(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
17 January 2013 (17.01.2013)

WIPO | PCT

(10) International Publication Number
WO 2013/008948 A1

(51) International Patent Classification: *H04W 28/04* (2009.01)

(21) International Application Number: PCT/JP2012/068254

(22) International Filing Date: 11 July 2012 (11.07.2012)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data: 201110196796.9 14 July 2011 (14.07.2011) CN

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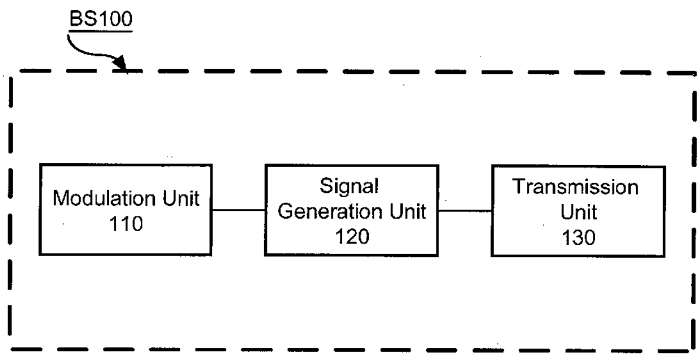
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report (Art. 21(3))*

(54) **Title**: METHOD FOR TRANSMITTING/RECEIVING DOWNLINK PHYSICAL HARQ INDICATOR, USER EQUIPMENT AND BASE STATION

FIG. 6



(57) **Abstract**: A method for transmitting a downlink physical Hybrid Automatic Repeat reQuest (HARQ) indicator is provided, which includes steps of: modulating the downlink physical HARQ indicator into a modulated symbol; generating, based on the modulated symbol, an HARQ indication signal to be demodulated based on a User Equipment (UE) specific reference signal; and transmitting the HARQ indication signal using the antenna port(s). Also provided are a method for receiving a downlink physical HARQ indicator, a user equipment and a base station.

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DESCRIPTION

TITLE OF INVENTION:

METHOD FOR TRANSMITTING/RECEIVING DOWNLINK PHYSICAL HARQ INDICATOR, USER EQUIPMENT AND BASE STATION

TECHNICAL FIELD

The present invention relates to the field of communication technology, and more particularly, to a method for transmitting/receiving a downlink physical Hybrid Automatic Repeat reQuest (HARQ) indicator, a User Equipment (UE) and a Base Station (BS).

BACKGROUND ART

The 3rd Generation Partnership Project (3GPP) organization is an international organization in mobile communication field and plays an important role in standardization of 3G cellular communication technologies. Since the second half of the year 2004, the 3GPP organization has initiated a so-called Long Term Evolution (LTE, also referred to as LTE Rel-8) project for designing Evolved Universal Terrestrial Radio Access (EUTRA) and Evolved Universal Terrestrial Radio Access Network (EUTRAN). In a conference held in Shenzhen, China in April 2008, the 3GPP organization started a discussion on the standardization of 4G cellul communication systems (currently referred to as LTE-A systems or LTE Rel-10). The standardization of LTE Rel-10 RAN 1 has been accomplished in March 2011. At the same time, in the 3GPP RAN meeting #51, the research contents for LTE Rel-11 RAN 1 have been determined, in which a research on enhanced technology for downlink control signaling is proposed (cf. RP-101425, Revised SID Proposal: Coordinated Multi-point Operation for LTE, Samsung) in view of the change in LTE Rel-10 in the reference signal on which the Physical Downlink Shared Channel (PDSCH) transmission is dependent, i.e., from common reference signal to UE specific reference signal. The UE specific reference signal is a signal specific to a UE for facilitating demodulation of downlink data by the UE. However, the demodulation of other UE specific control signaling, such as Physical Downlink Control Channel (PDCCH) and Physical Hybrid HARQ Indicator Channel (PHICH), is still dependent on the common reference signal, which significantly limits the flexibility in the use of these control channels. In addition, in Cooperative Multi-Point (CoMP) transmission and heterogeneous network architecture, Multicast Broadcast Single Frequency Network (MBSFN) frames will be used more frequently. Since there are at most two Orthogonal Frequency Division Multiplexing (OFDM) symbols in such subframe which can be assigned for transmission of control channel, the capacity of control signaling will be very limited. In order increase and improve the capacity and coverage of the control signaling, some techniques initially designed for PDSCH, such as CoMP, Multi-User MIMO (MU-MIMO) and beamforming, are also applied to the transmission of PDCCH/PHICH (cf. R1-110649, Aspects on Distributed RRUs with Shared Cell-ID for Heterogeneous Deployments, Ericsson, ST-Ericsson). In this case, it is necessary to support UE specific reference signal for the control signaling. Moreover, an area split gain can be easily achieved in a network architecture sharing a cell ID by demodulating the PDCCH/PHICH based on the UE specific reference signal.

In order to support the relay technique, a relay PDCCH demodulated based on the UE specific reference signal has been designed in LTE Rel-10 (cf. 36.216, Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer for relaying operation, V10.2.0, 3GPP) and is also referred to as R-PDCCH. Most of the design principles for the R-PDCCH can be used to design a generally applicable PDCCH demodulated based on UE specific reference signal (referred to as ePDCCH).

In the current standardization discussion, there is no existing approach for implementing a downlink physical HARQ indicator demodulated based on UE specific reference signal. This problem constitutes the major research content of the present invention.

SUMMARY OF INVENTION

It is an object of the present invention to solve the problem of how to implement a downlink physical HARQ indicator demodulated based on UE specific reference signal by providing a novel method for transmitting/receiving a downlink physical HARQ indicator, a UE and a BS, which supplements the current standard.

According to the first solution of the present invention, a method for transmitting a downlink physical Hybrid Automatic Repeat reQuest (HARQ) indicator is provided, which includes steps of: modulating the downlink physical HARQ indicator into a modulated symbol; generating, based on the modulated symbol, an HARQ indication signal to be demodulated based on a User Equipment (UE) specific reference signal; and transmitting the HARQ indication signal using the antenna port(s).

Preferably, the antenna port has two sets of UE specific reference signals in time domain, each set of UE specific reference signals being transmitted over a plurality of frequency domain sub-carriers and including two Resource Elements (REs) in each frequency domain sub-carrier, the two REs having the same frequency domain position and contiguous time domain positions. The step of generating the HARQ indication signal includes: multiplying the modulated symbol with one of the two sets of UE specific reference signa corresponding to the antenna port to generate the HARQ indication signal.

Preferably, the antenna port has two sets of UE specific reference signals in time domain, each set of UE specific reference signals being transmitted over a plurality of frequency domain sub-carriers and including two Resource Elements (REs) in each frequency domain sub-carrier, the two REs having the same frequency domain position and contiguous time domain positions. The step of generating the HARQ indication signal includes: multiplying the modulated symbol with the two sets of UE specific reference signals corresponding to the antenna port to generate the HARQ indication signal.

Preferably, the step of generating the HARQ indication signal includes: mapping the modulated signal to a data RE to be demodulated based on the UE specific reference signal, so as to generate the HARQ indication signal.

Preferably, the data RE includes one or more data REs each having a time domain position and a frequency domain position contiguous to the UE specific reference signal.

Preferably, the method further includes, prior to modulating the downlink physical HARQ indicator into the modulated symbol, determining the number of data REs for transmitting the downlink physical HARQ indicator in each Resource Block (RB).

Preferably, the number of data REs for transmitting tl downlink physical HARQ indicator in each RB is determined based on (i) the number of RBs used for uplink schedule transmission corresponding to the downlink physical HARQ indicator and (ii) the number of bits of the downlink physical HARQ indicator.

Preferably, if the downlink physical HARQ indicator is multiplexed with data in a Physical Downlink Shared Channel (PDSCH) of the UE, the number of data REs for transmitting the downlink physical HARQ indicator in each RB is determined based on (i) the number of uncoded bits transmitted in each RE in the PDSCH, (ii) the number of bits of the downlink physical HARQ indicator and (iii) an adjustment parameter.

According to the second solution of the present invention, a Base Station (BS) is provided, which includes: a modulation unit configured to modulate a downlink physical Hybrid Automatic Repeat reQuest (HARQ) indicator into a modulated symbol; a signal generation unit configured to generate, based on the modulated symbol modulated by the modulation unit, an HARQ indication signal to be demodulated based on a User Equipment (UE) specific reference signal; and a transmission unit configured to transmit the HARQ indication signal generated by the signal generation unit using the antenna port(s).

Preferably, the antenna port has two sets of UE specific reference signals in time domain, each set of UE specif reference signals being transmitted over a plurality of frequency domain sub-carriers and including two Resource Elements (REs) in each frequency domain sub-carrier, the two REs having the same frequency domain position and contiguous time domain positions. The signal generation unit is configured to: multiply the modulated symbol modulated by the modulation unit with one of the two sets of UE specific reference signals corresponding to the antenna port to generate the HARQ indication signal.

Preferably, the antenna port has two sets of UE specific reference signals in time domain, each set of UE specific reference signals being transmitted over a plurality of frequency domain sub-carriers and including two Resource Elements (REs) in each frequency domain sub-carrier, the two REs having the same frequency domain position and contiguous time domain positions. The signal generation unit is configured to: multiply the modulated symbol modulated by the modulation unit with the two sets of UE specific reference signals corresponding to the antenna port to generate the HARQ indication signal.

Preferably, the signal generation unit is configured to: map the modulated signal to a data RE to be demodulated based on the UE specific reference signal, so as to generate the HARQ indication signal.

Preferably, the data RE includes one or more data R each having a time domain position and a frequency domain position contiguous to the UE specific reference signal.

Preferably, the BS further includes: a determination unit configured to determine the number of data REs for transmitting the downlink physical HARQ indicator in each Resource Block (RB).

Preferably, the determination unit is configured to determine the number of data REs for transmitting the downlink physical HARQ indicator in each RB based on (i) the number of RBs used for uplink schedule transmission corresponding to the downlink physical HARQ indicator and (ii) the number of bits of the downlink physical HARQ indicator.

Preferably, the determination unit is configured to determine the number of data REs for transmitting the downlink physical HARQ indicator in each RB based on (i) the number of uncoded bits transmitted in each RE in the PDSCH, (ii) the number of bits of the downlink physical HARQ indicator and (iii) an adjustment parameter, if the downlink physical HARQ indicator is multiplexed with data in a Physical Downlink Shared Channel (PDSCH) of the UE.

According to the third solution of the present invention, a method for receiving a downlink physical Hybrid Automatic Repeat reQuest (HARQ) indicator is provided, which includes steps of: receiving from the antenna port(s) a User Equipment

(UE) specific reference signal; obtaining an HARQ indicati signal which is generated based on the downlink physical HARQ indicator; and demodulating the HARQ indication signal based on the UE specific reference signal to detect the downlink physical HARQ indicator.

Preferably, the antenna port has two sets of UE specific reference signals in time domain, each set of UE specific reference signals being transmitted over a plurality of frequency domain sub-carriers and including two Resource Elements (REs) in each frequency domain sub-carrier, the two REs having the same frequency domain position and contiguous time domain positions. The step of obtaining the HARQ indication signal includes: determining a signal in the REs corresponding to one of the two sets of UE specific reference signals as the HARQ indication signal. The step of demodulating the HARQ indication signal includes: providing a reference phase based on the UE specific reference signals in the REs corresponding to the other one of the two sets of UE specific reference signals; and demodulating the determined HARQ indication signal based on the reference phase.

Preferably, the antenna port has two sets of UE specific reference signals in time domain, each set of UE specific reference signals being transmitted over a plurality of frequency domain sub-carriers and including two Resource Elements (REs) in each frequency domain sub-carrier, the two

REs having the same frequency domain position and contiguo time domain positions. The step of obtaining the HARQ indication signal includes: determining a signal in the REs corresponding to the two sets of UE specific reference signals as the HARQ indication signal. The step of demodulating the HARQ indication signal includes: providing a reference phase based on two sets of UE specific reference signals received from a further antenna port; and demodulating the determined HARQ indication signal based on the reference phase.

Preferably, the step of obtaining the HARQ indication signal includes: obtaining the HARQ indication signal from a data RE to be demodulated based on the UE specific reference signal.

Preferably, the data RE includes one or more data REs each having a time domain position and a frequency domain position contiguous to the UE specific reference signal.

Preferably, the step of demodulating the HARQ indication signal includes: demodulating the HARQ indication signal also based on (i) the number of data REs for transmitting the downlink physical HARQ indicator in each Resource Block (RB) and (ii) a demodulation scheme of the HARQ indication signal.

