER	ART UNIT	CLASS-SUBCLASS
NEFF, MICHAEL R	2611	375-299000

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 Garlick Harrison & Markison
   2 Timothy W. Markison
   3 Jessica W. Smith

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: Broadcom Corporation

(B) RESIDENCE: (CITY and STATE OR COUNTRY): Irvine, CA

Please check the appropriate assignee category or categories (will not be printed on the patent) : ☐ Individual ☒ Corporation or other private group entity ☐ Government

4a. The following fee(s) are submitted:
- ☒ Issue Fee
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- ☒ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number 50-2126 (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)
- ☐ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.
- ☐ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature /Jessica W. Smith/ Date April 28, 2010

Typed or printed name Jessica W. Smith Registration No. 39,884

Docket BP4637

PTO/SB/47 (03-09)
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Address to:
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Fax to:
571-273-6500

INSTRUCTIONS: The issue fee must have been paid for application(s) listed on this form. In addition, only an address represented by a Customer Number can be established as the fee address for maintenance fee purposes (hereafter, fee address). A fee address should be established when correspondence related to maintenance fees should be mailed to a different address than the correspondence address for the application. **When to check the first box below**: If you have a Customer Number to represent the fee address. **When to check the second box below**: If you have no Customer Number representing the desired fee address, in which case a completed Request for Customer Number (PTO/SB/125) must be attached to this form. For more information on Customer Numbers, see the Manual of Patent Examining Procedure (MPEP) § 403.

For the following listed application(s), please recognize as the "Fee Address" under the provisions of 37 CFR 1.363 the address associated with:

[X] Customer Number: 51472

OR

[ ] The attached Request for Customer Number (PTO/SB/125) form.

PATENT NUMBER (if known)	APPLICATION NUMBER
	11/168,793

Completed by (check one):

[ ] Applicant/Inventor — /Jessica W. Smith/ (Signature)

[X] Attorney or Agent of record 39,884 (Reg. No.) — Jessica W. Smith (Typed or printed name)

[ ] Assignee of record of the entire interest. See 37 CFR 3.71. Statement under 37 CFR 3.73(b) is enclosed. (Form PTO/SB/96) — (972) 240-5324 (Requester's telephone number)

[ ] Assignee recorded at Reel ________ Frame________ — April 28, 2010 (Date)

NOTE: Signatures of all the inventors or assignees of record of the entire interest or their representative(s) are required. Submit multiple forms if more that one signature is required, see below*.

[X] * Total of 1 forms are submitted.

Electronic Patent Application Fee Transmittal

Application Number:	11168793
Filing Date:	28-Jun-2005
Title of Invention:	REDUCED FEEDBACK FOR BEAMFORMING IN A WIRELESS COMMUNICATION
First Named Inventor/Applicant Name:	Joonsuk Kim
Filer:	Jessica Smith/Melanie Murdock
Attorney Docket Number:	BP4637

Filed as Large Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Utility Appl issue fee	1501	1	1510	1510
Publ. Fee- early, voluntary, or normal	1504	1	300	300

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**1810**

Electronic Acknowledgement Receipt	
EFS ID:	7510065
Application Number:	11168793
International Application Number:	
Confirmation Number:	9094
Title of Invention:	REDUCED FEEDBACK FOR BEAMFORMING IN A WIRELESS COMMUNICATION
First Named Inventor/Applicant Name:	Joonsuk Kim
Customer Number:	51472
Filer:	Jessica Smith/Melanie Murdock
Filer Authorized By:	Jessica Smith
Attorney Docket Number:	BP4637
Receipt Date:	28-APR-2010
Filing Date:	28-JUN-2005
Time Stamp:	18:06:54
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Credit Card
Payment was successfully received in RAM	$1810
RAM confirmation Number	4764
Deposit Account	
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File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)

1	Issue Fee Payment (PTO-85B)	BP4637_Issue_Fee_Pymt.pdf	191670 4ce3c4c7f196cba78037121d9be9e784d435ab42	no	1
Warnings:					
Information:					
2	Miscellaneous Incoming Letter	BP4637_Fee_Address.pdf	43862 134f28137a7ac40c41d8a3462e4bb2f69fe92733	no	1
Warnings:					
Information:					
3	Fee Worksheet (PTO-875)	fee-info.pdf	32273 f0f840cadfed0976e3c8da6dea4699fb0cbc9570	no	2
Warnings:					
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If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

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If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

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If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

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APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/168,793	06/15/2010	7738583	BP4637	9094

51472 7590 05/26/2010

GARLICK HARRISON & MARKISON
P.O. BOX 160727
AUSTIN, TX 78716-0727

ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 772 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Data Management (ODM) at (571)-272-4200.

APPLICANT(s) (Please see PAIR WEB site http://pair.uspto.gov for additional applicants):

Joonsuk Kim, San Jose, CA;

IR103 (Rev. 10/09)