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(54) **ANTENNA AND PHASE SHIFTER**

(57) Disclosed are an antenna and a phase shifter. The phase shifter comprises: a first circuit layer, wherein the first circuit layer is provided with an input branch and a first output branch, and the first output branch and the input branch are insulated from each other; a second circuit layer capable of moving relative to the first circuit layer, wherein when the second circuit layer is moved to a first position relative to the first circuit layer, the first output branch is disconnected from the input branch, and when the second circuit layer is moved to a second position relative to the first circuit layer, the first output branch is connected to the input branch; and a dielectric plate capable of moving relative to the first circuit layer, and driving the second circuit layer to switch between the first position and the second position. The antenna using the phase shifter can adjust electrical down-tilt angle and beam width value.

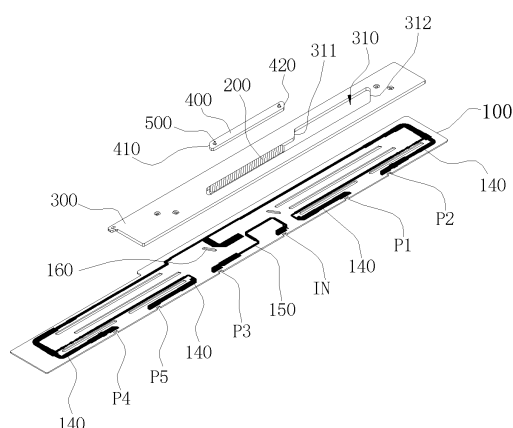


Figure 1

Description

Field of the Invention

[0001] The present invention relates to the field of communication technologies, and in particular to, an antenna and a phase shifter.

Background

[0002] Increasing much more sites has become an inevitable choice in order to meet coverage and capacity requirements of operators and with the development of mobile communications. Currently, after large-scale construction of base stations, in-depth coverage of residential communities, main streets and other places and blind coverage repair work have become the focus of major operators. The cost of adding conventional macro stations in these areas is high, and the cycle is long. At the same time, the antenna size is large and site selection is difficult. Therefore, in conventional technologies, micro-station antennas or low-gain directional antennas are usually used to achieve coverage or blind coverage compensation.

[0003] However, in practical applications, some coverage scenarios need to adjust the value of the beam width to cover different areas. However, a value of vertical beam width of a micro-station antenna or other low-gain antenna is fixed, and the corresponding coverage area is also relatively fixed, which fails to meet actual application requirements, consequently.

SUMMARY OF THE INVENTION

[0004] Based on this, it is necessary to provide an antenna and a phase shifter which can not only adjust the down-tilt of the antenna, but also change the number of radiation units that are electrically connected to the antenna, thereby realizing change of antenna beam width. The antenna adopts the above-mentioned phase shifter, which can not only realize the adjustment of the electric down-tilt angle, but also realize the adjustment of the value of the beam width, so that in practical applications, the value of the beam width of the antenna can be adjusted according to actual needs to cover different areas.

[0005] The technical scheme is as follows.

[0006] In one aspect, the present application provides a phase shifter, including: a first circuit layer, the first circuit layer including an input branch and a first output branch;

a second circuit layer, the second circuit layer being move relative to the first circuit layer, and, when the second circuit layer moves to a first position relative to the first circuit layer, the first output branch being disconnected from the input branch, when the second circuit layer moves to a second position relative to the first circuit layer, the first output branch being

connected to the input branch; and
a dielectric plate, which can move relative to the first circuit layer and can drive the second circuit layer to switch between the first position and the second position.

[0007] When the above-mentioned phase shifter is in use, the input branch is electrically connected to an input end of an antenna signal through an input port, and an output port of the first output branch is used to electrically connect to the corresponding radiation unit. When the second circuit layer is in the first position, the radiation unit connected to the first output branch is unenabled; when the second circuit layer moves to the second position, the radiation unit connected to the first output branch is in a working state, while the antenna has a beam width value; and when the output port of the phase shifter is connected to the radiation unit in the working state, by moving a dielectric plate of the phase shifter, the overlap area between the dielectric plate and the first circuit layer can be changed, thereby adjusting the down-tilt angle of the antenna. The phase shifter is provided with a second circuit layer, and uses the movement of the dielectric plate relative to the first circuit layer to drive the second circuit layer to move relative to the first circuit layer, which can realize the down-tilt angle adjustment. It can also conveniently control the connection/disconnection of the first output branch and the input branch, thereby changing the number of radiation units in working state connected to the phase shifter, thereby realizing the adjustment of the antenna beam width. The overall structure of the phase shifter is simple and compact, which can adapt to the requirements of different coverage scenarios and has a broad application prospect.

[0008] The technical solution is further explained below:

[0009] In one embodiment, the first output branch is insulated from the input branch, and the second circuit layer is provided between the first output branch and the input branch. The second circuit layer controls the connection/disconnection of the input branch and the first output branch through coupling/disconnection, respectively, with the input branch and the first output branch.

[0010] In one embodiment, the first circuit layer further includes a second output branch, and the second output branch is electrically connected to the input branch.

[0011] In one embodiment, the movement of the dielectric plate relative to the first circuit layer includes a forward movement and a reverse movement. The switching of the second circuit layer from the first position to the second position is realized by the reverse movement of the dielectric plate, and the switching of the second circuit layer from the second position to the first position is realized by the forward movement of the dielectric plate.

[0012] In one embodiment, the dielectric plate is provided with a first driving portion for driving the second circuit layer to move from the second position to the first

position, and a second driving portion for driving the second circuit layer to move from the first position to the second position. The first driving portion and the second driving portion are spaced apart.

[0013] In an embodiment, the second circuit layer is disposed on a substrate, and the first driving portion and the second driving portion drive the substrate to drive the second circuit layer switch between the first position and second position. The substrate is provided with a first oblique end surface that is at a certain angle to the moving direction of the dielectric plate, and a second oblique end surface opposite to the first oblique end surface. The first driving portion is a third oblique end surface provided on the dielectric plate and adapted to the first oblique end surface, and the second driving portion is a fourth oblique end surface provided on the dielectric plate and adapted to the second oblique end surface.

[0014] In one embodiment, the dielectric plate is provided with a groove capable of accommodating the substrate. The groove includes a first inner side wall and a second inner side wall disposed oppositely, and the first inner side wall and the second inner side wall correspond to the third oblique end surface and the fourth oblique end surface.

[0015] In one embodiment, the groove is substantially "⌌" shaped, and the "⌌" shaped groove includes first to third longitudinal walls arranged in sequence. The first longitudinal wall and the second longitudinal wall correspond to the first inner side wall and the second inner side wall.

[0016] In one embodiment, the spacing between a first and second lateral walls arranged from bottom to top in the "⌌"-shaped groove is adapted to the width of the substrate.

[0017] In one embodiment, the first circuit layer is further provided with a guiding structure for guiding the movement of the second circuit layer.

[0018] In one embodiment, the guide structure includes a guiding rail provided on the first circuit layer and a guiding member provided on the second circuit layer, and the guiding member is slidingly fitted with the guiding rail.

[0019] In one embodiment, the second circuit layer includes an upper circuit layer and a lower circuit layer that are relatively distributed on an upper and lower sides of the first circuit layer, and the upper circuit layer and the lower circuit layer are fixedly connected.

[0020] In one embodiment, there are two first circuit layers and two dielectric plates, and the two first circuit layers are arranged opposite to each other and maintain electrical connection. The two second circuit layers are both arranged between the two dielectric plates, and the two dielectric plates move synchronously.

[0021] In one embodiment, the first circuit layer further includes a third output branch, and there are at least two second circuit layers. These second circuit layers are arranged at intervals along the moving direction of the di-

electric plate, and at least one of the second circuit layers is arranged corresponding to the third output branch.

[0022] When the second circuit layer moves to a third position relative to the first circuit layer, the third output branch is disconnected from the input branch or from the adjacent first output branch.

