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Miniaturization Smart Antenna Array Design for TD-SCDMA System

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Abstract
In view of the development for TD-SCDMA communication system and combine with the miniaturization technology of smart antenna, by using balun feeding structure and consist of splitters and neural networks, this paper proposed a four units of dual polarized and a eight units of +45^o/-45^o polarized antenna array which on the basis of printed dipole antenna. The simulation results show that the isolation of dual-polarized unit between two ports is greater than -26dB, the isolation of 4-unit dual-polarized antenna array between dipole ports are less than -20dB and the 8-unit is less than -18dB. The polarization characteristics and isolation parameter of the proposed antenna has meets the demands of practical applications in the bands of TD-SCDMA communication system and its supplement bands.

Keywords: *smart antenna, dual-polarization, isolation, TD-SCDMA*

1. Introduction

In recent years, smart antenna technology has been used in China's TD-SCDMA network construction in a large scale. However, its huge transverse dimension of the antenna array has brought a plenty of inconvenience to engineering application, which can be easily limited by the construction, base station site and environment and so on. It has become a trend to realize the miniaturization of smart antenna array. The miniaturization technology of smart antenna mainly includes: reducing the number of arrays, reducing the distance between the arrays, and using the dual-polarized antenna instead of single polarization antenna. Reducing the number and distance is the most direct method to reduce the transverse dimension of smart antenna array.

As the mobile communication capacity and the interference problems increased, in the situation of same array number, multi-polarization antenna can effectively solve the problem of large volume of the smart antenna array [1-5]. A new structure which was based on a single polarized printed dipole to design a printed dipole antenna of broadband and dual-polarized for the near field measurement system, the isolation was basically greater than 20dB in bandwidth [6]. In the paper [7], it optimized the isolation and bandwidth through the method of changing the edge shape of printed dipole square patch and digging a hole in the middle. In order to enhancing the gain of far-fields, a Yagi-Uda antenna which consists of a micro-strip balun structure has been proposed [8]. A hybrid optimization method has been proposed consist of parallel center feeding dipoles elements with two complex nonlinear which to solve the problems of null synthesis of concentric rings circular array antenna optimization problems [9]. A dual-polarized broadband stacked antenna array has been proposed in [10] in order to meets the isolation and cross polarization requirements of the base station in the whole frequency band. So how to improve the isolation between the ports and the dual-band/dual-polarized antenna has become to be a hot spot in the antenna research fields.

In view of the unique advantages of the dual-polarized, this paper shows a dual polarized antenna unit which meets the requirements of TD-SCDMA communication system band and its supplementary band. Focus on the effect of distance for the isolation between the dual-polarized antenna elements. We proposed an 8-unit dual-polarized antenna array of +45^o/-45^o polarization based on the printed dipole dual-polarized antenna unit.

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2. Simulation and analysis of Dual-polarized antenna unit

In order to gain a wide frequency band and high efficiency, the feed method is radiation patch coupling by balun micro-strip. The general geometry of the printed dipole antenna is shown in Figure 1. The antenna is a double-plane structure. One plane is the radiation arm (the printed dipole patch). The other is the micro-strip balun feed. The dielectric material in the middle layer is Neltec NY9260 (IM) whose relative dielectric constant is ε_r=2.6 and thickness is 2mm. The working principle of the antenna is that the signal fed by the micro-strip balun is coupled to the radiation arm of the printed dipole, it will be radiated into free space by the radiation arm. The functions of the micro-strip balun in the proposed of the antenna are: balancing the current distribution, the mainly work of balun, and compensating the additional reactance by widening the frequency bandwidth of the printed dipole.

