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(54) **PHASED ARRAY ANTENNA AND PHASED ARRAY COMMUNICATION TERMINAL**

(57) The present disclosure, which relates to the field of phased array antennas, provides a phased array antenna and a phased array communication terminal, the phased array antenna comprising a first phased sub-array and a second phased sub-array; the first phased sub-array comprising a plurality of first antenna units and the second phased sub-array comprising a plurality of second antenna units; the arrangement of the plurality of first antenna units in the first phased sub-array being different from the arrangement of the plurality of second antenna units in the second phased sub-array; and the first phased sub-array and the second phased sub-array being randomly arranged in the phased array antenna. Through such arrangement, a phased array antenna structure capable of avoiding the occurrence of a grating lobe can be obtained.

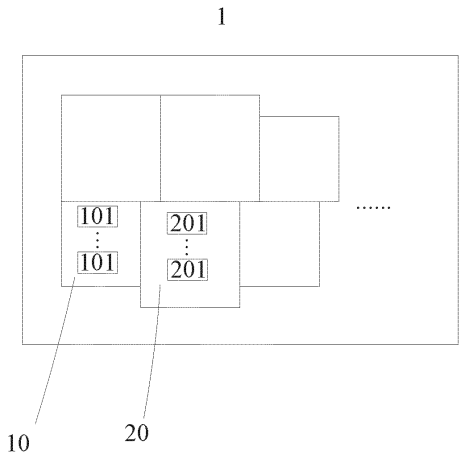

Fig. 1

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Description

FIELD OF THE DISCLOSURE

[0001] The present disclosure relates to the field of phased array antennas, and in particular, to a phased array antenna and a phased array communication terminal.

BACKGROUND OF THE DISCLOSURE

[0002] A phased array antenna is widely used in various scenarios in the field of communications due to its excellent performance. In the prior art, circularly polarized antenna elements are generally rotated sequentially to form an array. However, since it is difficult for phase centers of the antenna elements to coincide with geometric centers of the antenna, the distance between the phase centers of the antenna elements appears to be periodic after rotation, and such periodic spacing is greater than a distance of half wavelength, resulting in emergence of grating lobes in the array scanning, which seriously affects the performance of the phased array.

[0003] In view of this, how to provide a phased array antenna structure capable of avoiding grating lobes needs to be solved by those skilled in the art.

SUMMARY OF THE DISCLOSURE

[0004] An object of the present disclosure is to provide a phased array antenna and a phased array communication terminal.

[0005] Embodiments of the present disclosure are implemented as follows.

[0006] In a first aspect, the present disclosure provides a phased array antenna including a first phased sub-array and a second phased sub-array.

[0007] The first phased sub-array includes a plurality of first antenna units, and the second phased sub-array includes a plurality of second antenna units.

[0008] The arrangement of the plurality of first antenna units in the first phased sub-array is different from the arrangement of the plurality of second antenna units in the second phased sub-array.

the first phased sub-array and the second phased sub-array are randomly arranged in the phased array antenna.

[0009] In an optional implementation, the first phased sub-array includes a first number of first antenna units and the second phased sub-array includes a second number of second antenna units, the first number being smaller than the second number.

[0010] In an optional implementation, the first phased sub-array includes three first antenna units, and the second phased sub-array includes four second antenna units.

[0011] In an optional implementation, the three first antenna units of the first phased sub-array are arranged with rotations of 0°, 120°, and 240°, respectively;

The four second antenna units included in the second phased sub-array are arranged with rotations of 0°, 90°, 180°, and 270°, respectively.

[0012] In an optional implementation, the phased array antenna further comprises a third phased sub-array, the third phased sub-array comprising a plurality of third antenna units.

[0013] The arrangement of the plurality of first antenna units in the first phased sub-array, the arrangement of the plurality of second antenna units in the second phased sub-array, and the arrangement of the plurality of third antenna units in the third phased sub-array are different from one another.

[0014] In an optional implementation, the third phased sub-array includes a third number of third antenna units.

[0015] The second number is smaller than the third number.

[0016] In an optional implementation, the third phased sub-array includes eight third antenna units.

