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(54) **DECOUPLING ANTENNA AND DECOUPLING METHOD THEREFOR**

(57) Provided are a decoupling antenna and decoupling method. The decoupling antenna includes an antenna port, a decoupling network, a feed network, a phase-shift network, and at least two antenna arrays. The phase-shift network is connected to the at least two antenna arrays separately. An input end of the feed network

is connected to the decoupling network, and an output end of the feed network is connected to the phase-shift network. The decoupling network is disposed between the antenna port and the feed network and configured to eliminate a mutually-coupled signal generated between the at least two antenna arrays.

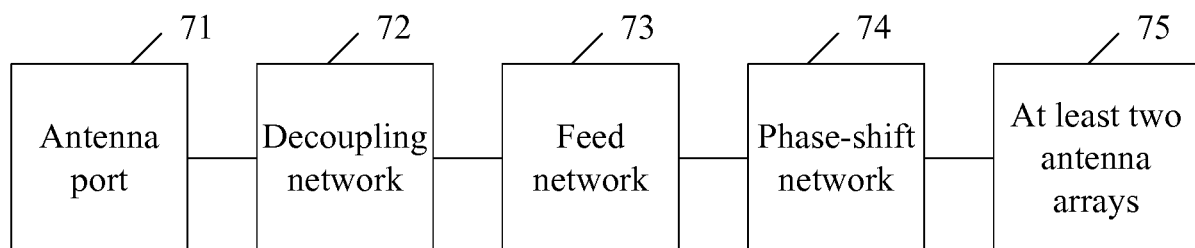


FIG. 7A

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Description**TECHNICAL FIELD**

5 **[0001]** The present disclosure relates to the field of antenna decoupling technologies, for example, a decoupling antenna and a decoupling method thereof.

BACKGROUND

10 **[0002]** With the rapid development of the communication system, to improve the signal capacity and throughput of the communication system, the RF front-end Multiple-Input Multiple-Output (MIMO) technology has received more and more attention from the industry, and the large-scale array antenna system has become a research hotspot of the communication technology in recent years. Due to an increase in the number of antenna arrays, multiple antennas are integrated in a limited space, and the spacing between the antenna arrays is much smaller than the half wavelength.
 15 As a result, the correlation between the antenna arrays is greatly increased, and the mutual coupling between the antennas is enhanced. Strong mutual coupling between antennas not only causes serious self-interference between channels, deterioration of the signal-to-noise ratio of the communication channel, a reduction in the channel capacity and a reduction in the radiation efficiency, but also affects the port standing wave of the communication system and causes a reduction in the false alarm rate of the system. To keep miniaturizing the large-scale antenna system while
 20 reducing the interference between the antenna arrays, the decoupling technology between the antenna arrays has become a subject to be studied.

[0003] In the existing art, as shown in FIG. 1, multiple antenna arrays are independent of each other, and the spatial distance between the antenna arrays is increased so that decoupling between the antenna arrays is achieved. However, as the number of antenna arrays increases, the size of an antenna is getting bigger and is difficult to meet the needs of
 25 the market application.

SUMMARY

30 **[0004]** A decoupling antenna and a decoupling method thereof are provided in the present disclosure to eliminate a coupled signal generated between antenna arrays.

[0005] A decoupling antenna is provided in the present disclosure. The decoupling antenna includes an antenna port, a decoupling network, a feed network, a phase-shift network, and at least two antenna arrays.

[0006] The phase-shift network is connected to the at least two antenna arrays separately.

35 **[0007]** An input end of the feed network is connected to the decoupling network, and an output end of the feed network is connected to the phase-shift network.

[0008] The decoupling network is disposed between the antenna port and the feed network and configured to eliminate a mutually-coupled signal generated between the at least two antenna arrays.

[0009] Optionally, the spacing between antenna arrays is less than or equal to a preset value.

[0010] Optionally, the decoupling network includes N stages of adjustable decoupling units. N is a positive integer.

40 **[0011]** An input end of a first-stage adjustable decoupling unit is connected to the antenna port via a first phase-delay network, and an output end of an Nth-stage adjustable decoupling unit is connected to the input end of the feed network via a second phase-delay network.

[0012] Optionally, the ith-stage adjustable decoupling unit and the (i+1)th-stage adjustable decoupling unit are connected by a first coupling tuning network. $1 \leq i \leq N-1$ and N is greater than or equal to 3.

45 **[0013]** Optionally, an adjustable decoupling unit includes at least two resonant networks. resonant networks are connected by a second coupling tuning network.

[0014] Optionally, the ith-stage adjustable decoupling unit and the (i+1)th-stage adjustable decoupling unit are connected by the first coupling tuning network in the following manner: resonant networks in the ith-stage adjustable decoupling unit and resonant networks in the (i+1)th-stage adjustable decoupling unit are connected by the first coupling
 50 tuning network.

[0015] Optionally, the first coupling tuning network and the second coupling tuning network respectively include coupling tuning screws, which is used for adjusting phases in the resonant networks.

[0016] Optionally, a resonant network includes a resonant cavity, a cylindrical resonator located inside the resonant cavity, and a frequency tuning screw coaxial with the cylindrical resonator. The frequency tuning screw is configured to
 55 adjust a frequency in the resonant network.

[0017] Optionally, M antenna ports and M antenna arrays are provided and, correspondingly, the adjustable decoupling unit includes M input ends and M output ends. M is a positive integer and greater than or equal to 3.

[0018] Optionally, the adjustable decoupling unit includes at least two resonant networks. resonant networks are

connected by a second coupling tuning network.

[0019] A decoupling method for a decoupling antenna is provided in the present disclosure. The decoupling antenna is the preceding decoupling antenna.

