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(54) **ANTENNA, ANTENNA MODULE, AND ELECTRONIC DEVICE**

(57) This application provides an antenna, an antenna module, and an electronic device. The antenna includes a tapered slot antenna, a folded dipole, and a feeding structure. The tapered slot antenna includes a first metal structure and a second metal structure that form a tapered slot, and two ends of the tapered slot are a narrow-gap end and a wide-gap end. An extension direction of the folded dipole intersects with an extension direction of the tapered slot. The folded dipole includes a main dipole and a parasitic dipole that are disposed opposite to each other. The main dipole is located between the parasitic dipole and the narrow-gap end. The main dipole includes a first stub electrically connected to the first metal structure and a second stub connected to the second metal structure. An area between the main dipole and the parasitic dipole forms a resonant tank of the tapered slot antenna. The feeding structure is electrically connected between the first stub and the second stub, and feeds the folded dipole and the tapered slot antenna at the same time, to excite the tapered slot antenna that is a directional antenna and excite the folded dipole that is an omnidirectional antenna. This application has an advantage of dual-antenna miniaturization.

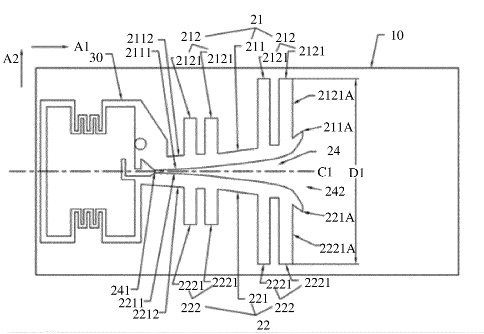

FIG. 6

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Description

[0001] This application claims priority to Chinese Patent Application No. 202011193934.3, filed with China National Intellectual Property Administration on October 30, 2020 and entitled "ANTENNA, ANTENNA MODULE, AND ELECTRONIC DEVICE", which is incorporated herein by reference in its entirety.

TECHNICAL FIELD

[0002] This application relates to the field of antenna technologies, and in particular, to an antenna, an antenna module, and an electronic device.

BACKGROUND

[0003] With evolution of Wi-Fi protocols, a quantity of spatial streams keeps increasing. Currently, a maximum of 16 spatial streams are supported. This means that a built-in product at most requires 16 groups of high-performance antennas, and requires that the antennas have little impact on each other to meet a radiation performance requirement of the product. Due to factors such as appearance, competitiveness, and use habits in home scenarios, a size and an ID of an existing ONT (Optical network terminal, optical network terminal) built-in product become increasingly small. This means that design space of a MIMO antenna is actually increasingly limited when product functions and performance are improved.

[0004] How to design a directional antenna and an omnidirectional antenna to be integrated to implement miniaturization is a research and development direction in the industry.

SUMMARY

[0005] Embodiments of this application provide an antenna and an electronic device. A tapered slot antenna and a folded dipole are integrated into the antenna to share one feed, and the folded dipole forms a resonant tank of the tapered slot antenna, to miniaturize the antenna.

[0006] According to a first aspect, an antenna provided in an implementation of this application includes a tapered slot antenna, a folded dipole, and a feeding structure.

[0007] The tapered slot antenna includes a first metal structure and a second metal structure, a tapered slot is formed between the first metal structure and the second metal structure, an extension direction of the tapered slot is a first direction, and two ends of the tapered slot are a narrow-gap end and a wide-gap end.

[0008] An extension direction of the folded dipole is a second direction, the second direction intersects with the first direction, the folded dipole includes a main dipole and a parasitic dipole that are disposed opposite to each other, an area between the main dipole and the parasitic dipole forms internal space of the folded dipole, the main dipole is located between the parasitic dipole and the narrow-gap end, the main dipole includes a first stub and a second stub that are alternately arranged in the second direction, the first stub is electrically connected to the first metal structure, and the second stub is electrically connected to the second metal structure, to enable the internal space of the folded dipole to form a resonant tank of the tapered slot antenna. That an extension direction of the folded dipole is a second direction may be understood as that an extension direction of a main radiation part of the folded dipole is the second direction. If the main dipole and the parasitic dipole in the folded dipole each are in a straight strip shape, an extension direction of the main dipole and an extension direction of the parasitic dipole are the second direction, and the two extension directions may be considered as parallel or nearly parallel. The main dipole and the parasitic dipole in the folded dipole may alternatively be configured to be wound at two ends, and a snake-shaped line is disposed between the main dipole and the parasitic dipole. A size may be reduced, and although a winding part is not in the second direction, and an extension direction of the folded dipole as a whole may be considered as the second direction.

[0009] The feeding structure is electrically connected between the first stub and the second stub, and feeds the folded dipole and the tapered slot antenna at the same time, to excite the tapered slot antenna that is a directional antenna and excite the folded dipole that is an omnidirectional antenna.

[0010] In this application, the folded dipole and the tapered slot antenna are integrated together to share one feed, and perform a dual-antenna function, so that the antenna can be miniaturized. In addition, radiation performance of the folded dipole and the tapered slot antenna can be separately implemented, and the two antennas further have a complementary function. For example, the folded dipole is used as a resonant tank of the tapered slot antenna, helping to tune the tapered slot antenna.

[0011] In a possible implementation, an operating frequency of the tapered slot antenna is lower than an operating frequency of the folded dipole. A range of the operating frequency of the folded dipole is 6 GHz to 7.125 GHz, and a range of the operating frequency of the tapered slot antenna is 5.1 GHz to 5.9 GHz. The tapered slot antenna and the folded dipole in the antenna provided in this implementation have different operating frequency ranges, and radiate different signals. This improves an application scope of the antenna and highlights an advantage of a miniaturized antenna.

[0012] The tapered slot may have an axisymmetric structure. To be specific, the tapered slot is symmetrically distributed by using a central axis as a center. The first metal structure and the second metal structure may also be symmetrically distributed on two sides of the central axis, and an extension direction of the symmetry axis may be understood as the first direction. Certainly, the tapered slot may alternatively have an asymmetric structure. In general, an extension direction from a central position of the narrow-gap end of the tapered slot to a central position of the wide-gap end of the tapered slot is the first direction. The first direction and the second direction may be orthogonal. Alternatively, an included angle between the first direction and the second direction may be an angle less than 90 degrees. In general, the antenna provided in this application is symmetrically distributed, and a center of symmetry of the antenna may be the central axis of the tapered slot. The antenna in such a symmetric architecture can match better bandwidth.

[0013] In a possible implementation, that, in the first direction, a gap between the first stub and the second stub is directly facing the narrow-gap end of the tapered slot may be understood as that an extension direction of a connection line between a middle position of the gap and a middle position of the narrow-gap end is the first direction. For the gap and the narrow-gap end, a size of the gap and a size of the narrow-gap end in the second direction are widths, and the width of the gap may be greater than the width of the narrow-gap end.

[0014] In a possible implementation, a connection line between an inner wall of the gap and an inner wall of the narrow-gap end is in a smooth transition state, and may be open and extended in a horn shape. In this way, a size changes gradually from the narrow-gap end to the gap, and then to the internal space of the folded dipole. Such a design helps the folded dipole serve as the resonant tank to feed and tune the tapered slot antenna.

[0015] The first stub and the first metal structure jointly form a first spacing area having a first opening, and the first opening is located at an end that is of the first spacing area and that is away from the tapered slot. The second stub and the second metal structure jointly form a second spacing area having a second opening, and the second opening is located at an end that is of the second spacing area and that is away from the tapered slot. A size of the first spacing area is smaller than a size of the second spacing area, because a size in which the first stub extends in the first direction is greater than a size in which the second stub extends in the first direction. That is, an area of the first stub part is wide. The wide area is reserved for configuring the feeding structure.

[0016] In a possible implementation, the first stub includes a first connection part, the first connection part is connected to the first metal structure, the second stub includes a second connection part, the second connection part is connected to the second metal structure, and in the first direction, a size in which the first connection part extends is greater than a size in which the second connection part extends. In this application, the feeding structure may be installed on the first connection part by using a size design of the first connection part.

[0017] In a possible implementation, the first connection part is provided with a through hole, the feeding structure includes an inner conductor and an external conductor, the feeding structure passes through the through hole, the external conductor is electrically connected to the first connection part, and the inner conductor is electrically connected to the second stub. The feeding structure is a feeding cable, and a feeding manner provided in this application is simple and easy to implement. In this application, feeding by using a microstrip is not required. The microstrip affects a radiation size of the folded dipole and a radiation size of the tapered slot antenna, and occupies carrier board area. Feeding by using a manner in which the feeding cable is connected to the first connection part does not affect radiation performance of the folded dipole and the tapered slot antenna.

[0018] In a possible implementation, the first metal structure includes a first microstrip and a first comb structure, the first microstrip includes a first edge facing the tapered slot and a second edge away from the tapered slot, the first comb structure is connected to the second edge and extends from the second edge to a direction away from the first edge, and an electrical length of the first comb structure is a quarter wavelength of an operating frequency of the tapered slot antenna. The electrical length of the first comb structure may be understood as, in the second direction, a distance from one end that is of the first comb structure and that is away from the second edge to the position of the central axis of the tapered slot. The second direction is perpendicular to the central axis of the tapered slot. The first metal structure of the tapered slot antenna in the antenna provided in this application is different from a large-area metal structure of a conventional tapered slot antenna. The microstrip and the first comb structure are combined to form a discrete comb hollow-out architecture. This not only ensures the radiation performance of the tapered slot antenna, but also helps improve electromagnetic wave penetration of an antenna body (which refers to the tapered slot antenna). Therefore, the radiation performance of the folded dipole can also be ensured.

[0019] In a possible implementation, the second metal structure includes a second microstrip and a second comb structure, the second microstrip includes a third edge facing the tapered slot and a fourth edge away from the tapered slot, the second comb structure is connected to the fourth edge and extends from the fourth edge to a direction away from the third edge, and an electrical length of the second comb structure is the quarter wavelength of the operating frequency of the tapered slot antenna. The electrical length of the second comb structure may be understood as, in the second direction, a distance from an end that is of the second comb structure and that is away from the fourth edge to the position of the central axis of the tapered slot. The second direction is perpendicular to the central axis of the tapered slot. The first comb structure and the second comb structure are symmetrically distributed on two sides of the tapered slot. In this implementation, performance of the antenna is optimized by using symmetrical distribution of the first comb structure and the second comb structure.

[0020] In a possible implementation, there are at least two first comb structures and at least two second comb structures, the at least two first comb structures are unequal in length and are alternately disposed, the first comb structure closer to the wide-gap end has a larger length, the at least two second comb structures are unequal in length and are alternately disposed, and the second comb structure closer to the wide-gap end has a larger length. In the antenna architecture provided in this implementation, a discrete comb hollow-out architecture with a gradient size is used to penetrate an electromagnetic wave signal, reduce an effective scattering area of the antenna body, provide stability of electromagnetic wave transmission, and reduce mutual impact between a plurality of antennas.

[0021] In a possible implementation, the tapered slot antenna can be excited to operate in a high frequency bandwidth, the high frequency bandwidth includes a maximum operating frequency and a minimum operating frequency, an electrical length of the first comb structure adjacent to the narrow-gap end is a quarter wavelength of the maximum operating frequency of the tapered slot antenna, and an electrical length of the first comb structure adjacent to the wide-gap end is a quarter wavelength of the minimum operating frequency of the tapered slot antenna. The first comb structure with the electrical length of the quarter wavelength has a radiation characteristic similar to that of a monopole. This can improve a gain of the tapered slot antenna.

[0022] In a possible implementation, the first comb structure includes a first comb tooth located at a position of the wide-gap end, the second comb structure includes a second comb tooth located at a position of the wide-gap end, and a distance between an end part that is of the first comb tooth and that is away from the first microstrip and an end part that is of the second comb tooth and that is away from the second microstrip is a half wavelength of the operating frequency of the tapered slot antenna. In this implementation, a size of the first microstrip at the wide-gap end is smaller than the half wavelength, and a function of the tapered slot antenna cannot be implemented. However, the first comb tooth and the second comb tooth are combined with the microstrip to form a basic architecture of the tapered slot antenna, a design in which the distance between the end part that is of the first comb tooth and that is away from the first microstrip and the end part that is of the second comb tooth and that is away from the second microstrip is the half wavelength of the operating frequency of the tapered slot antenna can meet a radiation requirement of the tapered slot antenna. In an aspect, the first comb tooth and the second comb tooth form the main radiation part of the tapered slot antenna. In another aspect, the first comb tooth and the second comb tooth, serving as tooth-shaped structures, may form a similar monopole architecture, to improve a gain of the tapered slot antenna.

[0023] In a possible implementation, the main dipole includes a first body and a first winding section and a second winding section that are separately located at two ends of the first body, the first body includes the first stub and the second stub, and the parasitic dipole includes a second body and a third winding section and a fourth winding section that are separately located at two ends of the second body, the folded dipole further includes a first winding line connected between the first winding section and the third winding section and a second winding line connected between the second winding section and the fourth winding section, and the first winding line and the second winding line are disposed opposite to each other. An objective of this implementation is to miniaturize the folded dipole. In an aspect, a size of the main dipole in the second direction may be reduced by using a structure in which the first winding section and the second winding section are located at two ends of the first body. Similarly, a size of the parasitic dipole in the second direction may be reduced by using a structure in which the third winding section and the fourth winding section are separately located at two ends of the second body. In another aspect, the first winding line and the second winding line are configured to form a radiation-free inductive load, to reduce the size of the folded dipole.

[0024] In a possible implementation, a first spacing is formed between the first winding section and the third winding section, a second spacing is formed between the second winding section and the fourth winding section, and the first winding line and the second winding line are located between the first spacing and the second spacing. In other words, a vertical projection of the first winding line and a vertical projection of the second winding line on the first body are located inside the first body. This architecture helps design a small size of the folded dipole.

[0025] In a possible implementation, in the second direction, a maximum size of the folded dipole is smaller than or equal to a maximum size of the tapered slot antenna. In this application, a maximum size of the antenna in the second direction is limited to a size in which the folded dipole extends in the second direction. The tapered slot antenna is disposed within a size range limited by the folded dipole in the second direction. This helps miniaturize the antenna.

[0026] In a possible implementation, the antenna further includes a parasitic element, and the parasitic element is located on a side that is of the tapered slot antenna and that is away from the folded dipole, for improving a gain of the tapered slot antenna. Specifically, that the parasitic element is in a straight strip shape may be understood as that a length size of the parasitic element is close to a dipole antenna at a corresponding operating frequency, and an extension direction of the parasitic element is the second direction. The tapered slot antenna can be excited to operate in a high frequency bandwidth, the high frequency bandwidth includes a high frequency band and a low frequency band, and when the tapered slot antenna operates in an operating condition of the low frequency band, the parasitic element is configured to enhance a radiated electromagnetic wave of the tapered slot antenna on the low frequency band, or when the tapered slot antenna operates in an operating condition of the high frequency band, the parasitic element configured to reflect a radiated electromagnetic wave of the tapered slot antenna on the high frequency band. The tapered slot antenna provided in this application is a directional antenna having a broadband and a high gain characteristic, and enhances an antenna radiation capability on the high frequency band. For example, the tapered slot antenna may perform coverage on a 5 GHz frequency band, or may perform cascaded backhaul on a Sub-7 GHz frequency band (where the cascaded backhaul mainly means that data or video traffic from one device to another device is transmitted to a next-level gateway in a wireless manner).

[0027] Specifically, the parasitic element extends in the second direction in a straight line shape, and the second direction is perpendicular to the first direction. The parasitic element is in a symmetric structure by using the central axis of the tapered slot as a center. A vertical projection of the parasitic element at the wide-gap end of the tapered slot antenna is located within a range of the opening end. To be specific, vertical distances between two ends of the parasitic element and the central axis of the tapered slot are both less than vertical distances between two ends of the opening end and the central axis of the tapered slot.

[0028] In a possible implementation, the high frequency bandwidth includes a maximum operating frequency and a minimum operating frequency, and an electrical length of the parasitic element is smaller than or equal to a half wavelength of a radiated electromagnetic wave of the tapered slot antenna at the minimum operating frequency, and is greater than a half wavelength of a radiated electromagnetic wave of the tapered slot antenna at the maximum operating frequency.

[0029] In a possible implementation, a spacing between the parasitic element and the wide-gap end is a quarter wavelength of an electromagnetic wave of the tapered slot antenna on a frequency band in which the parasitic element effectively acts on the tapered slot antenna.

[0030] In a possible implementation, there are at least two parasitic elements, and the at least two parasitic elements are alternately arranged in sequence along the first direction, and a spacing between adjacent parasitic elements is the quarter wavelength of the electromagnetic wave of the tapered slot antenna on the frequency band in which the parasitic element effectively acts on the tapered slot antenna.

[0031] In this application, the parasitic element is added in the first direction to enhance a gain of the tapered slot antenna on a specific frequency band, so that capability radiation has better directivity. The electrical length of the parasitic element is set, to be specific, a length of the parasitic element is slightly smaller than a half wavelength corresponding to a specific frequency, to enhance a direction function of an electromagnetic wave. Specifically, this application is mainly designed based on a low frequency enhancement gain. Therefore, for a length and a spacing of the parasitic element, refer to an operating wavelength corresponding to the tapered slot antenna in a low frequency band range. It may be understood that, under a condition of keeping a same spacing progressive, when a quantity of parasitic elements is set to a plurality, a direction function may be enhanced. In a high frequency band range, because the electrical length of the parasitic element is excessively long, the parasitic element serves as a reflection parasitic element, so that single-beam radiation becomes a multi-beam radiation in a reverse direction. Finally, such characteristic causes the entire tapered slot antenna to present different radiation effects on two sub-bands of a wide frequency band: a high frequency sub-band and a low frequency sub-band. This characteristic well matches a differentiated application requirement of a current Wi-Fi frequency band for different spectra.

