

Claims

[Claim 1] A transmission apparatus for transmitting a block of data over a plurality of transmission channels, the transmission apparatus comprising:

a modulator operable to generate one of a plurality of rotated constellation points in accordance with the block of data to be transmitted, each of the plurality of rotated constellation points having N components; and

a transmitter operable to transmit each component of the generated rotated constellation point over a different one of the plurality of transmission channels, wherein

the plurality of rotated constellation points are obtained by applying an orthogonal transformation to each of a plurality of initial constellation points that has N components,

N is a multiple of four,

the orthogonal transformation has one of (i) an N-by-N matrix representation with absolute values of all elements on a main diagonal equal to a first value, and with absolute values of all elements not on the main diagonal equal to a non-zero second value, and (ii) a matrix representation obtained by permuting either or both of rows and columns in the N-by-N matrix representation, and

when the N-by-N matrix representation is denoted by R,

$$R = \begin{pmatrix} s_{1,1}a & s_{1,2}b & \cdots & s_{1,N}b \\ s_{2,1}b & s_{2,2}a & & \vdots \\ \vdots & & \ddots & s_{N-1,N}b \\ s_{N,1}b & \cdots & s_{N,N-1}b & s_{N,N}a \end{pmatrix}$$

a and b denote real parameters,
each sign value $s_{i,j}$ satisfies

$$s_{i,j} \in \{-1, +1\}, \text{ and}$$

$$s_{i,i}s_{i,j} = -s_{j,i}s_{j,j} \quad \text{for all } i \neq j, \text{ and}$$

the real parameters a and b satisfy

$$a^2 + (N-1)b^2 = 1.$$

[Claim 2] A reception apparatus for receiving a block of data over a plurality of transmission channels, the reception apparatus comprising:

a receiver operable to receive N component signals over the plurality of transmission channels; and

a demodulator operable to select one of a plurality of rotated constellation points in accordance with the plurality of received N component signals, wherein

the plurality of rotated constellation points are obtained by applying an orthogonal transformation to each of a plurality of initial constellation points that has N components ,

N is a multiple of four, and

the orthogonal transformation has one of (i) an N-by-N matrix representation with absolute values of all elements on a main diagonal equal to a first value, and with absolute values of all elements not on the main diagonal equal to a non-zero second value, and (ii) a matrix representation obtained by permuting either or both of rows and columns in the N-by-N matrix representation, and

when the N-by-N matrix representation is denoted by R,

$$R = \begin{pmatrix} s_{1,1}a & s_{1,2}b & \cdots & s_{1,N}b \\ s_{2,1}b & s_{2,2}a & & \vdots \\ \vdots & & \ddots & s_{N-1,N}b \\ s_{N,1}b & \cdots & s_{N,N-1}b & s_{N,N}a \end{pmatrix}$$

a and b denote real parameters,
each sign value $s_{i,j}$ satisfies

$$s_{i,j} \in \{-1, +1\}, \text{ and}$$

$$s_{i,i}s_{i,j} = -s_{j,i}s_{j,j} \quad \text{for all } i \neq j, \text{ and}$$

the real parameters a and b satisfy

$$a^2 + (N-1)b^2 = 1.$$

[Claim 3] A transmission method for transmitting a block of data over a plurality of transmission channels, the transmission method comprising the steps of:

generating one of a plurality of rotated constellation points in accordance with the block of data to be transmitted, each of the plurality of rotated constellation points having N components; and

transmitting each component of the generated rotated constellation point over a different one of the plurality of transmission channels, wherein

the plurality of rotated constellation points are obtained by applying an orthogonal transformation to each of a plurality of initial constellation points that has N components,

N is a multiple of four, and

the orthogonal transformation has one of (i) an N-by-N matrix representation with absolute values of all elements on a main diagonal equal to a first value, and with absolute values of all elements not on the main diagonal equal to a non-zero second value, and (ii) a matrix representation obtained by permuting either or both of rows and columns in the N-by-N matrix representation, and

when the N-by-N matrix representation is denoted by R,

$$R = \begin{pmatrix} s_{1,1}a & s_{1,2}b & \cdots & s_{1,N}b \\ s_{2,1}b & s_{2,2}a & & \vdots \\ \vdots & & \ddots & s_{N-1,N}b \\ s_{N,1}b & \cdots & s_{N,N-1}b & s_{N,N}a \end{pmatrix}$$