[0020] The method includes controlling the decoupling network to generate a decoupling signal; and eliminating, through the decoupling signal, a mutually-coupled signal generated between the at least two antenna arrays.

[0021] In the solution provided in the present disclosure, the decoupling antenna includes an antenna port, a decoupling network, a feed network, a phase-shift network, and at least two antenna arrays. The phase-shift network is connected to the at least two antenna arrays separately. An input end of the feed network is connected to the decoupling network, and an output end of the feed network is connected to the phase-shift network. The decoupling network is disposed between the antenna port and the feed network and configured to eliminate a mutually-coupled signal generated between the at least two antenna arrays. In the solution of the present application, a decoupling network is disposed between the antenna port and the feed network, thereby eliminating the mutually-coupled signal generated between the antenna arrays and thus allowing the design of an antenna array structure occupying a small space.

BRIEF DESCRIPTION OF DRAWINGS

[0022]

FIG. 1 is a schematic diagram illustrating a network topology of an antenna array in the existing art.

FIG. 2 is a schematic diagram illustrating a network topology of an antenna array according to an embodiment.

FIG. 3 is a schematic diagram illustrating parameter passing of a decoupling antenna according to an embodiment.

FIG. 4 is a schematic diagram illustrating an adjustable factor for a decoupling network (CNDN) matrix according to an embodiment.

FIG. 5 is a schematic diagram illustrating a physical model of a decoupling network (CNDN) according to an embodiment.

FIG. 6 is an effect graph of a decoupling network (CNDN) according to an embodiment.

FIG. 7A is a structure diagram of a decoupling antenna according to an embodiment.

FIG. 7B is a structure diagram of at least two antenna arrays 75 of FIG. 7A.

FIG. 8 is a flowchart of a decoupling method for a decoupling antenna according to an embodiment.

FIG. 9 is a structure diagram of a resonant network 720 of FIG. 2.

DETAILED DESCRIPTION

[0023] The accompanying drawings are for illustrative purposes only and are not intended to limit embodiments of the present application.

[0024] FIG. 7A is a structure diagram of a decoupling antenna according to an embodiment. The decoupling antenna of this embodiment of the present application includes an antenna port 71, a decoupling network 72, a feed network 73, a phase-shift network 74, and at least two antenna arrays 75.

[0025] The phase-shift network 74 is connected to the at least two antenna arrays 75 separately.

[0026] An input end of the feed network 73 is connected to the decoupling network 72, and an output end of the feed network 73 is connected to the phase-shift network 74.

[0027] The decoupling network 72 is disposed between the antenna port 71 and the feed network 73 and is configured to eliminate a mutually-coupled signal generated between the at least two antenna arrays 75.

[0028] In this embodiment of the present application, optionally, referring to FIG. 7B, the at least two antenna arrays 75 may include multiple antenna elements 7511, and the spacing between antenna arrays 751 is less than or equal to a preset value.

[0029] When the spacing between the antenna arrays 751 is less than or equal to the preset value, the requirements for miniaturizing the antenna structure can be satisfied.

[0030] In this embodiment of the present application, optionally, referring to FIG. 2, the decoupling network 72 includes

N stages of adjustable decoupling units. N is a positive integer.

[0031] An input end of a first-stage adjustable decoupling unit 721 is connected to the antenna port 71 via a first phase-delay network 10, and an output end of an Nth-stage adjustable decoupling unit 72N is connected to the input end of the feed network 73 via a second phase-delay network 20.

[0032] The value of N may be determined according to the actual decoupling parameters.

[0033] In this embodiment of the present application, optionally, the *i*th-stage adjustable decoupling unit 72*i* and the (*i*+1)th-stage adjustable decoupling unit 72(*i*+1) are connected by a first coupling tuning network 30. $1 \leq i \leq N-1$ and N is greater than or equal to 3.

[0034] In this embodiment of the present application, optionally, adjustable decoupling unit includes at least two resonant networks 720. Resonant networks 720 are connected by a second coupling tuning network 40.

[0035] In this embodiment of the present application, optionally, the *i*th-stage adjustable decoupling unit 72*i* and the (*i*+1)th-stage adjustable decoupling unit 72(*i*+1) are connected by the first coupling tuning network 30 in the following manner: resonant networks in the *i*th-stage adjustable decoupling unit 72*i* and resonant networks in the (*i*+1)th-stage adjustable decoupling unit 72(*i*+1) are connected by the first coupling tuning network.

[0036] In this embodiment of the present application, optionally, the first coupling tuning network 30 and the second coupling tuning network 40 are coupling tuning screws, which are used for adjusting phases in the resonant networks 720.

[0037] In this embodiment of the present application, optionally, referring to FIG. 9, a resonant network 720 includes a resonant cavity 7201, a cylindrical resonator 7202 located inside the resonant cavity 7201, and a frequency tuning screw 7203 coaxial with the cylindrical resonator 7202. The frequency tuning screw 7203 is configured to adjust a frequency in the resonant network 720.

[0038] In this embodiment of the present application, optionally, M antenna ports 71 and M antenna arrays are provided and, correspondingly, each of the N stages of adjustable decoupling units includes M input ends and M output ends. M is greater than or equal to 2.

[0039] The decoupling antenna of this embodiment of the present application implements the antenna decoupling function through a decoupling network. In the decoupling antenna, the design of each network in the decoupling network can be completed according to the pre-designed decoupling parameters, and then a corresponding decoupling network is added between the antenna port and the feed network. Tuning screws in the decoupling network are adjusted to implement decoupling of the antenna system.

[0040] The solutions provided in embodiments of the present application are described below in conjunction with application examples.

