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(54) INTELLIGENT ANTENNA DEVICE

(57) An intelligent antenna device is disclosed, including: a dielectric plate, a coupling and calibrating network, an antenna array, a first radio frequency connector, and a second radio frequency connector; herein, the coupling and calibrating network is provided on one side of the dielectric plate, the antenna array is provided on the other side of the dielectric plate, the dielectric plate is provided with a via hole, the antenna array is connected with the coupling and calibrating network through the via hole, the first radio frequency connector and the second radio frequency connector are arranged on the side of the dielectric plate with the coupling and calibrating network, and are connected, respectively, with the coupling and calibrating network.

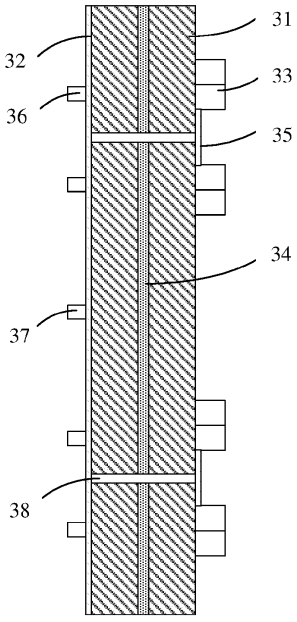

FIG. 3

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Description

Technical Field

[0001] The present document relates to an antenna device for a wireless communication system, and more particularly, to an intelligent antenna device.

Background

[0002] In contemporary cellular systems, due to growing demand for wireless data rates by users, limited bandwidth is shared by neighboring cells, and the caused inter-cell interference is a major limiting factor in data transmission rates and quality of service. The user at the edge of the cell is particularly severely disturbed by the cells. Many wireless service providers have been working hard to improve the quality of service for the user at the edge of the cell. In these attempts, that more freedom provided by using multi-antenna technology relieves the decline in service performance for the user at the edge of the cell is the most promising direction. At the same time, traditional 4-antenna, 8-antenna high-power base station systems cause difficulty of designing the transceiver link module of the base station system, if the high power is assigned uniformly to larger-scaled antennas, such as 16 antennas, 64 antennas, the power of a single antenna will be dramatically reduced, the difficulty of designing transceiver link of the base station system will be dramatically reduced. Therefore, large-scale intelligent antenna communication will become a development trend, and a coupling and calibrating network, as one of the key components of a large-scale intelligent antenna, its implementation not only directly affects the beamforming effect of the large-scale intelligent antenna, but also indirectly affects module architecture design of the base station system.

[0003] As shown in Fig. 1, a coupling and calibrating network device of a linear-arranging intelligent antenna array is given in Chinese patent No. CN2755871Y, including N antenna array elements, N couplers and multiple power shunt/combiners ($N \geq 2$). The N antenna array elements (11) are arranged in a straight line to form a linear antenna array; the coupler is a microstrip directional coupler, consisting of two short-range metallic parallel microstrips; the N microstrip directional couplers and multiple power shunt/combiners are fabricated on a circuit board of a coupling and calibrating network (12), the circuit board is arranged behind the radiation direction of the linear antenna array, and the N microstrip directional couplers are distributed on the circuit board of the coupling and calibrating network correspondingly to the N antennas array one by one. A metal reflection board (13) is arranged behind the circuit board of the coupling and calibrating network, so that the linear antenna array realizes directional coverage. In addition, the device further includes a radio frequency connector 14 for the coupling and calibrating network and the antenna elements, eight antenna array input/output connectors 15, and one calibration port input/output connector 16. All of the antenna array, the coupling and calibrating network, and the reflection board of the patent are separate sections rather than integrating into a single medium plate, which is harmful to integration of the base station system; the antenna array input/output connectors and the calibration port input/output connector are connected with the base station system by introducing the radio frequency connector at the edge of the coupling calibration network or introducing by direct soldering cable, it is necessary to increase the number of the radio frequency connectors or soldered cables for the large-scale antenna arrays, which is cumbersome and messy, and is harmful to minimization and production of the base station system.

[0004] As shown in Fig. 2, an intelligent antenna and a calibration device thereof are disclosed in Chinese Patent No. CN103746193A, including a reflection plate (21), an oscillator (22), an end cover (23) and an installation plate (24) for connecting the reflection plate (21) and the end cover (23), herein, the intelligent antenna includes a calibration device which includes a medium plate (25), multiple connectors (26) and a calibration network (27); the calibration network (27) is printed on the surface of the media plate (24) and includes a power distribution network formed by multiple power distributors, and multiple directional couplers; any of the shunt ports of the power distributor network is connected to a directional coupler; the inner core of a connector is directly connected with the combination port of the power distribution network or the signal input port of the directional coupler, and one connector corresponds to one port; the calibration device is fixed on one side of the installation plate; the installation plate (24) is provided with at least one bending bar (241) which runs through the calibration device (241) and is fixed to the reflection plate (21). In the patent, the oscillator and the calibration network are connected through the welding cable (28), if the antenna array is in large scale, the number of cables is large, which is harmful to production; the oscillator and the calibration network are arranged in a vertical relationship, so that a bending bar (241), by which the device is fixed, is required, which is harmful to the subsequent production, and integration of the system is not high.