[0017] The eight third antenna units included in the third phased sub-array are arranged with rotations of 0°, 45°, 90°, 135°, 180°, 225°, 270°, and 315°, respectively.

[0018] In an optional implementation, the phased array antenna further comprises a fourth phased sub-array, the fourth phased sub-array being configured to fill other positions of the phased array antenna than the first phased sub-array, the second phased sub-array, and the third phased sub-array.

[0019] In an optional implementation, the phased array antenna further comprises a radio frequency active channel; the radio frequency active channel and the first phased sub-array, and the radio frequency active channel and the second phased sub-array are both integrated into the phased array antenna through a multi-layer PCB processing process.

[0020] In a second aspect, the present disclosure provides a phased array communication terminal comprising a radio frequency unit and a phased array antenna of any one of the preceding implementations, the radio frequency unit and the phased array antenna being communicatively connected.

[0021] The beneficial effects of the embodiments of present disclosure are as follows. The present disclosure provides a phased array antenna and a phased array communication terminal, the phased array antenna including a first phased sub-array and a second phased sub-array, the first phased sub-array including a plurality of first antenna units, the second phased sub-array including a plurality of second antenna units, the arrangement of the plurality of first antenna units in the first phased sub-array being different from that of the plurality of second antenna units in the second phased sub-array, and the first phased sub-array and the second phased sub-array being randomly arranged in the phased array antenna. By ingeniously laying out the first phased sub-array and the second phased sub-array, a phased array antenna structure capable of avoiding the occurrence of

a grating lobe can be obtained.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] In order to more clearly illustrate the technical solutions of the embodiments of the present disclosure, the accompanying drawings to be used in the embodiments will be briefly introduced below. It should be understood that the following figures are only illustrative of certain embodiments of the present disclosure, and therefore should not be regarded as limiting to its scope. For those skilled in the art, other related drawings could also be obtained from these drawings without exercise of any ingenuity.

FIG. 1 is a schematic block diagram of the structure of a phased array antenna according to an embodiment of the present disclosure;

FIG. 2 is a schematic structural diagram of a first phased sub-array according to an embodiment of the present disclosure;

FIG. 3 is a schematic structural diagram of a second phased sub-array according to an embodiment of the present disclosure;

FIG. 4 is a schematic structural diagram of a third phased sub-array according to an embodiment of the present disclosure; and

FIG. 5 is a schematic diagram of a partial structure of a phased array antenna according to an embodiment of the present disclosure.

DETAILED IMPLEMENTATION OF THE DISCLOSURE

[0023] In order to make the objects, technical solutions and advantages of the embodiments of the present disclosure clearer, the technical solutions in the embodiments of the present disclosure will be clearly and completely described below in conjunction with the accompanying drawings. Apparently, the embodiments described herein are some, but not all, embodiments of the present disclosure. The components in the embodiments of the present disclosure described and illustrated herein may generally be arranged and designed in a variety of different configurations.

[0024] Accordingly, the following detailed description of the embodiments of the present disclosure as provided in the accompanying drawings is not intended to limit the scope of the present disclosure, but merely to indicate selected embodiments of the present disclosure. Based on the embodiments in the present disclosure, all other embodiments obtained without exercise of ingenuity by a person of ordinary skill in the art fall within the scope of protection of the present disclosure.

[0025] It should be noted that like reference numerals and letters refer to like items in the following figures, and thus, once an item is defined in one figure, it need not be further defined and explained in subsequent ones.

[0026] In the description of the present disclosure, it should be noted that an orientation or a positional relationship indicated by such terms as "center", "upper", "lower", "left", "right", "vertical", "horizontal", "inner", "outer", and the like, if any, is based on that shown in the drawings, or that of the product of the present disclosure as it is in use. This is only for ease and simplicity of description, without indicating or implying that the device or the element referred to must have a specific orientation, or be constructed and operated in a particular orientation, and thus it should not be construed as limiting to the present disclosure. Moreover, the terms "first", "second", "third" and the like, if any, are used solely to distinguish one from another and are not to be construed as indicating or implying relative importance.

