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(54) **ANTENNA**

(57) Embodiments of this application provide an antenna, including a dielectric substrate, at least one first antenna element that is resonant at a first frequency, at least one second antenna element that is resonant at a second frequency, a first resonant circuit, and a second resonant circuit. The at least one first antenna element and the at least one second antenna element are arranged on the dielectric substrate. When there are at least two first antenna elements, and there are at least two second antenna elements, there is a spacing between each first antenna element, there is a spacing between each second antenna element, and there is a spacing between each first antenna element and each second antenna element. The first resonant circuit is located on a port of the first antenna element, and the second resonant circuit is located on a port of the second antenna element. The first resonant circuit is connected for the first frequency, and the first resonant circuit is disconnected for the second frequency. The second resonant circuit is connected for the second frequency, and the second resonant circuit is disconnected for the first frequency. This improves a communication rate.

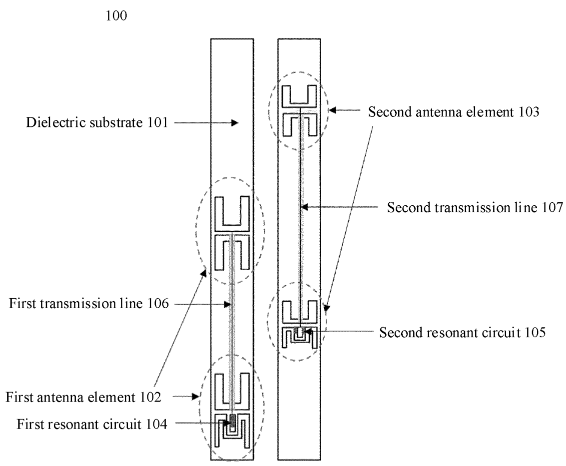

FIG. 1

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Description

[0001] This application claims priority to Chinese Patent Application No. 202011423434.4, filed with the China National Intellectual Property Administration on December 8, 2020 and entitled "ANTENNA", which is incorporated herein by reference in its entirety.

TECHNICAL FIELD

[0002] This application relates to the communications field, and in particular, to an antenna.

BACKGROUND

[0003] With rapid development of a modem communications system, people put forward increasingly high requirements for a communication rate, a channel capacity, a data throughput, user coverage, and the like of a communications system. In a development process of an antenna, such as a wireless local area network (Wireless Local Area Network, WLAN) antenna, a cellular antenna, or a mobile phone antenna, an external antenna is mainly developed in several directions, such as multi-frequency, high gain, miniaturization, and high isolation. An existing multi-frequency multi-feed external antenna is usually printed on a same dielectric substrate, and antenna elements (antenna element) at different frequencies on the same dielectric substrate are closely arranged, causing relatively low isolation between ports and mutual interference between frequency bands. As a result, a communication rate is reduced.

SUMMARY

[0004] Embodiments of this application provide an antenna, to improve a communication rate.

[0005] According to a first aspect, an antenna is provided, including a dielectric substrate, at least one first antenna element that is resonant at a first frequency, at least one second antenna element that is resonant at a second frequency, a first resonant circuit, and a second resonant circuit. The at least one first antenna element and the at least one second antenna element are arranged on the dielectric substrate. The first resonant circuit is located on a port of the first antenna element, and the second resonant circuit is located on a port of the second antenna element. The first resonant circuit is connected for the first frequency, and the first resonant circuit is disconnected for the second frequency. The second resonant circuit is connected for the second frequency, and the second resonant circuit is disconnected for the first frequency.

[0006] With reference to the implementation of the first aspect, in a first possible implementation of the first aspect, that the first resonant circuit is connected for the first frequency, and the first resonant circuit is disconnected for the second frequency is implemented via the following circuit structure: the first resonant circuit is connected in series to the first antenna element, and the first resonant circuit is a parallel resonance structure whose resonance frequency is the second frequency.

[0007] With reference to the first aspect or the first possible implementation of the first aspect, in a second possible implementation, that the second resonant circuit is connected for the second frequency, and the second resonant circuit is disconnected for the first frequency is implemented via the following circuit structure: the second resonant circuit is connected in series to the second antenna element, and the second resonant circuit is a parallel resonance structure whose resonance frequency is the first frequency.

[0008] With reference to any one of the first aspect, or the first and the second possible implementations of the first aspect, in a third possible implementation, that the first resonant circuit is connected for the first frequency, and the first resonant circuit is disconnected for the second frequency is implemented via the following circuit structure: the first resonant circuit is connected in series to the first antenna element, and the first resonant circuit is a series resonance structure whose resonance frequency is the first frequency.

[0009] With reference to any one of the first aspect, or the first to the third possible implementations of the first aspect, in a fourth possible implementation, that the second resonant circuit is connected for the second frequency, and the second resonant circuit is disconnected for the first frequency is implemented via the following circuit structure: the second resonant circuit is connected in series to the second antenna element, and the second resonant circuit is a series resonance structure whose resonance frequency is the second frequency.

[0010] With reference to any one of the first aspect, or the first to the fourth possible implementations of the first aspect, in a fifth possible implementation, that the first resonant circuit is connected for the first frequency, and the first resonant circuit is disconnected for the second frequency is implemented via the following circuit structure: the first resonant circuit is connected in parallel to the first antenna element, and the first resonant circuit is a series resonance structure whose resonance frequency is the second frequency.

[0011] With reference to any one of the first aspect, or the first to the fifth possible implementations of the first aspect, in a sixth possible implementation, that the second resonant circuit is connected for the second frequency, and the second resonant circuit is disconnected for the first frequency is implemented via the following circuit structure: the second resonant circuit is connected in parallel to the second antenna element, and the second resonant circuit is a series resonance structure whose resonance frequency is the first frequency.

[0012] With reference to any one of the first aspect, or the first to the sixth possible implementations of the first aspect, in a seventh possible implementation, that the first resonant circuit is connected for the first frequency, and the first resonant circuit is disconnected for the second frequency is implemented via the following circuit structure: the first resonant circuit is connected in parallel to the first antenna element, and the first resonant circuit is a parallel resonance structure whose resonance frequency is the first frequency.

[0013] With reference to any one of the first aspect, or the first to the seventh possible implementations of the first aspect, in an eighth possible implementation, the first resonant circuit is a lumped resonant circuit, or the first resonant circuit is a distributed resonant circuit.

[0014] With reference to any one of the first aspect, or the first to the eighth possible implementations of the first aspect, in a ninth possible implementation, the second resonant circuit is a lumped resonant circuit, or the second resonant circuit is a distributed resonant circuit.

