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(54) **PHASED ARRAY ANTENNA**

(57) The disclosure discloses a phased array antenna, and relates to the technical field of phased array antenna. The phased array antenna includes a plurality of antenna elements, and each of the plurality of the antenna elements includes: an intermediate substrate provided with electric dipoles, and short-circuit parasitic branches. There are two short-circuit parasitic branches, the two short-circuit parasitic branches are respectively arranged at two sides of the intermediate substrate, and the short-circuit parasitic branches are isolated from the electric dipoles. The disclosure can expand the bandwidth of end-fire circularly polarized phased array antenna.

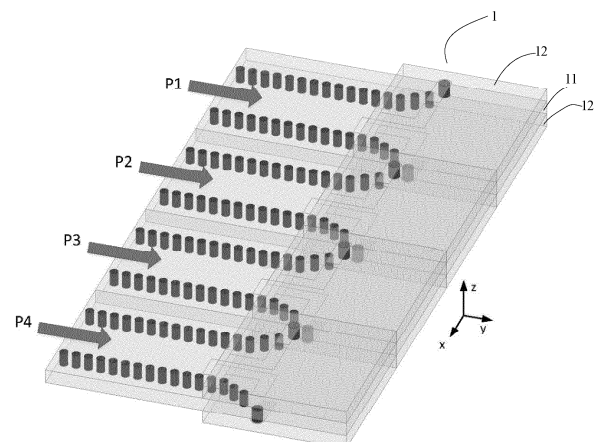


FIG. 5

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Description

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is based on and claims priority to Chinese patent application No. 2023111251765, filed on September 01, 2023, the entire contents of which are incorporated herein by reference.

TECHNICAL FIELD

[0002] The disclosure relates to a technical field of phased array antenna, in particular to a phased array antenna.

BACKGROUND

[0003] The replacement and development of wireless communication technology is getting faster. With the development of radio technology, various formats exist for the existing radio low-frequency spectrums. Although wireless transceiver systems for different communication purposes can use related technologies to improve system capacity and spectrum utilization, the microwave low frequency band is already close to saturation, and cannot meet personalized wireless communication requirements. Therefore, in order to realize more personalized wireless communication requirements and develop new spectrum resources, it is an inevitable trend to develop millimeter-wave frequency band spectrum resources. Millimeter-wave frequency band has the advantages of good directivity because of its short wavelength, extremely wide frequency band and narrow beam. Compared with the microwave frequency band, the millimeter-wave beam is much narrower than the microwave beam with the same antenna size, and the size of millimeter-wave component is much smaller. Therefore, devices such as millimeter-wave antennas can be used in wireless communication scenarios with limited space, e.g., mobile phone transceiver system. With the rapid development of wireless communication technology, millimeter-wave array antenna has a good development prospect.

[0004] In the existing antenna design technology, phased array antenna is based on the array antenna, and it changes the direction and shape of radiation pattern by controlling feeding amplitude and phase shift of different array radiating elements, so as to achieve the purposes of beam scanning, communication capacity adjustment and spatial distribution and synthesis of signal power. Compared with the traditional method of rotating antenna mechanically, phased array antenna overcomes the disadvantages of large inertia, slow rotation speed and large volume, and has the ability to fast scan the antenna beam, which can realize tracking and positioning for fast moving objects. Among them, the circularly polarized phased array antenna has some advantages of circularly polarized wave, and also has its unique advantages in solving polarization mismatch, re-

straining rain and fog interference and eliminating the Faraday effect, which makes it have a broad prospect. In the related art, end-fire circularly polarized phased array antenna has the problems of narrow operating bandwidth and small beam gain.

[0005] In conclusion, how to expand the bandwidth of end-fired circularly polarized phased array antenna is one of the important problems to be solved urgently in this field.

SUMMARY

[0006] The purpose of this disclosure is to provide a phased array antenna to solve the shortcomings in the related art, which can expand the bandwidth of end-fire circularly polarized phased array antenna.

[0007] The disclosure provides a phased array antenna. The phased array antenna includes a plurality of antenna elements, and each of the antenna elements includes:

an intermediate substrate provided with electric dipoles; and
short-circuit parasitic branches, in which there are at least two short-circuit parasitic branches, the at least two short-circuit parasitic branches being respectively arranged at two sides of the intermediate substrate, and the short-circuit parasitic branches are isolated from the electric dipoles.

[0008] In an optional embodiment, there are two short-circuit parasitic branches.

[0009] In an optional embodiment, the phased array antenna further includes two dielectric substrates.

[0010] The intermediate substrate is arranged between the two dielectric substrates, and the two short-circuit parasitic branches are arranged in the two dielectric substrates respectively.

[0011] In an optional embodiment, the two dielectric substrates are both abutted against the intermediate substrate, and each of the dielectric substrate is provided with a short-circuit through hole for electrical connection.

[0012] In an optional embodiment, the short-circuit parasitic branches and the electric dipoles are arranged in a first direction.

[0013] In an optional embodiment, the intermediate substrate is a substrate integrated waveguide substrate, and in an operating mode, the electric field direction is a second direction, and the first direction is perpendicular to the second direction.

[0014] In an optional embodiment, the intermediate substrate is also provided with magnetic dipoles and transmit lines, the magnetic dipoles are arranged in the second direction, and the magnetic dipoles and the electric dipoles are connected by a quarter-wavelength microstrip plane double-wires.

[0015] In an optional embodiment, each antenna element includes a power divider, and the power divider is

used for power distribution of an input signal to form multiple signals.

[0016] In an optional embodiment, each antenna element further includes a plurality of phase shifters, each of the plurality of the phase shifters is connected to the power divider, and the plurality of phase shifters correspond to the multiple signals.

[0017] In an optional embodiment, the multiple signals output after the plurality of phase shifters have the same phase, or are increased or decreased along the first direction by an equal phase difference.

[0018] In an optional embodiment, the power divider includes three cascaded two-way power dividers.

[0019] Compared with the related art, the disclosure introduces two short-circuit parasitic branches in each antenna element, which are located on the left and right sides of the intermediate substrate respectively. The two short-circuit parasitic branches are used to adjust the magnitude and phase of the electric field to be uniformly distributed over a width range, thereby extending the operating bandwidth. By isolating the short-circuit parasitic branches and the electric dipoles from contacts, it is ensured that the two have different potential distributions. Through the coupling effect, the short-circuit parasitic branches can receive the electromagnetic fields polarized in the first direction, and the superposition of electric fields in the first direction can achieve the purpose of broadband operating frequency band of end-fire circularly polarized phased array antenna array.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020]

FIG. 1 is a structural diagram of an end-fire circularly polarized phased array antenna according to an embodiment of the disclosure.

FIG. 2 is a schematic diagram of a power division phase-shifting network of an end-fire circularly polarized phased array antenna according to an embodiment of the disclosure.

FIG. 3 is a schematic diagram of a uniform gradient phase-shifting network of an end-fire circularly polarized phased array antenna according to an embodiment of the disclosure.

FIG. 4 is a schematic diagram of another uniform gradient phase-shifting network of an end-fire circularly polarized phased array antenna according to an embodiment of the disclosure.

FIG. 5 is a 3D schematic diagram of a radiation portion of an end-fire circularly polarized phased array antenna according to an embodiment of the disclosure.

FIG. 6 is a top view of the radiation portion of the end-fire circularly polarized phased array antenna in an x-z plane according to an embodiment of the disclosure.

FIG. 7 is a top view of the radiation portion of the end-

fire circularly polarized phased array antenna in an x-y plane according to an embodiment of the disclosure.

FIG. 8 is a planar stereoscopic structural diagram 1 of the end-fire circularly polarized phased array antenna according to an embodiment of the disclosure.

FIG. 9 is a planar stereoscopic structural diagram 2 of the end-fire circularly polarized phased array antenna according to an embodiment of the disclosure.

FIG. 10 is a planar stereoscopic structural diagram 3 of the end-fire circularly polarized phased array antenna according to an embodiment of the disclosure.

FIG. 11 is a graph of a curve of reflection coefficient of the end-fire circularly polarized phased array antenna as a function of frequency according to an embodiment of the disclosure.

FIG. 12 is a left-handed circularly polarized gain curve of the end-fire circularly polarized phased array antenna according to an embodiment of the disclosure.

FIG. 13 is a graph of a curve of axial ratio characteristics of the end-fire circularly polarized phased array antenna as a function of frequency according to an embodiment of the disclosure.

