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(54) Title: METHOD AND DEVICE FOR TRANSMITTING DATA UNIT

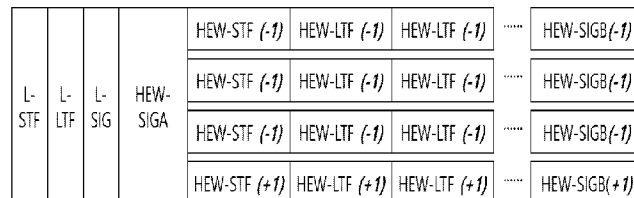


FIG. 5

(57) Abstract: A method for transmitting a data unit and a device using the same is provided. The device generates a physical layer protocol data unit (PPDU) that includes a first part and a second part. The first and second part are generated with different fast Fourier transform (FFT) size. A phase rotation of the second part is different from a phase rotation of the first part.

## METHOD AND DEVICE FOR TRANSMITTING DATA UNIT

### CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of priority of Korean Patent Application No. 10-2014-0080168 filed on June 27, 2014, all of which is incorporated by reference in its entirety herein.

### BACKGROUND OF THE INVENTION

#### Field of the invention

[0002] The present invention relates to wireless communications, and more particularly, to a method for transmitting a data unit for a wireless communication and a device using the same.

#### Related Art

[0003] Institute of Electrical and Electronics Engineers (IEEE) 802.11n standard established in 2009 provides a transfer rate of up to 600 Mbps at a frequency band of 2.4 GHz or 5 GHz on the basis of Multiple Input Multiple Output (MIMO) technique.

[0004] IEEE 802.11ac standard established in 2013 aims to provide a throughput greater than or equal to 1 Gbps utilizing Medium Access Control (MAC) Service Access Point (SAP) layer scheme at a frequency band less than or equal to 6 GHz. A system supporting IEEE 802.11ac standard is referred to as a Very High Throughput (VHT) system.

[0005] There are continuing efforts to implement more effective Wireless Local Area Network (WLAN) technologies in increasingly congested environments.

### SUMMARY OF THE INVENTION

[0006] The present invention provides a method for transmitting a data unit in a wireless local area network.

[0007] The present invention also provides a device for transmitting a data unit in a wireless local area network.

[0008] In an aspect, a method for transmitting a data unit in a wireless local area network is provided. The method includes generating a physical layer protocol data unit (PPDU),

the PPDU including a first part and a second part, and transmitting the PPDU to a receiver over a transmission bandwidth. The first part is generated with a first fast Fourier transform (FFT) size. The second part is generated with a second FFT size. The first FFT size is different from the second FFT size. A phase rotation of the second part is different from a phase rotation of the first part.

- [0009] Subcarriers for the second part may be divided into a plurality of subgroups, respective subgroup being phase-rotated by multiplying +1 or -1.
- [0010] Subcarriers for the first part may be divided into a plurality of subgroups, respective subgroup being phase-rotated by multiplying +1, -1 or +j.
- [0011] A number of subcarriers in respective subgroup of the second part may be different from a number of subcarriers in respective subgroup of the first part.
- [0012] The first part may include a legacy-short training field (L-STF), a legacy-long training field (L-LTF) and a legacy-signal (L-SIG).
- [0013] Two orthogonal frequency division multiplexing (OFDM) symbols next to the L-SIG may use binary phase shift keying (BPSK) modulations.
- [0014] In another aspect, a device configured for transmitting a data unit in a wireless local area network is provided. The device includes a radio frequency module configured to transmit and receive radio signals, and a processor operatively coupled with the radio frequency module. The processor is configured to generate a physical layer protocol data unit (PPDU), the PPDU including a first part and a second part, and instruct the radio frequency module to transmit the PPDU to a receiver over a transmission bandwidth. The first part is generated with a first fast Fourier transform (FFT) size. The second part is generated with a second FFT size. The first FFT size is different from the second FFT size. A phase rotation of the second part is different from a phase rotation of the first part.
- [0015] Since a greater amount of data can be transmitted during a same time period, a transmission efficiency can be increased. In addition, a Peak-to-Average Power Ratio (PAPR) of a transmitter can be decreased.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

- [0016] FIG. 1 shows PPDU formats used by the legacy system.
- [0017] FIG. 2 shows an HEW PPDU format according to an embodiment of the present

invention.

[0018] FIG. 3 shows constellation phases for the conventional PPDU.

[0019] FIG. 4 shows constellation phases for a proposed HEW PPDU.

[0020] FIG. 5 shows an HEW PPDU format in a 20 MHz channel.

[0021] FIG. 6 shows an HEW PPDU format in a 40 MHz channel.

[0022] FIG. 7 shows an HEW PPDU format in an 80 MHz channel.

[0023] FIG. 8 shows a PPDU format according to another embodiment of the present invention.

[0024] FIG. 9 shows a block diagram of an STA to implement embodiments of the present invention.

### DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0025] The proposed wireless local area network (WLAN) system may operate at a band less than or equal to 6 GHz or at a band of 60 GHz. The operating band less than or equal to 6 GHz may include at least one of 2.4 GHz and 5 GHz.

[0026] For clarity, a system complying with the Institute of Electrical and Electronics Engineers (IEEE) 802.11 a/g standard is referred to as a non-High Throughput (non-HT) system, a system complying with the IEEE 802.11n standard is referred to as a High Throughput (HT) system, and a system complying with IEEE 802.11ac standard is referred to as a Very High Throughput (VHT) system. In comparison thereto, a WLAN system complying with the proposed method is referred to as a High Efficiency WLAN (HEW) system. A WLAN system supporting systems used before the HEW system is released is referred to as a legacy system. The HEW system may include an HEW Station (STA) and an HEW Access Point (AP). The term HEW is only for the purpose of distinguishing from the conventional WLAN, and there is no restriction thereon. The HEW system may support IEEE 802.11/a/g/n/ac by providing backward compatibility in addition to the proposed method.

[0027] Hereinafter, unless a function of a station (STA) is additionally distinguished from a function of an Access Point (AP), the STA may be a non-AP STA and/or the AP. When it is described as an STA-to-AP communication, the STA may be expressed as the non-AP STA, and may correspond to communication between the non-AP STA and the AP. When it is described as STA-to-STA communication or when a function

of the AP is not additionally required, the STA may be the non-AP STA or the AP.

- [0028] A Physical layer Protocol Data unit (PPDU) is a data unit for data transmission.
- [0029] FIG. 1 shows PPDU formats used by the legacy system.
- [0030] A non-HT PPDU supporting IEEE 802.11a/g includes a Legacy-Short Training Field (L-STF), a Legacy-Long Training Field (L-LTF), and a Legacy-Signal (L-SIG).
- [0031] An HT PPDU supporting IEEE 802.11n includes a HT-SIG, a HT-STF, and a HT-LTF after the L-SIG.
- [0032] A VHT PPDU supporting IEEE 802.11ac includes a VHT-SIG-A, a VHT-STF, a VHT-LTF, and a VHT-SIG-B after the L-SIG.
- [0033] FIG. 2 shows an HEW PPDU format according to an embodiment of the present invention.
- [0034] An L-STF may be used for frame detection, Automatic Gain Control (AGC), diversity detection, and coarse frequency/time synchronization.
- [0035] An L-LTF may be used for fine frequency/time synchronization and channel estimation.
- [0036] An L-SIG may include information indicating a total length of a corresponding PPDU (or information indicating a transmission time of a physical layer protocol service unit (PSDU)).
- [0037] The L-STF, the L-LTF and the L-SIG may be identical to L-STF, L-LTF and L-SIG of the VHT system. The L-STF, the L-LTF and the L-SIG may be referred to as a legacy portion. The L-STF, the L-LTF, and the L-SIG may be transmitted in at least one Orthogonal Frequency Division Multiplexing (OFDM) symbol generated on the basis of 64-points Fast Fourier Transform (FFT) (or 64 subcarriers) in each 20MHz channel. For 20 MHz transmission, the legacy portion may be generated by performing an inverse Discrete Fourier Transform (IDFT) with 64 FFT points. For 40 MHz transmission, the legacy portion may be generated by performing an IDFT with 128 FFT points. For 80 MHz transmission, the legacy portion may be generated by performing an IDFT with 512 FFT points.
- [0038] A HEW-SIGA may include common control information commonly received by an STA which receives a PPDU. The HEW-SIGA may be transmitted in 2 OFDM symbols or 3 OFDM symbols.
- [0039] The following table exemplifies information included in the HEW-SIGA. A field

name or the number of bits is for exemplary purposes only.