According to the fourth solution of the present invention, a User Equipment (UE) is provided, which includes: a reception unit configured to receive from the antenna port(s) a UE specific reference signal; a signal obtaining unit configured to obtain a

Hybrid Automatic Repeat reQuest (HARQ) indication sign which is generated based on the downlink physical HARQ indicator; and a demodulation unit configured to demodulate the HARQ indication signal based on the UE specific reference signal to detect the downlink physical HARQ indicator.

Preferably, the antenna port has two sets of UE specific reference signals in time domain, each set of UE specific reference signals being transmitted over a plurality of frequency domain sub-carriers and including two Resource Elements (REs) in each frequency domain sub-carrier, the two REs having the same frequency domain position and contiguous time domain positions. The signal obtaining unit is configured to: determine a signal in the REs corresponding to one of the two sets of UE specific reference signals as the HARQ indication signal. The demodulation unit is configured to: provide a reference phase based on the UE specific reference signals in the REs corresponding to the other one of the two sets of UE specific reference signals; and demodulate the determined HARQ indication signal based on the reference phase.

Preferably, the antenna port has two sets of UE specific reference signals in time domain, each set of UE specific reference signals being transmitted over a plurality of frequency domain sub-carriers and including two Resource Elements (REs) in each frequency domain sub-carrier, the two REs having the same frequency domain position and contiguous time domain positions. The signal obtaining unit is configured to: determine a signal in the REs corresponding to the two sets of UE specific reference signals as the HARQ indication signal. The demodulation unit is configured to: provide a reference phase based on two sets of UE specific reference signals received from a further antenna port; and demodulate the determined HARQ indication signal based on the reference phase.

Preferably, the signal obtaining unit is configured to: obtain the HARQ indication signal from a data RE to be demodulated based on the UE specific reference signal.

Preferably, the data RE includes one or more data REs each having a time domain position and a frequency domain position contiguous to the UE specific reference signal.

Preferably, the demodulation unit is configured to: demodulate the HARQ indication signal also based on (i) the number of data REs for transmitting the downlink physical HARQ indicator in each Resource Block (RB) and (ii) a demodulation scheme of the HARQ indication signal.

According to the fifth solution of the present invention, a method for transmitting a downlink physical Hybrid Automatic Repeat reQuest (HARQ) indicator is provided, which includes steps of: generating an HARQ indication signal based on the downlink physical HARQ indicator; and transmitting the HARQ indication signal using a Resource Block (RB) and the antenna port(s), wherein the RB for transmitting the HARQ indicatic signal includes the first RB used for uplink schedule transmission corresponding to the HARQ indication signal and the antenna port for transmitting the HARQ indication signal includes the antenna port(s) used for the uplink schedule transmission corresponding to the HARQ indication signal.

Preferably, the antenna port for transmitting the HARQ indication signal further includes an additional antenna port.

BRIEF DESCRIPTION OF DRAWINGS

The above and other objects, features and advantages of the present invention will be more apparent from the following preferred embodiments illustrated with reference to the figures, in which:

Fig. 1 shows a resource map of downlink UE specific reference signals in a normal CP mode;

Fig. 2 shows a resource map of downlink UE specific reference signals in an extended CP mode;

Fig. 3 shows a schematic diagram of a downlink physical HARQ indicator when a single serving cell is configured in the uplink;

Fig. 4 shows a schematic diagram of downlink physical HARQ indicators when a plurality of serving cells are configured in the uplink, in which the downlink physical HARQ indicator corresponding to the PUSCH in each serving cell is simply the same as the downlink physical HARQ indicator when a sing serving cell is configured in the uplink;

Fig. 5 shows a schematic diagram of downlink physical HARQ indicators when a plurality of serving cells are configured in the uplink, in which the downlink physical HARQ indicators corresponding to the PUSCHs in the plurality of serving cells are jointly coded;

Fig. 6 shows a block diagram of the BS according to an embodiment of the present invention;

Fig. 7 shows a block diagram of the UE according to an embodiment of the present invention;

Fig. 8 shows a method for generating a UE specific reference signal;

Fig. 9 shows another method for generating a UE specific reference signal;

Fig. 10 shows a method of determining transmission resources for a downlink physical HARQ indicator;

Fig. 11 shows a method for mapping a modulated symbol to a data RE;

Fig. 12 shows a flowchart of the method for transmitting a downlink physical HARQ indicator according to an embodiment of the present invention; and

Fig. 13 shows a flowchart of the method for receiving a downlink physical HARQ indicator according to an embodiment of the present invention.

DESCRIPTION OF EMBODIMENTS

Preferred embodiments of the present invention will be detailed with reference to the drawings. In the following description, details and functions unnecessary to the present invention are omitted so as not to obscure the concept of the invention.

For clear and detailed explanation of the implementation steps of the present invention, some specific examples applicable to the LTE-A (Rel-10, Rel-11 and subsequent releases) cellular communication system are given below. Herein, it is to be noted that the present invention is not limited to the application exemplified in the embodiments. Rather, it is applicable to other communication systems, such as the future 5G system.

Before describing the principle of the present invention, the resource map of the UE specific reference signal will be explained first. Fig. 1 shows a resource map of downlink UE specific reference signals in a normal CP (Cyclic Prefix) mode (cf. 36.211, Evolved Universal Terrestrial Radio Access (E-UTRA); Physical Channels and Modulation, V10.1.0, 3GPP). In Fig. 1, each 12*14 block represents a pair of Resource Block (RB) and each element in the block represents a Resource Element (RE). The abscissa denotes time slots while the ordinate denotes frequency (sub-carriers). It can be seen from the figure that, in the normal CP mode, each of the antenna ports 7-10 (denoted R_7, R_8, R_9, R_{10}, respectively) has two sets of UE specific reference signals in the time domain. In the present invention, the term "antenna port" is a concept associated with data layer and is independent on any actual arrangement of physical antenna, as understood by those skilled in the art. Each set of UE specific reference signals is transmitted over a plurality of frequency domain sub-carriers (3 frequency domain sub-carriers shown in Fig. 1) and includes two REs in each frequency domain sub-carrier, the two REs having the same frequency domain position and contiguous time domain positions.

Mathematically, in the normal CP mode, the UE specific reference signal at the time-frequency position of (l, k) (herein the time domain position l is represented in units of OFDM symbols and the frequency domain position k is represented in units of sub-carriers) on the p-th antenna port is represent as a complex symbol $a_{k,l}^{(p)}$ (cf. 36.211, Evolved Universal Terrestrial Radio Access (E-UTRA); Physical Channels and Modulation, V10.1.0, 3GPP):

$$a_{k,l}^{(p)} = w_p(l') \cdot r(3 \cdot l' \cdot N_{\mathrm{RB}}^{\max,\mathrm{DL}} + 3 \cdot n_{\mathrm{PRB}} + m') \qquad (1)$$

where

$$w_p(i) = \begin{cases} \overline{w}_p(i), & (m' + n_{\mathrm{PRB}}) \bmod 2 = 0 \\ \overline{w}_p(3-i), & (m' + n_{\mathrm{PRB}}) \bmod 2 = 1 \end{cases}$$

$$k = 5m' + N_{\mathrm{sc}}^{\mathrm{RB}} n_{\mathrm{PRB}} + k'$$

$$k' = \begin{cases} 1, & p \in \{7,8\} \\ 0, & p \in \{9,10\} \end{cases}$$

$$l = \begin{cases} l' \bmod 2 + 2, & \text{for special subframes with TDD UL/DL configuration scheme 3, 4 or 8} \\ l' \bmod 2 + 2 + 3\lfloor l'/2 \rfloor, & \text{for special subframes with TDD UL/DL configuration scheme 1, 2, 6 or 7} \\ l' \bmod 2 + 5, & \text{for non-special subframes} \end{cases}$$

$$l' = \begin{cases} 0,1,2,3, & \text{for even slots of special subframes with TDD UL/DL configuration scheme 1, 2, 6 or 7} \\ 0,1, & \text{for even slots of non-special subframes with TDD UL/DL configuration scheme 1, 2, 6 or 7} \\ 2,3, & \text{for odd slots of special subframes with TDD UL/DL configuration scheme 1, 2, 6 or 7} \end{cases}$$

$$m' = 0,1,2$$

The above variable $w_p(i)$ is derived from $\overline{w}_p(i)$ which is an orthogonal sequence for distinguishing different antenna ports (cf. 3GPP TS 36.211, Table 6.10.3.2-1); $r(\cdot)$ is a well known reference signal sequence defined in 3GPP TS 36.211 (cf. 3GPP TS 36.211, Section 6.10.3.1); $N_{\mathrm{sc}}^{\mathrm{RB}}$ is the size of a RB in frequency domain in units of sub-carriers; $N_{\mathrm{RB}}^{\max,\mathrm{DL}}$ is the maximum downlink bandwidth configuration in units of $N_{\mathrm{sc}}^{\mathrm{RB}}$; and n_{PRB} is a physical RB number.

Fig. 2 shows a resource map of downlink UE specific reference signals in an extended CP mode. It can be seen from

Fig. 2 that, in the extended CP mode, for the special subfram with TDD (Time Division Duplex) uplink/downlink scheme of 1, 2, 3, 5 or 6, each of the antenna ports 7-8 has only one set of UE specific reference signals; while for any of the remaining downlink subframes, each of the antenna ports 7-8 has two sets of UE specific reference signals which are distributed over two time slots and located in contiguous frequency domain positions shifted from each other by one sub-carrier.

Mathematically, in the extended CP mode, the UE specific reference signal at the time-frequency position of (l, k) on the p-th antenna port is represent as a complex symbol $a_{k,l}^{(p)}$ (cf. 36.211, Evolved Universal Terrestrial Radio Access (E-UTRA); Physical Channels and Modulation, V10.1.0, 3GPP):

$$a_{k,l}^{(p)} = w_p(l') \cdot r(4 \cdot l' \cdot N_{\mathrm{RB}}^{\max,\mathrm{DL}} + 4 \cdot n_{\mathrm{PRB}} + m') \qquad (2)$$

where

$$w_p(i) = \begin{cases} \overline{w}_p(i) & m' \bmod 2 = 0 \\ \overline{w}_p(1-i) & m' \bmod 2 = 1 \end{cases}$$

$$k = 3m' + N_{\mathrm{sc}}^{\mathrm{RB}} n_{\mathrm{PRB}} + k'$$

$$k' = \begin{cases} 1 & \text{for even slots}, p \in \{7,8\} \\ 2 & \text{for odd slots}, p \in \{7,8\} \end{cases}$$

$$l = l' \bmod 2 + 4$$

$$l' = \begin{cases} 0,1 & \begin{array}{l}\text{for even slots of special subframes with TDD UL/DL} \\ \text{configuration scheme 1, 2, 3, 5 or 6}\end{array} \\ 0,1 & \text{for odd slots of non-special subframes} \end{cases}$$

$$m' = 0,1,2,3$$

The above notations in Equation (1) are reused in the Equation (2) except that $\overline{w}_p(i)$ is an orthogonal sequence for distinguishing different antenna ports (cf. 3GPP TS 36.21 Table 6.10.3.2-2).

Figs. 3 to 5 show schematic diagrams of downlink physical HARQ indicators when a single serving cell or a plurality of serving cells is/are configured in the uplink, respectively. As an example, in the FDD mode shown in Fig. 3, the basic process for configuring the uplink data transmission for a signal serving cell includes scheduling of the uplink data (PDCCH), transmission of uplink data (Physical Uplink Shared Channel, PUSCH) and indication of downlink HARQ (feedback of ACK/NACK). Herein, the resources for indication of downlink HARQ are located in the downlink serving cell transmitting the uplink schedule and correspond to the first physical RB on the uplink PUSCH. It can be seen from Figs. 4 and 5 that, when a plurality of serving cells are configured in the uplink, the scheme of Fig. 3 can be simply reused for the downlink physical HARQ indicator corresponding to the PUSCH in each serving cell (as in Fig. 4) or, alternatively, the downlink physical HARQ indicators corresponding to the PUSCHs in the plurality of serving cells can be jointly coded (as in Fig. 5).

The exemplary embodiments of the present invention will be explained in the following with reference to the figures.

Fig. 6 shows a block diagram of the BS 100 according to an embodiment of the present invention. The BS 100 includes a modulation unit 110, a signal generation unit 120 and a transmission unit 130. Preferably, the BS 100 can furth include a determination unit (not shown). It can be appreciated by those skilled in the art that the BS 100 further includes other functional units necessary for its operation, such as memory and processor.

Fig. 7 shows a block diagram of the UE 200 according to an embodiment of the present invention. The UE 200 includes a reception unit 210, a signal obtaining unit 220 and a demodulation unit 230.

In the following, the functions and operations of the respective components of the BS 100 and the UE 200 will be detailed with reference to specific embodiments.

