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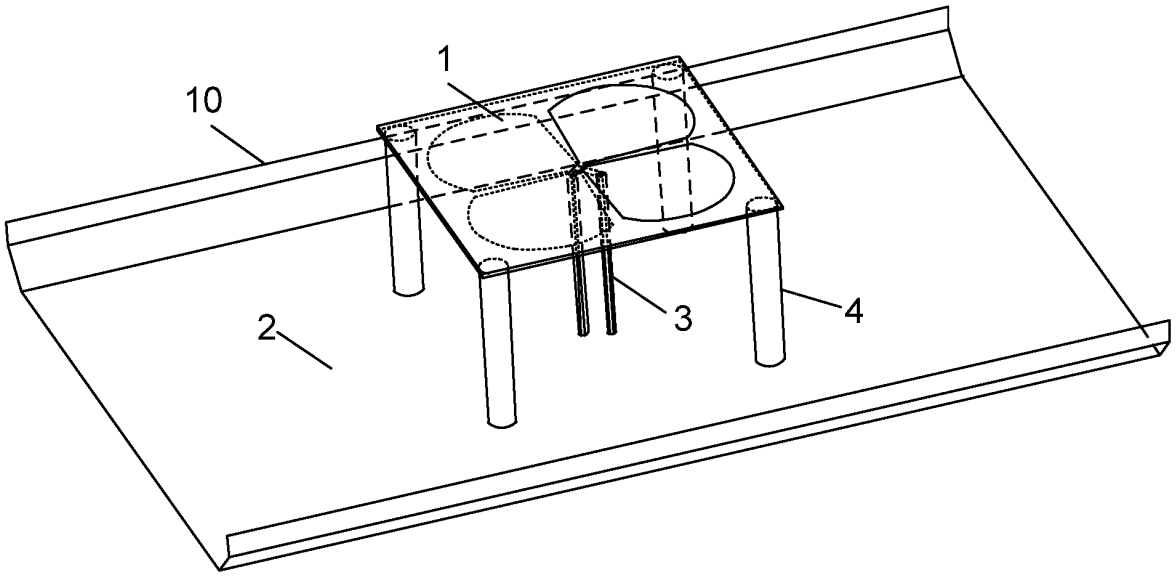
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(54) BROADBAND DUAL-POLARIZATION FOUR-LEAF CLOVER PLANAR AERIAL

(57) A broadband dual-polarization four-leaf clover planar antenna which is applied to the 2G/3G/LTE (4G) systems is described; the antenna includes an antenna radiating unit, a reflecting plate and two feeders. The antenna radiating unit is fixed directly above the reflecting plate via an insulated support structure, and includes a +45° polarized four-leaf clover oscillator and a -45° polarized four-leaf clover oscillator; the four-leaf clover oscillator includes a radiating arm and a microstrip line; the radiating arm being in a four-leaf clover shape is etched on a dielectric substrate, and the microstrip line being used for feeding the radiating arm is also etched on the dielectric substrate. The two feeders are respectively connected with the microstrip lines of the +45°/-45° polarized four-leaf clover oscillators.

Fig. 1



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Description

TECHNICAL FIELD

[0001] The disclosure relates to the technology of a mobile communication base station antenna, and in particular to a broadband dual-polarization four-leaf clover planar antenna.

BACKGROUND

[0002] With the rapid development of mobile communication technology, mobile communication systems using different frequency bands appear in succession; at the present stage, there are 2G, 3G and LTE (4G) systems in China; wherein the 2G system uses the frequency band 1710-1850 MHz, e.g., the GSM1800 system and the like; the 3G system uses the frequency band 1880-2170 MHz, e.g., the cdma2000 system of China Telecom, the TD-SCDMA system of China Mobile and the WCDMA system of China Unicom; as the 2.3 GHz frequency band (2300-2400 MHz) and the 2.6 GHz frequency band (2500-2690 MHz) are divided into the LTE (4G) frequency band, the wireless communication system in China has covered the frequency band 1710-2690 MHz currently. Thus, a bandwidth of a new designed and installed base station antenna is required to completely cover 1710-2690 MHz, so as to simultaneously support different mobile communication systems. Besides, because there is an explosive growth of users using wireless mobile services, the communication systems expand continuously, and spreading the frequency band cannot meet requirements any more. A dual-polarization antenna uses polarization diversity, frequency multiplexing and other technologies to effectively increase the capacity of a communication system; the dual-polarization antenna is widely applied in the base station antenna. So the broadband dual-polarization mobile communication base station antenna which can simultaneously support the 2G, 3G and LTE systems has a very important practical value and market value.