a and b denote real parameters,
each sign value $s_{i,j}$ satisfies

$$s_{i,j} \in \{-1, +1\}, \text{ and}$$

$$s_{i,i}s_{i,j} = -s_{j,i}s_{j,j} \quad \text{for all } i \neq j, \text{ and}$$

the real parameters a and b satisfy

$$a^2 + (N-1)b^2 = 1.$$

[Claim 4] A reception method for receiving a block of data over a plurality of transmission channels, the reception method comprising the steps of:

receiving N component signals over the plurality of transmission channels;
and

selecting one of a plurality of rotated constellation points in accordance with the plurality of received N component signals, wherein

the plurality of rotated constellation points are obtained by applying an orthogonal transformation to each of a plurality of initial constellation points that has N components ,

N is a multiple of four, and

the orthogonal transformation has one of (i) an N-by-N matrix representation with absolute values of all elements on a main diagonal equal to a first value, and with absolute values of all elements not on the main diagonal equal to a non-zero second value, and (ii) a matrix representation obtained by permuting either or both of rows and columns in the N-by-N matrix representation, and

when the N-by-N matrix representation is denoted by R,

$$R = \begin{pmatrix} s_{1,1}a & s_{1,2}b & \cdots & s_{1,N}b \\ s_{2,1}b & s_{2,2}a & & \vdots \\ \vdots & & \ddots & s_{N-1,N}b \\ s_{N,1}b & \cdots & s_{N,N-1}b & s_{N,N}a \end{pmatrix}$$

a and b denote real parameters,
each sign value $s_{i,j}$ satisfies

$$s_{i,j} \in \{-1, +1\}, \text{ and}$$

$$s_{i,i}s_{i,j} = -s_{j,i}s_{j,j} \quad \text{for all } i \neq j, \text{ and}$$

the real parameters a and b satisfy

$$a^2 + (N-1)b^2 = 1.$$

[Claim 5] A generation method for generating an N-dimensional rotated constellation for a digital modulation scheme in a data communication system, the generation method comprising the steps of:

receiving a plurality of vectors of an N-dimensional vector space; and

obtaining constellation points of the N-dimensional rotated constellation by applying an orthogonal transformation to the plurality of vectors received, wherein

the orthogonal transformation is adapted for increasing a minimum number of different values in components of any two distinct N-dimensional rotated constellation points relative to a minimum number of different values in components of any two distinct vectors received, and

the orthogonal transformation has one of (i) an N-by-N matrix representation, N being a multiple of four, with absolute values of all elements on a main diagonal equal to a first value, and with absolute values of all elements not on the main diagonal equal to a non-zero second value, and (ii) a matrix representation obtained by permuting either or both of rows and columns in the N-by-N matrix representation, and

when the N-by-N matrix representation is denoted by R,

$$R = \begin{pmatrix} s_{1,1}a & s_{1,2}b & \cdots & s_{1,N}b \\ s_{2,1}b & s_{2,2}a & & \vdots \\ \vdots & & \ddots & s_{N-1,N}b \\ s_{N,1}b & \cdots & s_{N,N-1}b & s_{N,N}a \end{pmatrix}$$

a and b denote real parameters,
each sign value $s_{i,j}$ satisfies

$$s_{i,j} \in \{-1, +1\}, \text{ and}$$

$$s_{i,i}s_{i,j} = -s_{j,i}s_{j,j} \quad \text{for all } i \neq j, \text{ and}$$

the real parameters a and b satisfy

$$a^2 + (N-1)b^2 = 1.$$

Claims

1. A transmission apparatus for transmitting a block of data over a plurality of transmission channels, the transmission apparatus comprising:

a modulator operable to obtain N constellation components in accordance with the block of data to be transmitted; and

a transmitter operable to transmit each of the obtained N constellation components, wherein

the N constellation components are obtained by using an orthogonal transformation,

