

CLAIMS

1. A transmission method of a transmission system, the transmission system having a first transmitter and a second transmitter, the transmission method comprising:

encoding input data to coded blocks each made up of a plurality of bits by using a predetermined error correction block coding scheme;

modulating each of the coded blocks to a first modulated signal s1 and a second modulated signal s2;

applying precoding by a fixed matrix F to the first modulated signal s1 and the second modulated signal s2 to obtain a first pre-coded signal z1' and a second pre-coded signal z2', wherein

the matrix F is expressed as:

$$\frac{1}{\sqrt{\alpha^2 + 1}} \begin{pmatrix} e^{j0} & \alpha \times e^{j0} \\ \alpha \times e^{j0} & e^{j\pi} \end{pmatrix}$$

where α represents a positive real number larger than or equal to 0;

inserting one or more pilots to each of the first pre-coded signal z1' and the second pre-coded signal z2' to obtain a first pilot-inserted signal z1'' and a second pilot-inserted signal z2'', respectively;

phase-changing, while regularly varying a scheme of phase change for each of a plurality of slots, at least one of the first pilot-inserted signal z1'' and the second pilot-inserted signal z2'' to obtain a first transmission signal z1 and a second transmission signal z2, wherein at least one of the encoding, the modulating, the precoding, the inserting, and the phase-changing is performed by both the first transmitter and the second transmitter; and

transmitting, by the first transmitter, (i) the first transmission signal z_1 from a first antenna at a first period at a first frequency, or (ii) the first transmission signal z_1 from the first antenna at the first period at the first frequency and the second transmission signal z_2 from a third antenna at the first period at the first frequency; and

transmitting, by the second transmitter, (i) the second transmission signal z_2 from a second antenna at the first period at the first frequency, or (ii) the first transmission signal z_1 from the second antenna at the first period at the first frequency and the second transmission signal z_2 from a fourth antenna at the first period at the first frequency.

2. The transmission method of claim 1, wherein

in a case in which data included in the first modulated signal s_1 is same as data included in the second modulated signal s_2 ,

the first transmitter performs at least one of:

applying precoding by the fixed matrix F , where α represents 0; and

transmitting (i) the first transmission signal z_1 from the first antenna at the first period at the first frequency, and

the second transmitter performs at least one of:

applying precoding by the fixed matrix F , where α represents 0; and

transmitting (i) the second transmission signal z_2 from the second antenna at the first period at the first frequency.

3. The transmission method of claim 1, wherein

in a case in which data included in the first modulated signal s_1 is different from data included in the second modulated signal s_2 ,

the first transmitter performs at least one of:

applying precoding by the fixed matrix F , where α represents a positive real number larger than 0; and

transmitting (ii) the first transmission signal $z1$ from the first antenna at the first period at the first frequency and the second transmission signal $z2$ from the third antenna at the first period at the first frequency, and

the second transmitter performs at least one of:

applying precoding by the fixed matrix F , where α represents a positive real number larger than 0; and

transmitting (ii) the first transmission signal $z1$ from the second antenna at the first period at the first frequency and the second transmission signal $z2$ from the fourth antenna at the first period at the first frequency.

4. A transmission system comprising, a first transmitter and a second transmitter, both the first transmitter and the second transmitter operable to:

encode input data to coded blocks each made up of a plurality of bits by using a predetermined error correction block coding scheme;

modulate each of the coded blocks to a first modulated signal $s1$ and a second modulated signal $s2$;

apply precoding by a fixed matrix F to the first modulated signal $s1$ and the second modulated signal $s2$ to obtain a first pre-coded signal $z1'$ and a second pre-coded signal $z2'$, wherein

the matrix F is expressed as:

$$\frac{1}{\sqrt{\alpha^2 + 1}} \begin{pmatrix} e^{j0} & \alpha \times e^{j0} \\ \alpha \times e^{j0} & e^{j\pi} \end{pmatrix}$$

where α represents a positive real number larger than or equal to 0;

insert one or more pilots to each of the first pre-coded signal $z1'$ and the second pre-coded signal $z2'$ to obtain a first pilot-inserted signal $z1''$ and a second pilot-inserted signal $z2''$, respectively; and