[Table 1]

Field	Bits	Description
Bandwidth	2	Set to 0 for 20 MHz, 1 for 40 MHz, 2 for 80 MHz, 3 for 160 MHz and 80+80 MHz mode
STBC	1	Set to 1 if all streams use STBC, otherwise set to 0. When STBC bit is 1, an odd number of space time streams per user is not allowed.
Group ID	6	Set to the value of the TXVECTOR parameter GROUP_ID. A value of 0 or 63 indicates a HEW SU PDU; otherwise, indicates a HEW MU PDU.
Nsts/Partial AID	12	For MU: 3 bits/user with maximum of 4 users - Set to 0 for 0 space time streams - Set to 1 for 1 space time stream - Set to 2 for 2 space time streams - Set to 3 for 3 space time streams - Set to 4 for 4 space time streams Otherwise: first 3 bits contain stream allocation for SU, set to 0 for 1 space time stream, set to 1 for 2 space time streams, etcetera up to 8 streams. Remaining 9 bits contain partial association identifier (AID).
No TXOP PS	1	Set to 1 to indicate that TXOP PS is not allowed. Set to 0 to indicate that TXOP PS is allowed. Set to the same value in all PDUs in downlink MU TXOP.
GI (Guard interval)	2	Set B0 to 0 for Long GI, set to 1 for Short GI. Set B1 to 1 when Short GI.
Coding	2	For SU: Set B2 to 0 for BCC, set to 1 for LDPC For MU: Set B2 to 0 for BCC, set to 1 for LDPC for 1st user If user 1 has 0 Nsts value, then B2 is reserved and set to 1
MCS	4	For SU/Broadcast/Multicast: Modulation and coding scheme (MCS) index For MU: B1: Set to 0 for BCC, 1 for LDPC for the 2nd user B2: Set to 0 for BCC, 1 for LDPC for the 3rd user B3: Set to 0 for BCC, 1 for LDPC for the 4th user If user 2, 3, or 4 has 0 Nsts value, then corresponding bit is reserved and set to 1
SU-Beamformed	1	Set to 1 when packet is a SU-beamformed packet Set to 0 otherwise For MU: Reserved, set to 1
CRC	8	
Tail	6	All zeros

[0040] A HEW-STF may be used to improve an AGC estimation in an MIMO transmission.

[0041] A HEW-LTF may be used to estimate a MIMO channel. The HEW-LTF may start at

the same point of time and may end at the same point of time across all users.

- [0042] A HEW-SIGB may include user-specific information required for each STA to receive its PSDU. For example, the HEW-SIGB may include information regarding a length of a corresponding PSDU and/or a bandwidth or channel in which the PSDU for a corresponding receiver is transmitted.
- [0043] A data portion may include at least one PSDU. The position of the HEW-SIGB is illustration purpose only. The HEW-SIGB may be followed by the data portion. The HEW-SIGB may be followed by the HEW-STF or the HEW-LTF.
- [0044] In the proposed PPDU format, the number of OFDM subcarriers may be increased per unit frequency. The number of OFDM subcarriers may increase K-times by increasing FFT size. K may be 2, 4, or 8. This increase may be accomplished via downclocking (e.g, using a larger FFT size with a same sampling rate).
- [0045] For example, K=4 downclocking is assumed. As for the legacy portion, 64 FFT is used in a 20MHz channel, 128 FFT is used in a 40MHz channel, and 256 FFT is used in an 80MHz channel. As for a HEW portion using the larger FFT size, 256 FFT is used in a 20MHz channel, 512 FFT is used in a 40MHz channel, and 1024 FFT is used in an 80MHz channel. The HEW-SIGA may have same FFT size as the legacy portion. The HEW portion may have larger FFT size than the legacy portion.
- [0046] The PPDU is generated by performing IDFT with two different FFT sizes. The PPDU may include a first part with a first FFT size and a second part with a second FFT size. The first part may include at least one of the L-STF, the L-LTF, the L-SIG and the HEW-SIGA. The second part may include at least one of the HEW-STF, the HEW-LTF and the data portion. The HEW-SIGB may be included in the first part or in the second part.
- [0047] When an FFT size is increased, an OFDM subcarrier spacing is decreased and thus the number of OFDM subcarriers per unit frequency is increased, but an OFDM symbol duration is increased. A guard interval (GI) (or also referred to as a Cyclic Prefix (CP) length) of the OFDM symbol time can be decreased when the FFT size is increased.
- [0048] If the number of OFDM subcarriers per unit frequency is increased, a legacy STA supporting the conventional IEEE 80.2.11a/g/n/ac cannot decode a corresponding PPDU. In order for the legacy STA and an HEW STA to co-exist, L-STF, L-LTF, and

L-SIG are transmitted through 64 FFT in a 20MHz channel so that the legacy STA can receive the L-STF, the L-LTF, and the L-SIG. For example, the L-SIG is transmitted in a single OFDM symbol, a symbol time of the single OFDM symbol is 4 micro seconds (us), and the GI is 0.8 us.

[0049] Although the HEW-SIGA includes information required to decode an HEW PPDU by the HEW STA, the HEW-SIGA may be transmitted through 64 FFT in an 20MHz channel so that it can be received by both of the legacy STA and the HEW STA. This is to allow the HEW STA to receive not only the HEW PPDU but also the conventional non-HT/HT/VHT PPDU.

[0050] FIG. 3 shows constellation phases for the conventional PPDU.

[0051] To identify a format of a PPDU, a phase of a constellation for two OFDM symbols transmitted after L-STF, L-LTF, and L-SIG is used.

[0052] A 'first OFDM symbol' is an OFDM symbol first appeared after the L-SIG. A 'second OFDM symbol' is an OFDM symbol subsequent to the first OFDM symbol.

[0053] In a non-HT PPDU, the same phase of the constellation is used in the 1st OFDM symbol and the 2nd OFDM symbol. Binary Phase Shift Keying (BPSK) is used in both of the 1st OFMD symbol and the 2nd OFDM symbol.

[0054] In an HT PPDU, although the same phase of the constellation is used in the 1st OFDM symbol and the 2nd OFDM symbol, the constellation rotates by 90 degrees in a counterclockwise direction with respect to the phase used in the non-HT PPDU. A modulation scheme having a constellation which rotates by 90 degrees is called Quadrature Binary Phase Shift Keying (QBPSK).