[0015] With reference to any one of the first aspect, or the first to the ninth possible implementations of the first aspect, in a tenth possible implementation, the lumped resonant circuit includes an inductor and a capacitor.

[0016] With reference to any one of the first aspect, or the first to the tenth possible implementations of the first aspect, in an eleventh possible implementation, the distributed resonant circuit is a printed circuit structure, and the distributed resonant circuit includes an equivalent inductor and an equivalent capacitor.

[0017] With reference to any one of the first aspect, or the first to the twelfth possible implementations of the first aspect, in a thirteenth possible implementation, the distributed resonant circuit structure includes one of a slot element, a circular ring element, and a helix element.

[0018] With reference to any one of the first aspect, or the first to the thirteenth possible implementations of the first aspect, in a fourteenth possible implementation, the first antenna element is at least one of a dipole antenna, a patch antenna, a monopole antenna, and a horn antenna, or the second antenna element is at least one of a dipole antenna, a patch antenna, a monopole antenna, and a horn antenna.

[0019] With reference to any one of the first aspect, or the first to the fourteenth possible implementations of the first aspect, in a fifteenth possible implementation, when there are at least two first antenna elements, the antenna further includes a first transmission line, where the first transmission line is configured to connect the at least two first antenna elements.

[0020] With reference to any one of the first aspect, or the first to the fifteenth possible implementations of the first aspect, in a sixteenth possible implementation, when there are at least two second antenna elements, the antenna further includes a second transmission line, where the second transmission line is configured to connect the at least two second antenna elements.

[0021] With reference to any one of the first aspect, or the first to the sixteenth possible implementations of the first aspect, in a seventeenth possible implementation, a length of the first transmission line is one dielectric wavelength of the first frequency, and a length of the second transmission line is one dielectric wavelength of the second frequency.

[0022] With reference to any one of the first aspect, or the first to the seventeenth possible implementations of the first aspect, in an eighteenth possible implementation, the first transmission line is a coaxial line or a coplanar waveguide CPW transmission line, and the second transmission line is a coaxial line or a CPW transmission line.

[0023] With reference to any one of the first aspect or the first to the eighteenth possible implementations of the first aspect, in a nineteenth possible implementation, that the at least one first antenna element and the at least one second antenna element are arranged on the dielectric substrate includes: the at least one first antenna element is arranged on one surface of the dielectric substrate, and the at least one second antenna element is arranged on the other surface of the dielectric substrate; the at least one first antenna element and the at least one second antenna element are both arranged on a same surface of the dielectric substrate; or the at least one first antenna element and at least one second antenna element are arranged on a same surface of the dielectric substrate.

[0024] According to the technical solutions provided in embodiments of this application, the first resonant circuit is disposed on the port of the first antenna element of the antenna, and the second resonant circuit is disposed on the port of the second antenna element; the first resonant circuit is connected for the first frequency, and the first resonant circuit is disconnected for the second frequency; and the second resonant circuit is connected for the second frequency, and the second resonant circuit is disconnected for the first frequency, so that a communication rate is improved.

BRIEF DESCRIPTION OF DRAWINGS

[0025] To describe the technical solutions in embodiments of this application more clearly, the following briefly describes the accompanying drawings used in embodiments.

FIG. 1 is a schematic diagram of a structure of an antenna 100 according to an embodiment of this application;

FIG. 2 is a schematic diagram of a structure of an antenna according to an embodiment of this application;

FIG. 3 is a schematic diagram of a structure of an antenna 300 according to an embodiment of this application;

FIG. 4 is a schematic diagram of a test result according to an embodiment of this application;

FIG. 5 is a schematic diagram of a structure of an antenna 500 according to an embodiment of this application; and

FIG. 6 is a schematic diagram of an emulation result according to an embodiment of this application.

DESCRIPTION OF EMBODIMENTS

[0026] FIG. 1 is a schematic diagram of a structure of an antenna 100 according to an embodiment of this application. The antenna 100 includes a dielectric substrate 101, at least one first antenna element 102 that is resonant at a first frequency, at least one second antenna element 103 that is resonant at a second frequency, a first resonant circuit 104, and a second resonant circuit 105. The at least one first antenna element 102 and the at least one second antenna element 103 are arranged on the dielectric substrate 101. The first resonant circuit 104 is located on a port of the first antenna element 102, and the second resonant circuit 105 is located on a port of the second antenna element 103. The first resonant circuit 104 is connected for the first frequency, and the first resonant circuit 104 is disconnected for the second frequency. The second resonant circuit 105 is connected for the second frequency, and the second resonant circuit 105 is disconnected for the first frequency. That the at least one first antenna element 102 and the at least one second antenna element 103 are arranged on the dielectric substrate 101 includes: all first antenna elements 102 are arranged on one surface of the dielectric substrate 101, and all second antenna elements 103 are arranged on the other surface of the dielectric substrate 101; all first antenna elements 102 and all second antenna elements 103 are arranged on a same surface of the dielectric substrate 101; all first antenna elements 102 and at least one second antenna element 103 are arranged on a same surface of the dielectric substrate 101; or all second antenna elements 103 and at least one first antenna element 102 are arranged on a same surface of the dielectric substrate 101. In a general case, a dielectric substrate is planar. In some cases, there may be alternatively a dielectric substrate of a flexible material, and the dielectric substrate can be bent. In this case, an antenna element may be located on an outer surface of the dielectric substrate. The first antenna element 102 may be at least one of a dipole antenna, a patch antenna, a monopole antenna, and a horn antenna, and the second antenna element 103 may also be at least one of a dipole antenna, a patch antenna, a monopole antenna, and a horn antenna.

[0027] When there are at least two first antenna elements 102, the antenna 100 further includes a first transmission line 106. The first transmission line 106 is configured to connect the at least two first antenna elements 102. When there are at least two second antenna elements 103, the antenna 100 further includes a second transmission line 107. The second transmission line is configured to connect the at least two second antenna elements 103. A length of the first transmission line 106 is one dielectric wavelength of the first frequency. A length of the second transmission line 107 is one dielectric wavelength of the second frequency. The first transmission line 106 may be a coaxial line or a coplanar waveguide (Coplanar waveguide, CPW) transmission line, and the second transmission line 107 may also be a coaxial line or a CPW transmission line.

[0028] Specifically, that the first resonant circuit 104 is connected for the first frequency and is disconnected for the second frequency may be implemented in the following manner 1 to manner 4.

[0029] Manner 1: The first resonant circuit 104 uses a parallel resonance structure, a resonance frequency is the second frequency, and the first resonant circuit 104 is connected in series to the first antenna element.