[0003] At present, there are two major dual-polarization base station antennae, which are respectively patch antenna and oscillator antenna. The patch antenna is usually a multilayered structure, which is complex in a feeding mode; the oscillator antenna is usually a crisscross vertical oscillator; there are also orthogonally placed (non-crisscross) vertical oscillators, most of them are three-dimensional structure, which occupies a relatively large radiation area. For realizing the dual-polarization, a feeding structure of the patch antenna has been relatively complicated, but the bandwidth of the patch antenna is relatively narrow, it is needed to improve the feeding structure for obtaining the wide bandwidth and high isolation, so the feeding mode becomes more complicated. The oscillator antenna is usually composed of a radiating arm and a support structure, its feeding usually needs a complex Balun structure, such as coaxial Balun, integrated Balun and the like; the Balun structure is usually set at the support structure. Both the patch antenna and the oscillator antenna have disadvantages of complex structure and being not beneficial for large-scale manufacture, and most of them do not have the bandwidth of completely supporting the 2G, 3G and LTE (4G) systems, or patterns and other performances are not ideal.

SUMMARY

[0004] In view of this, the disclosure is intended to provide a broadband dual-polarization four-leaf clover planar antenna, which is enhanced in performance, simple in structure and convenient to manufacture.

[0005] The technical solutions of the disclosure are implemented as follows.

[0006] A broadband dual-polarization four-leaf clover planar antenna is provided, which includes: an antenna radiating unit, a reflecting plate, a first feeder and a second feeder; the antenna radiating unit is fixed directly above the reflecting plate via a support structure; the antenna radiating unit being a planar structure includes a four-leaf clover oscillator and a dielectric substrate; the four-leaf clover oscillator includes a +45° polarized four-leaf clover oscillator and a -45° polarized four-leaf clover oscillator; the four-leaf clover oscillator includes a radiating arm and a microstrip line; the radiating arm in a four-leaf clover shape includes a first radiating arm and a second radiating arm; the +45° polarized four-leaf clover oscillator and the -45° polarized four-leaf clover oscillator are etched on the dielectric substrate with centres crisscrossed; the +45° polarized four-leaf clover oscillator and the -45° polarized four-leaf clover oscillator are not connected; the first radiating arm of the +45° polarized four-leaf clover oscillator is connected with the microstrip line of the +45° polarized four-leaf clover oscillator and etched on a front side of the dielectric substrate; the second radiating arm of the +45° polarized four-leaf clover oscillator is etched on a back side of the dielectric substrate; the first radiating arm of the -45° polarized four-leaf clover oscillator is connected with the microstrip line of the -45° polarized four-leaf clover oscillator and etched on the back side of the dielectric substrate; the second radiating arm of the -45° polarized four-leaf clover oscillator is etched on the front side of the dielectric substrate; the first feeder is connected with the microstrip line of the +45° polarized four-leaf clover oscillator, and the second feeder is connected with the microstrip line of the -45° polarized four-leaf clover oscillator.

[0007] Preferably, the broadband dual-polarization four-leaf clover planar antenna of the disclosure may use a radiating unit to realize ±45° dual-polarization; the antenna radiating unit in an axisymmetric structure may have an axis of symmetry; the axis of symmetry passes through a centre of the antenna radiating unit, and includes a +45° axis of symmetry and a -45° axis of sym-

metry; a pair of (namely two) radiating arms in the four-leaf clover shape on the +45° axis of symmetry and the microstrip line on this axis together form the +45° polarized four-leaf clover oscillator, wherein the +45° polarized four-leaf clover oscillator is used for realizing +45° polarization; a pair of radiating arms in the four-leaf clover shape on the -45° axis of symmetry and the microstrip line on this axis together form the -45° polarized four-leaf clover oscillator, wherein the -45° polarized four-leaf clover oscillator is used for realizing -45° polarization; the polarization isolation between the +45° polarization and the -45° polarization reaches 30 dB.

[0008] Preferably, the radiating arm of the radiating unit may be a four-leaf clover structure better, and the radiating arm in the four-leaf clover shape may be beneficial for the antenna to obtain broadband and good radiation performance. The four-leaf clover structure can be decomposed into a trapezoid structure and half an ellipsoidal structure; the ellipsoidal structure is a circular structure better, and the trapezoid structure is an isosceles trapezoid structure better; the length of the radiating arm is 0.15 λ0-0.35 λ0. For any transformation of transforming trapezoid or ellipse, its fundamental form can still be considered as the four-leaf clover shape.

[0009] Preferably, when a polarized four-leaf clover oscillator of the antenna is excited, the radiating arm of another polarized four-leaf clover oscillator may be used as a parasitic unit of the antenna, which enhances the bandwidth of the antenna by coupling; when the +45° polarized four-leaf clover oscillator is excited, the -45° polarized four-leaf clover oscillator may become the parasitic unit; when the -45° polarized four-leaf clover oscillator is excited, the +45° polarized four-leaf clover oscillator may become the parasitic unit; the smaller an angle between trapezoid hypotenuses of the two adjacent radiating arms is, the stronger the coupling is; a range of angles between the trapezoid hypotenuses at edges of the adjacent radiating arms is from 0° to 40°.

[0010] Preferably, a feeding structure is very simple; the four-leaf clover oscillator uses a microstrip line to feed; characteristic impedance of the microstrip line is from 40 Ω to 60 Ω, and a length range of the microstrip line is 0-0.2 λ1, wherein λ1 is a wavelength corresponding to the frequency 2.2 GHz in the dielectric substrate.