[0023] When the second circuit layer moves to a fourth position relative to the first circuit layer, the third output branch is connected to the input branch or the adjacent first output branch.

[0024] The dielectric plate can drive the second circuit layer corresponding to the third output branch to switch between the third position and the fourth position.

[0025] In another aspect, the present application also provides an antenna, including the above-mentioned phase shifter, and it also includes a feed network and a radiation unit corresponding to the output port of the phase shifter one-to-one.

[0026] When the antenna is used, the input branch is electrically connected to the input end of the antenna signal through the input port. The output ports of the second output branch and the first output branch are both used for electrical connection with the corresponding radiation units. When the second circuit layer is in the first position, the radiation unit connected to the first output branch is unenabled, while the antenna can have a relatively wide beam width. When the second circuit layer moves to the second position, the radiation unit connected to the first output branch is in working state, while the antenna has a relatively narrow beam width. When the output port of the phase shifter is connected with a working radiation unit, by moving the dielectric plate of the phase shifter, the overlap area between the dielectric plate and the first circuit layer can be changed to adjust the down-tilt angle of the antenna. Therefore, in the actual application of the antenna, the movement of the phase shifter dielectric plate relative to the first circuit layer can be used to drive the second circuit layer to move relative to the first circuit layer. While realizing the down-tilt angle adjustment, it can conveniently control the connection/disconnection of the first output branch and the input branch, thereby changing the number of radiation units connected to the phase shifter in working state, thereby realizing adjustment of the beam width of the antenna. The overall structure of the antenna is simple and compact, which can adapt to the requirements of different coverage scenarios and has a broad application prospect.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027]

Figure 1 is a schematic diagram of an exploded structure view of a phase shifter in a first embodiment;

Figure 2 is a schematic structural diagram of the phase shifter shown in Figure 1 in a first state;

Figure 3 is a schematic structural diagram of the phase shifter shown in Figure 1 in a second state; Figure 4 is a schematic structural diagram of the phase shifter shown in Figure 1 in a third state; Figure 5 is an enlarged schematic diagram of the second circuit layer in the phase shifter shown in Figure 1;

Figure 6 is a schematic structural diagram of the second circuit layer in the phase shifter shown in Figure 1 to connect the input branch and the first output branch;

Figure 7 is a schematic structural diagram of the second circuit layer in the phase shifter shown in Figure 1 to disconnect the input branch from the first output branch;

Figure 8 is a schematic diagram of the structure of the dielectric plate shown in Figure 1;

Figure 9 is another schematic diagram of the structure of the dielectric plate shown in Figure 1;

Figure 10 is a schematic diagram of the exploded structure of the phase shifter in a second embodiment;

Figure 11 is a schematic diagram of the structure of the first circuit layer of the phase shifter in a third embodiment;

Figure 12 is a schematic diagram of the structure of the phase shifter in the third embodiment in a first state;

Figure 13 is a schematic structural diagram of the phase shifter shown in Figure 12 in a second state;

Figure 14 is a schematic structural diagram of the phase shifter shown in Figure 12 in a third state; and

Figure 15 is a schematic structural diagram of the phase shifter shown in Figure 12 in a fourth state.

DETAILED DESCRIPTION

[0028] In order to make the objects, technical solution, and advantages of the present invention clearer, the following further describes the present invention in detail with reference to the accompanying drawings and specific embodiments. It should be understood that the specific embodiments described herein are only used to explain the present invention, and do not limit the protection scope of the present invention.

[0029] It should be noted that when an element is referred to as being "fixed at", "installed on", or "fixed on" another element, it can be directly located on the other element or an intermediate element may also be present. When an element is considered to be "connected" to another element, it can be directly connected to the other element or an intermediate element may be present at the same time. A component and another component are perpendicular or nearly perpendicular to each other, which means that the ideal state of the two is perpendicular, but due to the influence of manufacture and assembly, there may be a certain vertical error. The terms "vertical", "horizontal", "left", "right" and similar expressions

as used herein are for illustrative purposes only, and do not mean that they are the only embodiments.

[0030] In addition, the "oblique" in the "oblique guiding groove", "oblique track" and the like mentioned in the text refers to the oblique arrangement (intersecting state) with respect to the moving direction of the dielectric plate.

[0031] Unless otherwise defined, all technical and scientific terms used herein have the same meaning as commonly understood by those skilled in the technical field of the present invention. The terminology used in the specification of the present invention herein is only for the purpose of describing specific embodiments, and is not intended to limit the present invention. The term "and/or" as used herein includes any and all combinations of one or more related listed items.

[0032] The "first", "second", "third", "fourth" and "fifth" involved in the present invention do not represent specific numbers and orders, but are merely used to distinguish names.

[0033] As shown in Figure 1, this embodiment provides a phase shifter, including: a first circuit layer 100, the first circuit layer 100 having at least two output ports (specifically, in this embodiment, for ease of description, five output ports, namely P1 to P5 are described) and at least one input port IN (in order to simplify the first circuit layer 100, only one input port IN is provided in this embodiment), the first circuit layer 100 being provided with an input branch 130 and a first output branch 140, and the input branch 130 being electrically connected to the input port 110; a second circuit layer 200, with reference to Figures 2 to 7, the second circuit layer 200 being able to move relative to the first circuit layer 100, referring to figures 4 and 7, when the second circuit layer 200 moves to the first position relative to the first circuit layer 100, the first output branch 140 being disconnected from the input branch 130, with reference to figures 2, 3, 5 and 6, when the second circuit layer 200 moves to the second position relative to the first circuit layer 100, the first output branch 140 and the input branch 130 being connected, specifically in this embodiment, the second circuit layer 200 being provided with an electrical connection branch 210, when the second circuit layer 200 is in the first position, the electrical connection branch 210 and the input branch 130 being in a disconnected state, and when the second circuit layer 200 is in the second position, the electrical connection branch 210 and the input branch 130 being in an electrically connected state; and a dielectric plate 300. Referring to figures 2 to 4, the dielectric plate 300 can move relative to the first circuit layer 100. In addition, the dielectric plate 300 can drive the second circuit layer 200 to switch between the above-mentioned first position and the second position, thereby realizing the connection and disconnection between the first output branch 140 and the input branch 130.

[0034] Referring to figures 1-7, as a preferred embodiment of the present invention, the above-mentioned first circuit layer 100 further includes a second output branch 150, and the second output branch 150 and the input

branch 130 are always electrically connected. In this way, at least one branch in the first circuit layer 100 of the phase shifter can always be in a conductive state. Correspondingly, at least one of the radiation units connected to the output ports P1 to P5 of the phase shifter may always be in the working state. In this way, when there are two output branches in the first circuit layer 100 of the phase shifter, it can be avoided that the second circuit layer 200 is used to separately control the on/off of the two output branches and the input branch 130. And it must also ensure that at least one output branch and input branch 130 are connected during the operation of the phase shifter. Therefore, the complexity of the entire on/off control can be simplified, which is beneficial to simplify the structure of the phase shifter.

[0035] Of course, in other embodiments, the first circuit layer 100 of the phase shifter may also have multiple first output branches 140 without the second output branch 150, which is not limited.

[0036] Referring to figures 1 to 4, specifically in this embodiment, the phase shifter may include four first output branches 140 and one second output branch 150. The four first output branches 140 correspond to the output ports P1, P2, P4, and P5, respectively, and the second output branch 150 corresponds to output port P3. For ease of description, the following description is made using this number as an example.