Summary

[0005] The invention provides an intelligent antenna device which can reduce the size of an antenna, improve integration and miniaturization performances of a base station system, and is convenient for large-scale production.

[0006] An intelligent antenna device, includes: a dielectric plate, a coupling and calibrating network, an antenna array, a first radio frequency connector, and a second radio frequency connector; herein, the coupling and calibrating network is provided on one side of the dielectric plate, the antenna array is provided on the other side

of the dielectric plate, the dielectric plate is provided with a via hole, the antenna array is connected with the coupling and calibrating network through the via hole, the first radio frequency connector and the second radio frequency connector are arranged on the side of the dielectric plate provided with the coupling and calibrating network, and are connected, respectively, with the coupling and calibrating network.

[0007] In an exemplary embodiment, the coupling and calibrating network includes a shunt/combiner and M microstrip directional couplers; the antenna array includes M antenna array elements, a number of the first radio frequency connectors is M, there is one second radio frequency connector, M is an integer not less than 2; each of the antenna array elements is connected to a corresponding microstrip directional coupler on the coupling and calibrating network through the via hole, after shunt feeding; each of the first radio frequency connectors is connected to one of the microstrip directional couplers, a combination port of the shunt/combiner is connected to the second radio frequency connector.

[0008] In an exemplary embodiment, the M first radio frequency connectors and the second radio frequency connector are arranged inside the dielectric plate.

[0009] In an exemplary embodiment, each of the microstrip directional couplers includes two microstrips, one end of the microstrip is connected to a corresponding antenna array element via the via hole, and the other end connected to the first radio frequency connector.

[0010] In an exemplary embodiment, the M antenna array elements are in a linear arrangement, an annular arrangement, or other irregular shaped arrangements.

[0011] In an exemplary embodiment, the M antenna array elements are arranged at equal spacing, or arranged at unequal spacing.

[0012] In an exemplary embodiment, the M antenna array elements are in a directional mode, in a single polarization mode or in a dual polarization mode.

[0013] In an exemplary embodiment, a longitudinal metallic baffle is provided between every two adjacent columns of antenna array elements of the antenna array, and/or a transverse metallic baffle is provided between every two adjacent columns of antenna array elements of the antenna array, and/or a metallic side plate is provided surrounding the antenna array.

[0014] In an exemplary embodiment, a number of the shunt/combiners is determined based on a number of shunts and a number of antenna array elements.

[0015] In an exemplary embodiment, an intermediate layer of the dielectric plate serves as a ground layer and a metallic reflection plate simultaneously.

[0016] In an exemplary embodiment, the dielectric plate is a printed circuit board, PCB.

[0017] In the embodiment of the invention, an antenna array, a coupling and calibrating network and a metal reflection plate are all integrated into a same dielectric plate, and an antenna array elements and the coupling and calibrating network are connected by a via hole to increase the reliability and avoid the use of a large number of radio frequency cables, which may reduce the size of an antenna, improve integration and miniaturization performances of the base station system, it is beneficial to realization of the coupling and calibrating network device of large-scale intelligent antenna array, convenient for producing and debugging and large-scale production, more suitable for the popularization and development of wireless communication systems.

Brief Description of Drawings

[0018]

Figure 1 is an architectural schematic of a coupling and calibrating network device for a linear-arranging intelligent antenna array of a related patent.

Figure 2 is an architectural schematic of an intelligent antenna and its calibration device of a related patent;

Figure 3 is a side view of a stereoscopic structure of an antenna array coupling and calibrating network device with M = 16 antenna elements according to an embodiment of the present invention.

Figure 4 is a schematic top view of another example of an antenna array with M = 16 dual polarized array elements according to an embodiment of the present invention.

Figure 5 is a schematic top view of another example of an antenna with M = 16 dual polarized array elements array according to another embodiment of the present invention.

Figure 6 is a structural schematic of a coupling and calibrating network device with M = 16 antenna elements according to an embodiment of the present invention.

Figure 7 is a structural schematic of any one of the coupling units in the coupling and calibrating network device according to an embodiment of the present invention.

Detailed Description

[0019] The embodiments of the present invention will be described in detail in combination with the accompanying drawings below. It needs to be stated that the embodiments in the present application and the features in the embodiments may be mutually combined under the situation of no conflict.