[0011] Preferably, the support structure is an insulated support structure; a height of the insulated support structure depends on a height from an antenna radiator to the reflecting plate, and the height range is from 0.1 λ0 to 0.5 λ0, wherein λ0 is a wavelength corresponding to a free space frequency 2.2 GHz. The insulated support structure may be a plastic rod or a stick.

[0012] Preferably, the reflecting plate of the antenna may be a structure with broadsides; two sides of the reflecting plate are folded upwards to form the broadside structure; a bottom face of the reflecting plate is a rectangular flat plate; each of two long sides of a bottom plate has a broadside structure folded upwards; the broadside structure is divided into a bevel edge and a vertical edge; a bending angel of the bevel edge is 45° better, and the folding angle ranges from 0° to 90°; the length of the bevel edge is 10 mm better; the vertical edge is perpendicular to the bottom plate; the length of the vertical edge is 5 mm better; the length range of the bevel edge and the vertical edge is 1 mm.

[0013] The working principle of the disclosure is that: 45° dual-polarization is realized by using a single antenna radiating unit; the antenna is a full planar structure with a small volume and a width of only 135 mm; the antenna has a wide frequency band covering 1710-2690 MHz and a high isolation of 30 dB; because the antenna has a symmetrical structure, radiation patterns in two polarization modes are highly consistent, and a high gain, a high polarization ratio and a high front-to-back ratio characteristic are obtained; the broadband dual-polarization four-leaf clover planar antenna can completely support the 2G/3G/LTE (4G) systems.

[0014] Compared with the related art, the disclosure has the following advantages and effects:

1. the 45° dual-polarization four-leaf clover planar antenna is composed of the +45° polarized four-leaf clover oscillator and the -45° polarized four-leaf clover oscillator; each polarized four-leaf clover oscillator includes the radiating arms in the four-leaf clover shape and the microstrip line; the radiating unit of the antenna is etched on the dielectric substrate; the antenna has a simple full planar structure and is simple and convenient to manufacture;

2. the radiating arm of the antenna is in the four-leaf clover shape, which is beneficial for the antenna to obtain broadband and good radiation performance; when a polarized four-leaf clover oscillator of the antenna radiating unit is excited, the radiating arm of another polarized four-leaf clover oscillator is used as the parasitic unit of the antenna, which enhances the bandwidth of the antenna by coupling; the microstrip line is used for feeding the four-leaf clover oscillator, and the bandwidth performance which completely covers 1710-2690 MHz can be obtained without using the wideband Balun and other complex feeding structures;

3. the antenna realizes the ±45° dual-polarization by using a single radiating unit; the structure of the antenna is compact, and the width of the antenna is only 135 mm, which is less than 150 mm, namely an industrial standard; the antenna uses the reflecting plate with the broadsides, and has the stable radiation pattern; a horizontal half-power beam width of 65 5° is realized by design of the reflecting plate; at the same time, the high gain and the high front-to-back ratio characteristic are ensured;

4. when a base station antenna array is formed, element spacing can reach a wavelength of the max-

imum frequency, and there is no grating lobe at the high frequency; a vertical pattern is stable;

5. the antenna has a novel structure; its radiating unit is in the four-leaf clover shape, which is simple and full planar; the antenna has a few components, which is convenient to process and shape; besides, the antenna has the wide frequency band, the high isolation, the stable radiation pattern, the high gain, the high polarization ratio and the high front-to-back ratio characteristic.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015]

Fig. 1 is a three-dimensional structure diagram of a broadband dual-polarization four-leaf clover planar antenna;

Fig. 2 is a front elevation of a broadband dual-polarization four-leaf clover planar antenna;

Fig. 3 is a front sectional elevation of a broadband dual-polarization four-leaf clover planar antenna;

Fig. 4 is a left sectional elevation of a broadband dual-polarization four-leaf clover planar antenna; and

Fig. 5 is a measured result diagram of bandwidth of a broadband dual-polarization four-leaf clover planar antenna.

[0016] Reference signs in Fig. 1-Fig. 5 are indicated as follows:

1, antenna radiating unit; 2, reflecting plate; 3A, the first feeder; 3B, the second feeder; 4, support structure; 5A, the first radiating arm of a +45° polarized four-leaf clover oscillator; 5B, the second radiating arm of a +45° polarized four-leaf clover oscillator; 5C, the first radiating arm of a -45° polarized four-leaf clover oscillator; 5D, the second radiating arm of a -45° polarized four-leaf clover oscillator; 6A, feeding microstrip line of a +45° polarized four-leaf clover oscillator; 6B, feeding microstrip line of a -45° polarized four-leaf clover oscillator; 7, dielectric substrate; 8, non-metal through hole; 9, metal through hole; 10, broadside.

DETAILED DESCRIPTION

[0017] The disclosure is further elaborated below in combination with the accompanying drawings and embodiments, but the embodiments of the disclosure are not limited to this.