[First Embodiment]

According to this embodiment, the modulation unit 110 of the BS 100 is configured to modulate a downlink physical HARQ indicator into a modulated symbol.

For example, when a single serving cell is configured in the uplink, the downlink physical HARQ indicator contains a 1-bit or 2-bit HARQ ACK/NACK for indicating whether one or two transport blocks on the uplink PUSCH are correctly received by the BS. This 1-bit or 2-bit information can be mapped into a modulated symbol in accordance with the modulation scheme as shown in Table 1. However, it can be appreciated by those skilled in the art that the modulation/mapping shown in Table 1 is only a preferred example. Any other modulation/mapping can be used in tl present invention as long as it is known by both the BS 100 and the UE 200.

Table 1 – Modulation Scheme for Downlink Physical HARQ Indicator

DL Physical HARQ Indicator	$b(0), b(1)$	d
1-bit	0	1
	1	-1
2-bit	00	1
	01	$-j$
	10	j
	11	-1

In the above Table 1, b(0) and b(1) represent the downlink physical HARQ indicator; d represents the modulated symbol.

The signal generation unit 120 of the BS 100 is configured to generate, based on the modulated symbol modulated by the modulation unit 110, an HARQ indication signal to be demodulated based on a UE specific reference signal.

As described above with respect to Figs. 1 and 2, for the normal CP mode and the extended CP mode (except for the special subframes with TDD uplink/downlink configuration scheme 1, 2, 3, 5 or 6), the antenna port(s) has two sets of UE specific reference signals in time domain, and each set of UE specific reference signals is transmitted over a plurality of frequency domain sub-carriers and includes two REs in each frequency domain sub-carrier, the two REs having the same frequency domain position and contiguous time domain positions.

In the following, two approaches for generating HARQ indication signal will be described.

Approach I for Generating HARQ Indication Signal

As shown in Fig. 8, according to Approach I, the signal generation unit 120 is configured to multiply the modulated symbol modulated by the modulation unit 110 with one of the two sets of UE specific reference signals corresponding to the antenna port (the shaded REs surrounded by dashed line as shown in Fig. 8) to generate the HARQ indication signal.

For example, in the normal CP mode, the UE specific reference signal at the time-frequency position of (l, k) on the p-th antenna port is multiplied with the above modulated symbol to obtain a complex symbol $\hat{a}_{k,l}^{(p)}$:

$$\hat{a}_{k,l}^{(p)} = w_p(l')z(l')r(3 \cdot l' \cdot N_{\mathrm{RB}}^{\max,\mathrm{DL}} + 3 \cdot n_{\mathrm{PRB}} + m') \qquad (3)$$

where, in addition to the above notations in Equation (1) which are reused in the Equation (3), $z(l')=1$ for $l'=0,1$ and $z(l')=d$ for $l'=2,3$.

As another example, in the extended CP mode (except for the special subframes with TDD uplink/downlink configuration scheme 1, 2, 3, 5 or 6), the UE specific reference signal at the time-frequency position of (l, k) on the p-th antenna port is multiplied with the above modulated symbol to obtain a complex symbol $\hat{a}_{k,l}^{(p)}$:

$$\hat{a}_{k,l}^{(p)} = w_p(l')z(l')r(4 \cdot l' \cdot N_{\mathrm{RB}}^{\max,\mathrm{DL}} + 4 \cdot n_{\mathrm{PRB}} + m') \qquad (4)$$

where, in addition to the above notations in Equation (which are reused in the Equation (4), $z(l')=1$ for $l'=0,1$ and even slots; $z(l')=d$ for $l'=0,1$ and odd slots.

In this Approach I, one of the two sets of UE specific reference signals corresponding to the antenna port carries the HARQ indicator and thus becomes the HARQ indication signal, while the other set of UE specific reference signals does not carry the HARQ indicator and is still the original UE specific reference signals.

Approach II for Generating HARQ Indication Signal

As shown in Fig. 9, according to Approach II, the signal generation unit 120 is configured to multiply the modulated symbol modulated by the modulation unit 110 with the two sets of UE specific reference signals corresponding to the antenna port (the shaded REs surrounded by dashed line as shown in Fig. 9) to generate the HARQ indication signal.

For example, in the normal CP mode, the UE specific reference signal at the time-frequency position of (l, k) on the p-th antenna port is multiplied with the above modulated symbol to obtain a complex symbol $\hat{a}_{k,l}^{(p)}$:

$$\hat{a}_{k,l}^{(p)} = w_p(l')z(l')r(3\cdot l'\cdot N_{\mathrm{RB}}^{\max,\mathrm{DL}} + 3\cdot n_{\mathrm{PRB}} + m') \qquad (5)$$

where, in addition to the above notations in Equation (1) which are reused in the Equation (5), $z(l')=d$.

As another example, in the extended CP mode (except for the special subframes with TDD uplink/downlink configuration scheme 1, 2, 3, 5 or 6), the UE specific reference signal at t time-frequency position of (l, k) on the p-th antenna port is multiplied with the above modulated symbol to obtain a complex symbol $\hat{a}_{k,l}^{(p)}$:

$$\hat{a}_{k,l}^{(p)} = w_p(l')z(l')r(4 \cdot l' \cdot N_{\mathrm{RB}}^{\max,\mathrm{DL}} + 4 \cdot n_{\mathrm{PRB}} + m') \qquad (6)$$

where, in addition to the above notations in Equation (1) which are reused in the Equation (6), $z(l') = d$.

In this Approach II, both of the two sets of UE specific reference signals corresponding to the antenna port carry the HARQ indicator and thus become the HARQ indication signal.

The transmission unit 130 of the BS 100 is configured to transmit the HARQ indication signal generated by the signal generation unit 120 using the antenna port(s).

On the other hand, the reception unit 210 of the UE 200 is configured to receive from the antenna port the UE specific reference signal. The signal obtaining unit 220 of the UE 200 is configured to obtain the HARQ indication signal which is, as described above, generated based on the downlink physical HARQ indicator. The demodulation unit 230 of the UE 200 is configured to demodulate the HARQ indication signal based on the UE specific reference signal to detect the downlink physical HARQ indicator.

In an exemplary scenario, the HARQ indication signal generated by the BS 100 (which is transmitted in the REs for the UE specific reference signals in this embodiment) is transmitted over transmission resources (RB(s) and antenna port(s)) negotiated between the UE 200 and the BS 100. Herein, the number of RB resource is preferably one. For example, the BS 100 can notify the sequence numbers of RB(s) and antenna port(s) for transmitting the HARQ indication signal to the UE 200 via semi-static signaling. The number of antenna port(s) is 1 for the above Approach I and 2 for the above Approach II.

Alternatively, as shown in Fig. 10, it is assumed that the uplink schedule PDCCH (ePDCCH) to be demodulated based on the UE specific reference signal is transmitted over RB n, n+1, ..., n+x (where n, n+1, ..., n+x are RB indices) on the antenna port p. In this case, the transmission unit 130 of the BS 100 can transmit the HARQ indication signal corresponding to the uplink schedule over the RB n on the antenna port p (for Approach I) or transmit the HARQ indication signal corresponding to the uplink schedule over the RB n on the antenna ports p and p+1 (for Approach II). In other words, for the above Approach I, the RB for transmitting the HARQ indication signal can be the first RB used for uplink schedule transmission corresponding to the HARQ indication signal, and the antenna port for transmitting the HARQ indication signal can be the antenna port used for transmission of the uplink schedule corresponding to the HARQ indication signal. For the above Approach II, the RB for transmitting the HARQ indication signal can be the first RB used for uplink schedule transmission corresponding to the HARQ indication signal, ar the antenna ports for transmitting the HARQ indication signal can be the antenna port used for transmission of the uplink schedule corresponding to the HARQ indication signal and an additional antenna port. Advantageously, with the above solution for selecting the RB(s) and the antenna port(s) for transmitting the HARQ indication signal, the reliability of the HARQ indication signal transmission can be ensured since the BS generally selects RB(s) and antenna port(s) in good channel condition for transmission of the uplink schedule and, due to the temporal correlation of the channel, the RB(s) and antenna port(s) will still be in good channel condition in transmission of the HARQ indication signal.

Thus, based on a negotiation with the BS 100 or the above resource allocation scheme, the UE 200 (in particular, the signal obtaining unit 220) can receive the HARQ indication signal over the resources (RB(s) and antenna port(s)) on which the HARQ indication signal is transmitted, so as to detect the downlink physical HARQ indicator.

In particular, if the HARQ indication signal is generated using the above Approach I, the signal obtaining unit 220 of the UE 200 is configured to determine a signal in the REs corresponding to one of the two sets of UE specific reference signals as the HARQ indication signal. Herein, since the two sets of UE specific reference signals are both known by the UE

200, the signal obtaining unit 220 can compare the sigr transmitted in the REs corresponding to the UE specific reference signals with the known UE specific reference signals, so as to determine the signal transmitted in the REs corresponding to one of the two sets of UE specific reference signals as the HARQ indication signal. In this case, the signals transmitted in the REs corresponding to the other one of the two sets of UE specific reference signals are the original UE specific reference signals which are not modulated by a modulating signal, i.e., which do not carry the downlink physical HARQ indicator. Thus, the modulation unit 230 is configured to provide a reference phase based on the UE specific reference signals in the REs corresponding to the other one of the two sets of UE specific reference signals; and demodulate the determined HARQ indication signal based on the reference phase. For example, the demodulation unit 230 can demodulate the HARQ indication signal based on a phase difference between the two sets of UE specific reference signals (in which one carries the HARQ indicator and thus becomes the HARQ indication signal, while the other one does not carry the HARQ indicator and is still the original UE specific reference signal) in accordance with the number of bits of the downlink physical HARQ indicator and the modulation/mapping scheme as known (e.g., Table 1), such that the downlink physical HARQ indicator can be obtained.

On the other hand, if the HARQ indication signal generated using the above Approach II, the signal obtaining unit 220 is configured to determine a signal in the REs corresponding to the two sets of UE specific reference signals as the HARQ indication signal. The demodulation unit 230 is configured to: provide a reference phase based on two sets of UE specific reference signals received from a further antenna port; and demodulate the determined HARQ indication signal based on the reference phase. For example, the demodulation unit 230 can demodulate the HARQ indication signal based on a phase difference between the HARQ indication signal and the original UE specific reference signal from the further antenna port in accordance with the number of bits of the downlink physical HARQ indicator and the modulation/mapping scheme as known (e.g., Table 1), such that the downlink physical HARQ indicator can be obtained. It is to be noted that, in this case, for both antenna ports, the REs corresponding to the UE specific reference signal should be beamformed using the same pre-coding scheme.

When the downlink physical HARQ indicator is multiplexed with the PDSCH of the UE, a method for jointly detecting the PDSCH and the physical HARQ indicator can be used to further improve the accuracy of the detection (cf. R1-080190, Embedding ACK/NAK in CQI Reference Signals and Receiver Structures, Texas Instruments).

In addition, when the extended CP mode is used and t current sub-frame is a special sub-frame with TDD uplink/downlink configuration scheme 1 or 6 (according to the protocol, the special sub-frame with TDD uplink/downlink configuration scheme 2, 3 or 5 does not carry the HARQ indicator), it can be seen from Fig. 2 that one such sub-frame contains only one set of reference signals. In this case, the above method cannot be used for transmitting/receiving the downlink physical HARQ indicator. This problem can be solved by modifying the process of assigning physical HARQ indicator channel in TDD mode (cf. 36.213, Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer procedures, V10.1.0, 3GPP), i.e., such sub-frame is not used in assigning the physical HARQ indicator channel.

For example, as shown in Table 2, in the LTE Rel-10 TDD mode, if the PUSCH transmission is scheduled in the n-th sub-frame in the serving cell, the UE determines the resources for transmitting the downlink physical HARQ indicator in the (n+k_PHICH)-th sub-frame in the serving cell, where k_PHICH represents the transmission interval, in units of sub-frames, by which the HARQ indication signal is delayed with respect to the PUSCH. By modifying Table into Table 3 (bolded and underlined), the above described special sub-frames will no longer be used for transmitting downlink physical HARQ indicators. These downlink physical HARQ indicators will be moved to other sub-frames for transmission, which according increases the usage of the resources for transmission of the downlink physical HARQ indicators in the other sub-frames.