[0041] As shown in FIG. 1, for a MIMO antenna system, it is assumed that M antenna channels are provided and independent of each other. M is a positive integer. In FIG. 1, COM indicates a combined circuit/DIV indicates a shunt circuit, and ANT+45° and ANT-45° represents one antenna signal respectively. Typically, in a MIMO antenna system, the spatial spacing between antenna arrays is increased so that mutual coupling between the antenna arrays is reduced. In this case, the network characteristic matrix of the MIMO antenna system appears as all matrix elements are close to zero. As the number of antenna arrays increases, the distance between the antenna arrays decreases, and the mutual coupling between the antenna arrays increases. In this case, the network characteristic matrix of the MIMO antenna system becomes a non-zero matrix, the dominant diagonal element of the non-zero matrix is close to zero and the non-dominant diagonal element of the non-zero matrix is non-zero. To make the MIMO antenna system meet the requirements of small size and signal matching, an adjustable decoupling network needs to be disposed at the back end of the MIMO antenna system. As shown in FIGS. 1 and 2, the network matrix S_D of the decoupling network 72 is an $N \times N$ matrix in which the matrix elements are adjustable. In FIG. 2, p1 and p2 represent the input ends of the decoupling network 72, and p3 and p4 represent the output ends of the decoupling network 72.

[0042] Referring to parameter passing shown in FIG. 3, a1 and a2 represent incident signals at the two ports of the network, and b1 and b2 represent reflected signals at the two ports of the network. In this embodiment of the present application, multiple network matrixes in the decoupling antenna structure are defined below.

[0043] S denotes the network parameter of the antenna structure after the decoupling network 72 is added. Here, the antenna structure includes two or more antenna arrays.

[0044] S_D denotes the network parameter of the decoupling network 72.

[0045] S_A denotes the network parameter of the antenna structure.

[0046] Γ_{in} denotes the reflection coefficient of the antenna structure S after the decoupling network 72 is added.

[0047] Γ_L denotes the reflection coefficient of the antenna structure S_A .

[0048] On the basis of the preceding definition, the network parameter S_D of the decoupling network 72 can be represented by a scattering parameter matrix, as shown in formula (1):

$$S_D = \begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix} \quad (1)$$

[0049] S_{11} represents the reflection coefficient of the first port in the decoupling network 72. S_{22} represents the reflection coefficient of the second port in the decoupling network 72. S_{12} represents the transmission coefficient of the transmission from the first port to the second port. S_{21} represents the transmission coefficient of the transmission from the second port to the first port.

[0050] After the decoupling network 72 is added between the antenna port 71 and the feed network 73, according to the microwave network theory, the matrix S can be characterized by the matrix S_D and the matrix S_A , and the expression of the matrix S is formula (2):

$$S = S_D S_A \quad (2)$$

[0051] The expression of the reflection coefficient Γ_{in} of the antenna structure S after the decoupling network 72 is added is formula (3):

$$\Gamma_{in} = S_{11} + S_{12} (1 - S_{22} \Gamma_L)^{-1} S_{21} \Gamma_L \quad (3)$$

[0052] Γ_L denotes the reflection coefficient of the antenna structure S_A .

[0053] In this embodiment of the present application, to design a reasonable decoupling network S_D , it is needed to make the reflection coefficient Γ_{in} of the antenna structure S equal to or close to the zero matrix after the decoupling network 72 is added, and the reflection coefficient Γ_{in} of the antenna structure S after the decoupling network 72 is added represents the degree of coupling of the signals between the antenna arrays.

[0054] Thus, when $\Gamma_{in} = 0$ (the ideal condition for eliminating all couplings), the relationship between the reflection coefficient Γ_L of the antenna structure S_A and the network parameter S_D of the decoupling network is as follows:

$$\Gamma_L = \frac{S_{11}}{S_{11} S_{22} - S_{12} S_{21}} \quad (4)$$

[0055] That is to say, in the design process of the actual decoupling antenna structure, the coupled signal generated between the antenna arrays can be eliminated after a decoupling network S_D is designed.

[0056] In this embodiment of the present application, the decoupling network S_D can be dynamically adjusted according to the antenna structure. For the method of making the parameters of the decoupling network S_D adjustable, see FIG. 4. FIG. 4 is a topological diagram of a four-port decoupling network 72 according to an embodiment of the present application. The decoupling network 72 can be represented by a four-port coupling matrix M:

$$M = \begin{bmatrix} M_p & M_{pn} \\ M_{pn} & M_n \end{bmatrix} \quad (5)$$

[0057] M_p denotes a 4x4 port direct coupling zero matrix. M_n denotes a 6x6 resonant coupling matrix. M_{pn} denotes an input/output (I/O) port coupling matrix.

[0058] In this embodiment of the present application, the network parameter S_m of the resonant coupling matrix M_n can be expressed as:

$$[S_m] = I - 2M_{pn} (sI + jM_n + M_{pn}^T M_{pn})^{-1} M_{pn}^T \quad (6)$$

[0059] I denotes a 4x4 phase discrimination matrix, j denotes an imaginary-part symbol.

[0060] s denotes the frequency variable of the decoupling network 72. $s = jf_0/BW \times (f/f_0 - f_0/f)$. f denotes frequency. f_0 denotes the center frequency of the decoupling network 72. BW denotes the bandwidth of the decoupling network 72.

[0061] According to the microwave network theory, the network parameter S_D of the adjustable decoupling network 72 is expressed as follows:

$$[S_D] = [P_{12}][S_m][P_{34}] \quad (7)$$

[0062] $[P_{12}] = \text{diag}\{\ell^{j\theta_1}, \ell^{j\theta_2}\}$. $[P_{34}] = \text{diag}\{\ell^{j\theta_3}, \ell^{j\theta_4}\}$. θ_1 and θ_2 represent phase angles of the first phase-delay network 10, and θ_3 and θ_4 represent phase angles of the second phase-delay network 20.

