A Miniaturized 2*2 Antenna Array

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Abstract. Based on the research of the transmission line model of microstrip power splitter, based on the traditional T-type microstrip power splitter, a new symmetric T-type four-way microstrip power splitter is proposed, in which the front-end power split port. The phase difference is 180 degree, and the power distribution characteristics are good. By loading a rectangular patch microstrip antenna at each port of the power splitter and etching the metamaterial structure on the floor. A miniaturized 2*2 antenna array operating at 2.45 GHz was designed. The antenna size is 40*40mm, placed on a metal reflector, and its forward gain is about 8dB in the wide range of 2.1-2.7GHz.

1. Introduction

Microstrip power splitters have been used in many fields, such as phased array antennas and power amplifiers. The most common power splitter is the Wilkinson power splitter, which loads the isolation resistors to increase port isolation. The traditional Wilkinson power splitter has a narrow bandwidth limit. Research on Wilkinson power splitter broadband miniaturization is a hot topic. By loading centralized capacitors and inductive components, the size of the splitter can be effectively reduced while maintaining high isolation of the port[1-3].

After the introduction of metamaterial theory, it is found that using the backward wave characteristics of metamaterials, it is possible to design a cavity that is much smaller than half a wavelength, that is, the antenna resonance size does not have to meet the half-wavelength condition, but the left-hand medium and the conventional medium. The fill ratio is determined. This feature has been extensively studied for the miniaturization of antennas. Various new metamaterial structures and miniaturized metamaterial structures are also emerging [4-6].

2. Microstrip power splitter model

The traditional microstrip power splitter model is a parallel branch line that transforms to the output port through a quarter-wave impedance to achieve good impedance matching. Since the transmission line impedance has a quarter-wave impedance transformation and a half-wave repetition characteristic, the power splitter design principle and simulation model are as follows.

When the input impedance of each port is 50 ohms, let Z0 be a 50 ohm transmission line and Z1 be a 100 ohm transmission line. Each port is impedance-transformed to 200 ohms by a 100 ohm microstrip transmission line with a length of one quarter wavelength. Since h is a half wavelength, it has a one-half wavelength repeating characteristic. Therefore, the impedance of the rear-end port and the pre-port are connected in parallel to the input port to achieve good impedance matching. Among them, the phase difference between the front and rear stages is 180 degrees.
Using the power divider model, a one-way four-way microstrip power divider operating at 2.45 GHz was simulated using HFSS software. The dielectric plate is made of FR4 dielectric plate with a thickness of 1.6 mm. The parameters are as follows: The size of h is 32.6 mm and w is 16.6 mm. The 50 ohm microstrip line width was estimated to be 3.2 mm by the txline software, and the 100 ohm microstrip line width was 0.6 mm.

3. Miniaturized 2*2 antenna array

Based on the power splitter model described above, symmetrically placed rectangular microstrip antennas are loaded at the front and rear stage output ports to maintain the direction of current radiation in the same direction. Because the antenna width is much less than half a wavelength, the microstrip antenna cannot operate at 2.45 GHz. Therefore, we etch a "Wang" shaped metal trough metamaterial structure on the floor. Because the phase velocity (Vp) and the group velocity (Vg) of the supermaterial in the propagation of electromagnetic waves are opposite, the electric field E, the magnetic field H, and the wave vector K satisfy the left-hand rule, instead of the right-hand rule in the conventional medium, the wave vector K and the wave The Inthano n vector S has the opposite direction and has left-hand transmission characteristics and backward-wave characteristics, so that the antenna can be miniaturized.

3.1 Original mode

The size of the microstrip patch antenna is 12 mm*12 mm. A 0.8*1 mm metal slot is opened at each end of the rectangular patch feeder to adjust the input impedance of the patch antenna to match the power split port. The width of the "Wang" metal groove is 1.2 mm. Adjusting the width of the metal groove changes the resonant frequency of the metamaterial structure, thereby changing the operating frequency of the antenna. The antenna model and simulation results are as follows:
Fig. 4. Antenna model front and back surface simulation

Fig. 5. Antenna S parameter simulation diagram       Fig. 6. Antenna gain simulation

It can be seen from the simulation results that the antenna gain map is similar to a broadband monopole antenna and has good impedance bandwidth characteristics. The H-plane gain pattern is omnidirectional radiation with a maximum gain of approximately 3.2 dB.