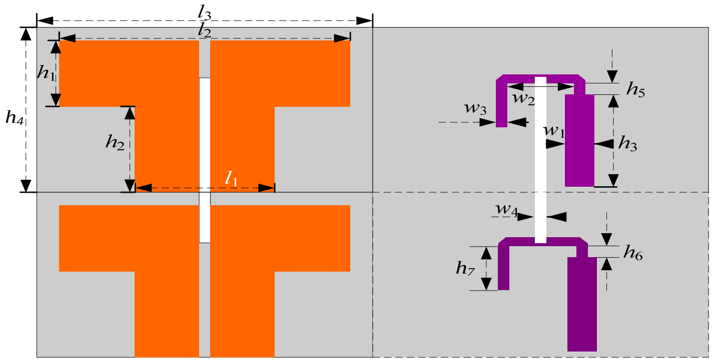


Figure 1. Geometry of the Proposed Dual-polarized Antenna

We should make the balun feed line of the two dipoles just stagger at the junction for convenient assembly which will not affect the performance of the antenna. In this paper, the distance of the height is 0.5mm and there is a slot with the height of 1.4mm on the top and bottom edges between the two feed lines respectively. Figure 2 is the simulation structure diagram of the dual-polarized antenna. Compared with Figure 1, there is a more base plane where the micro-strip line and balun feed line are connected. The signal fed-in by the port is passed from the micro-strip line to the balun feed line, then coupled to the patch. Then the arms produce induce current distribution which is ignite the electromagnetic radiation. Through simulations and optimizations, the values of the parameters are shown in Table 1.

Table 1. Parameters of Dual-polarized Antenna

Antenna Parameters	Values/mm
w_1	5.5
w_2	20
w_3	2.6
w_4	2.5
h_1	20
h_2	25
h_3	26.5
h_4	52
h_5	3
h_6	19
h_7	2.5
l_1	32.5
l_2	62.5
l_3	78

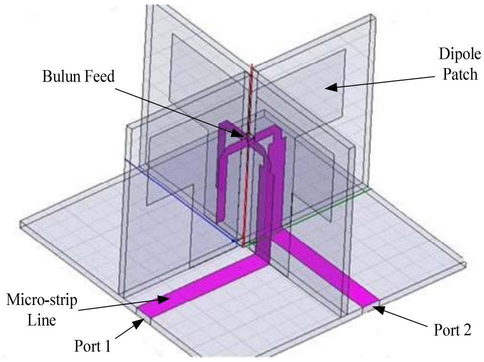


Figure 2. Simulation Structure Diagram of the Dual-polarized Antenna

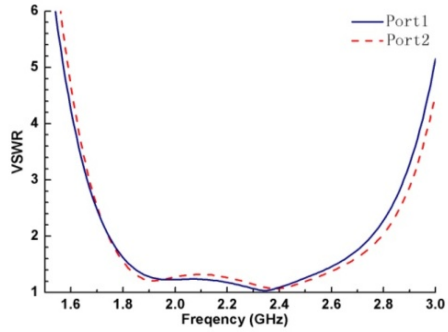


Figure 3. VSWR of Dual-polarized Antenna

The VSWR between the ports of dual-polarized antenna are shown in Figure 3, we can see that the proposed dual-polarized antenna has a good impedance characteristic. When the input VSWR of port 1 is less than 2, its operating frequency band is 1.74GHz~2.75GHz and when the input VSWR of port 2 is less than 2, its operating frequency band is 1.74GHz~2.8GHz, which all meet the requirement of operating frequency band of the TD-SCDMA system. Compared with a single printed dipole antenna, the resonant frequency of the two printed dipole antennas decreased at the second resonant point.