[0063] In FIG. 4, the resonant coupling matrix M_n can be expressed as:

$$[M_n] = \begin{bmatrix} M_{11} & M_{12} & M_{13} & M_{14} & M_{15} & M_{16} \\ M_{21} & M_{22} & M_{23} & M_{24} & M_{25} & M_{26} \\ M_{31} & M_{32} & M_{33} & M_{34} & M_{35} & M_{36} \\ M_{41} & M_{42} & M_{43} & M_{44} & M_{45} & M_{46} \\ M_{51} & M_{52} & M_{53} & M_{54} & M_{55} & M_{56} \\ M_{61} & M_{62} & M_{63} & M_{64} & M_{65} & M_{66} \end{bmatrix} \quad (8)$$

[0064] M_{11} , M_{22} , M_{33} , M_{44} , M_{55} and M_{66} represent resonant-cavity self-coupling matrix parameters. $M_{12} = M_{21}$, $M_{23} = M_{32}$, $M_{34} = M_{43}$, $M_{45} = M_{54}$, $M_{56} = M_{65}$, $M_{25} = M_{52}$ and $M_{16} = M_{61}$ represent adjacent-resonant-cavity mutual-coupling matrix parameters. Other coupling matrix parameters are denoted here by 0. In the resonant coupling matrix M_n , the self-coupling matrix parameters and the mutual-coupling matrix parameters are adjustable by the adjustable factor β_n . The matrix parameters of the matrix M_n are modified so that parameters of the decoupling network S_D are adjustable.

[0065] FIG. 5 is a schematic diagram illustrating a physical model of a decoupling network. For self-coupling matrix parameters M_{11} , M_{22} , M_{33} , M_{44} , M_{55} and M_{66} in the matrix, the frequency tuning screw 7203 is used to change the value variables. For mutual-coupling matrix parameters $M_{12} = M_{21}$, $M_{23} = M_{32}$, $M_{34} = M_{43}$, $M_{45} = M_{54}$, $M_{56} = M_{65}$, $M_{25} = M_{52}$ and $M_{16} = M_{61}$ in the matrix, the frequency tuning screw 7204 is used to change the value variables, and the depth of the tuning screw is controlled such that the model parameters of the resonant coupling matrix M_n are changed to match the network parameter S_A of the antenna structure so that the reflection coefficient Γ_{in} of the port of the new multi-antenna structure after the adjustable decoupling network S_D is added is approximately zero.

[0066] FIG. 6 is an effect graph of a decoupling network according to an embodiment of the present application. As shown in FIG. 6, the horizontal ordinate represents the frequency and the vertical ordinate represents the degree of coupling. In this example, it is assumed that two antenna ports are provided, and S_{21} represents the degree of coupling between the two ports. It can be seen from the figure that the degree of coupling is relatively high before the decoupling network 72 is added (corresponding to the curve before S_{21} destructive interference) and the degree of coupling is significantly reduced after the decoupling network 72 is added (corresponding to the curve after S_{21} destructive interference) so that the coupled signal at the antenna port is eliminated and an antenna array structure occupying a small space can be designed.

[0067] FIG. 8 is a flowchart of a decoupling method for a decoupling antenna according to an embodiment of the present application. The decoupling antenna is any one of the preceding decoupling antennas. As shown in FIG. 8, the method includes the steps described below.

[0068] In step 810, the decoupling network is controlled to generate a decoupling signal.

[0069] In step 820, a mutually-coupled signal generated between the at least two antenna arrays is eliminated through the decoupling signal.

[0070] A decoupling method for a decoupling antenna is provided in an embodiment of the present disclosure. The decoupling antenna is any one of the preceding decoupling antennas. The method includes step (1) and step (2).

[0071] In step (1), a decoupling network is configured between the antenna port and the feed network.

[0072] In this embodiment of the present application, optionally, the decoupling network is configured between the antenna port and the feed network in the manner described below.

[0073] N stages of adjustable decoupling units are configured between the antenna port and the feed network, where N is a positive integer.

[0074] An input end of a first-stage adjustable decoupling unit is connected to the antenna port via a first phase-delay network, and an output end of an Nth-stage adjustable decoupling unit is connected to the input end of the feed network via a second phase-delay network.

[0075] In step (2), a mutually-coupled signal generated between the at least two antenna arrays is eliminated through the decoupling network.

[0076] In this embodiment of the present application, optionally, each of the N stages of adjustable decoupling units includes at least two resonant networks. the resonant networks are connected by a second coupling tuning network. A resonant network in the ith-stage adjustable decoupling unit and a resonant network in the (i+1)th-stage adjustable decoupling unit are connected by the second coupling tuning network.

[0077] In this embodiment of the present application, the first coupling tuning network and the second coupling tuning network are coupling tuning screws; and a resonant network includes a resonant cavity, a cylindrical resonator located inside the resonant cavity, and a frequency tuning screw coaxial with the cylindrical resonator.

[0078] The mutually-coupled signal generated between the at least two antenna arrays is eliminated through the decoupling network in the manner described below.

[0079] The coupling tuning screws are used to adjust phases in the resonant networks and the frequency tuning screws are used to adjust frequencies in the resonant networks so that the mutually-coupled signal generated between the at least two antenna arrays is eliminated.

INDUSTRIAL APPLICABILITY

[0080] In the decoupling antenna and the decoupling method thereof provided in the present disclosure, a decoupling network is disposed between the antenna port and the feed network, thereby eliminating the mutually-coupled signal generated between the antenna arrays and thus allowing the design of an antenna array structure occupying a small space.

