CLAIMS

1. A method of encoding information, by a transmitting device using a parity check matrix of a low-density parity-check code, for transmission over a communication channel, the method comprising:

determining, by the transmitting device, the parity check matrix comprising at least 7Z rows and 17Z columns,

wherein the parity check matrix comprises a plurality of submatrices that each has dimensions $Z \times Z$ for a non-zero integer *Z*, and wherein a submatrix (m, n) of the parity check matrix, which is a m-th one in a row direction of the parity check matrix and a n-th one in a column direction of the parity check matrix, is:

for $m = 0$ and for $n = \{0, 1, 2, 3, 6, 9, 10, 11\}$, obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{145, 131, 71, 21, 23, 112, 1, 0\}$ by Z,

for $m = 1$ and for $n = \{0, 3, 4, 5, 6, 7, 8, 9, 11, 12\}$, obtained circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{142, 174, 183, 27, 96, 23, 9, 167, 0, 0\}$ by Z,

for $m = 2$ and for $n = \{0, 1, 3, 4, 8, 10, 12, 13\}$, obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{74, 31, 3, 53, 155, 0, 0, 0\}$ by Z,

for $m = 3$ and for $n = \{1, 2, 4, 5, 6, 7, 8, 9, 10, 13\}$, obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{239, 171, 95, 110, 159, 199, 43, 75, 1, 0\}$ by Z,

for $m = 4$ and for $n = \{0, 1, 11, 14\}$, obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{29, 140, 180, 0\}$ by Z,

for $m = 5$ and for $n = \{0, 1, 5, 7, 11, 15\}$, obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that

is defined by taking a modulo operation to a respective value among $\{121, 41, 169, 88, 207, 0\}$ by Z, and

for $m = 6$ and for $n = \{0, 5, 7, 9, 11, 16\}$, obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{137, 72, 172, 124, 56, 0\}$ by Z,

generating encoded data, by the transmitting device, based on encoding the information with the determined parity check matrix; and

transmitting, by a transceiver of the transmitting device, the encoded data over the communication channel.

2. The method according to claim 1, wherein

for $m = 0$ and for n other than $n = \{0, 1, 2, 3, 6, 9, 10, 11\}$, each submatrix (m, n) is equal to an all-zero matrix of size $Z \times Z$,

for $m = 1$ and for n other than $n = \{0, 3, 4, 5, 6, 7, 8, 9, 11, 12\}$, each submatrix (m, n) is equal to an all-zero matrix of size $Z \times Z$,

for $m = 2$ and for n other than $n = \{0, 1, 3, 4, 8, 10, 12, 13\}$, each submatrix (m, n) is equal to an all-zero matrix of size $Z \times Z$,

for $m = 3$ and for n other than $n = \{1, 2, 4, 5, 6, 7, 8, 9, 10, 13\}$, each submatrix (m, n) is equal to an all-zero matrix of size $Z \times Z$,

for $m = 4$ and for n other than $n = \{0, 1, 11, 14\}$, each submatrix (m, n) is equal to an all-zero matrix of size $Z \times Z$,

for $m = 5$ and for n other than $n = \{0, 1, 5, 7, 11, 15\}$, each submatrix (m, n) is equal to an all-zero matrix of size $Z \times Z$, and

for $m = 6$ and for n other than $n = \{0, 5, 7, 9, 11, 16\}$, each submatrix (m, n) is equal to an all-zero matrix of size $Z \times Z$.

3. The method according to claim 1, wherein the parity check matrix has at least $42Z$ rows comprising 42 $Z \times Z$-sized submatrices that are indexed by m (where $0 \leq m \leq 41$) in the row direction of the parity check matrix and at least $52Z$ columns comprising 52 $Z \times Z$-sized submatrices that are indexed by index n (where $0 \leq n \leq 51$) in the column direction of the parity check matrix,

wherein for $m = 7, \ldots, 41$ and for $n = 17, \ldots, 51$:

each submatrix $(m, m+10)$ is an un-shifted identity matrix of size $Z \times Z$, and each submatrix except for the submatrix $(m, m+10)$ is an all-zero matrix of size $Z \times Z$.

4. The method according to claim 1, wherein generating the encoded data, by the transmitting device, based on encoding the information with the determined parity check matrix comprises:

generating, based on the information and the parity check matrix, a plurality of parity bits $\vec{\boldsymbol{p}}$ that satisfy:

$$H \cdot (\vec{\boldsymbol{x}} \quad \vec{\boldsymbol{p}})^T = 0,$$

where *H* is the parity check matrix, and $\vec{\boldsymbol{x}}$ is the information.