[0032] In a possible implementation, the antenna includes a dielectric plate for bearing the tapered slot antenna and the folded dipole, and the tapered slot antenna and the folded dipole are disposed on a same surface. In this implementation, a metal part of the folded dipole and a metal part of the tapered slot antenna are disposed on a same surface of the dielectric plate. The surface may be a surface of the dielectric plate, or may be a middle layer of the dielectric plate.

[0033] In an implementation, the tapered slot antenna and the folded dipole are disposed on a front side of the dielectric plate, the feeding structure passes through the dielectric plate from a back side of the dielectric plate. An external conductor of the feeding structure is electrically connected to the first stub, for example, electrically connected in a welding manner. An inner conductor is electrically connected to the second stub. Specifically, the first stub and the first metal structure are connected to each other as a whole to form a floor of the antenna, and the external conductor of the feeding structure is electrically connected to the first stub for grounding. The second stub and the second metal structure are connected to each other as a whole. The inner conductor is electrically connected to the second stub. A feeding coplanar waveguide structure is formed at a joint between the first stub and the second stub. The feeding coplanar waveguide structure is fed by using the feeding structure.

[0034] In a possible implementation, the antenna includes a dielectric plate for bearing the tapered slot antenna and the folded dipole, and the antenna is distributed on different surfaces of the dielectric plate. For example, an example in which the antenna is distributed on two surfaces of the dielectric plate is used. That the dielectric plate includes a first surface and a second surface that are disposed in a stacked manner may include at least the following several specific implementations:

In a possible implementation, the second metal structure, the second stub, the second winding line, a part of the parasitic dipole, and the parasitic element are located on the first surface. The first metal structure, the first stub, the first winding line, and the other part of the parasitic dipole are located on the second surface. The parasitic dipole located on the first surface and the parasitic dipole located on the second surface are electrically connected by using a metal via on the dielectric plate.

[0035] In a possible implementation, the parasitic dipole is located on the first surface. The main dipole (including the first stub and the second stub), the first metal structure, the second metal structure, and the parasitic element are located on the second surface. The parasitic dipole and the main dipole are electrically connected by using a metal via on the dielectric plate.

[0036] In a possible implementation, the folded dipole and the tapered slot antenna are located on the first surface, and the parasitic element is located on the second surface. In this implementation, the first surface and the second surface do not need to be electrically connected.

[0037] This application may further include the following specific implementation. For example, the tapered slot antenna is located on the first surface, and the folded dipole is located on the second surface. It may be understood that the tapered slot antenna and the folded dipole may alternatively be distributed on three or more layers. If electrical connection is required between the folded dipole and the tapered slot antenna that do not share the same surface, the electrical connection may be implemented by using a metal via between dielectric substrates.

[0038] According to a second aspect, this application provides an electronic device, including a radio frequency circuit and an antenna according to any implementation of the first aspect. The feeding structure of the antenna is electrically connected to the radio frequency circuit.

[0039] According to a third aspect, this application further provides an antenna module, including a support and an antenna that is connected to the support. The antenna is the antenna provided in any implementation of the first aspect.

BRIEF DESCRIPTION OF DRAWINGS

[0040]

FIG. 1 is a schematic application diagram of an electronic device that includes an antenna and that is used as a home gateway in a home gateway system according to this application;
FIG. 2 is a schematic diagram of a specific application scenario of an electronic device (which is a home gateway) according to this application;
FIG. 3 is a three-dimensional diagram of an electronic device according to an implementation of this application;
FIG. 4 is a schematic diagram of a state in which a housing of the electronic device shown in FIG. 3 is removed;
FIG. 5 is a schematic diagram of removing a support for installing an antenna from the electronic device shown in FIG. 4, and mainly represents a position relationship between an antenna and a board in the electronic device;
FIG. 6 is a schematic diagram of an antenna distributed on a surface of a dielectric plate according to an implementation of this application;
FIG. 7 and FIG. 8 are schematic side views of a dielectric plate in two directions;
FIG. 9 is a schematic diagram of an antenna according to an implementation of this application;
FIG. 10 is a schematic diagram of an antenna according to an implementation of this application;
FIG. 11 is a schematic diagram of an antenna according to an implementation of this application;
FIG. 12 is a schematic diagram of an antenna according to an implementation of this application;
FIG. 13 is a schematic diagram of an antenna according to an implementation of this application;
FIG. 14 is a schematic diagram of an antenna according to an implementation of this application;
FIG. 15 is a schematic diagram of an antenna according to an implementation of this application;
FIG. 16 and FIG. 17 each are a schematic diagram of distribution of an antenna on two surfaces of a dielectric plate according to an implementation of this application;
FIG. 18 and FIG. 19 each are a schematic diagram of distribution of an antenna on two surfaces of a dielectric plate according to another implementation of this application;
FIG. 20 and FIG. 21 each are a schematic diagram of distribution of an antenna on two surfaces of a dielectric plate according to another implementation of this application;
FIG. 22 is a curve diagram of an S parameter of an antenna according to an implementation of this application; and
FIG. 23 is schematic radiation patterns of an antenna at four different operating frequencies (which are separately 5.5 GHz, 5.9 GHz, 6.5 GHz, and 7 GHz) according to an implementation of this application.

DESCRIPTION OF EMBODIMENTS

[0041] For ease of understanding, the following explains and describes related technical terms used in embodiments of this application.

[0042] A home gateway is a network device located inside a modern home. A function of the home gateway is to enable a home user to be connected to the Internet, so that various intelligent devices located in the home can obtain Internet services, or enable these intelligent devices to communicate with each other. In a word, the home gateway is a bridge that enables a plurality of intelligent devices in the home to be connected to each other and enables a home network to be connected to an external network. From a technical perspective, the home gateway implements bridging/routing, protocol conversion, and address management and conversion inside the home and from inside to outside, and functions as a firewall and provides a possible Video over IP (VoIP) service.

[0043] A wireless AP (AP, access point, a wireless access point, a session point, or an access bridge) is a widely-used name, and is not only a pure wireless access point (AP), but also a general term for devices such as wireless routers (including a wireless gateway and a wireless bridge). The wireless AP access point supports a 2.4 GHz wireless application, and sensitivity complies with the 802.11n standard. The wireless AP access point uses dual-channel radio frequency for outputting, with maximum output power of 600 milliwatts for each channel, and can deploy wireless coverage in a large area by using a wireless distribution system (point-to-point and point-to-multipoint bridging). The wireless AP access point is a necessary wireless AP device for wireless network development in hotels.

[0044] A multiple-input multiple-output (Multi-input Multi-output, MIMO) system is an abstract mathematical model used for describing a multi-antenna wireless communication system. The multiple-input multiple-output system may transmit signals independently by using a plurality of antennas at a transmitting end, and receive and restore original information by using a plurality of antennas at a receiving end. The technology was first proposed by Marconi in 1908. Marconi uses a plurality of antennas to suppress channel fading (fading). Based on a quantity of antennas at a transmitting end and a receiving end, compared with a common single-input single-output (Single-Input Single-Output, SISO) system, the multi-antenna technology such as the MIMO includes "smart antennas", to be specific, a single-input multiple-output (Single-Input Multi-Output, SIMO) system and a multiple-input single-output (Multiple-Input Single-Output, MISO) system.

[0045] An omnidirectional antenna radiates 360 degrees evenly in a horizontal pattern, that is, non-directionality. In a vertical pattern, the omnidirectional antenna is represented as a beam with a specific width. Generally, a small lobe width indicates a large gain. In a mobile communication system, the omnidirectional antenna is generally used for a suburban area with a large coverage range.

[0046] Horizontal polarization means that a vibration direction of an electromagnetic wave is horizontal. A polarized wave whose polarization plane is perpendicular to a normal plane of the earth is referred to as a horizontal polarized wave. An electric field direction of the horizontal polarized wave is parallel to the earth.

[0047] Vertical polarization means that an electric field vector vibrates in a fixed plane along a fixed direction. In this case, the electromagnetic wave is polarized. The plane including the electric field vector E is referred to as a polarization plane. Polarization in microwave remote sensing, includes horizontal polarization or vertical polarization. When the electric field vector of the electromagnetic wave is parallel to an incident plane of a beam, the polarization is referred to as vertical polarization that is represented by V

[0048] The following describes embodiments of this application with reference to the accompanying drawings in embodiments of this application.

[0049] FIG. 1 is a schematic application diagram of an electronic device that includes an antenna and that is used as a home gateway in a home gateway system according to this application. In an implementation shown in FIG. 1, the electronic device provided in this application is a home gateway. The home gateway is connected between an optical line termination and a terminal device. The optical line termination is connected to a wide area network (Internet). The optical line termination obtains a signal from the wide area network (Internet), and transmits the signal to the home gateway. Then, an antenna disposed in the home gateway transmits the signal to each terminal device. The home gateway includes a digital module, a radio frequency module, and an antenna. The digital module is connected between the optical line termination and the radio frequency module. The radio frequency module is configured to send a radio frequency signal to the antenna. With development of home intelligence, various intelligent terminal devices are configured in a home, and more antennas need to be configured in the home gateway to provide signals for various terminal devices. For example, there may be an antenna 1, an antenna 2, an antenna 3, an antenna 4, and an antenna 5. The antenna 1 may be a low frequency antenna. For example, the low frequency antenna may be a 2 GHz antenna or a 3 GHz antenna. The antenna 2, the antenna 3, the antenna 4, and the antenna 5 may be high frequency antennas. For example, the high frequency antenna may be a 5 GHz antenna or a 6 GHz antenna. In another implementation, the antenna may have another configuration. For example, there may be two or more low frequency antennas, and there may be one or two or more high frequency antennas.

[0050] In an implementation, the terminal devices may include a smartphone, a smart home (for example, an air conditioner, an electric fan, a washing machine, or a refrigerator), a smart television, and smart security protection (for example, a camera). The smartphone may be used in a low frequency range, or may be used in a high frequency range. For example, the smartphone may support signals of two frequencies: 2 GHz and 5 GHz. Therefore, as shown in FIG. 1, the antenna 1 and the antenna 2 each provide a signal for the smartphone. The antenna 3 provides a signal for the smart home. For the smart home, a user may check and control, by using a smart home gateway system platform, a status of a remote smart home appliance, a lighting system, a power supply system, and the like by using a mobile phone, a PC, and the like. The antenna 4 provides a signal for the smart television, and the user may alternatively remotely control the smart television by using the terminal device. The smart television may have a function of a web television, or may have a function of a video conference. The antenna 5 provides a signal for the smart security protection, and a smart video security protection system may include functions such as fire prevention, theft prevention, leakage prevention, and remote management. The user may use a mobile phone or the Internet to remotely check and configure a home security system. In addition, the user may remotely monitor a home internal environment. If an exception is detected, the security system may notify the user by making a call, sending a short message, or sending an email.

[0051] In this application, antennas with different operating frequencies may be integrated, omnidirectional radiation of the low frequency antenna can be implemented, and a directional gain of the high frequency antenna can be implemented. For example, the antenna 1 and the antenna 4 are integrated. The antenna 1 provides a signal for a low frequency operating frequency of the smartphone. The smartphone may appear at any position in the home. The antenna 1 needs omnidirectional radiation. The antenna 4 needs to provide a signal for the smart television. Usually, the smart television is fixed at a position in the home. The antenna 4 needs directional radiation to ensure signal strength.

[0052] FIG. 2 is a schematic diagram of a specific application scenario of an electronic device 100 (which is a home gateway) according to this application. As shown in FIG. 2, in a specific home scenario, different rooms on a same floor require Wi-Fi signals, and different floors also have Wi-Fi signal requirements. The home gateway 100 includes different antennas. Therefore, horizontal omnidirectional radiation can be implemented. To be specific, radiation to the different rooms on the same floor can be implemented, to meet Wi-Fi signal requirements of different rooms on the same floor. In addition, vertical through-building radiation can further be implemented, to meet the Wi-Fi signal requirements of the different floors. In FIG. 2, an ellipse marked as A represents that an antenna has a capability of horizontal polarization omnidirectional radiation, an ellipse marked as B represents that an antenna has a capability of horizontal polarization directional radiation, and an ellipse marked as C represents that an antenna has a capability of vertical polarization radiation and can radiate a signal vertically through a building.

[0053] The antenna provided in this application can integrate two antennas, to implement omnidirectional radiation and a directional gain in a same polarization direction, or integrate a plurality of antennas. To be specific, omnidirectional radiation and the directional gain in a same polarization direction can be ensured, and radiation in another polarization direction, for example, omnidirectional radiation and a directional gain in vertical polarization and radiation in horizontal polarization, can further be implemented.

[0054] FIG. 3, FIG. 4, and FIG. 5 each are a schematic diagram of an electronic device 100 according to an implementation of this application. The electronic device 100 may be a home gateway, or may be another electronic device, such as a wireless AP, a home hotspot, or CPE (Customer Premise Equipment, customer premise equipment).

[0055] Refer to FIG. 3. An example in which the electronic device 100 is a home gateway is used. The electronic device 100 includes a housing 1001. The housing 1001 may be in a barrel shape, or may be in another shape, for example, a square box shape or a circular box shape. In this implementation, a top cover 1002 is disposed on a top part of the barrel-shaped housing 1001. The top cover 1002 is made of a non-shielding material, for example, plastic. An antenna is disposed inside the top cover 1002. A plurality of through holes 1003 are provided on the top cover 1002. The through holes 1003 are provided to facilitate signal radiation of the antenna in the electronic device 100 and ventilation and heat dissipation inside the electronic device 100.

[0056] With reference to FIG. 3 and FIG. 4, based on FIG. 3, FIG. 4 is a schematic diagram of removing the housing 1001 from the electronic device 100 according to this application. A board 1004 is disposed in the electronic device 100. An antenna 1000 provided in an implementation of this application is disposed on one side of the board 1004. A radio frequency circuit 10041 may be disposed on the board 1004. The radio frequency circuit 10041 is electrically connected to a feeding part of the antenna 1000, and the radio frequency circuit 10041 receives and sends signals by using the antenna 1000. The board 1004 and the antenna 1000 are disposed inside the housing 1001. The board 1004 is vertically disposed to help dissipate heat of the board 1004. A base 1005 for securing the board 1004 is disposed in the housing 1001. The board 1004 is connected to the base 1005. A structure 1006 for providing heat conduction and heat dissipation for the board 1004, for example, a metal heat sink, a vapor chamber, a heat tube, and another heat conduction structure, may also be disposed on the base 1005, or different types of heat-conducting structures may be combined for use. In this implementation, two boards 1004 are disposed in the electronic device 100, the base 1005 is located at a bottom part of the electronic device 100. The heat-conducting and heat-dissipating structure 1006 is upright on the base 1005. The two boards 1004 are separately located on two opposite sides of the heat-conducting and heat-dissipating structure 1006. In other words, the heat-conducting and heat-dissipating structure 1006 is sandwiched between the two boards 1004. In this way, the heat-conducting and heat-dissipating structure 1006 can dissipate heat for the two boards 1004 at the same time, and that the boards are close to the housing 1001 is ensured. This helps dissipate heat of the boards 1004.

[0057] The antenna 1000 may be disposed on a top part of the board 1004 to ensure radiation performance of the antenna 1000. Specifically, as shown in FIG. 4, the antenna 1000 may be installed on a support 1007 to form an antenna module R, and then the antenna module R is assembled inside the housing 1001. Another antenna or electronic component may be further disposed on the support 1007. The support 1007 is provided with an air duct 10071, and the air duct 10071 communicate with the through hole 1003 on the top cover 1002, to implement ventilation and heat dissipation. The antenna module R is located on a top part of the board 1004 and the heat-conducting and heat-dissipating structure 1006, in other words, in a top area close to the housing 1001, and is located on an inner side of the top cover 1002. The air duct 10071 and the through hole 1003 are configured to implement ventilation between the heat-conducting and heat-dissipating structure 1006 and outside of the electronic device 100, to improve a heat dissipation effect. In the implementation shown in FIG. 4, a dielectric plate on which the antenna 1000 (having a tapered antenna architecture) is located is placed approximately horizontally, and the antenna is horizontally polarized. If a vertical polarized antenna is required in a specific application scenario, the electronic device 100 may be changed from vertical type to horizontal, and an opening of a tapered slot of a tapered antenna of the antenna is provided upward in a vertical direction. In another implementation, the antenna 1000 may alternatively be disposed at another position in the electronic device. As shown in FIG. 5, a vertical support in an electronic device, to be specific, a part located between two boards 1004, an antenna 1000 is disposed on the support, and an opening of a tapered slot of the antenna is provided upward in a vertical direction.

[0058] A housing 1001 may be made of a plastic material as a whole, or a part of the housing 1001 is made of a metal material, and a part of the housing 1001 is made of a plastic material (or a non-shielding material). The metal part of the housing 1001 is a part of the housing disposed on a periphery of the board 1004. The metal part of the housing has an advantage of good heat conduction performance. A power component or another heat emitting element is disposed on the board 1004. When the board 1004 operates, heat may be conducted to the housing 1001 by using a heat conduction structure, and heat dissipation may be improved by using the housing 1001 for assisting heat dissipation. Therefore, A service life of the electronic device 100 is ensured. The plastic (or non-shielding material) part of the housing 1001 is a part of the housing disposed on a periphery of the antenna 1000, and the plastic material does not interfere and shield a signal of the antenna 1000. This helps ensure radiation performance of the antenna 1000.