[0055] In a VHT PPDU, a constellation of the first OFDM symbol is identical to that of the non-HT PPDU, whereas a constellation of the second OFDM symbol is identical to that of the HT PPDU. The constellation of second OFDM symbol rotates 90 degrees in a counterclockwise direction with respect to the 1st OFDM symbol. The first OFDM symbol uses BPSK modulation, and the 2nd OFDM symbol uses QBPSK modulation. Since VHT-SIG-A is transmitted after L-SIG and the VHT-SIG-A is transmitted in two OFDM symbols, the first OFDM symbol and the second OFDM symbol are used to transmit the VHT-SIG-A.

[0056] FIG. 4 shows constellation phases for a proposed HEW PPDU.

[0057] To distinguish from a non-HT/HT/VHT PPDU, a constellation of at least one OFDM

symbol transmitted after L-SIG can be used.

- [0058] Just like the non-HT PPDU, a first OFDM symbol and a second OFDM symbol of the HEW PPDU have the same constellation phase. A BPSK modulation may be used for the first OFDM symbol and the second OFDM symbol. The STA can differentiate the HEW PPDU and HT/VHT PPDU.
- [0059] In an embodiment, to differentiate the HEW PPDU and the non-HT PPDU, the constellation of a third OFDM symbol can be utilized. The constellation of the third OFDM symbol may rotate by 90 degrees in a counterclockwise direction with respect to the second OFDM symbol. The first and second OFDM symbols may use BPSK modulation, but the third OFDM symbol may use QBPSK modulation.
- [0060] In another embodiment, the HEW-SIGA may provide an indication about the format of the PPDU. The indication may indicate whether the format of the PPDU is a HEW PPDU. The HEW-SIGA may provide an indication about a use of orthogonal frequency division multiple access (OFDMA).
- [0061] Hereinafter, a PPDU using a phase rotation in frequency domain is proposed in order to support lower Peak-to-Average Power Ratio (PAPR).
- [0062] For clarity, it is assumed that the second part (i.e. HEW part) of the PPDU uses 4-times FFT size via downclocking.
- [0063] Hereinafter, a subchannel refers to a resource allocation unit to be allocated to a STA. Operating bandwidth (i.e. 20 MHz channel, 40 MHz channel, 80 MHz channel or 160 MHz channel) can be divided into a plurality of subchannels. A subchannel may include one or more subcarriers. The plurality of subchannels may have same number of subcarriers or different number of subcarriers. One or more subchannels can be allocated to the STA. The STA can transmit one or more PPDU through the allocated subchannels to one or more receiving stations. The subchannel may be referred to as 'a subband' or 'a subgroup'.
- [0064] FIG. 5 shows an HEW PPDU format in a 20 MHz channel.
- [0065] The first part (i.e. L-LTF, L-LTF, L-SIG and HEW-SIGA) uses 64 FFT in the 20 MHz channel. In order to implement the 256 FFT in the second part, it is proposed to decrease an overhead by performing 1/4 down-clocking on a VHT 80MHz PPDU format and by decreasing GI to 0.8us and 0.4us.
- [0066] If the VHT 80MHz PPDU format is subjected to 1/4 down-clocking, an OFDM

symbol time is increased by four times, and thus is 16 us when using Long GI, and is 14.4 us when using Short GI. That is, the GI is also increased to 3.2 us in case of Long GI and to 1.6 us in case of Short GI. However, the GI may keep to 0.8 us in case of Long GI and to 0.4 us in case of Short GI. In doing so, after performing the 1/4 downclocking, the OFDM symbol time is 13.6 us when using Long GI and is 13.2 us when using Short GI.

[0067] If the VHT 80MHz PPDU format is subjected to 1/4 down-clocking in the 20 MHz channel, each of 64 FFT-based VHT-STF, VHT-LTF, and VHT-SIG-B may constitute one subchannel, and as a result, 4 subchannels are combined and transmitted through the 20 MHz channel in unit of 256 FFT.

[0068] In FIG. 5, in order to decrease a Peak-to-Average Power Ratio (PAPR) of a transmitter STA, the second part may be subjected to multiplication for a phase waveform in unit of subchannel as follows.

[0069] [Equation 1]

$$R(k) = \begin{cases} -1, & k \geq -64 \\ +1, & k < -64 \end{cases}$$

[0070] Herein, R(k) denotes a multiplication value for a phase waveform at a subcarrier index k. When a STA transmits a PPDU through the allocated subchannels, 256 subcarriers are divided into 4 subchannels. Respective subchannel is composed of 64 subcarriers. A sequence {+1, -1, -1, -1} may be multiplied for the 4 subchannels, starting from a subchannel having a smallest subcarrier index, that is, a lowermost subchannel. The number of 4 subchannels and the sequence {+1, -1, -1, -1} are exemplary purpose only. 256 subcarriers may be divided into a plurality of subchannels and respective subchannel may be phase-rotated by multiplying +1 or -1.

[0071] The equation 1 can be expressed as follows. The 256 subcarriers are divided into first and second subgroups that have different number of subcarriers. The first subgroup is phase-rotated by multiplying +1 and the second subgroup is phase-rotated by multiplying -1.

[0072] A sequence constituting the HEW-STF and the HEW-LTF may be as follows.

HEW-STF = {HTS-58,58, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, HTS-58,58},

HEW-LTF = {LTFleft, 1, LTFright, -1, -1, -1, 1, 1, -1, 1, -1, 1, 1, -1, LTFleft, 1,

LTFright, 1, -1, 1, -1, 0, 0, 0, 1, -1, -1, 1, LTFleft, 1, LTFright, -1, -1, -1, 1, 1, -1, 1, -1, 1, 1,



follows.

[0081] [Equation 3]

$$R(k) = \begin{cases} -1, 64 \leq k \\ +1, 0 \leq k < 64 \\ -1, -192 \leq k < 0 \\ +1, k < -192 \end{cases}$$

[0082] More specifically, according to Equation 3, 512 subcarriers are divided into 8 subchannels. Respective subchannel is composed of 64 subcarriers. A sequence {+1, -1, -1, -1, +1, -1, -1, -1} may be multiplied for the 8 subchannels, starting from a subchannel having a smallest subcarrier index, that is, a lowermost subchannel.

[0083] The equation 3 can be expressed as follows. The 512 subcarriers are divided into four subgroups. The first subgroup is phase-rotated by multiplying +1, the second subgroup is phase-rotated by multiplying -1, the third subgroup is phase-rotated by multiplying +1, and the fourth subgroup is phase-rotated by multiplying -1.

[0084] A sequence constituting the HEW-STF and the HEW-LTF may be as follows.

