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CLAIMS:

1. A transmission system (10) for transmitting radio frequency (RF) radiation in a predetermined direction at a sequence of K frequencies by an antenna array (14) comprising a predetermined number N of antenna elements, comprising:

5 an RF signal generator (11) configured for generating electrical signals having an initial amplitude and an initial phase through N transmission channels corresponding to N antenna elements, at the sequence of K frequencies;

a modification system (12) arranged downstream of the RF signal generator (11), configured for receiving and processing the electrical signals from said RF signal generator (11) for obtaining optimal electrical signals for which a transmission efficiency coefficient of the transmission system is equal to or greater than a predetermined threshold value, the optimal electrical signals including optimal unmodified signals provided by the RF signal generator (11) and optimal modified signals generated by the modification system (12); and

15 a steering system (13) arranged downstream of said modification system (12) and coupled to said antenna array (14), and configured for (i) receiving the optimal electrical signals obtained from the modification system (12), (ii) generating steering electrical signals related to the optimal electrical signals and (iii) relaying the steering electrical signals via the N transmission channels to the antenna array (14) to form a steered beam for transmission in the predetermined direction.

2. The transmission system of claim 1, wherein the modification system (12) comprises:

an efficiency determination unit (22) configured for receiving the electrical signals at the sequence of K frequencies from the RF signal generator (11) and for calculating the transmission efficiency coefficient of the transmission system for each k -th frequency f_k ;

a comparing unit (24) configured for

receiving the transmission efficiency coefficient for each k -th frequency f_k from the efficiency determination unit (22),

30 comparing the transmission efficiency coefficient with the predetermined threshold value,

separating electrical signals corresponding to the frequencies for which the transmission efficiency coefficient is less than the predetermined threshold

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value from the electrical corresponding to the frequencies for which the transmission efficiency coefficient is equal to or greater than the predetermined threshold value, and

providing the electrical signals corresponding to the frequencies for which the transmission efficiency coefficient is equal to or greater than the predetermined threshold value to the steering system (13); and
a randomization unit (26) configured for

receiving the electrical signals corresponding to the frequencies for which the transmission efficiency coefficient is less than a predetermined threshold value,

iteratively modifying these electrical signals by randomizing amplitude and phase of these electrical signals, thereby generating randomized signals, each randomized signal having a corresponding randomized amplitude and randomized phase, and

providing in each iteration said randomized signals to the efficiency determination unit (22) to calculate transmission efficiency coefficient for said randomized signals.

3. The transmission system of claim 1, wherein the optimal modified signals are the randomized signals for which the transmission efficiency coefficient is equal to or greater than the predetermined threshold value and the optimal unmodified signals are electrical signals having said initial amplitude and said initial phase for which the transmission efficiency coefficient is equal to or greater than the predetermined threshold value.

4. The transmission system of any one of claims 1 to 3, wherein the randomization system (12) is configured for performing iterative modification of the electrical signals corresponding to the frequencies for which the transmission efficiency coefficient is less than the predetermined threshold value until the transmission efficiency coefficient for these electrical signals is equal to or greater than said predetermined threshold value.

5. The transmission system of any one of claims 1 to 4, wherein the transmission efficiency coefficient is calculated by:

$$T_k = \frac{E_{trans}}{E_{total}} \cdot 100\% ,$$

where E_{total} is the total energy of the electrical signals for the k -th frequency f_k generated by the RF signal generator and E_{trans} is the energy transmitted in operation for the k -th

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frequency f_k and where E_{trans} is calculated by the efficiency determination unit (22) by $E_{trans} = E_{total} - E_{lost}$, where E_{lost} is the energy that is lost by the transmission system in operation for the k -th frequency f_k .

6. The transmission system of claim 5, wherein the lost energy E_{lost} is calculated by:

$$E_{lost} = \sum_{n=1}^N \widetilde{|s|}_n, \quad (5)$$

where $\widetilde{s}_n$ is a combined energy that an n -th antenna element ($n = 1, 2, \dots, N$) in the antenna array (14) receives from neighboring antenna elements and a self-reflected energy of the n -th antenna element.