FIG. 14 is a radiation E-plane pattern of the end-fire circularly polarized phased array antenna under different phase-shifting networks according to an embodiment of the disclosure.

30 Description of reference numerals:

[0021] 1-antenna element, 11-intermediate substrate, 12- dielectric substrate, 13- power divider, 14-phase shifter; 111-short-circuit parasitic branch, 112-electric dipole, 113- magnetic dipole.

DETAILED DESCRIPTION

[0022] The embodiments described below with reference to the drawings are exemplary and are only used for explaining the disclosure, and cannot be interpreted as limiting the disclosure.

[0023] In the present disclosure, the issues raised in the background technology are addressed by the following specific embodiments.

[0024] Please refer to FIGS. 1-10, the embodiment proposes a phased array antenna. The phased array antenna includes a plurality of antenna elements 1. In practice, the plurality of antenna elements 1 form an end-fire circularly polarized phased array antenna array. The antenna elements 1 corresponds to a plurality of phase shifters 14 one by one, and each antenna element 1 is connected to its corresponding phase shifter 14. Beam scanning characteristics for specific spatial area can be realized by setting up multiple power division phase-shifting networks.

[0025] In detail, in order to expand the bandwidth of phased array antenna, in this embodiment, each phased

array antenna includes a plurality of antenna elements 1. The plurality of antenna elements 1 are arranged in a first direction.

[0026] The antenna element 1 includes an intermediate substrate 11 and short-circuit parasitic branches 111 (see FIGS. 7-9 of this disclosure). The intermediate substrate 11 is a Substrate Integrated Waveguide (SIW) substrate, and its operating mode is main mode TE_{10} mode. This mode propagates along SIW transmit lines, and the electric field directed in a second direction. The width of the SIW transmit line is expanded at the end of the SIW transmit line, which improves impedance match between antenna and transmit line.

[0027] As illustrated in FIGS. 7-9, the intermediate substrate 11 is provided with electric dipoles 112, magnetic dipoles 113 and transmit lines. The electric dipoles 112 are distributed along the first direction, and the antenna element guides electromagnetic waves from the SIW opening to the electric dipoles 112 arranged along the first direction through quarter-wavelength microstrip planar double wires. Microwave transmit double wires with a planar structure is equivalent to an excitation port of dipoles, which excites the electric dipoles 112 to operate, and the polarization mode is polarization along the first direction. At the SIW opening, the magnetic field is distributed in the first direction, and the energy of magnetic field radiates into the free space, which is equivalent to radiation from the magnetic dipoles 113 placed in the second direction, and the polarization direction of the magnetic dipoles 113 is the second direction. The magnetic dipoles 113 are arranged along the second direction, and the magnetic dipoles 113 and the electric dipoles 112 are connected by the quarter-wavelength microstrip planar double wires. The magnetic dipoles 113 polarized in the second direction and the electric dipoles 112 polarized in the first direction are connected by the quarter-wavelength microstrip planar double wires. Due to this structure, the initial phase of the magnetic dipoles 113 in the second direction is 90 degrees ahead of the initial phase of the electric dipoles 112 in the first direction, and the amplitudes of their electromagnetic fields are almost equal. This structure for controlling the spatial distribution of electromagnetic field can generate a narrow-band circularly polarized wave. Considering that the electric field in the second direction is 90 degrees ahead of the electric field in the first direction and the amplitudes of electric fields are almost equal, the antenna radiates left-handed circularly polarized waves in the third direction. In detail, any two of the first direction, the second direction and the third direction are perpendicular to each other, and the third direction is perpendicular to the intermediate substrate 11. In combination with the attached drawings, the first direction refers to the x axis direction in the attached drawings, the second direction refers to the y axis direction in the attached drawings and the third direction refers to the z axis direction.

[0028] Due to the narrow operating bandwidth of the electric dipoles 112 excited by the quarter-wavelength

microstrip planar double wires, the end-fire circularly polarized phased array antenna array cannot be used in a broadband range. Therefore, the embodiment introduces a pair of short-circuit parasitic branches 111 to adjust the magnitude and phase of the electric field in the first direction to be uniformly distributed over the broadband range, so as to expand its operating bandwidth. In detail, the short-circuit parasitic branches 111 are arranged along the first direction, and the electric dipoles 112 are arranged along the first direction. There are at least two short-circuit parasitic branches 111, e.g., two, three, four, five, or six, etc. For example, if there are two short-circuit parasitic branches 111, the two short-circuit parasitic branches 111 are respectively arranged on two sides of the intermediate substrate 11 (for example, the left and right sides shown in FIG. 7), and are isolated from the electric dipoles 112. That is, by isolating the short-circuit parasitic branches 111 from the electric dipoles 112 contact, a different potential distribution is ensured between the two. Due to the coupling effect, the short-circuit parasitic branches 111 can still receive polarized electromagnetic fields in the first direction, and the superposition of the electric fields in the first direction can achieve the purpose of expanding the operating frequency band of the phased array antenna.

[0029] In detail, in order to achieve the isolation of the short-circuit parasitic branches 111 and the electric dipoles 112, in this embodiment, the phased array antenna further includes two dielectric substrates 12 (see FIGS. 5-6 and 8-10 of this disclosure). The two dielectric substrates 12 are located on the upper and lower sides of the intermediate substrate 11 (that is, the intermediate substrate 11 is arranged between the two dielectric substrates 12). The two short-circuit parasitic branches 111 are respectively arranged inside of the two dielectric substrates 12. That is, a pair of dielectric substrates 12 are introduced in the third direction to isolate the short-circuit parasitic branches 111 and the electric dipoles 112. Both of the dielectric substrates 12 are abut against the intermediate substrate 11, and are provided with short-circuit through holes for electrical connection. In detail, the short-circuit parasitic branches are placed along the first direction to couple the energy of electric field from the first direction, and they are placed at the upper and lower ends of the two short-circuit ends of the electric dipoles 112 (i.e., along the third direction), which is similar to the capacitive loading structure of the antenna. In other words, the electric dipoles 112 and the pair of short-circuit parasitic branches 111 between the two dielectric substrates 12 are all arranged along the first direction, and their projections in the third direction are overlapped, which can effectively improve the coupling degree and enhance the radiation of the electric dipoles 112. In practice, the intermediate substrate 11 is provided with a structure adapted to the short-circuit through hole. The short-circuit parasitic branches 111 are located on the dielectric substrates 12, and the two dielectric substrates 12 are separated by the intermediate substrate 12. In the

implementation, the short-circuit through hole is a trumpet-shaped metal through hole, which means that a metal layer is coated on the inner wall of the short-circuit through hole.

[0030] Through the above arrangements, the two dielectric substrates 12 can affect the guided wave environment in which the electric dipoles 112 and the magnetic dipoles 113 are in, so that the dielectric constants around them are all the dielectric constant of the dielectric substrate 12, which is beneficial to impedance matching of the end-fire circularly polarized phased array antenna. In the implementation, two dielectric substrates 12 are on the antenna element 1, and both of them are paved with metal grooves whose projections along the z-axis direction may partially overlapped or not overlapped at all. The metal grooves are located on the side of the second direction, i.e. the radiation direction.

[0031] In the implementation, the antenna elements 1 include a power divider 13 and a plurality of phase shifter 14. The power divider 13 is used for power distribution of input signals to form multiple signals. The plurality of phase shifters 14 are all connected to the power divider 13, and the plurality of phase shifters 14 are in one-to-one correspondence with the multiple signals. The power divider 13 and the phase shifters 14 form a power division phase-shifting network, which distributes the power of microwave input signal through a two-way power divider. Three two-way power dividers can be cascaded to form a four-way power divider and followed by a microwave phase shifter, and a phase-shifting range may include any angle. The multiple signals output after the phase shifters 14 have the same phase, or are increased or decreased by an equal phase difference along the first direction. Typical data for the phase-shifting of four signals given in this disclosure are: group 1 (0 degree, 0 degree, 0 degree and 0 degree), group 2 (0 degree, -100 degree, -200 degree and -300 degree) and group 3 (0 degree, 100 degree, 200 degree and 300 degree). The data given above is only an embodiment. In detail, the phase shifts of four signals can be expressed as $(x_0, x_0+x_1, x_0+2*x_1, x_0+3*x_1)$, in which x_0 represents a phase shift of the first signal, and x_1 represents a phase difference between two adjacent signals. Among the plurality of antenna elements 1 in this disclosure, there should be included an antenna element in which the phase shifts of multiple signals are sequentially and uniformly increasing, an antenna element in which the phase shifts of multiple signals are equal, and an antenna element in which the phase shifts of multiple signals are sequentially decreasing. The microwave signal passes through the power divider, and the phase shifting is accomplished by using the phase-shifting characteristics of the phase shifter 14 described above, and in the end-fire circularly polarized array antenna, it is realized that the four signals have different beam arrival times in order to regulate the propagation direction of the synthesized beam, and to achieve the purpose of phase modulation and scanning. In the implementation, the phase modula-

tion of the end-fire circularly polarized phased array antenna only occurs in the first direction, and the beam in the second direction is not capable of scanning. That is, the synthesized beam of the end-fire circularly polarized phased array antenna can be phase scanned in the first direction, maintaining the radiation characteristics of the antenna element 1 in the second direction. It should be noted that the multiple signals described in this disclosure does not limited to four, and the above four signals are merely an exemplary explanation. In the implementation, the signals can be divided into other numbers of paths as needed.