Table 2 – k_PHICH in TDD Mode

TDD UL/DL Configuration Scheme	**Subframe Index *n***									
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
0			4	7	6			4	7	6
1			4	6				4	6	
2			6					6		
3			6	6	6					
4			6	6						
5			6							
6			4	6	6			4	7	

Table 3 – Modified k_PHICH in TDD Mode

TDD UL/DL Configuration Scheme	**Subframe Index *n***									
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
0			4	7	6			4	7	6
1			**7**	6				**7**	6	
2			6					6		
3			6	6	6					
4			6	6						
5			6							
6			**7**	6	6			**8**	7	

For example, among the special sub-frames with the TDD uplink/downlink configuration scheme 1 as shown in the above Table 2, the sub-frame 2 is associated with a k_PHICH value of 4, which means that the HARQ indication signal will be transmitted with a delay of 4 sub-frames after PUSCH (i.e., in the sub-frame 6 with the TDD uplink/downlink configuration scheme 1). In the modified Table 3, the k_PHICH value associated with the sub-frame 2 is modified into 7, such that the HARQ indication signal will be transmitted with a delay of 7 sub-frames after PUSCH (i.e., in the sub-frame 9 with the TI uplink/downlink configuration scheme 1), thereby avoiding transmission of the HARQ indication signal in the special sub-frame 6 with the TDD uplink/downlink configuration scheme 1. The other modifications in Table 3 are made in the same manner. However, it is to be noted that these modifications are exemplary only and the present invention can be implemented as long as the above effect can be achieved, i.e., the downlink physical HARQ indicator is no longer transmitted in the special sub-frames with the TDD uplink/downlink configuration scheme 1 or 6 and is moved to other sub-frames for transmission.

[Second Embodiment]

In the following, the second embodiment of the present invention will be described. According to the above first embodiment, the BS 100 uses the REs corresponding to the UE specific reference signal to carry the HARQ indicator and demodulates it based on the UE specific reference signal. However, in the second embodiment given blow, the BS 100 uses data REs to carry the HARQ indicator and modulate it based on the UE specific reference signal. For the purpose of explanation, the following description will be focused on the differences between the first and the second embodiments while the details of the same features as the first embodiment will be omitted.

Similar to the first embodiment, in this embodiment, the BS 100 includes a modulation unit 110 configured to modulate a downlink physical HARQ indicator into a modulated symbol; a signal generation unit 120 configured to generate, based on the modulated symbol modulated by the modulation unit, an HARQ indication signal to be demodulated based on a UE specific reference signal; and a transmission unit 130 configured to transmit the HARQ indication signal generated by the signal generation unit using the antenna port(s).

For example, when a single serving cell is configured in the uplink, the downlink physical HARQ indicator contains a 1-bit or 2-bit HARQ ACK/NACK for indicating whether one or two transport blocks on the uplink PUSCH are correctly received by the BS. When n serving cells are configured in the uplink, the downlink physical HARQ indicator contains up to 2n-bit HARQ ACK/NACK, where each serving cell has at maximum 2 bits corresponding to 2 transport blocks, respectively. Currently, the maximum number of uplink serving cells is 5 and thus the downlink physical HARQ indicator contains up to 10 bits.

In this embodiment, the BS 100 can further include an optional determination unit (not shown). The determination unit is configured to determine the number of data REs for transmitting the downlink physical HARQ indicator in each RB.

The number of data REs for transmitting the downlink physic HARQ indicator in each RB, denoted as Q, can be notified from the BS 100 to the UE 200 via semi-static signaling or can be determined by using one of the following exemplary approaches.

The determination unit of the BS 100 can be configured to determine the number Q of data REs for transmitting the downlink physical HARQ indicator in each RB based on (i) the number of RBs used for uplink schedule transmission corresponding to the downlink physical HARQ indicator, denoted as N_RB and (ii) the number of bits of the downlink physical HARQ indicator (denoted as O). That is, Q is a function of N_RB and O. One exemplary determination approach is Q=min(4*N_RB*O, N_total), where N_total is the number of REs in the RB which are available for transmitting the downlink physical HARQ indicator.

Alternatively, if the downlink physical HARQ indicator is multiplexed with data in a Physical Downlink Shared Channel (PDSCH) of the UE, the determination unit of the BS 100 is configured to determine the number Q of data REs for transmitting the downlink physical HARQ indicator in each RB based on (i) the number of uncoded bits transmitted in each RE in the PDSCH (denoted as K), (ii) the number of bits of the downlink physical HARQ indicator (denoted as O) and (iii) an adjustment parameter B (which is optional and represents the shift between the semi-statically configured PDSC modulation/mapping scheme and the coding rate of the downlink physical HARQ indicator). That is, Q is a function of K, O and B. One exemplary determination approach is Q=min(ceil(O*B/K), N_total), where ceil() is a ceiling function and N_total is the number of REs in the RB which are available for transmitting the downlink physical HARQ indicator.

Preferably, if the downlink physical HARQ indicator is not multiplexed with data in the PDSCH of the UE (in this case the resources allocated for the downlink physical HARQ indicator are not reused for transmitting the PDSCH of the same UE), the modulation unit 110 of the BS 100 can select the modulation/mapping scheme of Quadrature Phase Shift Keying (QPSK). On the other hand, if the downlink physical HARQ indicator is multiplexed with data in the PDSCH of the UE (in this case the resources allocated for the downlink physical HARQ indicator are reused for transmitting the PDSCH of the same UE), the modulation unit 110 of the BS 100 can select the same modulation/mapping scheme as that of the PDSCH which is currently multiplexed with the corresponding RB(s) and antenna port(s).

In the case where the downlink physical HARQ indicator is multiplexed with data in the PDSCH of the UE, the modulation unit 110 of the BS 100 can reuse the method of control information channel coding in PUSCH in LTE Rel-10 (cf. 36.212, Evolved Universal Terrestrial Radio Access (E-UTR/ Multiplexing and channel coding, V10.1.0, 3GPP) to code and modulate the downlink physical HARQ indicator. In particular, if the downlink physical HARQ indicator contains 1-bit information, i.e., $[o_0^{ACK}]$, it can be coded according to the right column of Table 4 and then modulated into a modulated symbol according to the modulation order in the left column of Table 4. On the other hand, if the downlink physical HARQ indicator contains 2-bit information, i.e., $[o_0^{ACK}\ o_1^{ACK}]$, it can be coded according to the right column of Table 5 and then modulated into a modulated symbol according to the modulation order in the left column of Table 5, where $o_2^{ACK} = (o_0^{ACK} + o_1^{ACK}) \bmod 2$. If the physical HARQ indicator contains information of $3 \le O^{ACK} \le 10$ bits (i.e., the physical HARQ indicators corresponding to a number of uplink serving cells are aggregated) denoted as $o_0^{ACK}\ o_1^{ACK},...,o_{O^{ACK}-1}^{ACK}$, the bit sequence $o_0^{ACK}\ o_1^{ACK},...,o_{O^{ACK}-1}^{ACK}$ is input to Table 6 (which indicates a block coding approach defined in 3GPP TS 36.212, Section 5.2.2.6.4) to generate a bit sequence $\tilde{q}_0^{ACK}\ \tilde{q}_1^{ACK},...,\tilde{q}_{31}^{ACK}$, which is then repeated cyclically to generate a sequence $q_0^{ACK}, q_1^{ACK}, q_2^{ACK},..., q_{Q_{ACK}-1}^{ACK}$ (where $Q_{ACK} = Q_m \cdot Q$, with Q being the number of data REs for transmitting the downlink physical HARQ indicator in each RB as mentioned above and Q_m being the modulation order of the selected modulation scheme). Then, the sequence $q_0^{ACK}, q_1^{ACK}, q_2^{ACK},..., q_{Q_{ACK}-1}^{ACK}$ can be modulated into a modulated symbol according to the selected modulation order.

Table 4 – Coding and Modulation for 1-bit Downlink Physical HARQ Indicator

Modulation Order Q_m	**HARQ-ACK Coding Scheme**
2	$[o_0^{ACK}\ \mathrm{y}]$
4	$[o_0^{ACK}\ \mathrm{y\,x\,x}]$
6	$[o_0^{ACK}\ \mathrm{y\,x\,x\,x\,x}]$

Table 5 – Coding and Modulation for 2-bit Downlink Physical HARQ Indicator

Modulation Order Q_m	**HARQ-ACK Coding Scheme**
2	$[o_0^{ACK}\ o_1^{ACK}\ o_2^{ACK}\ o_0^{ACK}\ o_1^{ACK}\ o_2^{ACK}]$
4	$[o_0^{ACK}\ o_1^{ACK}\ \mathrm{x\,x}\ o_2^{ACK}\ o_0^{ACK}\ \mathrm{x\,x}\ o_1^{ACK}\ o_2^{ACK}\ \mathrm{x\,x}]$
6	$[o_0^{ACK}\ o_1^{ACK}\ \mathrm{x\,x\,x\,x}\ o_2^{ACK}\ o_0^{ACK}\ \mathrm{x\,x\,x\,x}\ o_1^{ACK}\ o_2^{ACK}\ \mathrm{x\,x\,x\,x}]$

In the above Table 4 and Table 5, “x” and “y” are used to maximize the Euclidean distance between the modulated symbols carrying the downlink physical HARQ indicator.

Table 6 – Coding and Modulation for 3 to 10-bit Downlink Physical HARQ Indicator

i	$M_{i,0}$	$M_{i,1}$	$M_{i,2}$	$M_{i,3}$	$M_{i,4}$	$M_{i,5}$	$M_{i,6}$	$M_{i,7}$	$M_{i,8}$	$M_{i,9}$	$M_{i,10}$
0	1	1	0	0	0	0	0	0	0	0	1
1	1	1	1	0	0	0	0	0	0	1	1
2	1	0	0	1	0	0	1	0	1	1	1
3	1	0	1	1	0	0	0	0	1	0	1
4	1	1	1	1	0	0	0	1	0	0	1
5	1	1	0	0	1	0	1	1	1	0	1
6	1	0	1	0	1	0	1	0	1	1	1
7	1	0	0	1	1	0	0	1	1	0	1
9	1	0	1	1	1	0	1	0	0	1	1
10	1	0	1	0	0	1	1	1	0	1	1
11	1	1	1	0	0	1	1	0	1	0	1
12	1	0	0	1	0	1	0	1	1	1	1
13	1	1	0	1	0	1	0	1	0	1	1
14	1	0	0	0	1	1	0	1	0	0	1
15	1	1	0	0	1	1	1	1	0	1	1
16	1	1	1	0	1	1	1	0	0	1	0
17	1	0	0	1	1	1	0	0	1	0	0
18	1	1	0	1	1	1	1	1	0	0	0
19	1	0	0	0	0	1	1	0	0	0	0
20	1	0	1	0	0	0	1	0	0	0	1
21	1	1	0	1	0	0	0	0	0	1	1
22	1	0	0	0	1	0	0	1	1	0	1
23	1	1	1	0	1	0	0	0	1	1	1
24	1	1	1	1	1	0	1	1	1	1	0
25	1	1	0	0	0	1	1	1	0	0	1
26	1	0	1	1	0	1	0	0	1	1	0
27	1	1	1	1	0	1	0	1	1	1	0
28	1	0	1	0	1	1	1	0	1	0	0
29	1	0	1	1	1	1	1	1	1	0	0
30	1	1	1	1	1	1	1	1	1	1	1
31	1	0	0	0	0	0	0	0	0	0	0

In this embodiment, the signal generation unit 120 is configured to map the modulated signal to a data RE to be demodulated based on the UE specific reference signal, so as to generate the HARQ indication signal. Preferably, the data RE includes one or more data REs each having a time domain position and a frequency domain position contiguous to the UE specific reference signal, such that the UE 200 can demodulate the HARQ by fully using the accurate channel information based on the UE specific reference signal. As shown in Fig. 11, for example, when the number Q of the data REs is 8, one or more REs (e.g., the shaded REs) each having a time domain position and a frequency domain position contiguous to the UE specific reference signal can be used to transmit the modulated symbols.

As an example, the data RE carrying the HARQ indication signal as generated by the signal generation unit 120 is transmitted over transmission resources (RB(s) and antenna port(s)) negotiated between the UE 200 and the BS 100. Herein, the number of RB resource is preferably one. For example, the BS 100 can notify the sequence numbers of RB(s) and antenna port(s) for transmitting the HARQ indication signal to the UE 200 via semi-static signaling.

Alternatively, when a single serving cell is configured in the uplink or when a plurality of serving cells are configured in the uplink and the scheme for downlink physical HARQ indicator when a single serving cell is configured in the uplink is simply reused for downlink physical HARQ indicator corresponding to the PUSCH in each serving cell (as shown in Fig. 4), the resources for transmitting the HARQ indication signal corresponding to the PUSCH in each serving cell can be allocated using the approach shown in Fig. 10. That is, it assumed that the uplink schedule PDCCH (ePDCCH) to be demodulated based on the UE specific reference signal is transmitted over RBs n, n+1, ..., n+x (where n, n+1, ..., n+x are RB indices) on the antenna port(s). In this case, the BS 100 can transmit the HARQ indication signal corresponding to the uplink schedule over the RB n on the antenna port p. In other words, the RB for transmitting the HARQ indication signal can be the first RB used for uplink schedule transmission corresponding to the HARQ indication signal, and the antenna port for transmitting the HARQ indication signal can be the antenna port used for transmission of the uplink schedule corresponding to the HARQ indication signal.