7. The transmission system of claim 6, wherein said combined energy $\widetilde{s}_n$ is calculated by:

$$\begin{pmatrix} \widetilde{s}_1 \\ \widetilde{s}_2 \\ \widetilde{s}_3 \\ \vdots \\ \widetilde{s}_N \end{pmatrix} = \begin{pmatrix} s_{11} & s_{12} & s_{13} & \cdots & s_{1N} \\ s_{21} & s_{22} & s_{23} & \cdots & s_{2N} \\ s_{31} & s_{32} & s_{33} & \cdots & s_{3N} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ s_{N1} & s_{N2} & \cdots & s_{N3} & \cdots & s_{NN} \end{pmatrix} \cdot \begin{pmatrix} A_1 e^{j\varphi_1} \\ A_2 e^{j\varphi_2} \\ A_3 e^{j\varphi_3} \\ \vdots \\ A_N e^{j\varphi_N} \end{pmatrix},$$

where $V_k^{init} = \begin{pmatrix} A_1 e^{j\varphi_1} \\ A_2 e^{j\varphi_2} \\ A_3 e^{j\varphi_3} \\ \vdots \\ A_N e^{j\varphi_N} \end{pmatrix}_k$ is an initial excitation vector representing the electrical

signals for N transmission channels for each k -th frequency f_k , and

$$S = \begin{pmatrix} s_{11} & s_{12} & s_{13} & \cdots & s_{1N} \\ s_{21} & s_{22} & s_{23} & \cdots & s_{2N} \\ s_{31} & s_{32} & s_{33} & \cdots & s_{3N} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ s_{N1} & s_{N2} & \cdots & s_{N3} & \cdots & s_{NN} \end{pmatrix} \text{ is a coupling matrix characterizing mutual coupling}$$

15 between antenna elements and a self-reflected energy of the antenna elements in the antenna array (14).

8. The transmission system of claim 7, wherein the transmitted energy E_{trans} of the transmission system is calculated by:

$$E_{trans} = E_{total} - E_{lost} = \sum_{n=1}^N |A_n e^{j\varphi_n}| - \sum_{n=1}^N \widetilde{|s|}_n$$

20 9. The transmission system of claim 2, wherein randomizing the amplitude and the phase of the electrical signals is carried out by iteratively generating two random

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numbers, each in the interval $[0, 1]$, and multiplying the initial amplitude and the initial phase of said electrical signals by the two random numbers, correspondingly; thereby generating said randomized signals.

10 **10.** The transmission system of claim 9, wherein said two random numbers are different for each electrical signal in an n -th transmission channel ($n = 1, 2, \dots, N$).

11. The transmission system of any one of claims 1 to 10, wherein the randomization system (12) further includes an optimal efficiency determination system (310) arranged downstream of the randomization unit (26) and coupled to the comparing unit (24) and to the efficiency determination unit (22), said optimal efficiency determination system (310)
15 is configured for sub-iteratively modifying said two random numbers thereby, generating in each sub-iteration two modified random numbers, and generating modified randomized signals for which the transmission efficiency coefficient is greater than the transmission efficiency coefficient of the randomized signals by using said two modified random numbers.

15 **12.** The transmission system of claim 11, wherein the optimal efficiency determination system (310) is configured to perform a predetermined number P of sub-iterations to generate said modified randomized signals for which the transmission efficiency coefficient is greater than the transmission efficiency coefficient of the randomized signals provided by the randomization unit (26).

20 **13.** The transmission system of claims 11 or 12, wherein the optimal efficiency determination system (310) comprises:

a modification unit (311) configured for (i) receiving the electrical signals for which the transmission efficiency coefficient is less than the predetermined threshold value from the comparing unit (24) and (ii) receiving the corresponding two random
25 numbers for each electrical signal from the randomization unit (26) and (iii) sub-iteratively modifying said electrical signals, thereby generating said modified randomized signals;

an efficiency determination sub-unit (312) arranged downstream of the modification unit (311) configured for sub-iteratively receiving the modified randomized
30 signals from the modification unit (311) and calculating a transmission efficiency coefficient for these modified randomized signals;

a storing unit (314) configured for storing the transmission efficiency coefficient for the modified randomized signals and a corresponding excitation vector sub-iteratively

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received from the efficiency determination sub-unit (312), and storing the transmission efficiency coefficient for the randomized signals, and a corresponding randomized vector iteratively obtained from the efficiency determination unit; and

a comparing sub-unit (313) coupled to the storing unit (314) configured for

5 sub-iteratively receiving a stored efficiency coefficient from the storing unit (314) and the transmission efficiency coefficient for the modified randomized signals from the efficiency determination sub-unit (312),

sub-iteratively comparing the stored efficiency coefficient with the transmission efficiency coefficient of the modified randomized signals, and

10 providing the transmission efficiency coefficient for the modified randomized signals and the corresponding excitation vector to the storing unit (314) for storing thereof when the value of this transmission efficiency coefficient for the modified randomized signals is greater than the value of said stored efficiency coefficient.