[0030] Manner 2: The first resonant circuit 104 uses a series resonance structure, a resonance frequency is the first frequency, and the first resonant circuit 104 is connected in series to the first antenna element.

[0031] Manner 3: The first resonant circuit 104 uses a series resonance structure, a resonance frequency is the second frequency, and the first resonant circuit 104 is connected in parallel to the first antenna element.

[0032] Manner 4: The first resonant circuit 104 uses a parallel resonance structure, a resonance frequency is the first frequency, and the first resonant circuit 104 is connected in parallel to the first antenna element.

[0033] That the second resonant circuit 105 is connected for the second frequency and is disconnected for the first frequency may be implemented in the following manner 5 to manner 8.

[0034] Manner 5: The second resonant circuit 105 uses a parallel resonance structure, a resonance frequency is the first frequency, and the second resonant circuit 105 is connected in series to the second antenna element.

[0035] Manner 6: The second resonant circuit 105 uses a series resonance structure, a resonance frequency is the second frequency, and the second resonant circuit 105 is connected in series to the second antenna element.

[0036] Manner 7: The second resonant circuit 105 uses a series resonance structure, a resonance frequency is the first frequency, and the second resonant circuit 105 is connected in parallel to the second antenna element.

[0037] Manner 8: The second resonant circuit 105 uses a parallel resonance structure, a resonance frequency is the second frequency, and the second resonant circuit 105 is connected in parallel to the second antenna element.

[0038] A principle in which a resonant circuit implements connection or disconnection for a frequency by using a series resonance structure or a parallel resonance structure is as follows: When the series resonance structure is connected in series to a transmission line, it is equivalent to connection for energy; and when the series resonance structure is connected in parallel to a transmission line, it is equivalent to disconnection for energy. When the parallel resonance structure is connected in series to a transmission line, it is equivalent to disconnection for energy; and when the parallel resonance structure is connected in parallel to a transmission line, it is equivalent to connection for energy.

[0039] The first resonant circuit in the manner 1 to the manner 4 is a lumped resonant circuit or a distributed resonant circuit.

[0040] The second resonant circuit in the manner 5 to the manner 8 is a lumped resonant circuit or a distributed resonant circuit.

[0041] The lumped resonant circuit includes an inductor and a capacitor. The distributed resonant circuit is a printed circuit structure, and the distributed resonant circuit includes an equivalent inductor and an equivalent capacitor.

[0042] The first resonant circuit 104 is designed to be connected for the first frequency and disconnected for the second frequency, and the second resonant circuit 105 is designed to be connected for the second frequency and be disconnected for the first frequency, so that isolation between ports can be improved. Further, when the resonant circuits are located on the ports of the antenna elements, it is not necessary to consider a difference that is in a spatial energy coupling path and that causes a decrease in isolation.

[0043] FIG. 1 shows antenna elements at only two types of resonance frequencies. In an actual application, the solution of the embodiment in FIG. 1 is alternatively applicable to antenna elements at three or more types of resonance frequencies. Specifically, the antenna includes m1 ($m1 \geq 1$) antenna elements that are resonant at a frequency f1, m2 ($m2 \geq 1$) antenna elements that are resonant at a frequency f2, ..., and mn ($mn \geq 1$, and $n \geq 3$) antenna elements that are resonant at a frequency fn, where the antenna elements are arranged on the dielectric substrate; and includes resonant circuits that are respectively located on ports of the antenna elements at the resonance frequencies f1, f2, ..., and fn. As shown in FIG. 2, when a quantity of antenna elements at each type of resonance frequency is greater than or equal to 2, the antenna further includes transmission lines connecting the antenna elements at the resonance frequencies f1, f2, ..., and fn. For implementations of the resonant circuits, refer to the descriptions in FIG. 1. Details are not described herein again.

[0044] FIG. 3 is a schematic diagram of a structure of an antenna 300 according to an embodiment of this application. The antenna 300 is a dual-band dual-feed antenna operating at 2G and 5G frequency bands. A dielectric substrate 201 has a length of 152 mm, a width of 13 mm, and a thickness of 0.8 mm. An antenna element that is resonant at the 2G frequency band is located on one surface of the dielectric substrate 201, and an antenna element that is resonant at the 5G frequency band is located on the other surface of the dielectric substrate 201. The antenna elements that are resonant at the 2G frequency band and the 5G frequency band are dipole structures. Two antenna elements are resonant at the 2G frequency band, and three antenna elements are resonant at the 5G frequency band. There is a specific spacing between antenna elements at a same resonance frequency. An antenna element a and an antenna element b that are resonant at the 5G frequency band are connected through a CPW transmission line, and the antenna element b and an antenna element c are connected through a coaxial line. An antenna element a and an antenna element b that are resonant at the 2G frequency band are connected through a coaxial line.

[0045] In this embodiment, a resonant circuit includes a lumped inductor L and a lumped capacitor C. A resonant circuit that is resonant at the 5G frequency band has the following L and C values: L=1.2 nH, and C=0.5 pF; and a resonant circuit that is resonant at the 2G frequency band has the following L and C values: L=2.2 nH, and C=2.4 pF. A first LC circuit structure that is resonant at the 5G frequency band is connected in series to a port of the 2G antenna element a, and the first LC circuit structure is a parallel LC structure, to improve isolation in the 5G frequency band. A second LC circuit structure that is resonant at the 2G frequency band is connected in series to a port of the 5G antenna element a, and the second LC circuit structure is a parallel LC structure, to improve isolation in the 2G frequency band. A test result is shown in FIG. 4: Compared with an antenna in which no resonant circuit is loaded onto a port, after the resonant circuits are loaded, the isolation in the 2G frequency band is improved by at least 7 dB, and the isolation in the 5G frequency band is improved by at least 10 dB.

[0046] FIG. 5 is a schematic diagram of a structure of an antenna 500 according to an embodiment of this application. Different from that in the embodiment in FIG. 3, a resonant circuit in the embodiment in FIG. 5 is implemented by printing a distributed resonant circuit structure. Specifically, a first distributed resonant circuit is connected in series to a port of a 2G antenna element a, and the first distributed resonant circuit includes two slot elements whose resonance frequencies are in a 5G frequency band, to improve isolation in the 5G frequency band. In this embodiment, a slot structure may be equivalent to a parallel LC resonant circuit structure. For each slot element of the first distributed resonant circuit, an outer slot length is 6.2 mm, an inner slot length is 1.6 mm, a slot width is 1.6 mm, a lateral spacing between slots is 0.2 mm, and a spacing between two slots is 0.3 mm. A second distributed resonant circuit is connected in series to a port of a 5G antenna element a, and the second distributed resonant circuit includes one slot element whose resonance frequency is in a 2G frequency band, to improve isolation in the 2G frequency band. For the slot element of the second distributed resonant circuit, an outer slot length is 14.5 mm, an inner slot length is 5.3 mm, a slot width is 1.4 mm, and a lateral spacing between slots is 0.2 mm. An emulation result is shown in FIG. 6: Compared with an antenna in which no resonant circuit is loaded onto a port, after the resonant circuits are loaded, the isolation in the 2G frequency band is improved by at least 4 dB, and the isolation in the 5G frequency band is improved by at least 8 dB.