[0020] Figure 3 is a side view of a stereoscopic structure of an antenna array coupling and calibrating network with M = 16 antenna elements according to an embodiment of the present invention, herein, the antenna array

coupling and calibrating network includes a dielectric plate 31, a coupling and calibrating network 32, an antenna array, 16 first radio frequency connectors 36 and one second radio frequency connector 37, herein, the antenna array and the coupling and calibrating network 32 are provided on the front and back sides of the dielectric plate 31, respectively, and an intermediate layer of the dielectric plate 31 serves as a ground layer and a metallic reflection plate 34 simultaneously, the dielectric plate 31 is provided with a via hole 38 through which the antenna array is connected to the coupling and calibrating network 32.

[0021] In practical application, the dielectric plate 31 is a printed circuit board (PCB), one side is provided with the antenna array, one side is printed with the coupling and calibrating network 32; the intermediate layer of the dielectric plate 31 serves as the ground layer of the coupling and calibrating network 32 and the antenna array, as well as the metallic reflection plate 34 of the antenna array, to enhance the directional radiation of the antenna array.

The antenna array consists of 16 antenna array elements 33 for receiving or transmitting signals, which may be in a linear arrangement, an annular arrangement or other irregular shaped arrangements; and/or the 16 antenna array elements 33 may also be arranged at equal spacing, or arranged at unequal spacing; and/or the 16 antenna array elements 33 may also be directional, unipolar or dual polarized; and/or the 16 antenna array elements 33 may be directional at any angle, such as 30 °, 60 °, and the like; and/or the dual-polarization of the 16 antenna array elements 33 may be horizontal and vertical polarization, or ± 45 ° polarization.

[0022] The coupling and calibrating network 32 includes a microstrip directional coupler and a shunt/combiner, the number of microstrip directional couplers is the same as the number of antenna array elements, and the microstrip directional couplers correspond to the antenna array elements one by one, and after realizing shunt feed by way of the microstrip line 35 and the like, each antenna element 33 is connected, through the via hole 38, to a corresponding microstrip directional coupler on the coupling and calibrating network 32, thus the antenna array and the coupling calibration network can be provided on the same dielectric plate, and cable welding way which is harmful to production is prevented.

[0023] The downstream calibration working link flow of the abovementioned device is that the 16 radio frequency signals of the base station system transmission channel are input by 16 first radio frequency connectors 36, respectively, and output to a calibration link of the base station system through the second radio frequency connector 37 for calibrating after coupling via the coupling and calibrating network 32 and combining into one calibration signal by way of "constant differential loss, constant phase shift".

[0024] The upstream calibration working link flow of the abovementioned device is that a calibration signal from the base station system calibration link is input through the second radio frequency connector 37, divided into 16 signals via the coupling and calibrating network 32 by way of "constant differential loss, constant phase shift", and after coupling, output to the receiving channel of the base station system by the 16 first radio frequency connectors 36, respectively.

[0025] The 16 first radio frequency connectors 36 and the second RF connector 37 are arranged inside the dielectric plate 31 (or mounted on the dielectric plate), non-edge extension area, which facilitates miniaturization and integration of the structure, any other reliable connection modes of similar functions can be used, not repetitively described. The first radio frequency connector 36 is used to input or output the radio frequency signal, the second radio frequency connector 37 is used to input or output the calibration signal, the radio frequency connector with blind insertion, radial and axial floating characteristics may be used to facilitate connection with the base station system.

[0026] Figure 4 is a schematic representation of an arrangement of an example of the antenna array, which is a schematic top view of an antenna array with M = 16 dual polarized array elements, herein, for four columns of the antenna array elements 41, 42, 43, 44, each column of the antenna array elements includes four antenna array elements 33 formed by dual polarized oscillators. Each antenna array element 33 of each column of the antenna array elements has a polarization direction of + 45° and -45° in the vertical direction or in the horizontal direction to transmit and receive signal; two adjacent antenna array elements 33, in the up-down direction, of each column of the antenna array elements employ the microstrip line 35 and so on to achieve the shunt feed, connect to the microstrip directional coupler through the via hole 38. Herein, each antenna array element may be distributed and arranged, not only in parallel, equidistant distribution, but also in staggered, unequal spacing distribution, or in different combinations of these modes. The antenna array element 33 may be a metallic oscillator, or in a form of a microstrip structure or a patch structure, the antenna array element 33 may be in a dual polarization mode or in a single polarization mode.

