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(54) ANTENNA UNIT AND ANTENNA ARRAY

(57) The present invention discloses an antenna unit and an antenna array, and relates to the communications field. The antenna unit includes: a baseplate and k patches that are above the baseplate and parallel to the baseplate, where an $(i+1)^{th}$ patch is above an i^{th} patch, $k > 1$, and $i < k$; and each patch includes a first feed point, the first feed point is connected to a first feed port, and the first feed port is configured to output a first signal; or each patch includes a first feed point and a second feed point, the first feed point is connected to a first feed port, the second feed point is connected to a second feed port, the first feed port outputs a first signal, the second feed port outputs a second signal, frequencies of the first signal and the second signal are the same, and polarization directions of the first signal and the second signal are perpendicular to each other. The present invention resolves a problem that circuit implementation of adding a filter after a feed port to separate two signals is complex, so that a structure of an antenna unit is simplified.

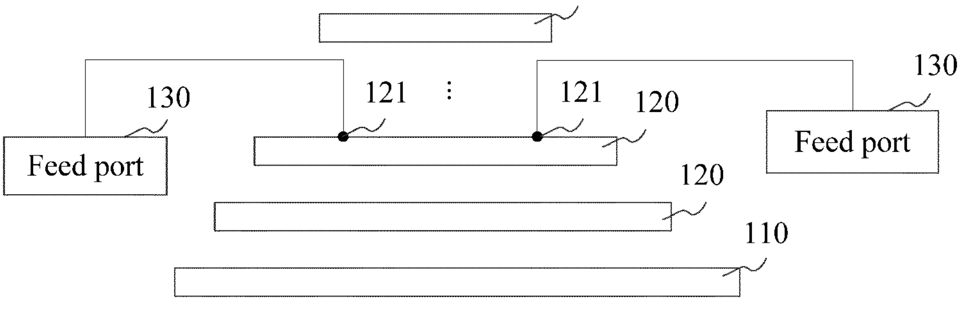

FIG. 1

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Description

TECHNICAL FIELD

[0001] The present invention relates to the communications field, and in particular, to an antenna unit and an antenna array.

BACKGROUND

[0002] As a mobile communications technology rapidly develops and a mobile communications service volume dramatically increases, a coverage area of a mobile communications network is increasingly expanded, and an antenna used as a critical component for mobile communication is becoming more important.

[0003] A conventional antenna unit includes a baseplate, a radiation patch that is above the baseplate and parallel to the baseplate, a director patch that is above the radiation patch and parallel to the radiation patch, and a probe. The probe is nailed from a baseplate side. A first feed point is formed by the probe and the radiation patch, and a second feed point is formed by the probe and the director patch. The first feed point and the second feed point each are connected to one feed port. The radiation patch is configured to radiate signal energy, the baseplate is configured to reflect signal energy radiated to the ground to the director patch, and the director patch is configured to reduce a beam angle of the radiated signal energy for energy concentration. Because of the probe, each feed port simultaneously outputs two signals with different frequencies but a same polarization direction, to implement dual frequency resonance. In such an antenna unit, a filter needs to be added after the feed port. The filter separates the two signals that are output by the feed port and have different frequencies, and then outputs the two separated signals. A structure of the antenna unit is complex because circuit implementation of adding the filter after the feed port is relatively complex.

SUMMARY

[0004] Embodiments of the present invention provide an antenna unit and an antenna array, to resolve a problem that a structure of an antenna unit is complex because circuit implementation of adding a filter after a feed port to separate two signals is relatively complex. The technical solutions are as follows:

A first aspect provides an antenna unit, where the antenna unit includes:

> a baseplate and k patches that are above the baseplate and parallel to the baseplate, where an $(i+1)^{th}$ patch is above an i^{th} patch, $k > 1$, and $i < k$; where each patch includes a first feed point, the first feed point is connected to a first feed port, and the first feed port is configured to output a first signal; or
> each patch includes a first feed point and a second feed point, the first feed point is connected to a first feed port, the second feed point is connected to a second feed port, the first feed port outputs a first signal, the second feed port outputs a second signal, frequencies of the first signal and the second signal are the same, and polarization directions of the first signal and the second signal are perpendicular to each other.

[0005] In a first possible implementation of the first aspect, a center frequency of a frequency band i corresponding to the i^{th} patch is in a negative correlation to an area of the i^{th} patch.

[0006] In a second possible implementation of the first aspect, bandwidth of a frequency band (i+1) corresponding to the $(i+1)^{th}$ patch is in a negative correlation to a height between the $(i+1)^{th}$ patch and the i^{th} patch.

[0007] With reference to any one of the first aspect, or the first or the second possible implementation of the first aspect, in a third possible implementation of the first aspect,

for the frequency band i corresponding to the i^{th} patch, the i^{th} patch is a radiation patch for the frequency band i; any j^{th} patch is a director patch for the frequency band i, where $i < j < k+1$; any m^{th} patch is a reflection patch of the frequency i, where $m < i$; and the baseplate is a reflection panel.

[0008] With reference to any one of the first aspect, or the first or the second or the fourth possible implementation of the first aspect, in a fifth possible implementation of the first aspect, an area of the $(i+1)^{th}$ patch is less than or equal to the area of the i^{th} patch.

[0009] With reference to any one of the first aspect, or the first or the second or the fourth or the fifth possible implementation of the first aspect, in a sixth possible implementation of the first aspect, central points of the k patches and the baseplate are on a same linear axis.

[0010] A second aspect provides an antenna array, where the antenna array includes at least two antenna units according to any one of the first aspect or the possible implementations.

[0011] In a first possible implementation of the second aspect, the antenna array includes at least one second antenna unit, a central location of the second antenna unit is deployed according to at least one of the following manners: on a connection line of central locations of the two first antenna units in a same row, or on a connection line of central locations of the two first antenna units in a same column, or on a connection line of central locations of the two second antenna units in a same row, or on a connection line of central locations of the two second antenna units in a same column.

[0012] With reference to either the second aspect or the first possible implementation of the second aspect, in a second possible implementation of the second aspect, the first antenna unit includes at least two patches, and a center frequency of a frequency band corresponding to a first patch is less than a center frequency of a frequency band corresponding to any other patch; and a center frequency of a frequency band corresponding to the second antenna unit is greater than the center frequency of the frequency band corresponding to the first patch.

[0013] Beneficial effects of the technical solutions provided in the embodiments of the present invention are as follows:

When at least two patches with different frequencies are superposed, one feed point is connected to one feed port, so that the feed port outputs only one signal, and there is no need to add a filter after the feed port to separate signals with different frequencies. This resolves a problem that a structure of an antenna unit is complex because circuit implementation of adding a filter after a feed port in a dual-band antenna to separate signals is complex, so that the structure of the antenna unit is simplified.

BRIEF DESCRIPTION OF DRAWINGS

[0014] To describe the technical solutions in the embodiments of the present invention more clearly, the following briefly describes the accompanying drawings required for describing the embodiments. Apparently, the accompanying drawings in the following description show merely some embodiments of the present invention, and a person of ordinary skill in the art may still derive other drawings from these accompanying drawings without creative efforts.