[0059] In this application, a tapered slot antenna (Tapered slot antenna, TSA) and a folded dipole are integrated into one antenna to share one feed. It may alternatively be understood as that the tapered slot antenna is fed by using the folded dipole. This improves an application scope of the antenna, so that the antenna can implement omnidirectional radiation of the folded dipole, and can also implement directional radiation of the tapered slot antenna. The antenna provided in this application can well match a requirement of an ONT (Optical network terminal, optical network terminal) on a Wi-Fi antenna design (for example, more antennas are disposed in limited space, and more areas can be covered), and satisfy a strategy of a home network Wi-Fi antenna design (to be specific, high-performance Wi-Fi coverage capabilities at different frequencies). In an implementation, polarization of the tapered slot antenna and the folded dipole in this application is the same. For example, both the tapered slot antenna and the folded dipole may be vertically polarized (where the tapered slot antenna and the folded dipole may be horizontally polarized by changing a placement angle). The tapered slot antenna may be a directional antenna of a first frequency, the folded dipole may be an omnidirectional antenna of a second frequency, and the first frequency is lower than the second frequency. A range of an operating frequency of the folded dipole is 6 GHz to 7.125 GHz, and a range of an operating frequency of the tapered slot antenna is 5.1 GHz to 5.9 GHz. The tapered slot antenna and the folded dipole in the antenna provided in this implementation have different operating frequency ranges, and radiate different signals. This improves the application scope of the antenna and highlights an advantage of a miniaturized antenna.

[0060] Refer to FIG. 6, FIG. 7, and FIG. 8. In an implementation, an antenna provided in this application is disposed on a dielectric plate 10. The dielectric plate 10 may also be considered as a part of the antenna. In other words, it may be understood as that the antenna includes the dielectric plate 10. The dielectric plate 10 may be any insulating substrate such as a ceramic substrate or a PCB. The dielectric plate 10 may be a plate of a single material, or may be a composite plate, for example, formed by press-fitting plates of two different materials. The dielectric plate 10 may have a single-layer plate structure, or may have a two-layer plate structure or a multi-layer plate structure. The antenna provided in this application is in a microstrip antenna architecture formed on a dielectric plate. The microstrip antenna architecture has the following advantages: a small section, a light weight, being conformal to a carrier (which refers to the dielectric plate), and easy integration with an active component (for example, a radio frequency circuit, a filter circuit, or a signal amplification circuit).

[0061] FIG. 6 is a schematic diagram of an antenna distributed on a surface of the dielectric plate 10 according to an implementation of this application. FIG. 7 and FIG. 8 are schematic side views of the dielectric plate in two directions. The antenna includes a tapered slot antenna 20, a folded dipole 30, and a feeding structure 40. Two opposite ends of the tapered slot antenna are a radiation end and a feeding end. As shown in FIG. 6, a radiation direction of the tapered slot antenna 20 is rightward, a right end of the tapered slot antenna 20 is the radiation end, and correspondingly, a left end of the tapered slot antenna 20 is the feeding end. The folded dipole 30 is connected to the feeding end of the tapered slot antenna 20, and may be used as a resonant tank of the tapered slot antenna 20. The feeding structure 40 feeds the folded dipole 30 and excites the tapered slot antenna 20 at the same time. In this application, the folded dipole 30 and the tapered slot antenna 20 are integrated to share one feed and perform a dual-antenna function, so that the antenna can be miniaturized. In addition, radiation performance of the folded dipole 30 and the tapered slot antenna 20 can be separately implemented, and the two antennas further have a complementary function. For example, in this application, the folded dipole 30 is disposed at the feeding end of the tapered slot antenna 20. The folded dipole 30 can not only perform a radiation function of the folded dipole 30, but also form the resonant tank of the tapered slot antenna 20, and has a tuning function for the radiation performance of the tapered slot antenna 20. In this application, functions of the folded dipole 30 are extended, so that the folded dipole 30 has two functions (to be specific, performing radiation of the folded dipole 30 and forming a resonant structure of the tapered slot antenna).

[0062] A basic architecture of the tapered slot antenna 20 is as follows. The tapered slot antenna 20 includes a first metal structure 21 and a second metal structure 22. A tapered slot 24 is formed between the first metal structure 21 and the second metal structure 22. An extension direction of the tapered slot 24 is a first direction A1. Two ends of the tapered slot 24 are a narrow-gap end 241 and a wide-gap end 242. The folded dipole 30 is connected to the narrow-gap end 241 and is located on a side that is of the narrow-gap end 241 and that is away from the wide-gap end 242. In this implementation, the tapered slot 24 may have an axisymmetric structure. To be specific, the tapered slot 24 is symmetrically distributed by using a central axis C1 as a center. The first metal structure 21 and the second metal structure 22 may also be symmetrically distributed on two sides of the central axis C1, and an extension direction of the symmetry axis C1 is the first direction A1. Certainly, the tapered slot 24 may alternatively have an asymmetric structure. For example, the first metal structure 21 and the second metal structure 22 have different shapes or sizes. In general, an extension direction from a central position of the narrow-gap end 241 of the tapered slot 24 to a central position of the wide-gap end 242 of the tapered slot 24 is the first direction A1. The dielectric plate 10 is approximately rectangular, and a direction of a long side of the dielectric plate 10 is the first direction A1.

[0063] A specific structure of the first metal structure 21 and a specific structure of the second metal structure 22 may have a plurality of different forms. For example, FIG. 6, FIG. 9, FIG. 10, FIG. 11, and FIG. 12 schematically describe several different implementations of the first metal structure 21 and the second metal structure 22.

[0064] As shown in FIG. 6, the first metal structure 21 includes a first microstrip 211 and a first comb structure 212. The first microstrip 211 includes a first edge 2111 facing the tapered slot 24 and a second edge 2112 away from the tapered slot. The first microstrip 211 may be in an arc line shape, or the first microstrip 211 includes a straight line and an arc line. A line width of the first microstrip 211 is a vertical distance between the first edge 2111 and the second edge 2112. In this application, the line width of the first microstrip 211 may be set to be the same at all positions from the narrow-gap end 241 to the wide-gap end 242. Alternatively, the line width changes gradually from the narrow-gap end 241 to the wide-gap end 242. Alternatively, from the narrow-gap end 241 to the wide-gap end 242, a line width of a part of the first microstrip is the same, and a line width of the other part of the first microstrip changes gradually. A specific shape of the first microstrip 211 is not limited in this application. The first comb structure 212 is connected to the second edge 2112 and extends from the second edge 2112 to a direction away from the first edge 2111. An extension direction of the first comb structure 212 is a second direction. The second direction may be perpendicular to the first direction, or may form an included angle less than 90 degrees relative to the first direction. The extension direction of the first comb structure 212 shown in FIG. 6 is perpendicular to the first direction A 1. It may be understood that, in the implementation shown in FIG. 6, the first comb structure 212 may tilt leftward or rightward by a specific angle.

[0065] In an implementation shown in FIG. 6, there are two first comb structures 212, and the two first comb structures 212 are separately close to the narrow-gap end 241 and the wide-gap end 242. In another implementation, there may be one, three, or more first comb structures 212. Each first comb structure 212 includes two first comb teeth 2121. It may be understood that there may be one, three, or more first comb teeth in each first comb structure 212. This is not limited in this application. In the implementation shown in FIG. 6, extension directions of the two first comb structures 212 are the same, both are the second direction A2, and are perpendicular to the first direction A1. This architecture is easy to be manufactured from a perspective of manufacturing work, and facilitates easy adjustment of a physical parameter of an antenna from perspectives of antenna tuning, bandwidth configuration, and directivity pattern control. In another implementation, different first comb structures 212 may have different extension directions. For example, one of the first comb structures 212 in the implementation shown in FIG. 6 may tilt leftward or rightward by a specific angle.

[0066] In the implementation shown in FIG. 6, each first comb tooth 2121 is in a straight line shape. It may be understood that, in another implementation, each first comb tooth 2121 may alternatively be in a curve shape, for example, in a C shape or an S shape.

[0067] The first metal structure 21 of the tapered slot antenna 20 in the antenna provided in this application is different from a large-area metal structure of a conventional tapered slot antenna. That the first microstrip 211 and the first comb structure 212 are combined may also be understood as that a part of materials is removed from the conventional large-area metal structure, to form a hollow-out structure, in other words, to form a discrete comb hollow-out structure. This not only ensures the radiation performance of the tapered slot antenna 20, but also helps improve electromagnetic wave penetration of an antenna body (which refers to the tapered slot antenna). Therefore, the radiation performance of the folded dipole 30 is also ensured. An electrical length of the first comb structure 212 is a quarter wavelength of an operating frequency of the tapered slot antenna 20. The electrical length of the first comb structure 212 may be understood as, in the second direction A2, a distance from one end that is of the first comb structure 212 and that is away from the second edge 2112 to a position of the central axis C1 of the tapered slot 24. The second direction A2 is perpendicular to the central axis C1 of the tapered slot 24. The electrical length of the first comb structure 212 is configured to be the quarter wavelength, so that the first comb structure 212 can form a monopole antenna architecture, to radiate redundant energy of the tapered slot antenna 20. This can improve the radiation performance of the tapered slot antenna. This may be understood as that the tapered slot antenna 20 radiates an electromagnetic wave mainly at a position of an edge of the tapered slot 24. However, inevitably, a part of currents diffuse outward along the first metal structure 21. In other words, a part of currents flow to the first comb structure. In this application, the first comb structure is designed to have the electrical length of the quarter wavelength of the operating frequency of the tapered slot antenna, so that the first comb structure can radiate this part of currents. This enhances a signal radiation capability of the tapered slot antenna.

[0068] In the implementation shown in FIG. 6, a structure of the second metal structure 22 and a structure of the first metal structure 21 are the same. The second metal structure 22 includes a second microstrip 221 and a second comb structure 222. The second microstrip 221 includes a third edge 2211 facing the tapered slot 24 and a fourth edge 2212 away from the tapered slot 24. The second comb structure 222 is connected to the fourth edge 2212 and extends from the fourth edge 2212 to a direction away from the third edge 2211. An electrical length of the second comb structure 222 is the quarter wavelength of the operating frequency of the tapered slot antenna 20. The electrical length of the second comb structure 222 may be understood as, in the second direction, a distance from an end that is of the second comb structure 222 and that is away from the fourth edge 2212 to the position of the central axis C1 of the tapered slot 24. The second direction A2 is perpendicular to the central axis C1 of the tapered slot 24. Each second comb structure 222 includes a second comb tooth 2221, and there may be one, two, or more second comb teeth 2221 in each second comb structure 222. A specific structure of the second comb structure 222 and a specific structure of the first comb structure 212 may be the same. For details, refer to the foregoing descriptions of the first comb structure 212. Details are not described again.

[0069] The antenna provided in this application is generally in a symmetric distribution architecture. The central axis C1 of the tapered slot 24 may be considered as a center of symmetry. In other words, the tapered slot antenna 20 may be in a symmetric distribution architecture by using the central axis C1 as a center. For the folded dipole 30, a part of a feeding structure of the folded dipole 30 is in an asymmetric architecture. The first comb structure 212 and the second comb structure 222 are symmetrically distributed on two sides of the tapered slot 24. In this implementation, the first comb structure 212 and the second comb structure 222 are symmetrically distributed. This helps optimize performance of the antenna.

[0070] Refer to the implementation shown in FIG. 6. When there are at least two first comb structures and at least two second comb structures, the at least two first comb structures are not equal in length and are alternately disposed, and the first comb structure closer to the wide-gap end has a larger length. Similarly, the at least two second comb structures are not equal in length and are alternately disposed, and the second comb structure closer to the wide-gap end has a larger length. FIG. 6 schematically shows two first comb structures and two second comb structures that are respectively close to the narrow-gap end and a wide-gap end. It may be understood that, at least one first comb structure having a different electrical length may be disposed between the two first comb structures. Similarly, at least one second comb structure having a different electrical length may also be disposed between the two second comb structures. In the antenna architecture provided in this implementation, a discrete comb hollow-out architecture with a gradient size is used to penetrate an electromagnetic wave signal, and provide stability of electromagnetic wave transmission. The tapered slot antenna can be excited to operate in a high frequency bandwidth, the high frequency bandwidth includes a maximum operating frequency and a minimum operating frequency, an electrical length of the first comb structure adjacent to the narrow-gap end is a quarter wavelength of the maximum operating frequency of the tapered slot antenna, and an electrical length of the first comb structure adjacent to the wide-gap end is a quarter wavelength of the minimum operating frequency of the tapered slot antenna. The first comb structure with the electrical length of the quarter wavelength has a radiation characteristic similar to that of a monopole. This can improve a gain of the tapered slot antenna. In this implementation, the first comb structure and the second comb structure of different sizes are disposed, so that gains of the tapered slot antenna at different operating frequencies can be met.

[0071] In a possible implementation, the first comb structure 212 includes a first comb tooth 2121A located at a position of the wide-gap end 242, and the second comb structure 222 includes a second comb tooth 2221A located at a position of the wide-gap end 242. A distance D1 between an end part that is of the first comb tooth 2121A and that is away from the first microstrip 211 and an end part that is of the second comb tooth 2221A and that is away from the second microstrip 221 is a half wavelength of the operating frequency of the tapered slot antenna 20. In this implementation, a size of the first microstrip and a size of the second microstrip at the wide-gap end are smaller than the half wavelength. As shown in FIG. 6, at the wide-gap end, an end part of the first microstrip is correspondingly disposed at a position of a root part of the first comb tooth 2121A, and an end part of the second microstrip is correspondingly disposed at a position of a root part of the second comb tooth 2221A. A distance between the end part 211A of the first microstrip 211 and the end part 221A of the second microstrip 221 is less than the half wavelength of the operating frequency of the tapered slot antenna 20, and a function of the tapered slot antenna 20 cannot be implemented. However, the first comb tooth 2121A and the second comb tooth 2221A are combined with the first microstrip 211 and the second microstrip 221 to form the basic architecture of the tapered slot antenna 20. In other words, a design in which the distance between the end part that is of the first comb tooth 2121A and that is away from the first microstrip 211 and the end part that is of the second comb tooth 2221A and that is away from the second microstrip 221 is the half wavelength of the operating frequency of the tapered slot antenna 20 can meet a radiation requirement of the tapered slot antenna 20. In an aspect, the first comb tooth 2121A located at the position of the wide-gap end 242 and the second comb tooth 2221A located at the position of the wide-gap end 242 form a main radiation part of the tapered slot antenna 20. In another aspect, the first comb tooth 2121A and the second comb tooth 2221A, serving as tooth-shaped structures, may form a similar monopole architecture. Therefore, the gain of the tapered slot antenna 20 can be improved.

[0072] In the implementation shown in FIG. 6, the end part 211A of the first microstrip 211 is located on a side that is of the first comb tooth 2121Aand that is away from the folded dipole 30. It may be understood as that: there is a specific distance between a position of the first microstrip 211 correspondingly connected to the root part of the first comb tooth 2121A and the end part 211A. Similarly, the end part 221A of the second microstrip 221 is located on a side that is of the second comb tooth 2221A and that is away from the folded dipole 30, and there is a specific distance between a position of the second microstrip 221 correspondingly connected to the root part of the second comb tooth 2221A and the end part 221A. In this implementation, a design in which the end part 211A of the first microstrip 211 protrudes relative to the first comb tooth 2121A, and the end part 221A of the second microstrip 221 protrudes relative to the second comb tooth 2221A can be used to adjust current distribution at an opening end. This improves radiation efficiency of the tapered slot antenna.

[0073] FIG. 9 schematically describes an antenna provided in an implementation of this application. A specific structure of a first metal structure 21 and a specific structure of a second metal structure 22 are different from those in the implementation shown in FIG. 6. Specifically, a position of an end part 211A of a first microstrip 211 and a position of an end part 221A of a second microstrip 221 are different from those in FIG. 6. In an implementation shown in FIG. 9, the end part 211A of the first microstrip 211 is connected to a position of a root part of a first comb tooth 2121A, and the end part 211A of the first microstrip 211 forms a smooth transition connection at a position of the root part of the first comb tooth 2121A. Similarly, the end part 221A of the second microstrip 221 is connected to a position of a root part of the second comb tooth 2221A, and the end part 221A of the second microstrip 221 forms a smooth transition connection at a position of the root part of the second comb tooth 2221A. In this implementation, the first comb tooth 2121A is formed by extending along a second direction at the position of the end part 211A of the first microstrip 211, and the second comb tooth 2221A is formed by extending along a second direction at the position of the end part 221A of the second microstrip 221. An extension direction of the first comb tooth 2121A and an extension direction of the second comb tooth 2221A are opposite and collinear, to form a symmetrical distribution architecture.

[0074] FIG. 10 schematically describes an antenna provided in an implementation of this application. A specific structure of a first metal structure 21 and a specific structure of a second metal structure 22 are different from those in the implementation shown in FIG. 6. Specifically, a quantity of first comb structures 212 and a quantity of second comb structures 222 are different from those in FIG. 6. In an implementation shown in FIG. 10, the first metal structure 21 includes one first comb structure 212, and the first comb structure 212 is disposed close to a wide-gap end 242. The second metal structure 22 includes one second comb structure 222, and the second comb structure 222 is disposed close to the wide-gap end 242.

[0075] FIG. 11 schematically describes an antenna provided in an implementation of this application. A specific structure of a first metal structure 21 and a specific structure of a second metal structure 22 are different from the implementation shown in FIG. 6. In an implementation shown in FIG. 11, the first metal structure 21 includes only a first microstrip 211 and does not include a first comb structure, and the second metal structure 22 includes only a second microstrip 221 and does not include a second comb structure. A structure of the first microstrip 211 and a structure of the second microstrip 221 are different from that of the first microstrip and that of the second microstrip in the implementation shown in FIG. 6. In this implementation, at a position of an opening end 242. A distance D1 between an end part of the first microstrip

211 and an end part of the second microstrip 221 is a half wavelength of an operating frequency of a tapered slot antenna 20. It may be understood as that, in the antenna provided in this application, the first metal structure and the second metal structure of the tapered slot antenna may include a single microstrip, and no comb structure is disposed. Radiation performance of the tapered slot antenna and radiation performance of a folded dipole can also be ensured.