Alternatively, if a plurality of serving cells are configured in the uplink and the downlink physical HARQ indicators corresponding to the PUSCHs in the plurality of serving cells are jointly coded (as shown in Fig. 5), the resources for transmitting the jointly coded HARQ indication signals can be allocated using the approach shown in Fig. 10. That is, the RB for transmitting the jointly coded HARQ indication signals can be the first RB used for uplink schedule transmission corresponding to the jointly coded HARQ indication signals, and the antenna ports for transmitting the jointly coded HARQ indication signals can be the antenna port used for transmission of the uplink schedule corresponding to the jointly coded HARQ indication signals. Herein the upli: schedule can be determined by: if the main downlink serving cell has an uplink schedule, always selecting the uplink schedule of the main serving cell; if the main serving cell does not have an uplink schedule, always selecting the uplink schedule in the secondary serving cell which has the smallest cell ID (ScellIndex-r10) among the secondary serving cells having uplink schedules; or if the main downlink serving cell has more than one uplink schedules, always selecting from these uplink schedules the uplink schedule in the serving cell corresponding to the uplink serving cell having the smallest cell ID. Alternatively, the uplink schedule can be determined by always selecting from all uplink schedules the uplink schedule in the serving cell corresponding to the uplink serving cell having the smallest cell ID.

Thus, based on a negotiation with the BS 100 or the above resource allocation scheme, the UE 200 (in particular, the signal obtaining unit 220) can receive the HARQ indication signal over the resources (RB(s) and antenna port(s)) on which the HARQ indication signal is transmitted, so as to detect the downlink physical HARQ indicator.

In this embodiment, the UE 200 includes: a reception unit 210 configured to receive from the antenna port(s) a UE specific reference signal; a signal obtaining unit 220 configured to obtain a Hybrid Automatic Repeat reQuest (HARQ) indication signal which is generated based on the downlink physical HA indicator; and a demodulation unit 230configured to demodulate the HARQ indication signal based on the UE specific reference signal to detect the downlink physical HARQ indicator.

In particular, the signal obtaining unit 220 of the UE 200 is configured to: obtain the HARQ indication signal from a data RE to be demodulated based on the UE specific reference signal. The demodulation unit 230 is configured to: demodulate the HARQ indication signal based on the UE specific reference signal and also based on (i) the number of data REs for transmitting the downlink physical HARQ indicator in each Resource Block (RB) and (ii) a demodulation scheme of the HARQ indication signal.

Fig. 12 shows a flowchart of the method 300 for transmitting a downlink physical HARQ indicator according to an embodiment of the present invention. In the following description, the method will be described in connection with the above embodiments of the BS 100 for the purpose of clarity. However, it can be appreciated by those skilled in the art that it is illustrative only to describe the method of present invention in connection with the specific functional units of the BS 100. In the case where the method is implemented in computer program, for example, such definitions of the functional units and components are unnecessary and the BS 100 can act as a whole to implement the method of the present invention.

According to the present invention, the method 300 for transmitting a downlink physical HARQ indicator includes the following steps.

At step 302, the modulation unit 110 modulates the downlink physical HARQ indicator into a modulated symbol.

At step 304, the signal generation unit 120 generates, based on the modulated symbol, an HARQ indication signal to be demodulated based on a UE specific reference signal.

At step 306, the transmission unit 130 transmits the HARQ indication signal using the antenna port(s).

According to an embodiment, the antenna port has two sets of UE specific reference signals in time domain, each set of UE specific reference signals being transmitted over a plurality of frequency domain sub-carriers and including two Resource Elements (REs) in each frequency domain sub-carrier, the two REs having the same frequency domain position and contiguous time domain positions. In step 304, the signal generation unit 120 multiplies the modulated symbol with one of the two sets of UE specific reference signals corresponding to the antenna port to generate the HARQ indication signal. Alternatively, in step 304, the signal generation unit 120 multiplies the modulated symbol with the two sets of UE specific reference signals corresponding to the antenna port to generate the HARQ indication signal.

According to another embodiment, in step 304, the sign generation unit 120 maps the modulated signal to a data RE to be demodulated based on the UE specific reference signal, so as to generate the HARQ indication signal. Preferably, the data RE includes one or more data REs each having a time domain position and a frequency domain position contiguous to the UE specific reference signal.

Preferably, the method further includes, prior to step 302, determining the number of data REs for transmitting the downlink physical HARQ indicator in each Resource Block (RB). Herein, the number of data REs for transmitting the downlink physical HARQ indicator in each RB is determined based on (i) the number of RBs used for uplink schedule transmission corresponding to the downlink physical HARQ indicator and (ii) the number of bits of the downlink physical HARQ indicator. Alternatively, if the downlink physical HARQ indicator is multiplexed with data in a Physical Downlink Shared Channel (PDSCH) of the UE, the number of data REs for transmitting the downlink physical HARQ indicator in each RB is determined based on (i) the number of uncoded bits transmitted in each RE in the PDSCH, (ii) the number of bits of the downlink physical HARQ indicator and (iii) an adjustment parameter.

Fig. 13 shows a flowchart of the method 400 for receiving a downlink physical HARQ indicator according to an embodiment of the present invention. In the following description, the method will be described in connection wi the above embodiments of the UE 200 for the purpose of clarity. However, it can be appreciated by those skilled in the art that it is illustrative only to describe the method of present invention in connection with the specific functional units of the UE 200. In the case where the method is implemented in computer program, for example, such definitions of the functional units and components are unnecessary and the UE 200 can act as a whole to implement the method of the present invention.

According to the present invention, the method 400 for receiving a downlink physical Hybrid Automatic Repeat reQuest (HARQ) indicator includes the following steps.

At step 402, the reception unit 210 receives from the antenna port(s) a User Equipment (UE) specific reference signal.

At step 404, the signal obtaining unit 220 obtains an HARQ indication signal which is generated based on the downlink physical HARQ indicator.

At step 406, the demodulation unit 230 demodulates the HARQ indication signal based on the UE specific reference signal to detect the downlink physical HARQ indicator.

According to an embodiment, the antenna port has two sets of UE specific reference signals in time domain, each set of UE specific reference signals being transmitted over a plurality of frequency domain sub-carriers and including two Resource

Elements (REs) in each frequency domain sub-carrier, the tv REs having the same frequency domain position and contiguous time domain positions. In step 404, the signal obtaining unit 220 determines a signal in the REs corresponding to one of the two sets of UE specific reference signals as the HARQ indication signal. In step 406, the demodulation unit 230 provides a reference phase based on the UE specific reference signals in the REs corresponding to the other one of the two sets of UE specific reference signals and demodulates the determined HARQ indication signal based on the reference phase. Alternatively, in step 404, the demodulation unit 220 determines a signal in the REs corresponding to the two sets of UE specific reference signals as the HARQ indication signal. In step 406, the demodulation unit 230 provides a reference phase based on two sets of UE specific reference signals received from a further antenna port; and demodulates the determined HARQ indication signal based on the reference phase.

According to another embodiment, in step 406, the signal obtaining unit 220 obtains the HARQ indication signal from a data RE to be demodulated based on the UE specific reference signal. Preferably, the data RE includes one or more data REs each having a time domain position and a frequency domain position contiguous to the UE specific reference signal.

Preferably, in step 406, the demodulation unit 230 demodulates the HARQ indication signal also based on (i) the number of data REs for transmitting the downlink physic HARQ indicator in each Resource Block (RB) and (ii) a demodulation scheme of the HARQ indication signal.

The present invention demodulates a downlink physical HARQ indicator based on UE specific reference signal by providing a novel method for transmitting/receiving a downlink physical HARQ indicator, a UE and a BS, which supplements the current standard.

It should be noted that the solution of the present invention has been described above by a way of example only. However, the present invention is not limited to the above steps and element structures. It is possible to adjust, add and remove the steps and elements structures depending on actual requirements. Thus, some of the steps and elements are not essential for achieving the general inventive concept of the present invention. Therefore, the features necessary for the present invention is only limited to a minimum requirement for achieving the general inventive concept of the present invention, rather than the above specific examples.

A number of examples have been illustrated in the above description. While the inventor has tried to list the examples in association with each other, it does not imply that it is required for the listed examples to have such correspondence as described. A number of solutions can be achieved by selecting examples having no correspondence as long as the conditions underlying the selected examples do not conflict with ea other. Such solutions are encompassed by the scope of the present invention.

The present invention has been described above with reference to the preferred embodiments thereof. It should be understood that various modifications, alternations and additions can be made by those skilled in the art without departing from the spirits and scope of the present invention. Therefore, the scope of the present invention is not limited to the above particular embodiments but only defined by the claims as attached.

CLAIMS

1. A method for transmitting a downlink physical Hybrid Automatic Repeat reQuest (HARQ) indicator, comprising steps of:

modulating the downlink physical HARQ indicator into a modulated symbol;

generating, based on the modulated symbol, an HARQ indication signal to be demodulated based on a User Equipment (UE) specific reference signal; and

transmitting the HARQ indication signal using the antenna port(s).

2. The method of claim 1, wherein

the antenna port has two sets of UE specific reference signals in time domain, each set of UE specific reference signals being transmitted over a plurality of frequency domain sub-carriers and including two Resource Elements (REs) in each frequency domain sub-carrier, the two REs having the same frequency domain position and contiguous time domain positions; and

the step of generating the HARQ indication signal comprises:

multiplying the modulated symbol with one of the two sets of UE specific reference signals corresponding to the antenna port to generate the HARQ indication signal.

3. The method of claim 1, wherein

the antenna port has two sets of UE specific reference signals in time domain, each set of UE specific reference signals being transmitted over a plurality of frequency domain sub-carriers and including two Resource Elements (REs) in each frequency domain sub-carrier, the two REs having the same frequency domain position and contiguous time domain positions; and

the step of generating the HARQ indication signal comprises:

multiplying the modulated symbol with the two sets of UE specific reference signals corresponding to the antenna port to generate the HARQ indication signal.

4. The method of claim 1, wherein the step of generating the HARQ indication signal comprises:

mapping the modulated signal to a data RE to be demodulated based on the UE specific reference signal, so as to generate the HARQ indication signal.

5. The method of claim 4, wherein

the data RE comprises one or more data REs each having a time domain position and a frequency domain position contiguous to the UE specific reference signal.

6. The method of claim 4 or 5, further comprising, prior to modulating the downlink physical HARQ indicator into the modulated symbol,

determining the number of data REs for transmitting the downlink physical HARQ indicator in each Resource Block (RB).

7. The method of claim 6, wherein

the number of data REs for transmitting the downlink physical HARQ indicator in each RB is determined based on (i) the number of RBs used for uplink schedule transmission corresponding to the downlink physical HARQ indicator and (2) the number of bits of the downlink physical HARQ indicator.

8. The method of claim 6, wherein

if the downlink physical HARQ indicator is multiplexed with data in a Physical Downlink Shared Channel (PDSCH) of the UE, the number of data REs for transmitting the downlink physical HARQ indicator in each RB is determined based on the number of uncoded bits transmitted in each RE in the PDSCH, the number of bits of the downlink physical HARQ indicator and an adjustment parameter.

9. A Base Station (BS), comprising:

a modulation unit configured to modulate a downli physical Hybrid Automatic Repeat reQuest (HARQ) indicator into a modulated symbol;

a signal generation unit configured to generate, based on the modulated symbol modulated by the modulation unit, an HARQ indication signal to be demodulated based on a User Equipment (UE) specific reference signal; and

a transmission unit configured to transmit the HARQ indication signal generated by the signal generation unit using the antenna port(s).

10. The BS of claim 9, wherein

the antenna port has two sets of UE specific reference signals in time domain, each set of UE specific reference signals being transmitted over a plurality of frequency domain sub-carriers and including two Resource Elements (REs) in each frequency domain sub-carrier, the two REs having the same frequency domain position and contiguous time domain positions; and

the signal generation unit is configured to:

multiply the modulated symbol modulated by the modulation unit with one of the two sets of UE specific reference signals corresponding to the antenna port to generate the HARQ indication signal.

11. The BS of claim 9, wherein

the antenna port has two sets of UE specific reference signals in time domain, each set of UE specific reference signals being transmitted over a plurality of frequency domain sub-carriers and including two Resource Elements (REs) in each frequency domain sub-carrier, the two REs having the same frequency domain position and contiguous time domain positions; and

the signal generation unit is configured to:

multiply the modulated symbol modulated by the modulation unit with the two sets of UE specific reference signals corresponding to the antenna port to generate the HARQ indication signal.

