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Design of Microstrip Antenna Used in Beidou Terminal

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***Abstract*—A design of microstrip antenna for application in Beidou navigation system is presented in this paper. To achieve the miniaturization of microstrip antenna sizes for better using in Beidou navigation system, the techniques of bending the microstrip line on the substrate layer and the through-hole on the patch are employed. The software HFSS is employed to simulate, analyze and optimize the designed antenna. The simulation results demonstrate that the designed antenna satisfy the requirements of application in Beidou navigation system.**

***Keywords*—beidou navigation; microstrip antenna; microstrip patch; miniaturization**

I. Introduction

During the last two decades, a lot of studies, developments and realizations for wireless devices have been done to multiply the number of the possible applications, all of this while respecting the size constraints of the communicating object [1]. With the rapid development of the satellite communication and positioning system, more and more attention has been paid to circularly polarized (CP) antennas [2]. Circularly polarized single feed microstrip patch antennas are widely employed in radar, GPS, and mobile communication systems [3]. The wireless communication technology advances rapidly. In order to satisfy the various wireless communication protocol systems demands, the future communication terminal antennas must not only be with a multi-band operation, but also have a simple structure, compact size and easy integration with the circuit [4], therefore, the miniaturization of the antenna will become an inevitable trend. The miniaturized microstrip antenna means that when the antenna works at a fixed frequency, the volume of the antenna is reduced or the operating frequency of the antenna is decreased when the size of the antenna is constant. Recently, ITS (Intelligent Transport Systems) has received much attention as a system for traffic safety and environmental protection. ITS applications such as ETC (electric toll collection system), GPS (global positioning system), SDRAS (satellite digital audio radio service) and VICS (vehicle information and communications system) are proposed and widely used presently [5]. Beidou navigation technology is a navigation system developed by the Chinese themselves, and is one of the four systems. Beidou navigation technology in the rapid development of the area involved gradually expanded, Beidou navigation technology requirements of the terminal will also be higher and higher. Optimizing the antenna performance is the most important task nowadays. The center frequency of signals used by citizens in the Beidou system is (1575.42 ± 10) MHz. In this system, the antenna is an indispensable part. Whether the received Beidou signal is good or not is closely related to the performance of the antenna and the function of the antenna is affected by many parameters such as antenna size, effective bandwidth and S11.

II. Antenna Structure

Antennas play an increasingly important role in people's daily contact and interaction. They are important hubs for people to connect with the cloud. In people's life, mobile communication systems, satellite navigation systems, satellite TV systems and other antennas are also important devices to receive and radiate electromagnetic waves. There are many types of antennas, of which microstrip antennas have been applied more and more frequently because of their low cost, light weight, easy integration, low profile, small size and easy conformality. The main structure of the microstrip antenna is a dielectric substrate on which a conductor foil is applied and the other side is grounded. It is through two kinds of feeding method, so that the patch and the ground between the excitation of the electromagnetic field, and then through the gap between the patch and the ground radiation spread.

In order to facilitate the antenna performance after optimization, first determine the approximate range of the antenna parameters, the use of HFSS initial modeling design, temporarily determine a series of variables. In the modeling, the length of the antenna arm is based on L2 as the basic variable. The length of the antenna arm is L2 and the vertical length is 2×L2. The other modifications are made to optimize the L2 so that the model will not change and the optimization fails, And in order to ensure that the antenna will not be too large because of L2 out of the surface of the dielectric layer or because L2 is too small to make the media layer a large area of waste, so the length of the medium is set to 10×L2 length, so that the dielectric layer Will change with the change of L2, the problem mentioned above will not happen. As the optimization progresses inevitably, some mistakes have been made. Due to the limited length of the antenna arm, it can not make full use of the space area of the dielectric layer. However, the method for bending the antenna arm is proved to be capable of Suitable for other similar antennas, but also has great flexibility and will not be limited to a few models. In this design, the optimized antenna parameters, names and values are as follows:

TABLE I. BASIC VARIABLES OF THE ANTENNA

significance	name	Value (unit: mm)
Dielectric layer thickness	H	1.6
Transmission line width	W1	3.9
Transmission line length	L1	24.5
Antenna arm width	W2	2.6
Single arm length	L2	5.74
Triangle side rectangular side length	L3	10
Triangle bottom edge of the right side length	L4	12
Rectangular width	W3	2.9

According to the idea of this design, the basic model of the antenna is established, the number of bends of the antenna is increased, the space occupied by the antenna is fully occupied, the unbent antenna arm in the antenna model is bent, and the number of bends of the antenna arm is increased to utilize Space to reduce the size of the idea.