[0047] The solutions described in embodiments of this application are applicable to a scenario of improving inter-frequency isolation of an antenna, and are applicable to a product that includes but is not limited to a base station, a mobile phone, a vehicle-mounted product, a WIFI product, a microwave product, or the like.

[0048] The foregoing descriptions are merely specific implementations of this application, but are not intended to limit the protection scope of this application. Any variation or replacement readily figured out by a person skilled in the art within the technical scope disclosed in this application shall fall within the protection scope of this application. Therefore, the protection scope of this application shall be subject to the protection scope of the claims.

Claims

1. An antenna, comprising a dielectric substrate, at least one first antenna element that is resonant at a first frequency, at least one second antenna element that is resonant at a second frequency, a first resonant circuit, and a second resonant circuit, wherein

    the at least one first antenna element and the at least one second antenna element are arranged on the dielectric substrate; and
    the first resonant circuit is located on a port of the first antenna element, and the second resonant circuit is located on a port of the second antenna element; the first resonant circuit is connected for the first frequency, and the first resonant circuit is disconnected for the second frequency; and the second resonant circuit is connected for the second frequency, and the second resonant circuit is disconnected for the first frequency.

2. The antenna according to claim 1, wherein that the first resonant circuit is connected for the first frequency, and the first resonant circuit is disconnected for the second frequency is implemented via the following circuit structure:
the first resonant circuit is connected in series to the first antenna element, and the first resonant circuit is a parallel resonance structure whose resonance frequency is the second frequency.

3. The antenna according to claim 1 or 2, wherein that the second resonant circuit is connected for the second frequency, and the second resonant circuit is disconnected for the first frequency is implemented via the following circuit structure:
the second resonant circuit is connected in series to the second antenna element, and the second resonant circuit is a parallel resonance structure whose resonance frequency is the first frequency.

4. The antenna according to claim 1, wherein that the first resonant circuit is connected for the first frequency, and the first resonant circuit is disconnected for the second frequency is implemented via the following circuit structure:
the first resonant circuit is connected in series to the first antenna element, and the first resonant circuit is a series resonance structure whose resonance frequency is the first frequency.

5. The antenna according to claim 1 or 4, wherein that the second resonant circuit is connected for the second frequency, and the second resonant circuit is disconnected for the first frequency is implemented via the following circuit structure:
the second resonant circuit is connected in series to the second antenna element, and the second resonant circuit is a series resonance structure whose resonance frequency is the second frequency.

6. The antenna according to claim 1, wherein that the first resonant circuit is connected for the first frequency, and the first resonant circuit is disconnected for the second frequency is implemented via the following circuit structure:
the first resonant circuit is connected in parallel to the first antenna element, and the first resonant circuit is a series resonance structure whose resonance frequency is the second frequency.

7. The antenna according to claim 1, wherein that the second resonant circuit is connected for the second frequency, and the second resonant circuit is disconnected for the first frequency is implemented via the following circuit structure:
the second resonant circuit is connected in parallel to the second antenna element, and the second resonant circuit is a series resonance structure whose resonance frequency is the first frequency.

8. The antenna according to claim 1, wherein that the first resonant circuit is connected for the first frequency, and the first resonant circuit is disconnected for the second frequency is implemented via the following circuit structure:
the first resonant circuit is connected in parallel to the first antenna element, and the first resonant circuit is a parallel resonance structure whose resonance frequency is the first frequency.

9. The antenna according to claim 1, wherein that the second resonant circuit is connected for the second frequency, and the second resonant circuit is disconnected for the first frequency is implemented via the following circuit structure:
the second resonant circuit is connected in parallel to the second antenna element, and the second resonant circuit is a parallel resonance structure whose

resonance frequency is the second frequency.

10. The antenna according to any one of claims 2, 4, 6, and 8, wherein the first resonant circuit is a lumped resonant circuit, or the first resonant circuit is a distributed resonant circuit.

11. The antenna according to any one of claims 3, 5, 7, and 9, wherein the second resonant circuit is a lumped resonant circuit, or the second resonant circuit is a distributed resonant circuit.

12. The antenna according to claim 10 or 11, wherein the lumped resonant circuit comprises an inductor and a capacitor.

13. The antenna according to claim 10 or 11, wherein the distributed resonant circuit is a printed circuit structure, and the distributed resonant circuit comprises an equivalent inductor and an equivalent capacitor.

14. The antenna according to claim 6 or 7, wherein the distributed resonant circuit comprises a slot element, a circular ring element, and a helix element.

15. The antenna according to any one of claims 1 to 14, wherein the first antenna element is at least one of a dipole antenna, a patch antenna, a monopole antenna, or a horn antenna, or the second antenna element is at least one of a dipole antenna, a patch antenna, a monopole antenna, or a horn antenna.

16. The antenna according to any one of claims 1 to 15, wherein when there are at least two first antenna elements, the antenna further comprises a first transmission line, wherein the first transmission line is configured to connect the at least two first antenna elements.

17. The antenna according to any one of claims 1 to 16, wherein when there are at least two second antenna elements, the antenna further comprises a second transmission line, wherein the second transmission line is configured to connect the at least two second antenna elements.

18. The antenna according to claim 16 or 17, wherein a length of the first transmission line is one dielectric wavelength of the first frequency, and a length of the second transmission line is one dielectric wavelength of the second frequency.

19. The antenna according to any one of claims 16 to 18, wherein the first transmission line is a coaxial line or a coplanar waveguide CPW transmission line, and the second transmission line is a coaxial line or a CPW transmission line.

20. The antenna according to any one of claims 1 to 19, wherein that the at least one first antenna element and the at least one second antenna element are arranged on the dielectric substrate comprises:

the at least one first antenna element is arranged on one surface of the dielectric substrate, and the at least one second antenna element is arranged on the other surface of the dielectric substrate;
the at least one first antenna element and the at least one second antenna element are both arranged on a same surface of the dielectric substrate; or
the at least one first antenna element and at least one second antenna element are arranged on a same surface of the dielectric substrate.