Claims

1. A decoupling antenna, comprising an antenna port, a decoupling network, a feed network, a phase-shift network, and at least two antenna arrays, wherein
the phase-shift network is connected to the at least two antenna arrays separately;
an input end of the feed network is connected to the decoupling network, and an output end of the feed network is connected to the phase-shift network; and
the decoupling network is disposed between the antenna port and the feed network, and the decoupling network is configured to eliminate a mutually-coupled signal generated between the at least two antenna arrays.
2. The decoupling antenna of claim 1, wherein a spacing between antenna arrays is less than or equal to a preset value.
3. The decoupling antenna of claim 1, wherein the decoupling network comprises N stages of adjustable decoupling units, wherein N is a positive integer, wherein
an input end of a first-stage adjustable decoupling unit is connected to the antenna port via a first phase-delay network, and an output end of an Nth-stage adjustable decoupling unit is connected to the input end of the feed network via a second phase-delay network.
4. The decoupling antenna of claim 3, wherein an ith-stage adjustable decoupling unit and an (i+1)th-stage adjustable decoupling unit are connected by a first coupling tuning network, wherein $1 \leq i \leq N-1$ and N is greater than or equal to 3.
5. The decoupling antenna of claim 4, wherein an adjustable decoupling unit comprises at least two resonant networks, wherein resonant networks are connected by a second coupling tuning network.
6. The decoupling antenna of claim 5, wherein the ith-stage adjustable decoupling unit and the (i+1)th-stage adjustable decoupling unit are connected by the first coupling tuning network in a following manner:
resonant networks in the ith-stage adjustable decoupling unit and resonant networks in the (i+1)th-stage adjustable decoupling unit are connected by the first coupling tuning network.
7. The decoupling antenna of claim 5, wherein the first coupling tuning network and the second coupling tuning network respectively comprise coupling tuning screws, which are used for adjusting phases in the resonant networks.

8. The decoupling antenna of claim 5, wherein the resonant network comprises a resonant cavity, a cylindrical resonator located inside the resonant cavity, and a frequency tuning screw coaxial with the cylindrical resonator, wherein the frequency tuning screw is configured to adjust a frequency in the resonant network.

5 9. The decoupling antenna of claim 3, wherein M antenna ports and M antenna arrays are provided and, correspondingly, the adjustable decoupling unit comprises M input ends and M output ends, wherein M is a positive integer and greater than or equal to 3.

10 10. The decoupling antenna of claim 3, wherein the adjustable decoupling unit comprises at least two resonant networks, wherein resonant networks are connected by a second coupling tuning network.

11. A decoupling method for a decoupling antenna, wherein the decoupling antenna comprises the decoupling antenna of any one of claims 1 to 10 and the method comprises:

15 controlling the decoupling network to generate a decoupling signal; and
eliminating, through the decoupling signal, the mutually-coupled signal generated between the at least two antenna arrays.

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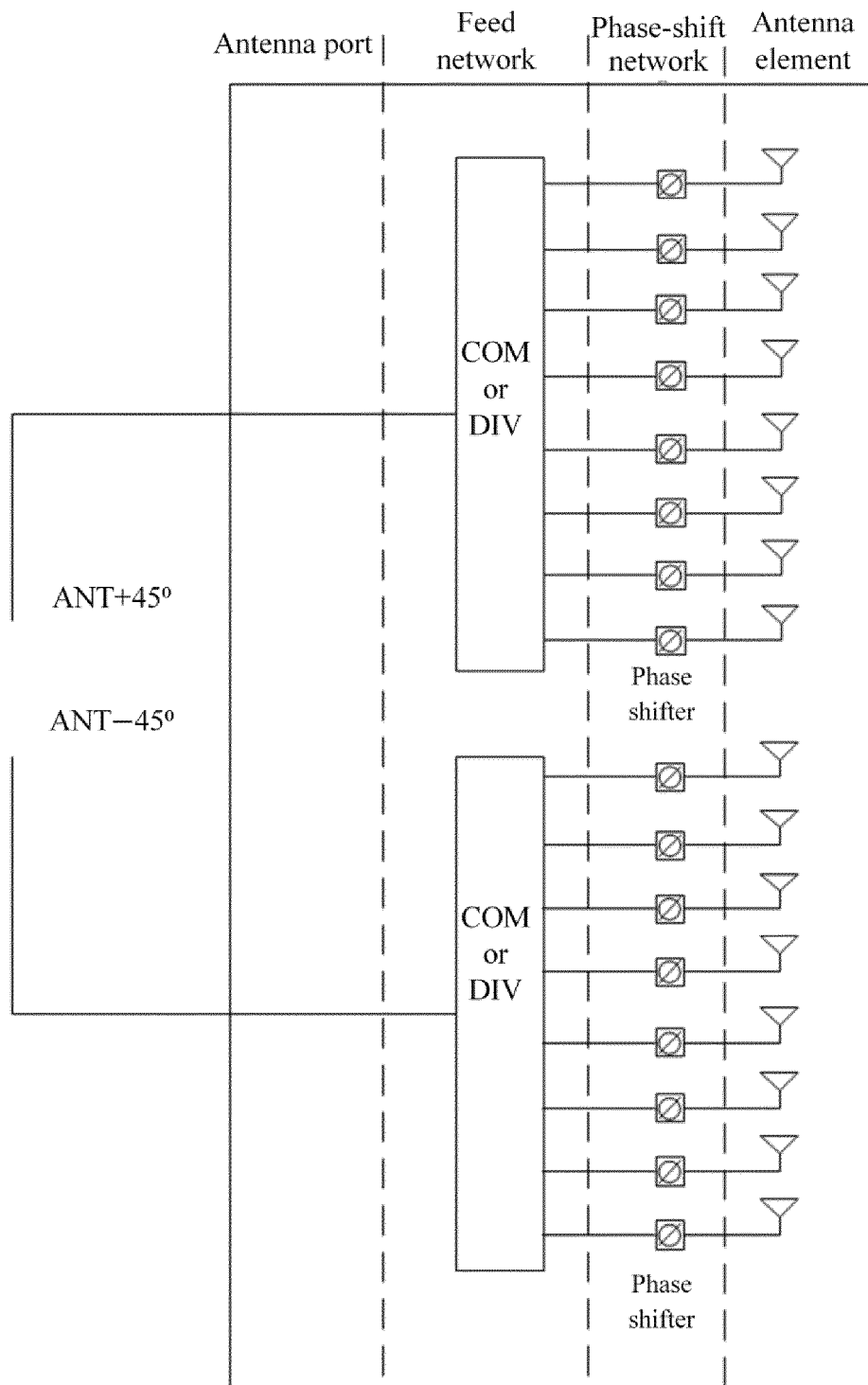


