transmission modes.

[0026] (Configuration of Base Station)

FIG.~~11~~4 is a block diagram showing the configuration of base station 100 according to this embodiment.

[0027] In base station 100 as shown in FIG.4, setting section 101 sets control parameters related to resource allocation for control information (including at least ACK/NACK signals or CQIs) transmitted in an uplink data channel (PUSCH) used to communicate with a terminal for which the control parameters are set based on the transmitting and receiving capability of the terminal (i.e., UE capability) or the state of the transmission path. The control parameters include, for example, an amount of offset (for example, an amount of offset β_{offset}^{PUSCH} as shown in equation 2) used in allocation of resource of control information transmitted by the terminal for which the control parameters are set. Setting section 101 outputs setting information including the control parameters to coding and modulating section 102 and ACK/NACK and CQI receiving section 111.

[0028] For terminals performing the non-MIMO transmission, setting section 101 generates MCS information for a single CW (or transport block) and allocation control information including resource (or resource block (RB)) allocation information, while for terminals performing SU-MIMO transmission, setting section 101 generates allocation control information including MCS information for the two CWs (or transport blocks), or the like.

[0029] The allocation control information generated by setting section 101 includes uplink allocation control information

data (PDSCH signals) from the channel (for example, PUSCH) to which uplink data signals have been assigned.

[0039] If the traffic state in cells covered by base station 100 remains unchanged or if the measurement of an average reception quality is needed, control parameters (for example, the amount of offset β_{offset}^{PUSCH}) to be notified by base station 100 to terminal 200 should preferably be transmitted in an upper layer at a long notification interval (RRC signaling) from a perspective of signaling. Transmitting all or part of these control parameters as broadcast information leads to a reduction in an amount of resource required for the notification. On the contrary, if control parameters need to be dynamically changed in response to the traffic state in cells covered by base station 100, all or part of these control parameters should preferably be notified in a PDCCH at a short notification interval.

[0040] (Terminal Configuration)

FIG.~~12~~5 is a block diagram showing the configuration of terminal 200 in accordance with Embodiment 1 of the present invention. Terminal 200 is an LTE-A terminal which receives data signals (downlink data) and transmits an ACK/NACK signal corresponding to the data signals through a physical uplink control channel (PUCCH) or PUSCH to base station 100. Terminal 200 transmits a CQI to base station 100 in accordance with instruction information notified through a physical downlink control channel (PDCCH).

[0041] In terminal 200 shown in FIG.5, reception section 202 performs radio processing (down-conversion and analog-digital

CLAIMS

1. A terminal apparatus that transmits control information ~~in~~ on a plurality of layers, the apparatus comprising:

a determining section that determines an amount of resource of the control information ~~in~~ on the plurality of layers; and

a transmission section that transmits the control information based on the amount of the resource of the control information, wherein

the amount of the resource $Q_{CW\#0+CW\#1}$ of the control information is common among the plurality of layers and is determined by equation 1:

$$Q_{CW\#0+CW\#1} = \left\lceil (O+P) \cdot \frac{L_{CW\#0} + L_{CW\#1}}{\frac{\sum_{r=0}^{C_{CW\#0}-1} K_r^{CW\#0}}{M_{CW\#0sc}^{PUSCH\text{-}initial} \cdot N_{CW\#0symb}^{PUSCH\text{-}initial}} \times L_{CW\#0} + \frac{\sum_{r=0}^{C_{CW\#1}-1} K_r^{CW\#1}}{M_{CW\#1sc}^{PUSCH\text{-}initial} \cdot N_{CW\#1symb}^{PUSCH\text{-}initial}} \times L_{CW\#1}} \cdot \beta_{offset}^{PUSCH} / L \right\rceil$$

... (Equation 1)

where O indicates the number of bits in the control information, P indicates the number of error correction bits added to the control information, β_{offset}^{PUSCH} indicates an amount of offset, L indicates the number of the plurality of layers, $L_{CW\#0}$ and $L_{CW\#1}$ each indicate the number of layers assigned to a corresponding one of code words #0 and #1, $M_{CW\#0SC}^{PUSCH\text{-}initial}$ and $M_{CW\#1SC}^{PUSCH\text{-}initial}$ indicate physical uplink shared channel (PUSCH) transmission bandwidths for the code words #0 and #1, respectively, the transmission bandwidth for the code word #0 can be different from the transmission bandwidth for the code word #1, $N_{CW\#0symb}^{PUSCH\text{-}initial}$ and $N_{CW\#1symb}^{PUSCH\text{-}initial}$ each indicate the number of transmission symbols for a corresponding one of the code words #0 and #1, $K_r^{CW\#0}$ and $K_r^{CW\#1}$ each indicate the number of bits in each code block r for a corresponding one of the code words #0 and #1, and $C_{CW\#0}$ and $C_{CW\#1}$ each indicate the number of code blocks into which a data signal in a corresponding one of the code words #0 and #1 is divided.