FIG. 1 is a schematic structural diagram of an antenna unit according to an embodiment of the present invention;

FIG. 2A is a schematic structural diagram of another antenna unit according to an embodiment of the present invention;

FIG. 2B is a schematic diagram of a current direction according to an embodiment of the present invention;

FIG. 2C is a schematic diagram of first emulation according to an embodiment of the present invention;

FIG. 2D is a schematic diagram of second emulation according to an embodiment of the present invention;

FIG. 3 is a schematic structural diagram of an antenna array according to an embodiment of the present invention;

FIG. 4 is a schematic structural diagram of another antenna array according to an embodiment of the present invention;

FIG. 5 is a schematic structural diagram of another antenna array according to an embodiment of the present invention;

FIG. 6 is a schematic structural diagram of another antenna array according to an embodiment of the present invention; and

FIG. 7 is a schematic structural diagram of another antenna array according to an embodiment of the present invention.

DESCRIPTION OF EMBODIMENTS

[0015] To make the objectives, technical solutions, and advantages of the present invention clearer, the following further describes the embodiments of the present invention in detail with reference to the accompanying drawings.

[0016] Referring to FIG. 1, FIG. 1 is a schematic structural diagram of an antenna unit according to an embodiment of the present invention. The antenna unit may include:

a baseplate 110 and k patches 120 that are above the baseplate 110 and parallel to the baseplate 110, where an $(i+1)^{th}$ patch 120 is above an i^{th} patch 120, $k > 1$, and $i < k$.

[0017] Each patch 120 includes a first feed point 121, the first feed point 121 is connected to a first feed port 130, the first feed port 130 is configured to output a first signal, and the first signal is a single polarization signal, or each patch 120 includes a first feed point 121 and a second feed point 121, the first feed point 121 is connected to a first feed port 130, the second feed point 121 is connected to a second feed port 130, the first feed port 130 outputs a first signal, the second feed port 130 outputs a second signal, frequencies of the first signal and the second signal are the same, and polarization directions of the first signal and the second signal are perpendicular to each other. For ease of drawing, FIG. 1 shows only an example in which one patch 120 includes two feed points 121.

[0018] In conclusion, according to the antenna unit provided in this embodiment of the present invention, when at least two patches with different frequencies are superposed, one feed point is connected to one feed port, so that the feed port outputs only one signal, and there is no need to add a filter after the feed port to separate signals with different frequencies. This resolves a problem that a structure of an antenna unit is complex because circuit implementation of adding a filter after a feed port in a dual-band antenna to separate signals is complex, so that the structure of the antenna unit is simplified.

[0019] Referring to FIG. 1, the antenna unit provided in this embodiment of the present invention may include a baseplate 110 and k patches 120 that are above the baseplate 110 and parallel to the baseplate 110, where an $(i+1)^{th}$ patch 120 is above an i^{th} patch 120, $k > 1$, and $i < k$.

[0020] The baseplate 110 is made of a metallic material. For example, the baseplate 110 may be made of aluminum.

[0021] Each of the k patches 120 included in the antenna unit are parallel to the baseplate 110, and the $(i+1)^{th}$ patch 120 is above the i^{th} patch 120. That is, a projection of the $(i+1)^{th}$ patch 120 is above that of the i^{th} patch 120 in a predetermined direction, and the predetermined direction is a perpendicular direction of a plane on which the $(i+1)^{th}$ patch 120 is located.

[0022] In a preferred solution, central points of the k patches 120 and the baseplate 110 are on a same linear axis, so as to ensure that a directivity pattern of the antenna unit does not shift.

[0023] Each of the k patches 120 corresponds to one frequency band. For example, a first patch 120 corresponds to a frequency band 1 of 2.6 GHz, a second patch 120 corresponds to a frequency band 2 of 3.5 GHz, and a third patch 120 corresponds to a frequency band 3 of 5 GHz.

[0024] In a first possible implementation, each patch 120 includes a first feed point 121, the first feed point 121 is connected to a first feed port 130, and the first feed port 130 is configured to output a first signal. The first feed port 130 is located outside the patch, and the first signal is a single polarization signal.

[0025] When the first feed point 121 of each patch 120 is connected to the first feed port 130, the first feed port 130 outputs only one single polarization signal. In this case, there is no need to add a filter after the first feed port 130 to separate signals. This resolves a problem that a structure of an antenna unit is complex because circuit implementation of adding a filter after a feed port to separate two signals is complex, so that the structure of the antenna unit is simplified.

[0026] In a second possible implementation, referring to a schematic structural diagram of another antenna unit shown in FIG. 2A, each patch 120 includes a first feed point 121 and a second feed point 121, the first feed point 121 is connected to a first feed port 130, the second feed point 121 is connected to a second feed port 130, the first feed port 130 outputs a first signal, and the second feed port 130 outputs a second signal. Frequencies of the first signal and the second signal are the same, and polarization directions of the first signal and the second signal are perpendicular to each other. The first feed port 130 and the second feed port 130 are located outside the patch.

[0027] For example, when a first patch 120 corresponds to a frequency band 1 of 2.6 GHz, and a polarization direction is ±45°, a first feed port 130 corresponding to the first patch 120 outputs a signal whose polarization direction is 45° and that is of the frequency band 1 of 2.6 GHz, and a second feed port 130 corresponding to the first patch 120 outputs a signal whose polarization direction is -45° and that is of the frequency band 1 of 2.6 GHz. When a second patch 120 corresponds to a frequency band 2 of 3.5 GHz, and a polarization direction is ±45°, a first feed port 130 corresponding to the second patch 120 outputs a signal whose polarization direction is 45° and that is of the frequency band 2 of 3.5 GHz, and a second feed port 130 corresponding to the second patch 120 outputs a signal whose polarization direction is -45° and that is of the frequency band 2 of 3.5 GHz.

[0028] A shape of each feed point 121 may be independently set. For example, the shape of the feed point 121 may be set as a rectangle, a triangle, a circle, a regular polygon, or the like. This is not limited in this embodiment. In addition, a location of each feed point 121 may also be independently set, and details are not described in this embodiment.

[0029] Each feed port 130 outputs only one signal, and there is no need to add a filter after the feed port 130 to separate signals. Therefore, each feed port 130 can directly output a signal, and a structure of the antenna unit is simplified.

[0030] It should be noted that the antenna unit further includes a feeding network 140, and each feeding network 140 is connected to at least one feed port 130.

[0031] When the antenna unit provided in this embodiment operates, a correlation between the k patches 120 is as follows:

For a frequency band i corresponding to the i^{th} patch, the i^{th} patch is a radiation patch for the frequency band i; any j^{th} patch is a director patch for the frequency band i, where $i < j < k+1$; any m^{th} patch is a reflection patch of the frequency i, where $m < i$; and the baseplate is a reflection panel.

[0032] For example, it is assumed that k = 3, and the example in which the first patch 120 corresponds to the frequency band 1 of 2.6 GHz, the second patch 120 corresponds to the frequency band 2 of 3.5 GHz, and the third patch 120 corresponds to the frequency band 3 of 5 GHz is still used for description. In this case, for the frequency band 1, the first patch is a radiation patch, the second patch and the third patch that are above the radiation patch are director patches, and the baseplate is a reflection panel. For the frequency band 2, the second patch is a radiation patch, the third patch above the radiation patch is a director patch, the first patch below the radiation patch is a reflection patch, and the baseplate is a reflection panel. For the frequency band 3, the third patch is a radiation patch, the first patch and the second patch that are below the radiation patch are reflection patches, and the baseplate is a reflection panel.