[0027] For the purpose of optimizing the performance, in order to enhance the isolation between the array elements, as shown in Fig. 5, longitudinal metallic baffles 51, 52, 53 may be provided vertically between the two adjacent columns of antenna array elements 41 and 42, 42 and 43, and 43 and 44, respectively, the metallic baffles 51, 52, 53 are electrically connected or capacitively coupled with the metal reflector 34. To optimize the performance, by using the antenna array element as a unit, baffles may be further provided around, that is, the metallic baffles 54, 55, 56, which intersect perpendicularly with the metallic baffles 51, 52, and 53, may be added, and at the same time, metallic side plates 57, 58, 59, 60 may be provided surrounding the antenna array elements, the way for adding the metallic baffles and the

surrounding side plates is not limited to the way shown in Fig. 5, and the metallic baffles may be designed separately or may be integrated on an antenna housing structure to improve the strength of the antenna housing and enhance the antenna system security and stability. By other ways such as adding a small cover above the antenna array element, etc., each antenna array element may have a more independent space, which would not be repetitively described.

[0028] Figure 6 is a schematic top view of a coupling and calibrating network with M =16 array elements according to an embodiment of the present invention, the coupling and calibrating network includes 16 identical microstrip directional coupling circuits 61, 15 1: 2 power shunt/combiners 62, 16 first radio frequency connectors 36, one second radio frequency connector 37 for calibrating the input and output of the signal. Herein, every two adjacent microstrip directional coupling circuits 61 are connected through a 1: 2 power shunt/combiner 62, one end of each microstrip directional coupling circuit 61 is connected to a first radio frequency connector 36 and the other end is connected to an adjacent microstrip directional coupling circuit through a 1: 2 power shunt/combiner 62. Two shunt ports of each 1: 2 power shunt/combiner 62 are connected to two microstrip directional coupling circuits 61, respectively, 15 1: 2 power shunt/combiners are connected to the second radio frequency connector 37 after the combiner ports of the 15 1: 2 power shunt/combiners are connected.

[0029] The number of 16 microstrip directional couplers is equal to the number of the antenna array elements, by using two similar metallic parallel microstrip lines, an excellent product performance consistency is obtained. The 16 microstrip directional coupling circuits 61 are distributed with 16 antenna array elements on a circuit board of the coupling and calibrating network correspondingly, and each microstrip directional coupler is connected to a first radio frequency connector to facilitate communication with the radio frequency transceiver of the base station system, and the 16 microstrip directional couplers are identical and easy to product and debug, the 16 microstrip directional couplers are electrically connected with the corresponding antenna elements by the via hole, which has a better performance to ensure consistency between amplitude and phase of the signal from the microstrip directional coupler to the oscillator of the antenna, while the structure is simply integrated, highly reliable and ease for producing.

[0030] The number of power shunt/combiner 62 is limited by the number of shunt/combination-channels, and the embodiment of Figure 6 employs a 1: 2 power shunt/combiner, requiring 15 power shunt/combiners 62 to achieve the shunt/combination of the16-way signal, finally a signal is composed to the second radio frequency connector 37. If a 1: 4 power shunt/combiner is employed, only 5 1: 4 power shunt/combiners are required to achieve the shunt/combination of the 16 signals after the 16 antenna array elements and 16 microstrip directional couplers are provided.

[0031] Figure 7 is a schematic diagram of any one of the coupling units in the coupling and calibrating network of an embodiment of the present invention, herein, a coupling unit includes two microstrip directional couplers 61 and a 1: 2 power shunt/combiner, each microstrip directional coupler 61 includes two microstrips, one end of a microstrip 71 is connected to an antenna element 33 via the via hole 38, and the other end is connected to the radio frequency input of the radio frequency transceiver corresponding to the base station system, i.e., connected to the first radio frequency connector 36; one end of another microstrip 72 is connected to a matched load 74 of 50Ω (also grounded) and the other end is connected to a shunt port of the 1: 2 power shunt/combiner 62. The reference number 73 in Figure 7 is the isolation resistor of the power shunt/combiner 62.

[0032] The abovementioned embodiment is the coupling and calibrating network device of the antenna array of 16 array elements, and a coupling and calibrating network device of a larger-scale antenna array, such as of 32, 64, 128 array elements, can be designed according to the same principle. The embodiment of the present invention is particularly applicable to a large scale antenna array.

[0033] Each unit, module described in the embodiments of the present invention is only an example divided according to its function, and understandably, in the case that a system/apparatus/device achieves the same function, one skilled in the art can provide one or more other function division methods, in application, any one or more functional modules therein can be achieved with one functional entity apparatus or unit, undeniably, the above transformations are within the protection scope of the present application.

Industrial Applicability

[0034] In the embodiments of the invention, an antenna array, a coupling and calibrating network and a metal reflection plate are all integrated into a same dielectric plate, and an antenna array elements and the coupling and calibrating network are connected by a via hole to increase the reliability and avoid the use of a large number of radio frequency cables, which may reduce the size of an antenna, improve integration and miniaturization performances of the base station system, it is beneficial to realization of the coupling and calibrating network device of large-scale intelligent antenna array, convenient for producing and debugging and large-scale production, more suitable for the popularization and development of wireless communication systems.