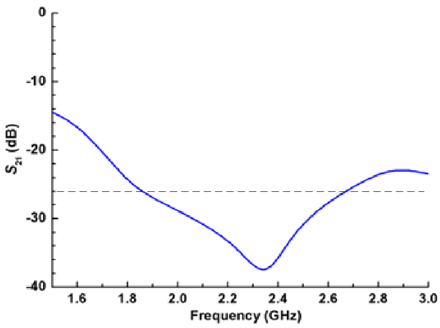


Figure 4. Isolation of the Dual-polarized Antenna

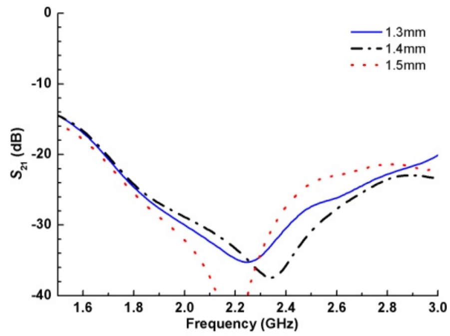


Figure 5. Isolation with Different Height of the Slot

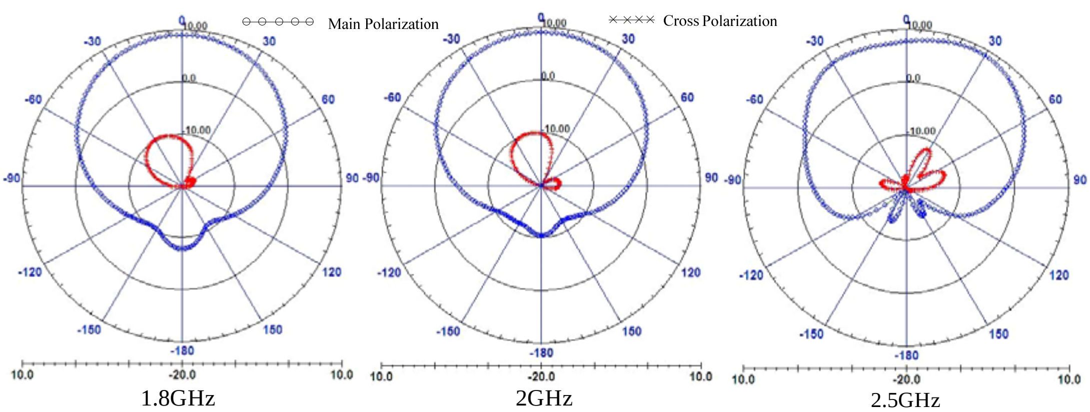


Figure 6. Horizontal Radiation Pattern of Dual-polarized Antenna

As can be seen from Figure 4, the isolation of the dual-polarized antenna is less than -26dB when the operating frequency is 1.84GHz~2.64GHz. Figure 5 reflects the impact on isolation with different height of the slot. When the height of the slot is 1.4mm and the isolation is excellent.

The direction of polarization of the proposed dual-polarized antenna is in $+45^{o}/-45^{o}$. The radiation pattern of main polarization and cross polarization for the horizon plane of the dual-polarized antenna at 1.8GHz, 2.0GHz, 2.5GHz are shown in Figure 6, respectively. The gain of the antenna is 9dB, 9dB, 7dB and the cross polarization is -10dB, -10dB, -12dB, respectively at the three frequency point above. We can see that the main polarization and cross polarization radiation pattern in the horizontal plane changes a little in the low frequency band. The gain of the main polarization maintains at around 9dB and the cross polarization keeps at around -10dB. However in the high frequency, the main lobe of the main polarization radiation pattern broadens and the cross polarization radiation pattern began to split and reduced while the cross polarization ratio of the horizontal radiation pattern is greater than 19dB in the whole frequency band.

3. Analysis of 4-unit Dual-polarized Antenna Array

We adopt the dual-polarized antenna unit above to comprise a 4-unit dual- polarized linear array. The general geometry of the proposed antenna is shown in Figure 7. The distance among each unit is L, the size of the substrate is $(3L+l_3)\times l_3$, the lower is a dielectric plane with copper on it and the material of the substrate is the same as the material of the dielectric plane of the printed dipole. Through the simulation we can see that the distance of the unit L does not have a great impact on the input impedance of each port. But there is a greater effect on the isolation for different polarization ports. We only analyze dipole 12 and dipole 34 due to the symmetry of dipole 56 and dipole 78.

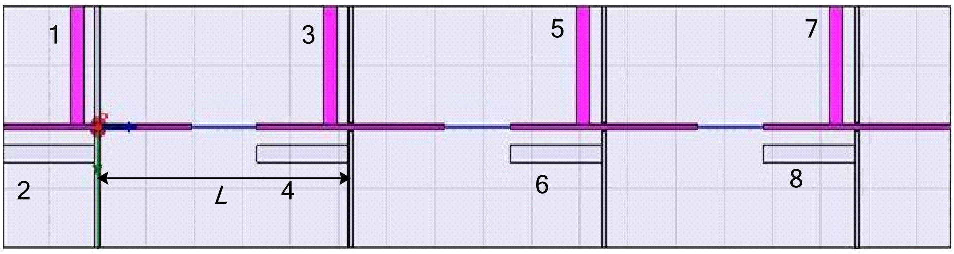
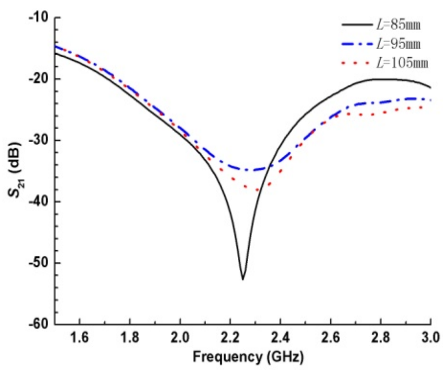
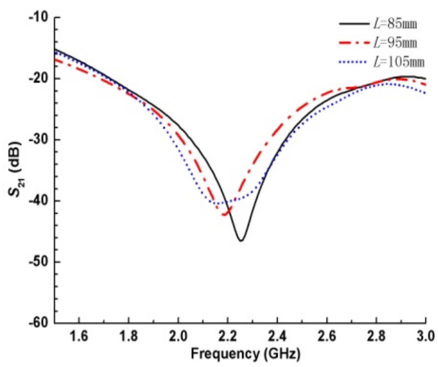