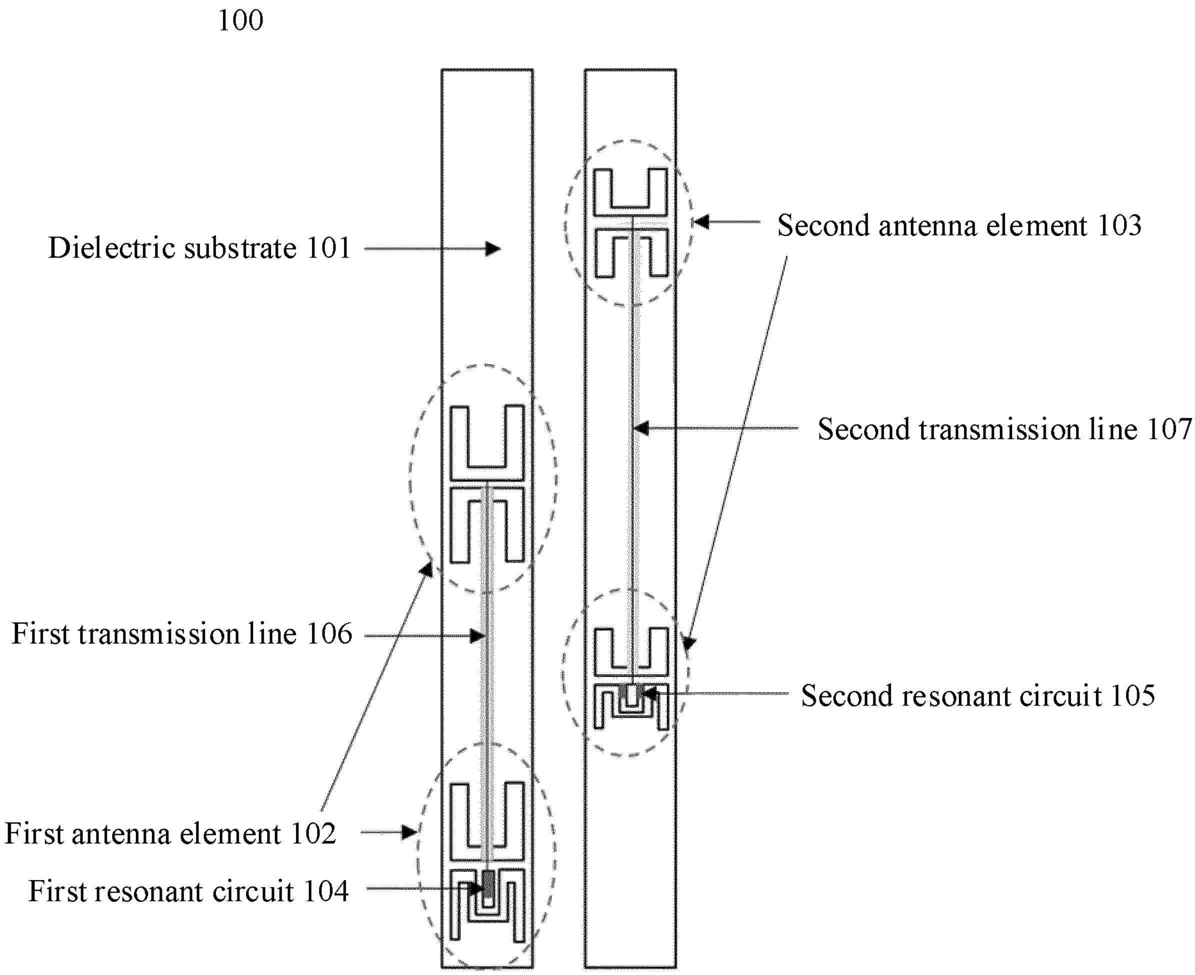
100
Dielectric substrate 101
Second antenna element 103
Second transmission line 107
First transmission line 106
Second resonant circuit 105
First antenna element 102
First resonant circuit 104

FIG. 1

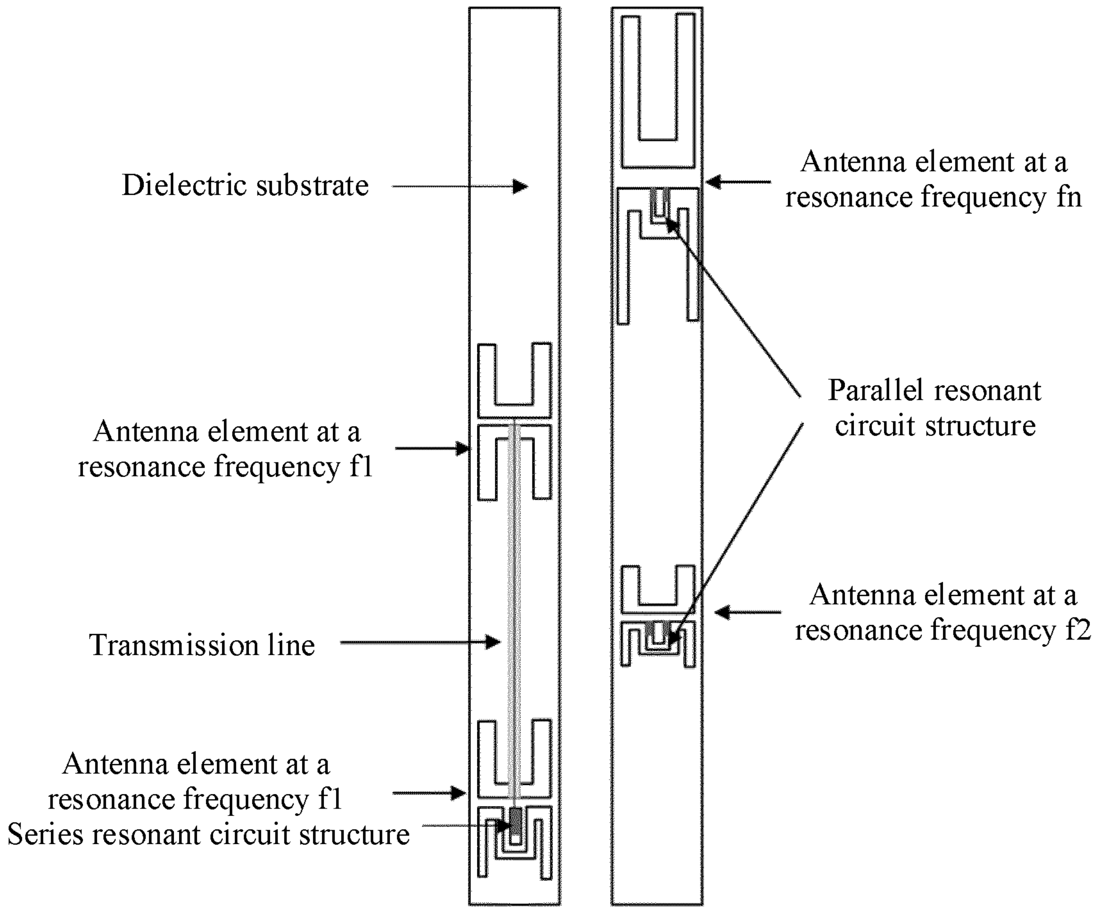
Dielectric substrate
Antenna element at a resonance frequency fn
Parallel resonant circuit structure
Antenna element at a resonance frequency f1
Transmission line
Antenna element at a resonance frequency f2
Antenna element at a resonance frequency f1
Series resonant circuit structure