The excitation signal is fed at the feed point of the antenna and passes through the triangular structure and the microstrip transmission line to the antenna arms on both sides. In the transmission line, due to the different current flow, so there will be no electromagnetic radiation. But in the two antenna arm when the charge current direction of movement is the same, it will emit electromagnetic waves.

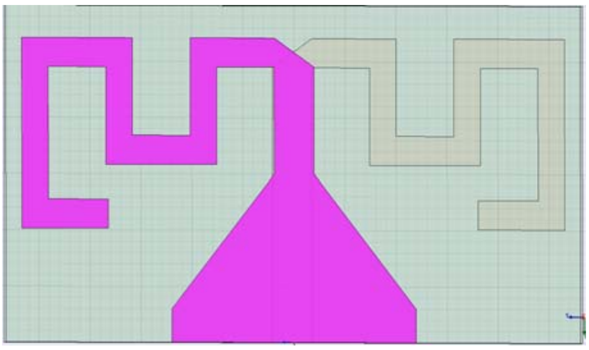

FIGURE I. BOTTOM VIEW

III. SIMULATION RESULTS

The designed model is analyzed by HFSS. The return loss S11 is shown in Fig. 2. It can be seen from Fig. 2 that the center frequency is 1.5740 GHz and the S11 is -40.6 dB. Relative bandwidth is (1.589-1.561)/1.574=1.78%. The input impedance of the designed antenna is (51.1-2.5j) Ω, which is close to the match impedance of 50Ω, as depicted in Fig. 3. This indicates that the antenna well match with the coaxial line. The standing-wave ratio (SWR) for the designed antenna is given in Fig. 4. It can be found that the minimum value of SWR is 0.2dB at 1.575GHz. This meets the engineering application requirements of SWR<2dB. The better the match, the closer the wave ratio is to 1. The axial ratio (AR) represents the polarization property of electric field. When the axial ratio is infinite, the electric field is linear polarization; When the axial ratio is 1, the electric field is circular polarization; When 0<RA< ∞, the electric field is elliptically polarized. Figure 5 illustrates the axial ratio of the designed antenna. The value of AR is 0.5, which means that the antenna is approximately circularly polarized. The navigation system requires that the receive antenna will be right-handed circular polarization. Figure 6 shows the right-handed gain and total gain. It can be clearly observed that the right-handed gain and total gain are overlapped within the range of -1200 to 1200. This indicates that the radiation wave is right-handed circularly polarized, which reaches the requirements of navigation antenna. The 2D pattern gain and 3D total gain are illustrated in Fig. 7 and Fig. 8, respectively. From Fig. 7 and Fig. 8, we can see that the maximum gain for the designed antenna is 2.0 dB, which meets the design requirements.