[0037] When the above-mentioned phase shifter is in use, the input branch 130 is electrically connected to an input end of the antenna signal through the input port 110. The output ports of the first output branch 140 (specifically the output ports P1, P2, P4, and P5 in this embodiment) and the output ports of the second output branch 150 (specifically output port P3 in this embodiment) are used for electrical connection with the corresponding radiation unit (not shown). When the second circuit layer 200 is in the first position, the first output branch 140 is disconnected from the input branch 130, and the radiation units connected to the first output ports P1, P2, P4, and P5 are unenabled, the radiation unit connected to the output port P3 is in working condition, while the antenna can have a wider beam width. When the second circuit layer 200 moves to the second position, the first output branch 140 is connected to the input branch 130, and the radiation units connected to the output ports P1 to P5 are all in working state. During this time, the antenna has a narrow beam width. When the output port of the phase shifter is connected to at least two radiation units in working state, by moving the dielectric plate 300 of the phase shifter, the overlap area between the dielectric plate 300 and the first circuit layer 100 can be changed, thereby performing adjustment of the down-tilt angle of the antenna. The phase shifter has the second circuit layer 200 and uses the movement of the dielectric plate 300 relative to the first circuit layer 100 to drive the second circuit layer 200 to move relative to the first circuit layer 100. It can control the connection/disconnection of the first output branch 140 and the

input branch 130 while realizing the down-tilt angle adjustment, thereby changing the number of radiation units connected to the phase shifter in working state, and then realizing the adjustment of the antenna's beam width. Its overall structure is simple and compact, it can adapt to different coverage scenarios, and has broad application prospects.

[0038] Referring to figures 1 and 7, preferably, in some embodiments, the first output branch 140 and the input branch 130 are insulated from each other. The second circuit layer 200 is provided between the first output branch 140 and the input branch 130. In addition, the second circuit layer 200 controls the connection/disconnection between the input branch 130 and the first output branch 140 through coupling/disconnection with the input branch 130 and the first output branch 140. In this way, the second circuit layer 200 can act like a coupling switch, and it is more convenient for the dielectric plate 300 to control its on/off.

[0039] Referring to figures 2-4, as a preferred embodiment of the present invention, the movement of the dielectric plate 300 relative to the first circuit layer 100 includes a forward movement (in the direction shown by the solid arrow in the figures) and a reverse movement (as shown in the direction indicated by the hollow arrow of the same figures). The above-mentioned switching of the second circuit layer 200 from the first position to the second position is realized by the reverse movement of the dielectric plate 300. The above-mentioned switching of the second circuit layer 200 from the second position to the first position is realized by the forward movement of the dielectric plate 300. This one-way control method can further simplify the structure of the phase shifter.

[0040] As shown in Figures 1 to 5, the phase shifter further includes a substrate 400, and the second circuit layer 200 is disposed on the substrate 400. In this way, the movement of the second circuit layer 200 is facilitated. The material of the substrate 400 can be any one or more of existing insulating materials, such as circuit plate substrates or plastics.

[0041] In the same way, the first circuit layer 100 can also be disposed on another substrate, and then fixed in the cavity of the phase shifter through the substrate, which is not described in detail here.

[0042] The above-mentioned dielectric plate 300 may be slidably connected to the substrate provided with the first circuit layer 100, so as to more accurately control the relative position of the dielectric plate 300 and the first circuit layer 100.

[0043] As shown in Figures 1 to 4, in one embodiment, the dielectric plate 300 is provided with a first driving portion 311 for driving the second circuit layer 200 to move from a first position to a second position, and a second driving portion 312 for driving the second circuit layer 200 to move from the second position to the first position. The first driving portion 311 and the second driving portion 312 are spaced apart. The first driving portion 311 and the second driving portion 312 drive the substrate 400 to

drive the second circuit layer 200 to switch between the first position and the second position. When the dielectric plate 300 moves in a first preset direction (that is, the reverse movement described above), that is, when the state shown in Figure 4 is switched to the state shown in Figure 3, the substrate 400 is pushed by the first driving portion 311 to move from the first position to the second position. When the dielectric plate 300 moves in the opposite direction of the first preset direction (that is, the above-mentioned forward movement), that is, when the state shown in Figure 3 is switched to the state shown in Figure 4, the substrate is pushed by the second driving portion 312 400 to move from the second position to the first position.

[0044] As shown in Figures 2 to 4, in this embodiment, it is more preferable that the movement of the dielectric plate 300 relative to the first circuit layer 100 is a linear movement. The dielectric plate 300 can move along a preset straight line. In this way, the area of the dielectric plate 300 corresponding to each output port 120 can be changed, thereby changing the phase difference of each output port 120 and realizing the adjustment of the antenna down-tilt angle. Using the above technical solution, when the dielectric plate 300 moves in the reverse direction from the state shown in Figure 4 to the state shown in Figure 3, the dielectric plate 300 can continue to move in the reverse direction according to a preset straight line, thereby forming the state shown in Figure 2. During this time, the second driving portion 312 will not cooperate with the substrate 400, and the second circuit layer 200 is still in the second position. The first output branch 140 and the four second output branches 150 of the phase shifter are all in a conducting state. The radiation units connected to the output ports P1~P5 are all in working condition. During the movement of the dielectric plate 300 from the state shown in Figure 3 to the state shown in Figure 2 and then from the state shown in Figure 2 to the state shown in Figure 3. When the five radiation units are working, the phase shifter can adjust the down-tilt angle of the antenna through the movement of the dielectric plate 300. When the dielectric plate 300 continues to move from the state shown in Figure 3 to the state shown in Figure 4, the second driving portion 312 can push the substrate 400 and accordingly drive the second circuit layer 200 to move from the second position to the first position. During this time, the input branch and the four first output branches 140 are disconnected, so that the four radiation units are unenabled, and only the radiation unit connected to the port P3 works, thereby realizing the adjustment of the antenna beam width.

[0045] It should be understood that the above-mentioned first position and second position can be set according to actual needs.

[0046] In one embodiment, as shown in Figures 1 to 4, the substrate 400 is provided with a first oblique end surface 410 that is at a certain angle to the moving direction of the dielectric plate 300 and a second oblique end surface 420 opposite to the first oblique end surface

410. The first driving portion 311 is a third oblique end surface provided on the dielectric plate 300 and adapted to the first oblique end surface 410. The second driving portion 312 is a fourth oblique end surface provided on the dielectric plate 300 and adapted to the second oblique end surface 420. In this way, each of the above-mentioned oblique end surfaces can generate a force that pushes the substrate 400 toward one side of the movement direction of the dielectric plate 300 when moving, so that the substrate 400 and the corresponding second circuit layer 200 are able to shift between the first position and the second position along an oblique track. This is beneficial to avoid interference with the normal movement of the dielectric plate 300, and is easy to implement, and at the same time, it does not damage the original structure of the housing of the phase shifter.

[0047] Specifically, in this embodiment, the first oblique end surface 410 and the second oblique end surface 420 preferably have an angle of 45° with respect to the reverse movement direction of the dielectric plate 300, or 145° with respect to the forward movement direction of the dielectric plate 300. For ease of description, the following angle is also used as an example for description. It should be understood that in actual applications, the angle of the above-mentioned oblique end surfaces can be adjusted according to the actual switching direction of the second circuit layer 200, which is not limited here.

[0048] Based on the foregoing embodiments, and more specifically, as shown in Figures 1 to 4, the dielectric plate 300 is provided with a groove 310 that can accommodate the substrate 400. As shown in Figure 8, the groove 310 includes a first inner side wall 11 and a second inner side wall 12 that are arranged oppositely. The third oblique end surface and the fourth oblique end surface are provided by the first inner side wall 11 and the second inner side wall 12, respectively. By providing the groove 310, not only can the dielectric plate 300 drive the movement of the second circuit layer 200 conveniently, but also can make full use of the space of the groove 310 to place therein the substrate 400 with the second circuit layer 200, so that the phase shifter's structure is more compact, which is beneficial to the miniaturization of the phase shifter. As shown in Figure 1 to Figure 4, the above-mentioned groove is roughly in the shape of " $\sqsubset$ ". As shown in Figure 8, the " $\sqsubset$ "-shaped groove includes a first longitudinal wall, a second longitudinal wall and a third longitudinal wall 13 arranged in sequence. Here, the second longitudinal wall is the above-mentioned first inner side wall 11, and the first longitudinal wall is the above-mentioned second inner side wall 12. The height relationship between the first longitudinal wall and the second longitudinal wall is $H1 > H2$, and the height relationship between the first longitudinal wall and the third longitudinal wall is $H1 > H3$, and the height between the first to third longitudinal walls The relationship is $H1 > H2 \geq H3$. The overall structure is simple and it is easy