FIG. 2

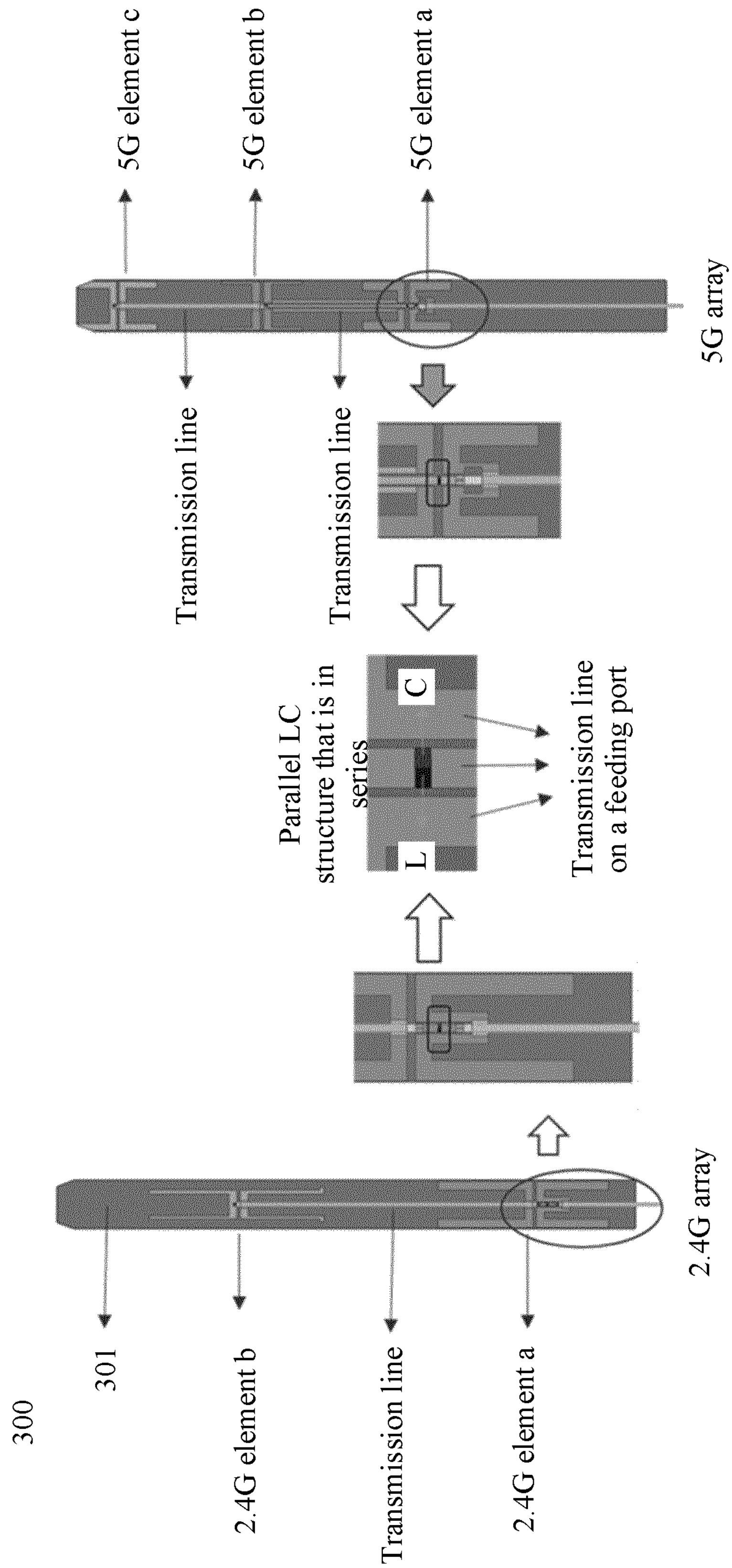
300
301
2.4G element b
Transmission line
2.4G element a
2.4G array
Parallel LC structure that is in series
L
C
Transmission line on a feeding port
Transmission line
Transmission line
5G element c
5G element b
5G element a
5G array