Embodiment

[0018] As shown in Fig. 1, a broadband dual-polarization four-leaf clover planar antenna according to an embodiment of the disclosure includes: an antenna radiating unit 1, a reflecting plate 2, a feeder 3 and a support structure 4. The antenna radiating unit 1 is fixed directly above the reflecting plate 2 via the support structure 4, and the distance is 36mm.

[0019] Fig. 2 is a front elevation of a broadband dual-polarization four-leaf clover planar antenna; the antenna radiating unit 1 includes four radiating arms 5A-5D and microstrip lines 6A and 6B; the radiating arms 5A-5D and the microstrip lines 6A and 6B are etched on a same dielectric substrate 7; the dielectric substrate 7 is made of high-frequency plate RO4350B, whose thickness is 0.76mm and relative dielectric constant is 3.48; the radiating arms 5A and 5D are etched on an upper surface of the dielectric substrate; the radiating arms 5B and 5C are etched on a lower surface of the dielectric substrate; the microstrip line 6A is etched on the upper surface of the dielectric substrate; the microstrip line 6B is etched on the lower surface of the dielectric substrate. The radiating arm 5A, the radiating arm 5B and the microstrip line 6A form a +45° polarized four-leaf clover oscillator, wherein the radiating arm 5A is the first radiating arm of the +45° polarized four-leaf clover oscillator, and the radiating arm 5B is the second radiating arm of the +45° polarized four-leaf clover oscillator; the radiating arm 5C, the radiating arm 5D and the feeding microstrip line 6B form a -45° polarized four-leaf clover oscillator, wherein the radiating arm 5C is the first radiating arm of the -45° polarized four-leaf clover oscillator, and the radiating arm 5D is the second radiating arm of the -45° polarized four-leaf clover oscillator.

[0020] The shape of the radiating arms 5A-5D are very similar to the shape of the four-leaf clover; four radiating arms form a four-leaf clover. The radiating arm is composed of an isosceles trapezoid and half an ellipse which is split by a major axis; an upper base of the isosceles trapezoid is 1.6 mm, which is the same as the width of the feeding microstrip line; the height is 16.2 mm, a lower base is 32.35 mm, and the angle between two waists and the lower base is 46.5°; preferably, a special ellipse, namely a circle is adopted; its diameter is 32.35 mm, which is the same as the base length of the trapezoid; the total length of the radiating arm is 32.4 mm.

[0021] The disclosure realizes the 45° dual-polarization by using a single radiating unit; when a polarized four-leaf clover oscillator is excited, the radiating arm of another polarized four-leaf clover oscillator is used as a parasitic unit of the antenna; the antenna bandwidth is enhanced by coupling between the adjacent radiating arms, such as the coupling between the radiating arms 5A and 5D, the coupling between the radiating arms 5D and 5B, the coupling between the radiating arms 5B and 5C, and the coupling between the radiating arms 5C and 5A; the smaller the angle between the adjacent radiating

arms is, the stronger the coupling is; the angle keeps in the range of 0-40°. The microstrip lines 6A and 6B are orthogonal to each other and respectively used for feeding the ±45° polarized four-leaf clover oscillators; the width of the microstrip line is 1.6 mm, the corresponding characteristic impedance is 50 Ω, and the length of the feeding microstrip line is 5 mm. The coupling between the radiating arms and coupled feeding by the microstrip line enable the antenna to have the bandwidth which can completely cover 1710-2690 MHz; at the same time, when a polarized four-leaf clover oscillator is excited, a coupled current at a feeding port of another polarized four-leaf clover oscillator is very small, so the high isolation of 30 dB is obtained.

[0022] As shown in Fig. 3 and Fig. 4, two feeders 3A and 3B are respectively used for feeding the +45° polarized four-leaf clover oscillator and the -45° polarized four-leaf clover oscillator; the feeders can be flexible coaxial feeder or rigid coaxial feeder; this embodiment adopts flexible coaxial feeder; a non-metal through hole 8 is set on the second radiating arm 5B of the +45° polarized four-leaf clover oscillator, an inner core of the first feeder 3A passes through the non-metal through hole 8 to be welded with the microstrip line 6A; an outer conductor of the first feeder 3A is welded with the second radiating arm 5B of the +45° polarized four-leaf clover oscillator; a metal through hole 9 is set on the second radiating arm 5D of the -45° polarized four-leaf clover oscillator, an inner core of the second feeder 3B is welded with the microstrip line 6B; an outer conductor of the second feeder 3B penetrates the metal through hole 9 to be welded with the radiating arm 5D; the antenna only needs two welding spots, which is beneficial for the antenna to obtain a good cross modulation performance.

[0023] The reflecting plate 2 adopts the structure with a broadside 10; the broadside protrudes out of a surface of the reflecting plate; the length of the reflecting plate 2 is 200 mm, and the total width is 135 mm; the reflecting plate 2 can adopt aluminium, copper and other plates; the width of a flat plate reserved on a bottom plate of the reflecting plate 2 is 120 mm; the two broadsides are folded upwards twice; a folding angle of the first time is 135°, and the length of a folded part is 10 mm; a folding angle of the second time is 135°, and the length of a folded part is 5 mm.