phase-change, while regularly varying a scheme of phase change for each of a plurality of slots, at least one of the first pilot-inserted signal $z1''$ and the second pilot-inserted signal $z2''$ to obtain a first transmission signal $z1$ and a second transmission signal $z2$; and

the first transmitter operable to:

transmit (i) the first transmission signal $z1$ from a first antenna at a first period at a first frequency or (ii) the first transmission signal $z1$ from the first antenna at the first period at the first frequency and the second transmission signal $z2$ from a third antenna at the first period at the first frequency; and

the second transmitter operable to:

transmit (i) the second transmission signal $z2$ from a second antenna at the first period at the first frequency, or (ii) the first transmission signal $z1$ from the second antenna at the first period at the first frequency and the second transmission signal $z2$ from a fourth antenna at the first period at the first frequency.

5. The transmission system of claim 4, wherein

in a case in which data included in the first modulated signal $s1$ is same as data included

in the second modulated signal s_2 ,

the first transmitter is operable to:

apply precoding by the fixed matrix F , where α represents 0; and

transmit (i) the first transmission signal z_1 from the first antenna at the first period at the first frequency, and

the second transmitter is operable to:

apply precoding by the fixed matrix F , where α represents 0; and

transmit (i) the second transmission signal z_2 from the second antenna at the first period at the first frequency.

6. The transmission system of claim 4, wherein

in a case in which data included in the first modulated signal s_1 is different from data included in the second modulated signal s_2 ,

the first transmitter is operable to:

apply precoding by the fixed matrix F , where α represents a positive real number larger than 0; and

transmit (ii) the first transmission signal z_1 from the first antenna at the first period at the first frequency and the second transmission signal z_2 from the third antenna at the first period at the first frequency, and

the second transmitter is operable to:

apply precoding by the fixed matrix F , where α represents a positive real number larger than 0; and

transmit (ii) the first transmission signal z_1 from the second antenna at the first

period at the first frequency and the second transmission signal z_2 from the fourth antenna at the first period at the first frequency.

7. A reception method of a reception apparatus, the method comprising:

acquiring a reception signal obtained by receiving (i) a first transmission signal z_1 transmitted from a first antenna of a first transmitter at a first period at a first frequency and a second transmission signal z_2 transmitted from a second antenna of a second transmitter at the first period at the first frequency, or (ii) the first transmission signal z_1 transmitted from the first antenna of the first transmitter at the first period at the first frequency and the second transmission signal z_2 transmitted from a third antenna of the first transmitter at the first period at the first frequency, the first transmission signal z_1 and the second transmission signal z_2 having been generated through a predetermined generation process; and

demodulating the reception signal to reception data, through a demodulation process corresponding to the predetermined generation process, wherein

at least one of the acquiring and the demodulating is performed by the reception apparatus, and

the predetermined generation process is a process of:

encoding input data to coded blocks each made up of a plurality of bits by using a predetermined error correction block coding scheme;

modulating each of the coded blocks to a first modulated signal s_1 and a second modulated signal s_2 ;

applying precoding by a fixed matrix F to the first modulated signal s_1 and the second modulated signal s_2 to obtain a first pre-coded signal z_1' and a second pre-coded signal z_2' , wherein

the matrix F is expressed as:

$$\frac{1}{\sqrt{\alpha^2 + 1}} \begin{pmatrix} e^{j0} & \alpha \times e^{j0} \\ \alpha \times e^{j0} & e^{j\pi} \end{pmatrix}$$

where α represents a positive real number larger than or equal to 0;

inserting one or more pilots to each of the first pre-coded signal $z1'$ and the second pre-coded signal $z2'$ to obtain a first pilot-inserted signal $z1''$ and a second pilot-inserted signal $z2''$, respectively; and

phase-changing, while regularly varying a scheme of phase change for each of a plurality of slots, at least one of the first pilot-inserted signal $z1''$ and the second pilot-inserted signal $z2''$ to obtain the first transmission signal $z1$ and the second transmission signal $z2$.