2. The terminal apparatus according to claim 1, wherein P is zero.

3. The terminal apparatus according to claim 1, wherein L is a sum of $L_{CW\#0}$ and $L_{CW\#1}$.

4. The terminal apparatus according to claim 1, wherein a product of $M_{CW\#0SC}^{PUSCH\text{-}initial}$ and $N_{CW\#0symb}^{PUSCH\text{-}initial}$ is a product of $M_{CW\#0SC}^{PUSCH\text{-}initial(0)}$, $L_{CW\#0}$ and the number of transmission symbols in each layer for code word #0, and a product of $M_{CW\#1SC}^{PUSCH\text{-}initial}$ and

$N_{CW\#1symb}^{PUSCH\text{-}initial}$ is a product of $M_{CW\#1SC}^{PUSCH\text{-}initial(1)}$, $L_{CW\#1}$, and the number of transmission symbols in each layer for the code word #1.

5. The terminal apparatus according to claim 1, wherein the control information is an acknowledgement/negative acknowledgement (ACK/NACK) signal.

6. A base station apparatus that receives control information ~~in~~ on a plurality of layers, the apparatus comprising:

a reception section that receives a signal including the control information; and

a control information extracting section that determines an amount of resource of the control information ~~in~~ on the plurality of layers and extracts the control information from the received signal based on the amount of the resource of the control information, wherein

the amount of the resource $Q_{CW\#0+CW\#1}$ of the control information is common among the plurality of layers and is determined by equation 1:

$$Q_{CW\#0+CW\#1} = \left\lceil (O+P) \cdot \frac{L_{CW\#0} + L_{CW\#1}}{\frac{\sum_{r=0}^{C_{CW\#0}-1} K_r^{CW\#0}}{M_{CW\#0sc}^{PUSCH\text{-}initial} \cdot N_{CW\#0symb}^{PUSCH\text{-}initial}} \times L_{CW\#0} + \frac{\sum_{r=0}^{C_{CW\#1}-1} K_r^{CW\#1}}{M_{CW\#1sc}^{PUSCH\text{-}initial} \cdot N_{CW\#1symb}^{PUSCH\text{-}initial}} \times L_{CW\#1}} \cdot \beta_{offset}^{PUSCH} / L \right\rceil$$

... (Equation 1)

where O indicates the number of bits in the control information, P indicates the number of error correction bits added to the control information, β_{offset}^{PUSCH} indicates an amount of offset, L indicates the number of the plurality of layers, $L_{CW\#0}$ and $L_{CW\#1}$ each indicate the number of layers assigned to a corresponding one of code words #0 and #1, $M_{CW\#0SC}^{PUSCH\text{-}initial}$ and $M_{CW\#1SC}^{PUSCH\text{-}initial}$ indicate physical uplink shared channel (PUSCH) transmission bandwidths for the code words #0 and #1, respectively, the transmission bandwidth for the code word #0 can be different from the transmission bandwidth for the code word #1, $N_{CW\#0symb}^{PUSCH\text{-}initial}$ and $N_{CW\#1symb}^{PUSCH\text{-}initial}$ each indicate the number of transmission symbols for a corresponding one of the code words #0 and #1, and $K_r^{CW\#0}$ and $K_r^{CW\#1}$ each indicate the number of bits in each code block r for a corresponding one of the code words #0 and #1, and $C_{CW\#0}$ and $C_{CW\#1}$ each indicate the number of code blocks into which a data signal in a corresponding one of the code words #0 and #1 is divided.

7. The base station apparatus according to claim 6, wherein P is zero.

8. The base station apparatus according to claim 6, wherein L is a sum of $L_{CW\#0}$ and $L_{CW\#1}$.

9. The base station apparatus according to claim 6, wherein a product of $M_{CW\#0SC}^{PUSCH\text{-}initial}$ and $N_{CW\#0symb}^{PUSCH\text{-}initial}$ is a product of $M_{CW\#0SC}^{PUSCH\text{-}initial(0)}$, $L_{CW\#0}$ and the number of transmission symbols in each layer for code word #0, and a product of $M_{CW\#1SC}^{PUSCH\text{-}initial}$ and $N_{CW\#1symb}^{PUSCH\text{-}initial}$ is a product of $M_{CW\#1SC}^{PUSCH\text{-}initial(1)}$, $L_{CW\#1}$ and the number of transmission symbols in each layer for the code word #1.

10. The base station apparatus according to claim 6, wherein the control information is an acknowledgement/negative acknowledgement (ACK/NACK) signal.