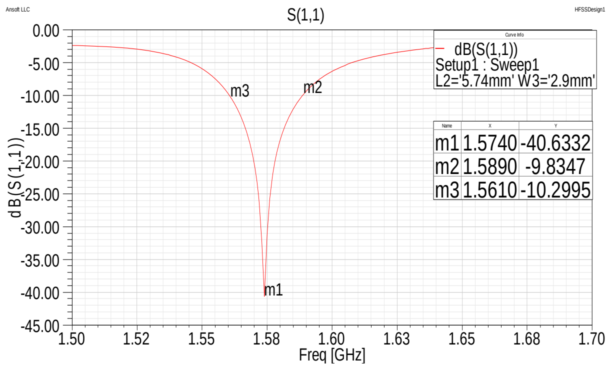

FIGURE II. RETURN LOSS S11

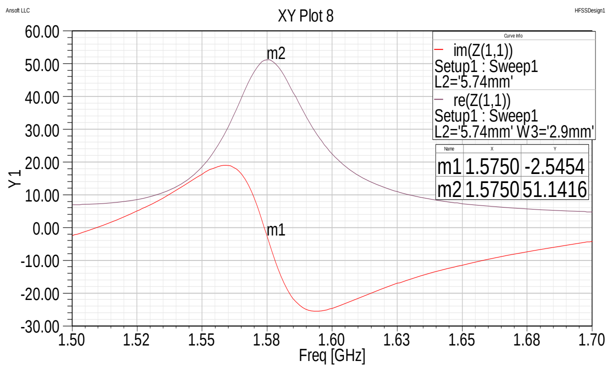

FIGURE III. INPUT IMPEDANCE

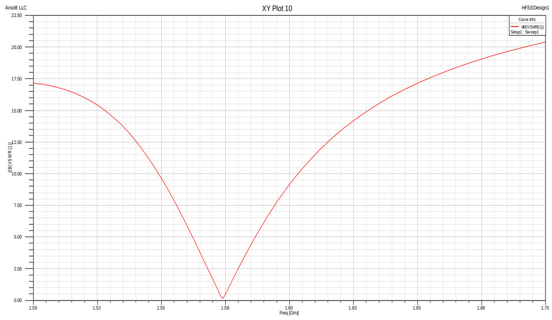

FIGURE IV. STANDING-WAVE RATIO

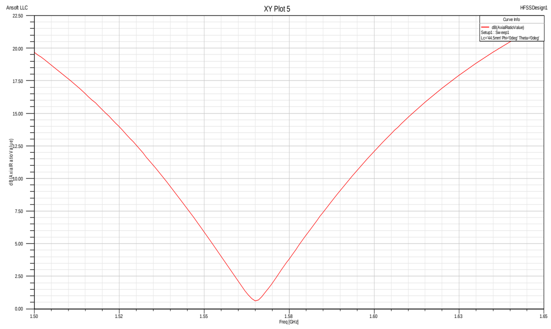

FIGURE V. AXIAL RATIO

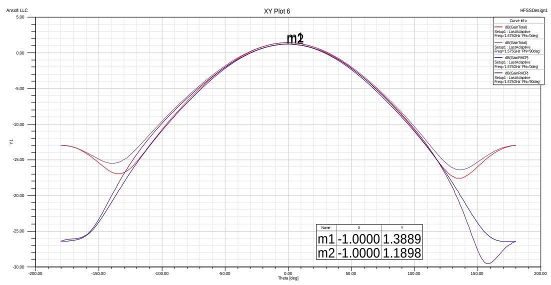

FIGURE VI. RIGHT-HANDED GAIN AND TOTAL GAIN

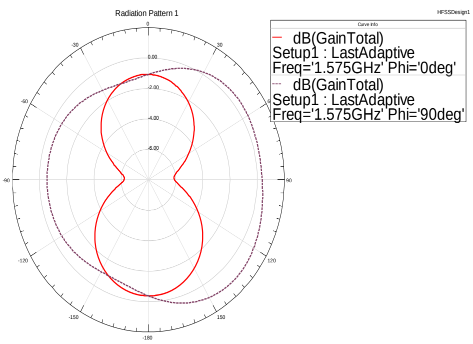

FIGURE VII. 2D PATTERN GAIN

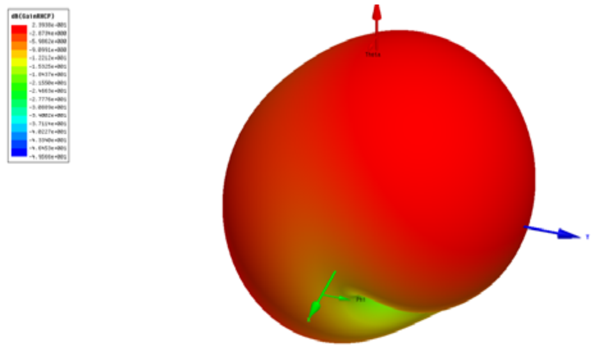

FIGURE VIII. 3D TOTAL GAIN

IV. SUMMARY

The design to achieve the miniaturization of the antenna, the curved transmission line to take full advantage of the space area of the dielectric layer, both to ensure the stability of the resonant frequency, but also to ensure good input impedance and power gain. Microstrip antenna has the advantages of small quality, low price, easy to hold and easy to implement, has been extensive research and rapid development. According to the above optimization shows, this design will be 101.7×30 medium size reduced to the size of 56.5×30, while ensuring the stability of the antenna performance, to prove that increasing the number of antenna bending, do the skin similar to the skin Arnold curve bending, take full advantage of the feasibility of the idea of spatial area and this method has great plasticity.

ACKNOWLEDGEMENT

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