HEW-STF = {HTS<sub>-58,58</sub>, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, HTS<sub>-58,58</sub>, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, HTS<sub>-58,58</sub>, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, HTS<sub>-58,58</sub>},

HEW-LTF = {LTFleft, 1, LTFright, -1, -1, -1, 1, 1, -1, 1, -1, 1, 1, -1, LTFleft, 1, LTFright, 1, -1, 1, -1, 0, 0, 0, 1, -1, -1, 1, LTFleft, 1, LTFright, -1, -1, -1, 1, 1, -1, 1, -1, 1, 1, -1, LTFleft, 1, LTFright, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, LTFleft, 1, LTFright, -1, -1, -1, 1, 1, -1, 1, -1, 1, 1, -1, LTFleft, 1, LTFright, 1, -1, 1, -1, 0, 0, 0, 1, -1, -1, 1, LTFleft, 1, LTFright, -1, -1, -1, 1, 1, -1, 1, 1, -1, 1, -1, 1, 1, -1, LTFleft, 1, LTFright}

Herein,

$$HTS_{-58,58} = \sqrt{1/2} \{0, 0, 1+j, 0, 0, 0, -1-j, 0, 0, 0, 1+j, 0, 0, 0, -1-j, 0, 0, 0, -1-j, 0, 0, 0, 1+j, 0, 0, 0, 0, 0, 0, 0, -1-j, 0, 0, 0, -1-j, 0, 0, 0, 1+j, 0, 0, 0, 1+j, 0, 0, 0, 1+j, 0, 0, 0, 1+j, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1+j, 0, 0, 0, -1-j, 0, 0, 0, 1+j, 0, 0, 0, -1-j, 0, 0, 0, -1-j, 0, 0, 0, 1+j, 0, 0, 0, 0, 0, 0, 0, 0, -1-j, 0, 0, 0, -1-j, 0, 0, 0, 1+j, 0, 0, 0, 1+j, 0, 0, 0, 1+j, 0, 0, 0\}$$

LTFleft = {1, 1, -1, -1, 1, 1, -1, 1, -1, 1, 1, 1, 1, 1, 1, -1, -1, 1, 1, -1, 1, -1, 1, 1, 1, 1},

LTFright = {1, -1, -1, 1, 1, -1, 1, -1, 1, -1, -1, -1, -1, -1, 1, 1, -1, -1, 1, -1, 1, -1, 1, 1, 1, 1},

1}.

[0085] FIG. 7 shows an HEW PPDU format in an 80 MHz channel.

[0086] In order to implement the 1024 FFT in the 80 MHz channel, it is proposed to use four blocks for the aforementioned 256 FFT transmission of the 20MHz channel. Like in

the 256 FFT transmission in the 20MHz channel, an OFDM symbol time is 13.6 us when using Long GI, and is 13.2 us when using Short GI.

[0087] L-STF, L-LTF, L-SIG, and HEW-SIGA which are transmitted using 64 FFT are also transmitted in a duplicated manner four times in the 80MHz channel. That is, the first part is transmitted in a first 20 MHz subchannel and its duplications are transmitted in second, third and fourth 20 MHz subchannels respectively.

[0088] In order to decrease a PAPR of a transmitter STA for transmitting the L-STF, the L-LTF, the L-SIG, and the HEW-SIGA, multiplication may be performed on a phase waveform in unit of 20MHz channel as follows.

[0089] [Equation 4]

$$R(k) = \begin{cases} -1, & k \geq -64 \\ +1, & k < -64 \end{cases}$$

[0090] This means that the first part is phase-rotated by multiplying +1 for the first 20 MHz subchannel and is phase-rotated by multiplying -1 for the second, third and fourth 20 MHz subchannels.

[0091] The equation 4 can be expressed as follows. The 256 subcarriers are divided into first and second subgroups that have different number of subcarriers. The first subgroup is phase-rotated by multiplying +1 and the second subgroup is phase-rotated by multiplying -1.

[0092] For each 64 FFT-based subchannel constituting 1024 FFT, in order to decrease a PAPR of a transmitter STA for transmitting HEW-STF, HEW-LTF, and HEW-SIGB, multiplication may be performed on a phase waveform in unit of subchannel as follows.

[0093] [Equation 5]

$$R(k) = \begin{cases} -1, & 256 \leq k \\ +1, & 192 \leq k < 256 \\ -1, & 64 \leq k < 192 \\ +1, & 0 \leq k < 64 \\ -1, & -192 \leq k < 0 \\ +1, & -256 \leq k < -192 \\ -1, & -448 \leq k < -256 \\ +1, & k < -448 \end{cases}$$

[0094] More specifically, according to Equation 5, 1024 subcarriers are divided into 16 subchannels. Respective subchannel is composed of 64 subcarriers. A sequence {+1, -1, -1, -1, +1, -1, -1, -1, +1, -1, -1, -1, +1, -1, -1, -1} may be multiplied for the 16

subchannels, starting from a subchannel having a smallest subcarrier index, that is, a lowermost subchannel.

[0095] The equation 5 can be expressed as follows. The 1024 subcarriers are divided into 8 subgroups. The first subgroup is phase-rotated by multiplying +1, the second subgroup is phase-rotated by multiplying -1, the third subgroup is phase-rotated by multiplying +1, the fourth subgroup is phase-rotated by multiplying -1, the fifth subgroup is phase-rotated by multiplying +1, the sixth subgroup is phase-rotated by multiplying -1, the seventh subgroup is phase-rotated by multiplying +1 and the eighth subgroup is phase-rotated by multiplying -1.

[0096] A sequence constituting the HEW-STF and the HEW-LTF is as follows.

$$\text{HEW-STF} = \{\text{HTS}_{-58,58}, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, \text{HTS}_{-58,58}, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, \text{HTS}_{-58,58}, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, \text{HTS}_{-58,58}, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, \text{HTS}_{-58,58}, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, \text{HTS}_{-58,58}, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, \text{HTS}_{-58,58}\},$$

$$\begin{aligned} \text{HEW-LTF} = \{ & \text{LTFleft}, 1, \text{LTFright}, -1, -1, -1, 1, 1, -1, 1, -1, 1, 1, -1, \text{LTFleft}, 1, \\ & \text{LTFright}, 1, -1, 1, -1, 0, 0, 1, -1, -1, 1, \text{LTFleft}, 1, \text{LTFright}, -1, -1, -1, 1, 1, -1, 1, -1, 1, 1, \\ & -1, \text{LTFleft}, 1, \text{LTFright}, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, \text{LTFleft}, 1, \text{LTFright}, -1, -1, -1, 1, 1, -1, \\ & 1, -1, 1, 1, -1, \text{LTFleft}, 1, \text{LTFright}, 1, -1, 1, -1, 0, 0, 1, -1, -1, 1, \text{LTFleft}, 1, \text{LTFright}, -1, - \\ & 1, -1, 1, 1, -1, 1, -1, 1, 1, -1, \text{LTFleft}, 1, \text{LTFright}, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, \text{LTFleft}, 1, \\ & \text{LTFright}, -1, -1, -1, 1, 1, -1, 1, -1, 1, 1, -1, \text{LTFleft}, 1, \text{LTFright}, 1, -1, 1, -1, 0, 0, 1, -1, -1, \\ & 1, \text{LTFleft}, 1, \text{LTFright}, -1, -1, -1, 1, 1, -1, 1, -1, 1, 1, -1, \text{LTFleft}, 1, \text{LTFright}, 0, 0, 0, 0, 0, 0, \\ & 0, 0, 0, 0, 0, \text{LTFleft}, 1, \text{LTFright}, -1, -1, -1, 1, 1, -1, 1, -1, 1, 1, -1, \text{LTFleft}, 1, \text{LTFright}, 1, - \\ & 1, 1, -1, 0, 0, 1, -1, -1, 1, \text{LTFleft}, 1, \text{LTFright}, -1, -1, -1, 1, 1, -1, 1, -1, 1, 1, -1, \text{LTFleft}, 1, \\ & \text{LTFright}\}, \end{aligned}$$