FIG. 1

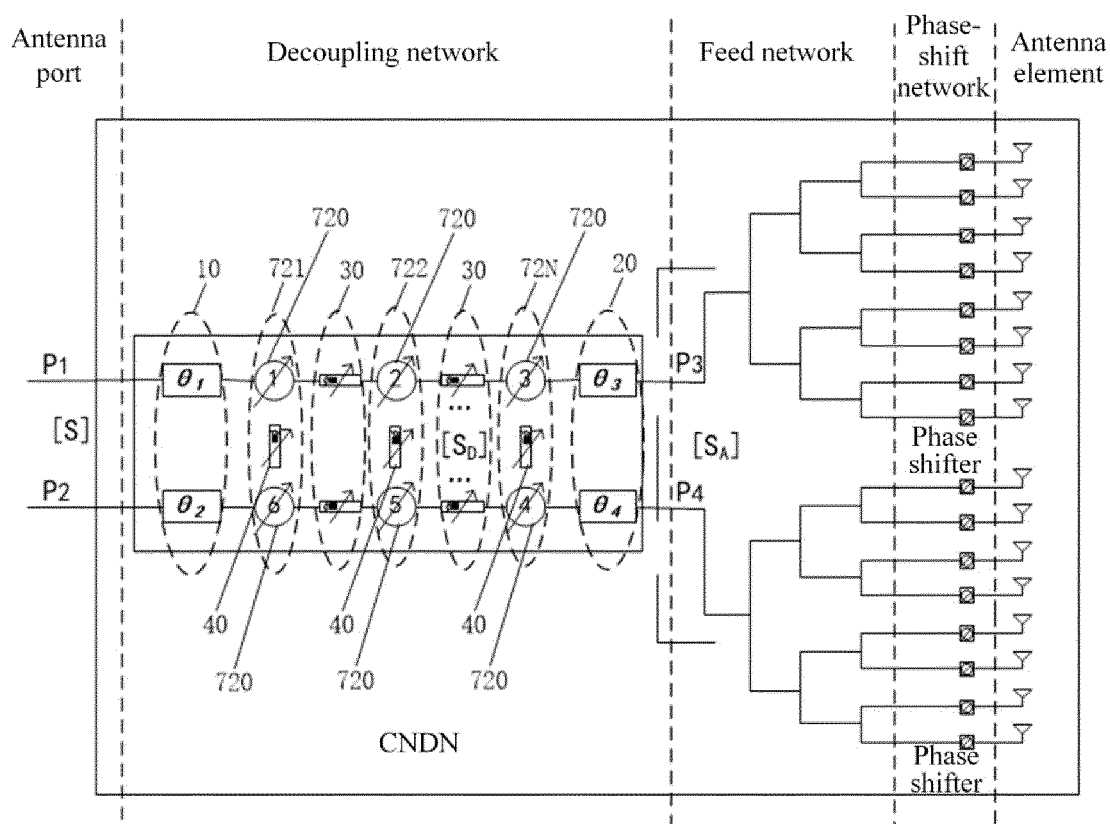


FIG. 2

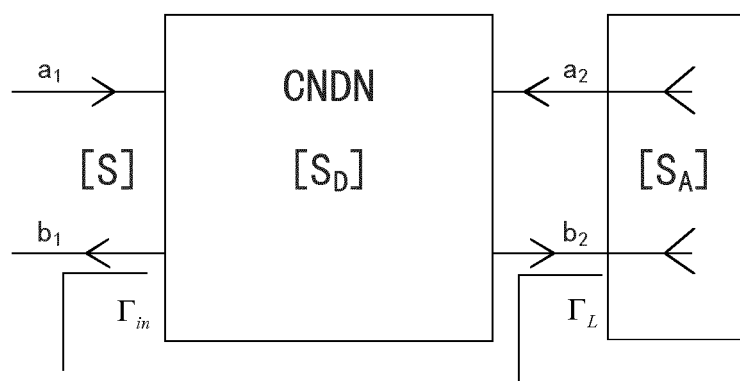


FIG. 3

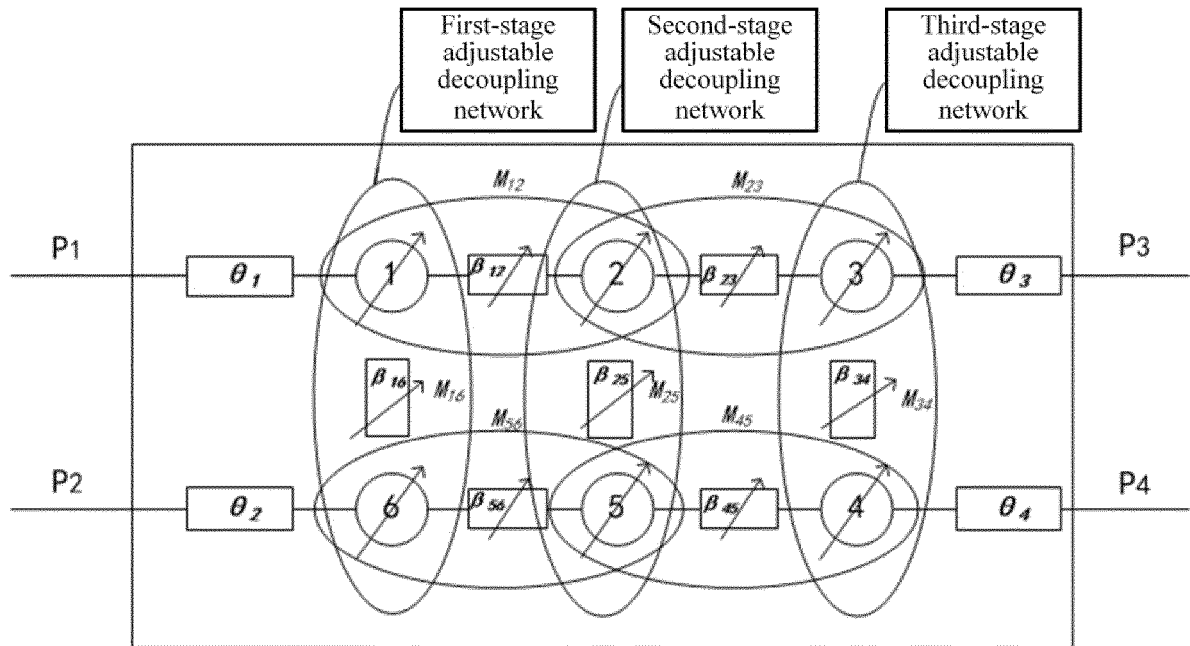