[0033] It can be learned according to the foregoing content that one patch 120 may be a director patch, a radiation patch, or a reflection patch. This specifically depends on a frequency band for which the patch 120 functions. The example in which k = 3 is still used for description. In this case, the first patch is a radiation patch for the frequency band 1, and is a reflection patch for the frequency band 2 and the frequency band 3. The second patch is a director patch for the frequency band 1, is a radiation patch for the frequency band 2, and is a reflection patch for the frequency band 3. The third patch is a director patch for the frequency band 1 and the frequency band 2, and is a radiation patch for the frequency band 3.

[0034] Refer to a schematic diagram of a current direction shown in FIG. 2B. A direction of a vertical arrow that points upwards in a left view is the current direction, and two paths of currents vertically flow from the baseplate 110 to a first patch. When the currents arrive at two feed points 121 of the first patch, radiation is performed, a second patch plays a directive role, and the baseplate plays a reflection role. When the currents flow to two feed points 121 of the second patch, radiation is performed, and the first patch and the baseplate play a reflection role. A right view is structural decomposition of an antenna unit.

[0035] Generally, when there are multiple director patches for a radiation patch, a director patch adjacent to the radiation patch plays a biggest directive role, and directive roles of other director patches may be ignored. When there are multiple reflection patches for a radiation patch, a reflection patch adjacent to the radiation patch plays a biggest reflection role, and reflection roles of other reflection patches may be ignored.

[0036] In this embodiment, a center frequency of a frequency band i corresponding to the i^{th} patch is in a negative correlation to an area of the i^{th} patch. In addition, bandwidth of a frequency band (i+1) corresponding to the $(i+1)^{th}$ patch is in a negative correlation to a height between the $(i+1)^{th}$ patch and the i^{th} patch.

[0037] In a possible implementation scenario, if an area of the $(i+1)^{th}$ patch is adjusted, a center frequency of the frequency band (i+1) accordingly changes. When the $(i+1)^{th}$ patch is used as a director patch of the i^{th} patch, adjustment to the area of the $(i+1)^{th}$ patch also affects the frequency band i. In this case, a height between the i^{th} patch and an $(i-1)^{th}$ patch is adjusted to compensate for impact on the frequency band i.

[0038] It should be noted that impact imposed on bandwidth by a height between a radiation patch and a reflection patch is greater than impact imposed on bandwidth by a height between a director patch and a radiation patch.

[0039] A center frequency corresponding to a patch is in a negative correlation to an area of the patch. Therefore, to obtain a multi-band antenna, areas of all patches may be set to be unequal. It is still assumed that k = 3, the first patch 120 corresponds to the frequency band 1 of 2.6 GHz, the second patch 120 corresponds to the frequency band 2 of 3.5 GHz, and the third patch 120 corresponds to the frequency band 3 of 5 GHz. In this case, an area of the first patch is the largest, an area of the second patch is slightly smaller, and an area of the third patch is the smallest.

[0040] In actual implementation, when the area of the i^{th} patch is equal to the area of the $(i+1)^{th}$ patch, a center frequency of the $(i+1)^{th}$ patch is pulled by the reflection panel and the reflection patch located below, and is slightly greater than a center frequency of the i^{th} patch. For example, the center frequency corresponding to the i^{th} patch is 3.3 GHz, and the center frequency corresponding to the $(i+1)^{th}$ frequency is 3.5 GHz.

[0041] Therefore, in a preferred solution, the area of the $(i+1)^{th}$ patch is less than or equal to the area of the i^{th} patch.

[0042] Refer to a schematic diagram of first emulation of an antenna unit in FIG. 2C. The antenna unit meets a requirement that a standing wave is less than -10 dB for 2.5 GHz to 2.7 GHz.

[0043] Refer to a schematic diagram of second emulation of an antenna unit in FIG. 2D. The antenna unit also meets a requirement that a standing wave is less than -10 dB for 3.4 GHz to 3.6 GHz.

[0044] It should be noted that in a related technology, each probe is connected to a first feed point of each radiation patch, and is connected to a second feed point of a director patch. The probe is a conductor and a current is the largest at a feed point. In this case, a current loop is formed between the radiation patch and the director patch. When a center frequency of a frequency band corresponding to the director patch is relatively close to a center frequency of a frequency band corresponding to the radiation patch, coupling between the director patch and the radiation patch is relatively strong, and the director patch plays a radiation role. In this case, the director patch cannot be distinguished from the radiation patch. Consequently, an antenna unit cannot receive or send a signal. Therefore, a difference between center frequencies of two frequency bands of the antenna unit needs to be relatively large in an implementation of the feed point in the related technology. However, in this embodiment, when a center frequency of a frequency band corresponding to a director patch is relatively close to a center frequency of a frequency band corresponding to a radiation patch, coupling between the director patch and the radiation patch is relatively weak because the director patch and the radiation patch are not connected by using a probe, and the director patch still plays a directive role. Therefore, a difference between center frequencies of two frequency bands of the antenna unit does not need to be relatively large away from each other in an implementation of a feed point. When center frequencies of two frequency bands of the antenna unit are relatively close to each other, the two frequency bands may be considered as a relatively broad frequency band. That is, the antenna unit in this embodiment can be implemented as a broadband antenna. For example, when center frequencies of two frequency bands are 2.4 GHz and 3 GHz, a broadband antenna of 2.4 GHz to 3 GHz can be implemented.

[0045] In conclusion, according to the antenna unit provided in this embodiment of the present invention, when at least two patches with different frequencies are superposed, one feed point is connected to one feed port, so that the feed port outputs only one signal, and there is no need to add a filter after the feed port to separate signals with different frequencies. This resolves a problem that a structure of an antenna unit is complex because circuit implementation of adding a filter after a feed port in a dual-band antenna to separate signals is complex, so that the structure of the antenna unit is simplified.

[0046] In addition, the center frequency of the frequency band (i+1) is in a negative correlation to the area of the $(i+1)^{th}$ patch, and the bandwidth of the frequency band (i+1) is in a negative correlation to the height between the $(i+1)^{th}$ patch and the i^{th} patch. A center frequency band of a frequency band can be adjusted by setting a patch area and a height, so that receiving accuracy of the antenna unit is improved.

[0047] Referring to FIG. 3, FIG. 3 is a schematic structural diagram of an antenna array according to an embodiment of the present invention. The antenna array may include at least two first antenna units. The first antenna unit is the antenna unit shown in FIG. 1, FIG. 2A, or FIG. 2B.

[0048] The at least two first antenna units may form the antenna array by means of arrangement. A distance between central locations of all first antenna units in one row of first antenna units may be equal or unequal to a distance between central locations of all first antenna units in one column of first antenna units. This is not limited in this embodiment. The central location may be referred to as a physical center or the like. Details are not repeatedly described below.

[0049] An example in which a first antenna unit includes two patches is used in FIG. 3 for description. In addition, a center frequency of a frequency band corresponding to a first patch is less than a center frequency of a frequency band corresponding to a second patch. A larger area of a patch indicates a smaller center frequency of a frequency band corresponding to the patch. Therefore, an area of the first patch is greater than an area of the second patch. In FIG. 3, an outer block 301 represents the first patch, and an inner block 302 represents the second patch. A distance between two adjacent outer blocks 301 is less than a distance between two adjacent inner blocks 302. Therefore, it is relatively simple to implement beamforming between low frequency signals, and a beamforming effect is also relatively favorable, that is, an effect of receiving and sending a low frequency signal by such an antenna array is relatively favorable.