3.2 Loading metal reflector model

In the actual application of the antenna, the antenna is usually placed on the metal reflector, so that the antenna becomes unidirectional radiation to improve the gain of the antenna, and the influence of the surrounding environment on the performance of the antenna can be effectively reduced. The profile height of the antenna is typically a quarter of a wavelength of the center frequency of the antenna. We added a metal reflector to the HFSS simulation model as shown below.

Fig. 7. Loading reflector antenna model diagram

Through simulation optimization, the height H of the antenna is 20 mm, which is less than a quarter wavelength. This may be due to the etching of the metamaterial structure on the floor, extending the phase path of the antenna reflection. The simulation results of the antenna are as follows:
It can be seen from the simulation results that loading the metal reflector makes the antenna become unidirectional radiation, and the maximum gain is about 8.2 dB. At the same time, the low-frequency impedance bandwidth characteristics of the antenna are expanded. The antenna has good impedance characteristics in a wide frequency range from 2.1 GHz to 2.7 GHz. The former resonance point is the resonant running frequency corresponding to the floor etching metamaterial structure, and changing the width of the metal groove can change its resonant frequency. The latter resonance point is the resonance frequency corresponding to the height of the metal reflector plate. The gain curve characteristics of the antenna in the operating frequency range are given below.

It can be seen from the gain curve that the antenna has a gain of about 8 dB in the operating frequency range of 2.1 to 2.7 GHz. Because the power divider works at 2.45 GHz, the front and rear stages are 180 degrees out of phase. The direction of current radiation is the same direction. In principle, the gain can reach the maximum value. From 2.45 GHz to both sides, the gain will gradually decrease. The simulated graph rises to a low frequency and rises at 2.1 GHz to produce a gain peak. It is because the metamaterial structure has a left-handed characteristic at the resonance frequency, and the binding effect on the electromagnetic wave is enhanced to increase the gain.

**4. Conclusion**

This paper proposes a miniaturized 2*2 microstrip array antenna model. The antenna model consists of a novel one-way four-way power splitter loaded rectangular microstrip antenna, wherein the power splitter front and rear power split ports are 180 degrees out of phase. The loaded rectangular microstrip antenna is placed symmetrically in front and rear to maintain the current radiation in the same direction. The antenna size can be reduced by more than half compared to conventional array antennas. At the same time, the super-material structure is etched on the floor to achieve high gain and wide-band characteristics of the antenna.
References

[1] Wang, Xiaoqing, T. Zhang, and W. Che. "A miniaturized wideband power divider." IEEE International Conference on Ubiquitous Wireless Broadband IEEE, 2016:1-3.

[2] Ning, Junsong, et al. "A new design of compact microstrip Wilkinson power dividers." IEEE International Symposium on Radio-Frequency Integration Technology IEEE, 2014:1-3.

[3] Yuan, Zhenguo. "Design of a new radial eight orientation microstrip divider." IEEE, Information Technology and Mechatronics Engineering Conference IEEE, 2017:127-130.

[4] Ramezanpour, Shahab, S. Nikmehr, and A. Pourziad. "A Novel Design of Modified Composite Right/Left-Handed Unit Cell." Progress in Electromagnetics Research M 20(2011):13-27.

[5] Khan, Safiullah, and T. F. Eibert. "A Multifunctional Metamaterial Based Dual-Band Isotropic Frequency Selective Surface." IEEE Transactions on Antennas & Propagation PP.99:1-1.

[6] Liu, Yahao, et al. "A novel miniaturized and wideband microstrip antenna based on metamaterials." Progress in Electromagnetic Research Symposium IEEE, 2016:481-483.