to manufacture. The height H3 of the third longitudinal wall 13 should be greater than or equal to the width of the substrate 400 on which the second circuit layer 200 is provided. The first longitudinal wall and the second longitudinal wall having the above-mentioned height can ensure that the substrate 400 has a sufficient moving space for switching between on and off. The above-mentioned "⌒"-shaped groove 310 is sequentially provided with a first lateral wall 14, a second lateral wall 15 and a third lateral wall 16 from bottom to top. The "⌒"-shaped groove 310 is defined by a first longitudinal wall, a first lateral wall 14, a second longitudinal wall, a second lateral wall 15, a third longitudinal wall 13, and a third lateral wall 16 in sequence. Further preferably, the distance between the first lateral wall 14 and the second lateral wall 15 is adapted to the width of the substrate 400, so that when the substrate 400 is located in the space of the groove 310 between the first lateral wall 14 and the second lateral wall 15 (During this time, the second circuit layer 200 is in the second position, and the four first output branches 140 are in a conductive state with the input branch 130, the radiation units corresponding to the output ports P1, P2, P4, and P5 of the first output branch 140 are in the working state), and when the dielectric plate 300 moves relative to the first circuit layer 100, the first lateral wall 14 and the second lateral wall 15 can limit the substrate 400 in the longitudinal direction. This makes the first output branch 140 and the input branch 130 in the conducting state have better stability, which is beneficial to further phase adjustment.

[0049] With reference to Figures 8 and 9, for further description, the above-mentioned groove 310 may also include a first strip-shaped groove 330 and a second strip-shaped groove 340 communicating with the first strip-shaped groove 330. The first strip-shaped groove 330 is located on one side of a lateral direction of the second strip-shaped groove 340, and the horizontal length of the first strip-shaped groove 330 is smaller than the horizontal length of the second strip-shaped groove 340. The second inner side wall 12 is defined by a side-wall of the first strip-shaped groove 330 and a sidewall of the second strip-shaped groove 340 which are joined to each other. The second inner side wall 12 is formed by another side wall, opposite to the first inner side wall 11, of the first strip-shaped groove 330. As the first inner side wall 11 serves as the first driving portion 311 and the second inner side wall 12 serves as the second driving portion 312, when the second circuit layer 200 is located in the first strip-shaped groove 330, the second circuit layer 200 is in the first position. When the second circuit layer 200 is located in the second strip-shaped groove 340, the second circuit layer 200 is in the second position. Moreover, when the second circuit layer 200 moves from the first strip-shaped groove 330 to the second strip-shaped groove 340, within a great distance range of the horizontal space defined by the second strip-shaped groove 340 and in which the dielectric plate 300

continues moving forwardly from the state shown in Figure 3 to the state shown in Figure 2 and then reversely moving from the state shown in Figure 2 to the state shown in Figure 3 (The second inner side wall 12 is pressed against the second oblique end surface 420 of the substrate 400), the second circuit layer 200 may not move relative to the first circuit layer 100, so that when the first output branch 140 and the input branch 130 are in a conductive state, the phase can be further stabilized and adjusted in a wide range through the dielectric plate 300. The horizontal length of the first strip-shaped groove 330 is preferably $\geq$ the length of the substrate 400, and the horizontal length of the second strip-shaped groove 330 is preferably more than twice the length of the substrate 400.

[0050] Of course, in other embodiments, the above-mentioned dielectric plate and the second circuit layer can also be matched by other guiding members. In this case, the first driving portion and the second driving portion may be of a convex structure.

[0051] In addition, the direction of the driving force may be set according to the movement track of the second circuit layer 200, or the movement track of the second circuit layer 200 may be set according to the direction of the formed driving force.

[0052] As shown in Figures 1 to 4, in one embodiment, a guiding structure (not shown) for guiding the movement of the second circuit layer 200 is further provided on the first circuit layer 100. The second circuit layer 200 can be moved between the first position and the second position through the guiding structure. This in turn uses the guiding structure to guide the movement of the second circuit layer 200 to form a movement track, which facilitates obtaining the direction of the pushing force, and furthermore it can set the shape and positional relationship of the first driving portion 311 and the second driving portion 312. In other words, the guiding structure should be adapted to the switching movement track of the substrate 400, so as to better cooperate with the first driving portion 311 and the second driving portion 312 on the dielectric plate 300 to control the movement of the substrate 400. The specific manner of the guiding structure can be realized by any prior art technology that meets the requirements of use. For example, in one embodiment, the guiding structure includes a guiding rail 160 disposed on the first circuit layer 100, and a guiding member 500 disposed on the second circuit layer 200 (specifically on the substrate 400 in this embodiment). The guiding member 500 is in sliding fit with the guiding rail 160. Accordingly, the guiding rail 160 is provided to make the second circuit layer 200 move on the first circuit layer 100 along a preset track. The guiding rail 160 can have various structures, such as guiding grooves, sliding rails, and the structure of the guiding member 500 can be adaptively adjusted according to the structure of the guiding rail 160. Specifically, in this embodiment, two guiding structures arranged in parallel are preferably provided, so as to further improve the stability of the substrate 400

during the switching movement.

[0053] As shown in Figures 1 and 3, in one embodiment, the guiding rail 160 is an oblique guiding groove, and the guiding member 500 is slidably fitted with the oblique guiding groove, thus enabling the second circuit layer 200 to slide along an oblique track between the first position and the second position. In this way, it is convenient to realize guiding cooperation between the second circuit layer 200 and the first circuit layer 100 without affecting the performance of the first circuit layer 100. In addition, the moving track of the second circuit layer 200 is oblique, and the moving directions of the dielectric plate 300 intersect, which facilitates the formation of an oblique pushing force by arranging the first driving portion 311 and the second driving portion 312 on the dielectric plate 300.

[0054] Based on Figure 1 and in conjunction with Figure 10, in some embodiments, the first circuit layer 100 in the phase shifter may have two layers, and the two first circuit layers 100 may be electrically connected through a metal through hole, and for example, the structure may be formed by a double-layered PCB plate or by electroplating/laser carving on a non-metallic substrate. There may also be two dielectric plates 300 correspondingly, and the double-layered PCB plate or non-metallic substrate is arranged between the two dielectric plates 300. That is to say, the two dielectric plates 300 are arranged correspondingly to the two first circuit layers 100. And the movement of the two dielectric plates is synchronized and in the same direction. In this way, when the dielectric plate 300 is moved by a unit distance relative to the first circuit layer 100, the amount of change in the overlap area between the dielectric plate 300 and the first circuit layer 100 is relatively large. This is beneficial to the overall layout of the antenna when the phase shifter is required to have a larger phase shift amount.

[0055] Based on Figure 1 and in conjunction with Figure 10, in some embodiments, the second circuit layer 200 may include an upper circuit layer 201 and a lower circuit layer 201, and the upper circuit layer 201 and the lower circuit layer 201 are fixedly connected to each other and distributed in the upper and lower sides of the first circuit layer 100 respectively. In this way, under the premise that the second circuit layer 200 is movably connected to the first circuit layer 100, the assembly between the second circuit layer 200 and the first circuit layer 100 is more convenient, and it is beneficial to the second circuit layer 200 and the first circuit layer 100 to be arranged close to each other. The simpler thing is that the upper circuit layer 201 and the lower circuit layer 201 are connected together by the guiding member 500. The guiding member 500 may be of a structure such as a buckle.