11. A transmission method for transmitting control information ~~in~~ on a plurality of layers, the method comprising:

determining an amount of resource of the control information ~~in~~ on the plurality of layers; and

transmitting the control information based on the amount of the resource of the control information, wherein

the amount of the resource $Q_{CW\#0+CW\#1}$ of the control information is common among the plurality of layers and is determined by equation 1:

$$Q_{CW\#0+CW\#1} = \left\lceil (O+P) \cdot \frac{L_{CW\#0} + L_{CW\#1}}{\frac{\sum_{r=0}^{C_{CW\#0}-1} K_r^{CW\#0}}{M_{CW\#0_{sc}}^{PUSCH\text{-}initial} \cdot N_{CW\#0_{symb}}^{PUSCH\text{-}initial}} \times L_{CW\#0} + \frac{\sum_{r=0}^{C_{CW\#1}-1} K_r^{CW\#1}}{M_{CW\#1_{sc}}^{PUSCH\text{-}initial} \cdot N_{CW\#1_{symb}}^{PUSCH\text{-}initial}} \times L_{CW\#1}} \cdot \beta_{offset}^{PUSCH} / L \right\rceil$$

... (Equation 1)

where O indicates the number of bits in the control information, P indicates the number of error correction bits added to the control information, β_{offset}^{PUSCH} indicates an amount of offset, L indicates the number of the plurality of layers, $L_{CW\#0}$ and $L_{CW\#1}$ each indicate the number of layers assigned to a corresponding one of code words #0 and #1, $M_{CW\#0SC}^{PUSCH\text{-}initial}$ and $M_{CW\#1SC}^{PUSCH\text{-}initial}$ indicate physical uplink shared channel (PUSCH) transmission bandwidths for the code words #0 and #1, respectively, the transmission bandwidth for the code word #0 can be different from the transmission bandwidth for the code word #1, $N_{CW\#0symb}^{PUSCH\text{-}initial}$ and $N_{CW\#1symb}^{PUSCH\text{-}initial}$ each indicate the number of transmission symbols for a corresponding one of the code words #0 and #1, $K_r^{CW\#0}$ and $K_r^{CW\#1}$ each indicate the number of bits in each code block r for a corresponding one of the code words #0 and #1, and $C_{CW\#0}$ and $C_{CW\#1}$ each indicate the

number of code blocks into which a data signal in a corresponding one of the code words #0 and #1 is divided.

12. A reception method for receiving control information ~~in~~ on a plurality of layers, the method comprising:

receiving a signal containing the control information;

determining an amount of resource of the control information ~~in~~ on the plurality of layers; and

extracting the control information from the received signal based on the amount of the resource of the control information, wherein

the amount of the resource $Q_{CW\#0+CW\#1}$ of the control information is common among the plurality of layers and is determined by equation 1:

$$Q_{CW\#0+CW\#1}=\left\lceil (O+P)\cdot \frac{L_{CW\#0}+L_{CW\#1}}{\frac{\sum_{r=0}^{C_{CW\#0}-1}K_r^{CW\#0}}{M_{CW\#0sc}^{PUSCH\text{-}initial}\cdot N_{CW\#0symb}^{PUSCH\text{-}initial}}\times L_{CW\#0}+\frac{\sum_{r=0}^{C_{CW\#1}-1}K_r^{CW\#1}}{M_{CW\#1sc}^{PUSCH\text{-}initial}\cdot N_{CW\#1symb}^{PUSCH\text{-}initial}}\times L_{CW\#1}}\cdot \beta_{offset}^{PUSCH}/L \right\rceil$$

... (Equation 1)

where O indicates the number of bits in the control information, P indicates the number of error correction bits added to the control information, β_{offset}^{PUSCH} indicates an amount of offset, L indicates the number of the plurality of layers, $L_{CW\#0}$ and $L_{CW\#1}$ each indicate the number of layers assigned to a corresponding one of code words #0 and #1, $M_{CW\#0SC}^{PUSCH\text{-}initial}$ and $M_{CW\#1SC}^{PUSCH\text{-}initial}$ indicate physical uplink shared channel (PUSCH) transmission bandwidths for the code words #0 and #1, respectively, the transmission bandwidth for the code word #0 can be different from the transmission bandwidth for the code word #1, $N_{CW\#0symb}^{PUSCH\text{-}initial}$ and $N_{CW\#1symb}^{PUSCH\text{-}initial}$ each indicate the number of transmission symbols for a corresponding one of the code words #0 and #1, $K_r^{CW\#0}$ and $K_r^{CW\#1}$ each indicate the number of bits in each code block r for a corresponding one of the code words #0 and #1, and $C_{CW\#0}$ and $C_{CW\#1}$ each indicate the number of code blocks into which a data signal in a corresponding one of the code words #0 and #1 is divided.