Figure 7. Geometry of the Proposed Horizontal/Vertical Dual-polarized Antenna



(a)



(b)

Figure 8. Isolation between port1 and port2, port3 and port4 with different value of L

The isolation of the port changes with the distance of unit are shown in Figure 8. Both of the isolation for dipole 12 and 34 are less than -20dB in 1.880GHz~1.920GHz, 2.010GHz~2.025GHz and the supplement frequency band 2.3GHz~2.4GHz. However the isolation in the frequency band with the change of distance will vary slightly which is caused by the coupling between the dipoles. How to reduce the isolation between the ports of dual-polarized antenna in the limited distance is a hard work for the design of dual-polarized antenna.

4. Design of 8-unit Dual-polarized Antenna Array

In terms of design ideas of dual-polarized antenna, there are two polarization modes: horizontal or vertical polarization and $+45^{o}/-45^{o}$ polarization. However, it will produce polarization current on the ground surface when the signal which transmits in horizontal polarization is close to the ground. The polarization current will produce heat energy caused by the effect of the impedance of the ground which makes the electric signal attenuates rapidly so that the transmission distance is limited. Therefore, we usually use the $+45^{o}/-45^{o}$ polarization mode. The performance of $+45^{o}/-45^{o}$ polarization is better than horizontal/vertical polarization due to the common posture that people use mobile phone and the polarization deflection occurred in the propagation of waves especially in the densely built areas of cities.

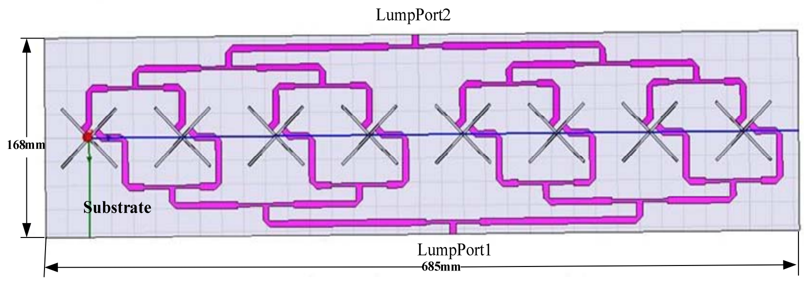


Figure 9. Geometry of the Proposed 8-unit Dual-polarized Antenna Array of $+45^{o}/-45^{o}$ Polarization

The geometry of 8-unit dual-polarized antenna array of $+45^{o}/-45^{o}$ polarization is shown in Figure 9. Adjust the two polarization direction of dual-polarized antenna unit to $+45^{o}/-45^{o}$ and arrange them in a straight line with equal distance. The distance is 85mm. We can adopt the corporate feed network to realize the equal amplitude and phase feed for each unit. We use seven micro-strip equal-power dividers to design the corporate feed and the input and two output resistance of each power divider is 50Ω which can match the unit easily. The feed network requests that the amplitude and phase of the excitation of each unit is the same. Therefore, the feed network is designed completely symmetrically and each unit is totally identical. In order to reduce the radiation at the corner of the right angle we cut the angle at the corner. The lower plane is the ground floor. The size of substrate is 168mm×685mm. The $+45^{o}$ polarization port corresponds to LumpPort1, and -45^{o} port corresponds to LumpPort2.