Herein,

$$\begin{aligned} \text{HTS}_{-58,58} = & \sqrt{1/2} \\ & \{0, 0, 1+j, 0, 0, 0, -1-j, 0, 0, 0, 1+j, 0, 0, 0, -1-j, 0, 0, 0, -1-j, 0, 0, 0, 1+j, 0, 0, 0, \\ & 0, 0, 0, 0, -1-j, 0, 0, 0, -1-j, 0, 0, 0, 1+j, 0, 0, 0, 1+j, 0, 0, 0, 1+j, 0, 0, 0, 0, 0, \\ & 0, 0, 0, 0, 0, 0, 0, 0, 1+j, 0, 0, 0, -1-j, 0, 0, 0, 1+j, 0, 0, 0, -1-j, 0, 0, 0, -1-j, 0, 0, 0, 1+j, \\ & 0, 0, 0, 0, 0, 0, -1-j, 0, 0, 0, -1-j, 0, 0, 0, 1+j, 0, 0, 0, 1+j, 0, 0, 0, 1+j, 0, 0, 0, 1+j, 0, 0\} \end{aligned}$$

$$\text{LTFleft} = \{1, 1, -1, -1, 1, 1, -1, 1, -1, 1, 1, 1, 1, 1, -1, -1, 1, 1, -1, 1, -1, 1, 1, 1, 1\},$$

$$\text{LTFright} = \{1, -1, -1, 1, 1, -1, 1, -1, 1, -1, -1, -1, -1, 1, 1, -1, -1, 1, -1, 1, -1, 1, 1, 1, 1\},$$

1}

[0097] An FFT size can be increased to improve PPDU transmission efficiency. In order to provide compatibility with the legacy STA, the first part (STF, LTF, L-SIG and HEW-SIGA) using the same FFT size as the legacy PPDU is first transmitted, and subsequently the second part (HEW-STF, HEW-LTF, HEW-SIGB and a PSDU) using a larger FFT size are transmitted.

[0098] In order to decrease a PAPR of a transmitter STA, the first part and the second part use different phase rotation in frequency domain. It means that a phase rotation for subcarriers in the first part is different from a phase rotation for subcarriers in the second part.

[0099] FIG. 8 shows a PPDU format according to another embodiment of the present invention.

[0100] Since the number of OFDM subcarriers per unit frequency increases after transmitting L-STF, L-LTF, L-SIG, and HEW-SIGA, a processing time may be required to process data with larger FFT size. The processing time may be called an HEW transition gap.

[0101] In an embodiment, the HEW transition gap may be implemented by defining a Short Inter-Frame Space (SIFS) followed by the HEW-STF. The SIFS may be positioned between the HEW-SIGA and the HEW-STF. The SIFS may be positioned between the HEW-SIGB and the HEW-STF.

[0102] In another embodiment, the HEW transition gap may be implemented in such a manner that the HEW-STF is transmitted one more time. The duration of the HEW-STF may vary depending on the processing time or STA's capability. If the processing time is required, the duration of the HEW-STF may become double.

[0103] FIG. 9 shows a block diagram of an STA to implement embodiments of the present invention.

[0104] The STA may include a processor 21, a memory 22, and a Radio Frequency (RF) module 23.

[0105] The processor 21 implements an operation of the STA according to the embodiment of the present invention. The processor 21 may generate a PPDU according to an embodiment of the present invention and may instruct the RF module 23 to transmit the PPDU. The memory 22 stores instructions for the operation of the processor 21. The stored instructions may be executed by the processor 21 and may be implemented

to perform the aforementioned operation of the STA. The RF module 23 transmits and receives a radio signal.

[00106] The processor may include Application-Specific Integrated Circuits (ASICs), other chipsets, logic circuits, and/or data processors. The memory may include Read-Only Memory (ROM), Random Access Memory (RAM), flash memory, memory cards, storage media and/or other storage devices. The RF unit may include a baseband circuit for processing a radio signal. When the above-described embodiment is implemented in software, the above-described scheme may be implemented using a module (process or function) which performs the above function. The module may be stored in the memory and executed by the processor. The memory may be disposed to the processor internally or externally and connected to the processor using a variety of well-known means.

[00107] In the above exemplary systems, although the methods have been described on the basis of the flowcharts using a series of the steps or blocks, the present invention is not limited to the sequence of the steps, and some of the steps may be performed at different sequences from the remaining steps or may be performed simultaneously with the remaining steps. Furthermore, those skilled in the art will understand that the steps shown in the flowcharts are not exclusive and may include other steps or one or more steps of the flowcharts may be deleted without affecting the scope of the present invention.

**What is claimed is:**

1. A method for transmitting a data unit in a wireless local area network, the method comprising:  
generating a physical layer protocol data unit (PPDU), the PPDU including a first part and a second part; and  
transmitting the PPDU to a receiver,  
wherein the first part is generated with a first fast Fourier transform (FFT) size,  
wherein the second part is generated with a second FFT size,  
wherein the first FFT size is different from the second FFT size, and  
wherein a phase rotation of the second part is different from a phase rotation of the first part.
2. The method of claim 1, wherein subcarriers for the second part are divided into a plurality of subgroups, respective subgroup being phase-rotated by multiplying +1 or -1.
3. The method of claim 2, wherein subcarriers for the first part are divided into a plurality of subgroups, respective subgroup being phase-rotated by multiplying +1, -1 or +j.
4. The method of claim 3, wherein a number of subcarriers in respective subgroup of the second part is different from a number of subcarriers in respective subgroup of the first part.
5. The method of claim 1, wherein the first part includes a legacy-short training field (L-STF), a legacy-long training field (L-LTF) and a legacy-signal (L-SIG).
6. The method of claim 5, wherein two orthogonal frequency division multiplexing (OFDM) symbols next to the L-SIG use binary phase shift keying (BPSK) modulations.
7. The method of claim 1, wherein the second part includes a STF and a LTF.
8. The method of claim 1, wherein the PPDU is transmitted over a transmission bandwidth of 20 MHz.
9. The method of claim 8, wherein the first FFT size is 64 and the second FFT size is 256.
10. The method of claim 9, wherein subcarriers for the second part are divided into two subgroups that are phase-rotated by multiplying {+1, -1}.

11. The method of claim 1, wherein the PPDU is transmitted over at transmission bandwidth of 40 MHz.
12. The method of claim 11, wherein the first FFT size is 128 and the second FFT size is 512.
13. The method of claim 12, wherein subcarriers for the second part are divided into four subgroups that are phase-rotated by multiplying  $\{+1, -1, +1, -1\}$ .
14. The method of claim 1, wherein the PPDU is transmitted over a transmission bandwidth of 80 MHz.
15. The method of claim 14, wherein the first FFT size is 256 and the second FFT size is 1024.
16. The method of claim 15, wherein subcarriers for the second part are divided into eight subgroups that are phase-rotated by multiplying  $\{+1, -1, +1, -1, +1, -1, +1, -1\}$ .
17. A device configured for transmitting a data unit in a wireless local area network, the device comprising:
  - a radio frequency module configured to transmit and receive radio signals; and
  - a processor operatively coupled with the radio frequency module and configured to: generate a physical layer protocol data unit (PPDU), the PPDU including a first part and a second part; andinstruct the radio frequency module to transmit the PPDU to a receiver, wherein the first part is generated with a first fast Fourier transform (FFT) size, wherein the second part is generated with a second FFT size, wherein the first FFT size is different from the second FFT size, and wherein a phase rotation of the second part is different from a phase rotation of the first part.
18. The device of claim 17, wherein subcarriers for the second part are divided into a plurality of subgroups, respective subgroup being phase-rotated by multiplying +1 or -1.
19. The device of claim 18, wherein subcarriers for the first part are divided into a plurality of subgroups, respective subgroup being phase-rotated by multiplying +1, -1 or +j.

20. The device of claim 19, wherein a number of subcarriers in respective subgroup of the second part is different from a number of subcarriers in respective subgroup of the first part.