5. The method according to claim 1, wherein *Z* is related to a size of the information that is encoded by the transmitting device.

6. The method according to claim 5, wherein *Z* represents a lifting value that is any one of 15, 30, 60, 120, or 240.

7. The method according to claim 1, further comprising:

determining a base matrix of size at least 42×52 in which an element at location (m, n) of the base matrix indicates whether the submatrix (m, n) is equal to a matrix obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by the shift index value $a_{m,n}$.

8. The method according to claim 1, further comprising:

determining, by the transmitting device, a modulation and coding scheme (MCS) index according to downlink control information received by the transmitting device;

deriving, by the transmitting device and from the MCS index, a code rate;

determining, by the transmitting device, that the code rate does not satisfy a threshold criterion; and

based on a determination that the code rate does not satisfy the threshold criterion, determining the parity check matrix and performing encoding on the information using the parity check matrix to generate the encoded data.

9. The method according to any one of claims 1 to 7, wherein the parity check matrix has $42Z$ rows comprising 42 $Z \times Z$-sized submatrices that are indexed by m (where $0 \leq m \leq 41$) in the row direction of the parity check matrix, and

wherein:

for $m = 7$ and for $n = \{1, 5, 7, 11, 13\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{86, 186, 87, 172, 154\}$ by Z,

for $m = 8$ and for $n = \{0, 1, 12\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{176, 169, 225\}$ by Z,

for $m = 9$ and for $n = \{1, 8, 10, 11\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{167, 238, 48, 68\}$ by Z,

for $m = 10$ and for $n = \{0, 1, 6, 7\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{38, 217, 208, 232\}$ by Z,

for $m = 11$ and for $n = \{0, 7, 9, 13\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{178, 214, 168, 51\}$ by Z,

for $m = 12$ and for $n = \{1, 3, 11\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{124, 122, 72\}$ by Z,

for $m = 13$ and for $n = \{0, 1, 8, 13\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{48, 57, 167, 219\}$ by Z,

for $m = 14$ and for $n = \{1, 6, 11, 13\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{82, 232, 204, 162\}$ by Z,

for $m = 15$ and for $n = \{0, 10, 11\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{38, 217, 157\}$ by Z,

for $m = 16$ and for $n = \{1, 9, 11, 12\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{170, 23, 175, 202\}$ by Z,

for $m = 17$ and for $n = \{1, 5, 11, 12\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{196, 173, 195, 218\}$ by Z,

for $m = 18$ and for $n = \{0, 6, 7\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{128, 211, 210\}$ by Z,

for $m = 19$ and for $n = \{0, 1, 10\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{39, 84, 88\}$ by Z,

for $m = 20$ and for $n = \{1, 4, 11\}$, each submatrix (m, n) is obtained based on a respective value among $\{117, 227, 6\}$ by Z,

for $m = 21$ and for $n = \{0, 8, 13\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{238, 13, 11\}$ by Z,

for $m = 22$ and for $n = \{1, 2\}$, each submatrix (m, n) is obtained based on a respective value among $\{195, 44\}$ by Z,

for $m = 23$ and for $n = \{0, 3, 5\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{5, 94, 111\}$ by Z,

for $m = 24$ and for $n = \{1, 2, 9\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{81, 19, 130\}$ by Z,

for $m = 25$ and for $n = \{0, 5\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{66, 95\}$ by Z,

for $m = 26$ and for $n = \{3, 8, 13, 14\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{146, 66, 190, 86\}$ by Z,

for $m = 27$ and for $n = \{0, 6\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is

defined by taking a modulo operation to a respective value among $\{64, 181\}$ by Z,

for $m = 28$ and for $n = \{1, 2, 5\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{7, 144, 16\}$ by Z,

for $m = 29$ and for $n = \{0, 4\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{25, 57\}$ by Z,

for $m = 30$ and for $n = \{2, 5, 7, 9\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{37, 139, 221, 17\}$ by Z,

for $m = 31$ and for $n = \{1, 13\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{201, 46\}$ by Z,

for $m = 32$ and for $n = \{0, 5, 12\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{179, 14, 116\}$ by Z,

for $m = 33$ and for $n = \{2, 7, 10\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{46, 2, 106\}$ by Z,

for $m = 34$ and for $n = \{0, 12, 13\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{184, 135, 141\}$ by Z,

for $m = 35$ and for $n = \{1, 5, 11\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{85, 225, 175\}$ by Z,

for $m = 36$ and for $n = \{0, 2, 7\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{178, 112, 106\}$ by Z,

for $m = 37$ and for $n = \{10, 13\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{154, 114\}$ by Z,

for $m = 38$ and for $n = \{1, 5, 11\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that

is defined by taking a modulo operation to a respective value among $\{42, 41, 105\}$ by Z,

for $m = 39$ and for $n = \{0, 7, 12\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{167, 45, 189\}$ by Z,

for $m = 40$ and for $n = \{2, 10, 13\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{78, 67, 180\}$ by Z, and

for $m = 41$ and for $n = \{1, 5, 11\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{53, 215, 230\}$ by Z.

