Design of the Tree Growth Array Ultra Wideband Antenna

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Abstract. According to the performance requirements of the antenna for multi-network wireless communication terminal equipment, the present paper originally combines the structure of inductive multi-line antenna with the tree growth array, designs a tree growth array ultra-wideband antenna, and we also complete the production and the test of antenna samples. The measured results show that the antenna has stable ultra-wideband performance and can work in mobile communication systems, radio frequency identification systems, ultra-wideband communication systems and mobile digital TV systems at the same time. It has excellent compatibility and it is also a performance microwave frequency band multi-network and one terminal device antenna.

1. Introduction
Fusion multiplexing of wireless communication networks and multi-functional compatibility of wireless communication terminal equipment, it is an urgent problem to be solved in the development of wireless communication technology. As 5G technology matures and is put into commercial operation, the most important branch of the wireless communication field, the field of mobile communications will have a long-term coexistence and common development of the second, third, fourth and fifth generation mobile communication technologies. The mobile communication system operates in the microwave band, radio frequency identification systems, ultra-wideband communication systems, and mobile digital television systems that are close to their working frequency bands have also developed rapidly in recent years. To achieve wireless communication in the microwave band, multi-network and multi-band compatibility, the integration of second to fifth generation mobile communication systems, radio frequency identification systems, ultra-wideband communication systems, and mobile digital TV systems must be realized.

The second generation mobile communication frequency bands currently used in China are the GSM standard 0.905-0.915 GHz, 0.950-0.960 GHz, 1.710-1.785 GHz, and 1.805-1.880 GHz bands; the third generation mobile communication frequency bands are TD-SCDMA standard 1.880-1.920 GHz, 2.010-2.025 GHz, 2.300-2.400 GHz band and WCDMA standard 1.920-1.980 GHz, 2.110-2.170 GHz band; the fourth-generation mobile communication band is the 2.570-2.620 GHz band of the TD-LTE system. The fifth-generation mobile communication that will be put into use has three candidate frequency bands: 3.300-3.400 GHz, 4.400-4.500 GHz, 4.800-4.990 GHz [1-3]. The radio frequency identification system has three main operating bands: 0.902-0.928 GHz, 2.400-2.4835 GHz, 5.725-5.875 GHz [4-5]. The operating band of the ultra-wideband system is 3.100-10.600 GHz [6-7]. The mobile digital TV system operates in the frequency range of 11.700-12.200 GHz [8]. After the integration, the microwave frequency band multi-network system antenna needs to use a single working frequency band with less fluctuation of return loss, completely covering the second to fifth...
generation mobile communication bands, radio frequency identification bands, ultra-wideband communication bands and mobile digital TV bands, and meet the requirements of small size, high radiation intensity, and sufficient performance redundancy.

2. Brief Introduction of Inductive Multi-line Antenna
The structure of the inductive multi-line antenna is shown in Figure 1. The inductive multi-fold line antenna is an antenna that realizes ultra-wide frequency band operation by using the principle of inductive radiation and superposition. It consists of the outermost group of feeding vertical fold lines and the inner three sets of inductive vertical fold lines whose length is gradually reduced. The fold line absorbs part of the radiant energy of the outer feed vertical fold line to produce inductive radiation. The lengths of the four vertical fold lines and the working frequency bands are different, and four different working frequency bands are superimposed to achieve ultra-wide frequency band coverage.

![Figure 1](image1.png)

Figure 1. The schematic diagram of inductive multi-line antenna.

3. Brief Introduction of tree-growth array
The plurality of inductive multi-fold line antennas is formed into an antenna array, and the radiation superposition of the array element antenna can be used to effectively enhance the radiation intensity of the antenna, thereby solving the problem that the radiation intensity of the single inductive multi-fold line antenna is insufficient. The most important problem in antenna array design is to ensure that the array antenna has the same ultra-wideband operating characteristics as the array element antenna while enhancing the radiation intensity.

The iterative law of the tree-growth array structure is shown in Figure 2. The initial structure of the tree-growth array structure is a rectangular array consisting of 8 rows and 4 columns of 32 array elements, with the initial structure as the "trunk" and two "twigs" growing at the top of the "trunk", each " The branch is a rectangular array composed of 8 array elements of 4 rows and 2 columns, and a 1st-order tree-growth array structure can be obtained. Two "small branches" are grown at the top of each "twig" of the first-order tree-growth array structure, and each "twig" is a rectangular array of two array elements of two rows and one column, which can be obtained 2 Order tree growth array structure. The arrangement of the tree-shaped growth array structure has self-similarity, which can ensure that the antenna array has both high radiation intensity and an ultra-wide operating frequency band.

![Figure 2](image2.png)

(a) 0-order (b) 1st-order (c) 2nd-order
Figure 2. The schematic diagram of iterative law of tree-growth array structure.