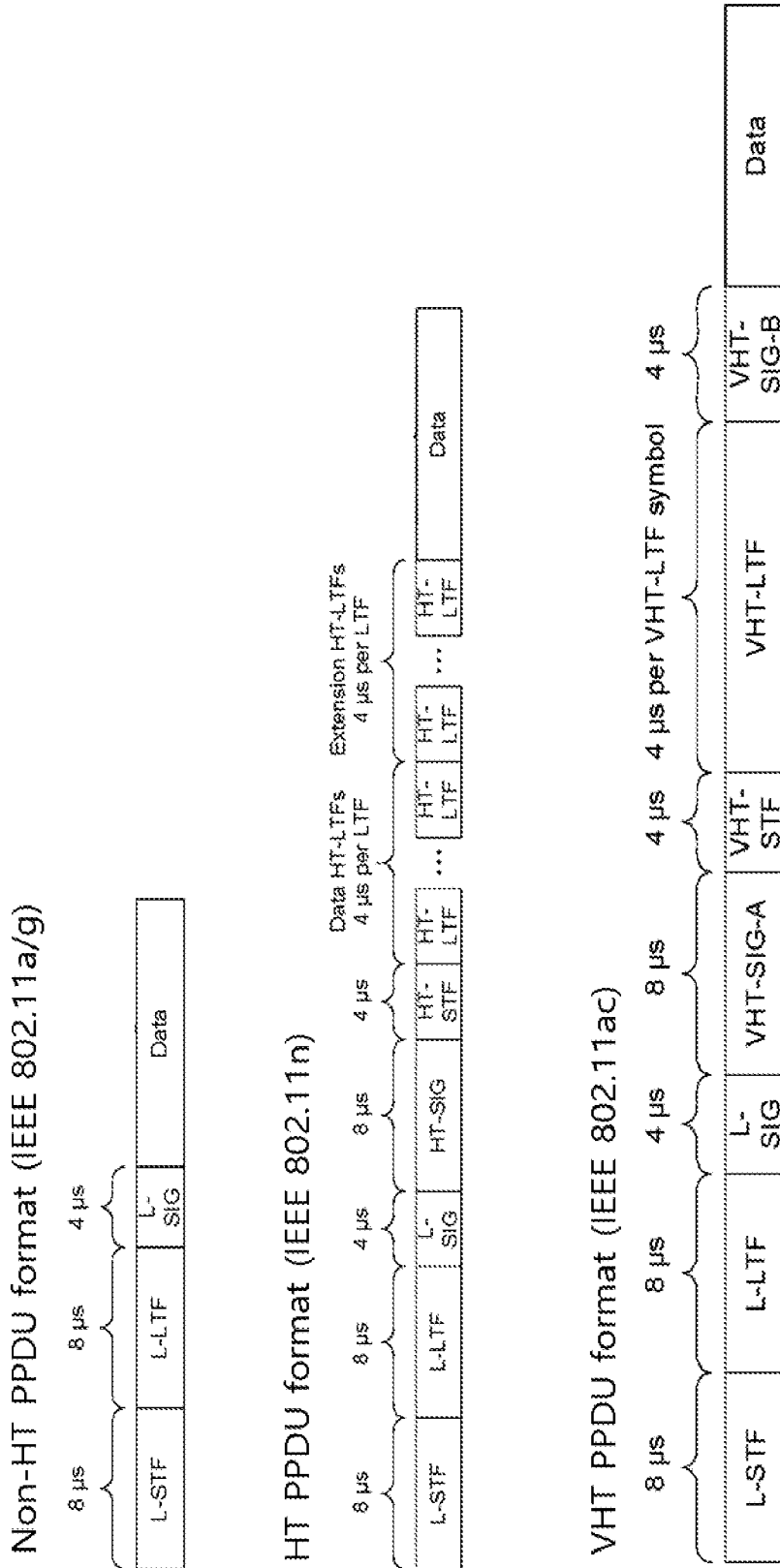


FIG. 1  
(PRIOR ART)



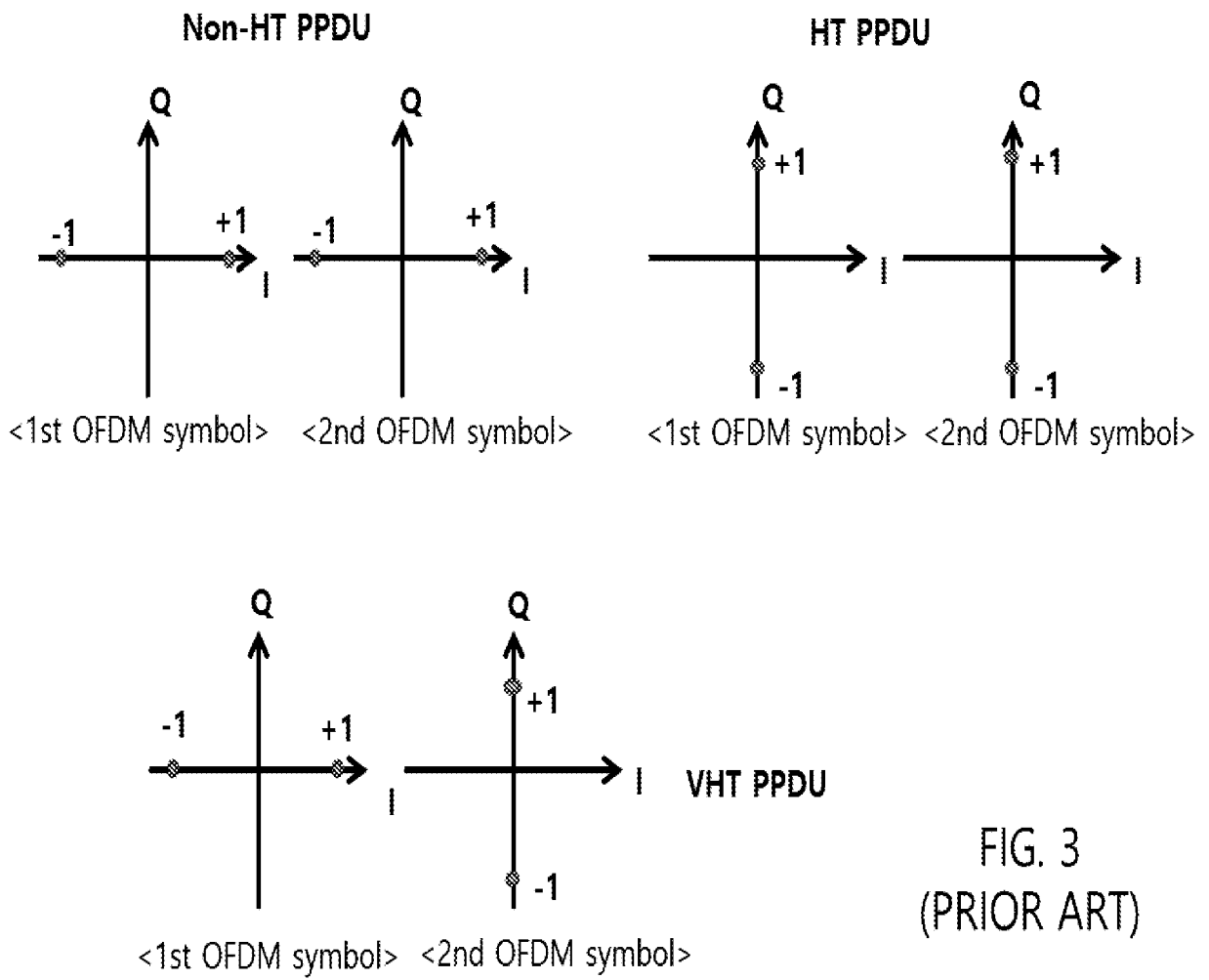


FIG. 3  
(PRIOR ART)