Claims

1. An intelligent antenna device, comprising: a dielectric plate, a coupling and calibrating network, an an-

tenna array, a first radio frequency connector, and a second radio frequency connector;
wherein, the coupling and calibrating network is provided on one side of the dielectric plate, the antenna array is provided on the other side of the dielectric plate, the dielectric plate is provided with a via hole, the antenna array is connected with the coupling and calibrating network through the via hole, the first radio frequency connector and the second radio frequency connector are arranged on the side of the dielectric plate provided with the coupling and calibrating network, and are connected, respectively, with the coupling and calibrating network.

2. The apparatus according to claim 1, wherein, the coupling and calibrating network comprises a shunt/combiner and M microstrip directional couplers; the antenna array comprises M antenna array elements, a number of the first radio frequency connectors is M, there is one second radio frequency connector, M is an integer not less than 2;
each of the antenna array elements is connected to a corresponding microstrip directional coupler on the coupling and calibrating network through the via hole, after shunt feeding;
each of the first radio frequency connectors is connected to one of the microstrip directional couplers, a combination port of the shunt/combiner is connected to the second radio frequency connector.

3. The apparatus according to claim 2, wherein, the M first radio frequency connectors and the second radio frequency connector are arranged inside the dielectric plate.

4. The apparatus according to claim 2, wherein, each of the microstrip directional couplers comprises two microstrips, one end of the microstrip is connected to a corresponding antenna array element via the via hole, and the other end is connected to the first radio frequency connector.

5. The apparatus according to claim 2, wherein, the M antenna array elements are in a linear arrangement, an annular arrangement, or other irregular shaped arrangements.

6. The apparatus according to claim 2, wherein, the M antenna array elements are arranged at equal spacing, or arranged at unequal spacing.

7. The apparatus according to claim 2, wherein, the M antenna array elements are in a directional mode, in a single polarization mode or in a dual polarization mode.

8. The apparatus according to claim 2, wherein,
a longitudinal metallic baffle is provided between every two adjacent columns of antenna array elements of the antenna array;
and/or, a transverse metallic baffle is provided between every two adjacent columns of antenna array elements of the antenna array;
and/or, a metallic side plate is provided surrounding the antenna array.

9. The apparatus according to claim 2, wherein, a number of the shunt/combiners is determined based on a number of shunts and a number of antenna array elements.

10. The apparatus according to claim 1, wherein, an intermediate layer of the dielectric plate serves as a ground layer and a metallic reflection plate simultaneously.