13. An integrated circuit for controlling a process comprising:

determining an amount of resource of control information ~~in~~ on a plurality of layers; and

transmitting the control information based on the amount of the resource of the control information, wherein

the amount of the resource $Q_{CW\#0+CW\#1}$ of the control information is common among the

plurality of layers and is determined by equation 1:

$$Q_{CW\#0+CW\#1}=\left\lceil (O+P)\cdot \frac{L_{CW\#0}+L_{CW\#1}}{\frac{\sum_{r=0}^{C_{CW\#0}-1}K_r^{CW\#0}}{M_{CW\#0sc}^{PUSCH\text{-}initial}\cdot N_{CW\#0symb}^{PUSCH\text{-}initial}}\times L_{CW\#0}+\frac{\sum_{r=0}^{C_{CW\#1}-1}K_r^{CW\#1}}{M_{CW\#1sc}^{PUSCH\text{-}initial}\cdot N_{CW\#1symb}^{PUSCH\text{-}initial}}\times L_{CW\#1}}\cdot \beta_{offset}^{PUSCH}/L \right\rceil$$

... (Equation 1)

where O indicates the number of bits in the control information, P indicates the number of error correction bits added to the control information, β_{offset}^{PUSCH} indicates an amount of offset, L indicates the number of the plurality of layers, $L_{CW\#0}$ and $L_{CW\#1}$ each indicate the number of layers assigned to a corresponding one of code words #0 and #1, $M_{CW\#0SC}^{PUSCH\text{-}initial}$ and $M_{CW\#1SC}^{PUSCH\text{-}initial}$ indicate physical uplink shared channel (PUSCH) transmission bandwidths for the code words #0 and #1, respectively, the transmission bandwidth for the code word #0 can be different from the transmission bandwidth for the code word #1, $N_{CW\#0symb}^{PUSCH\text{-}initial}$ and $N_{CW\#1symb}^{PUSCH\text{-}initial}$ each indicate the number of transmission symbols for a corresponding one of the code words #0 and #1, $K_r^{CW\#0}$ and $K_r^{CW\#1}$ each indicate the number of bits in each code block r for a corresponding one of the code words #0 and #1, and $C_{CW\#0}$ and $C_{CW\#1}$ each indicate the number of code blocks into which a data signal in a corresponding one of the code words #0 and #1 is divided.

14. An integrated circuit for controlling a process comprising:

receiving a signal containing control information;

determining an amount of resource of the control information ~~in~~ on a plurality of layers; and

extracting the control information from the received signal based on the amount of the resource of the control information, wherein

the amount of the resource $Q_{CW\#0+CW\#1}$ of the control information is common among the plurality of layers and is determined by equation 1:

$$Q_{CW\#0+CW\#1}=\left\lceil (O+P)\cdot \frac{L_{CW\#0}+L_{CW\#1}}{\frac{\sum_{r=0}^{C_{CW\#0}-1}K_r^{CW\#0}}{M_{CW\#0sc}^{PUSCH\text{-}initial}\cdot N_{CW\#0symb}^{PUSCH\text{-}initial}}\times L_{CW\#0}+\frac{\sum_{r=0}^{C_{CW\#1}-1}K_r^{CW\#1}}{M_{CW\#1sc}^{PUSCH\text{-}initial}\cdot N_{CW\#1symb}^{PUSCH\text{-}initial}}\times L_{CW\#1}}\cdot \beta_{offset}^{PUSCH}/L \right\rceil$$

... (Equation 1)

where O indicates the number of bits in the control information, P indicates the number of error correction bits added to the control information, β_{offset}^{PUSCH} indicates an amount of offset,

L indicates the number of the plurality of layers, $L_{CW\#0}$ and $L_{CW\#1}$ each indicate the number of layers assigned to a corresponding one of code words #0 and #1, $M_{CW\#0SC}^{PUSCH\text{-}initial}$ and $M_{CW\#1SC}^{PUSCH\text{-}initial}$ indicate physical uplink shared channel (PUSCH) transmission bandwidths for the code words #0 and #1, respectively, the transmission bandwidth for the code word #0 can be different from the transmission bandwidth for the code word #1, $N_{CW\#0symb}^{PUSCH\text{-}initial}$ and $N_{CW\#1symb}^{PUSCH\text{-}initial}$ each indicate the number of transmission symbols for a corresponding one of the code words #0 and #1, $K_r^{CW\#0}$ and $K_r^{CW\#1}$ each indicate the number of bits in each code block r for a corresponding one of the code words #0 and #1, and $C_{CW\#0}$ and $C_{CW\#1}$ each indicate the number of code blocks into which a data signal in a corresponding one of the code words #0 and #1 is divided.