[0024] Fig. 5 is a measured bandwidth of an antenna according to this embodiment; the conclusions can be drawn from the diagram that: the broadband dual-polarization four-leaf clover planar antenna of the disclosure has the bandwidth of 1.7-2.7 GHz, and a return loss reaches -15 dB; the bandwidth can completely cover the frequency band of 1710-2690 MHz, and on this broadband, the polarization isolation is more than 30 dB.

[0025] The disclosure realizes the 45° dual-polarization by using a single radiating unit, which requires a small arrangement space and is favourable to miniaturization of the base station antenna. When a base station antenna array is formed, the spacing between the radiating units can reach 110 mm ($\lambda 2$, and $\lambda 2$ is the wavelength corresponding to a free space frequency 2.7 GHz), and there is no grating lobe on the high frequency band; in the two polarization modes, the horizontal and vertical radiation patterns are stable on the frequency band 1710-2690 MHz; a uniform linear array gain of 8 units can reach up to 17 dBi, and the gain change is below 2 dB on the frequency band 1710-2690 MHz.

[0026] The disclosure has the characteristics of full planar simple structure, small volume, simple manufacture, wide bandwidth, high isolation, stable radiation pattern and high gain; and it is very suitable to be used as the mobile communication base station antenna.

[0027] The above embodiments are the preferred implementation modes of the disclosure, but the implementation modes of the disclosure are not limited to the above embodiments; any other change, modification, replacement, combination and simplification within the spirit and principle of the disclosure should be equivalent displacement modes and fall within the scope of the claims of the disclosure.

INDUSTRIAL APPLICABILITY

[0028] The disclosure realizes 45° dual-polarization by using a single antenna radiating unit; the disclosure is a full planar structure; it has a small volume and a width of only 135 mm; the disclosure has a wide frequency band which can cover 1710-2690 MHz and a high isolation of 30 dB; because the antenna structure is symmetrical, the radiation patterns are highly consistent in two polarization modes, and a high gain characteristic is obtained; the broadband dual-polarization four-leaf clover planar antenna can completely support the 2G/3G/LTE (4G) systems, and has the characteristics of full planar simple structure, small volume, simple manufacture, wide bandwidth, high isolation, stable radiation pattern and high gain.

Claims

1. A broadband dual-polarization four-leaf clover planar antenna, comprising: an antenna radiating unit, a reflecting plate, a first feeder and a second feeder; the antenna radiating unit is fixed directly above the reflecting plate via a support structure; the antenna radiating unit being a planar structure comprises a four-leaf clover oscillator and a dielectric substrate; the four-leaf clover oscillator comprises a +45° polarized four-leaf clover oscillator and a -45° polarized four-leaf clover oscillator; the four-leaf clover oscillator comprises a radiating arm and a microstrip line; the radiating arm in a four-leaf clover shape comprises a first radiating arm and a second radiating arm; the first radiating arm of the +45° polarized four-leaf clover oscillator is connected with the microstrip line of the +45° polarized four-leaf clover oscillator

and etched on a front side of the dielectric substrate; the second radiating arm of the +45° polarized four-leaf clover oscillator is etched on a back side of the dielectric substrate; the first radiating arm of the -45° polarized four-leaf clover oscillator is connected with the microstrip line of the -45° polarized four-leaf clover oscillator and etched on the back side of the dielectric substrate; the second radiating arm of the -45° polarized four-leaf clover oscillator is etched on the front side of the dielectric substrate; the microstrip line of the +45° polarized four-leaf clover oscillator is etched on the front side of the dielectric substrate; the microstrip line of the -45° polarized four-leaf clover oscillator is etched on the back side of the dielectric substrate; the first feeder is connected with the microstrip line of the +45° polarized four-leaf clover oscillator, and the second feeder is connected with the microstrip line of the -45° polarized four-leaf clover oscillator.

2. The broadband dual-polarization four-leaf clover planar antenna according to claim 1, wherein,
the antenna radiating unit in an axisymmetric structure has an axis of symmetry; the axis of symmetry passes through a centre of the antenna radiating unit, and comprises a +45° axis of symmetry and a -45° axis of symmetry; the +45° polarized four-leaf clover oscillator comprises the first radiating arm and the second radiating arm on the +45° axis of symmetry and the microstrip line on the +45° axis of symmetry; the -45° polarized four-leaf clover oscillator comprises the first radiating arm and the second radiating arm on the -45° axis of symmetry and the microstrip line on the -45° axis of symmetry.

3. The broadband dual-polarization four-leaf clover planar antenna according to claim 1, wherein,
the radiating arm in the four-leaf clover shape has a four-leaf clover structure; the four-leaf clover structure comprises a trapezoid structure and an ellipsoidal structure; a length range of the radiating arm is from 20.454 mm to 47.726 mm.