[0050] An embodiment of the present invention provides a schematic structural diagram of another antenna array. The antenna array may include at least two first antenna units and at least one second antenna unit. A central location of the second antenna unit is deployed according to at least one of the following manners: on a connection line of central locations of two first antenna units in a same row, or on a connection line of central locations of two first antenna units in a same column, or on a connection line of central locations of two second antenna units in a same row, or on a connection line of central locations of two second antenna units in a same column. The first antenna unit is the antenna unit shown in FIG. 1, FIG. 2A, or FIG. 2B.

[0051] In a first possible implementation, the central location of the second antenna unit is on the connection line of the central locations of the two first antenna units in the same row, or the connection line of the central locations of the two second antenna units in the same row.

[0052] When there are one or two columns of second antenna units between two columns of first antenna units, a central location of each second antenna unit is on the connection line of the central locations of the two first antenna units in the same row. When there are three or more columns of second antenna units between two columns of first antenna units, central locations of some second antenna units are on the connection line of the central locations of the two first antenna units in the same row, and central locations of the other second antenna units are on the connection line of the central locations of the two second antenna units in the same row.

[0053] Referring to FIG. 4, an example in which a first antenna unit includes two patches is used in FIG. 4 for description. In addition, an outer block 401 represents a first patch, and an inner block 402 represents a second patch. For a specific rule, refer to descriptions in the embodiment shown in FIG. 3.

[0054] Generally, there is an antenna transmitting a high frequency signal between antennas transmitting a low frequency signal. Therefore, a second antenna unit between outer blocks 401 is an antenna transmitting a high frequency signal, and a block 403 represents the second antenna unit. A center frequency of a frequency band corresponding to the second antenna unit is greater than a center frequency of a frequency band corresponding to the first patch, and a magnitude relationship between the center frequency of the frequency band corresponding to the second antenna unit and a center frequency of a frequency band corresponding to the second patch is not limited in this embodiment. In this embodiment, the high frequency signal is relative to the low frequency signal, and specific frequency bands of the high frequency signal and the low frequency signal are not limited. Details are not repeatedly described below.

[0055] In a row direction, a distance between two adjacent outer blocks 401 is greater than a distance between an inner block 402 and a block 403 that are adjacent to each other. Therefore, it is relatively simple to implement beamforming between high frequency signals, and a beamforming effect is also relatively favorable, that is, an effect of receiving and sending a high frequency signal by such an antenna array is relatively favorable.

[0056] In a second possible implementation, the central location of the second antenna unit is on the connection line of the central locations of the two first antenna units in the same column, or the connection line of the central locations of the two second antenna units in the same column.

[0057] When there are one or two rows of second antenna units between two rows of first antenna units, a central location of each second antenna unit is on the connection line of the central locations of the two first antenna units in the same column. When there are three or more rows of second antenna units between two rows of first antenna units, central locations of some second antenna units are on the connection line of the central locations of the two first antenna units in the same column, and central locations of the other second antenna units are on the connection line of the central locations of the two second antenna units in the same column.

[0058] Referring to FIG. 5, an example in which a first antenna unit includes two patches is used in FIG. 5 for description. In addition, an outer block 501 represents a first patch, an inner block 502 represents a second patch, and a block 503 represents a second antenna unit. For a specific rule, refer to descriptions in the embodiment shown in FIG. 3. A center frequency of a frequency band corresponding to the second antenna unit is greater than a center frequency of a frequency band corresponding to the first patch, and a magnitude relationship between the center frequency of the frequency band corresponding to the second antenna unit and a center frequency of a frequency band corresponding to the second patch is not limited in this embodiment.

[0059] In a column direction, a distance between two adjacent outer blocks 501 is greater than a distance between an inner block 502 and a block 503 that are adjacent to each other. Therefore, it is relatively simple to implement beamforming between high frequency signals, and a beamforming effect is also relatively favorable, that is, an effect of receiving and sending a high frequency signal by such an antenna array is relatively favorable.

[0060] In a third possible implementation, the central location of the second antenna unit is on the connection line of the central locations of the two first antenna units in the same row, or the connection line of the central locations of the two first antenna units in the same column, or the connection line of the central locations of the two second antenna units in the same row, or the connection line of the central locations of the two second antenna units in the same column.

[0061] Referring to FIG. 6, an example in which a first antenna unit includes two patches is used in FIG. 6 for description. In addition, an outer block 601 represents a first patch, an inner block 602 represents a second patch, and a block 603 represents a second antenna unit. For a specific rule, refer to descriptions in the embodiment shown in FIG. 3. A center frequency of a frequency band corresponding to the second antenna unit is greater than a center frequency of a frequency band corresponding to the first patch, and a magnitude relationship between the center frequency of the frequency band corresponding to the second antenna unit and a center frequency of a frequency band corresponding to the second patch is not limited in this embodiment.

[0062] In both a row direction and a column direction, a distance between two adjacent outer blocks 601 is greater than a distance between an inner block 602 and a block 603 that are adjacent to each other. Therefore, it is relatively simple to implement beamforming between high frequency signals, and a beamforming effect is also relatively favorable, that is, an effect of receiving and sending a high frequency signal by such an antenna array is relatively favorable.

[0063] In a fourth possible implementation, the central location of the second antenna unit is on the connection line of the central locations of the two first antenna units in the same column. That is, a required antenna topology form can be obtained by shifting each column of second antenna units between two columns of first antenna units shown in FIG. 6 downwards by a specific distance.

[0064] Referring to FIG. 7, an example in which a first antenna unit includes two patches is used in FIG. 7 for description. In addition, an outer block 701 represents a first patch, an inner block 702 represents a second patch, and a block 703 represents a second antenna unit. For a specific rule, refer to descriptions in the embodiment shown in FIG. 3. A center frequency of a frequency band corresponding to the second antenna unit is greater than a center frequency of a frequency band corresponding to the first patch, and a magnitude relationship between the center frequency of the frequency band corresponding to the second antenna unit and a center frequency of a frequency band corresponding to the second patch is not limited in this embodiment.

[0065] In both a row direction and a column direction, a distance between two adjacent outer blocks 701 is greater than a distance between an inner block 702 and a block 703 that are adjacent to each other. Therefore, it is relatively simple to implement beamforming between high frequency signals, and a beamforming effect is also relatively favorable, that is, an effect of receiving and sending a high frequency signal by such an antenna array is relatively favorable.

[0066] It should be noted that a distance d1 between central locations of two adjacent high frequency antennas in FIG. 7 is equal to a distance d2 between central locations of two adjacent high frequency antennas in FIG. 6. In this case, a distance between first patches of two adjacent first antenna units in FIG. 7 is closer than that in FIG. 6. Therefore, it is relatively simple to implement beamforming between low frequency signals, and a beamforming effect is also relatively favorable, that is, an effect of receiving and sending a low frequency signal by such an antenna array is relatively favorable.

[0067] The sequence numbers of the foregoing embodiments of the present invention are merely for illustrative purposes, and are not intended to indicate priorities of the embodiments.