8. The reception method of claim 7, wherein

in a case of acquiring a reception signal obtained by receiving (i) the first transmission signal $z1$ transmitted from the first antenna of the first transmitter at the first period at the first frequency and the second transmission signal $z2$ transmitted from the second antenna of the second transmitter at the first period at the first frequency,

the predetermined generation process is a process of:

precoding by using the fixed matrix F , where α represents 0, and

the reception apparatus demodulates the first modulated signal $s1$ included in the reception signal to first reception data and demodulates the second modulated signal $s2$ included in the reception signal to second reception data, the first reception data is same as the second reception data.

9. The reception method of claim 7, wherein

in a case of acquiring a reception signal obtained by receiving (ii) the first transmission signal z_1 transmitted from the first antenna of the first transmitter at the first period at the first frequency and the second transmission signal z_2 transmitted from the third antenna of the first transmitter at the first period at the first frequency,

the predetermined generation process is a process of:

applying precoding by the fixed matrix F , where α represents a positive real number larger than 0, and

the reception apparatus demodulates the first modulated signal s_1 included in the reception signal to first reception data and the second modulated signal s_2 included in the reception signal to second reception data, the first reception data differing from the second reception data.

10. A reception apparatus comprising control circuitry, the control circuitry operable to:

acquiring a reception signal obtained by receiving (i) a first transmission signal z_1 transmitted from a first antenna of a first transmitter at a first period at a first frequency and a second transmission signal z_2 transmitted from a second antenna of a second transmitter at the first period at the first frequency, or (ii) the first transmission signal z_1 transmitted from the first antenna of the first transmitter at the first period at the first frequency and the second transmission signal z_2 transmitted from a third antenna of the first transmitter at the first period at the first frequency, the first transmission signal z_1 and the second transmission signal z_2 having been generated through a predetermined generation process; and

demodulating the reception signal to reception data, through a demodulation process corresponding to the predetermined generation process, wherein

at least one of the acquiring and the demodulating is performed by the control circuitry, and

the predetermined generation process is a process of;

encoding input data to coded blocks each made up of a plurality of bits by using a predetermined error correction block coding scheme;

modulating each of the coded blocks to a first modulated signal s1 and a second modulated signal s2;

applying precoding by a fixed matrix F to the first modulated signal s1 and the second modulated signal s2 to obtain a first pre-coded signal z1' and a second pre-coded signal z2', wherein

the matrix F is expressed as:

$$\frac{1}{\sqrt{\alpha^2 + 1}} \begin{pmatrix} e^{j0} & \alpha \times e^{j0} \\ \alpha \times e^{j0} & e^{j\pi} \end{pmatrix}$$

where α represents a positive real number larger than or equal to 0;

inserting one or more pilots to each of the first pre-coded signal z1' and the second pre-coded signal z2' to obtain a first pilot-inserted signal z1'' and a second pilot-inserted signal z2'', respectively; and

phase-changing, while regularly varying a scheme of phase change for each of a plurality of slots, at least one of the first pilot-inserted signal z1'' and the second pilot-inserted signal z2'' to obtain the first transmission signal z1 and the second transmission signal z2.

11. The reception apparatus of claim 10, wherein

in a case of acquiring a reception signal obtained by receiving (i) the first transmission

signal z_1 transmitted from the first antenna of the first transmitter at the first period at the first frequency and the second transmission signal z_2 transmitted from the second antenna of the second transmitter at the first period at the first frequency,

the predetermined generation process is a process of:

applying precoding by the fixed matrix F , where α represents 0, and

the control circuitry demodulates the first modulated signal s_1 included in the reception signal to first reception data and demodulates the second modulated signal s_2 included in the reception signal to second reception data, the first reception data is same as the second reception data.

12. The reception apparatus of claim 10, wherein

in a case of acquiring a reception signal obtained by receiving (ii) the first transmission signal z_1 transmitted from the first antenna of the first transmitter at the first period at the first frequency and the second transmission signal z_2 transmitted from the third antenna of the first transmitter at the first period at the first frequency:

the predetermined generation process is a process of:

applying precoding by the fixed matrix F , where α represents a positive real number larger than 0, and

the control circuitry demodulates the first modulated signal s_1 included in the reception signal to first reception data and the second modulated signal s_2 included in the reception signal to second reception data, the first reception data differing from the second reception data.