14. The transmission system of claim 13, wherein the modification of the electrical signals corresponding to the frequencies for which the transmission efficiency coefficient is less than the predetermined threshold value by the modification unit (311) is carried out by multiplying the initial amplitude and initial phase of each electrical signal by corresponding two modified random numbers.

15. The transmission system of any one of claims claim 11 to 14, wherein said two modified random numbers are generated by sub-iteratively adding $\pm A\beta_1 \cdot p$ and $\pm A\beta_2 \cdot p$ to the two random numbers, correspondingly, where $p = 1, 2, \dots, P$.

16. A method for transmitting radio frequency (RF) radiation in a predetermined direction at a sequence of K frequencies by an antenna array (14) comprising a predetermined number N of antenna elements, comprising:

25 generating electrical signals having an initial amplitude and an initial phase at a sequence of K frequencies;

processing the electrical signals and obtaining optimal electrical signals for which the transmission efficiency coefficient is equal to or greater than a predetermined threshold value, the optimal electrical signals including optimal unmodified signals and

30 optimal modified signals;

generating steering electrical signals related to the optimal electrical signals; and

forming a steered beam based on the steering electrical signals for transmission in the predetermined direction.

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17. The method of claim 16, wherein the obtaining of the optimal electrical signals comprises:

calculating a transmission efficiency coefficient for each k -th frequency f_k of the sequence of K frequencies;

5 comparing the transmission efficiency coefficient for each k -th frequency f_k with a predetermined threshold value;

separating electrical signals corresponding to the frequencies for which the transmission efficiency coefficient is less than the predetermined threshold value from the electrical corresponding to the frequencies for which the transmission efficiency

10 coefficient is equal to or greater than the predetermined threshold value;

iteratively modifying the electrical signals corresponding to the frequencies for which the transmission efficiency coefficient is less than a predetermined threshold value by randomizing amplitude and phase of these electrical signals, thereby generating randomized signals; and

15 providing optimal electrical signals including optimal unmodified signals and optimal modified signals.

18. The method of claims 16 or 17, wherein the optimal modified signals are the randomized signals for which the transmission efficiency coefficient is equal to or greater than the predetermined threshold value, and the optimal unmodified signals are the
20 electrical signals having said initial amplitude and said initial phase for which the transmission efficiency coefficient is equal to or greater than the predetermined threshold value.

19. The method of claim 17, wherein the iterative modifying of the electrical signals corresponding to the frequencies for which the transmission efficiency coefficient is less
25 than the predetermined threshold value, is performed until the transmission efficiency coefficient for these electrical signals is equal to or greater than said predetermined threshold value thereby generating the optimal modified signals.

20. The method of claim 17, wherein the transmission efficiency coefficient is calculated by:

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$$T_k = \frac{E_{trans}}{E_{total}} \cdot 100\% \quad ,$$

where E_{total} is the total energy of the electrical signals for the k -th frequency f_k , E_{trans} is the energy transmitted in operation for the k -th frequency f_k and where E_{trans} is calculated

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by $E_{trans} = E_{total} - E_{lost}$, where E_{lost} is the energy that is lost in operation for the k -th frequency f_k .

21. The transmission system of any one of claims 16 to 20, wherein the lost energy E_{lost} is calculated by:

$$E_{lost} = \sum_{n=1}^N |\widetilde{s}|_n$$

where $\widetilde{s}_n$ is a combined energy that an n -th antenna element in the antenna array (14) receives from neighboring antenna elements and a self-reflected energy of the n -th antenna element.