[0068] A person of ordinary skill in the art may be aware that, in combination with the examples described in the embodiments disclosed in this specification, units and algorithm steps may be implemented by electronic hardware or a combination of computer software and electronic hardware. Whether the functions are performed by hardware or software depends on particular applications and design constraint conditions of the technical solutions. A person skilled in the art may use different methods to implement the described functions for each particular application, but it should not be considered that the implementation goes beyond the scope of the present invention.

[0069] It may be clearly understood by a person skilled in the art that, for the purpose of convenient and brief description, for a detailed working process of the foregoing system, apparatus, and unit, refer to a corresponding process in the foregoing method embodiments, and details are not described herein again.

[0070] In the several embodiments provided in this application, it should be understood that the disclosed system, apparatus, and method may be implemented in other manners. For example, the described apparatus embodiment is merely an example. For example, the unit division may merely be logical function division and may be other division in actual implementation. For example, a plurality of units or components may be combined or integrated into another system, or some features may be ignored or not performed. In addition, the displayed or discussed mutual couplings or direct couplings or communication connections may be implemented by using some interfaces. The indirect couplings or communication connections between the apparatuses or units may be implemented in electronic, mechanical, or other forms.

[0071] The units described as separate parts may or may not be physically separate, and parts displayed as units may or may not be physical units, may be located in one position, or may be distributed on a plurality of network units. Some or all of the units may be selected according to actual requirements to achieve the objectives of the solutions of the embodiments.

[0072] In addition, functional units in the embodiments of the present invention may be integrated into one processing unit, or each of the units may exist alone physically, or two or more units may be integrated into one unit.

[0073] When the functions are implemented in the form of a software functional unit and sold or used as an independent product, the functions may be stored in a computer-readable storage medium. Based on such an understanding, the technical solutions of the present invention essentially, or the part contributing to the prior art, or some of the technical solutions may be implemented in a form of a software product. The software product is stored in a storage medium, and includes several instructions for instructing a computer device (which may be a personal computer, a server, or a network device) to perform all or some of the steps of the methods described in the embodiments of the present invention. The foregoing storage medium includes: any medium that can store program code, such as a USB flash drive, a removable hard disk, a read-only memory (Read-Only Memory, ROM), a random access memory (Random Access Memory, RAM), a magnetic disk, or an optical disc.

[0074] The foregoing descriptions are merely specific implementations of the present invention, but are not intended to limit the protection scope of the present invention. Any variation or replacement readily figured out by a person skilled in the art within the technical scope disclosed in the present invention shall fall within the protection scope of the present invention. Therefore, the protection scope of the present invention shall be subject to the protection scope of the claims.

Claims

1. An antenna unit, wherein the antenna unit comprises:

a baseplate and k patches that are above the baseplate and parallel to the baseplate, wherein an $(i+1)^{th}$ patch is above an i^{th} patch, $k > 1$, and $i < k$; wherein

each patch comprises a first feed point, the first feed point is connected to a first feed port, and the first feed port is configured to output a first signal; or

each patch comprises a first feed point and a second feed point, the first feed point is connected to a first feed port, the second feed point is connected to a second feed port, the first feed port outputs a first signal, the second feed port outputs a second signal, frequencies of the first signal and the second signal are the same, and polarization directions of the first signal and the second signal are perpendicular to each other.

2. The antenna unit according to claim 1, wherein a center frequency of a frequency band i corresponding to the i^{th} patch is in a negative correlation to an area of the i^{th} patch.

3. The antenna unit according to claim 1, wherein bandwidth of a frequency band (i+1) corresponding to the $(i+1)^{th}$ patch is in a negative correlation to a height between the $(i+1)^{th}$ patch and the i^{th} patch.

4. The antenna unit according to any one of claims 1 to 3, wherein

for the frequency band i corresponding to the i^{th} patch, the i^{th} patch is a radiation patch for the frequency band i; any j^{th} patch is a director patch for the frequency band i, wherein $i < j < k+1$; any m^{th} patch is a reflection patch of the frequency i, wherein $m < i$; and the baseplate is a reflection panel.

5. The antenna unit according to any one of claims 1 to 4, wherein an area of the $(i+1)^{th}$ patch is less than or equal to the area of the i^{th} patch.

6. The antenna unit according to any one of claims 1 to 5, wherein central points of the k patches and the baseplate are on a same linear axis.

7. An antenna array, wherein the antenna array comprises at least two antenna units according to any one of claims 1 to 6.

8. The antenna array according to claim 7, wherein the antenna array further comprises at least one second antenna unit, a central location of the second antenna unit is deployed according to at least one of the following manners: on a connection line of central locations of the two first antenna units in a same row, or on a connection line of central locations of the two first antenna units in a same column, or on a connection line of central locations of the two second antenna units in a same row, or on a connection line of central locations of the two second antenna units in a same column.

9. The antenna array according to claim 7 or 8, wherein the first antenna unit comprises at least two patches, and a center frequency of a frequency band corresponding to a first patch is less than a center frequency of a frequency band corresponding to any other patch; and
a center frequency of a frequency band corresponding to the second antenna unit is greater than the center frequency of the frequency band corresponding to the first patch.

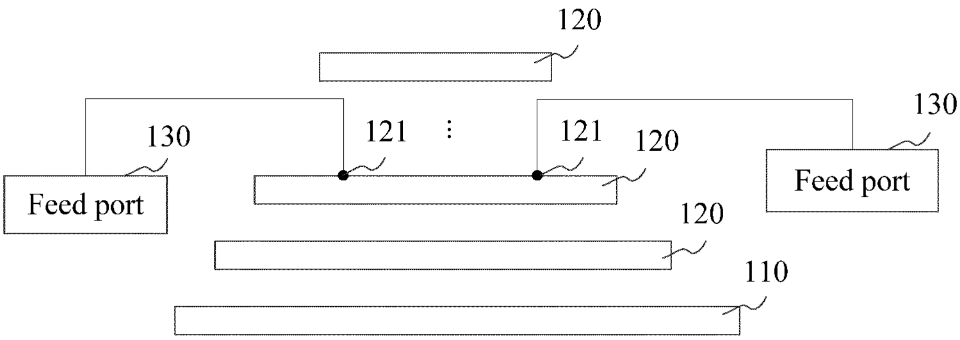

120
130
121
121
120
Feed port
130
Feed port
120
110

FIG. 1

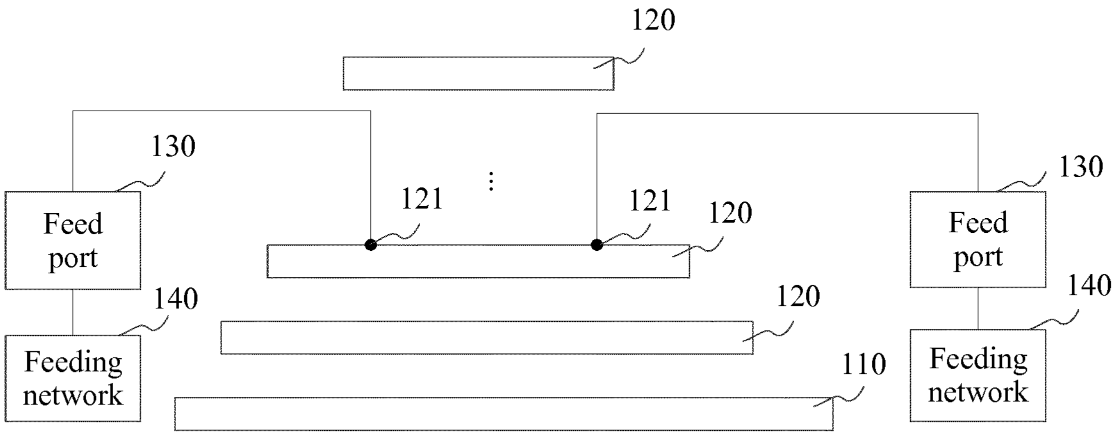

120
130
Feed port
121
121
120
130
Feed port
140
Feeding network
120
110
140
Feeding network