12. The BS of claim 9, wherein the signal generation unit is configured to:

map the modulated signal to a data RE to be demodulated based on the UE specific reference signal, so as to generate the HARQ indication signal.

13. The BS of claim 12, wherein

the data RE comprises one or more data REs each having a time domain position and a frequency domain position contiguous to the UE specific reference signal.

14. The BS of claim 12 or 13, further comprising:

a determination unit configured to determine the number of data REs for transmitting the downlink physical HARQ indicator in each Resource Block (RB).

15. The BS of claim 14, wherein

the determination unit is configured to determine the number of data REs for transmitting the downlink physical HARQ indicator in each RB based on (i) the number of RBs used for uplink schedule transmission corresponding to the downlink physical HARQ indicator and (ii) the number of bits of the downlink physical HARQ indicator.

16. The BS of claim 14, wherein

the determination unit is configured to determine the number of data REs for transmitting the downlink physical HARQ indicator in each RB based on (i) the number of uncoded bits transmitted in each RE in the PDSCH, (ii) the number of bits of the downlink physical HARQ indicator and (iii) an adjustment parameter, if the downlink physical HARQ indicator is multiplexed with data in a Physical Downlink Shared Channel (PDSCH) of the UE.

17. A method for receiving a downlink physical Hybrid Automatic Repeat reQuest (HARQ) indicator, comprising steps

of:

receiving from the antenna port(s) a User Equipment (UE) specific reference signal;

obtaining an HARQ indication signal which is generated based on the downlink physical HARQ indicator; and

demodulating the HARQ indication signal based on the UE specific reference signal to detect the downlink physical HARQ indicator.

18. The method of claim 17, wherein

the antenna port has two sets of UE specific reference signals in time domain, each set of UE specific reference signals being transmitted over a plurality of frequency domain sub-carriers and including two Resource Elements (REs) in each frequency domain sub-carrier, the two REs having the same frequency domain position and contiguous time domain positions; and

the step of obtaining the HARQ indication signal comprises:

determining a signal in the REs corresponding to one of the two sets of UE specific reference signals as the HARQ indication signal,

the step of demodulating the HARQ indication signal comprises:

providing a reference phase based on the UE specific reference signals in the REs corresponding to the other one the two sets of UE specific reference signals; and

demodulating the determined HARQ indication signal based on the reference phase.

19. The method of claim 17, wherein

the antenna port has two sets of UE specific reference signals in time domain, each set of UE specific reference signals being transmitted over a plurality of frequency domain sub-carriers and including two Resource Elements (REs) in each frequency domain sub-carrier, the two REs having the same frequency domain position and contiguous time domain positions; and

the step of obtaining the HARQ indication signal comprises:

determining a signal in the REs corresponding to the two sets of UE specific reference signals as the HARQ indication signal,

the step of demodulating the HARQ indication signal comprises:

providing a reference phase based on two sets of UE specific reference signals received from a further antenna port; and

demodulating the determined HARQ indication signal based on the reference phase.

20. The method of claim 17, wherein the step of obtaining the HARQ indication signal comprises:

obtaining the HARQ indication signal from a data RE to be demodulated based on the UE specific reference signal.

21. The method of claim 20, wherein

the data RE comprises one or more data REs each having a time domain position and a frequency domain position contiguous to the UE specific reference signal.

22. The method of claim 20 or 21, wherein the step of demodulating the HARQ indication signal comprises:

demodulating the HARQ indication signal also based on (i) the number of data REs for transmitting the downlink physical HARQ indicator in each Resource Block (RB) and (ii) a demodulation scheme of the HARQ indication signal.

23. A User Equipment (UE), comprising:

a reception unit configured to receive from the antenna port(s) a UE specific reference signal;

a signal obtaining unit configured to obtain a Hybrid Automatic Repeat reQuest (HARQ) indication signal which is generated based on the downlink physical HARQ indicator; and

a demodulation unit configured to demodulate the HARQ indication signal based on the UE specific reference signal detect the downlink physical HARQ indicator.

24. The UE of claim 23, wherein

the antenna port has two sets of UE specific reference signals in time domain, each set of UE specific reference signals being transmitted over a plurality of frequency domain sub-carriers and including two Resource Elements (REs) in each frequency domain sub-carrier, the two REs having the same frequency domain position and contiguous time domain positions; and

the signal obtaining unit is configured to:

determine a signal in the REs corresponding to one of the two sets of UE specific reference signals as the HARQ indication signal,

the demodulation unit is configured to:

provide a reference phase based on the UE specific reference signals in the REs corresponding to the other one of the two sets of UE specific reference signals; and

demodulate the determined HARQ indication signal based on the reference phase.

25. The UE of claim 23, wherein

the antenna port has two sets of UE specific reference signals in time domain, each set of UE specific reference signals being transmitted over a plurality of frequency doma sub-carriers and including two Resource Elements (REs) in each frequency domain sub-carrier, the two REs having the same frequency domain position and contiguous time domain positions; and

the signal obtaining unit is configured to:

determine a signal in the REs corresponding to the two sets of UE specific reference signals as the HARQ indication signal,

the demodulation unit is configured to:

provide a reference phase based on two sets of UE specific reference signals received from a further antenna port; and

demodulate the determined HARQ indication signal based on the reference phase.

26. The UE of claim 23, wherein the signal obtaining unit is configured to:

obtain the HARQ indication signal from a data RE to be demodulated based on the UE specific reference signal.

27. The UE of claim 26, wherein

the data RE comprises one or more data REs each having a time domain position and a frequency domain position contiguous to the UE specific reference signal.

28. The UE of claim 26 or 27, wherein the demodulatic unit is configured to:

demodulate the HARQ indication signal also based on (i) the number of data REs for transmitting the downlink physical HARQ indicator in each Resource Block (RB) and (ii) a demodulation scheme of the HARQ indication signal.

29. A method for transmitting a downlink physical Hybrid Automatic Repeat reQuest (HARQ) indicator, comprising steps of:

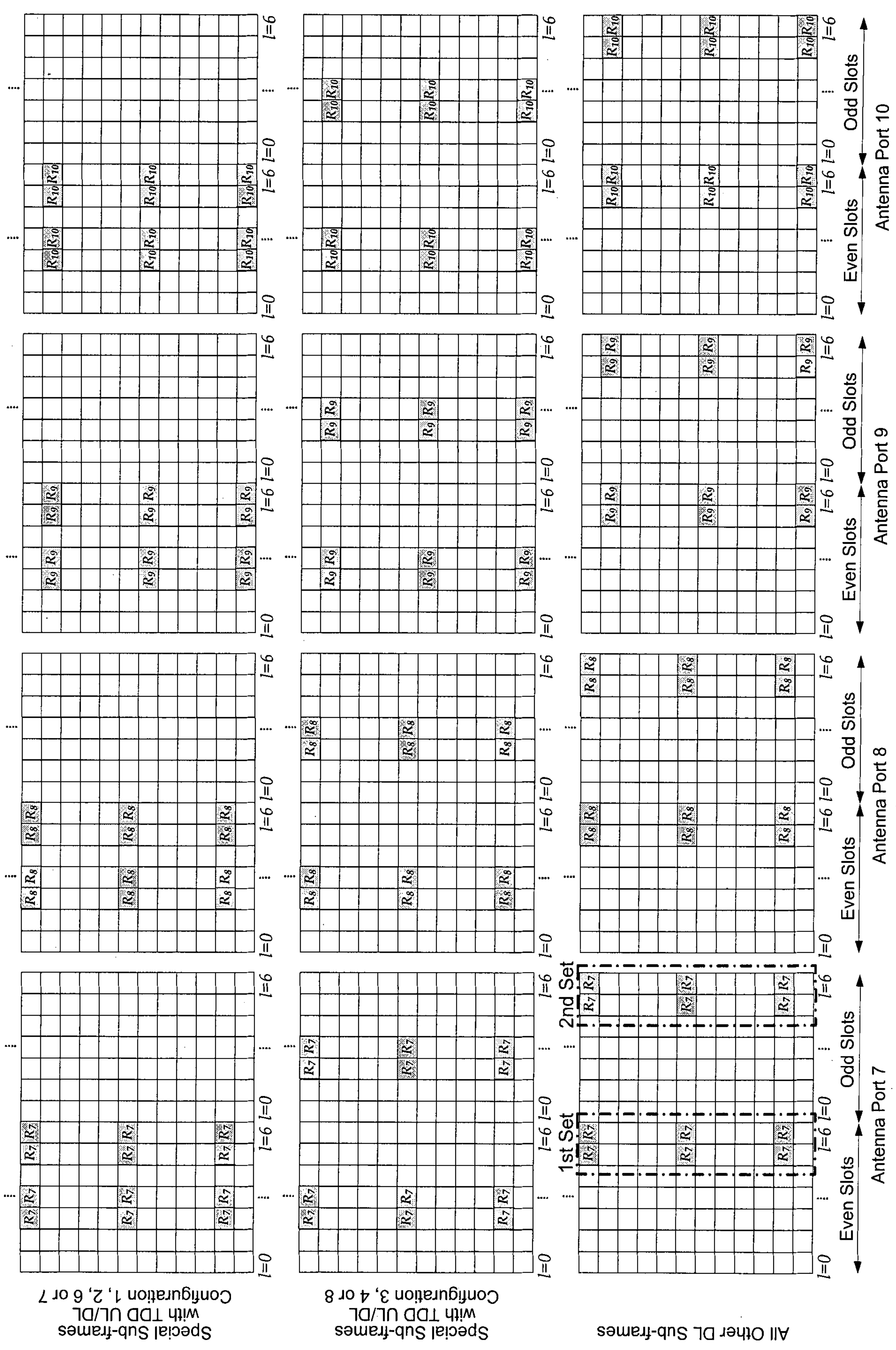
generating an HARQ indication signal based on the downlink physical HARQ indicator; and

transmitting the HARQ indication signal using a Resource Block (RB) and the antenna port(s),

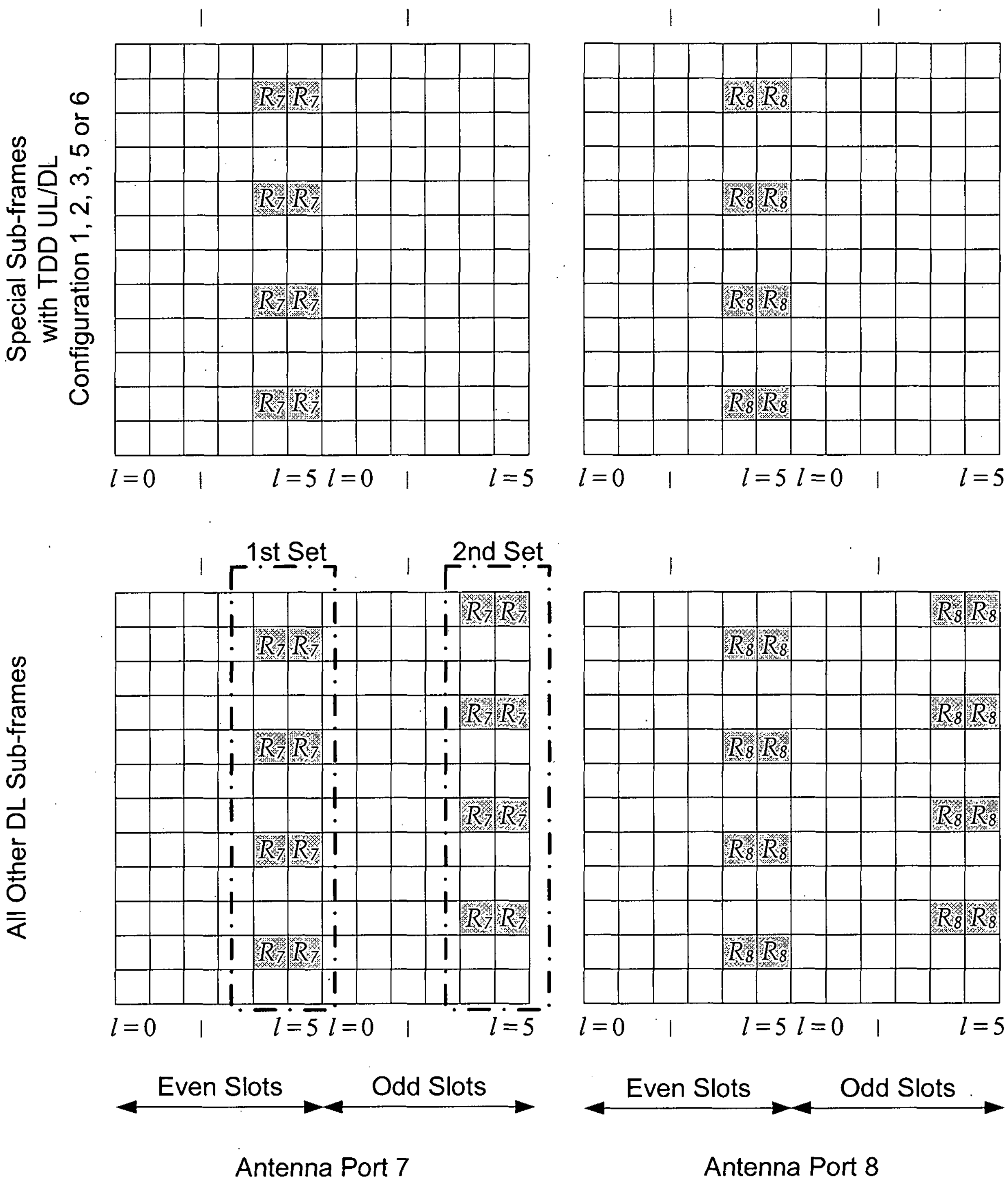
wherein the RB for transmitting the HARQ indication signal comprises the first RB used for uplink schedule transmission corresponding to the HARQ indication signal and the antenna port for transmitting the HARQ indication signal comprises the antenna port(s) used for transmission of the uplink schedule corresponding to the HARQ indication signal.