[0027] Furthermore, the terms "horizontal", "vertical" and the like do not imply that a component is absolutely horizontal or vertical, but may be slightly tilted. For example, "horizontal" only means that its direction is more horizontal relative to "vertical", rather than meaning that the structure must be completely horizontal, but may be slightly tilted.

[0028] In the description of the present disclosure, it should also be noted that, unless otherwise expressly specified or defined, the terms "arranged", "mounted", "interconnected", "connected" and the like are to be interpreted broadly. For example, it may be a fixed connection, a detachable connection, or an integral connection; it may be a mechanical connection or an electrical connection; it may be a direct connection, or an indirect connection through an intermediary, or an internal communication of two elements. For a person of ordinary skill in the art, the specific meanings of these terms in the present disclosure may be understood in specific contexts.

[0029] Referring to FIG. 1, an embodiment of the present disclosure provides a phased array antenna 1 comprising a first phased sub-array 10 and a second phased sub-array 20.

[0030] The first phased sub-array 10 includes a plurality of first antenna units 101, and the second phased sub-array 20 includes a plurality of second antenna units 201.

[0031] The arrangement of the plurality of first antenna units 101 in the first phased sub-array 10 is different from the arrangement of the plurality of second antenna units 201 in the second phased sub-array 20.

[0032] The first phased sub-array 10 and the second phased sub-array 20 are randomly arranged in the phased array antenna 1.

[0033] In the embodiment of the present disclosure, the phased array antenna 1 is composed of a large number of antenna units, and the above two kinds of phased sub-arrays comprising a plurality of antenna units respectively are proposed. By setting the arrangement of the plurality of first antenna units 101 in the first phased sub-array 10 differently from the arrangement of the plurality of second antenna units 201 in the second phased sub-array 20, as well as by randomly arranging the first

phased sub-array 10 and the second phased sub-array 20 in the phased-array antenna 1, it is possible to make the arrangement of and distance between phase centers and geometrical canters of the antenna units involved irregular, i.e., to eliminate the periodicity due to offsets of the phase centers from the geometrical canters, thus avoiding the formation of grating lobes.

[0034] In order to elucidate the solution provided by the embodiment of the present disclosure, the first phased sub-array 10 comprises a first number of first antenna units 101, and the second phased sub-array 20 comprises a second number of second antenna units 201, the first number being smaller than the second number.

[0035] In order to achieve the aforementioned purpose of avoiding the formation of grating lobes, in addition to requiring a different and random arrangement of the plurality of first antenna units 101 and the plurality of second antenna units 201 included in the first phased sub-array 10 and the second phased sub-array 20 per se, the number of antenna units included in the first phased sub-array 10 and the second phased sub-array 20 may also be limited to be different, which effectively eliminates, in the phased array antenna 1 having a large number of antenna units, the possible occurrence of a small number of periodic offsets between phase centers and geometric centers even with a random arrangement, and thus the formation of grating lobes.

[0036] On this basis, further referring to FIGS. 2 and 3, the first phased sub-array 10 comprises three first antenna units 101, and the second phased sub-array 20 comprises four second antenna units 201. The three first antenna units 101 of the first phased sub-array 10 are arranged with rotations of 0°, 120°, and 240°, respectively. The four second antenna units 201included in the second phased sub-array 20 are arranged with rotations of 0°, 90°, 180°, and 270°, respectively.

[0037] In order to describe the solutions provided in the embodiments of the present disclosure more clearly, the embodiments of the present disclosure have proposed a specific number and arrangement of the first antenna units 101 included in the first phase control sub-array 10, and a specific number and arrangement of the second antenna units 201 included in the second phase control sub-array 20. It should be appreciated that the first phased sub-array 10 and the second phased sub-array 20 may be arranged in the phased array antenna 1 through any scheme of splicing and combining, without limitation herein.

[0038] As an alternative embodiment, the phased array antenna 1 further comprises a third phased sub-array 30, the third phased sub-array 30 comprising a plurality of third antenna units 301. The arrangement of the plurality of first antenna units 101 in the first phased sub-array 10, the arrangement of the plurality of second antenna units 201 in the second phased sub-array 20, and the arrangement of the plurality of third antenna units 301 in the third phased sub-array 30 are all different.