FIG. 3

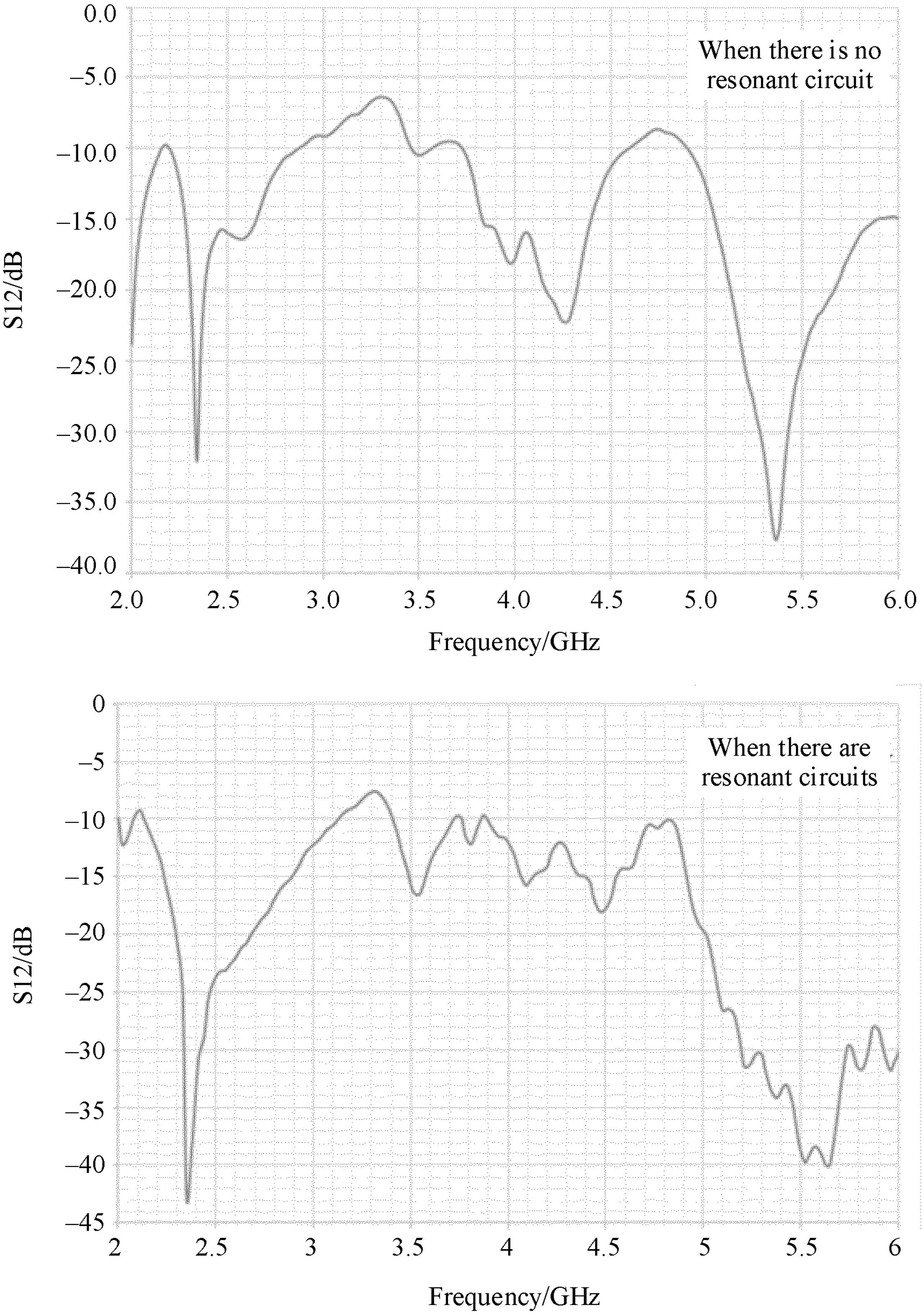
When there is no resonant circuit
S12/dB
0.0
−5.0
−10.0
−15.0
−20.0
−25.0
−30.0
−35.0
−40.0
2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0
Frequency/GHz
When there are resonant circuits
S12/dB
0
−5
−10
−15
−20
−25
−30
−35
−40
−45
2 2.5 3 3.5 4 4.5 5 5.5 6
Frequency/GHz

FIG. 4

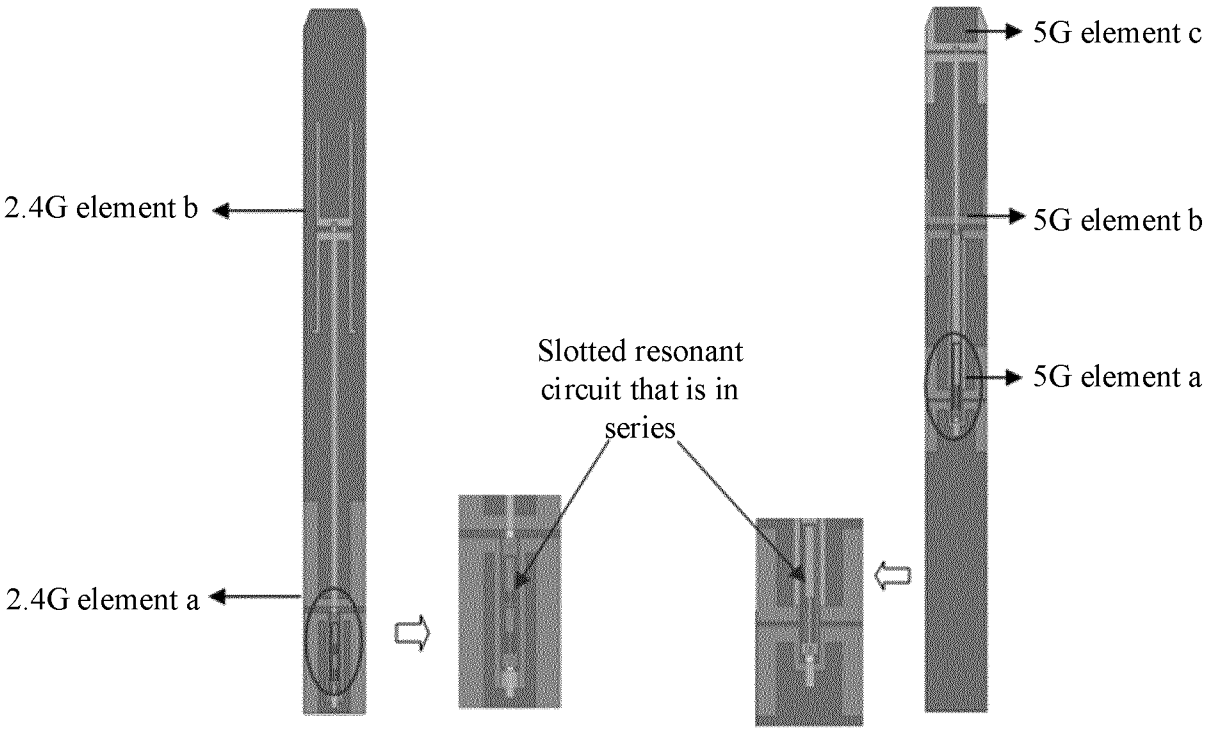
2.4G element b
2.4G element a
Slotted resonant circuit that is in series
5G element c
5G element b
5G element a