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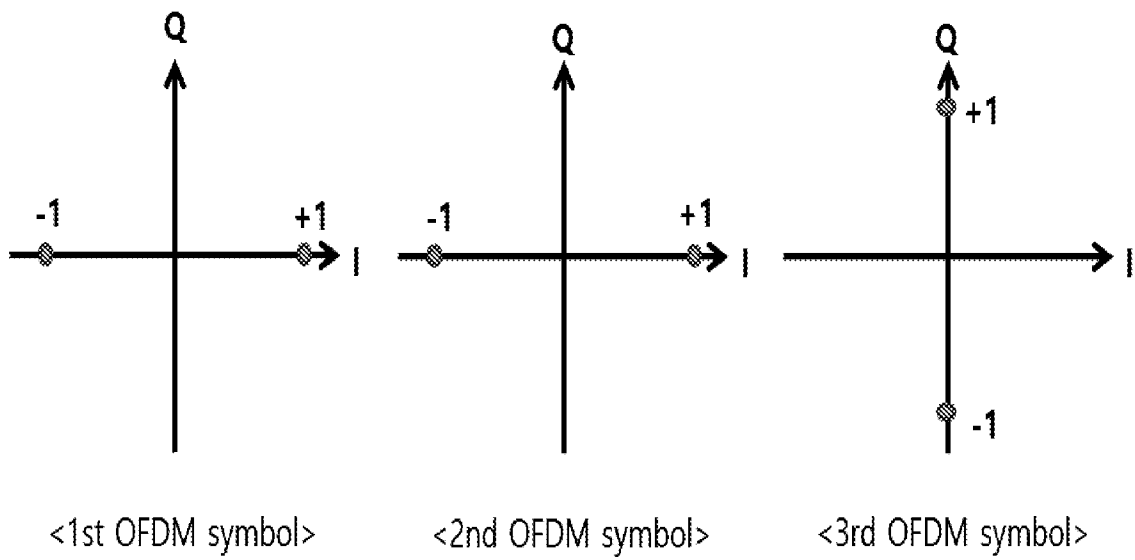


FIG. 4

L- STF	L- LTF	L- SIG	HEW- SIGA	HEW-STF (-1)	HEW-LTF (-1)	HEW-LTF (-1)	HEW-SIGB(-1)
				HEW-STF (-1)	HEW-LTF (-1)	HEW-LTF (-1)	HEW-SIGB(-1)
				HEW-STF (-1)	HEW-LTF (-1)	HEW-LTF (-1)	HEW-SIGB(-1)
				HEW-STF (+1)	HEW-LTF (+1)	HEW-LTF (+1)	HEW-SIGB(+1)

FIG. 5

L-STF (+j)	L-LTF (+j)	L-SIG (+j)	HEW-SIGA (+j)	HEW-STF (-1)	HEW-LTF (-1)	HEW-LTF (-1)	.....	HEW-SIGB(-1)
				HEW-STF (-1)	HEW-LTF (-1)	HEW-LTF (-1)	.....	HEW-SIGB(-1)
				HEW-STF (-1)	HEW-LTF (-1)	HEW-LTF (-1)	.....	HEW-SIGB(-1)
				HEW-STF (+1)	HEW-LTF (+1)	HEW-LTF (+1)	.....	HEW-SIGB(+1)
L-STF (+1)	L-LTF (+1)	L-SIG (+1)	HEW-SIGA (+1)	HEW-STF (-1)	HEW-LTF (-1)	HEW-LTF (-1)	.....	HEW-SIGB(-1)
				HEW-STF (-1)	HEW-LTF (-1)	HEW-LTF (-1)	.....	HEW-SIGB(-1)
				HEW-STF (-1)	HEW-LTF (-1)	HEW-LTF (-1)	.....	HEW-SIGB(-1)
				HEW-STF (+1)	HEW-LTF (+1)	HEW-LTF (+1)	.....	HEW-SIGB(+1)

FIG. 6

L-STF (-1)	L-LTF (-1)	L-SIG (-1)	HEW-SIGA (-1)	HEW-STF (-1)	HEW-LTF (-1)	HEW-LTF (-1)	.....	HEW-SIGB(-1)
				HEW-STF (-1)	HEW-LTF (-1)	HEW-LTF (-1)	.....	HEW-SIGB(-1)
				HEW-STF (-1)	HEW-LTF (-1)	HEW-LTF (-1)	.....	HEW-SIGB(-1)
				HEW-STF (+1)	HEW-LTF (+1)	HEW-LTF (+1)	.....	HEW-SIGB(+1)
L-STF (-1)	L-LTF (-1)	L-SIG (-1)	HEW-SIGA (-1)	HEW-STF (-1)	HEW-LTF (-1)	HEW-LTF (-1)	.....	HEW-SIGB(-1)
				HEW-STF (-1)	HEW-LTF (-1)	HEW-LTF (-1)	.....	HEW-SIGB(-1)
				HEW-STF (-1)	HEW-LTF (-1)	HEW-LTF (-1)	.....	HEW-SIGB(-1)
				HEW-STF (+1)	HEW-LTF (+1)	HEW-LTF (+1)	.....	HEW-SIGB(+1)
L-STF (-1)	L-LTF (-1)	L-SIG (-1)	HEW-SIGA (-1)	HEW-STF (-1)	HEW-LTF (-1)	HEW-LTF (-1)	.....	HEW-SIGB(-1)
				HEW-STF (-1)	HEW-LTF (-1)	HEW-LTF (-1)	.....	HEW-SIGB(-1)
				HEW-STF (-1)	HEW-LTF (-1)	HEW-LTF (-1)	.....	HEW-SIGB(-1)
				HEW-STF (+1)	HEW-LTF (+1)	HEW-LTF (+1)	.....	HEW-SIGB(+1)
L-STF (+1)	L-LTF (+1)	L-SIG (+1)	HEW-SIGA (+1)	HEW-STF (-1)	HEW-LTF (-1)	HEW-LTF (-1)	.....	HEW-SIGB(-1)
				HEW-STF (-1)	HEW-LTF (-1)	HEW-LTF (-1)	.....	HEW-SIGB(-1)
				HEW-STF (-1)	HEW-LTF (-1)	HEW-LTF (-1)	.....	HEW-SIGB(-1)
				HEW-STF (+1)	HEW-LTF (+1)	HEW-LTF (+1)	.....	HEW-SIGB(+1)