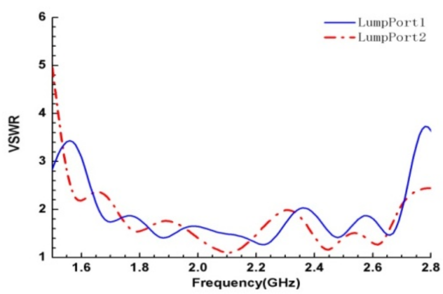


Figure 10. VSWR of Dual-polarized Antenna Array

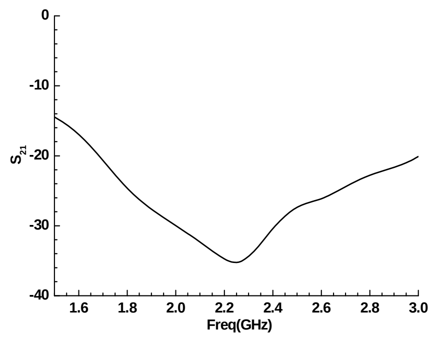


Figure 11. Isolation between LumpPort1 and LumpPort2

The simulation results are shown in Figure 10-12, respectively. As we can see from Figure 10, the frequency of LumpPort1 is 1.66GHz~2.7GHz when the VSWR<2 while the frequency of LumpPort2 is 1.72GHz~2.68GHz when the VSWR<2. Both of them meet the requirements of operating frequency and the supplement frequency band of TD-SCDMA system (1.880GHz~1.920GHz, 2.010 GHz~2.025GHz). The bandwidth changes little compared with the range of frequency band of the former when the VSWR<2. From Figure 11 we can see that the isolation of LumpPort1 and LumpPort2 is less than -18dB in the whole frequency band. The isolation of unit antenna decreases compared with no feed network. This is mainly because that both the feed network of the two polarization ports are covered on the dielectric plane of the same ground plane and increase the coupling of signal between the two polarization ports.

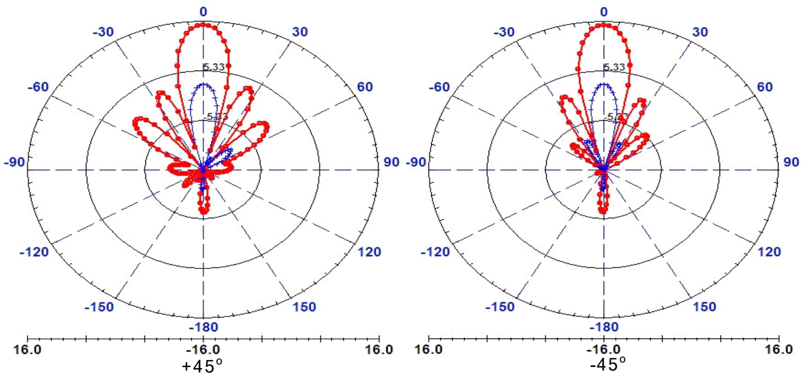


Figure 12. Radiation Pattern of +45°/-45°

Figure 12 shows the main polarization and cross polarization radiation pattern of the antenna array which is fed by LumpPort1 and LumpPort2 respectively in +45°/-45° plane at 2.0GHz. From Figure 12 we can see that the level of the side lobe and the cross polarization are relatively high which is caused by the integrated design of the feed network and the small distance between the units. The stray radiation produced by a large area of feed network will have a bad effect on the radiation pattern which will disrupt the field structure of the antenna and make the cross polarization component increases and the cross polarization level go up. What's more, the distance between feed and each unit is so long that the loss of feed network is relatively great.

5. Conclusion

This paper focus on reducing the inconvenient of the huge transverse dimension of the smart antenna array for engineering applications, shows a kind of antenna and takes simulation of smart antenna array for the application of TD-SCDMA system. We design a dual- polarized unit which is composed of the two mutually orthogonal single polarized printed dipole antennas through using balun feed. Its operating frequency band meets the requirement of band and supplement band of TD-SCDMA communication system. The isolation between two ports is greater than -26dB. On the basics of the dual-polarized unit, an 8-unit dual-polarized antenna array of +45°/-45° polarization with the integrated of feed network and antenna is designed through a corporate feed network which is composed of seven equal-power dividers. Because of the stray radiation of feed network, the isolation of two ports is not as we expected, all of these need be further research in the future.

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