[0056] As shown in Figures 11-15, the difference from the above-mentioned embodiment is that there are at least two second circuit layers 200, and each second circuit layer 200 is arranged at intervals along the moving direction of the dielectric plate 300. The above-mentioned first circuit layer 100 further includes a third output

branch 170, and the third output branch 170 is correspondingly provided with a second circuit layer 200. When the second circuit layer 200 moves to the third position relative to the first circuit layer 100, the third output branch 170 is disconnected from the input branch 130 or from the adjacent first output branch 140. When the second circuit layer 200 moves to the fourth position relative to the first circuit layer 100, the third output branch 170 is connected to the input branch 130 or to the adjacent first output branch 140. The dielectric plate 300 can drive the second circuit layer 200 corresponding to the third output branch 170 to switch between the third position and the fourth position. In this way, it is convenient for the dielectric plate 300 to drive each second circuit layer 200 to switch between its corresponding first position and second position, and between the third position and the fourth position in different intervals of its movement distance, thereby respectively controlling the on/off between the corresponding input branch 130 and each first output branch 140. In this case, only a plurality of grooves 310 are needed to be correspondingly opened on the dielectric plate 300, and each second circuit layer 200 can be driven to move respectively, thereby further improving the beam adjustment range of the phase shifter to adapt to more coverage scene.

[0057] Specifically in this embodiment, as shown in Figure 11, for ease of description, it is assumed that there are 3 second circuit layers 200. There are two first output branches 140 corresponding to the output ports P2 and P4 respectively. There is a second output branch 150, which is always electrically connected to the input branch 130, and there are two third output branches 170, respectively which correspond to output ports P1 and P5 respectively. In order to simplify the circuit structure, in the first circuit layer 100, the first output branch 140 electrically connected to the output ports P2 and P4 is insulated from the input branch 130. The third output branch 170 corresponding to the output ports P1 and P5 is preferably insulated from the adjacent first output branch 140. In this way, it is easier to control the coupling/separation of the third output branch 170 and the corresponding first output branch 140. For the convenience of description, the first circuit layer 100 is also described below.

[0058] Define the 3 forward directions as 200a, 200b, and 200c in sequence. In this direction, the three second circuit layers 200 move along the dielectric plate 300. As shown in Figure 12, in this state, the first output branch 140 and the input branch 130 respectively connected to the ports P2 and P4 corresponding to the second circuit layer 200b are in a conductive state. The third output branch 170 connected to the ports P1 and P5 corresponding to the second circuit layers 200a and 200b is in a disconnected state. During this time, the radiation units connected to the output ports P2, P3, and P4 are in working condition. Meanwhile, the phase shifter is connected to 3 radiation units, and the beam width value of the antenna is about 22°. As shown in Figure 13 and Figure 14, in this state, the first output branch 140 cor-

responding to the second circuit layer 200b and the third output branch 170 corresponding to the second circuit layers 200a and 200c are both in a conducting state. During this time, the radiation units connected to the output ports P1-P5 are all in working state. That is, the phase shifter can be connected to 5 radiation units, and the beam width value of the antenna is about 13°. Meanwhile, pulling the dielectric plate 300 can change the phase of each port, so that the phase of the output port has a change relationship of 2φ , φ , 0, $-\varphi$, -2φ , thereby adjusting the down-tilt angle of the antenna. As shown in Figure 15, in this state, the input port IN and the output port P3 are kept in a conductive state, the first output branch 140 corresponding to the second circuit layer 200b is in a disconnected state, the corresponding third output branch 170 is also in a disconnected state, and the input port and the output ports P1, P2, P3 and P5 are all in the disconnected state. That is, meanwhile, the phase shifter is only connected to one radiation unit, and the beam width value of the antenna is about 65°.

[0059] In conclusion, by means of the output branches in the first circuit layer 200, the second circuit layer 200, and the groove 310 on the dielectric plate 300, the on/off of each port of the phase shifter can be controlled, and the number of antenna radiation units can be changed, thus changing the beam width of the antenna.

[0060] It should be noted that the expressions of "first position", "second position", "third position" and "fourth position" are only to indicate that the second circuit layer 200 has a position for switching on/off of the circuit. The "first position", "second position", "third position" and "fourth position" can be set according to actual conditions. When a plurality of second circuit layers 200 are provided, the direction of movement of each second circuit layer 200 when switching in a conduction direction may also be different. The number of the above-mentioned second circuit layers 200 and the number of grooves 310 on the dielectric plate 300 can be set according to actual needs, and there is no specific limitation. At the same time, the number of ports of the phase shifter is not limited to 5, and can be set to any number of ports ≥ 2 .

[0061] In other embodiments, the movement of the dielectric plate 300 relative to the first circuit layer 100 may also be an arc movement, that is, the phase shifter is an arc-shaped phase shifter. Those skilled in the art can make similar settings according to the idea of the above-mentioned embodiments of the present invention. No detailed description is provided here in order to save space.

[0062] In another embodiment, the present application also provides an antenna including the above-mentioned phase shifter and radiation units respectively and correspondingly connected to the output branch of the phase shifter.

[0063] The above-mentioned antenna is based on the same concept as the above-mentioned phase shifter embodiments, and its technical effect is the same as that of the phase shifter embodiments of the present invention.

For specific content, please refer to the description in the embodiments of the phase shifter of the present invention, which will not be repeated here.

[0064] The technical features of the above-mentioned embodiments can be combined arbitrarily. In order to make the description concise, all possible combinations of the various technical features in the above-mentioned embodiments are not described. However, as long as there is no contradiction in the combination of these technical features, all should be considered within the scope of this specification.

[0065] The above-mentioned embodiments only express several embodiments of the present invention, and the descriptions are relatively specific and detailed, but they should not be interpreted as limiting the scope of the invention patent. It should be pointed out that for those of ordinary skill in the art, without departing from the concept of the present invention, several modifications and improvements can be made, and these all fall within the protection scope of the present invention. Therefore, the protection scope of the patent of the present invention should be subject to the appended claims.

Claims

1. A phase shifter, **characterized in** comprising:

a first circuit layer, the first circuit layer including an input branch and a first output branch;
a second circuit layer, the second circuit layer being move relative to the first circuit layer, and, in case that the second circuit layer moves to a first position relative to the first circuit layer, the first output branch being disconnected from the input branch, in case that the second circuit layer moves to a second position relative to the first circuit layer, the first output branch being connected to the input branch; and
a dielectric plate, which can move relative to the first circuit layer and can drive the second circuit layer to switch between the first position and the second position.

2. The phase shifter as recited in claim 1, **characterized in that** the first output branch is insulated from the input branch, the second circuit layer is provided between the first output branch and the input branch; and the second circuit layer controls the connection/disconnection of the input branch and the first output branch through coupling/disconnection, respectively, with the input branch and the first output branch.

3. The phase shifter as recited in claim 1, **characterized in that** the first circuit layer further includes a second output branch, and the second output branch is electrically connected to the input branch.