FIG. 2A

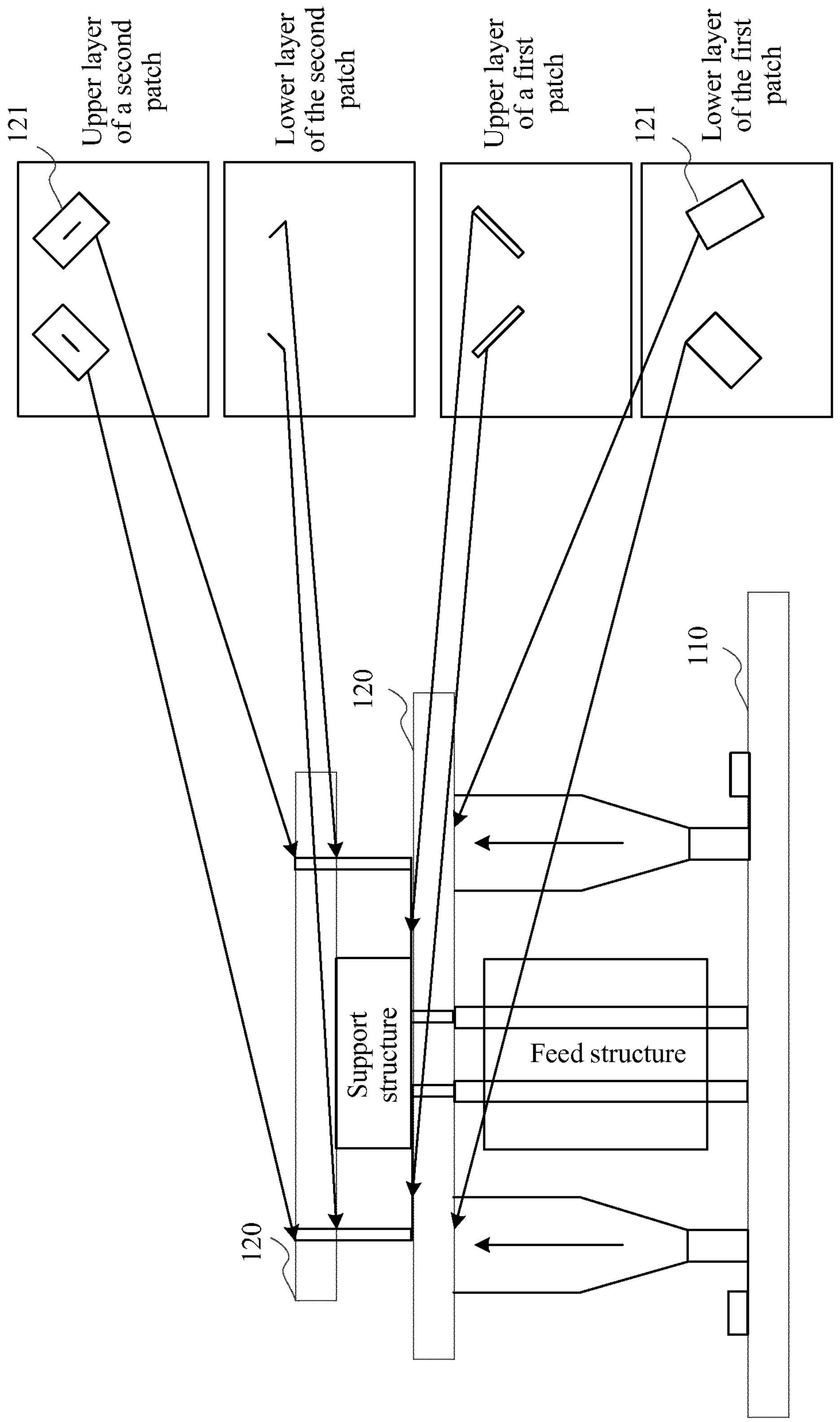
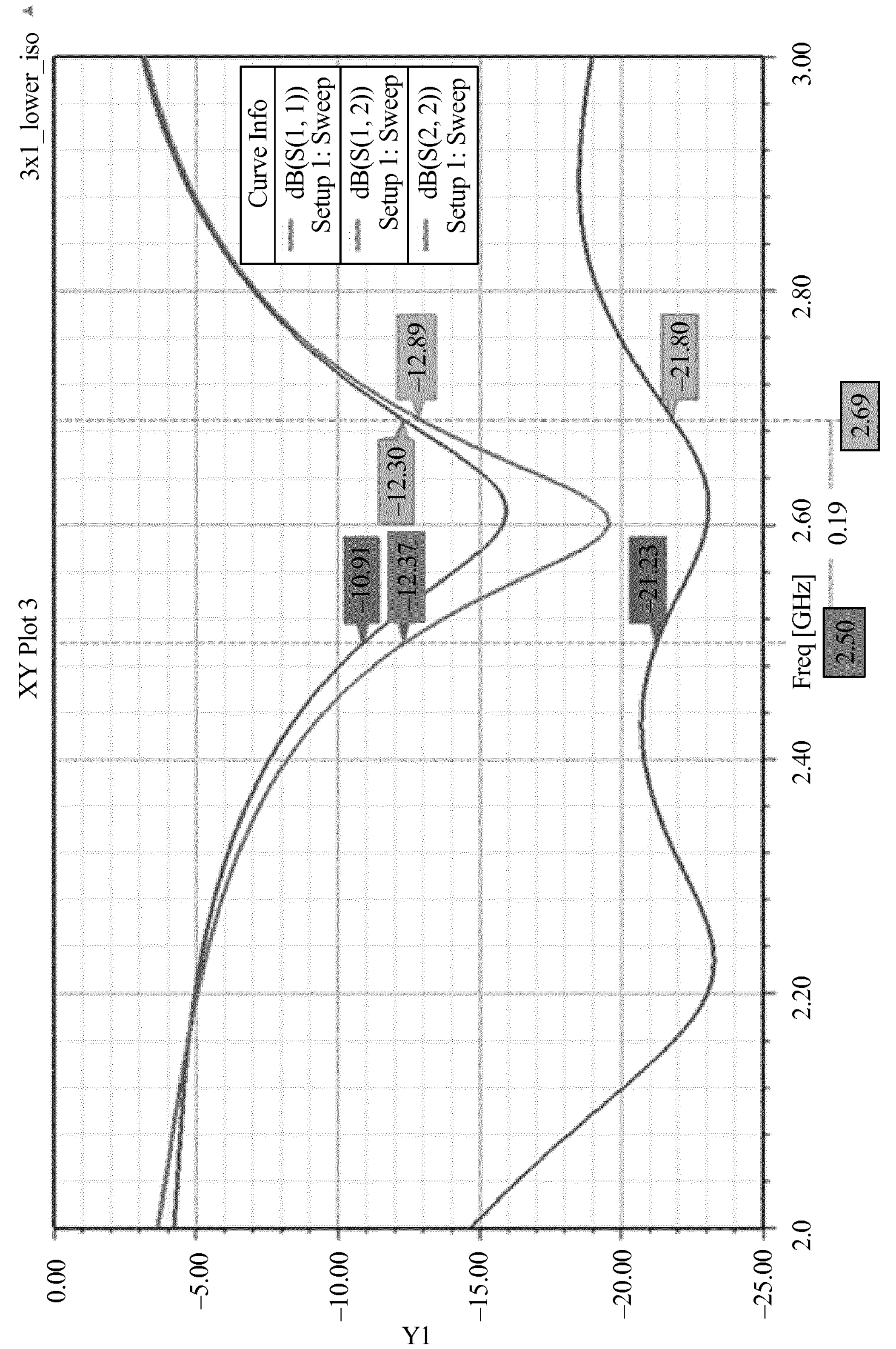