4. Structure Design of the Antenna
The dielectric substrate used for the antenna is a low-loss epoxy glass cloth substrate having a relative dielectric constant of 7.5, a rectangular shape of the substrate, a size of 28 mm × 28 mm, and a
thickness of 1 mm. The antenna radiating patch and the antenna grounding plate are made of copper. The tree growth type array ultra-wideband antenna comprises a substrate, an antenna grounding plate attached to the back surface of the substrate, and a tree growth type array radiation patch attached to the front surface of the substrate, and the antenna grounding plate is an all-electric grounding structure. The structure of the tree-shaped growth array radiation patch is as shown in Figure 3, which uses a tree-shaped growth array structure as a basic array arrangement structure, each of which has a size of 2.0 mm × 2.0 mm in the tree growth type array structure. At the center of the antenna area, an inductive multi-line antenna is placed.

The size of the inductive polyline antenna is 2.0 mm × 2.0 mm, which consists of 4 sets of vertical fold lines with a line width of 0.2 mm. The lengths of the four sets of vertical fold lines are 0.6 mm, 1.0 mm, 1.4 mm, and 1.8 mm, respectively. The longitudinal lengths of the vertical fold lines are 0.6 mm, 1.0 mm, 1.4 mm, and 1.8 mm, respectively. An antenna feed point is provided at the intersection of the transverse line segment and the longitudinal line segment of the outermost vertical fold line of each of the inductive multi-polyline antennas.

The tree-shaped growth array structure used in the antenna design is a 2nd-order tree-growth array structure, which is in a rectangular region composed of 10 rows and 12 columns and a total of 120 square regions, in the first row, the first column, the first row 12 columns, row 2, column 1, column 12, row 3, column 1, column 2, column 3, column 4, column 5, column 6, column 7, column 8, column 9, column 10, column 11, column 12, row 4, column 1, column 2, column 3, column 4, column 5, column 6, column 7, column 8, Column 9, column 10, column 11, column 12, row 5, column 1, column 5, column 6, column 7, column 8, column 12, row 1, column 1, 5th, 6th, 7th, 8th, 12th, 7th, 5th, 6th, 7th, 8th, 5th, 6th, Columns 7, 8th, 9th, 5th, 6th, 7th, 8th, 10th, 5th, 6th, 7th, 8th, a total of 56 squares. The array element antenna is placed in the area.

![Diagram of tree-growth array radiation patch](image)

Figure 3. The schematic diagram of tree-growth array radiation patch.

5. Fabrication and Test of Antenna Sample

We fabricated the antenna sample using the corrosion-making process and tested its radiation performance. The measured results are shown in Figures 4 and 5. As can be seen from Figure 4, the antenna has an operating frequency range of 0.604-17.312 GHz, an operating bandwidth of 16.708 GHz, a bandwidth octave of 28.66, and an antenna return loss of -46.31 dB. This antenna completely covers all working frequencies of the second to fifth generation...
mobile communication system, radio frequency identification bands, ultra-wideband communication bands and mobile digital TV bands.

It can be seen from the Figure 5 that both the E and H faces of the antenna can work in omnidirectional radiation.

Compared with the existing antennas of mobile communication systems, radio frequency identification systems, ultra-wideband communication systems, and mobile digital television systems, the antenna has many unique performance advantages. The antenna has excellent ultra-wideband operation capability, achieves stable coverage in a single operating band up to 16.708 GHz, and has low return loss fluctuations in the operating band, and is compatible with both second- and fifth-generation mobile communications. All working frequency bands, radio frequency identification bands, ultra-wideband communication bands and mobile digital TV bands. This antenna has obvious advantages in miniaturization design. As a large-scale array antenna with 56 array elements, the size is only 28 mm × 28 mm × 1 mm, which can be used as a miniaturized terminal antenna. Besides, the minimum return loss of this antenna is as low as -46.31 dB, and the bandwidth octave is up to 28.66. The radiation performance is uniform and stable in each working frequency band, and there is sufficient performance redundancy to ensure the multi-network wireless communication signal in the microwave frequency band. Good transmission effect.

![Figure 4. Antenna measured radiation performance](image)

![Figure 5. Antenna measured direction](image)

6. Conclusion
In this paper, a tree-shaped array ultra-wideband antenna is designed according to the performance requirements of the antenna for multi-network wireless communication terminal equipment. In the design, the inductive multi-polyline antenna is used as the array element antenna, and the radiation vertical superposition of the feeding vertical fold line and the induced vertical fold line of different working frequency bands are used to ensure that the array element antenna has an ultra-wide frequency band working capability and strong compatibility; The iteratively generated tree-growth
array structure with self-similarity is used as the basic array arrangement structure to ensure that the antenna array has both high radiation intensity and an ultra-wide operating frequency band. The measured results of the antenna sample show that the antenna has stable ultra-wideband performance and can cover the second to fifth generation mobile communication bands, radio frequency identification bands and super with a single operating frequency band with less fluctuation of return loss. The broadband communication frequency band and the mobile digital TV frequency band have small size, high radiation intensity and sufficient performance redundancy, and are expected to be widely used as a microwave band multi-network integrated terminal device antenna.

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