[0032] The disclosure can use the rich frequency band resources of millimeter wave frequency band and adopt the end-fire circularly polarized phased array antenna technology to realize a circularly polarized phased array antenna under with beam scanning under wide frequency band. In the disclosure, a wideband end-fire circularly polarized antenna element is obtained by using the technology of loading short-circuit parasitic branches, to ensure the operating wide frequency band of the array antenna. The phase shifter designed in this disclosure can obtain the required beam scanning characteristics, so as to meet the requirements of E-plane coverage, and acquires the advantages of easy implementation, miniaturization and low cost.

[0033] In order to further illustrate the principles and effects of the disclosure, an embodiment will be used for further explanation.

[0034] Please refer to FIGS. 2-4, in this example, three two-way power dividers are cascaded to form a four-way power divider, which is followed by a microwave phase shifter. The phase shifting range may include any angle. The phase shifting is completed by using the phase shifting characteristics of the phase shifter. In the end-fire circularly polarized phased array antenna, four signals with different beam arrival times are realized to regulate the propagation direction of the synthesized beam for the purpose of phase modulation and scanning.

[0035] FIG. 5 is a three-dimensional schematic diagram of a radiation portion of an end-fire circularly polarized phased array antenna according to an embodiment of the disclosure. As illustrated in FIG. 5, the dielectric substrates 12 and the intermediate substrate 11 are close to each other along the third direction, and the electrical connection is realized through an array of short-circuit through-holes. The width of the transmit lines is the same as that of the electric dipoles 112, the transmit lines are parallel to the second direction, and the transmission direction is along the second direction. FIG. 6 is a top view of the end-fire circularly polarized phased array antenna in an x-z plane according to an embodiment of the disclosure. As illustrated in FIG. 6, the projections of the end-fire circularly polarized phased array antenna in the z-axis direction are partially overlapped, because the electric dipoles 112 and a pair of short-circuit parasitic branches 111 located on the two dielectric substrates 12 are all placed along the first direction, so that the projec-

tions of the three are overlapped in the z-axis direction. The projection of the short-circuit parasitic branches of one of the antenna elements has a period interval of 1.05mm along the first direction. FIG. 7 is a top view of the end-fire circularly polarized phased array antenna in an x-y plane according to an embodiment of the disclosure.

[0036] As illustrated in FIGS. 8-10, the three-dimensional plane structural diagram of the end-fire circularly polarized phased array antenna in different phases in this example includes three layers of substrates, i.e., an intermediate substrate 11, and two dielectric substrates 12 immediately above and below the intermediate substrate 11 respectively. The specification of the SIW substrate 11 is 8mm in length, 8mm in width and 0.5mm in height. The specification of the upper and lower dielectric substrates 12 are 1.95mm in length, 1.95mm in width and 0.5mm in height. The size of metal short-circuit through holes on the SIW substrate is 0.25mm in diameter, and 0.1mm spacing between adjacent metal short-circuit through holes. The dielectric constant value of the three-layer substrates are all 3.55. The dielectric substrate 12 is placed with short-circuit parasitic branches 111, and the intermediate substrate is arranged between the dielectric substrates 12. The specification of short-circuit parasitic branches is 0.49mm in length and 0.26mm in width.

[0037] FIG. 11 is a graph illustrating a curve of reflection coefficient of the antenna as a function of frequency. This example covers the 22 GHz to 34 GHz frequency band and has a reflection coefficient of $-4\text{dB} < S_{11} < 19\text{dB}$.

[0038] FIG. 12 is a left-handed circularly polarized gain curve of the end-fire circularly polarized phased array antenna according to an embodiment of the disclosure. As illustrated in FIG. 12, in this example, a short-circuit parasitic branch is added to each of the upper and lower substrates respectively, which can effectively improve the coupling degree, improve the radiation of the electric dipoles 112 and increase the gain of the antenna.

[0039] FIG. 13 is a graph of a curve of axial ratio characteristics of the end-fire circularly polarized phased array antenna as a function of frequency according to an embodiment of the disclosure. As can be seen from FIG. 13, the axial ratio fluctuates in the range of 2dB-4dB in the frequency band of 23GHz-32GHz in this example, so it can be seen that it has good axial ratio characteristics due to its small axial ratios.

[0040] FIG. 14 is a radiation E-plane pattern of the end-fire circularly polarized phased array antenna under different phase-shifting networks according to an embodiment of the disclosure. As illustrated in FIG. 14, in this example, the scanning range of E-plane pattern under different phase-shifting networks reaches $\pm 60^\circ$, so it can be seen that the end-fire circularly polarized phased array antenna provided by this disclosure has good beam scanning characteristics.

[0041] The structure, features and effects of the disclosure have been described in detail above according to

the embodiments shown in the drawings. Only the preferred embodiments of this disclosure are illustrated above, but this disclosure does not limit the scope of implementation as shown in the drawings. Any changes made in accordance with the concept of this disclosure, or modifications to equivalent embodiments of equivalent changes, still do not exceed the spirit covered by the specification and drawings, and should be within the protection scope of this disclosure.

Claims

1. A phased array antenna comprising a plurality of antenna elements, each of the plurality of the antenna elements comprises:

an intermediate substrate provided with electric dipoles; and
short-circuit parasitic branches, wherein the number of the short-circuit parasitic branches is at least two, the at least two short-circuit parasitic branches are respectively arranged at two sides of the intermediate substrate, and the short-circuit parasitic branches are isolated from the electric dipoles.

2. The phased array antenna of claim 1, wherein the number of the short-circuit parasitic branches is two.
3. The phased array antenna of claim 1, wherein the phased array antenna further comprises two dielectric substrates, the intermediate substrate is arranged between the two dielectric substrates, and the two short-circuit parasitic branches are arranged in the two dielectric substrates respectively.
4. The phased array antenna of claim 3, wherein each of the two dielectric substrates are abutted against the intermediate substrate, and each of the dielectric substrates is provided with a short-circuit through hole for electrical connection.
5. The phased array antenna of claim 1, wherein the short-circuit parasitic branches and the electric dipoles are arranged in a first direction, and the short-circuit parasitic branches are placed on both sides of the intermediate substrate in the first direction.
6. The phased array antenna of claim 5, wherein the intermediate substrate is a substrate integrated waveguide substrate with the electric field pointing in a second direction in an operating mode, and the first direction is perpendicular to the second direction.
7. The phased array antenna of claim 6, wherein the intermediate substrate is further provided with magnetic dipoles and transmit lines, the magnetic dipoles

are arranged in the second direction, and the magnetic dipoles and the electric dipoles are connected by a quarter-wavelength microstrip plane double wires.