FIG. 4

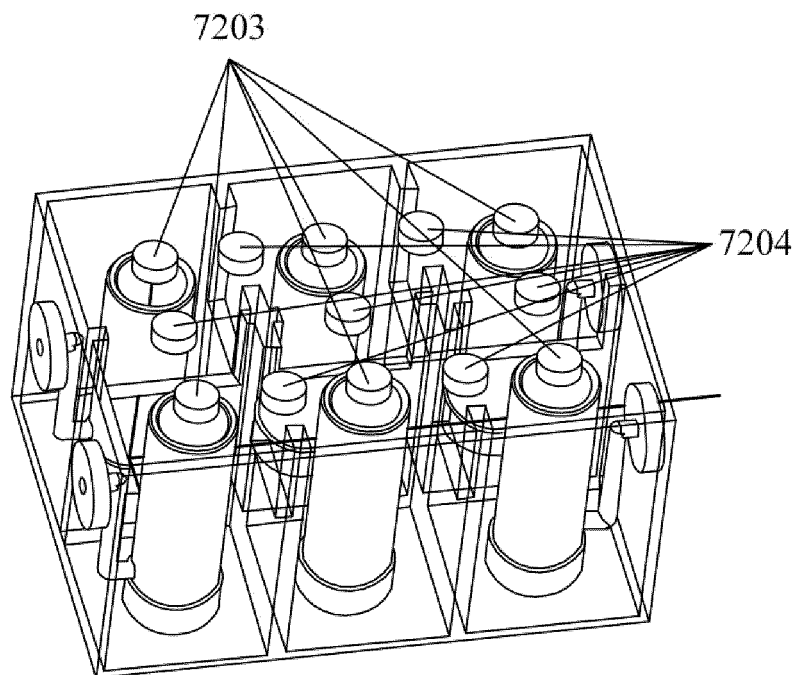
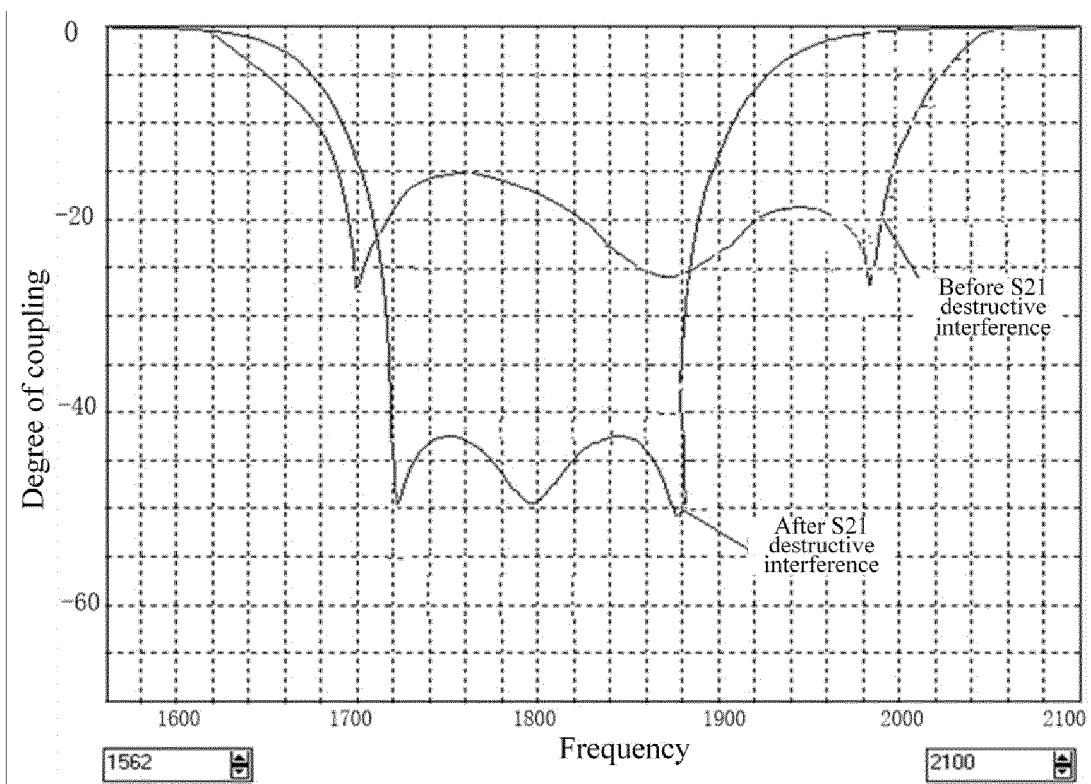
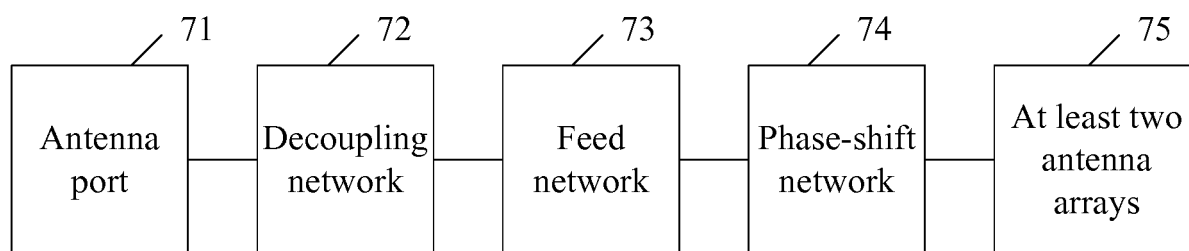