30. The method of claim 29, wherein the antenna port for transmitting the HARQ indication signal further comprises an additional antenna port.

F I G. 1


Special Sub-frames with TDD UL/DL Configuration 1, 2, 6 or 7
Special Sub-frames with TDD UL/DL Configuration 3, 4 or 8
All Other DL Sub-frames
Antenna Port 7
Antenna Port 8
Antenna Port 9
Antenna Port 10
Even Slots
Odd Slots
1st Set
2nd Set
l=0
l=6
R7
R8
R9
R10

F I G. 2



Special Sub-frames with TDD UL/DL Configuration 1, 2, 3, 5 or 6
All Other DL Sub-frames
1st Set
2nd Set
R7
R8
l=0
l=5
Even Slots
Odd Slots
Antenna Port 7
Antenna Port 8

F I G. 3

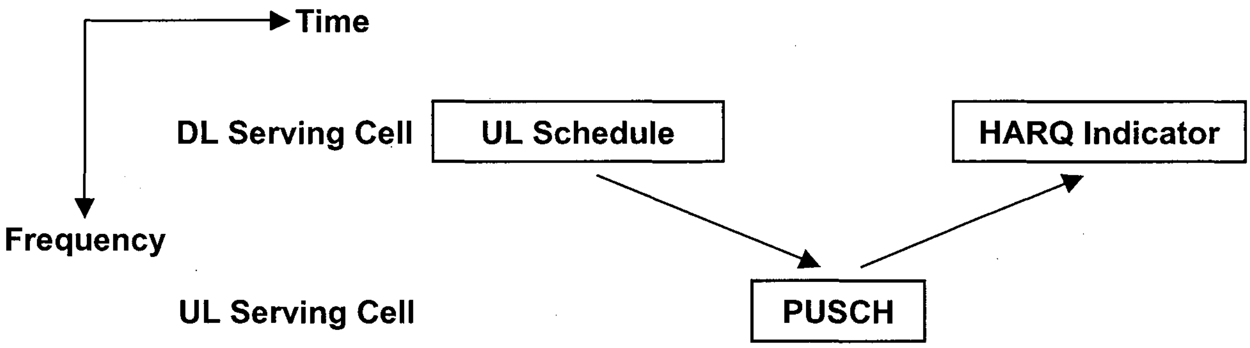

Time
Frequency
DL Serving Cell
UL Schedule
HARQ Indicator
UL Serving Cell
PUSCH

FIG. 4

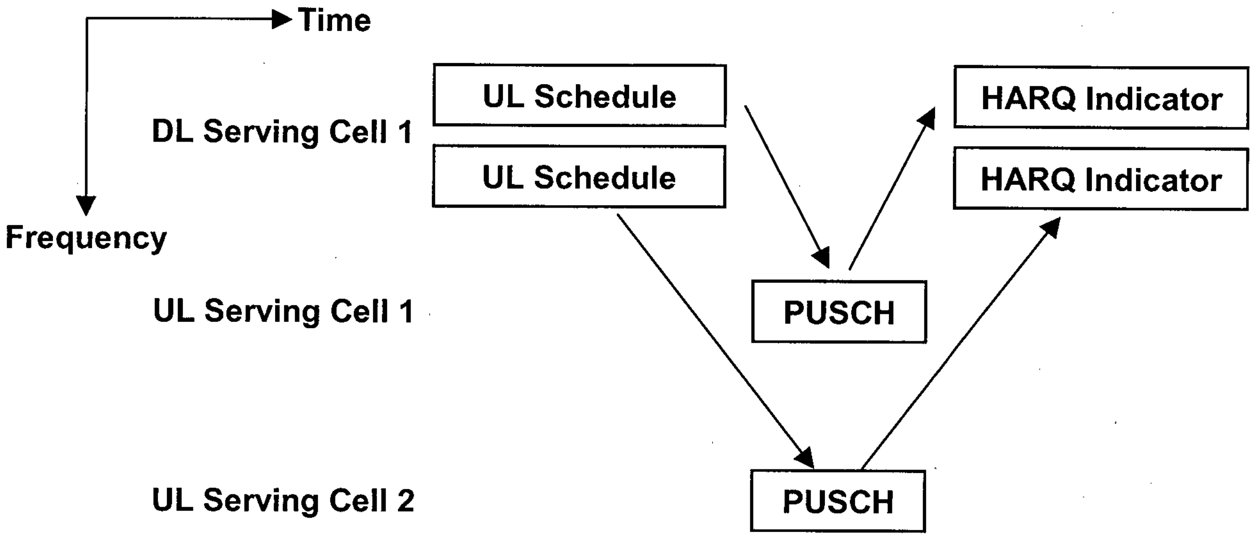

Time
Frequency
DL Serving Cell 1
UL Serving Cell 1
UL Serving Cell 2
UL Schedule
UL Schedule
HARQ Indicator
HARQ Indicator
PUSCH
PUSCH

FIG. 5

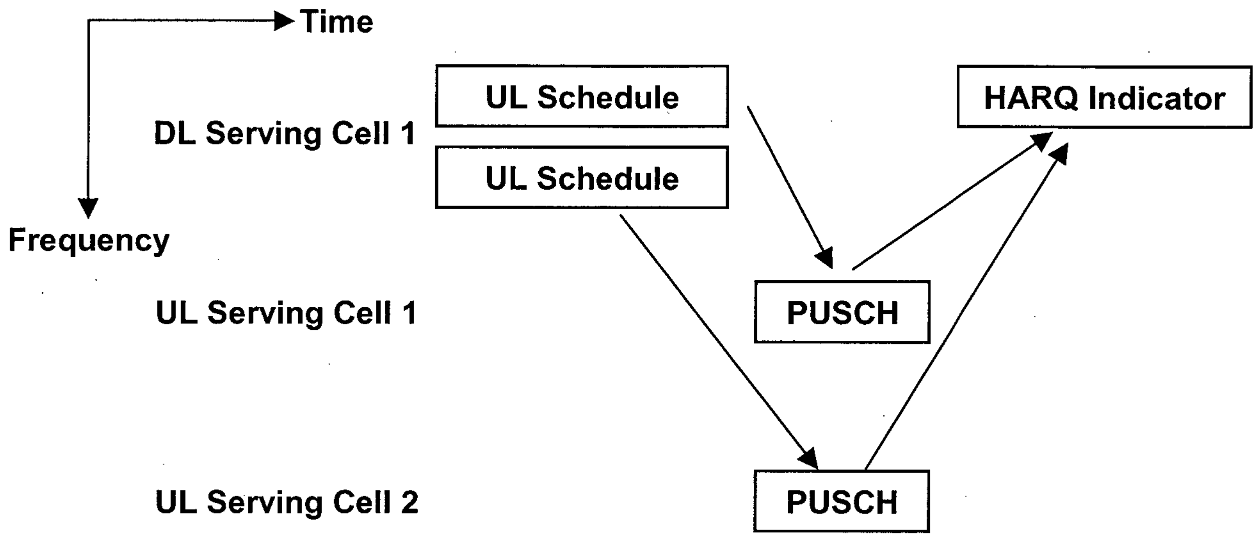
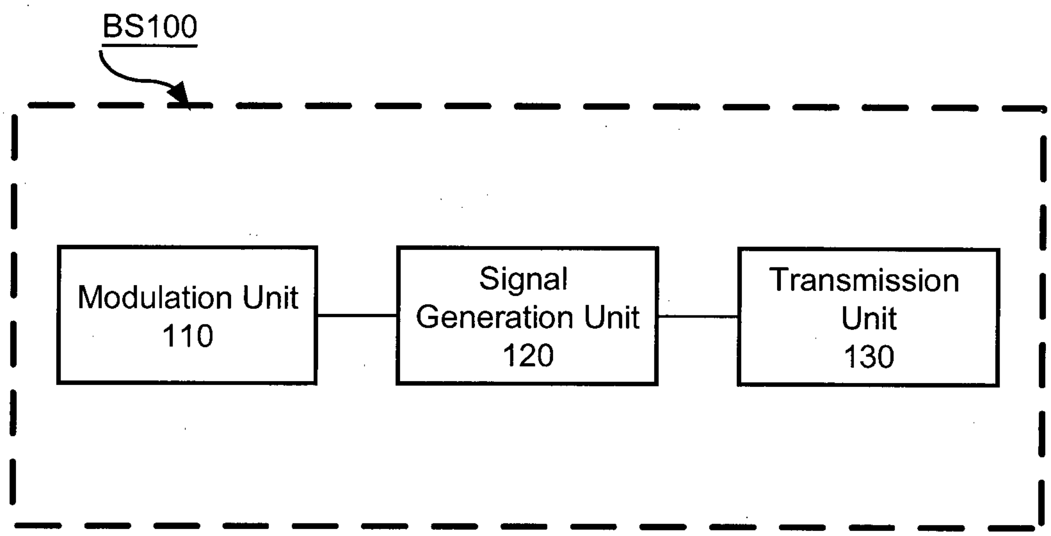

Time
Frequency
DL Serving Cell 1
UL Serving Cell 1
UL Serving Cell 2
UL Schedule
UL Schedule
PUSCH
PUSCH
HARQ Indicator