4. The broadband dual-polarization four-leaf clover planar antenna according to claim 1 or 2, wherein,
when the +45° polarized four-leaf clover oscillator is excited, the -45° polarized four-leaf clover oscillator serves as a parasitic unit; when the -45° polarized four-leaf clover oscillator is excited, the +45° polarized four-leaf clover oscillator serves as the parasitic unit; a range of angles between trapezoid hypotenuses of the two radiating arms in the four-leaf clover shape is from 0° to 40°.

5. The broadband dual-polarization four-leaf clover planar antenna according to claim 1 or 2, wherein,
a value range of characteristic impedance of the microstrip line is from 40 Ω to 60 Ω, and a length range of the microstrip line is from 0 mm to 16.472 mm.

6. The broadband dual-polarization four-leaf clover planar antenna according to any one of claims 1 to 3, wherein a height range of the support structure is from 13.636 mm to 68.18 mm.

7. The broadband dual-polarization four-leaf clover planar antenna according to claim 3, wherein the trapezoid structure is an isosceles trapezoid structure.

8. The broadband dual-polarization four-leaf clover planar antenna according to any one of claims 1 to 3, wherein the support structure is an insulated support structure; and the insulated support structure is a plastic rod or a stick.

9. The broadband dual-polarization four-leaf clover planar antenna according to any one of claims 1 to 3, wherein the reflecting plate is a structure with broadsides; the broadside protrudes out of a surface of the reflecting plate.