FIG. 5

**FIG. 6****FIG. 7A**

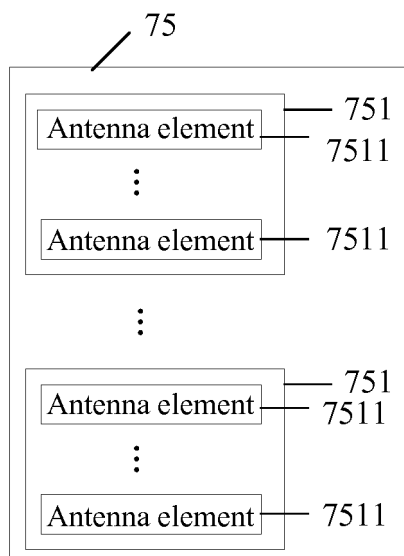


FIG. 7B

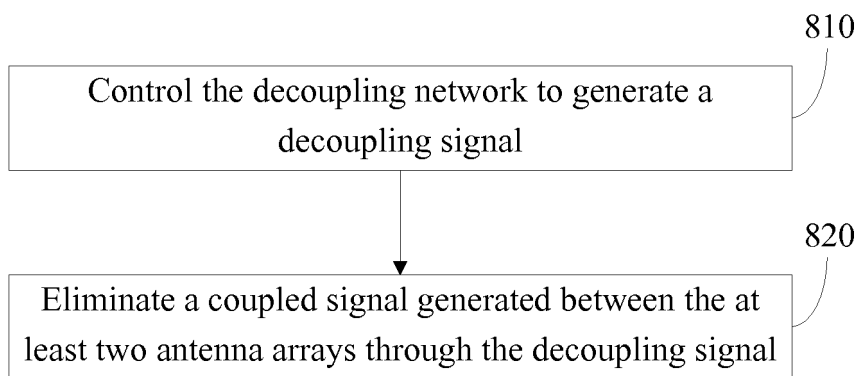


FIG. 8

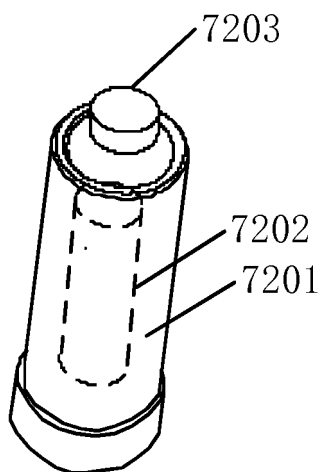


FIG. 9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2017/120320

A. CLASSIFICATION OF SUBJECT MATTER

H01Q 1/52 (2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H01Q; H04W; H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNAPT, CNKI, WPI, VEN, EPODOC, GOOGLE: 天线, 互耦, 去耦, 解耦, 耦合, 移相, 馈电, 阵列, antenna, feed, phase, shift,
decoupl+

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 203445240 U (NANJING UNIVERSITY OF INFORMATION SCIENCE & TECHNOLOGY) 19 February 2014 (19.02.2014), description, paragraphs [0027]-[0065], and figures 1-11	1-11
A	CN 101848471 A (MOBI ANTENNA TECHNOLOGIES SHENZHEN CO., LTD.) 29 September 2010 (29.09.2010), entire document	1-11
A	CN 104392597 A (WUXI HUAPU MICROELECTRONICS CO., LTD.) 04 March 2015 (04.03.2015), entire document	1-11
A	CN 205069884 U (GUANGDONG JIANBOTONG TECHNOLOGY CO., LTD.) 02 March 2016 (02.03.2016), entire document	1-11
A	US 2012013519 A1 (SONY ERICSSON MOBILE COMMUNICATIONS AB) 19 January 2012 (19.01.2012), entire document	1-11

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/CN2017/120320

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN 203445240 U	19 February 2014	None	
CN 101848471 A	29 September 2010	None	
CN 104392597 A	04 March 2015	None	
CN 205069884 U	02 March 2016	None	
US 2012013519 A1	19 January 2012	EP 2416444 A2	08 February 2012