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8. The phased array antenna of claim 6, wherein projections of the short-circuit parasitic branches in a third direction coincides with projections of the electric dipoles in the intermediate substrate in the third direction, and the third direction is perpendicular to the first direction and the second direction. 10
9. The phased array antenna of any one of claims 1-8, wherein each of the antenna elements comprises a power divider, and the power divider is used to distribute the power of input signals to form multiple signals. 15
10. The phased array antenna of claim 9, wherein each of the antenna elements further comprises a plurality of phase shifters, each of the plurality of phase shifters is connected to the power divider, and the phase shifters are in one-to-one correspondence with the multiple signals. 20
11. The phased array antenna of claim 10, wherein the multiple signals output after the plurality of phase shifters have the same phase, or are incremented or decremented by equal phase difference along the first direction. 25
12. The phased array antenna of claim 9, wherein the power divider comprises three cascaded two-way power dividers. 30

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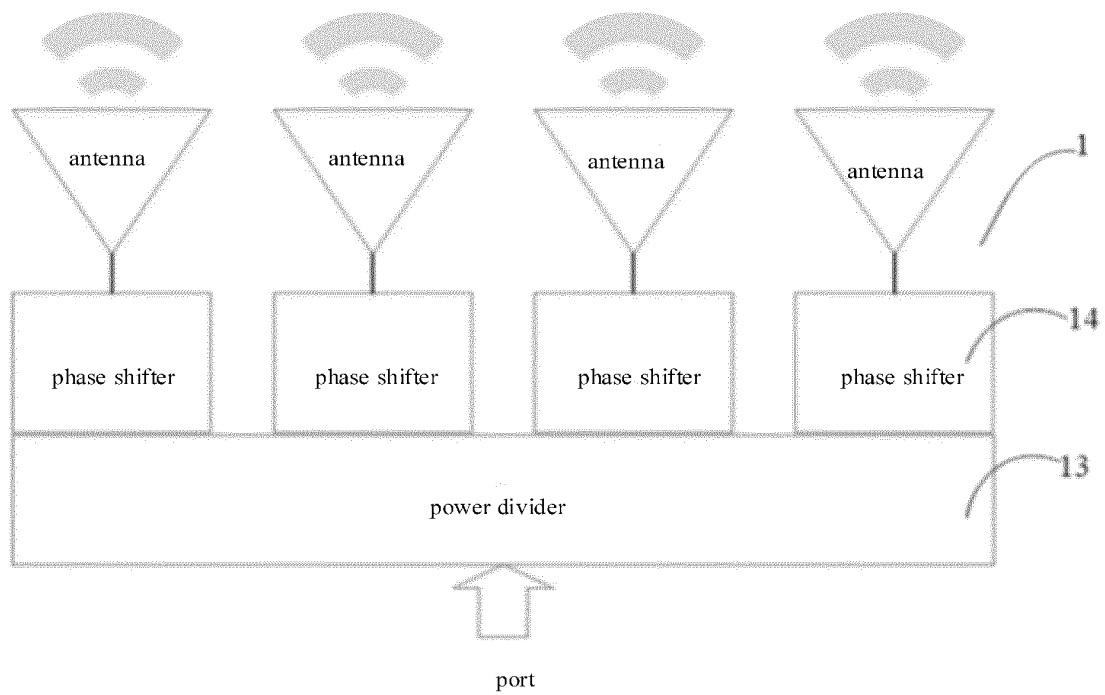


