in a lower reception quality than that required for all the CWs (i.e., reception quality required for control information in the LTE system).

[0019] Accordingly, embodiments~~it is an object~~ of the present invention ~~to~~ provide a terminal capable of preventing the degradation of reception quality of control information even in a case of adopting the SU-MIMO transmission method, and also ~~to~~ provide a communication method thereof.

Solution to Problem

[0020] Disclosed herein is~~A first aspect of the present invention provides~~ a terminal apparatus that transmits two code words to which control information is allocated, in a plurality of different layers, the apparatus including: a determination section that determines the amount of resource of the control information in each of the plurality of layers; and a transmission signal generating section that generates a transmission signal through modulation of the control information using the amount of the resource and allocation of the modulated control information to the two code words, in which the determination section determines the amount of the resource based on a lower coding rate of the coding rates of the two code words, or the average of the inverses of the coding rates of the two code words.

[0020a] According to a first aspect, there is provided a terminal apparatus that transmits control information on a plurality of layers, the apparatus comprising:

a determining section that determines an amount of resource of

the control information 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:

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

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, $M_{CW\#0SC}^{PUSCH-initial}$ and $M_{CW\#1SC}^{PUSCH-initial}$ 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, $N_{CW\#0symb}^{PUSCH-initial}$ and $N_{CW\#1symb}^{PUSCH-initial}$ 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.

[0020b] According to a second aspect, there is provided a base station apparatus that receives control information 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 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:

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

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.

[0021] Disclosed herein is ~~A second aspect of the present invention provides~~ a communication method including: determining an amount of resource of control information in each of a plurality of different layers in which two code words are transmitted, the control

information being allocated in the two code words; modulating the control information using the amount of the resource; and allocating the modulated control information in the two code words to generate a transmission signal, in which the amount of the resource is determined based on a lower coding rate of the coding rates of the two code words, or the average of the inverses of the coding rates of the two code words.

[0021a] According to a third aspect, there is provided a transmission method for transmitting control information on a plurality of layers, the method comprising:

determining an amount of resource of the control information 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:

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

... (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.

[0021b] According to a fourth aspect, there is provided a reception method for receiving control information on a plurality of layers, the method comprising:

receiving a signal containing the control information;

determining an amount of resource of the control information 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.

[0021c] According to a fifth aspect, there is provided an integrated circuit for controlling a process comprising:

determining an amount of resource of control information 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:

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

... (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.

[0021d] According to a sixth aspect, there is provided an integrated circuit for controlling a process comprising:

receiving a signal containing control information;

determining an amount of resource of the control information 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:

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

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.

Advantageous Effects of Invention

[0022] Embodiments of tThe present invention can prevent the degradation of reception quality of control information even in a case of adopting the SU-MIMO transmission method.

Brief Description of Drawings

[0023]

FIG.1 shows a conventional allocation of ACKs/NACKs and CQIs;

FIG.2 is a diagram provided for describing a table containing candidates for an offset amount in the conventional case;

FIG.3 is a diagram provided for describing a technical problem;

FIG.4 is a block diagram showing the configuration of a base station according to Embodiment 1 of the present invention;

FIG.5 is a block diagram showing the configuration of a terminal according to Embodiment 1 of the present invention;

FIG.6 shows exemplary correction factors according to