[0076] FIG. 12 schematically describes an antenna provided in an implementation of this application. A specific structure of a first metal structure 21 and a specific structure of a second metal structure 22 are different from those in the implementation shown in FIG. 6. In the implementation shown in FIG. 12, the first metal structure 21 and the second metal structure 22 are not structures of microstrips, but structures of metal patches with large area. The first metal structure 21 includes an inner edge 213 and an external edge 214 that are disposed opposite to each other. The second metal structure 22 includes an inner edge 223 and an external edge 224 that are disposed opposite to each other. A tapered slot 24 is formed between the inner edge 213 of the first metal structure 21 and the inner edge 223 of the second metal structure 22. The first metal structure 21 includes a first end 215 connected to a folded dipole 30 and a second end 216 away from the folded dipole 30. The second metal structure 22 includes a first end 225 connected to the folded dipole 30 and a second end 226 away from the folded dipole 30. A size in which the first end 215 of the first metal structure 21 extends in a second direction is smaller than a size in which the second end 216 of the first metal structure 21 extends in the second direction. Similarly, a size in which the first end 225 of the second metal structure 22 extends in the second direction is also smaller than a size in which the second end 226 of the second metal structure 22 extends in the second direction. A narrow-gap end 241 of the tapered slot 24 is formed between the first end 215 of the first metal structure 21 and the first end 225 of the second metal structure 22. A wide-gap end 242 of the tapered slot 24 is formed between the second end 216 of the first metal structure 21 and the second end 226 of the second metal structure 22. A first spacing area R1 is formed between the first metal structure 21 and the folded dipole 30. Second spacing area R2 is formed between the second metal structure 22 and the folded dipole 30. The first spacing area R1 and the second spacing area R2 are disposed to help ensure a structure form and radiation performance of the folded dipole 30, and may be used as a hollow area between a tapered slot antenna and the folded dipole 30. This can ensure that an electromagnetic wave signal radiated by the folded dipole 30 can pass through the tapered slot antenna 20, to form omnidirectional radiation.

[0077] In the implementations shown in FIG. 6, FIG. 9 to FIG. 12, the folded dipole 30 in the antenna has a same architecture. The following uses the implementation shown in FIG. 12 as an example to describe a structure of the folded dipole 30 in detail.

[0078] Refer to FIG. 12. An extension direction of the folded dipole 30 is the second direction A2, and the second direction A2 intersects with a first direction A1 (where the second direction A2 and the first direction A1 may be orthogonal or may form an included angle less than 90 degrees). That an extension direction of the folded dipole 30 is the second direction may be understood as that an extension direction of a main radiation part of the folded dipole is the second direction. If a main dipole and a parasitic dipole in the folded dipole each are in a straight strip shape, an extension direction of the main dipole and an extension direction of the parasitic dipole are the second direction, and the two extension directions may be considered as parallel or nearly parallel. The main dipole and the parasitic dipole in the folded dipole may alternatively be configured to be wound at two ends, and a snake-shaped line is disposed between the main dipole and the parasitic dipole. A size may be reduced, and although a winding part is not in the second direction, and an extension direction of the folded dipole as a whole may be considered as the second direction.

[0079] The folded dipole 30 includes a main dipole 31 and a parasitic dipole 32 that are disposed opposite to each other. An area between the main dipole 31 and the parasitic dipole 32 forms internal space of the folded dipole 30. The main dipole 31 is located between the parasitic dipole 32 and the narrow-gap end 241. The main dipole 31 includes a first body 311, and a first winding section 312 and a second winding section 313 that are separately located at two ends of the first body 311. The first body 311 includes a first stub 3111 and a second stub 3112. The first stub 3111 and the second stub 3112 are alternately arranged in the second direction, and a gap is formed between the first stub 3111 and the second stub 3112. The parasitic dipole 32 includes a second body 321 and a third winding section 322 and a fourth winding section 323 that are separately located at two ends of the second body 321. The folded dipole 30 further includes a first winding line 33 connected between the first winding section 312 and the third winding section 322 and a second winding line 34 connected between the second winding section 313 and the fourth winding section 323. The first winding line 33 and the second winding line 34 are disposed opposite to each other. In this implementation, two ends of the main dipole 31 and two ends of the parasitic dipole 32 are wound, so that the folded dipole 30 can be miniaturized. In an aspect, a size of the main dipole 31 in the second direction A2 may be reduced by using a structure in which the first winding section 312 and the second winding section 313 are located at the two ends of the first body 311. Similarly, a size of the parasitic dipole 32 in the second direction A2 may be reduced by using a structure in which the third winding section 322 and the fourth winding section 323 are located at the two ends of the second body 321. In another aspect, the first winding line 33 and the second winding line 34 are configured to form radiation-free inductive load to reduce the size of the folded dipole 30.

[0080] A first spacing 35 is formed between the first winding section 312 and the third winding section 322. A second spacing 36 is formed between the second winding section 313 and the fourth winding section 323. The first winding line 33 and the second winding line 34 are located between the first spacing 35 and the second spacing 36. In other words, a vertical projection of the first winding line 33 and a vertical projection of the second winding line 34 on the first body 311 are located inside the first body 311. In such an architecture, the first winding part line 33 and the second winding line 34 form a concave architecture. This facilitates a design of a small size of the folded dipole 30. It may be understood that, when a size in the second direction A2 is allowed, the first winding part line 33 and/or the second winding line 34 may alternatively form a convex architecture. Specifically, the first winding part line 33 and the first body 311 are separately located on two sides of the first winding section 312 (where in the implementation shown in FIG. 12, the first winding part line 33 and the first body 311 are located on a same side of the first winding section 312).

[0081] Refer to FIG. 12. The first stub 3111 is electrically connected to the first metal structure 21, and the second stub 3112 is electrically connected to the second metal structure 22, to enable the internal space of the folded dipole 30 to form a resonant tank of the tapered slot antenna 20. In the first direction A1, that a gap 37 between the first stub 3111 and the second stub 3112 directly faces the narrow-gap end 241 of the tapered slot 24 may be understood as that an extension direction of a connection line between a middle position of the gap 37 and a middle position of the narrow-gap end 241 is the first direction A1. For the gap 37 and the narrow-gap end 241, a size of the gap 37 and a size of the narrow-gap end 241 in the second direction A2 are widths. The width of the gap 37 may be greater than the width of the narrow-gap end 241. In a possible implementation, a connection line between an inner wall of the gap 37 and an inner wall of the narrow-gap end 241 is in a smooth transition state, and may be open and extended in a horn shape. In this way, a size changes gradually from the narrow-gap end 241 to the gap 37, and then to the internal space of the folded dipole 30. Such a design helps the folded dipole 30 serve as the resonant tank to feed and tune the tapered slot antenna 20.

[0082] In a possible implementation, the first stub 3111 includes a first connection part 38, and the first connection part 38 is connected to the first metal structure 21. The second stub 3112 includes a second connection part 39, and the second connection part 39 is connected to the second metal structure 22. Both the first connection part 38 and the second connection part 39 are adjacent to the narrow-gap end 241. In the first direction A1, a size in which the first connection part 38 extends is greater than a size in which the second connection part 39 extends. In this way, the first stub 3111 and the first metal structure 21 jointly form the first spacing area R1 having a first opening, and the first opening is located at one end that is of the first spacing area R1 and that is away from the tapered slot 24. The second stub 3112 and the second metal structure 22 jointly form the second spacing area R2 having a second opening, and the second opening is located at an end that is of the second spacing area R2 and that is away from the tapered slot 24. A size of the first spacing area R1 is smaller than a size of the second spacing area R2. In this implementation, a part of the first stub 3111 is widened. The widened area is reserved for configuring a feeding structure. To be specific, the feeding structure may be installed on the first connection part 38 by using a design of the size of the first connection part 38.

[0083] Refer to FIG. 12, FIG. 7, and FIG. 8. In a possible implementation, the first connection part 38 is provided with a through hole 381. The feeding structure 40 includes an inner conductor 41 and an external conductor 42. The feeding structure 40 passes through the through hole 381 (specifically, the external conductor 42 passes through the through hole 381). The external conductor 42 is electrically connected to the first stub 3111 (specifically, electrically connected to the first connection part 38) after passing through the through hole 381. The inner conductor 41 is electrically connected to the second stub 3112 across the gap 37. The feeding structure 40 may be a feeding cable, and a feeding manner provided in this application is simple and easy to implement. In this application, feeding by using a microstrip is not required. The microstrip affects a radiation size of the folded dipole 30 and a radiation size of the tapered slot antenna 20, and occupies carrier board area. Feeding by using a manner in which the feeding cable is connected to the first connection part does not affect radiation performance of the folded dipole 30 and the tapered slot antenna 20. The external conductor 42 of the feeding structure 40 is configured to be grounded, and the inner conductor 41 is configured to transmit a signal. For the tapered slot antenna 20, the first metal structure 21 is the ground of the antenna in this application, an electrical potential of the second metal structure 22 and an electrical potential of the first metal structure 21 are different. The second metal structure 22 is electrically connected to the inner conductor 41. For the folded dipole 30, the first stub 3111 is electrically connected to the external conductor 42 of the feeding structure 40, the first stub 3111 is grounded, and the second stub 3112 is electrically connected to the inner conductor 41. Therefore, in the folded dipole 30 of the antenna provided in this application, an electrical potential of the second stub 3112 and an electrical potential of the first stub 3 111 are different.

[0084] In another implementation, if a size in the second direction A2 is allowed, the main dipole 31 and the parasitic dipole 32 each may alternatively be disposed in a straight strip shape. In other words, two ends of the main dipole 31 and two ends of the parasitic dipole 32 are not wound. In this way, the size of the folded dipole

30 in the first direction A1 may be saved. Correspondingly, the first winding line 33 and the second winding line 34 in the folded dipole 30 may alternatively be replaced by a transmission line in a straight line shape. As shown in FIG. 13, a folded dipole 30 in an implementation shown in FIG. 13 is in a simpler form, is in a rectangular structure, and is formed by using connected straight strip microstrips.

[0085] In this application, a feeding structure 40 is electrically connected between a first stub 3111 and a second stub 3112, and feeds the folded dipole 30 and a tapered slot antenna 20 at the same time, to excite the tapered slot antenna 20 that is a directional antenna and excite the folded dipole 30 that is an omnidirectional antenna.

[0086] In a possible implementation, an operating frequency of the tapered slot antenna 20 is lower than an operating frequency of the folded dipole 30. A range of the operating frequency of the folded dipole 30 is 6 GHz to 7.125 GHz, and a range of the operating frequency of the tapered slot antenna 20 is 5.1 GHz to 5.9 GHz. The tapered slot antenna 20 and the folded dipole 30 in the antenna provided in this implementation have different operating frequency ranges, and radiate different signals. This improves an application scope of the antenna and highlights an advantage of a miniaturized antenna.

[0087] In the implementations shown in FIG. 6 and FIG. 9 to FIG. 13, in the second direction A2, a maximum size of the folded dipole 30 is smaller than or equal to a maximum size of the tapered slot antenna 20. In this application, a maximum size of the antenna in the second direction A2 is limited to a size in which the folded dipole 30 extends in the second direction A2. The tapered slot antenna 20 is disposed within a size range limited by the folded dipole 30 in the second direction A2. This helps miniaturize the antenna.

[0088] Refer to FIG. 14. In a possible implementation, an antenna further includes a parasitic element 50. The parasitic element 50 is located on a side that is of a tapered slot antenna 20 and that is away from a folded dipole 30, for improving a gain of the tapered slot antenna 20. Specifically, the parasitic element 50 is a dipole antenna, and an extension direction of the parasitic element 50 is a second direction A2. Specifically, the parasitic element 50 extends in the second direction A2 in a straight line shape, and the second direction A2 is perpendicular to a first direction A1. The parasitic element 50 is in a symmetric structure by using a central axis C1 of a tapered slot 24 as a center. That an electrical length of the parasitic element 50 is smaller than an electrical length of a wide-gap end 242 may be understood as that a vertical projection of the parasitic element 50 at the opening end 242 of the tapered slot antenna 20 is located within a range of the opening end 242. To be specific, vertical distances between two ends of the parasitic element 50 and the central axis C1 of the tapered slot 24 are both less than vertical distances between two ends of the opening end 242 and the central axis C1 of the tapered slot 24.

[0089] The tapered slot antenna 20 can be excited to operate in a high frequency bandwidth. The high frequency bandwidth includes a high frequency band and a low frequency band. The parasitic element 50 is configured to enhance a radiated electromagnetic wave of the tapered slot antenna 20 on the low frequency band, and the parasitic element 50 is configured to reflect a radiated electromagnetic wave of the tapered slot antenna 20 on the high frequency band. The high frequency bandwidth includes a maximum operating frequency and a minimum operating frequency. An electrical length of the parasitic element 50 is smaller than or equal to a half wavelength of a radiated electromagnetic wave of the tapered slot antenna 20 at the minimum operating frequency, and is greater than a half wavelength of a radiated electromagnetic wave of the tapered slot antenna 20 at the maximum operating frequency. A spacing between the parasitic element 50 and the wide-gap end 242 is a quarter wavelength of an electromagnetic wave on a frequency band in which the parasitic element 50 effectively acts on the tapered slot antenna 20.

[0090] Refer to FIG. 15. In a possible implementation, there are at least two parasitic elements 50 (where three parasitic elements 50 are included in the implementation shown in FIG. 15). The at least two parasitic elements 50 are alternately arranged along a first direction A1. A spacing D2 between the parasitic element 50 closest to a wide-gap end 242 and the wide-gap end 242 is a quarter wavelength of an electromagnetic wave on a frequency band in which the parasitic element 50 effectively acts on a tapered slot antenna 20. A spacing between adjacent parasitic elements 50 may alternatively be D2. In other words, the spacing between the adjacent parasitic elements 50 may alternatively be a quarter wavelength of the electromagnetic wave on the frequency band in which the parasitic element 50 acts on the tapered slot antenna 20.

[0091] In this application, the parasitic element 50 is added in the first direction A1, to enhance a gain of the tapered slot antenna 20 on a specific frequency band, so that energy radiation of the tapered slot antenna 20 has better directivity. An electrical length of the parasitic element 50 is set, to be specific, a length of the parasitic element 50 is slightly smaller than a half wavelength corresponding to a specific frequency, to enhance a direction function of an electromagnetic wave. Specifically, this application is mainly designed based on a low frequency enhancement gain. Therefore, for a length and a spacing of the parasitic element 50, refer to an operating wavelength corresponding to the tapered slot antenna in a low frequency band range. It may be understood that, under a condition of keeping a same spacing progressive, when a quantity of parasitic elements 50 is set to a plurality, a direction function may be enhanced. In a high frequency band range, because the electrical length of the parasitic element is excessively long, the parasitic element serves as a reflection parasitic element 50, so that single-beam radiation becomes a multi-beam radiation in a reverse direction. Finally, such characteristic causes the entire tapered slot antenna 20 to present different radiation effects on two sub-bands of a wide frequency band: a high frequency sub-band and a low frequency sub-band. This characteristic well matches a differentiated application requirement of a current Wi-Fi frequency band for different spectra.

[0092] In summary, the antenna provided in this application may be disposed on a surface of the dielectric plate 10. In the implementations shown in FIG. 6 and FIG. 9 to FIG. 15, the tapered slot antenna, the folded dipole, and the parasitic element are all located on a same surface of the dielectric plate 10. For example, the tapered slot antenna 20 and the folded dipole 30 are disposed on a front side of the dielectric plate 10. The feeding structure 40 passes through the dielectric plate 10 from a back side of the dielectric plate 10. The external conductor 42 of the feeding structure 40 is electrically connected to the first stub 3111, for example, electrically connected in a welding manner. The inner conductor 41 is electrically connected to the second stub 3112. Specifically, the first stub 3111 and the first metal structure 21 are connected to each other as a whole to form a floor of the antenna. The external conductor 42 of the feeding structure 40 is electrically connected to the first stub 3111 for grounding. The second stub 3112 and the second metal structure 22 are connected to each other as a whole. The inner conductor 41 is electrically connected to the second stub 3112. A feeding coplanar waveguide structure is formed at a joint between the first stub 3111 and the second stub 3112. The feeding coplanar waveguide structure is fed by using the feeding structure 40.

[0093] In another possible implementation, the antenna may be distributed on different surfaces of the dielectric plate 10. For example, an example in which the antenna is distributed on two surfaces of the dielectric plate 10 is used. Refer to FIG. 16 to FIG. 17, FIG. 18 to FIG. 19, and FIG. 20 to FIG. 21. The dielectric plate 10 includes a first surface S1 and a second surface S2 that are disposed in a stacked manner.

[0094] As shown in FIG. 16 and FIG. 17, a second metal structure 22, a second stub 3112, a second winding line 34, a part of a parasitic dipole 32, and a parasitic element 50 are located on the first surface S1. A first metal structure 21, a first stub 3111, a first winding line 33, and the other part of the parasitic dipole 32 are located on the second surface S2. The parasitic dipole 32 located on the first surface S1 and the parasitic dipole 32 located on the second surface S2 are electrically connected by using a metal via on the dielectric plate 10.

[0095] As shown in FIG. 18 and FIG. 19, a parasitic dipole 32 is located on the first surface S1. A main dipole 31 (including a first stub 3111 and a second stub 3112), a first metal structure 21, a second metal structure 22, and a parasitic element 50 are located on the second surface S2. The parasitic dipole 32 and the main dipole 31 are electrically connected by using a metal via on the dielectric plate 10.

[0096] As shown in FIG. 20 and FIG. 21, a folded dipole 30 and a tapered slot antenna 20 are located on the first surface S1. A parasitic element 50 is located on the second surface S2. In this implementation, the first surface S1 and the second surface S2 do not need to be electrically connected.

[0097] This application may further include the following specific implementation. For example, the tapered slot antenna is located on the first surface, and the folded dipole is located on the second surface. It may be understood that the tapered slot antenna and the folded dipole may alternatively be distributed on three or more layers. If electrical connection is required between the folded dipole and the tapered slot antenna that do not share the same surface, the electrical connection may be implemented by using a metal via between dielectric substrates.