4. The phase shifter as recited in claim 1, **characterized in that** the movement of the dielectric plate relative to the first circuit layer includes a forward movement and a reverse movement; the switching of the second circuit layer from the first position to the second position is realized by the reverse movement of the dielectric plate, and the switching of the second circuit layer from the second position to the first position is realized by the forward movement of the dielectric plate.
5. The phase shifter as recited in claim 1, **characterized in that** the dielectric plate is provided with a first driving portion for driving the second circuit layer to move from the second position to the first position, a second driving portion for driving the second circuit layer to move from the first position to the second position; and the first driving portion and the second driving portion are spaced apart.
6. The phase shifter as recited in claim 3, **characterized in that** the second circuit layer is disposed on a substrate, and the first driving portion and the second driving portion drive the substrate to drive the second circuit layer switch between the first position and second position; the substrate is provided with a first oblique end surface that is at a certain angle to the moving direction of the dielectric plate, and a second oblique end surface opposite to the first oblique end surface; the first driving portion is a third oblique end surface provided on the dielectric plate and adapted to the first oblique end surface, and the second driving portion is a fourth oblique end surface provided on the dielectric plate and adapted to the second oblique end surface.
7. The phase shifter as recited in claim 6, **characterized in that** the dielectric plate is provided with a groove capable of accommodating the substrate; the groove includes a first inner side wall and a second inner side wall disposed oppositely, and the first inner side wall and the second inner side wall correspond to the third oblique end surface and the fourth oblique end surface.
8. The phase shifter as recited in claim 7, **characterized in that** the groove is substantially "⌌" shaped, and the "⌌" shaped groove includes first to third longitudinal walls arranged in sequence; and the first longitudinal wall and the second longitudinal wall correspond to the first inner side wall and the second inner side wall.
9. The phase shifter as recited in claim 8, **characterized in that** the spacing between a first and second lateral walls arranged from bottom to top in the "⌌" shaped groove is adapted to the width of the substrate.
10. The phase shifter as recited in claim 1, **characterized in that** the first circuit layer is further provided with a guiding structure for guiding the movement of the second circuit layer.
11. The phase shifter as recited in claim 10, **characterized in that** the guide structure includes a guiding rail provided on the first circuit layer and a guiding member provided on the second circuit layer, and the guiding member is slidably fitted with the guiding rail.
12. The phase shifter as recited in claim 1, **characterized in that** the second circuit layer includes an upper circuit layer and a lower circuit layer that are relatively distributed on an upper and lower sides of the first circuit layer, and the upper circuit layer and the lower circuit layer are fixedly connected.
13. The phase shifter as recited in claim 1, **characterized in that** there are two first circuit layers, two dielectric plates, and the two first circuit layers are arranged opposite to each other and maintain electrical connection; the two second circuit layers are both arranged between the two dielectric plates, and the two dielectric plates move synchronously.
14. The phase shifter as recited in any one of claims 1-13, wherein the first circuit layer further includes a third output branch, and there are at least two second circuit layers;

these second circuit layers are arranged at intervals along the moving direction of the dielectric plate, and at least one of the second circuit layers is arranged corresponding to the third output branch;

in case that the second circuit layer moves to a third position relative to the first circuit layer, the third output branch is disconnected from the input branch or from the adjacent first output branch;

in case that the second circuit layer moves to a fourth position relative to the first circuit layer, the third output branch is connected to the input branch or the adjacent first output branch; and the dielectric plate can drive the second circuit layer corresponding to the third output branch to switch between the third position and the fourth position.
15. An antenna, **characterized in** comprising: the phase shifter as recited in any one of claims 1-14, and a plurality of radiation units connected to the output ports of the phase shifter respectively.

