CLAIMS

1. A signal generation method for generating, from a plurality of baseband signals, a plurality of signals for transmission on a common frequency band and at a common time, comprising the steps of:

generating M first encoded blocks usable as a first set of bits and M second encoded blocks usable as a second set of bits using a predetermined error-correcting block coding method, where M is a natural number;

performing a change of phase on each of a first baseband signal s1 generated from the first set of bits and a second baseband signal s2 generated from the second set of bits, thus generating a first post-phase change baseband signal s1′ and a second post-phase change baseband signal s2′, each including M symbols; and

applying weighting to the first post-phase change baseband signal s1′ and to the second post-phase change baseband signal s2′ according to a predetermined matrix F, thus generating the plurality of signals for transmission on the common frequency band and at the common time as a combination of M pairs of a first weighted signal z1 and a second weighted signal z2, wherein

the first weighted signal z1 and the second weighted signal z2 satisfy the relation:

$$(z1, z2)^T = F(s1', s2')^T$$

and the change of phase is performed on the first baseband signal s1 and the second baseband signal s2 using a phase modification value sequentially selected from among N phase modification value candidates.

2. A signal generation apparatus for generating, from a plurality of baseband signals, a plurality of signals for transmission on a common frequency band and at a common time, comprising:

an encoder generating M first encoded blocks usable as a first set of bits and M second encoded blocks usable as a second set of bits using a predetermined

error-correcting block coding method, where M is a natural number;

a phase changer performing a change of phase on each of a first baseband signal s1 generated from the first set of bits and a second baseband signal s2 generated from the second set of bits, thus generating a first post-phase change baseband signal s1′ and a second post-phase change baseband signal s2′, each including M symbols; and

a weighting unit applying weighting to the first post-phase change baseband signal s1′ and to the second post-phase change baseband signal s2′ according to a predetermined matrix F, thus generating the plurality of signals for transmission on the common frequency band and at the common time as a combination of M pairs of a first weighted signal z1 and a second weighted signal z2, wherein

the first weighted signal z1 and the second weighted signal z2 satisfy the relation:

$$(z1, z2)^T = F(s1', s2')^T$$

and the change of phase is performed on the first baseband signal s1 and the second baseband signal s2 using a phase modification value sequentially selected from among N phase modification value candidates.

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:

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

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 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

transmitting, by the second transmitter, (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 forth antenna at the first period at the first frequency.

2. The transmission method of claim 1, wherein

in a case that data included in the first modulated signal s1 is same as data included in the second modulated signal s2,

the first transmitter performs at least one of:

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

transmitting (i) the first transmission signal z1 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 z2 from the second antenna at the first period at the first frequency.

3. The transmission method of claim 1, wherein

in a case that data included in the first modulated signal s1 is different from data included in the second modulated signal s2,

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 forth 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:

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

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 the 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 forth antenna at the first period at the first frequency.

5. The transmission system of claim 4, wherein

in a case that data included in the first modulated signal s1 is same as data included in the second modulated signal s2,

the first transmitter is operable to:

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

transmit (i) the first transmission signal z1 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 z2 from the second antenna at the first period at the first frequency.

6. The transmission system of claim 4, wherein

in a case that data included in the first modulated signal s1 is different from data included in the second modulated signal s2,

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 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 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 z1 from the second antenna at the first period at the first frequency and the second transmission signal z2 from the forth 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 z1 transmitted from a first antenna of a first transmitter at a first period at a first frequency and a second transmission signal z2 transmitted from a second antenna of a second transmitter at the first period at the first frequency, or (ii) 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 a third antenna of the first transmitter at the first period at the first frequency, the first transmission signal z1 and the second transmission signal z2 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 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:

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

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 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 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 s1 included in the reception signal to first reception data and the second modulated signal s2 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 z1 transmitted from a first antenna of a first transmitter at a first period at a first frequency and a second transmission signal z2 transmitted from a second antenna of a second transmitter at the first period at the first frequency, or (ii) 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 a third antenna of the first transmitter at the first period at the first frequency, the first transmission signal z1 and the second transmission signal z2 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:

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

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 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:

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

the control circuitry 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.

12. The reception apparatus of claim 10, wherein

in a case of acquiring a reception signal obtained by receiving (ii) 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 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 s1 included in the reception signal to first reception data and the second modulated signal s2 included in the reception signal to second reception data, the first reception data differing from the second reception data.