FIG. 1

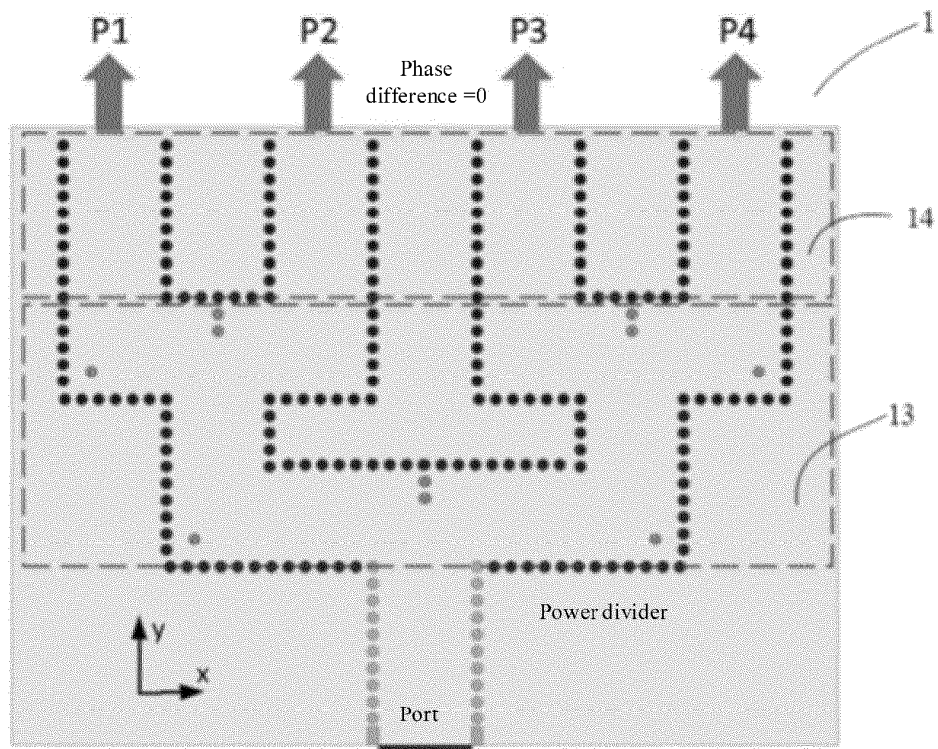


FIG. 2

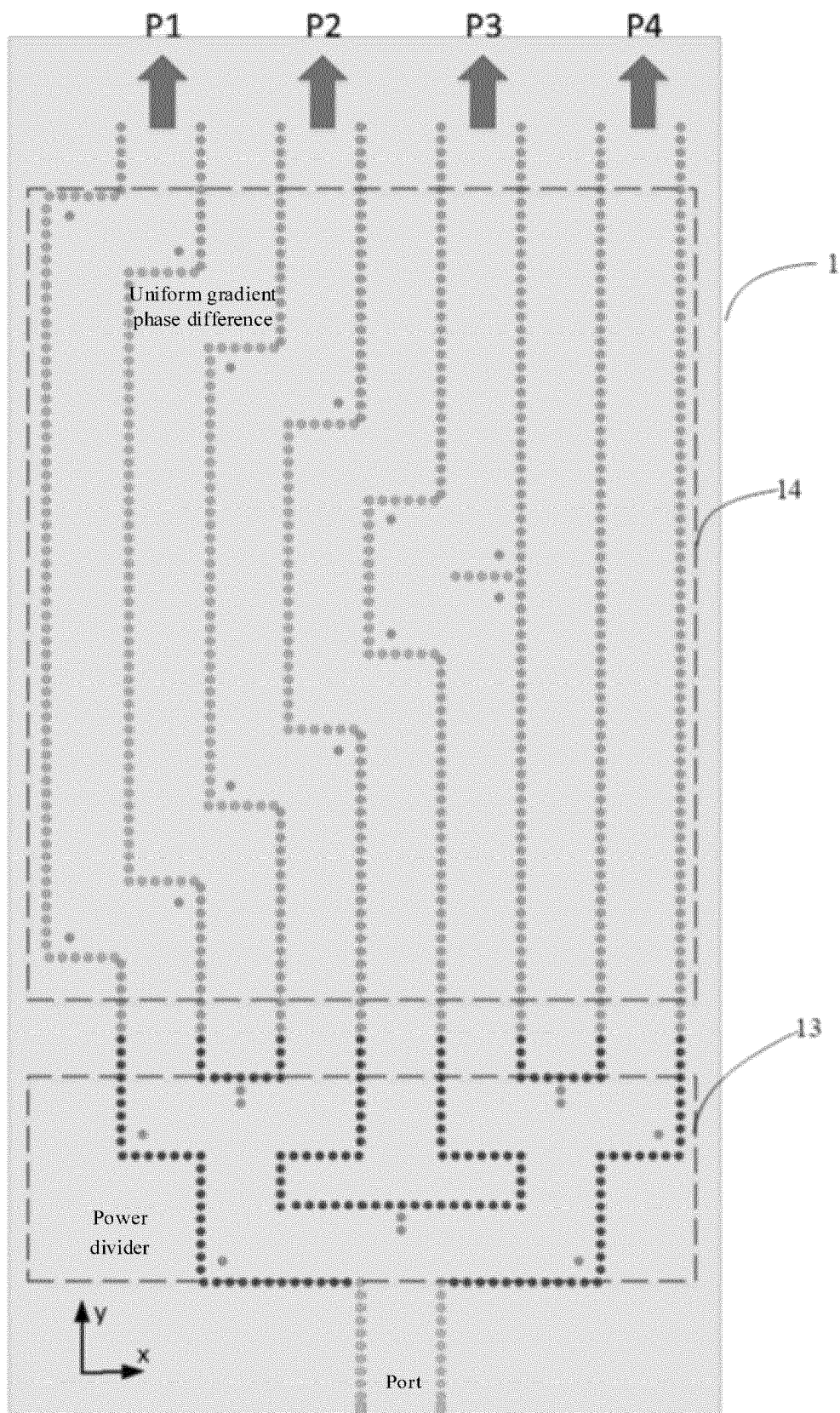


FIG. 3

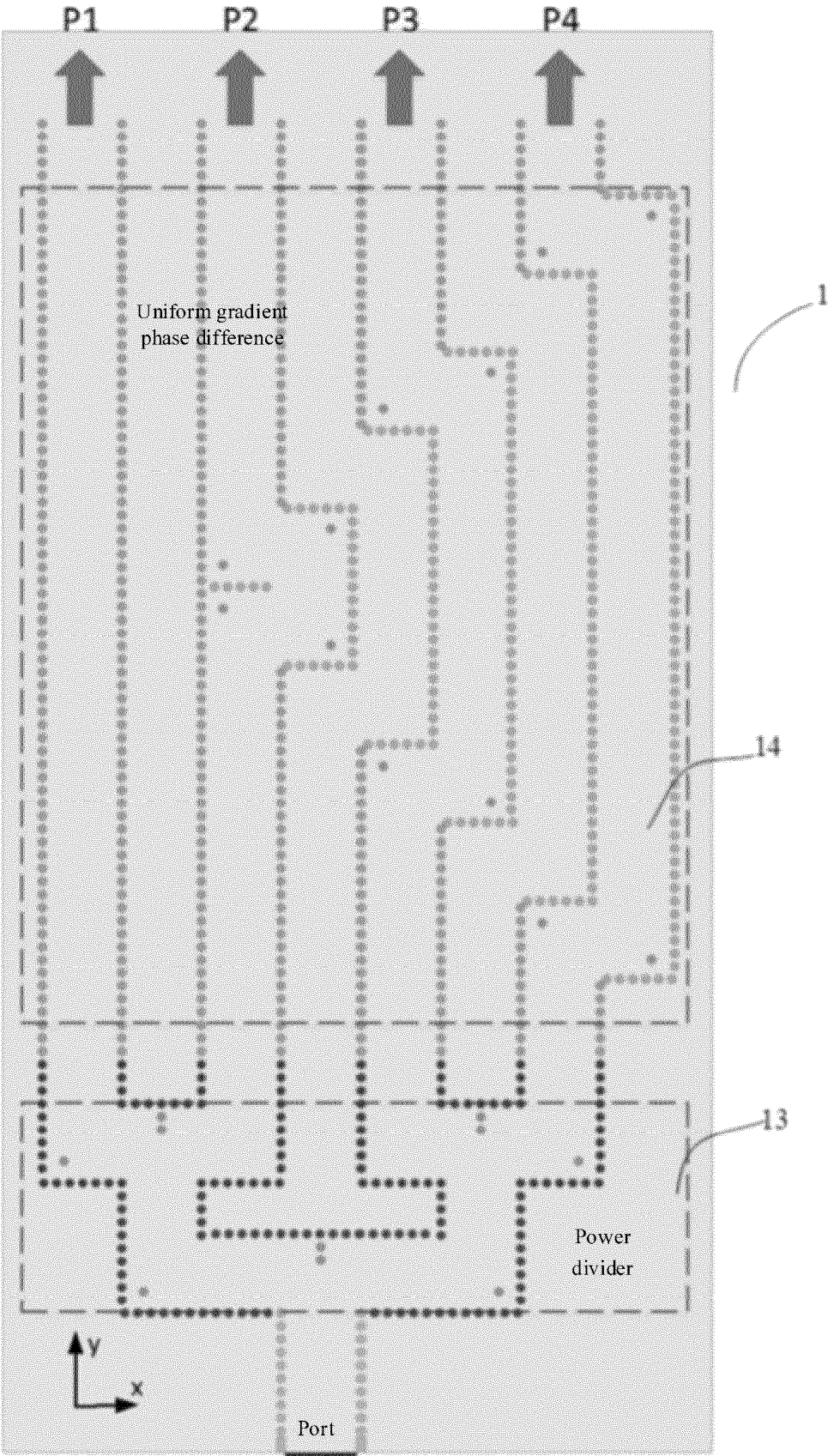


FIG. 4

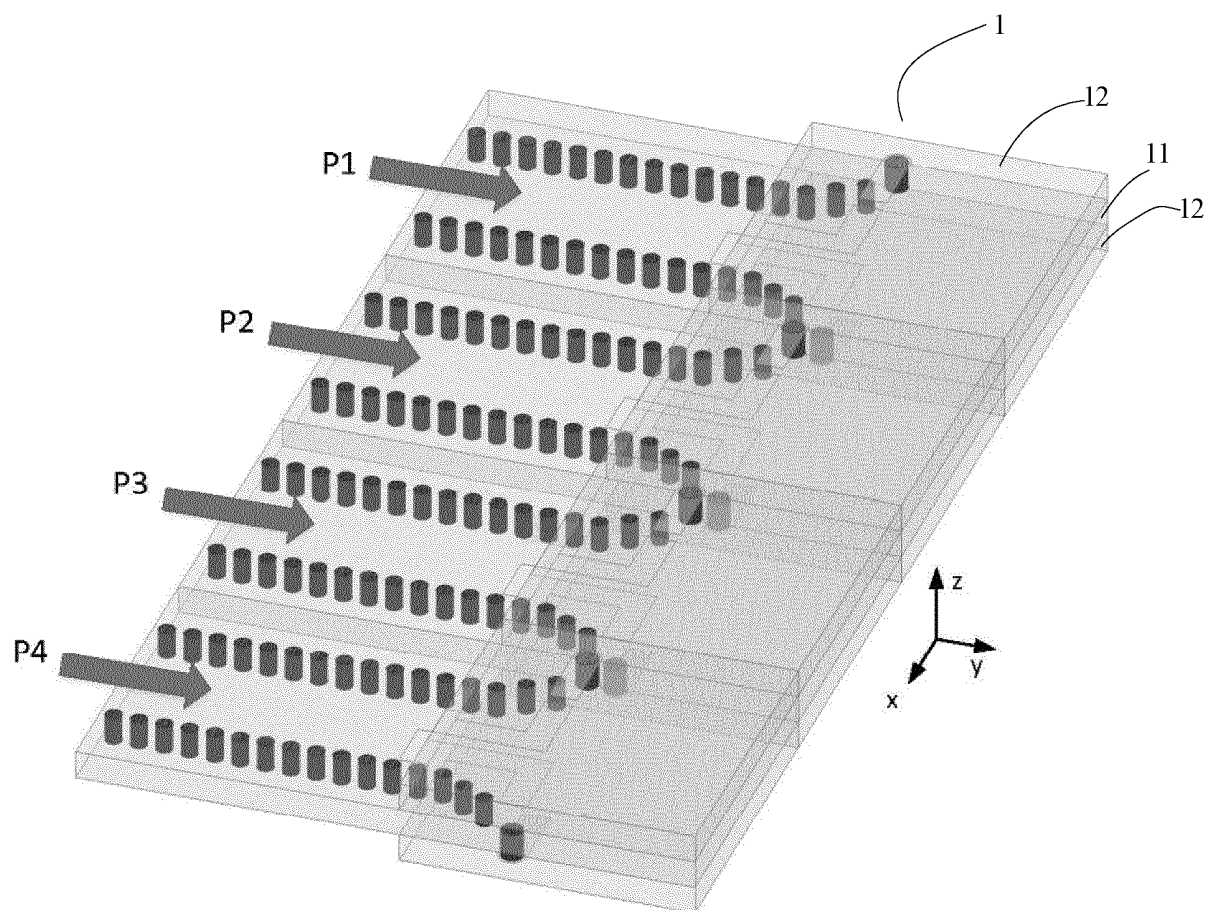


FIG. 5

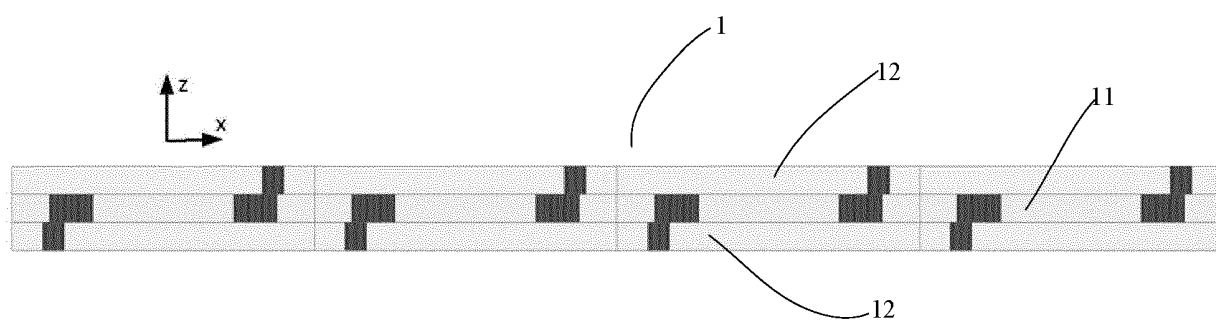


FIG. 6

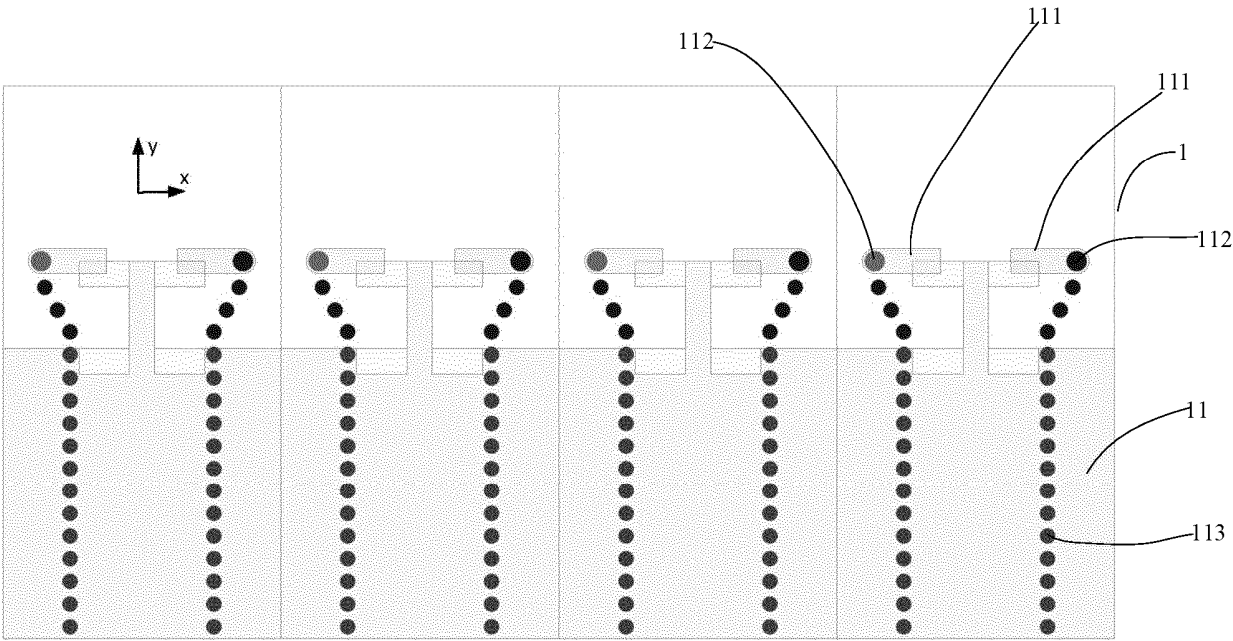


FIG. 7

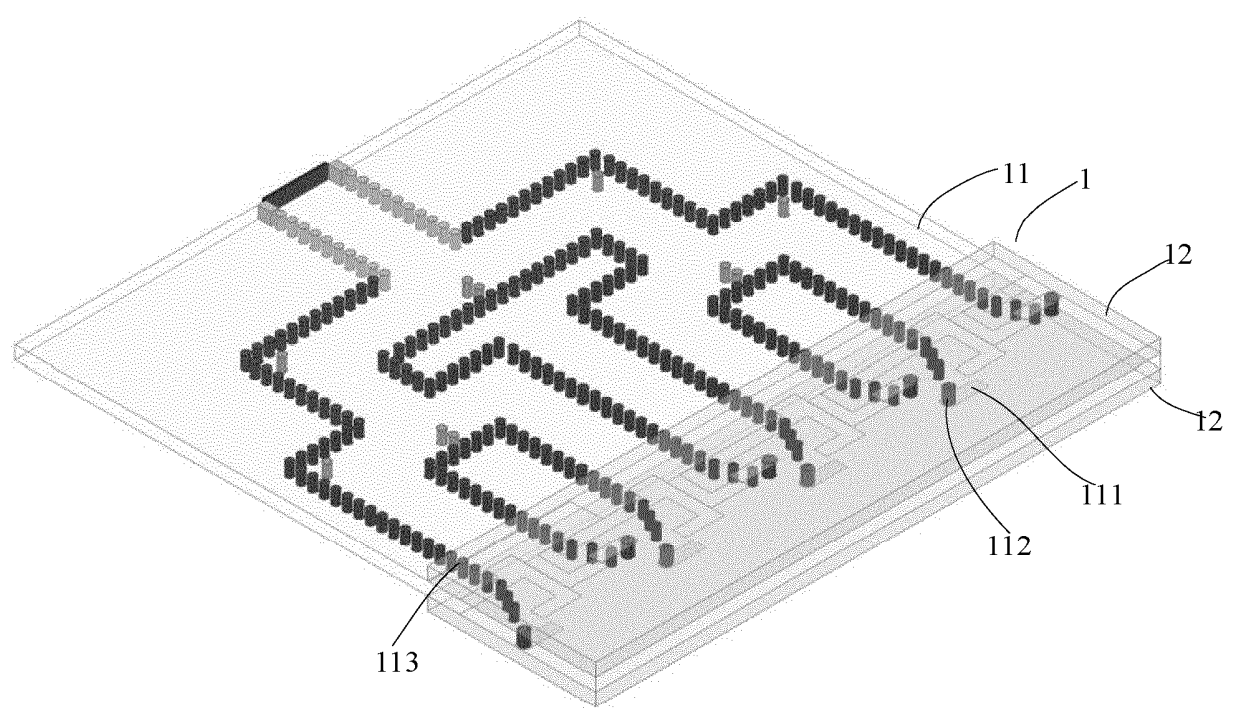


FIG. 8

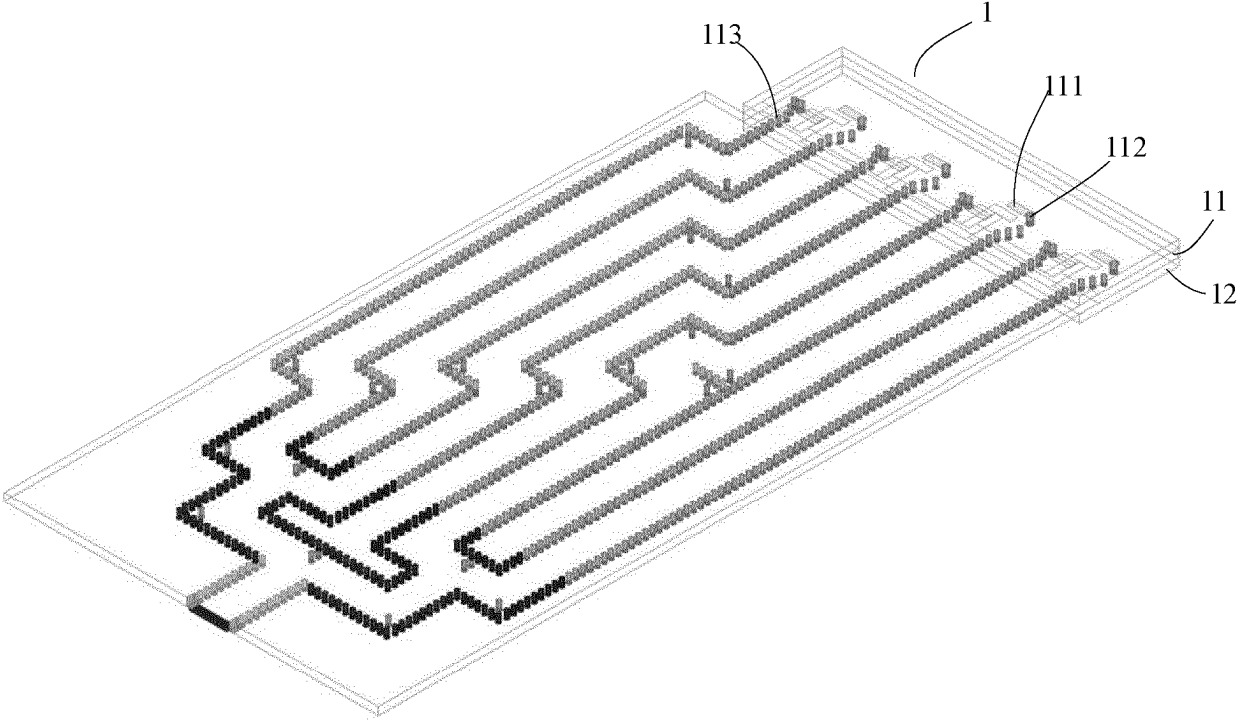


FIG. 9

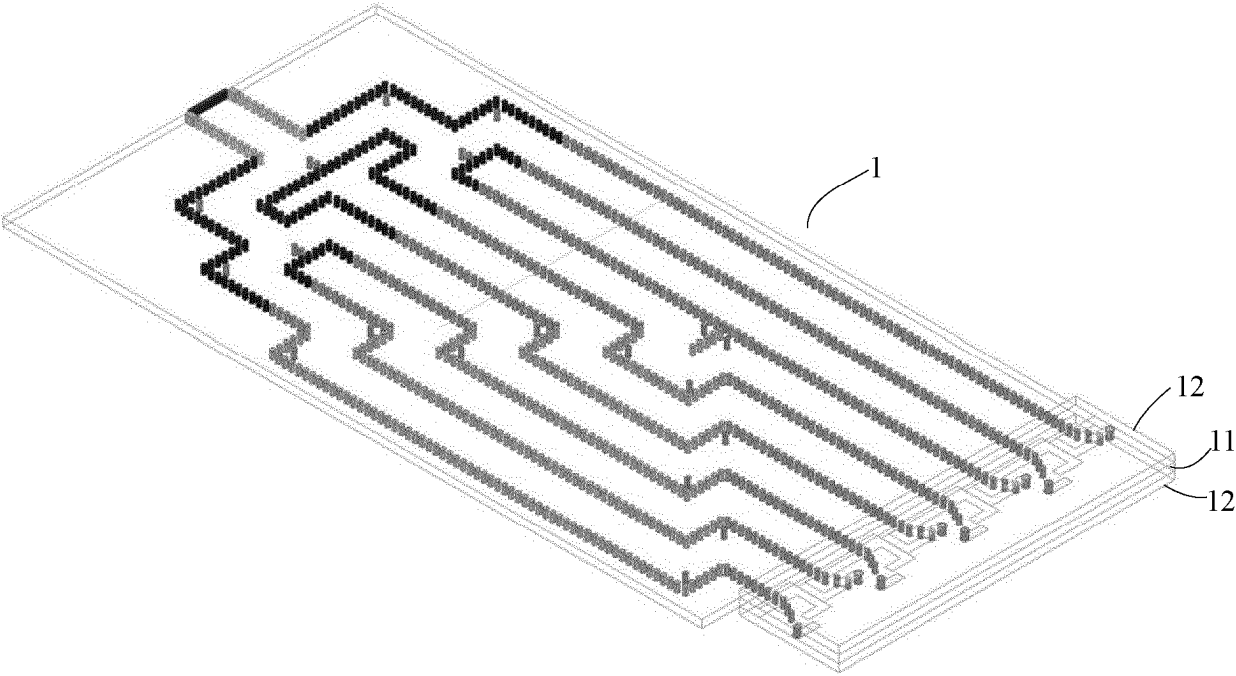


FIG. 10

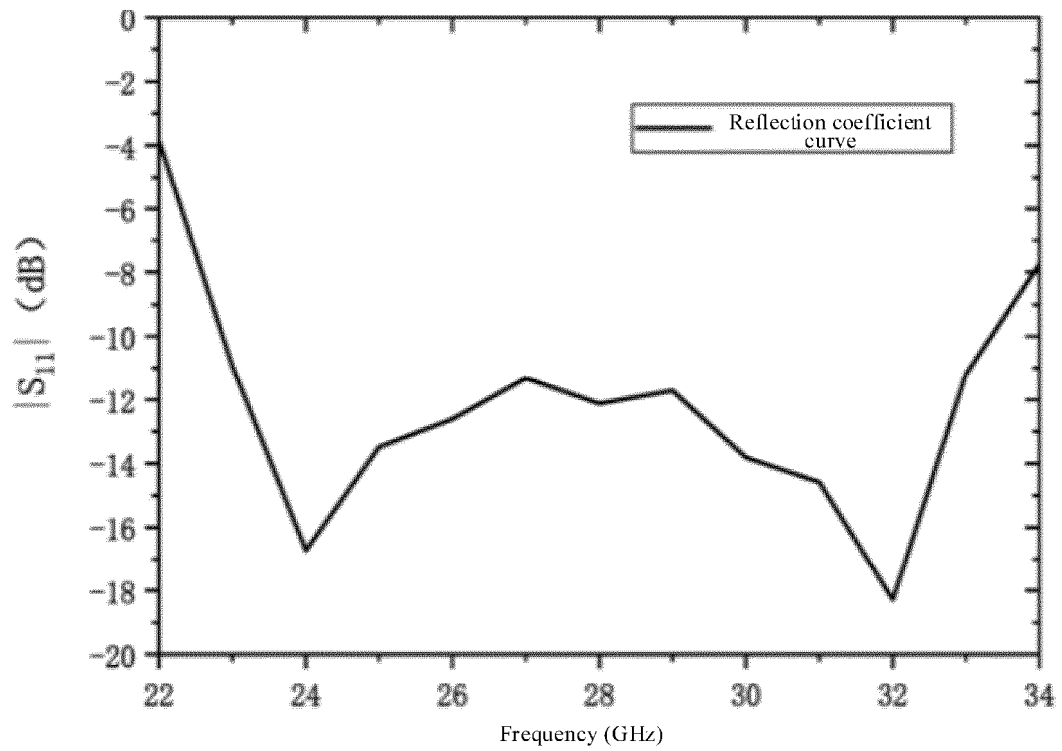


FIG. 11

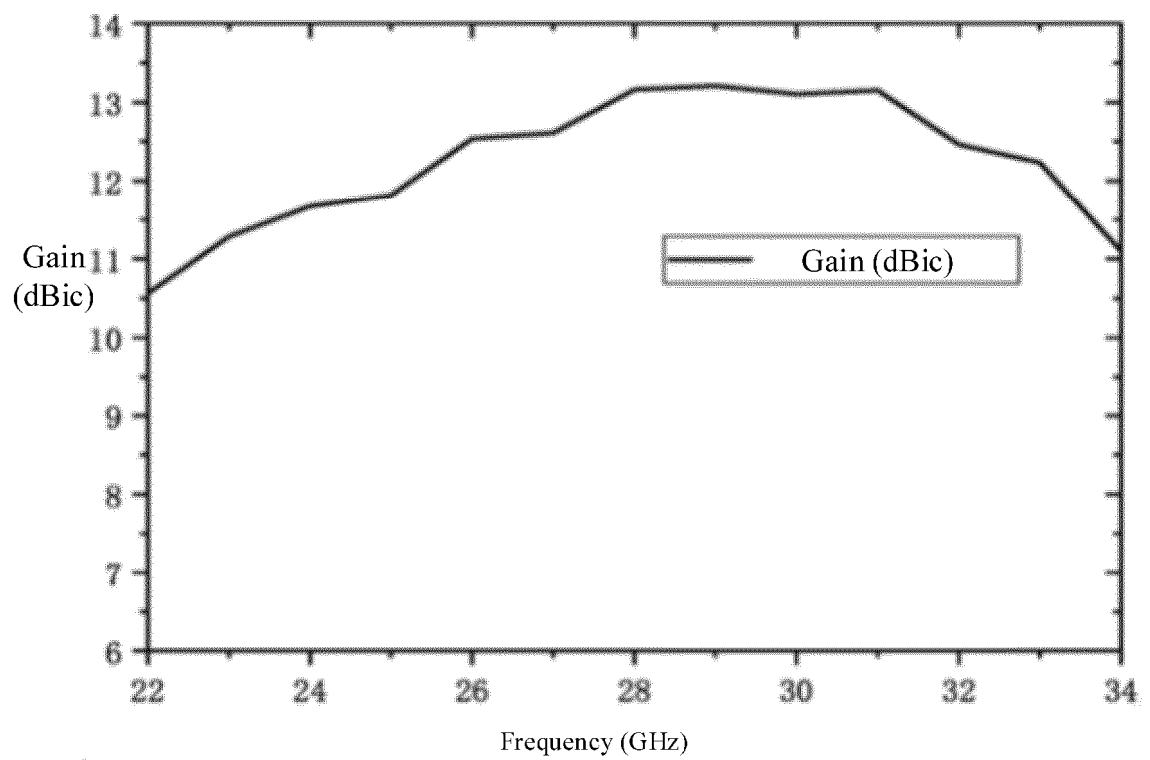


FIG. 12

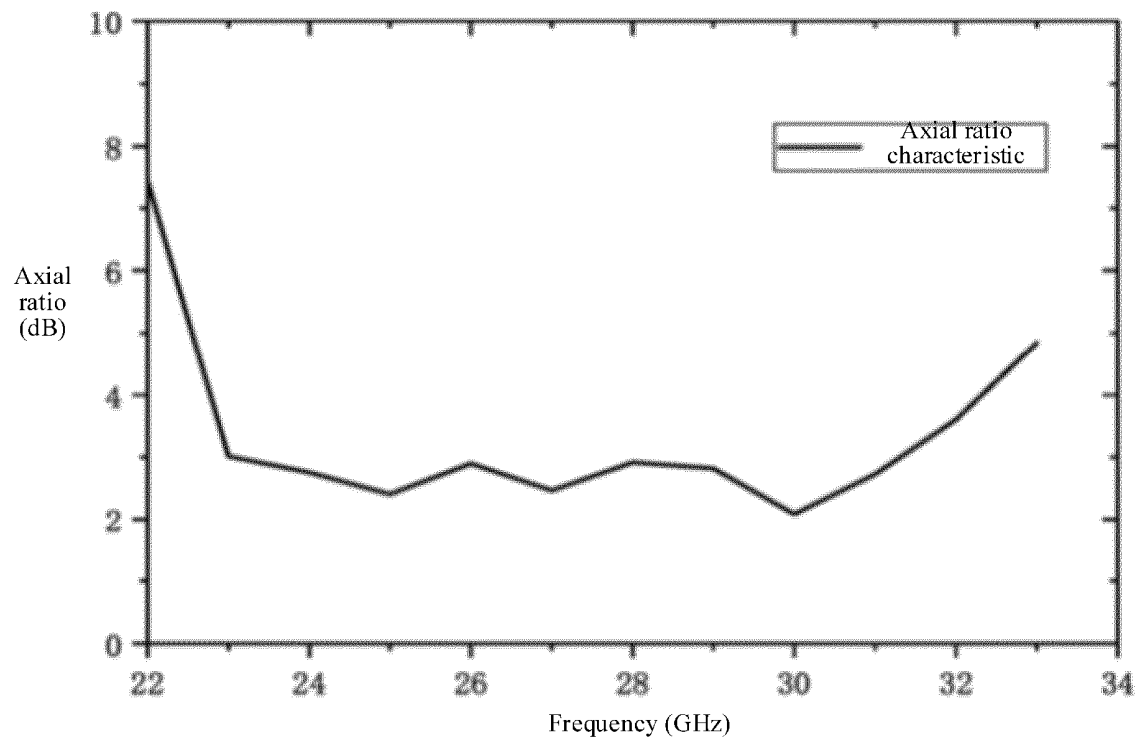


FIG. 13

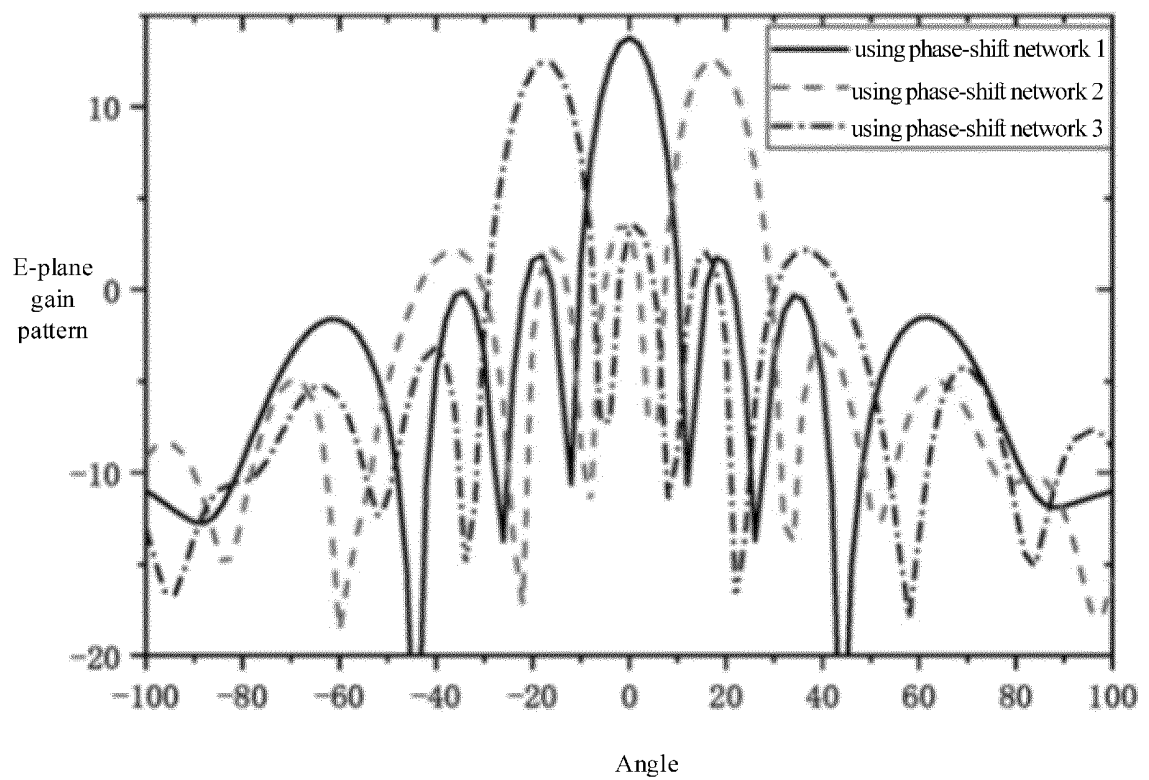


FIG. 14

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2024/091314

A. CLASSIFICATION OF SUBJECT MATTER