[0039] As previously stated, in order to ensure that no grating lobe will be formed, a third phase control sub-array 30 may also be added, and at the same time, in order to ensure that there is no periodic offset between phase centers and geometric centers of the antenna units due to randomness, the arrangement of the plurality of third antenna units 301 in the third phase control sub-array 30 is different both from the arrangement of the plurality of first antenna units 101 in the first phase control sub-array 10, and from the arrangement of the plurality of second antenna units 201 in the second phased sub-array 20.

[0040] As an alternative embodiment, referring to FIG. 4, the third phased sub-array 30 includes a third number of third antenna units 301; the second number is smaller than the third number. In order to describe the solution provided by the embodiment of the present disclosure more clearly, the third phased sub-array 30 comprises eight third antenna units 301; the eight third antenna units 301 comprised in the third phased sub-array 30 are arranged with rotations of 0°, 45°, 90°, 135°, 180°, 225°, 270°, and 315°, respectively.

[0041] In the embodiment of the present disclosure, the arrangement of the first phased sub-array 10, the second phased sub-array 20, and the third phased sub-array 30 in the phased array antenna 1 may be random. By means of the above arrangement, the first phased sub-array 10, the second phased sub-array 20, and the third phased sub-array 30, on the basis that the antenna units included in themselves have regular rotations to realize respective functions, are not similar to each other, and a regular arrangement of antenna units is not possible by simple combination, thereby enabling further assurance that no grating lobes will be formed.

[0042] As an alternative embodiment, referring to FIG. 5, the phased array antenna 1 further comprises a fourth phased sub-array 40, the fourth phased sub-array 40 being configured to fill other positions of the phased array antenna 1 than the first phase control sub-array 10, the second phase control sub-array 20, and the third phase control sub-array 30.

[0043] It should be understood that in the foregoing embodiments, the first phased array 10, the second phased array 20 and the third phased array 30, when randomly combined together, are not perfectly matched, i.e., there is necessarily a gap between the first phase control sub-array 10, the second phase control sub-array 20 and the third phase control sub-array 30, which may be filled with the fourth phased sub-array 40,so as to obtain a complete phased array antenna 1. There is no limitation on the number of the fourth phased sub-arrays 40, which may be one or two, for example. As shown in FIG. 5, a portion of a 4*5 phased array antenna 1 may be formed by two first phased sub-arrays 10, one second phased sub-array 20, one third phased sub-array 30, and a fourth phased sub-array 40 including two antenna units.

[0044] As an alternative embodiment, the phased array antenna 1 further comprises a radio frequency active

channel; the radio frequency active channel and the first phased sub-array 10, and the radio frequency active channel and the second phased sub-array 20 are both integrated into the phased array antenna 1 through a multi-layer PCB processing process.

[0045] In the embodiments of the present disclosure, the radio frequency active channel, the first phased-controller sub-array 10, the second phased-controller sub-array 20, the third phased-controller sub-array 30, and the fourth phased-controller sub-array 40 that are integrated through a multi-layer PCB processing process are lightweight and thin, and can be used to prepare communication devices that require a low profile, lightweight, small size and the like.

[0046] An embodiment of the present disclosure provides a phased array communication terminal comprising a radio frequency unit and the aforementioned phased array antenna 1, the radio frequency unit and the phased array antenna 1 being communicatively connected.

[0047] Using the foregoing phased array antenna 1, a phased array communication terminal may be formed by combining with components such as a radio frequency unit, a communication unit and a control unit, which may be a terminal product in the field of microwave and millimeter wave applications such as phased array communications and radars.

[0048] In summary, the present disclosure provides a phased array antenna and a phased array communication terminal, the phased array antenna comprising a first phased array and a second phased array; the first phased array comprising a plurality of first antenna units, and the second phased array comprising a plurality of second antenna units; the arrangement of the plurality of first antenna units in the first phased sub-array is different from the arrangement of the plurality of second antenna units in the second phased sub-array; the first phased sub-array and the second phased sub-array are randomly arranged in the phased array antenna. By ingeniously laying out the first phased sub-array and the second phased sub-array, a phased array antenna structure capable of avoiding the occurrence of a grating lobe can be obtained.