FIG. 6


BS100
Modulation Unit
110
Signal
Generation Unit
120
Transmission
Unit
130

F I G. 7

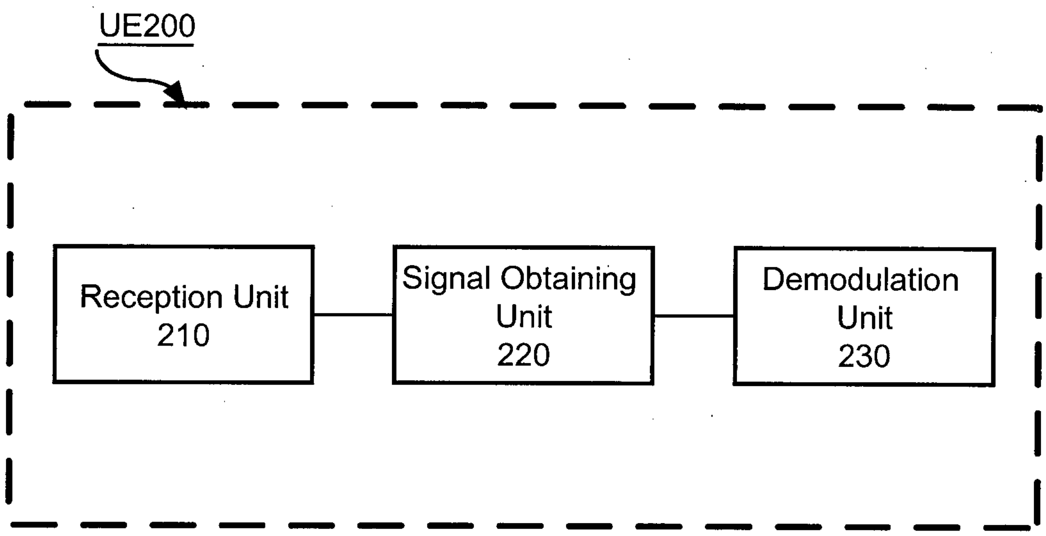
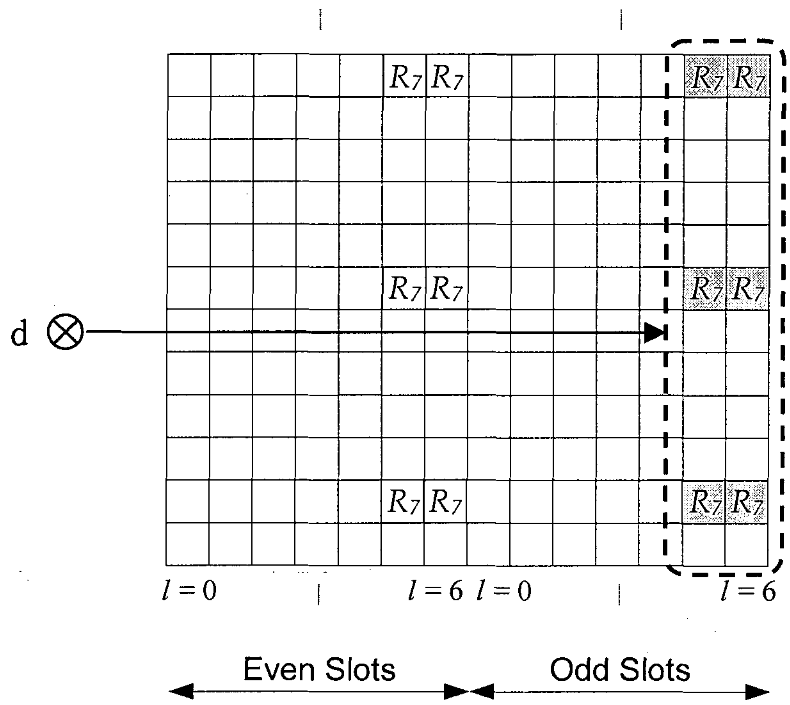
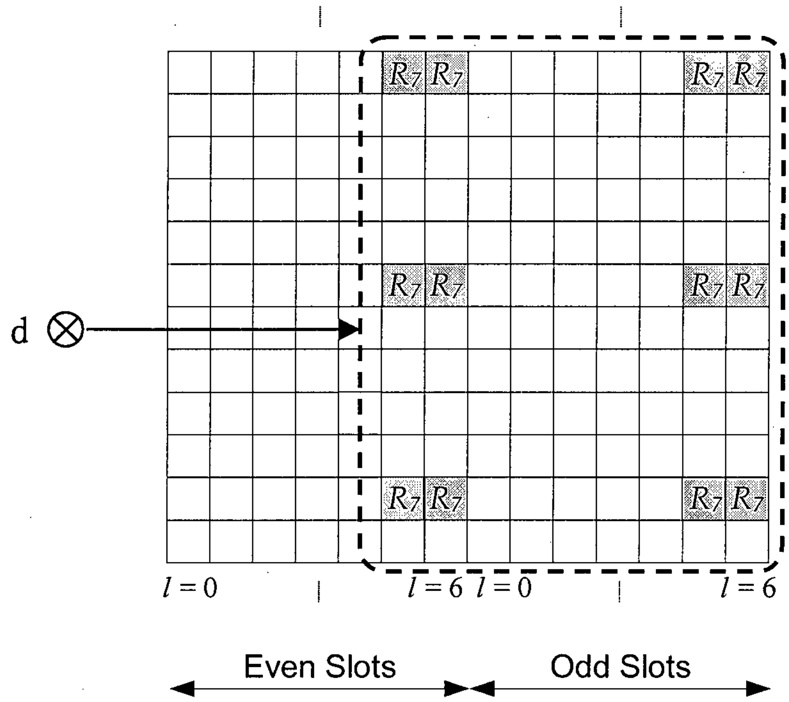

UE200
Reception Unit 210
Signal Obtaining Unit 220
Demodulation Unit 230

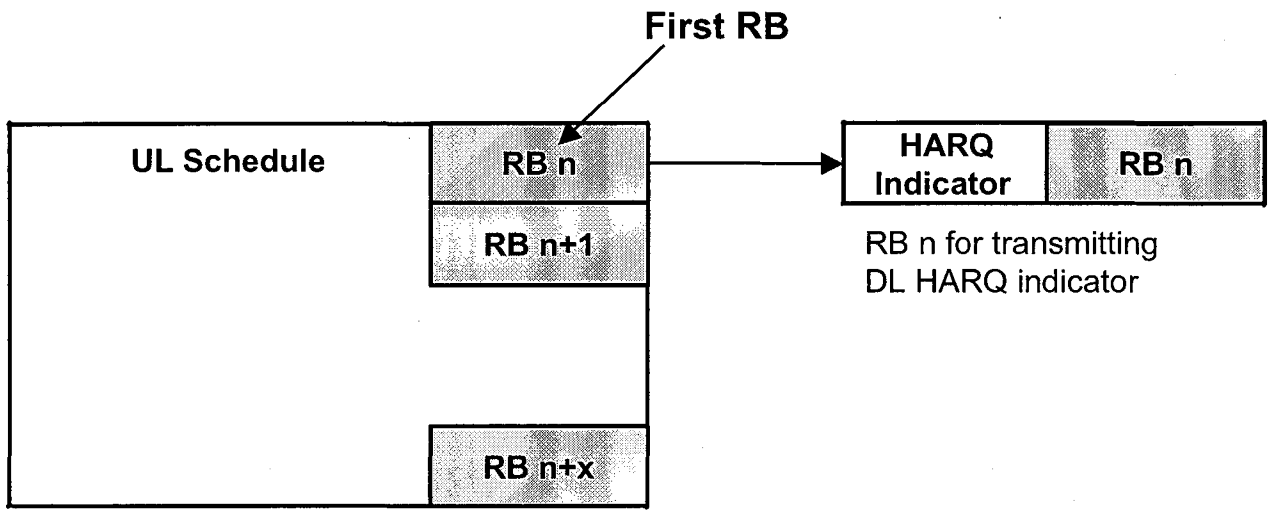
FIG. 8



F I G. 9


R_7 R_7 R_7 R_7
R_7 R_7 R_7 R_7
R_7 R_7 R_7 R_7
d ⊗
$l = 0$
$l = 6$ $l = 0$
$l = 6$
Even Slots
Odd Slots

F I G. 1 0



RBs for UL schedule transmission

FIG. 11

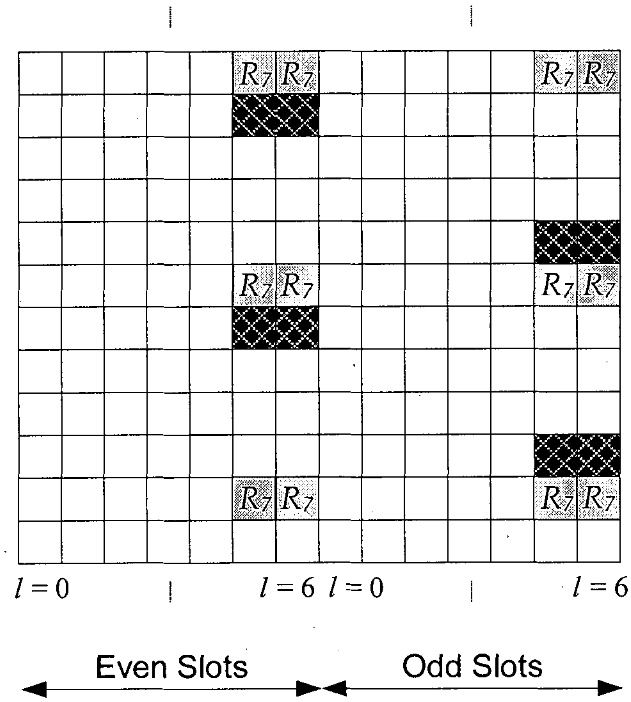


FIG. 12

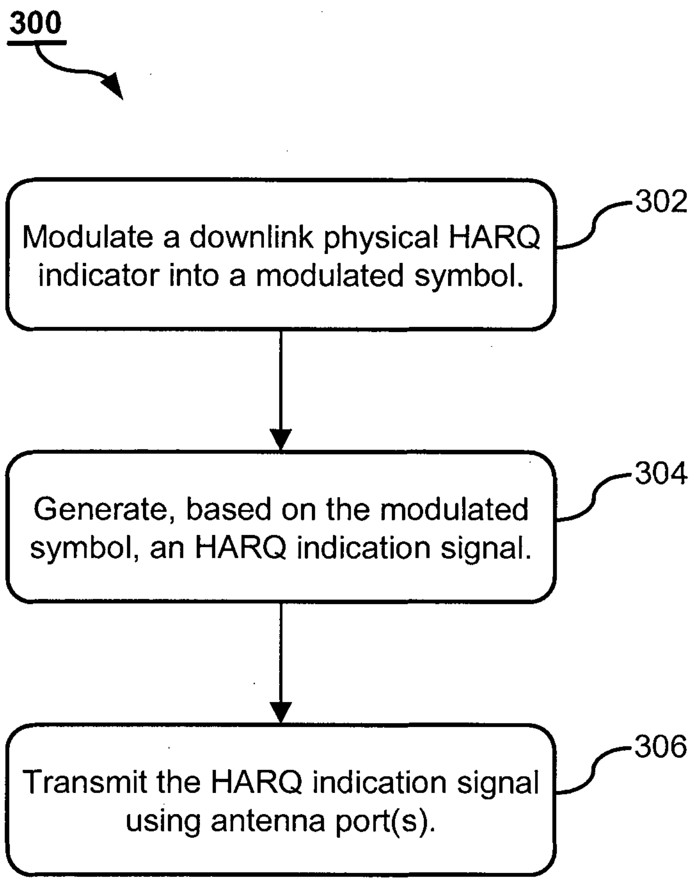
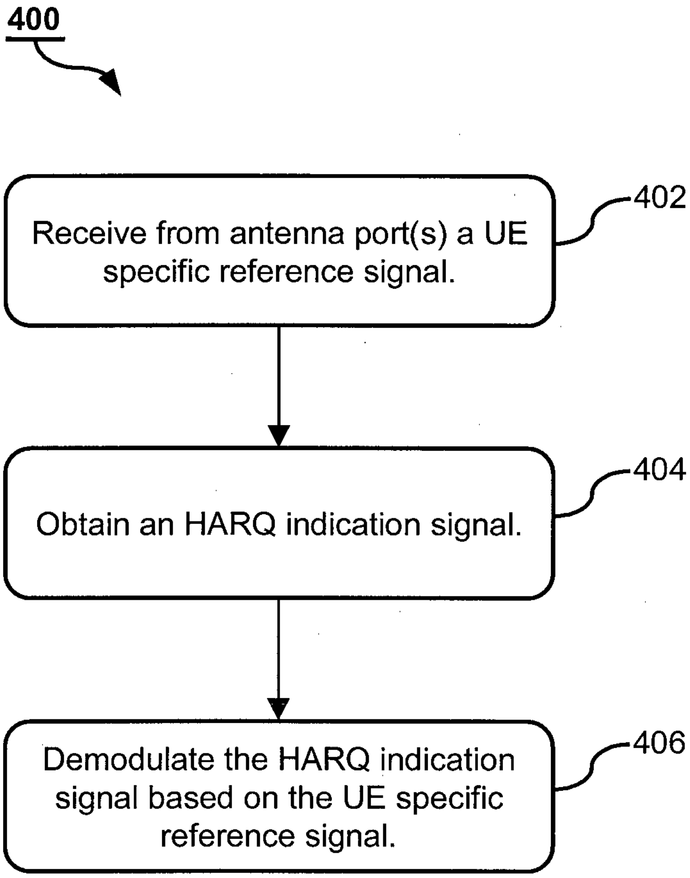

300
Modulate a downlink physical HARQ indicator into a modulated symbol.
302
Generate, based on the modulated symbol, an HARQ indication signal.
304
Transmit the HARQ indication signal using antenna port(s).
306

FIG. 13


400
Receive from antenna port(s) a UE specific reference signal.
402
Obtain an HARQ indication signal.
404
Demodulate the HARQ indication signal based on the UE specific reference signal.
406

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/068254

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. H04W28/04(2009.01)i

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)

Int.Cl. H04W28/04

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

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2012
Registered utility model specifications of Japan 1996-2012
Published registered utility model applications of Japan 1994-2012

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	3GPP TS 36.213, V10.2.0, 2011.06, p.64-70,92-114	1-30
A	Samsung, HARQ operation in Un downlink and uplink, 3GPP TSG RAN WG1 Meeting #60, R1-101195, 2010.02.26	1-30
A	3GPP TS 36.211, V10.2.0, 2011.06, p.80-85	1-30

☐ Further documents are listed in the continuation of Box C.　　☐ 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
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
05.10.2012	16.10.2012

Name and mailing address of the ISA/JP	Authorized officer
Japan Patent Office	Kazushige Ito　5J 8839
3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Telephone No. +81-3-3581-1101 Ext. 3534