[0098] The tapered slot antenna provided in this application is a directional antenna having a broadband and a high gain characteristic, and enhances an antenna radiation capability on the high frequency band. For example, the tapered slot antenna may perform coverage on a 5 GHz frequency band, or may perform cascaded backhaul on a Sub-7 GHz frequency band (where the cascaded backhaul mainly means that data or video traffic from one device to another device is transmitted to a next-level gateway in a wireless manner). FIG. 22 is a curve diagram of an S parameter of an antenna according to an implementation of this application. It may be learned from the diagram that an effective bandwidth range of the antenna provided in this application is 5.3 GHz to 7 GHz.

[0099] FIG. 23 schematically shows radiation patterns of an antenna at four different operating frequencies (which are separately 5.5 GHz, 5.9 GHz, 6.5 GHz, and 7 GHz) according to an implementation of this application. A solid line and a dashed line are used to separately represent radiation patterns of different polarizations. A pattern corresponding to the solid line represents an E-plane pattern. A pattern corresponding to the dashed line represents an H-plane pattern. The E-plane is a plane on which an electric field vector direction and a maximum propagation direction are located. The H plane is a plane on which a magnetic field vector direction and a maximum propagation direction are located. For example, the E plane is an XOZ plane, and the H plane is a YOZ plane. The radiation patterns at the two frequencies of 5.5 GHz and 5.9 GHz represent radiation patterns of a tapered slot antenna. It may be learned from the radiation patterns that, in operating states of the two frequencies, a directional gain effect of the antenna is good. The radiation patterns at the two frequencies of 6.5 GHz and 7 GHz represent a radiation pattern under a common action of a folded dipole, the tapered slot antenna, and a parasitic element having an electromagnetic wave reflection effect. It may be learned from the radiation patterns that, in operating states of the two frequencies, a wide-angle multi-beam characteristic can be implemented. The radiation direction is opposite to a radiation direction on a low frequency band. This can implement upward and downward seamless cascading, and cascading networking and backhaul can be implemented in a high-frequency and wide-bandwidth mode in this application.

[0100] 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 tapered slot antenna, a folded dipole, and a feeding structure, wherein

    the tapered slot antenna comprises a first metal structure and a second metal structure, a tapered slot is formed between the first metal structure and the second metal structure, an extension direction of the tapered slot is a first direction, and two ends of the tapered slot are a narrow-gap end and a wide-gap end;
    an extension direction of the folded dipole is a second direction, the second direction intersects with the first direction, the folded dipole comprises a main dipole and a parasitic dipole that are disposed opposite to each other, an area between the main dipole and the parasitic dipole forms internal space of the folded dipole, the main dipole is located between the parasitic dipole and the narrow-gap end, the main dipole comprises a first stub and a second stub that are alternately arranged in the second direction, the first stub is electrically connected to the first metal structure, and the second stub is electrically connected to the second metal structure, to enable the internal space of the folded dipole to form a resonant tank of the tapered slot antenna; and
    the feeding structure is electrically connected between the first stub and the second stub, and feeds the folded dipole and the tapered slot antenna at the same time, to excite the tapered slot antenna that is a directional antenna and excite the folded dipole that is an omnidirectional antenna.

2. The antenna according to claim 1, wherein an operating frequency of the tapered slot antenna is lower than an operating frequency of the folded dipole.

3. The antenna according to claim 2, wherein the first stub comprises a first connection part, the first connection part is connected to the first metal structure, the second stub comprises a second connection part, the second connection part is connected to the second metal structure, and in the first direction, a size in which the first connection part extends is greater than a size in which the second connection part extends.

4. The antenna according to claim 3, wherein the first connection part is provided with a through hole, the feeding structure comprises an inner conductor and an external conductor, the feeding structure passes through the through hole, the external conductor is electrically connected to the first connection part, and the inner conductor is electrically connected to the second stub.

5. The antenna according to claim 1, wherein the first metal structure comprises a first microstrip and a first comb structure, the first microstrip comprises a first edge facing the tapered slot and a second edge away from the tapered slot, the first comb structure is connected to the second edge and extends from the second edge to a direction away from the first edge, and an electrical length of the first comb structure is a quarter wavelength of an operating frequency of the tapered slot antenna.

6. The antenna according to claim 5, wherein the second metal structure comprises a second microstrip and a second comb structure, the second microstrip comprises a third edge facing the tapered slot and a fourth edge away from the tapered slot, the second comb structure is connected to the fourth edge and extends from the fourth edge to a direction away from the third edge, an electrical length of the second comb structure is the quarter wavelength of the operating frequency of the tapered slot antenna, and the first comb structure and the second comb structure are symmetrically distributed on two sides of the tapered slot.

7. The antenna according to claim 6, wherein there are at least two first comb structures and at least two second comb structures, the at least two first comb structures are unequal in length and are alternately disposed, the first comb structure closer to the wide-gap end has a larger length, the at least two second comb structures are unequal in length and are alternately disposed, and the second comb structure closer to the wide-gap end has a larger length.

8. The antenna according to claim 7, wherein the tapered slot antenna can be excited to operate in a high frequency bandwidth, the high frequency bandwidth comprises a maximum operating frequency

and a minimum operating frequency, an electrical length of the first comb structure adjacent to the narrow-gap end is a quarter wavelength of the maximum operating frequency of the tapered slot antenna, and an electrical length of the first comb structure adjacent to the wide-gap end is a quarter wavelength of the minimum operating frequency of the tapered slot antenna.

9. The antenna according to claim 6, wherein the first comb structure comprises a first comb located at a position of the wide-gap end, the second comb structure comprises a second comb tooth located at a position of the wide-gap end, and a distance between an end part that is of the first comb tooth and that is away from the first microstrip and an end part that is of the second comb tooth and that is away from the second microstrip is a half wavelength of the operating frequency of the tapered slot antenna.

10. The antenna according to claim 1, wherein the main dipole comprises a first body and a first winding section and a second winding section that are separately located at two ends of the first body, the first body comprises the first stub and the second stub, the parasitic dipole comprises a second body and a third winding section and a fourth winding section that are separately located at two ends of the second body, the folded dipole further comprises a first winding line connected between the first winding section and the third winding section and a second winding line connected between the second winding section and the fourth winding section, and the first winding line and the second winding line are disposed opposite to each other.

11. The antenna according to claim 10, wherein in the second direction, a maximum size of the folded dipole is smaller than or equal to a maximum size of the tapered slot antenna.

12. The antenna according to claim 1, wherein the antenna further comprises a parasitic element, and the parasitic element is located on a side that is of the tapered slot antenna and that is away from the folded dipole, for improving a gain of the tapered slot antenna.

13. The antenna according to claim 12, wherein the parasitic element is in a straight strip shape, and an extension direction is the second direction.

14. The antenna according to claim 12, wherein the tapered slot antenna can be excited to operate in a high frequency bandwidth, the high frequency bandwidth comprises a high frequency band and a low frequency band, and when the tapered slot antenna operates on the low frequency band status, the parasitic element is configured to enhance a radiated electromagnetic wave of the tapered slot antenna on the low frequency band, or when the tapered slot antenna operates on the high frequency band status, the parasitic element reflects a radiated electromagnetic wave of the tapered slot antenna on the high frequency band.

15. The antenna according to claim 14, wherein the high frequency bandwidth comprises a maximum operating frequency and a minimum operating frequency, and an electrical length of the parasitic element is smaller than or equal to a half wavelength of a radiated electromagnetic wave of the tapered slot antenna at the minimum operating frequency, and is greater than a half wavelength of a radiated electromagnetic wave of the tapered slot antenna at the maximum operating frequency.

16. The antenna according to claim 15, wherein a spacing between the parasitic element and the wide-gap end is a quarter wavelength of an electromagnetic wave of the tapered slot antenna on a frequency band in which the parasitic element effectively acts on the tapered slot antenna.

17. The antenna according to claim 16, wherein there are at least two parasitic elements, and the at least two parasitic elements are alternately arranged in sequence along the first direction, and a spacing between adjacent parasitic elements is the quarter wavelength of the electromagnetic wave of the tapered slot antenna on the frequency band in which the parasitic element effectively acts on the tapered slot antenna.

18. The antenna according to claim 1, wherein the antenna comprises a dielectric plate for bearing the tapered slot antenna and the folded dipole, and the antenna is distributed on a same layer of the dielectric plate; or the antenna is distributed on different layers of the dielectric plate.

19. An electronic device, comprising a radio frequency circuit and the antenna according to any one of claims 1 to 18, wherein the feeding structure of the antenna is electrically connected to the radio frequency circuit.

20. An antenna module, comprising a support and the antenna according to any one of claims 1 to 18 that is connected to the support.

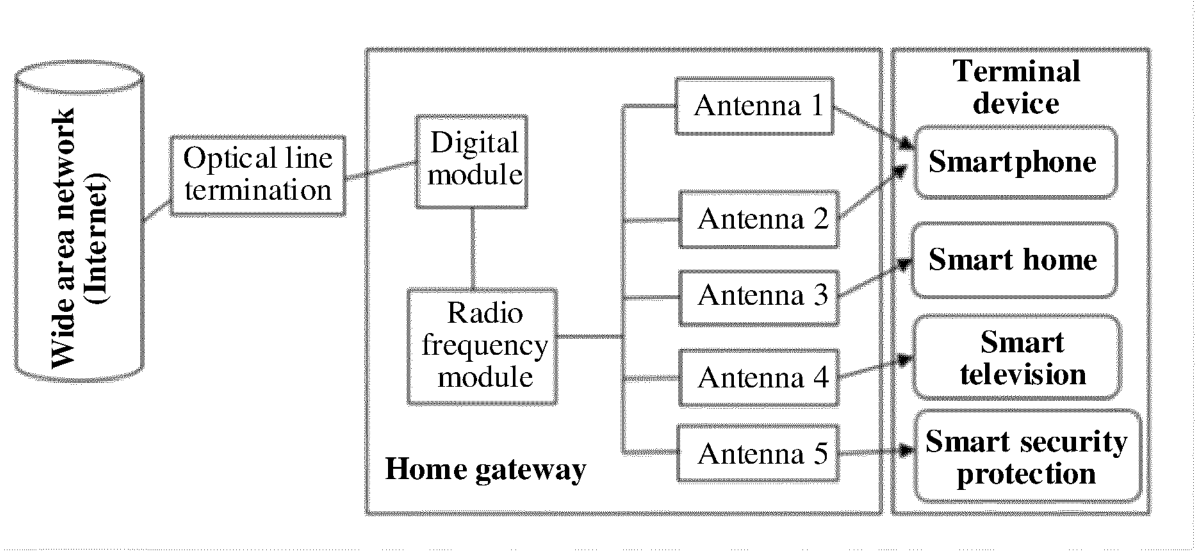

Wide area network (Internet)
Optical line termination
Digital module
Radio frequency module
Home gateway
Antenna 1
Antenna 2
Antenna 3
Antenna 4
Antenna 5
Terminal device
Smartphone
Smart home
Smart television
Smart security protection