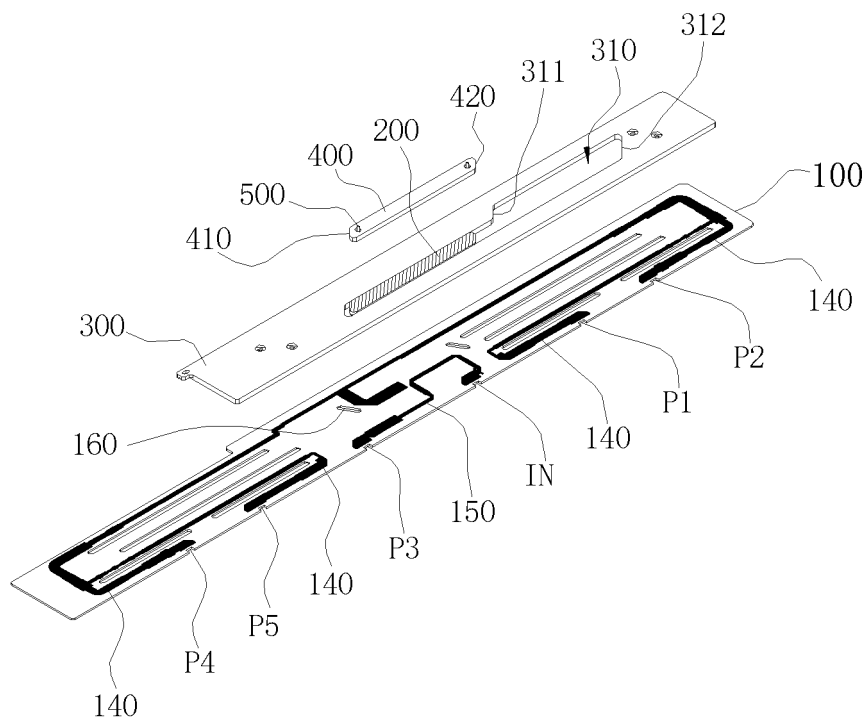


Figure 1

Forward direction ← → Reverse direction

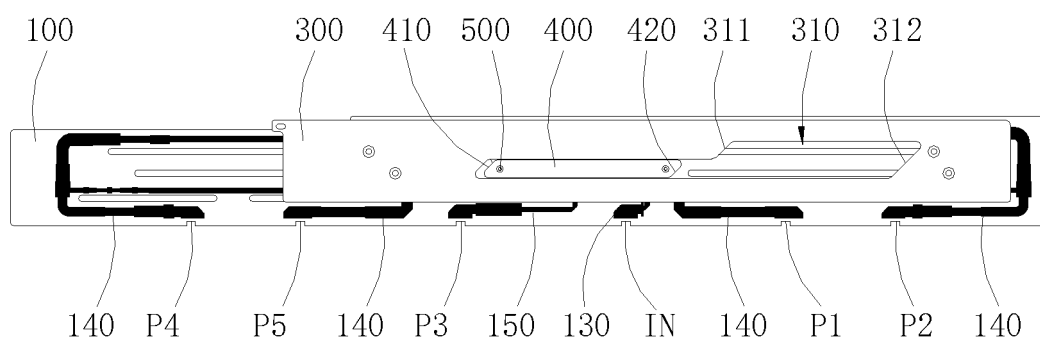


Figure 2

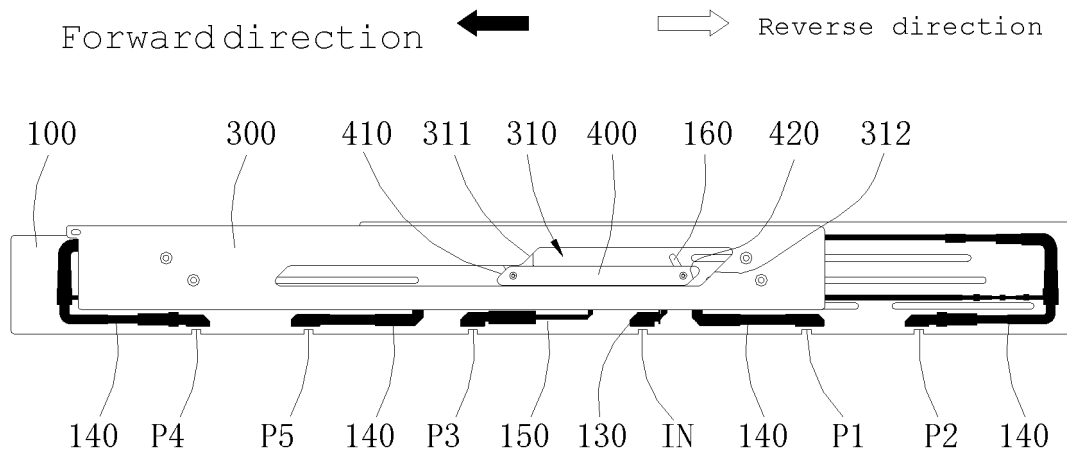


Figure 3

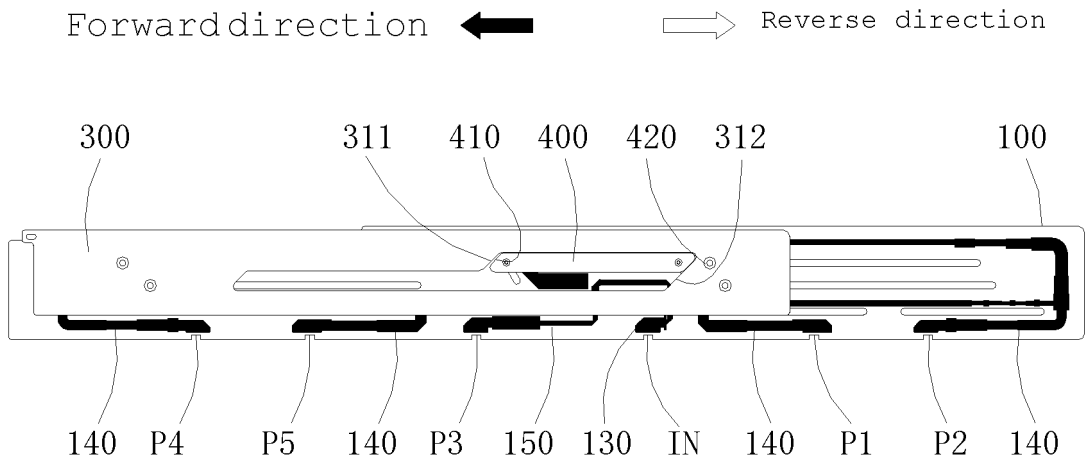


Figure 4

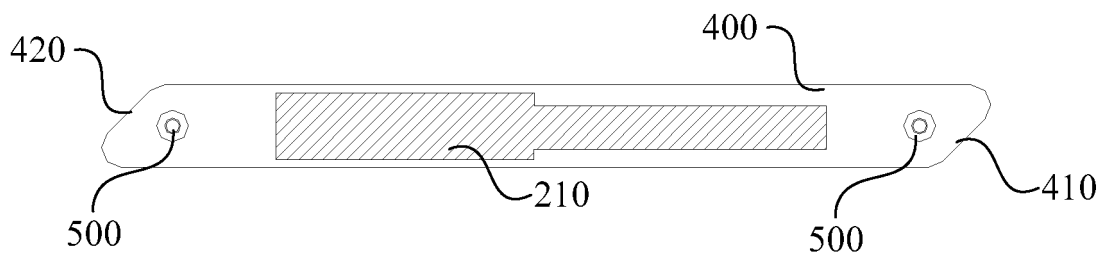


Figure 5

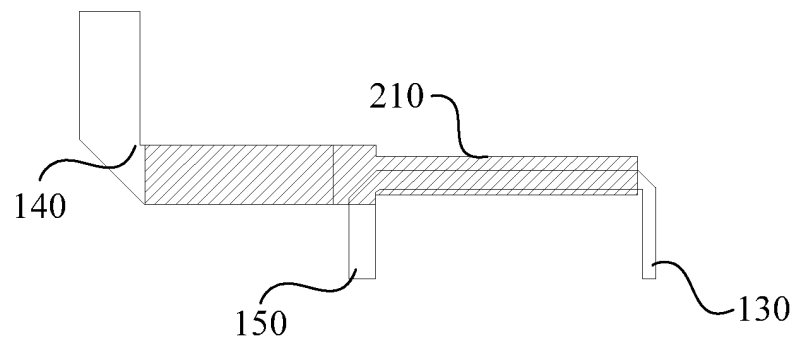


Figure 6

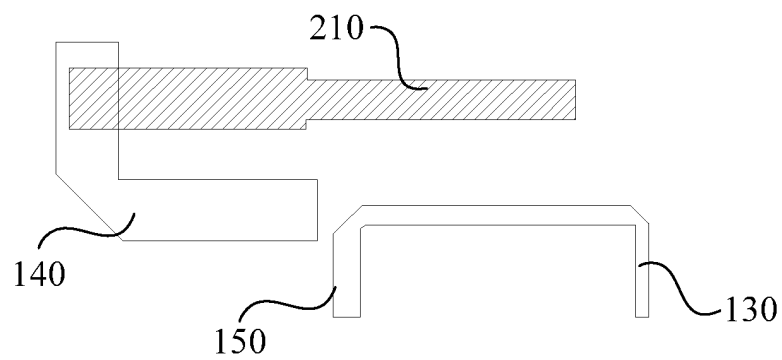


Figure 7

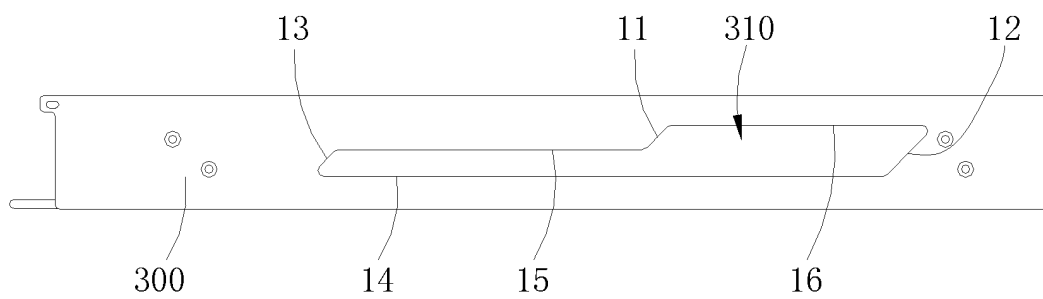


Figure 8

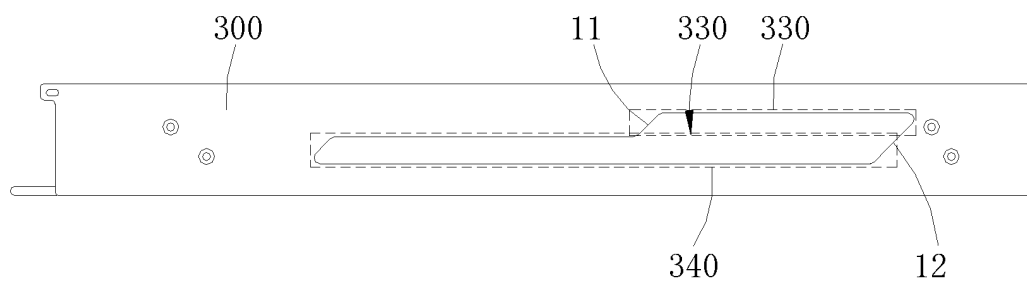


Figure 9

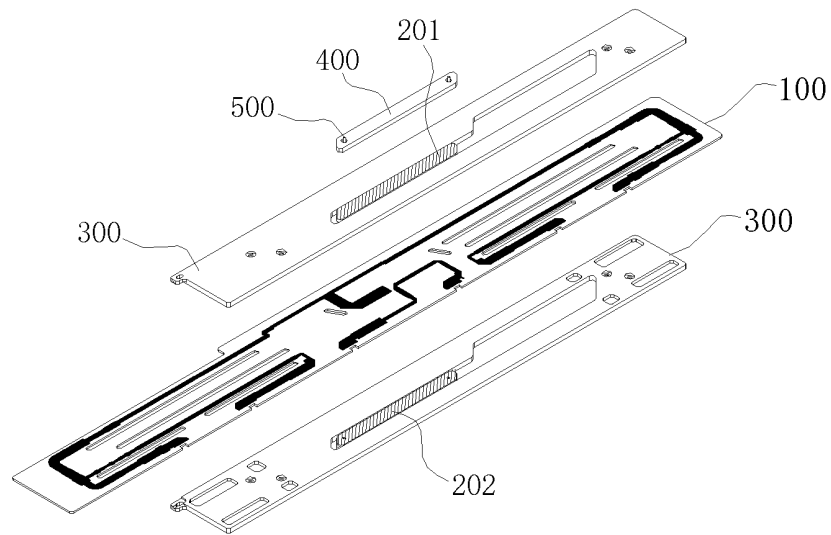


Figure 10

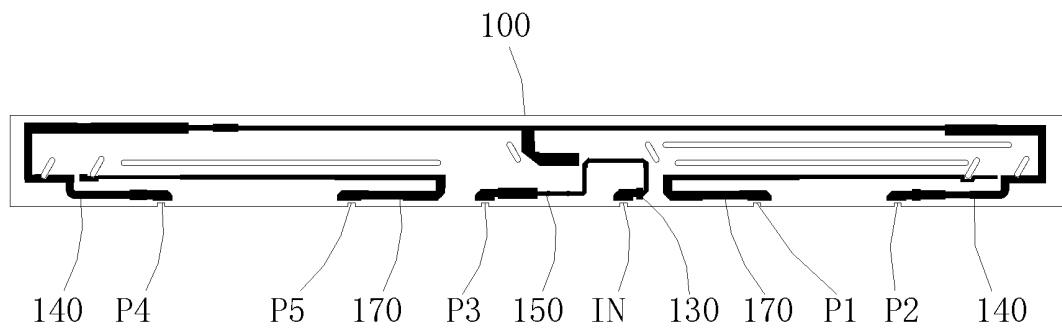


Figure 11

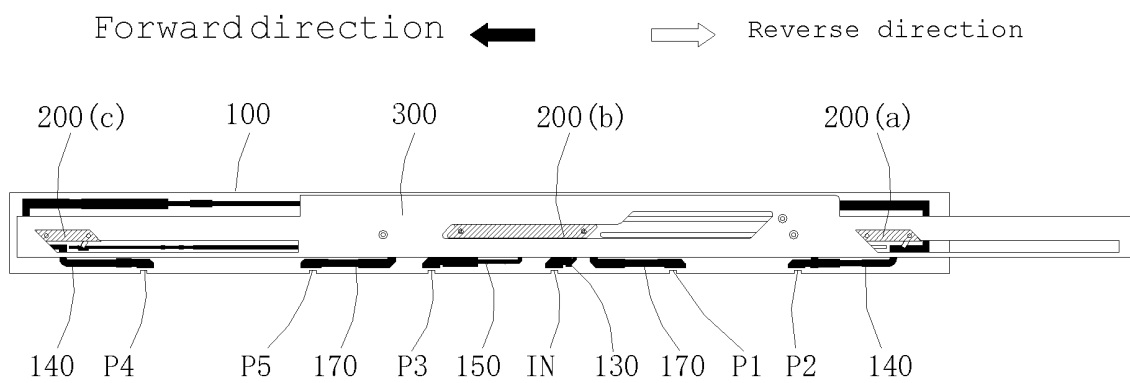


Figure 12

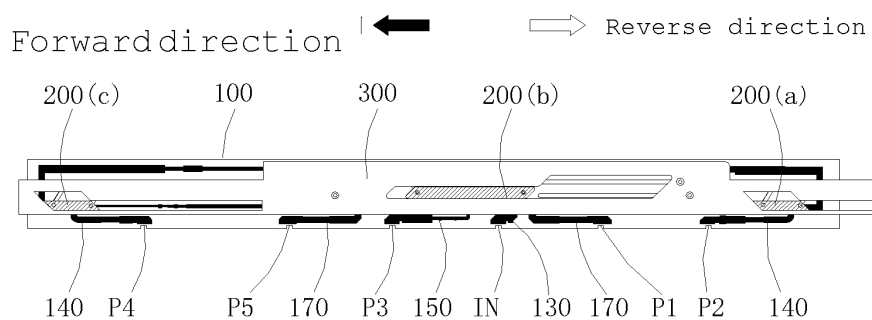


Figure 13

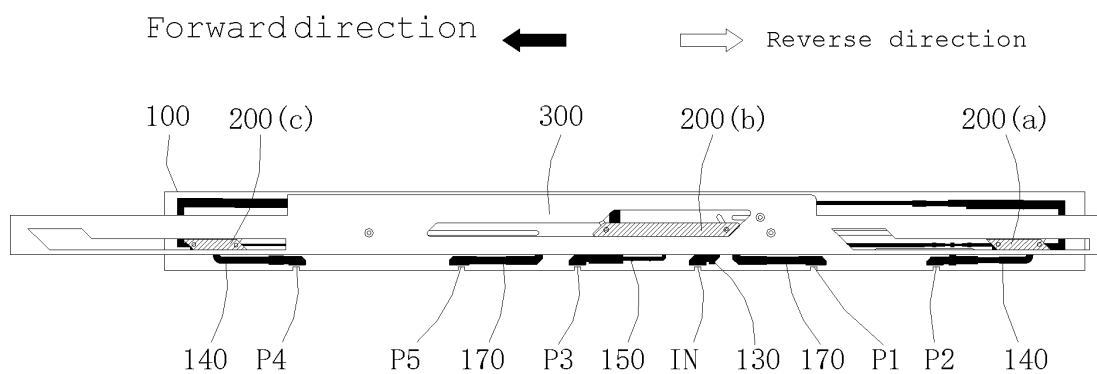


Figure 14

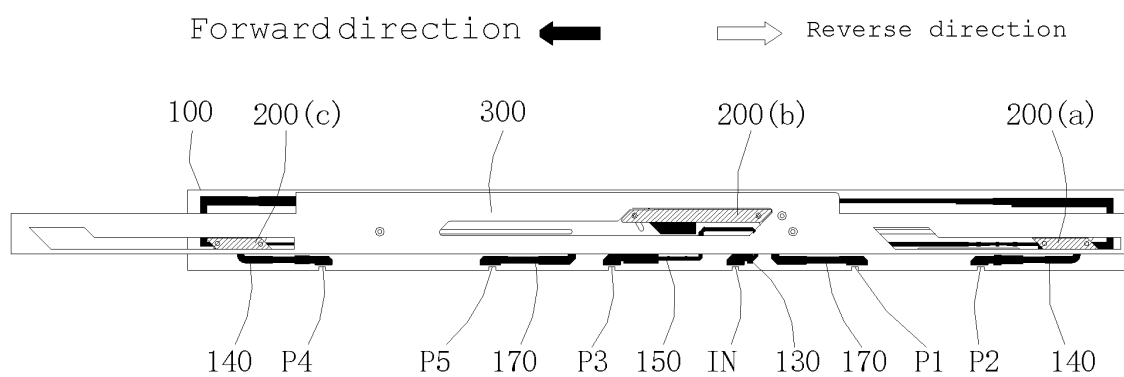


Figure 15

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2019/090786

5	A. CLASSIFICATION OF SUBJECT MATTER H01Q 3/30(2006.01)i	
	According to International Patent Classification (IPC) or to both national classification and IPC	
	B. FIELDS SEARCHED	
10	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	
15	Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) CNPAT, CNKI, WPI, EPODOC: 天线, 移相, 相移, 调相, 位置, 输入, 输出, 导通, 连通, 接通, 断开, 关断, 移动, 滑动, antenna, phase shifter, phase changer, position, input, output, on, off, connect, move, slide	
	C. DOCUMENTS CONSIDERED TO BE RELEVANT	
20	Category*	Citation of document, with indication, where appropriate, of the relevant passages
	PX	CN 109638391 A (SOUTH CHINA UNIVERSITY OF TECHNOLOGY et al.) 16 April 2019 (2019-04-16) the abstract, and description, paragraphs [0034]-[0070]
25	A	EP 1033773 A1 (LUCENT TECHNOLOGIES INC.) 06 September 2000 (2000-09-06) description, paragraphs [0011]-[0018], and figures 2-7
	A	CN 106684561 A (SOUTHEAST UNIVERSITY et al.) 17 May 2017 (2017-05-17) entire document
30	A	CN 101820090 A (UNIVERSITY OF SCIENCE AND TECHNOLOGY OF CHINA) 01 September 2010 (2010-09-01) entire document
	A	JP 2005303690 A (MAKITA CORPORATION) 27 October 2005 (2005-10-27) entire document
35	A	JP H104305 A (FURUKAWA ELECTRIC CO., LTD.) 06 January 1998 (1998-01-06) entire document
	☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.	
40	* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "D" document cited by the applicant in the international application "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	
45	Date of the actual completion of the international search	Date of mailing of the international search report
	23 July 2019	02 September 2019
50	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	
55	Facsimile No. (86-10)62019451	Telephone No.

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

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2019/090786

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	KR 20110085583 A (HIGH GAIN ANTENNA CO., LTD.) 27 July 2011 (2011-07-27) entire document	1-15

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

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Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
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		JP 2000261203 A	22 September 2000
		CA 2298326 A1	02 September 2000
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