10. A transmitting device configured to encode, based on a parity check matrix of a low-density parity-check code, information for transmission over a communication channel, the transmitting device comprising:

at least one processor; and

at least one computer memory operably connectable to the at least one processor and storing instructions that, when executed, cause the at least one processor to perform operations comprising:

determining, by the transmitting device, the parity check matrix comprising at least 7Z rows and 17Z columns,

wherein the parity check matrix comprises a plurality of submatrices that each has dimensions $Z \times Z$ for a non-zero integer *Z*, and wherein a submatrix (m, n) of the parity check matrix, which is a m-th one in a row direction of the parity check matrix and a n-th one in a column direction of the parity check matrix, is:

for $m = 0$ and for $n = \{0, 1, 2, 3, 6, 9, 10, 11\}$, obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{145, 131, 71, 21, 23, 112, 1, 0\}$ by Z,

for $m = 1$ and for $n = \{0, 3, 4, 5, 6, 7, 8, 9, 11, 12\}$, obtained circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{142, 174, 183, 27, 96, 23, 9, 167, 0, 0\}$ by Z,

for $m = 2$ and for $n = \{0, 1, 3, 4, 8, 10, 12, 13\}$, obtained by circularly shifting

columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{74, 31, 3, 53, 155, 0, 0, 0\}$ by Z,

for $m = 3$ and for $n = \{1, 2, 4, 5, 6, 7, 8, 9, 10, 13\}$, obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{239, 171, 95, 110, 159, 199, 43, 75, 1, 0\}$ by Z,

for $m = 4$ and for $n = \{0, 1, 11, 14\}$, obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{29, 140, 180, 0\}$ by Z,

for $m = 5$ and for $n = \{0, 1, 5, 7, 11, 15\}$, obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{121, 41, 169, 88, 207, 0\}$ by Z, and

for $m = 6$ and for $n = \{0, 5, 7, 9, 11, 16\}$, obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{137, 72, 172, 124, 56, 0\}$ by Z,

generating encoded data based on encoding the information with the determined parity check matrix; and

transmitting the encoded data.

11. The transmitting device according to claim 10, wherein

for $m = 0$ and for n other than $n = \{0, 1, 2, 3, 6, 9, 10, 11\}$, each submatrix (m, n) is equal to an all-zero matrix of size $Z \times Z$,

for $m = 1$ and for n other than $n = \{0, 3, 4, 5, 6, 7, 8, 9, 11, 12\}$, each submatrix (m, n) is equal to an all-zero matrix of size $Z \times Z$,

for $m = 2$ and for n other than $n = \{0, 1, 3, 4, 8, 10, 12, 13\}$, each submatrix (m, n) is equal to an all-zero matrix of size $Z \times Z$,

for $m = 3$ and for n other than $n = \{1, 2, 4, 5, 6, 7, 8, 9, 10, 13\}$, each submatrix (m, n) is equal to an all-zero matrix of size $Z \times Z$,

for $m = 4$ and for n other than $n = \{0, 1, 11, 14\}$, each submatrix (m, n) is equal to an all-zero matrix of size $Z \times Z$,

for $m = 5$ and for n other than $n = \{0, 1, 5, 7, 11, 15\}$, each submatrix (m, n) is equal to an all-zero matrix of size $Z \times Z$, and

for $m = 6$ and for n other than $n = \{0, 5, 7, 9, 11, 16\}$, each submatrix (m, n) is equal to an all-zero matrix of size $Z \times Z$.

12. The device according to claim 10, wherein the parity check matrix has at least $42Z$ rows comprising 42 $Z \times Z$-sized submatrices that are indexed by m (where $0 \leq m \leq 41$) in the row direction of the parity check matrix and at least $52Z$ columns comprising 52 $Z \times Z$-sized submatrices that are indexed by index n (where $0 \leq n \leq 51$) in the column direction of the parity check matrix,

wherein for $m = 7, \ldots, 41$ and for $n = 17, \ldots, 51$:

each submatrix $(m, m + 10)$ is an un-shifted identity matrix of size $Z \times Z$, and

each submatrix except for the submatrix $(m, m + 10)$ is an all-zero matrix of size $Z \times Z$.