22. The method of claim 21, wherein said combined energy $\widetilde{s}_n$ is calculated by:

$$\begin{pmatrix} \widetilde{s}_1 \\ \widetilde{s}_2 \\ \widetilde{s}_3 \\ \vdots \\ \widetilde{s}_N \end{pmatrix} = \begin{pmatrix} S_{11} & S_{12} & S_{13} & \cdots & S_{1N} \\ S_{21} & S_{22} & S_{23} & \cdots & S_{2N} \\ S_{31} & S_{32} & S_{33} & \cdots & S_{3N} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ S_{N1} & S_{N2} & \cdots & S_{N3} & \cdots & S_{NN} \end{pmatrix} \cdot \begin{pmatrix} A_1 e^{j\varphi_1} \\ A_2 e^{j\varphi_2} \\ A_3 e^{j\varphi_3} \\ \vdots \\ A_N e^{j\varphi_N} \end{pmatrix},$$

where $V_k^{init} = \begin{pmatrix} A_1 e^{j\varphi_1} \\ A_2 e^{j\varphi_2} \\ A_3 e^{j\varphi_3} \\ \vdots \\ A_N e^{j\varphi_N} \end{pmatrix}_k$ is an initial excitation vector representing the electrical

signals for N transmission channels for each k -th frequency f_k and

$$S = \begin{pmatrix} S_{11} & S_{12} & S_{13} & \cdots & S_{1N} \\ S_{21} & S_{22} & S_{23} & \cdots & S_{2N} \\ S_{31} & S_{32} & S_{33} & \cdots & S_{3N} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ S_{N1} & S_{N2} & \cdots & S_{N3} & \cdots & S_{NN} \end{pmatrix}$$
 is a coupling matrix characterizing mutual coupling

between antenna elements and the self-reflected energy of the antenna elements in the

antenna array (14).

23. The method of claim 22, wherein the transmitted energy E_{trans} of the transmission system is calculated by:

$$E_{trans} = E_{total} - E_{lost} = \sum_{n=1}^N |A_n e^{j\varphi_n}| - \sum_{n=1}^N |\widetilde{s}|_n$$

24. The method of claim 23, wherein randomizing the amplitude and the phase of the electrical signals is carried out by generating two random numbers, each in the interval

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[0, 1], and multiplying the initial amplitude and the initial phase of said electrical signals by the two random numbers, correspondingly.

25. The method of claim 24, wherein said two random numbers can be different for each electrical signal in an n -th transmission channel selected from the N transmission
5 channels.

26. The method of claims 16 to 25, wherein the iteratively modifying of the electrical signals further includes providing modified randomized signals for which the transmission efficiency coefficient is greater than the transmission efficiency coefficient of the randomized signals.

10 27. The method of claim 26, wherein the providing of the modified randomized signals for which the transmission efficiency coefficient is greater than the transmission efficiency coefficient of the randomized signals comprises:

receiving and storing the transmission efficiency coefficient of the randomized signals and a corresponding randomized excitation vector;

15 sub-iteratively modifying the electrical signals corresponding to the frequencies for which the transmission efficiency coefficient is less than the predetermined threshold value, thereby generating the modified randomized signals;

sub-iteratively calculating a transmission efficiency coefficient for these modified randomized signals;

20 sub-iteratively comparing the transmission efficiency coefficient for the modified randomized signals with a previously stored transmission efficiency coefficient; and

sub-iteratively replacing the previously stored transmission efficiency coefficient and the previously stored randomized excitation vector with the transmission efficiency coefficient for the modified randomized signals and a corresponding modified excitation
25 vector when the transmission efficiency coefficient for the modified randomized signals is greater than the previously stored transmission efficiency coefficient.

28. The method of claim 27, wherein the providing of the modified randomized signals for which the transmission efficiency coefficient is greater than the transmission efficiency coefficient of the randomized signals is carried out by performing a
30 predetermined number P of sub-iterations.

29. The method of claim 28, wherein the sub-iteratively modifying of the electrical signals corresponding to the frequencies for which the transmission efficiency coefficient is less than the predetermined threshold value, is carried out by multiplying the initial

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amplitude and initial phase of each electrical signal by corresponding two modified random numbers.

30. The method of claim 29, wherein said two modified random numbers are generated by sub-iteratively adding $\pm A\beta_1 \cdot p$ and $\pm A\beta_2 \cdot p$ to the two random numbers,
5 correspondingly, where $p = 1, 2, \dots, P$.

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