FIG. 7

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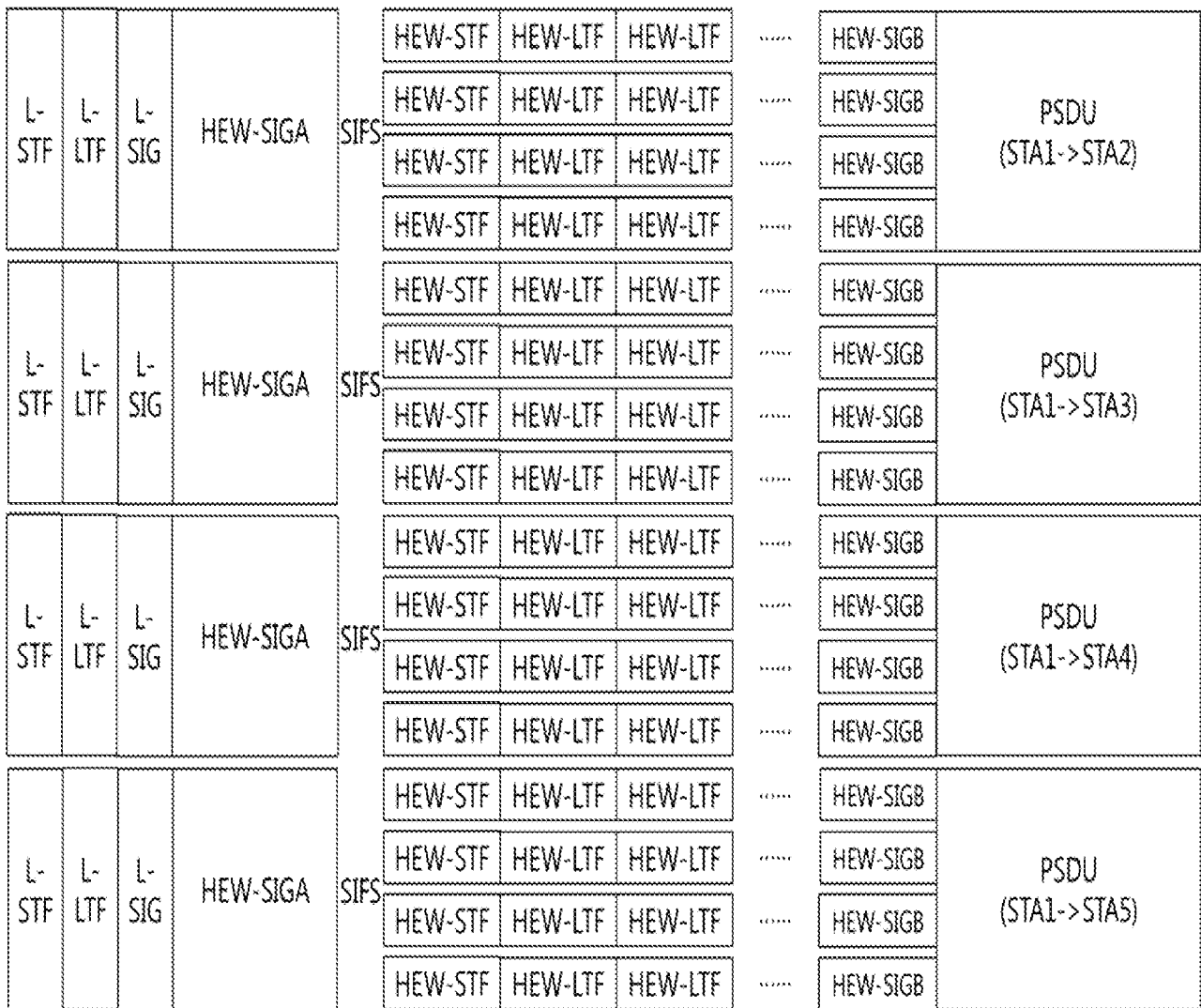


FIG. 8

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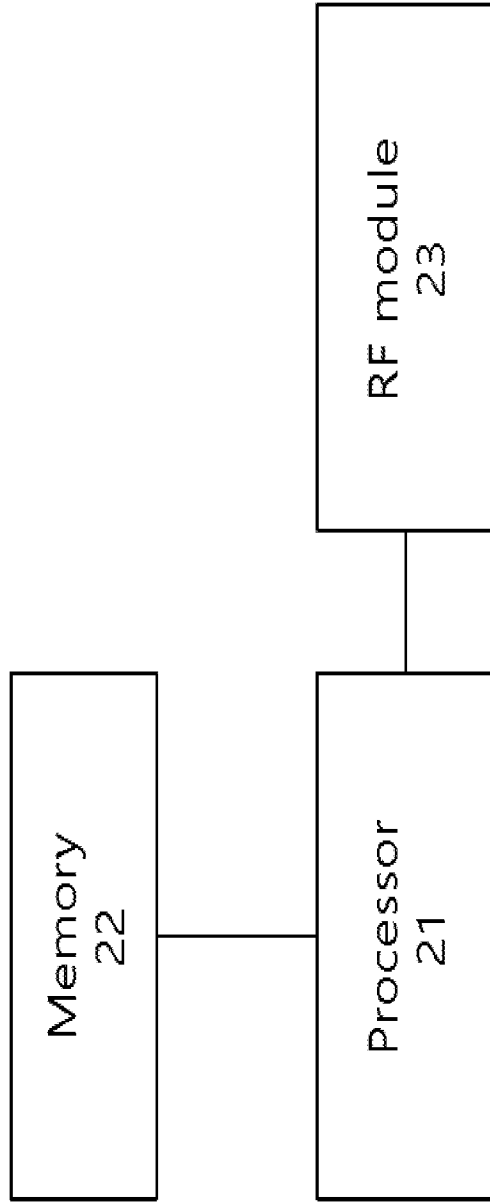


FIG. 9

## INTERNATIONAL SEARCH REPORT

International application No.

PCT / IB 2015/001239

A. CLASSIFICATION OF SUBJECT MATTER IPC: <b>H04L 27/26</b> (2006.01); <b>H04W 84/12</b> (2009.01) According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) <b>H04L, H04W</b> Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) <b>EPODOC, WPIAP</b>		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2013074917 A1 (MARVELL WORLD TRADE LTD.) 23 May 2013 (23.05.2013) abstract, figs. 3A-11; paragraphs [0061]-[0071], [0074], [0082], [0083], [0090].	1-5, 8-20
Y		6, 7
Y	ZHANG, H. et al. "802.11ac Preamble Discussions", IEEE DRAFT; 11-09-1174-00-00AC-802-11AC-PREAMBLE-DISCUSSIONS, IEEE-SA MENTOR, PISCATAWAY, NJ USA, vol. 802.11ac, 17 November 2009 (2009-11-17), pages 1-10, XP017678101 page 5-9.	6, 7
A	WO 2011099765 A2 (LG ELECTRONICS INC.) 18 August 2011 (18.08.2011) abstract, figs. 3-7, 9; paragraphs [0097]-[0111].	1-20
A	US 2012314636 A1 (LIU, Y.) 13 December 2012 (13.12.2012) abstract, fig. 14, 24; paragraphs [0052], [0064], [0065].	1-20
<input checked="" type="checkbox"/>	Further documents are listed in the continuation of Box C.	<input checked="" type="checkbox"/> See patent family annex.
* Special categories of cited documents:		
"A" document defining the general state of the art which is not considered to be of particular relevance		"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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Date of the actual completion of the international search 30 November 2015 (30.11.2015)	Date of mailing of the international search report 02 December 2015 (02.12.2015)	
Name and mailing address of the ISA/AT Austrian Patent Office Dresdner Straße 87, A-1200 Vienna Facsimile No. +43 / 1 / 534 24-535	Authorized officer LOIBNER K. Telephone No. +43 / 1 / 534 24-323	

## INTERNATIONAL SEARCH REPORT

International application No.

PCT / IB 2015/001239

C. (Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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E	WO 2015102181 A1 (LG ELECTRONICS INC.) 09 July 2015 (09.07.2015) abstract, figs. 3, 4; paragraphs [0007]-[0011], [0043], [0044], [0063]-[0068], [0079].	1-20

**INTERNATIONAL SEARCH REPORT**  
Information on patent family members

International application No.

PCT / IB 2015/001239

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			EP	A1	2781038	2014-09-24
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			KR	A	20140103909	2014-08-27
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			WO	A2	2011099765	2011-08-18
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			US	A1	2014241451	2014-08-28
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