121
Upper layer of a second patch
Lower layer of the second patch
Upper layer of a first patch
121
Lower layer of the first patch
120
110
Support structure
Feed structure
120

FIG. 2B


XY Plot 3
3x1_lower_iso
Curve Info
dB(S(1, 1))
Setup 1: Sweep
dB(S(1, 2))
Setup 1: Sweep
dB(S(2, 2))
Setup 1: Sweep
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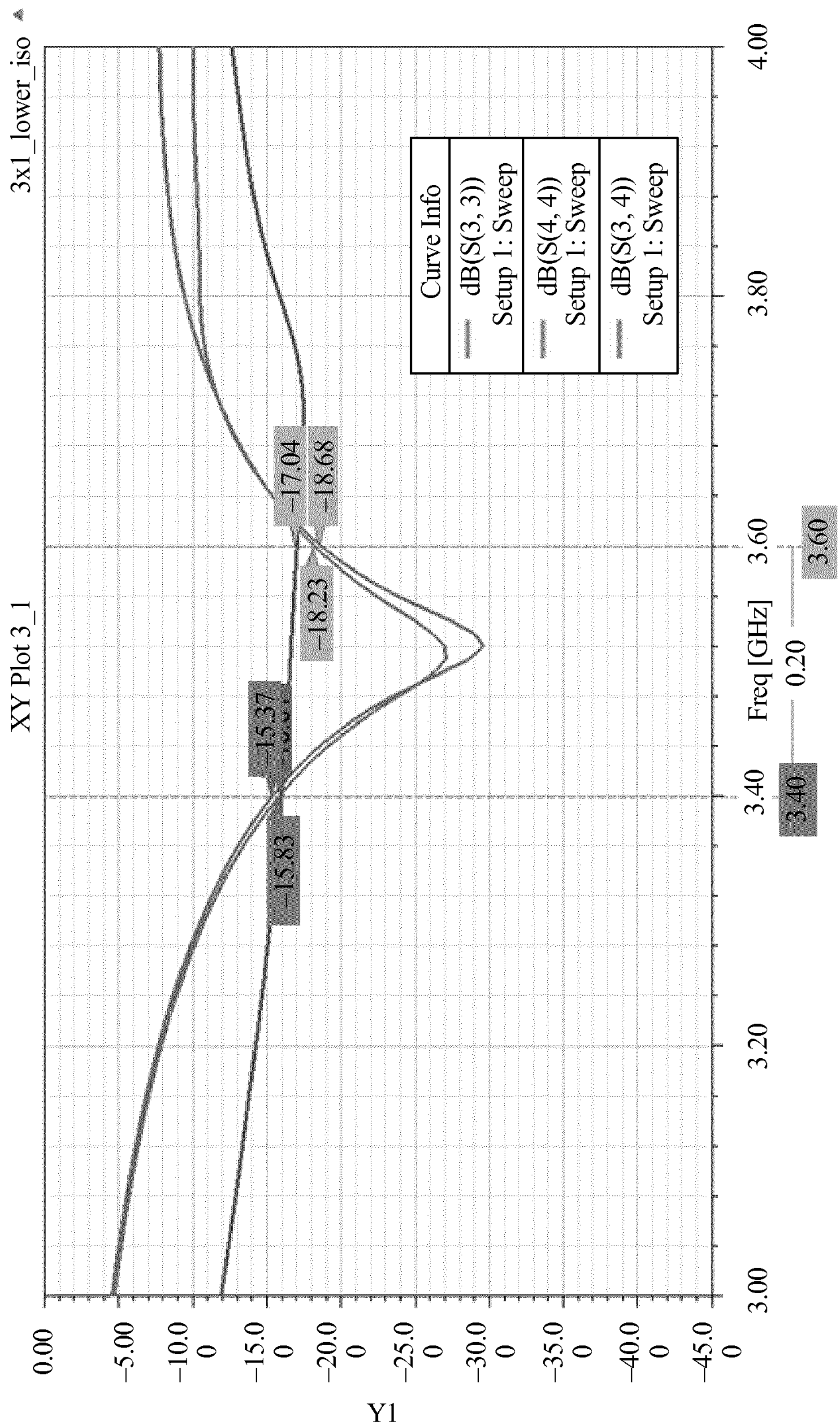
-12.37
-21.23
-12.30
-12.89
-21.80
2.50
0.19
2.69
Freq [GHz]
Y1
0.00
-5.00
-10.00
-15.00
-20.00
-25.00
2.0
2.20
2.40
2.60
2.80
3.00

FIG. 2C


XY Plot 3_1
3x1_lower_iso
Curve Info
dB(S(3, 3))
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dB(S(4, 4))
Setup 1: Sweep
dB(S(3, 4))
Setup 1: Sweep
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−18.68
−18.23
−15.37
−15.83
Y1
0.00
−5.00
−10.00
−15.00
−20.00
−25.00
−30.00
−35.00
−40.00
−45.00
3.00
3.20
3.40
3.60
3.80
4.00
Freq [GHz]
3.40
0.20
3.60