FIG. 1

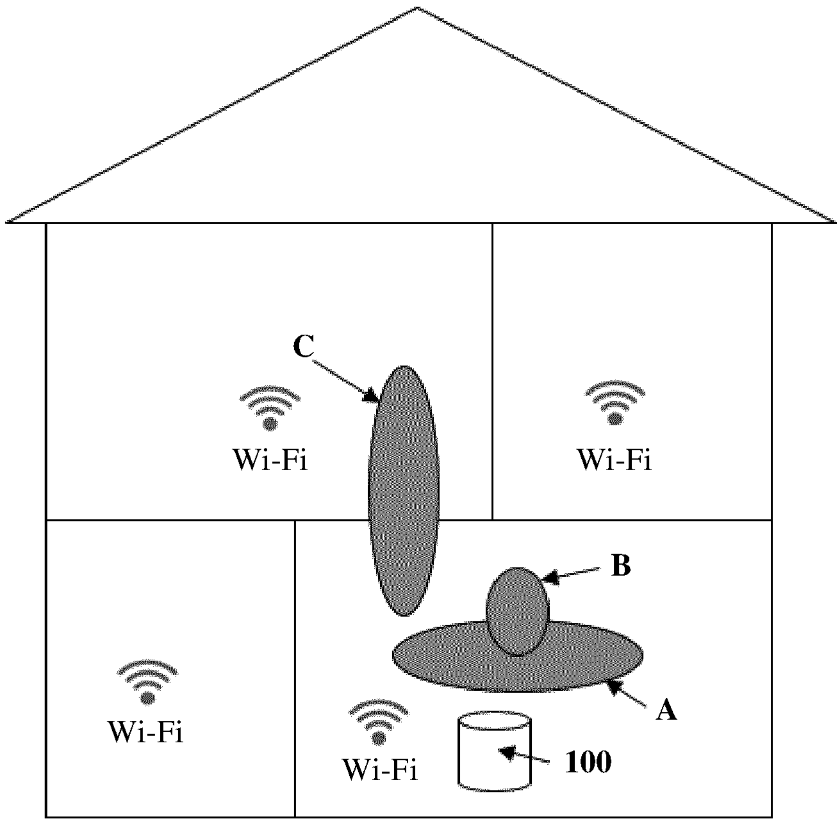

C
Wi-Fi
Wi-Fi
B
A
Wi-Fi
Wi-Fi
100

FIG. 2

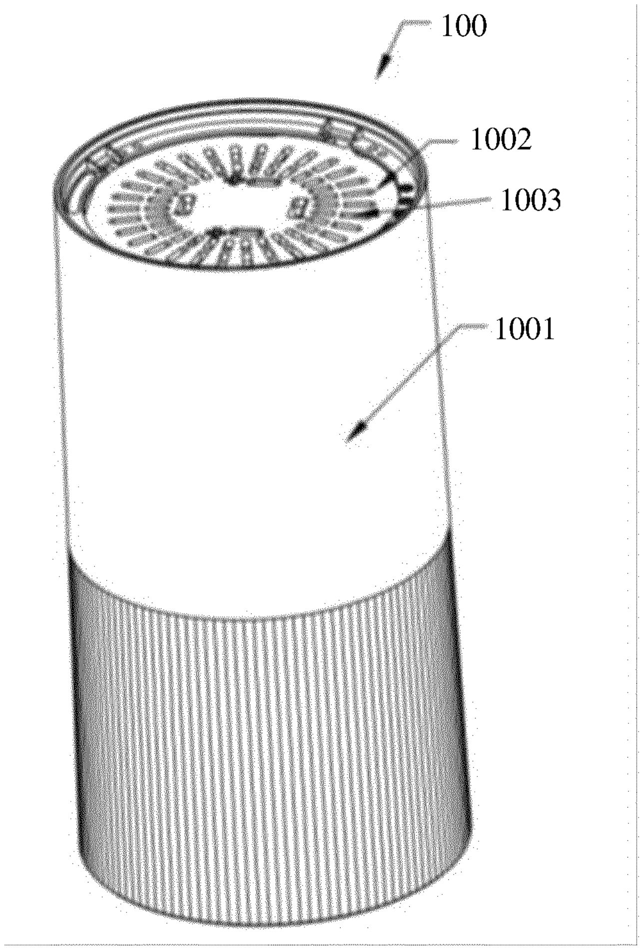


FIG. 3

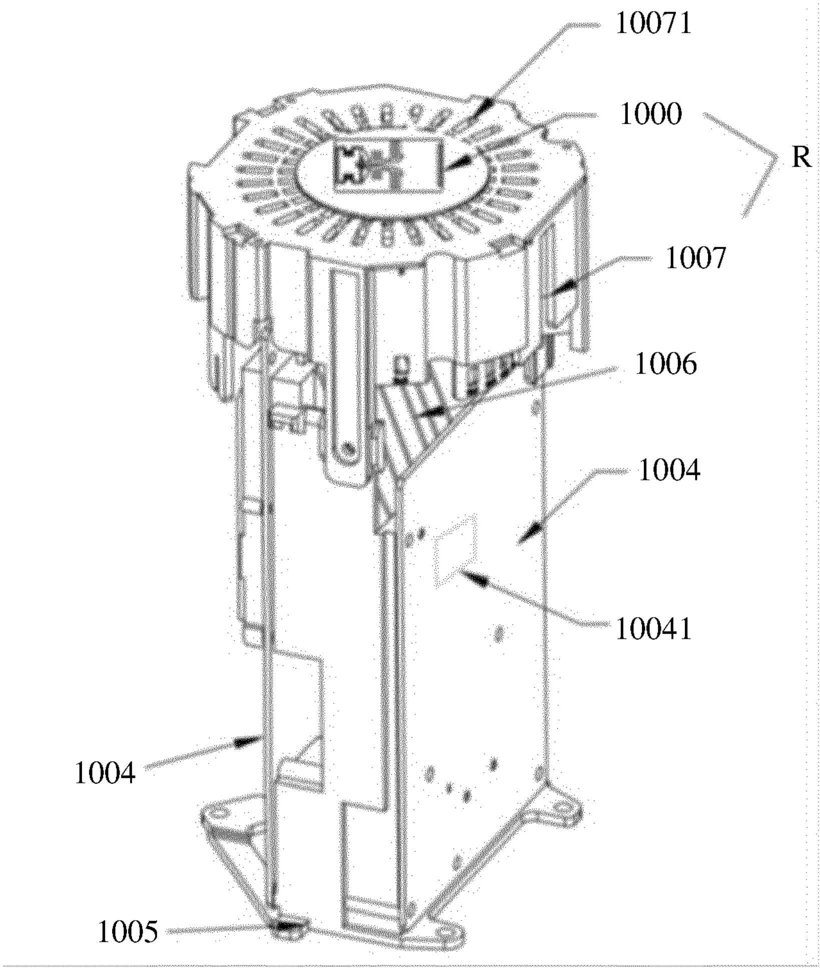


FIG. 4

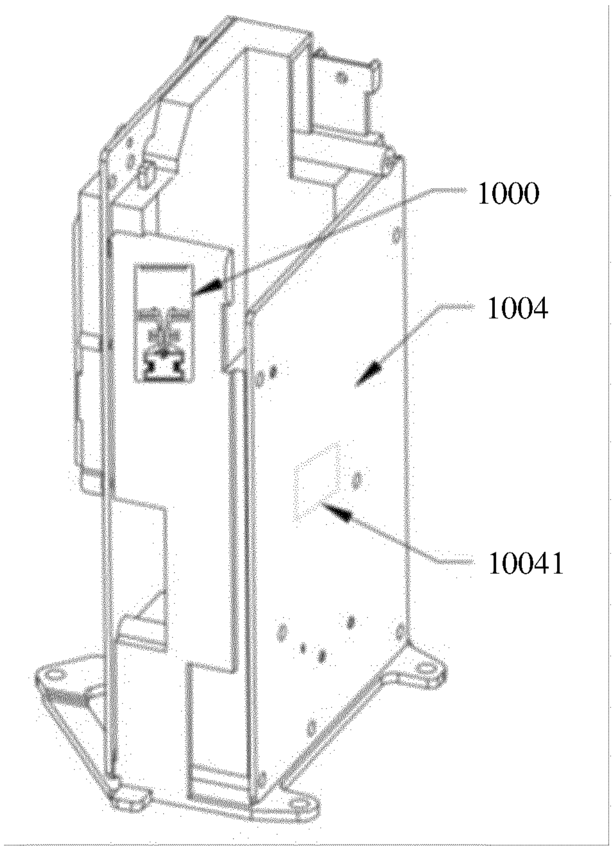
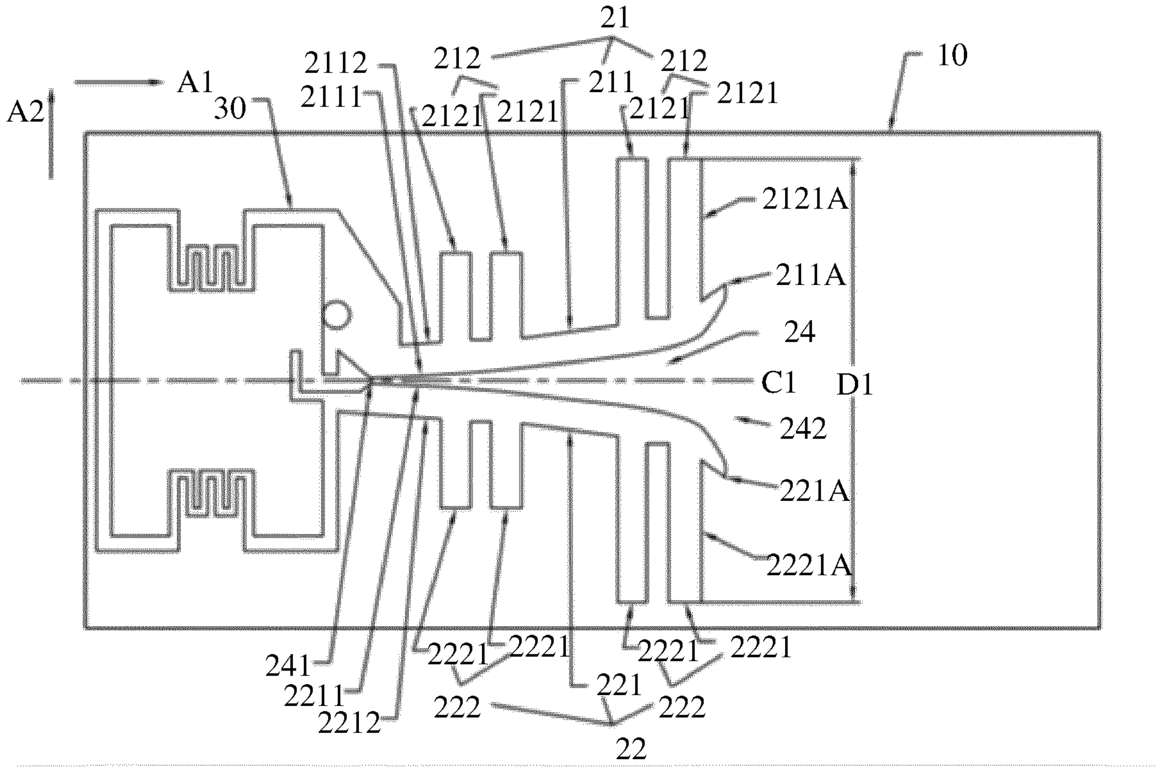


FIG. 5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212
212
2112
10
211
2111
2121
A2
A1
30
2121
2121
2121
2121A
211A
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C1
D1
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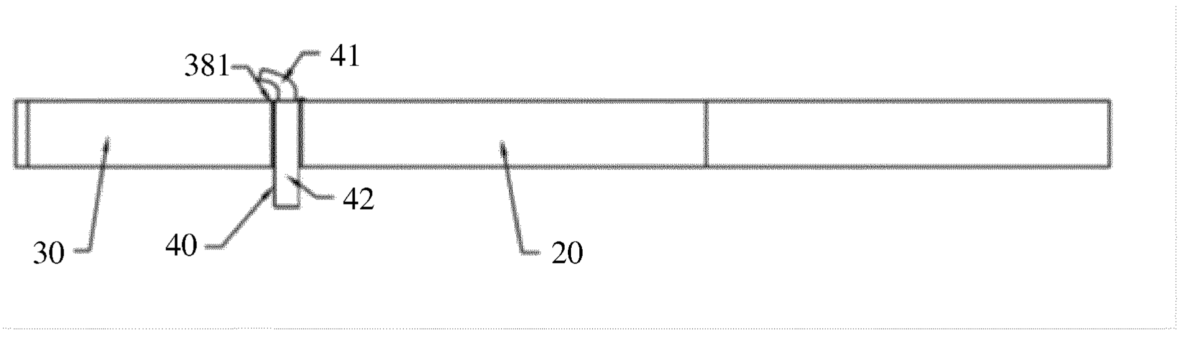
2212
222
222
22

FIG. 6


381
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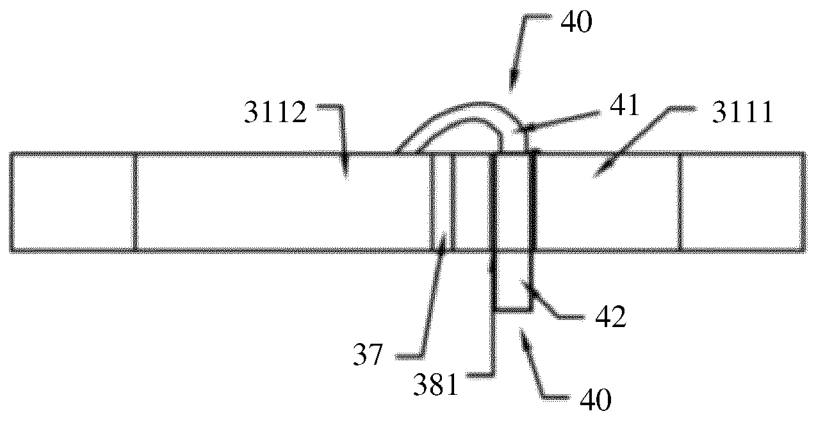
42
30
40
20

FIG. 7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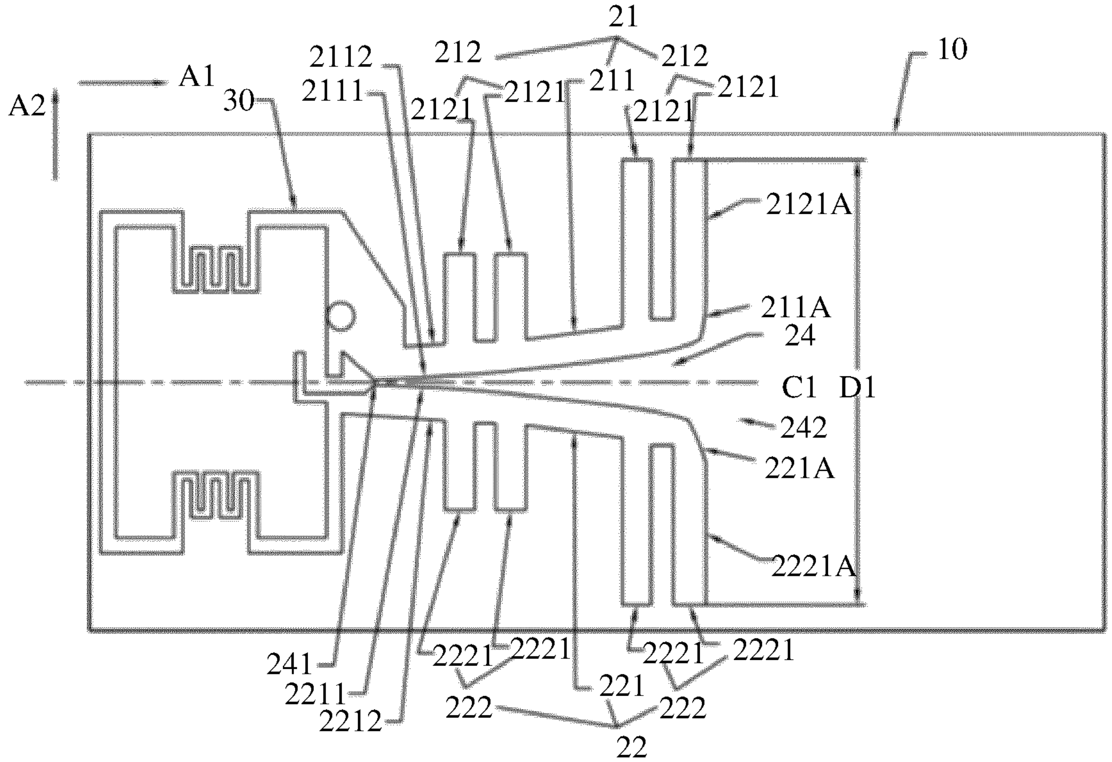
3112
41
3111
42
37
381
40

FIG. 8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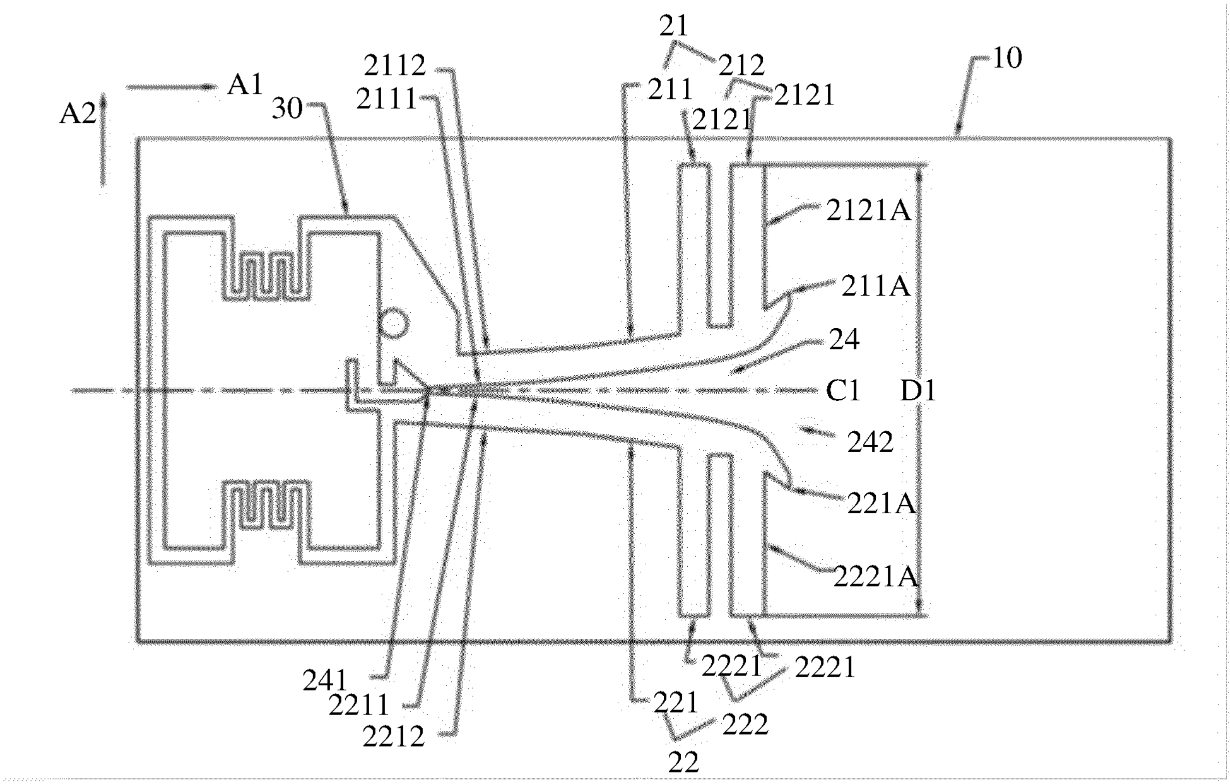
212
212
10
2112
211
2111
2121
2121
2121
2121
A2
A1
30
2121A
211A
24
C1
D1
242
221A
2221A
241
2211
2212
2221
2221
2221
2221
221
222
222
22

FIG. 9


21
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2112
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A1
211
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2121
2111
A2
30
2121
2121A
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24
C1
D1
242
221A
2221A
2221
2221
241
2211
221
222
2212
22

FIG. 10

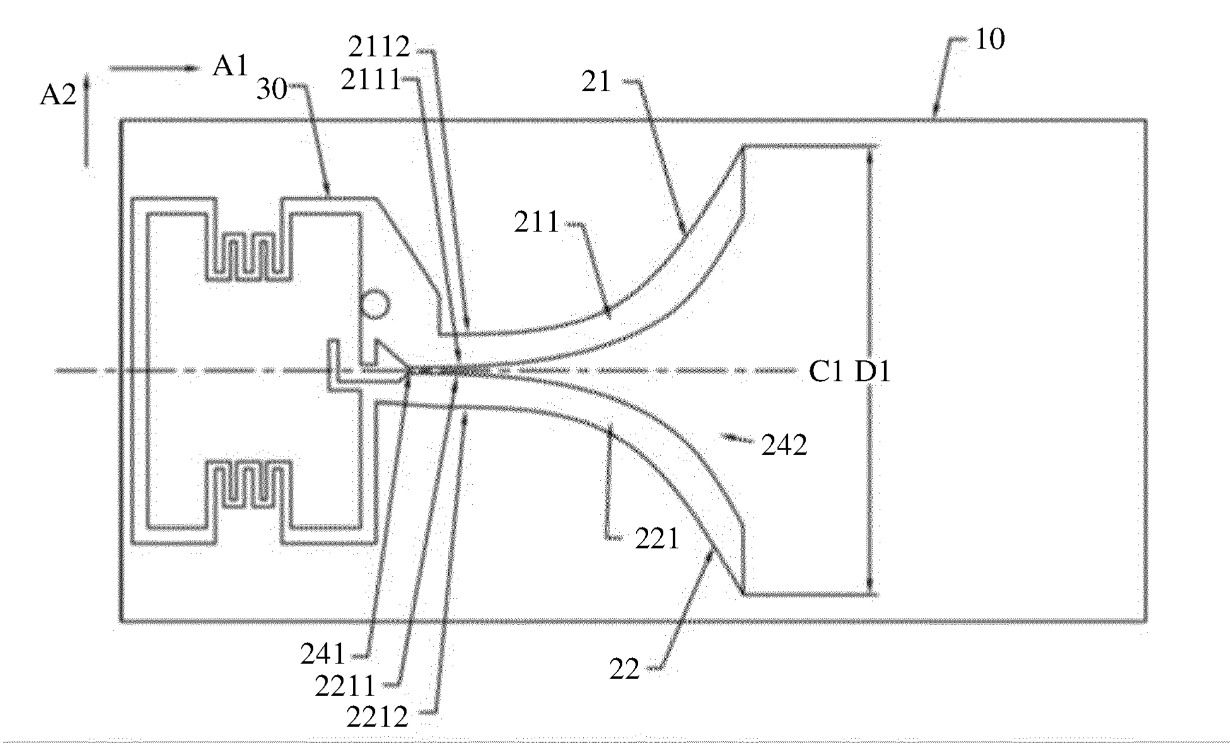
2112
10
A1
2111
21
A2
30
211
C1 D1
242
221
241
2211
22
2212