11. The device according to claim 1, wherein, the dielectric plate is a printed circuit board, PCB.

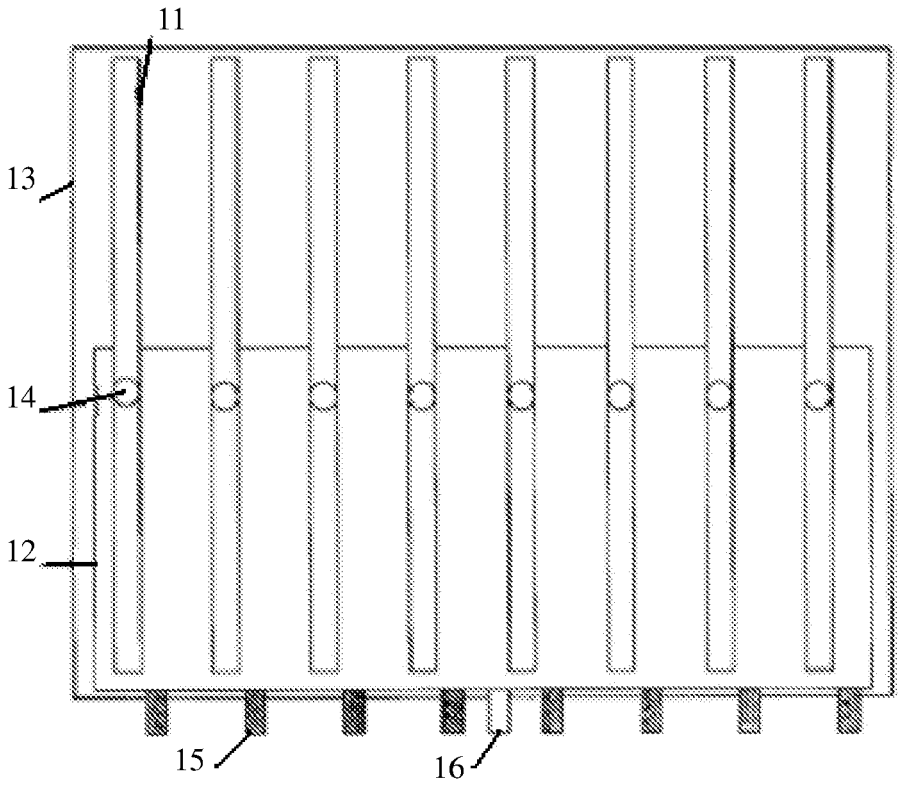

FIG. 1

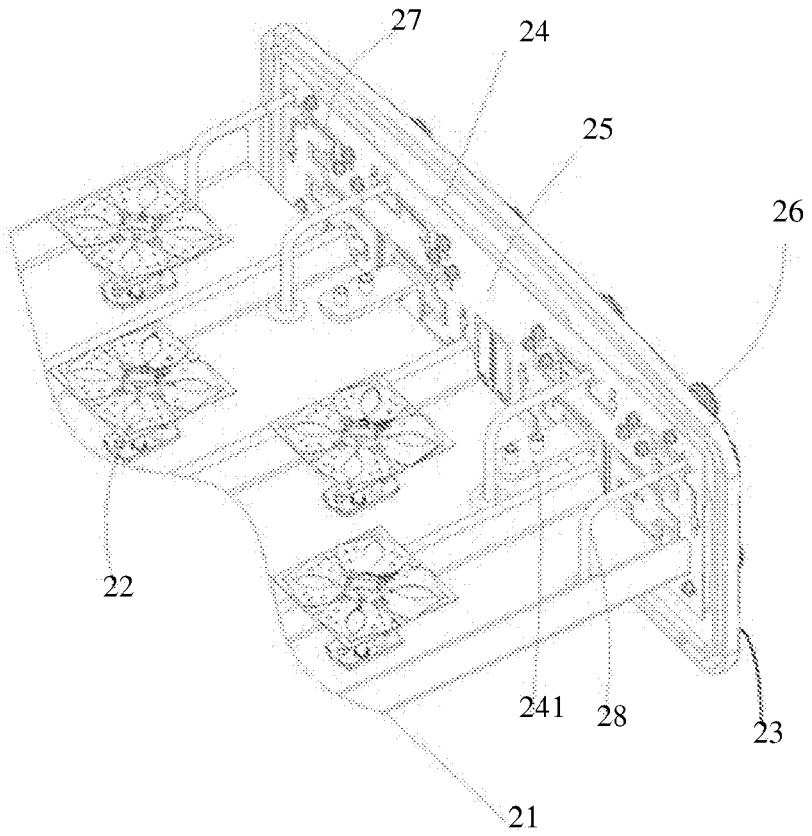

FIG. 2

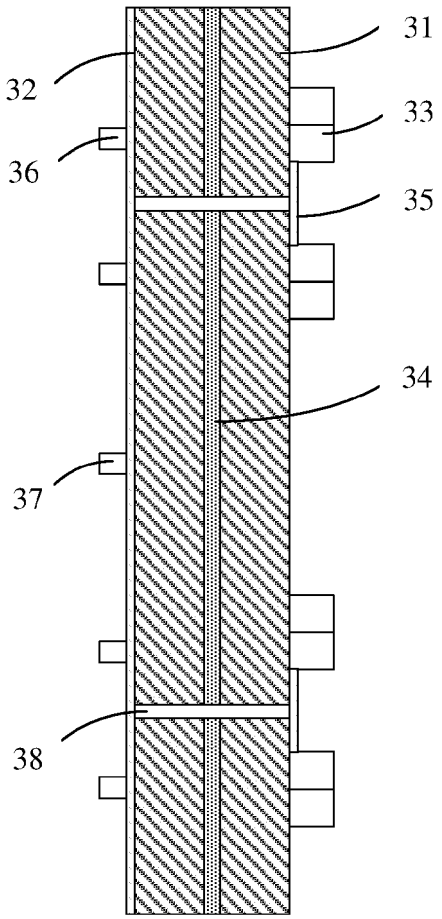

FIG. 3

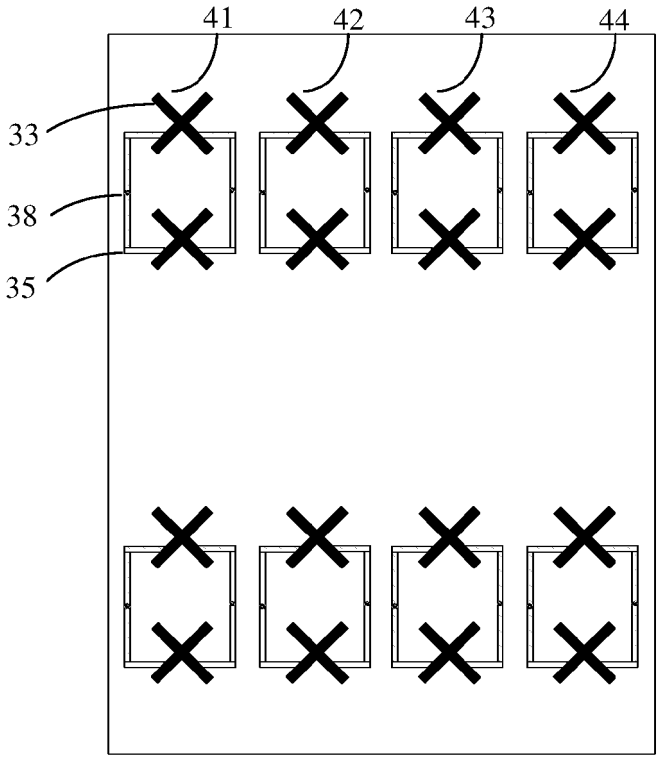

FIG. 4

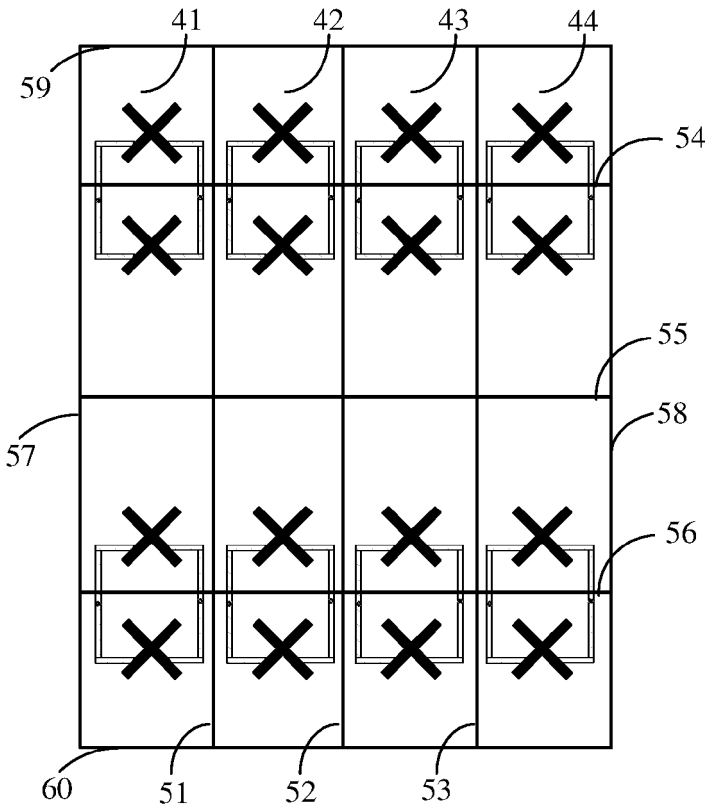

FIG. 5

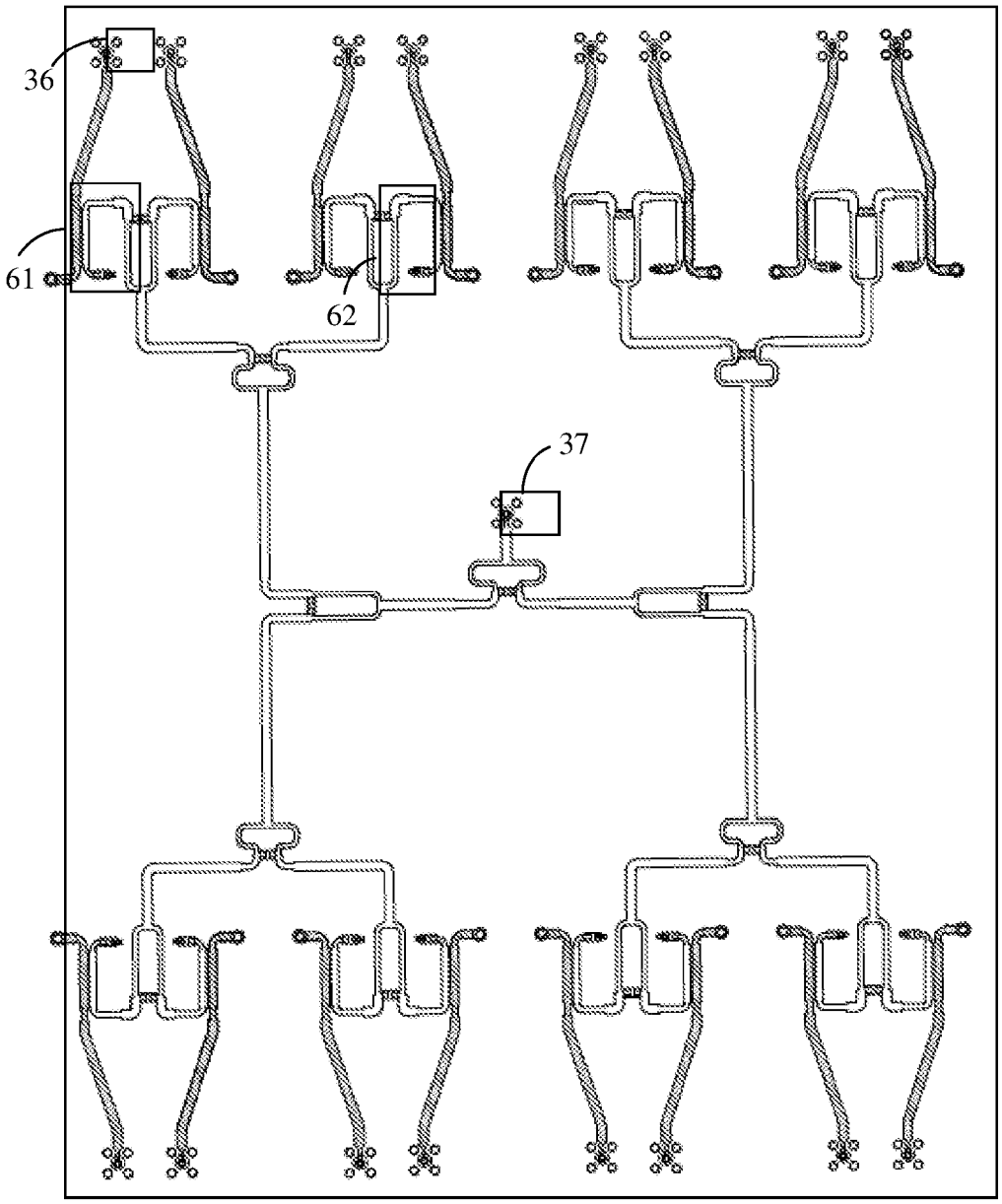

FIG. 6

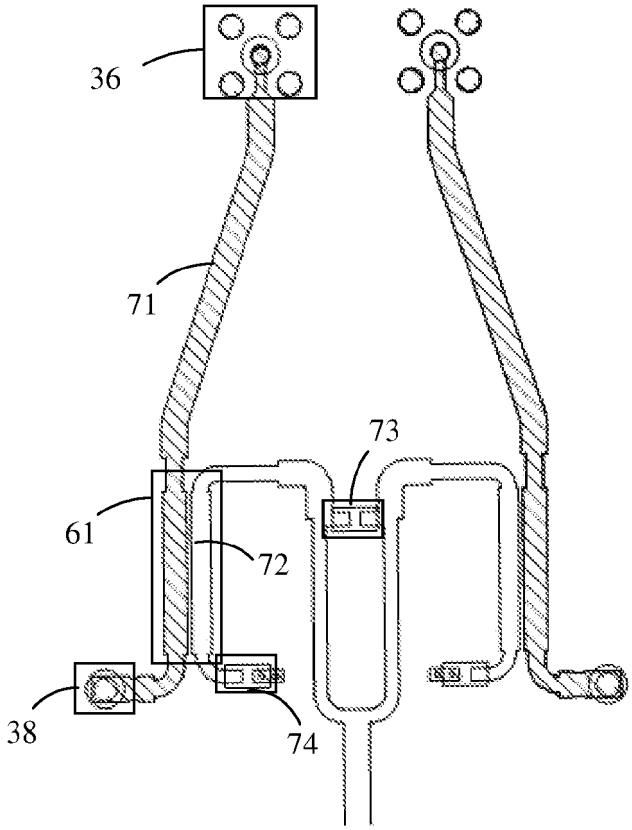

FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2015/076648

A. CLASSIFICATION OF SUBJECT MATTER

H01Q 23/00 (2006.01) i; H01Q 21/00 (2006.01) n
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; H04B

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)