FIG. 5

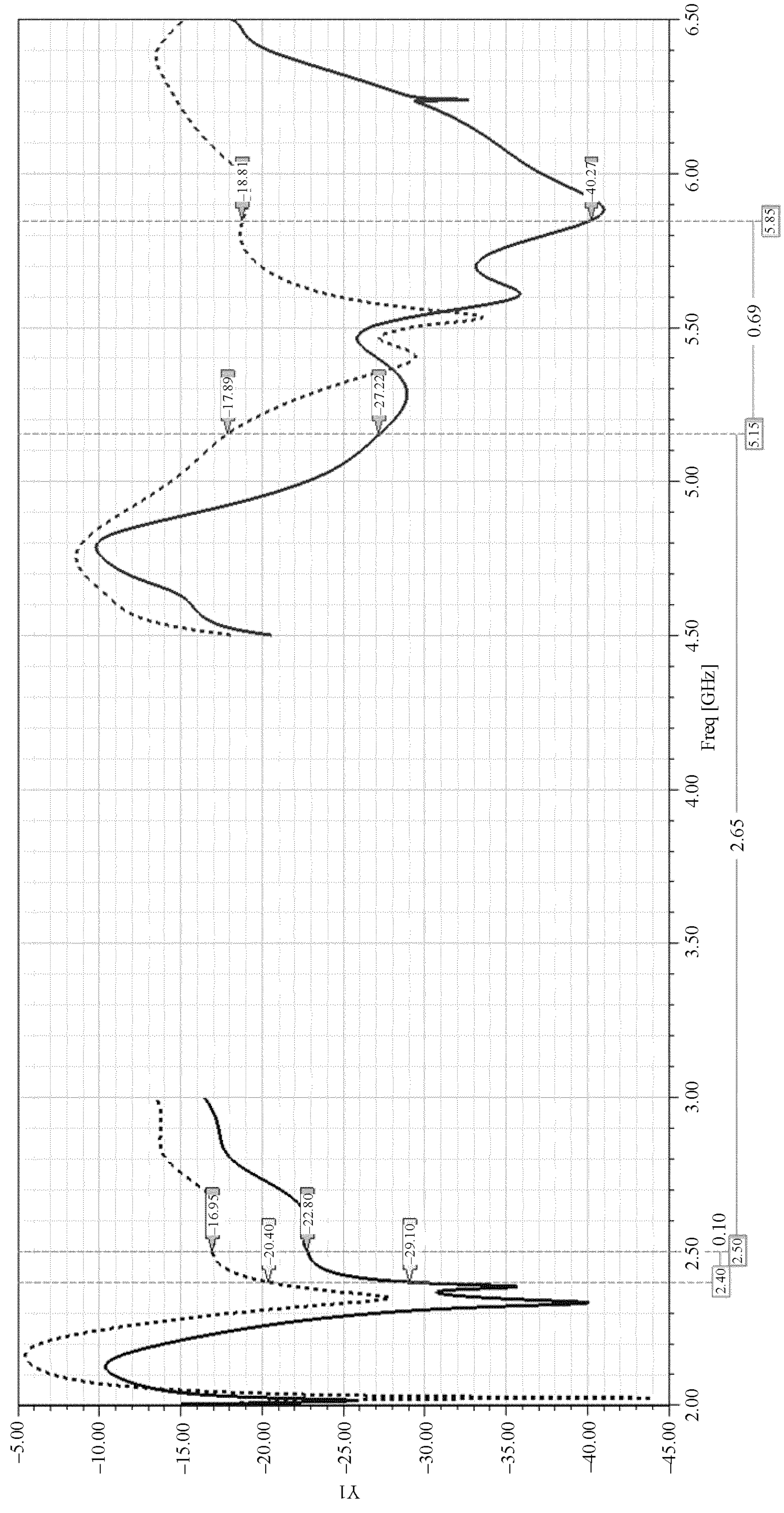
Freq [GHz]
Y1
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
−5.00
−10.00
−15.00
−20.00
−25.00
−30.00
−35.00
−40.00
−45.00
−16.95
−20.40
−22.80
−29.10
−17.89
−27.22
−18.81
−40.27
2.40
2.50
0.10
2.65
5.15
0.69
5.85

FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2021/124252

A. CLASSIFICATION OF SUBJECT MATTER

H01Q 1/52(2006.01)i；H01Q 1/50(2006.01)i；H01Q 21/30(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

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)

CNKI, CNPAT, EPODOC, WPI: 第一, 第二, 天线, 辐射, 滤波, 谐振, 匹配, 电路, 去耦, 解耦, 隔离, 干扰, 并联, 串联, 电容, 电感, first, second, antenna, radiat+, filter, resona+, match, circuit, decoupl+, isolat+, interfer+, series, shunt, capacit+, induct+

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
PX	CN 112086753 A (GUANGDONG OPPO MOBILE TELECOMMUNICATIONS CORP., LTD.) 15 December 2020 (2020-12-15) description, paragraphs [0031]-[0100], and figures 1-20	1-20
PX	CN 112072291 A (BEIJING BYTEDANCE NETWORK TECHNOLOGY CO., LTD.) 11 December 2020 (2020-12-11) description, paragraphs [0032]-[0083], and figures 1-8	1-20
X	CN 207800915 U (AAC PRECISION MANUFACTURING TECHNOLOGY (CHANGZHOU) CO., LTD.) 31 August 2018 (2018-08-31) description, paragraphs [0026]-[0051], and figures 1-9	1-20
X	CN 109193129 A (BEIJING XIAOMI MOBILE SOFTWARE CO., LTD.) 11 January 2019 (2019-01-11) description, paragraphs [0031]-[0065], and figures 1-9	1-20
X	CN 108199141 A (AAC PRECISION MANUFACTURING TECHNOLOGY (CHANGZHOU) CO., LTD.) 22 June 2018 (2018-06-22) description, paragraphs [0034]-[0055], and figures 1-5	1-20
A	CN 111628298 A (HUAWEI TECHNOLOGIES CO., LTD.) 04 September 2020 (2020-09-04) entire document	1-20

☑ 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)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "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
06 January 2022	**19 January 2022**

Name and mailing address of the ISA/CN	Authorized officer
China National Intellectual Property Administration (ISA/CN) **No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088, China**	
Facsimile No. **(86-10)62019451**	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2021/124252

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2016365623 A1 (SAMSUNG ELECTRONICS CO., LTD.) 15 December 2016 (2016-12-15) entire document	1-20

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

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2021/124252

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
CN 112086753 A	15 December 2020	CN 212277399 U	01 January 2021
CN 112072291 A	11 December 2020	None	
CN 207800915 U	31 August 2018	None	
CN 109193129 A	11 January 2019	JP 2020534710 A	26 November 2020
		KR 20200027461 A	12 March 2020
		KR 20210049978 A	06 May 2021
		WO 2020042361 A1	05 March 2020
		EP 3618181 A1	04 March 2020
		US 2020076080 A1	05 March 2020
CN 108199141 A	22 June 2018	None	
CN 111628298 A	04 September 2020	WO 2020173294 A1	03 September 2020
US 2016365623 A1	15 December 2016	EP 3104456 A1	14 December 2016
		CN 106252829 A	21 December 2016
		KR 20160146138 A	21 December 2016

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

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- CN 202011423434 **[0001]**