H01Q1/38(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)

IPC:H01Q

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, ENTXTC, VEN, ENTXT, CNKI, IEEE, CJFD: 天线, 相控, 阵, 偶极子, 寄生, 短路, 圆极化, 枝节, 单元, 拓展, 带宽, 隔离, 电场, 调节, antenna, array, dipole, parasitic, short circuit, circular polarization, , branch, unit, broad, bandwidth, isolation, electric field, adjust+

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 219513328 U (SOOCHOW UNIVERSITY) 11 August 2023 (2023-08-11) description, paragraphs 27-47	1-12
A	CN 109687124 A (SOUTHEAST UNIVERSITY) 26 April 2019 (2019-04-26) entire document	1-12
A	CN 111817001 A (UNIVERSITY OF ELECTRONIC SCIENCE AND TECHNOLOGY OF CHINA) 23 October 2020 (2020-10-23) entire document	1-12
A	CN 216354772 U (ZHEJIANG GEESPACE TECHNOLOGY CO., LTD. et al.) 19 April 2022 (2022-04-19) entire document	1-12
A	US 2013176177 A1 (UTAH STATE UNIVERSITY et al.) 11 July 2013 (2013-07-11) entire document	1-12

☒ 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

24 June 2024

Date of mailing of the international search report

10 July 2024

Name and mailing address of the ISA/CN

China National Intellectual Property Administration (ISA/
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Beijing 100088

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2024/091314

C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	YU, Yingrui. "Broadband Millimeter-Wave Endfire Circularly Polarized Array With a Low-Profile Feeding Structure" <i>IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION</i> , 11 April 2022 (2022-04-11), entire document	1-12
A	郭萌萌 (GUO, Mengmeng). "基于间隙波导馈电毫米波阵列天线研究 (Research on Millimeter Wave Array Antenna Based on Gap Waveguide Feeding Network)" <i>中国优秀硕士学位论文全文数据库 (China Master's Theses Full-text Database)</i> , 15 June 2022 (2022-06-15), entire document	1-12

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/CN2024/091314

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	219513328	U	11 August 2023	None			
CN	109687124	A	26 April 2019	CN	209448012	U	27 September 2019
CN	111817001	A	23 October 2020	CN	111817001	B	10 May 2022
CN	216354772	U	19 April 2022	None			
US	2013176177	A1	11 July 2013	WO	2013106106	A2	18 July 2013
				WO	2013106106	A3	03 October 2013
				WO	2013106106	A9	14 November 2013
				US	9379449	B2	28 June 2016

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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