CNABS, CNTXT, CNKI, VEN: antenna, array, couple, calibrate, dielectric, substrate, board, PCB, via, hole, aperture, integrate

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	CN 201134510 Y (COMBA TELECOM SYS CHINA CO., LTD.) 15 October 2008 (15.10.2008) description, page 3, lines 13 to 22, and figures 7 and 8	1-11
Y	CN 1507176 A (TRANGO SYSTEM INC.) 23 June 2004 (23.06.2004) description, page 31, line 31 to page 34, line 11, and figures 20-22	1-11
PX	CN 204243214 U (ZTE CORP.) 01 April 2015 (01.04.2015) the whole document	1-11
A	CN 1398124 A (CHINA ACADEMY OF TELECOMMUNICATIONS TECHNOLOGY) 19 February 2003 (19.02.2003) the whole document	1-11
A	JP 06125214 A (HITACHI CHEMICAL CO., LTD.) 06 May 1994 (06.05.1994) the whole document	1-11

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

* Special categories of cited documents:

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"&"document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
08 July 2015	29 July 2015
Name and mailing address of the ISA State Intellectual Property Office of the P. R. China No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing 100088, China Facsimile No. (86-10) 62019451	Authorized officer WANG, Tingting Telephone No. (86-10) 62412161

Form PCT/ISA /210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2015/076648

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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