FIG. 2D

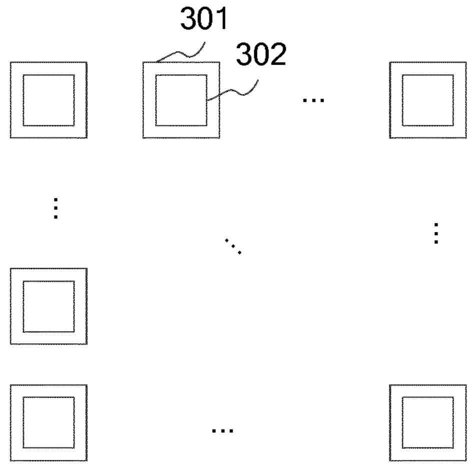

FIG. 3

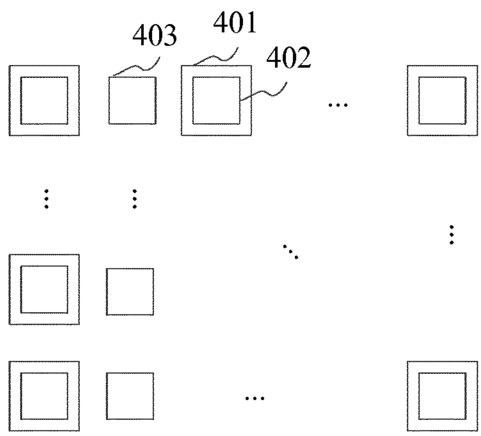

FIG. 4

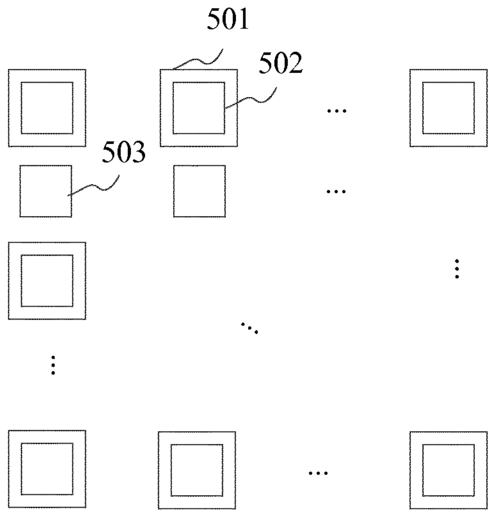

FIG. 5

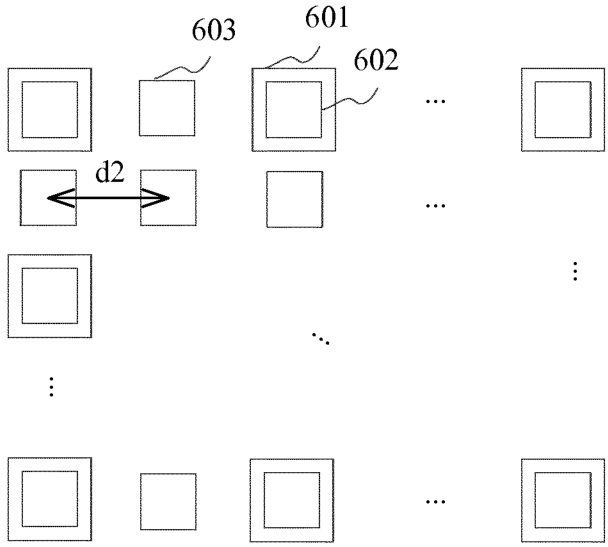

FIG. 6

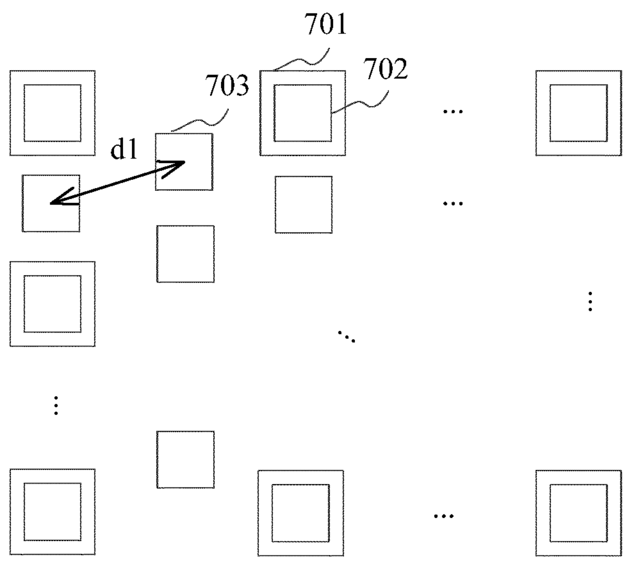

FIG. 7

INTERNATIONAL SEARCH REPORT

International application No. PCT/CN2015/095264

A. CLASSIFICATION OF SUBJECT MATTER

H01Q 21/29 (2006.01) i; 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)

CNTXT; VEN; USTXT; EPTXT; WOTXT; IEEE: patch, layer?, microstrip, micro strip, parasitic, director?, reflect+, direct+, orient+, stack+, multi-layer?, multilayer?, overlap+, interleav+, imbricat+, planar, plane, plate

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 102117964 A (SHENZHEN HUAXIN ANTENNA TECHNOLOGY CO., LTD.) 06 July 2011 (06.07.2011) description, paragraphs [0033]-[0041], and figure 1	1-3, 5-7
Y	CN 102117964 A (SHENZHEN HUAXIN ANTENNA TECHNOLOGY CO., LTD.) 06 July 2011 (06.07.2011) description, paragraphs [0033]-[0041], and figure 1	8, 9
A	CN 102117964 A (SHENZHEN HUAXIN ANTENNA TECHNOLOGY CO., LTD.) 06 July 2011 (06.07.2011) description, paragraphs [0033]-[0041], and figure 1	4
Y	US 2003137456 A1 (AJAY I. SREENIVAS et al.) 24 July 2003 (24.07.2003) the abstract, and figures 1A and 3-7	8, 9

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

* Special categories of cited documents:

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"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

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"&"document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
05 August 2016	12 August 2016

Name and mailing address of the ISA	Authorized officer
State Intellectual Property Office of the P. R. China No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing 100088, China Facsimile No. (86-10) 62019451	NING, Hualing Telephone No. (86-10) 62411521

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INTERNATIONAL SEARCH REPORT

International application No. PCT/CN2015/095264

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 103259085 A (SHENZHEN HUAXIN ANTENNA TECHNOLOGY CO., LTD.) 21 August 2013 (21.08.2013) description, paragraphs [0028]-[0038], and figure 1	1-3, 5-7
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X	US 4089003 A (MOTOROLA INCORPORATED) 09 May 1978 (09.05.1978) description, column 2, line 14 to column 3, line 3, and figures 1 and 2	1-3, 5-7
Y	US 4089003 A (MOTOROLA INCORPORATED) 09 May 1978 (09.05.1978) description, column 2, line 14 to column 3, line 3, and figures 1 and 2	8, 9
X	JP 2010226633 A (MITSUBISHI ELECTRIC CORPORATION) 07 October 2010 (07.10.2010) description, paragraphs [0008] and [0009], and figures 1b and 2	1-3, 5-7
Y	JP 2010226633 A (MITSUBISHI ELECTRIC CORPORATION) 07 October 2010 (07.10.2010) description, paragraphs [0008] and [0009], and figures 1b and 2	8, 9
X	CN 1483230 A (KATHREIN WERKE AG) 17 March 2004 (17.03.2004) description, page 4, line 4 to page 6, line 16, and figures 1 and 2	1-3, 5-7
Y	CN 1483230 A (KATHREIN WERKE AG) 17 March 2004 (17.03.2004) description, page 4, line 4 to page 6, line 16, and figures 1 and 2	8, 9
X	Bing Bai et al.. "Stacked Dual-Band Circularly Polarized Microstrip Patch Antenna" IEEE 2007 International Symposium on Microwave, Antenna, Propagation, and EMC Technologies For Wireless Communications, 31 December 2007 (31.12.2007), pages 706-709	1-3, 5-7
Y	Bing Bai et al.. "Stacked Dual-Band Circularly Polarized Microstrip Patch Antenna" IEEE 2007 International Symposium on Microwave, Antenna, Propagation, and EMC Technologies For Wireless Communications, 31 December 2007 (31.12.2007), pages 706-709	8, 9

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2015/095264

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		WO 0250940 A3	29 August 2002
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		DE 10064128 A1	25 July 2002
		DE 50105395 D1	24 March 2005
		AU 2002238428 B2	23 June 2006

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