[0049] The foregoing are only preferred embodiments of the present disclosure, which are not intended to limit the present disclosure but are subject to various modifications or changes for those skilled in the art. Any modifications, equivalent substitutions, improvements or the like made within the spirit and principle of the present disclosure shall be included in the scope of present disclosure.

Claims

1. A phased array antenna, comprising a first phased sub-array and a second phased sub-array,

   wherein the first phased sub-array includes a plurality of first antenna units, and the second phased sub-array includes a plurality of second antenna units;

   wherein the arrangement of the plurality of first antenna units in the first phased sub-array is different from the arrangement of the plurality of second antenna units in the second phased sub-array;

   and wherein the first phased sub-array and the second phased sub-array are randomly arranged in the phased array antenna.

2. The phased array antenna according to claim 1, wherein the first phased sub-array comprises a first number of first antenna units and the second phased sub-array comprises a second number of second antenna units, the first number being smaller than the second number.

3. The phased array antenna according to claim 2, wherein the first phased sub-array comprises three first antenna units and the second phased sub-array comprises four second antenna units.

4. The phased array antenna according to claim 2, wherein the three first antenna units of the first phased sub-array are arranged with rotations of 0°, 120°, and 240°, respectively, and

   wherein the four second antenna units included in the second phased sub-array are arranged with rotations of 0°, 90°, 180°, and 270°, respectively.

5. The phased array antenna according to claim 2, wherein the phased array antenna further comprises a third phased sub-array, the third phased sub-array comprising a plurality of third antenna units, and

   wherein the arrangement of the plurality of first antenna units in the first phased sub-array, the arrangement of the plurality of second antenna units in the second phased sub-array, and the arrangement of the plurality of third antenna units in the third phased sub-array are different from one another.

6. The phased array antenna according to claim 5, wherein the third phased sub-array comprises a third number of third antenna units, the second number being smaller than the third number.

7. The phased array antenna according to claim 5, wherein the third phased sub-array comprises eight third antenna units, and

   wherein the eight third antenna units included in the third phased sub-array are arranged with rotations of 0°, 45°, 90°, 135°, 180°, 225°, 270°, and 315°, respectively.

8. The phased array antenna according to claim 5, wherein the phased array antenna further comprises

a fourth phased sub-array, the fourth phased sub-array being configured to fill other positions of the phased array antenna than the first phased sub-array, the second phased sub-array, and the third phased sub-array.

9. The phased array antenna according to claim 1, wherein the phased array antenna further comprises a radio frequency active channel, and wherein the radio frequency active channel and the first phased sub-array, and the radio frequency active channel and the second phased sub-array are both integrated into the phased array antenna through a multi-layer PCB processing process.

10. A phased array communication terminal comprising a radio frequency unit and a phased array antenna according to any one of claims 1-9, wherein the radio frequency unit and the phased array antenna are communicatively connected.