FIG. 11

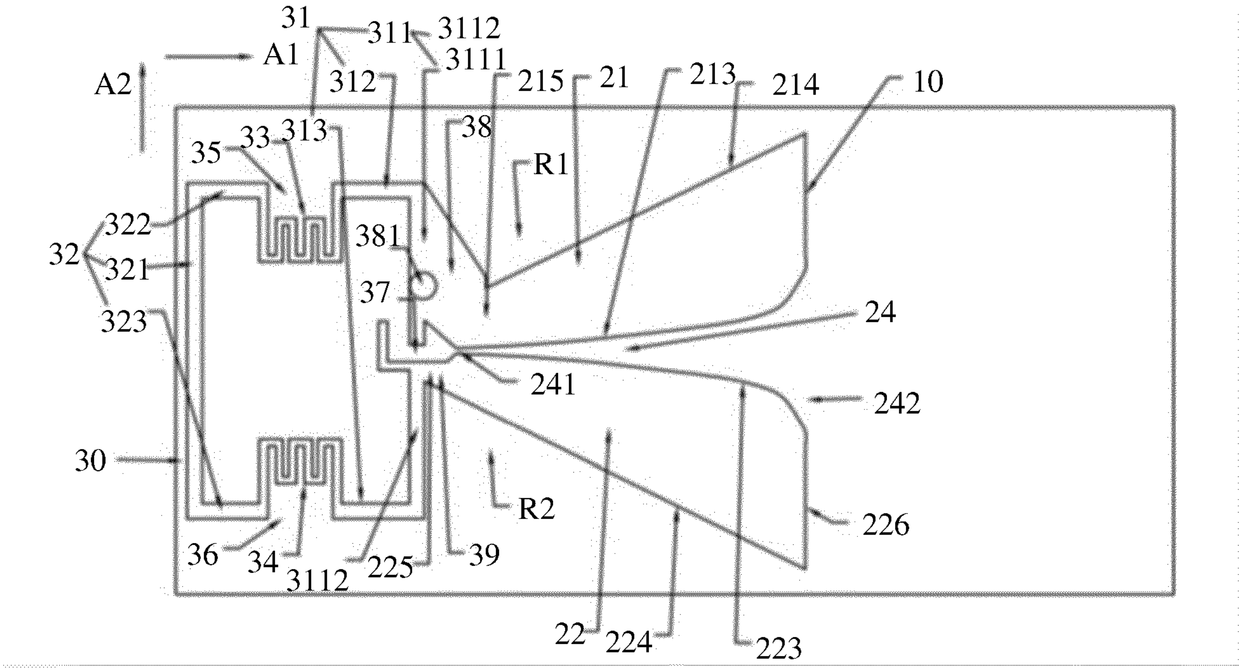
31
311
3112
3111
A1
A2
312
215
21
213
214
10
38
33
313
35
R1
322
381
32
321
37
24
323
241
242
30
R2
226
36
34
3112
225
39
22
224
223

FIG. 12

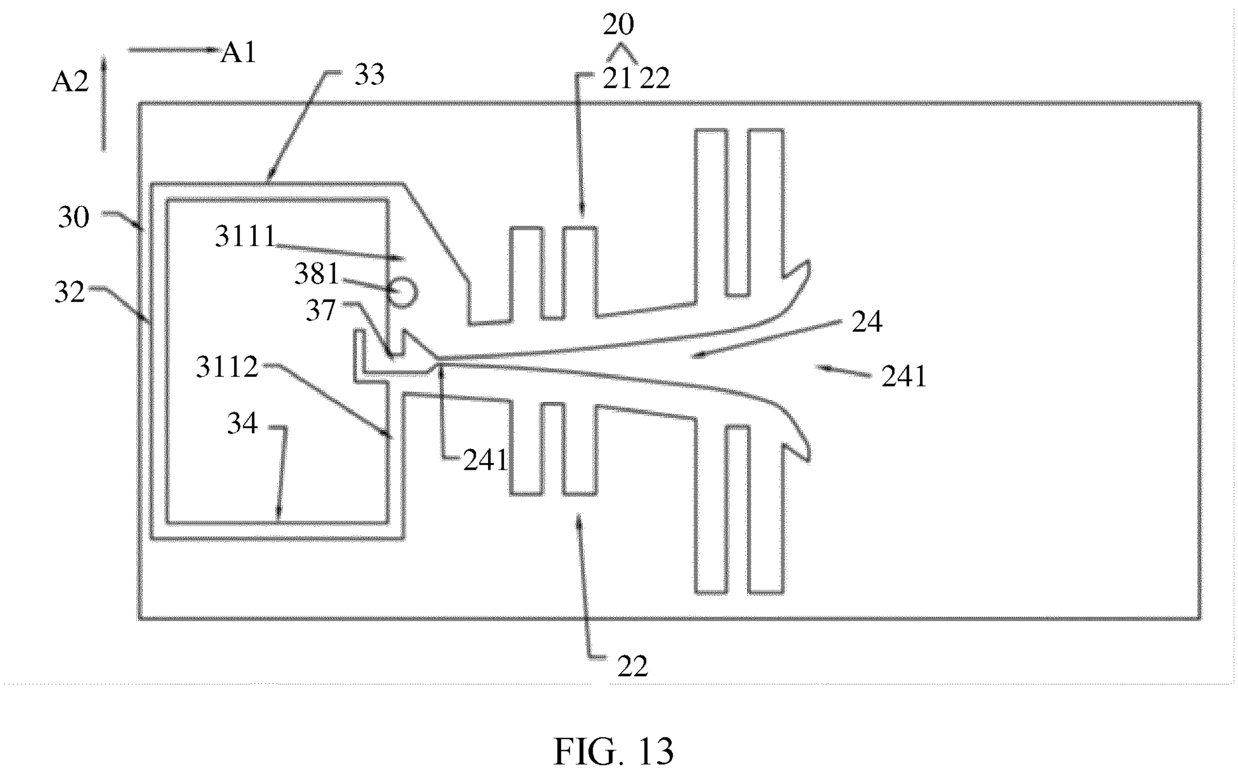
20
A1
A2
33
21
22
30
3111
381
32
37
24
3112
241
34
241
22

FIG. 13

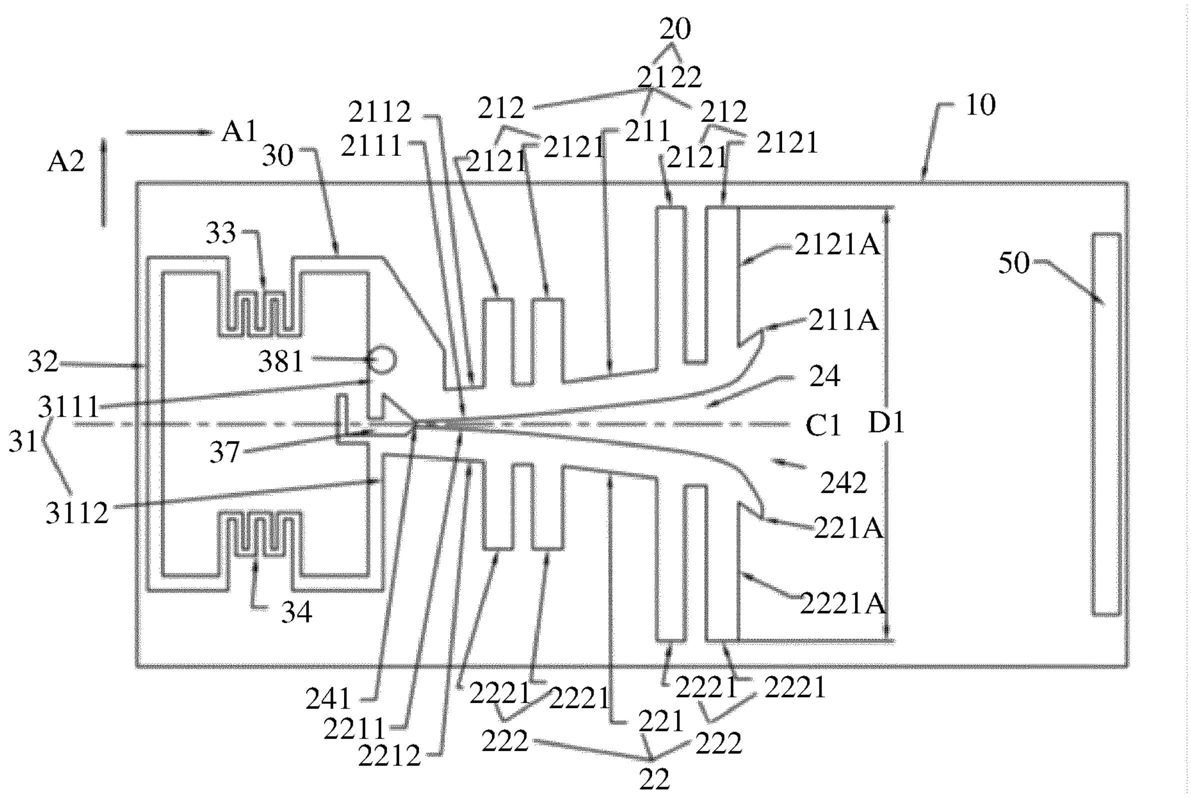
20
2122
212
212
10
2112
2111
A1
A2
30
2121
2121
211
2121
2121
2121A
33
50
211A
32
381
24
3111
31
C1
D1
37
242
3112
221A
34
2221A
241
2221
2221
2221
2221
2211
221
2212
222
222
22