Fig. 1

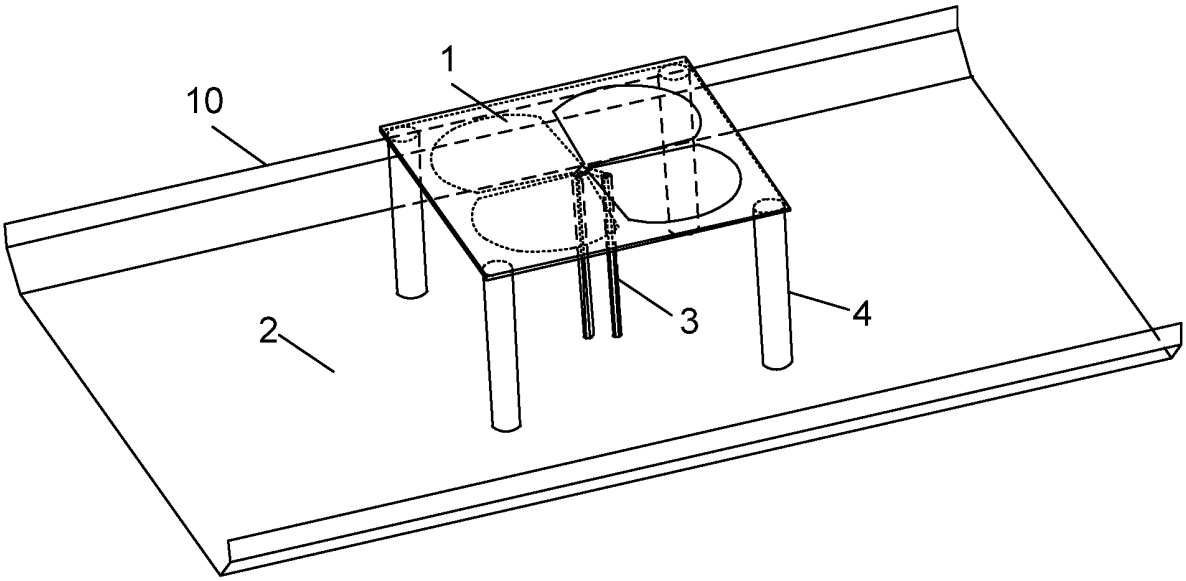


Fig. 2

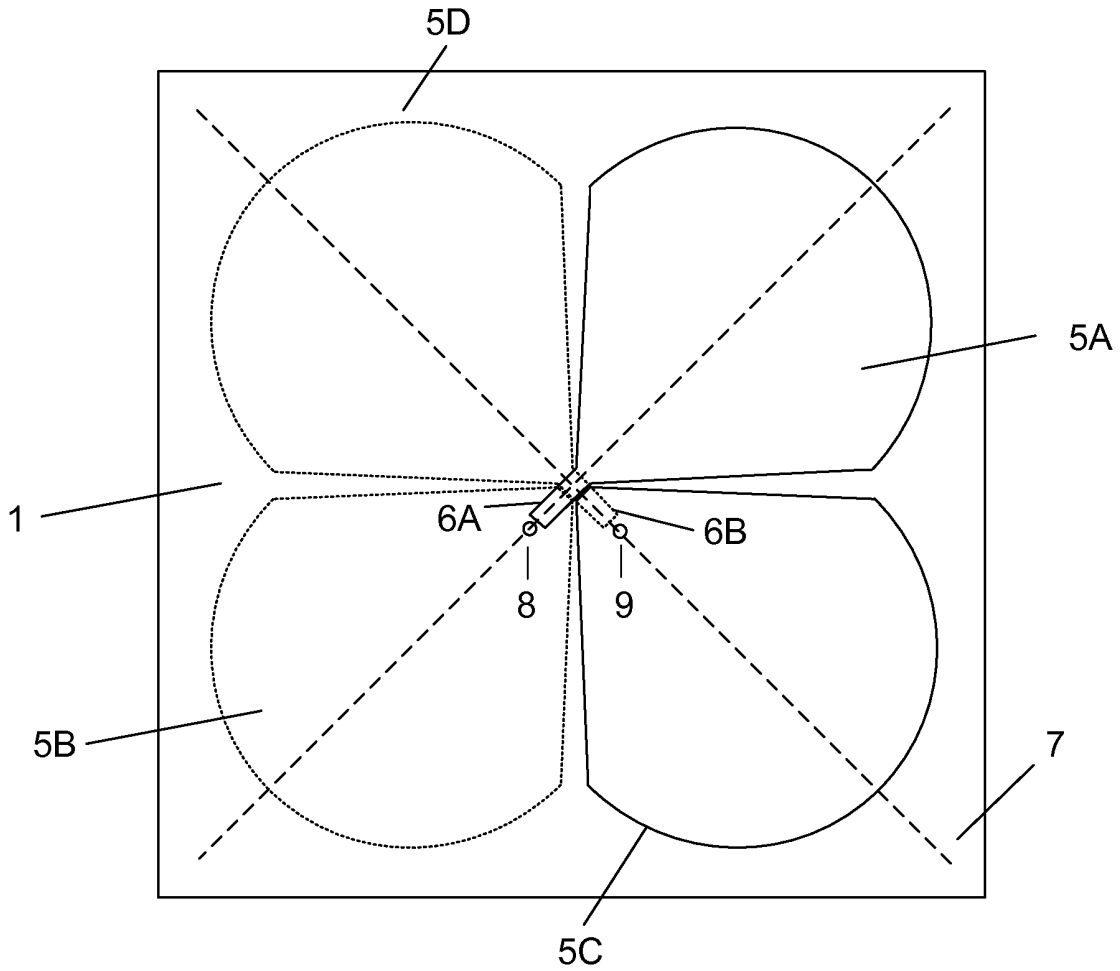


Fig. 3

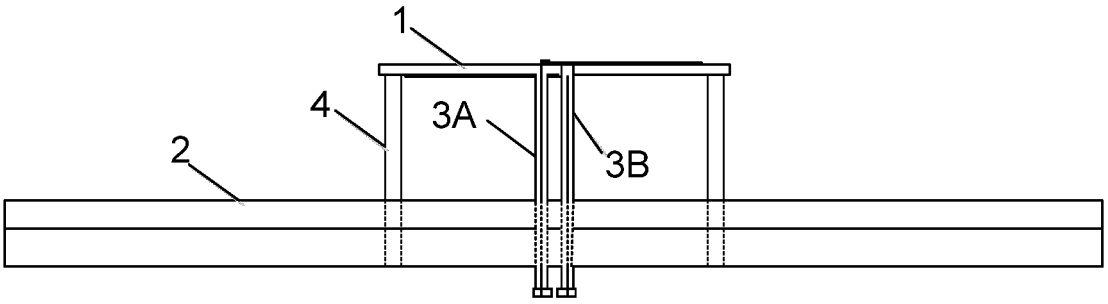


Fig. 4

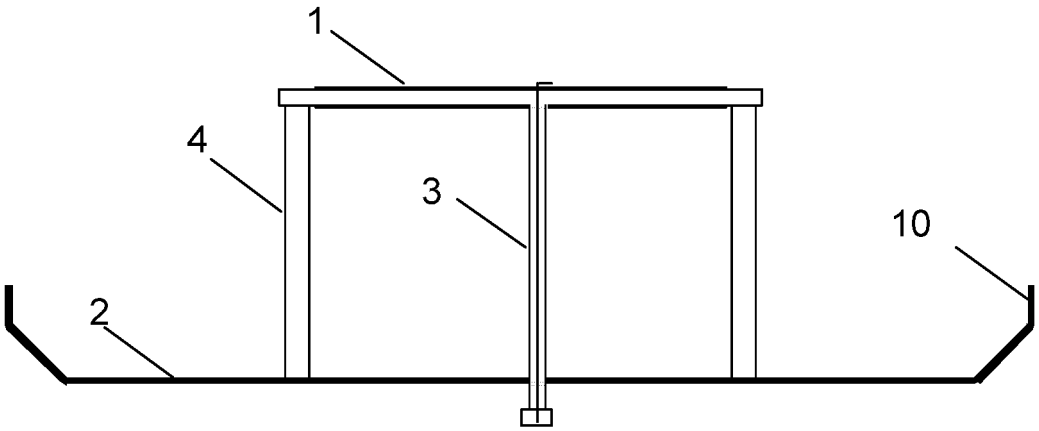
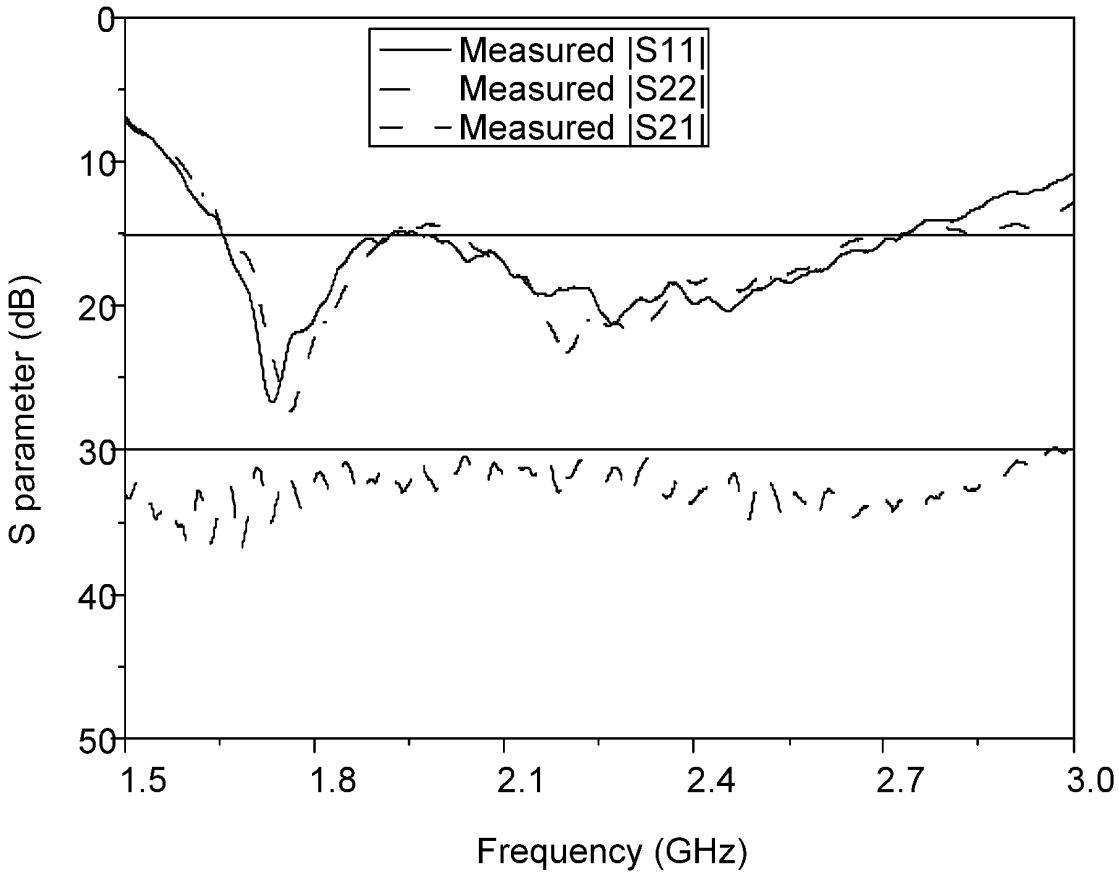


Fig. 5


Measured |S11|
Measured |S22|
Measured |S21|
S parameter (dB)
0
10
20
30
40
50
1.5
1.8
2.1
2.4
2.7
3.0
Frequency (GHz)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2014/080391

A. CLASSIFICATION OF SUBJECT MATTER

H01Q 1/38 (2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H01Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNABS, CNTXT, VEN, CNKI: dual polarization, dielectric plate, circuit board, reflecting plate, plane, ANTENNA, BASE STATION, DUAL POLARIZED, PCB, SUBSTRATE, REFLECTOR, PATCH

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	CN 101834345 A (COMBA TELECOM SYSTEMS (CHINA) CO., LTD.), 15 September 2010 (15.09.2010), claims 8 and 16, description, paragraphs [0049]-[0052], and figure 8	1-9
Y	US 6400332 B1 (HON HAI PREC IND CO., LTD.), 04 June 2002 (04.06.2002), description, column 2, line 32 to column 3, line 18, and figure 2	1-9
PX	CN 103326117 A (SOUTH CHINA UNIVERSITY OF TECHNOLOGY), 25 September 2013 (25.09.2013), the whole document	1-9
PX	CN 203339298 U (SOUTH CHINA UNIVERSITY OF TECHNOLOGY), 11 December 2013 (11.12.2013), the whole document	1-9

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

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Date of the actual completion of the international search	Date of mailing of the international search report
12 September 2014 (12.09.2014)	**26 September 2014 (26.09.2014)**
Name and mailing address of the ISA/CN: State Intellectual Property Office of the P. R. China No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing 100088, China Facsimile No.: (86-10) 62019451	Authorized officer **JIANG, Shan** Telephone No.: (86-10) **62089147**

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INTERNATIONAL SEARCH REPORT
Information on patent family members

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