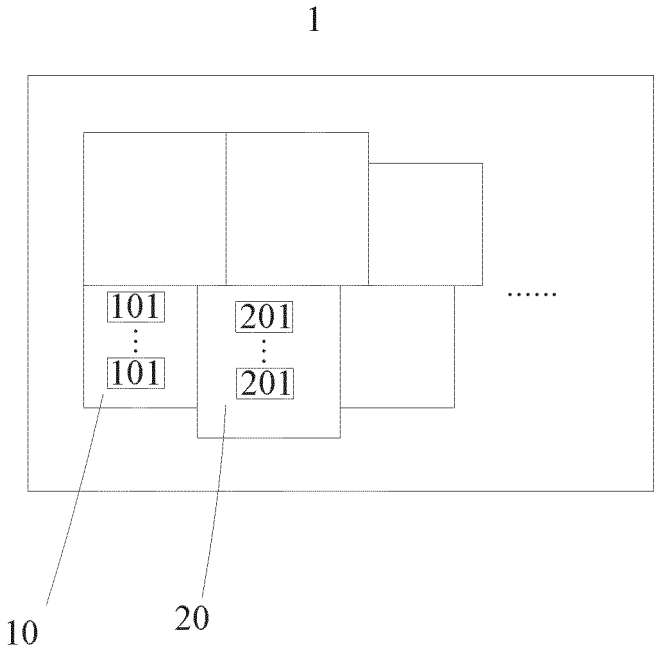

Fig. 1

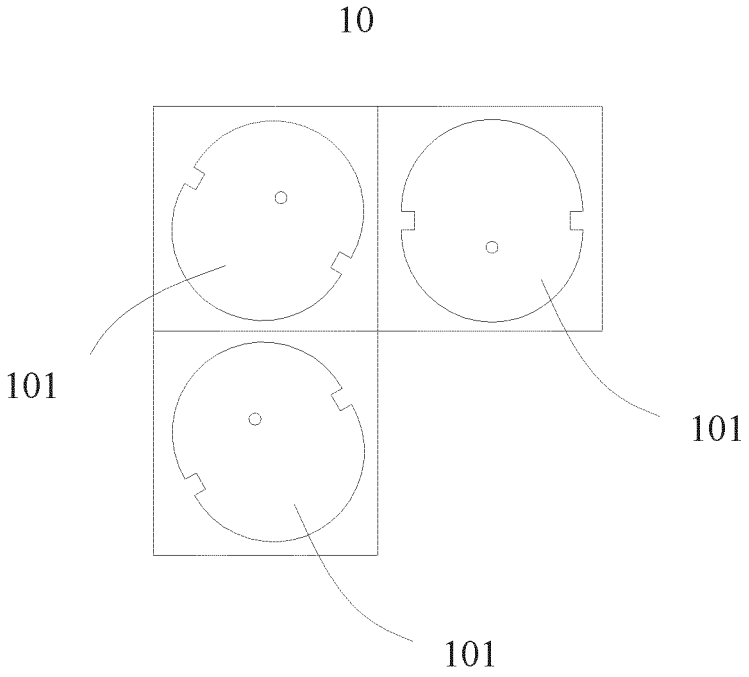

Fig.2

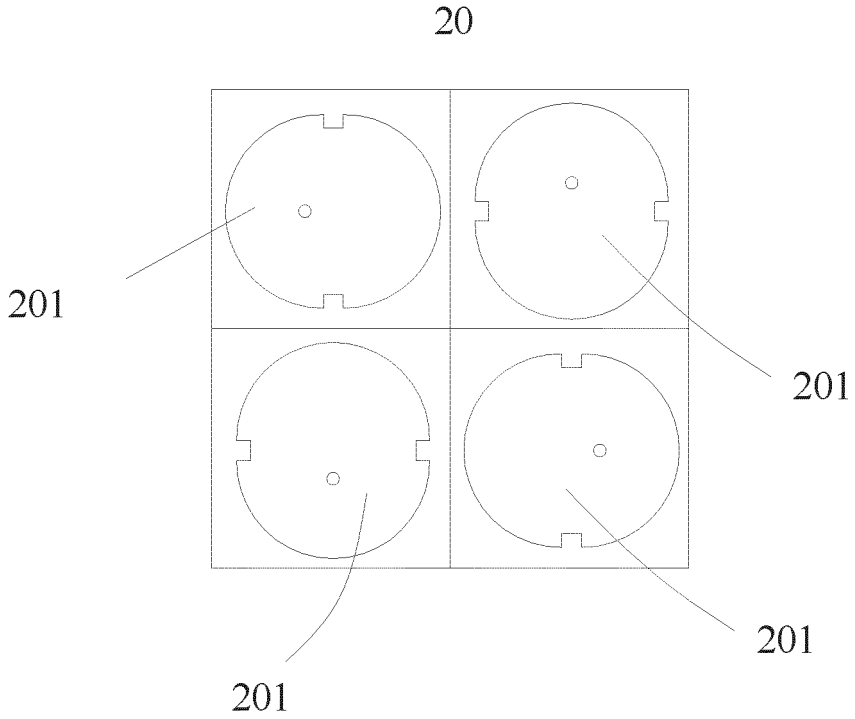

Fig. 3

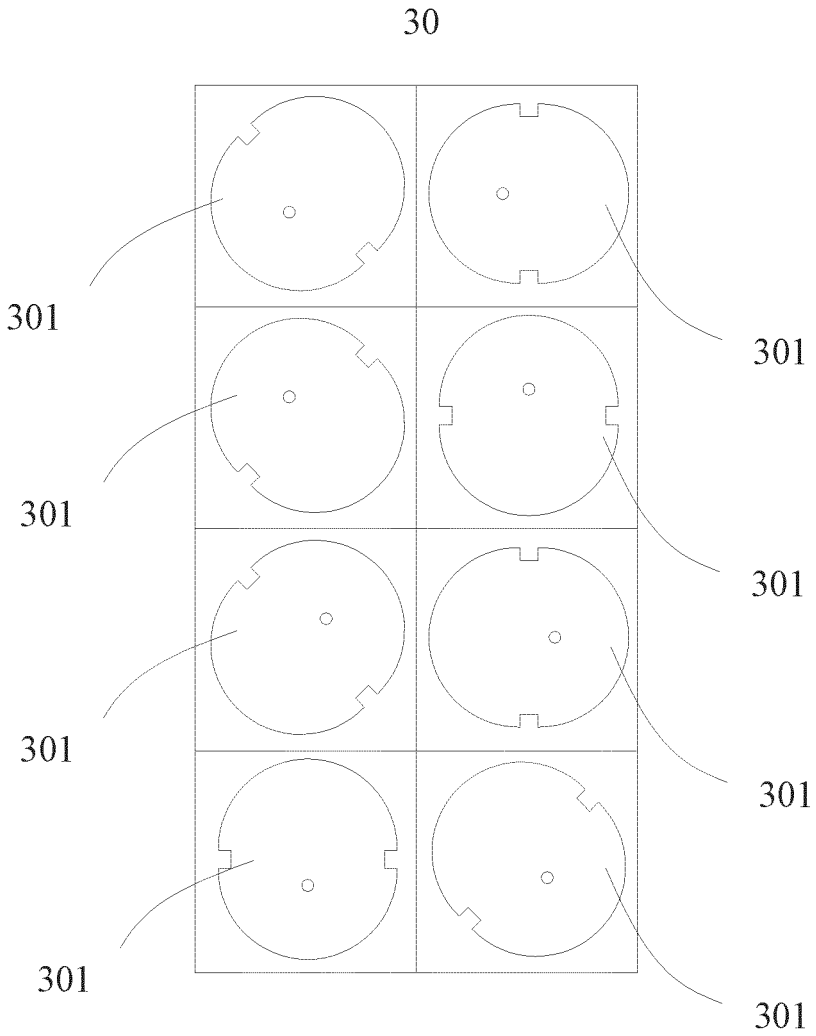

Fig. 4

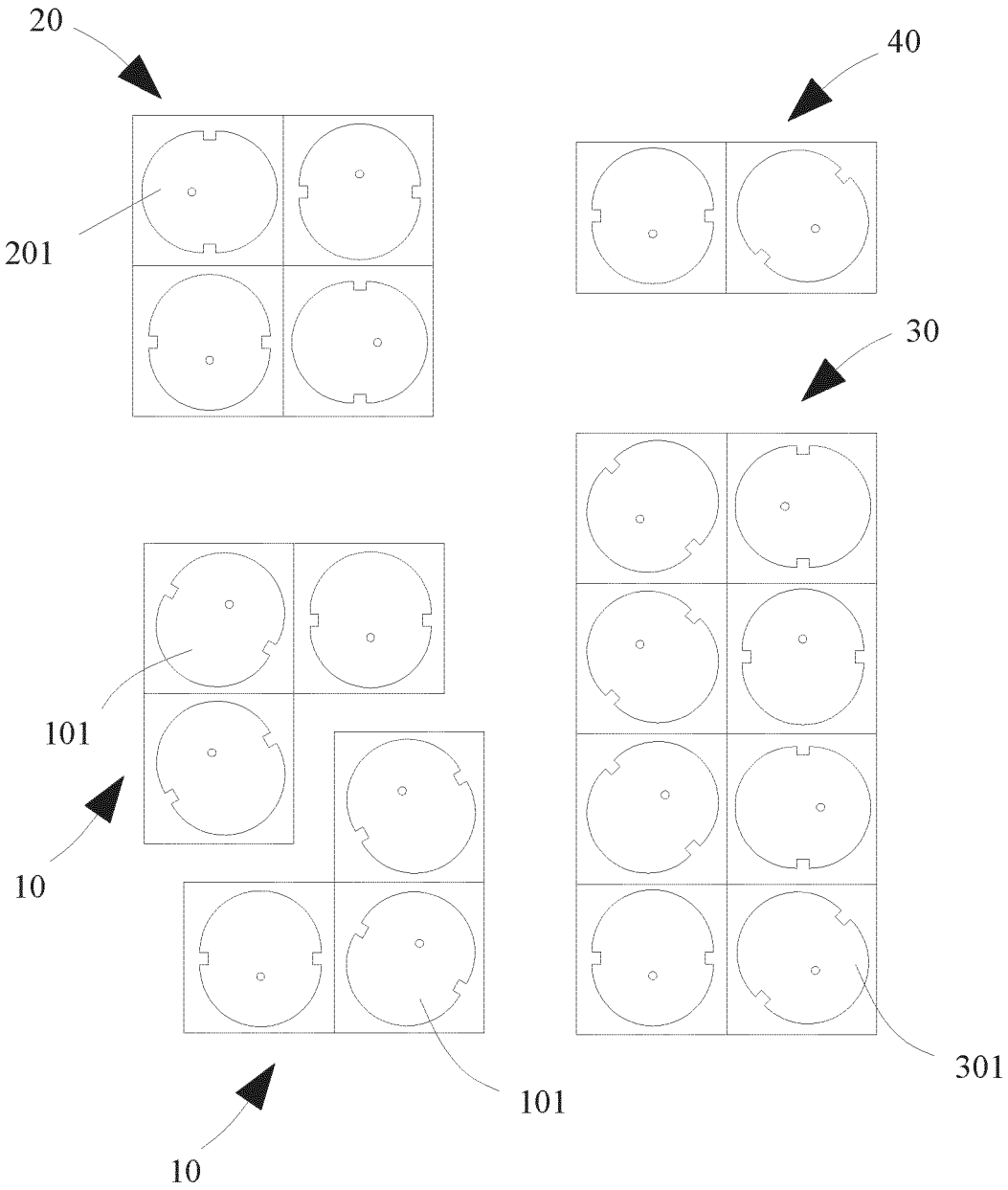

Fig. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2022/079212

A. CLASSIFICATION OF SUBJECT MATTER

H01Q 21/00(2006.01)i; H01Q 3/30(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 H01P

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)

CNTXT; WPABS; ENTXT; CJFD; WFCJ; WFCD; WFCCP; IEEE: 相控, 阵列, 天线, 排列, 子阵, 旋转; phase, array, antenna, arrangement, sub-array, rotat+

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	CN 112038756 A (CHENGDU T-RAY TECHNOLOGY CO., LTD.) 04 December 2020 (2020-12-04) entire document	1-10
A	CN 107230843 A (NO.38 RESEARCH INSTITUTE OF CHINA ELECTRONICS TECHNOLOGY GROUP CORPORATIONE) 03 October 2017 (2017-10-03) entire document	1-10
A	CN 112531313 A (SHANGHAI SPACEFLIGHT MEASUREMENT & CONTROL COMMUNICATION INSTITUTE) 19 March 2021 (2021-03-19) entire document	1-10
PX	CN 214477923 U (CHENGDU T-RAY TECHNOLOGY CO., LTD.) 22 October 2021 (2021-10-22) description, paragraphs [0036]-[0053], and figures 1-5, and claims 1-10	1-10

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
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"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
24 March 2022	**30 March 2022**
Name and mailing address of the ISA/CN **China National Intellectual Property Administration (ISA/CN)** **No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088, China** Facsimile No. **(86-10)62019451**	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2022/079212

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CN 112531313 A	19 March 2021	None	
CN 214477923 U	22 October 2021	None	

Form PCT/ISA/210 (patent family annex) (January 2015)