N is four, and

the orthogonal transformation has one of (i) an N-by-N matrix R representation with absolute values of all elements on a main diagonal equal to a first value, and with absolute values of all elements not on the main diagonal equal to a non-zero second value, and (ii) a matrix representation obtained by permuting rows and/or columns in the N-by-N matrix R representation,

$$R = \begin{pmatrix} s_{1,1}a & s_{1,2}b & s_{1,3}b & s_{1,4}b \\ s_{2,1}b & s_{2,2}a & s_{2,3}b & s_{2,4}b \\ s_{3,1}b & s_{3,2}b & s_{3,3}a & s_{3,4}b \\ s_{4,1}b & s_{4,2}b & s_{4,3}b & s_{4,4}a \end{pmatrix}$$

a and b denote real parameters,

$$\text{each sign value } s_{i,j} \text{ satisfies } \begin{pmatrix} s_{1,1} & s_{1,2} & s_{1,3} & s_{1,4} \\ s_{2,1} & s_{2,2} & s_{2,3} & s_{2,4} \\ s_{3,1} & s_{3,2} & s_{3,3} & s_{3,4} \\ s_{4,1} & s_{4,2} & s_{4,3} & s_{4,4} \end{pmatrix} = \begin{pmatrix} +1 & -1 & -1 & -1 \\ +1 & +1 & -1 & +1 \\ +1 & +1 & +1 & -1 \\ +1 & -1 & +1 & +1 \end{pmatrix}, \text{ and}$$

the real parameters a and b satisfy $a^2 + (N-1)b^2 = 1$.

2. A reception apparatus for receiving a block of data over a plurality of transmission channels, the reception apparatus comprising:

a receiver operable to receive a plurality of component signals; and

a demodulator operable to perform demapping processing of N constellation components in accordance with the plurality of received component signals, wherein

the N constellation components are obtained by using an orthogonal transformation,

N is four, and

the orthogonal transformation has one of (i) an N-by-N matrix R representation with absolute values of all elements on a main diagonal equal to a first value, and with absolute values of all elements not on the main diagonal equal to a non-zero second value, and (ii) a matrix representation obtained by permuting rows and/or columns in the N-by-N matrix R representation,

$$R = \begin{pmatrix} s_{1,1}a & s_{1,2}b & s_{1,3}b & s_{1,4}b \\ s_{2,1}b & s_{2,2}a & s_{2,3}b & s_{2,4}b \\ s_{3,1}b & s_{3,2}b & s_{3,3}a & s_{3,4}b \\ s_{4,1}b & s_{4,2}b & s_{4,3}b & s_{4,4}a \end{pmatrix}$$

a and b denote real parameters,

$$\text{each sign value } s_{ij} \text{ satisfies } \begin{pmatrix} s_{1,1} & s_{1,2} & s_{1,3} & s_{1,4} \\ s_{2,1} & s_{2,2} & s_{2,3} & s_{2,4} \\ s_{3,1} & s_{3,2} & s_{3,3} & s_{3,4} \\ s_{4,1} & s_{4,2} & s_{4,3} & s_{4,4} \end{pmatrix} = \begin{pmatrix} +1 & -1 & -1 & -1 \\ +1 & +1 & -1 & +1 \\ +1 & +1 & +1 & -1 \\ +1 & -1 & +1 & +1 \end{pmatrix}, \text{ and}$$

the real parameters a and b satisfy $a^2 + (N-1)b^2 = 1$.

3. A transmission method for transmitting a block of data over a plurality of transmission channels, the transmission method comprising:

obtaining N constellation components in accordance with the block of data to be transmitted; and

transmitting each of the obtained N constellation components, wherein

the N constellation components are obtained by using an orthogonal transformation,

N is four, and

the orthogonal transformation has one of (i) an N -by- N matrix R representation with absolute values of all elements on a main diagonal equal to a first value, and with absolute values of all elements not on the main diagonal equal to a non-zero second value, and (ii) a matrix representation obtained by permuting rows and/or columns in the N -by- N matrix R representation,

$$R = \begin{pmatrix} s_{1,1}a & s_{1,2}b & s_{1,3}b & s_{1,4}b \\ s_{2,1}b & s_{2,2}a & s_{2,3}b & s_{2,4}b \\ s_{3,1}b & s_{3,2}b & s_{3,3}a & s_{3,4}b \\ s_{4,1}b & s_{4,2}b & s_{4,3}b & s_{4,4}a \end{pmatrix}$$