13. The transmitting device according to claim 10, wherein Z is related to a size of the information that is encoded by the transmitting device.

14. The transmitting device according to claim 13, wherein Z represents a lifting value that is any one of 15, 30, 60, 120, or 240.

15. The transmitting device according to any one of claims 10 to 14, wherein the parity check matrix has $42Z$ rows comprising 42 $Z \times Z$-sized submatrices that are indexed by m (where $0 \leq m \leq 41$) in the row direction of the parity check matrix, and

wherein:

for $m = 7$ and for $n = \{1, 5, 7, 11, 13\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{86, 186, 87, 172, 154\}$ by Z,

for $m = 8$ and for $n = \{0, 1, 12\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{176, 169, 225\}$ by Z,

for $m = 9$ and for $n = \{1, 8, 10, 11\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{167, 238, 48, 68\}$ by Z,

for $m = 10$ and for $n = \{0, 1, 6, 7\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{38, 217, 208, 232\}$ by Z,

for $m = 11$ and for $n = \{0, 7, 9, 13\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{178, 214, 168, 51\}$ by Z,

for $m = 12$ and for $n = \{1, 3, 11\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{124, 122, 72\}$ by Z,

for $m = 13$ and for $n = \{0, 1, 8, 13\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{48, 57, 167, 219\}$ by Z,

for $m = 14$ and for $n = \{1, 6, 11, 13\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{82, 232, 204, 162\}$ by Z,

for $m = 15$ and for $n = \{0, 10, 11\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{38, 217, 157\}$ by Z,

for $m = 16$ and for $n = \{1, 9, 11, 12\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{170, 23, 175, 202\}$ by Z,

for $m = 17$ and for $n = \{1, 5, 11, 12\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{196, 173, 195, 218\}$ by Z,

for $m = 18$ and for $n = \{0, 6, 7\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{128, 211, 210\}$ by Z,

for $m = 19$ and for $n = \{0, 1, 10\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{39, 84, 88\}$ by Z,

for $m = 20$ and for $n = \{1, 4, 11\}$, each submatrix (m, n) is obtained based on a respective value among $\{117, 227, 6\}$ by Z,

for $m = 21$ and for $n = \{0, 8, 13\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{238, 13, 11\}$ by Z,

for $m = 22$ and for $n = \{1, 2\}$, each submatrix (m, n) is obtained based on a respective value among $\{195, 44\}$ by Z,

for $m = 23$ and for $n = \{0, 3, 5\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{5, 94, 111\}$ by Z,

for $m = 24$ and for $n = \{1, 2, 9\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{81, 19, 130\}$ by Z,

for $m = 25$ and for $n = \{0, 5\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{66, 95\}$ by Z,

for $m = 26$ and for $n = \{3, 8, 13, 14\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{146, 66, 190, 86\}$ by Z,

for $m = 27$ and for $n = \{0, 6\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{64, 181\}$ by Z,

for $m = 28$ and for $n = \{1, 2, 5\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{7, 144, 16\}$ by Z,

for $m = 29$ and for $n = \{0, 4\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{25, 57\}$ by Z,

for $m = 30$ and for $n = \{2, 5, 7, 9\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{37, 139, 221, 17\}$ by Z,

for $m = 31$ and for $n = \{1, 13\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that

is defined by taking a modulo operation to a respective value among $\{201, 46\}$ by Z,

for $m = 32$ and for $n = \{0, 5, 12\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{179, 14, 116\}$ by Z,

for $m = 33$ and for $n = \{2, 7, 10\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{46, 2, 106\}$ by Z,

for $m = 34$ and for $n = \{0, 12, 13\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{184, 135, 141\}$ by Z,

for $m = 35$ and for $n = \{1, 5, 11\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{85, 225, 175\}$ by Z,

for $m = 36$ and for $n = \{0, 2, 7\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{178, 112, 106\}$ by Z,

for $m = 37$ and for $n = \{10, 13\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{154, 114\}$ by Z,

for $m = 38$ and for $n = \{1, 5, 11\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{42, 41, 105\}$ by Z,

for $m = 39$ and for $n = \{0, 7, 12\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{167, 45, 189\}$ by Z,

for $m = 40$ and for $n = \{2, 10, 13\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{78, 67, 180\}$ by Z, and

for $m = 41$ and for $n = \{1, 5, 11\}$, each submatrix (m, n) is obtained by circularly shifting columns of an identity matrix of size $Z \times Z$ to the right by a shift index value $a_{m,n}$ that is defined by taking a modulo operation to a respective value among $\{53, 215, 230\}$ by Z.