FIG. 14

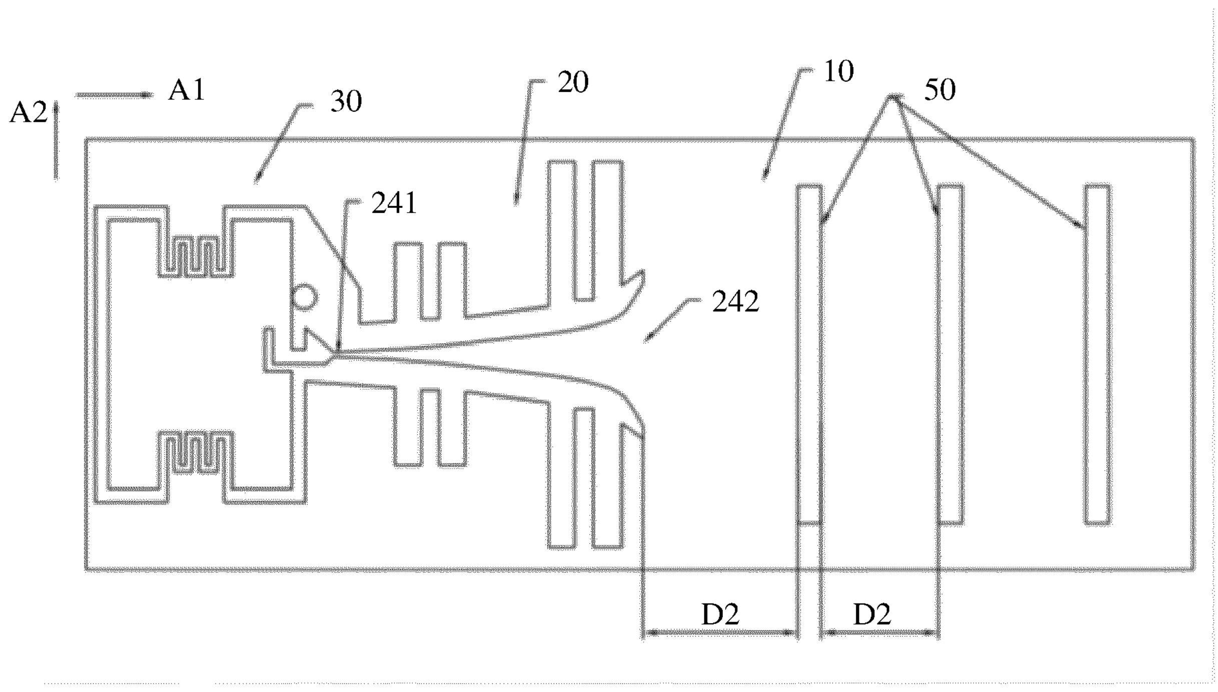
A1
A2
30
20
10
50
241
242
D2
D2

FIG. 15

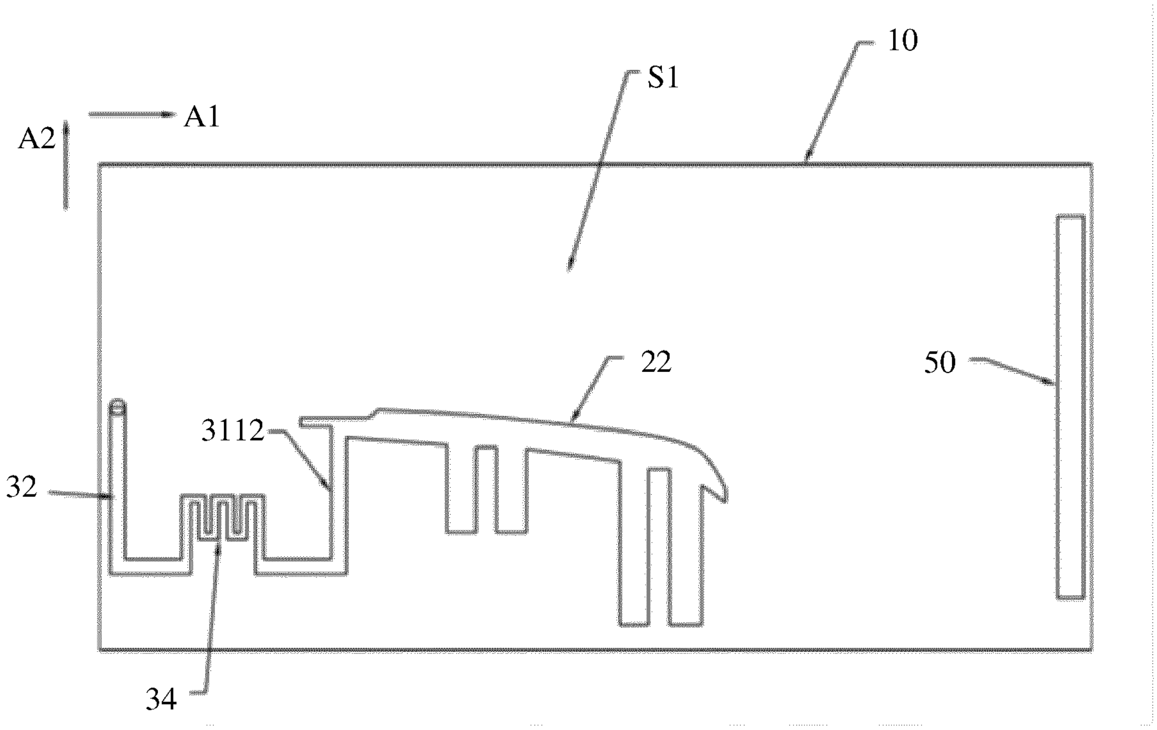

FIG. 16

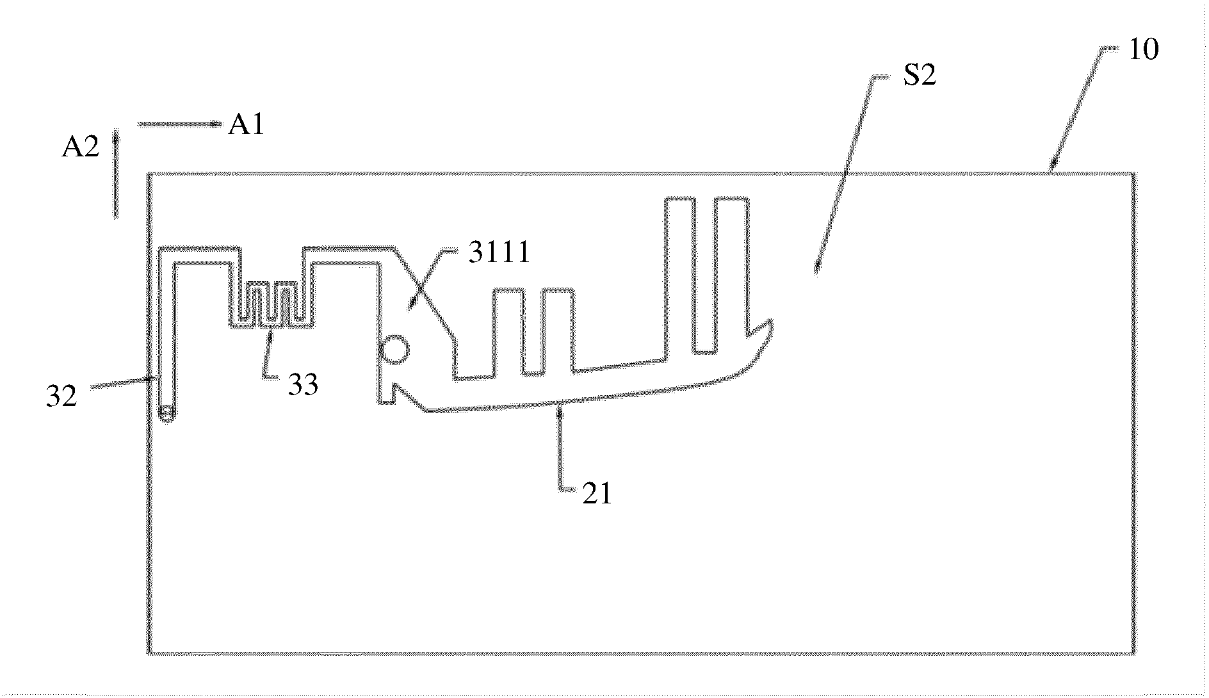

FIG. 17

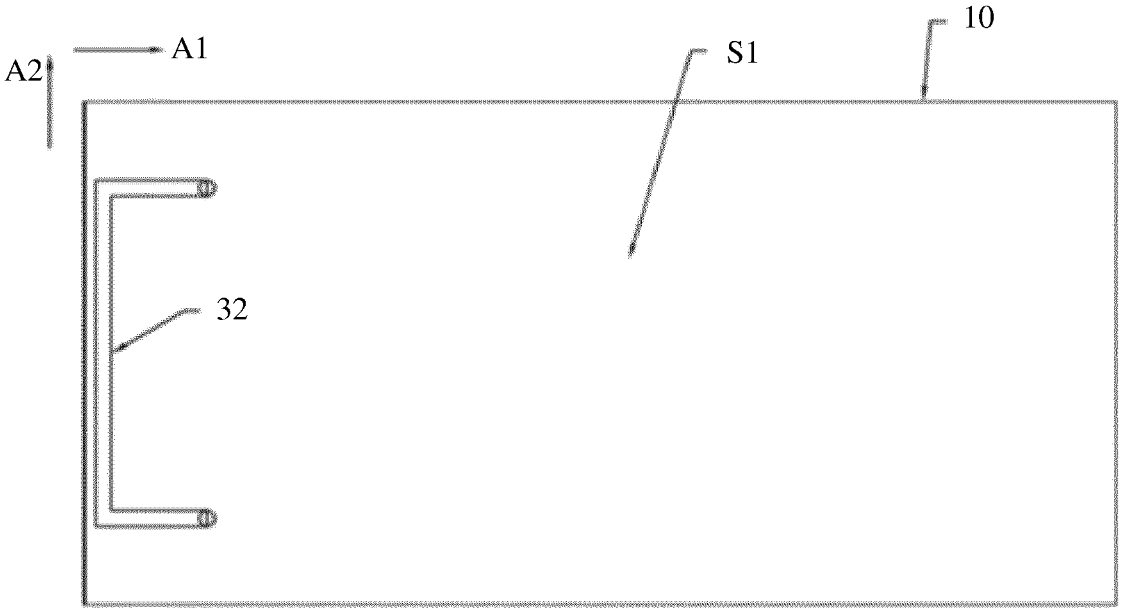

FIG. 18

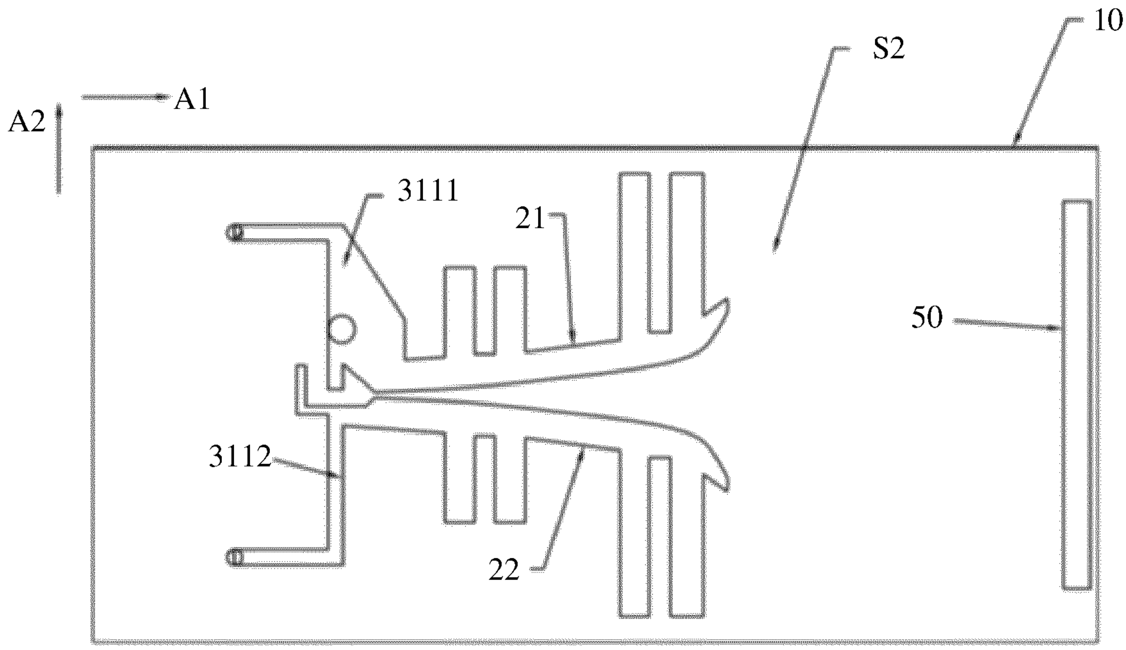

FIG. 19

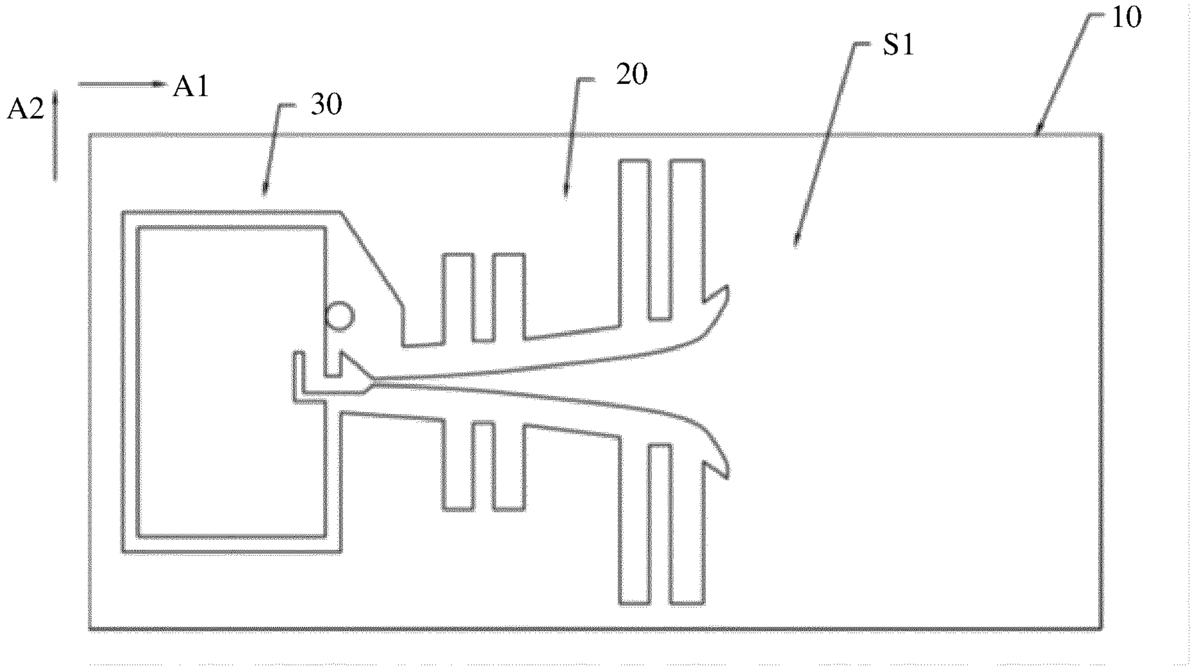

FIG. 20

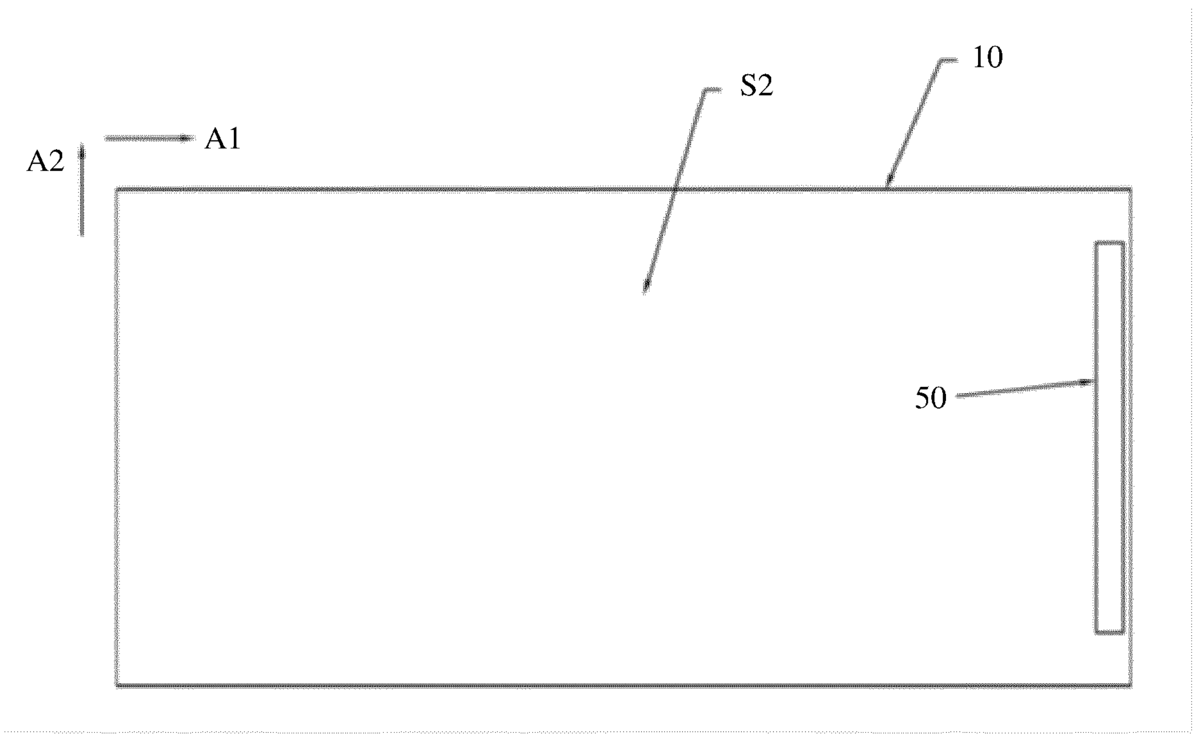

FIG. 21

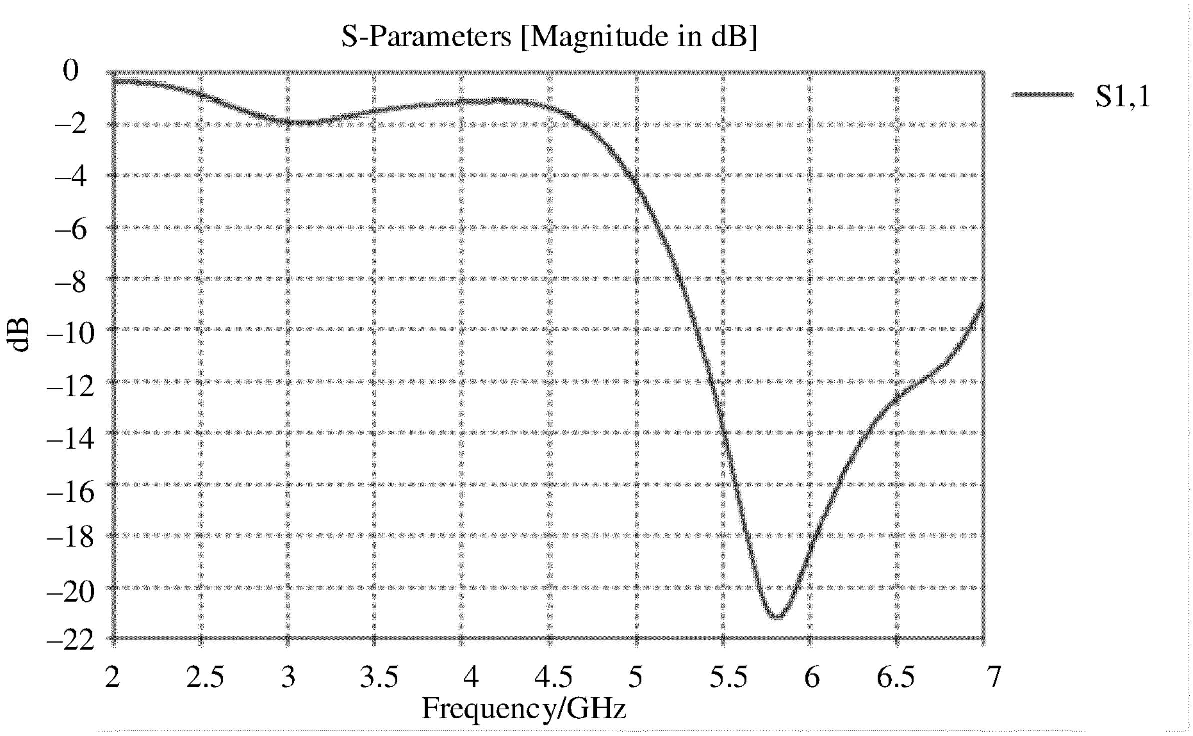
S-Parameters [Magnitude in dB]
S1,1
dB
0
−2
−4
−6
−8
−10
−12
−14
−16
−18
−20
−22
2
2.5
3
3.5
4
4.5
5
5.5
6
6.5
7
Frequency/GHz

FIG. 22

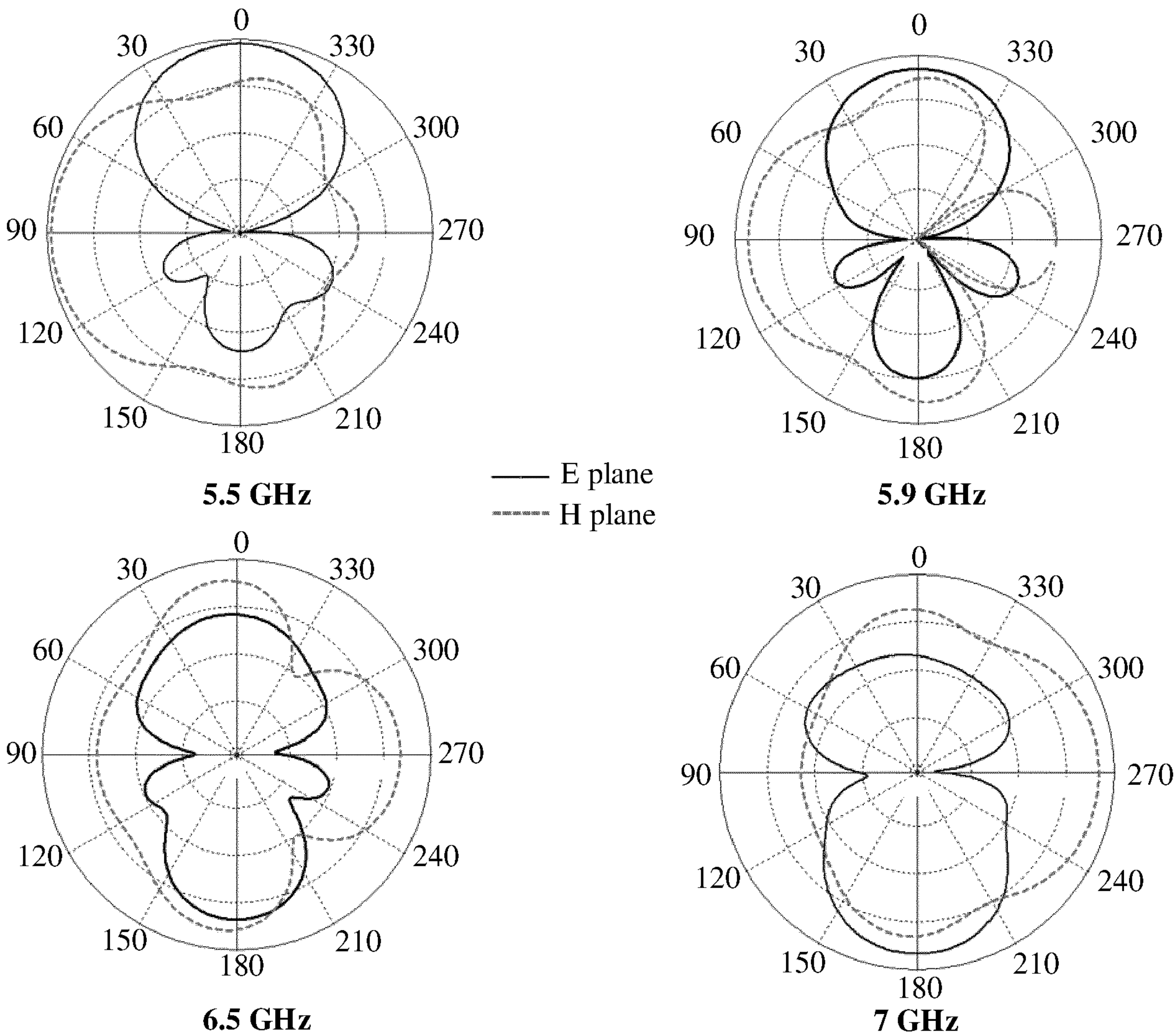
0
30
330
60
300
90
270
120
240
150
210
180
5.5 GHz
0
30
330
60
300
90
270
120
240
150
210
180
5.9 GHz
E plane
H plane
0
30
330
60
300
90
270
120
240
150
210
180
6.5 GHz
0
30
330
60
300
90
270
120
240
150
210
180
7 GHz

FIG. 23

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2021/113630

A. CLASSIFICATION OF SUBJECT MATTER

H01Q 1/38(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)

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)

CNPAT, CNKI, WPI, EPODOC, IEEE: 天线, 渐变, 槽, 折合, 曲折, 弯折, 振子, 谐振, 馈电, antenna, TSA, tapered slot antenna, tapered notch antenna, flared slot antenna, vivaldi, meander, element, resonance, feed+

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2005078043 A1 (APOSTOLOS, John T.) 14 April 2005 (2005-04-14) description, paragraphs [0086]-[0094] and figure 2	1-20
A	US 2013038495 A1 (LAWRENCE LIVERMORE NATIONAL SECURITY, L.L.C.) 14 February 2013 (2013-02-14) entire document	1-20
A	CN 101895009 A (NANJING UNIVERSITY OF POSTS AND TELECOMMUNICATIONS) 24 November 2010 (2010-11-24) entire document	1-20
A	CN 206370494 U (XI'AN JIAOTONG UNIVERSITY) 01 August 2017 (2017-08-01) entire document	1-20
A	ZHANG, Feng. "A Novel Compact Double Exponentially Tapered Slot Antenna (DETSA) for GPR Applications" *IEEE ANTENNAS AND WIRELESS PROPAGATION LETTERS,* Vol. 10, 07 March 2011 (2011-03-07), 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
02 November 2021	**18 November 2021**

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/CN2021/113630

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	王友成 等 (WANG, Youcheng et al.). "渐变槽天线端射特性优化设计 (Design of Tapered-slot Antenna with Optimized End-fire Characteristics)" *电子与信息学报 (Journal of Electronics & Information Technology),* Vol. 39, No. 1, 31 January 2017 (2017-01-31), entire document	1-20

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

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2021/113630

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
US 2005078043 A1	14 April 2005	None	
US 2013038495 A1	14 February 2013	US 2017207546 A1	20 July 2017
CN 101895009 A	24 November 2010	None	
CN 206370494 U	01 August 2017	None	

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

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- CN 202011193934 **[0001]**