a and b denote real parameters,

$$\text{each sign value } s_{i,j} \text{ satisfies } \begin{pmatrix} s_{1,1} & s_{1,2} & s_{1,3} & s_{1,4} \\ s_{2,1} & s_{2,2} & s_{2,3} & s_{2,4} \\ s_{3,1} & s_{3,2} & s_{3,3} & s_{3,4} \\ s_{4,1} & s_{4,2} & s_{4,3} & s_{4,4} \end{pmatrix} = \begin{pmatrix} +1 & -1 & -1 & -1 \\ +1 & +1 & -1 & +1 \\ +1 & +1 & +1 & -1 \\ +1 & -1 & +1 & +1 \end{pmatrix}, \text{ and}$$

the real parameters a and b satisfy $a^2 + (N-1)b^2 = 1$.

4. A reception method for receiving a block of data over a plurality of transmission channels, the reception method comprising:

receiving a plurality of component signals; and

performing demapping processing of N constellation components in accordance with the

plurality of received component signals, wherein

the N constellation components are obtained by using an orthogonal transformation,

N is four, and

the orthogonal transformation has one of (i) an N-by-N matrix R representation with absolute values of all elements on a main diagonal equal to a first value, and with absolute values of all elements not on the main diagonal equal to a non-zero second value, and (ii) a matrix representation obtained by permuting rows and/or columns in the N-by-N matrix R representation,

$$R = \begin{pmatrix} s_{1,1}a & s_{1,2}b & s_{1,3}b & s_{1,4}b \\ s_{2,1}b & s_{2,2}a & s_{2,3}b & s_{2,4}b \\ s_{3,1}b & s_{3,2}b & s_{3,3}a & s_{3,4}b \\ s_{4,1}b & s_{4,2}b & s_{4,3}b & s_{4,4}a \end{pmatrix}$$

a and b denote real parameters,

$$\text{each sign value } s_{i,j} \text{ satisfies } \begin{pmatrix} s_{1,1} & s_{1,2} & s_{1,3} & s_{1,4} \\ s_{2,1} & s_{2,2} & s_{2,3} & s_{2,4} \\ s_{3,1} & s_{3,2} & s_{3,3} & s_{3,4} \\ s_{4,1} & s_{4,2} & s_{4,3} & s_{4,4} \end{pmatrix} = \begin{pmatrix} +1 & -1 & -1 & -1 \\ +1 & +1 & -1 & +1 \\ +1 & +1 & +1 & -1 \\ +1 & -1 & +1 & +1 \end{pmatrix}, \text{ and}$$

the real parameters a and b satisfy $a^2 + (N-1)b^2 = 1$.

5. A generation method for generating an N-dimensional constellation for a digital modulation scheme in a data communication system, N being four, the generation method comprising:

receiving a plurality of vectors of an N-dimensional space; and

obtaining constellation points of the N-dimensional constellation by applying an orthogonal transformation to the plurality of vectors received.

wherein the orthogonal transformation has one of (i) an N -by- N matrix R representation, with absolute values of all elements on a main diagonal equal to a first value, and with absolute values of all elements not on the main diagonal equal to a non-zero second value, and (ii) a matrix R representation obtained by permuting rows and/or columns in the N -by- N matrix representation,

$$R = \begin{pmatrix} s_{1,1}a & s_{1,2}b & s_{1,3}b & s_{1,4}b \\ s_{2,1}b & s_{2,2}a & s_{2,3}b & s_{2,4}b \\ s_{3,1}b & s_{3,2}b & s_{3,3}a & s_{3,4}b \\ s_{4,1}b & s_{4,2}b & s_{4,3}b & s_{4,4}a \end{pmatrix}$$

a and b denote real parameters,

each sign value s_{ij} satisfies $\begin{pmatrix} s_{1,1} & s_{1,2} & s_{1,3} & s_{1,4} \\ s_{2,1} & s_{2,2} & s_{2,3} & s_{2,4} \\ s_{3,1} & s_{3,2} & s_{3,3} & s_{3,4} \\ s_{4,1} & s_{4,2} & s_{4,3} & s_{4,4} \end{pmatrix} = \begin{pmatrix} +1 & -1 & -1 & -1 \\ +1 & +1 & -1 & +1 \\ +1 & +1 & +1 & -1 \\ +1 & -1 & +1 & +1 \end{pmatrix}$, and

the real parameters a and b satisfy $a^2 + (N-1)b^2 = 1$.