Conformal Monopulse Antenna Design Based on Microstrip Yagi Antenna

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***Abstract*-In this paper, a kind of microstrip Yagi antenna whose central frequency is 5.2GHz is designed, because of its planar and end-fire characteristics, it is sticked on a cylindrical supporter to form a conformal monopulse antenna; the performance of antenna is simulated in electromagnetic simulation software HFSS.**

***Keywords*- cylinder; conformal antenna; monopulse**

I. INTRODUCTION

Today, conformal antenna as a more and more popular direction of development in science and technology has a wide range of applications in the area of civil, military and aerospace. In the civilian area, it can be applied to communications [1] as well as the automotive sector [2]; it also has great development prospects in military area like Radar and Fighter. In literature [3], a kind of conformal microstrip antenna which can be affixed around the surface of cylinder is described, but its actual value is limited because it is an Omni-directional antenna. Monopulse antenna, also known as simultaneous multi-beam, is a kind of antenna which can produce several beams simultaneously; they are sum beam, azimuth difference beam and elevation difference beam. If we can combine monopulse antenna and conformal antenna together, may produce gorgeous results.

Until now, research on conformal monopulse antenna is still not enough, especially the end-fire and broadband conformal antennas. If the monopulse antenna can be made into conformal antenna and be conformal on the cylindrical body, it can be used for positioning and tracking. In this paper, we mainly focus on the researching of end-fire conformal antenna; our goal is the design of wideband conformal antenna, and the simulation of that.

II. DESIGN OF MICROSTRIP YAGI ANTENNA

Yagi antenna is invented by two Japanese Electrical Engineering Professor Shintaro Uda and Hidetsugu Yagi in the 1920 's, Yagi antenna is also known as To Antennas or Wave Channel Antenna. Yagi antenna consists of a feed and a few passive parasitic arrays which ranked side-by-side, it is an end-fire antenna widely used in meter-wave, decimeter wave band communication, radar, TV and other radio equipment. The development of traditional Yagi antenna is limited because of its large size. In the early of 1970 of the 20th century there was

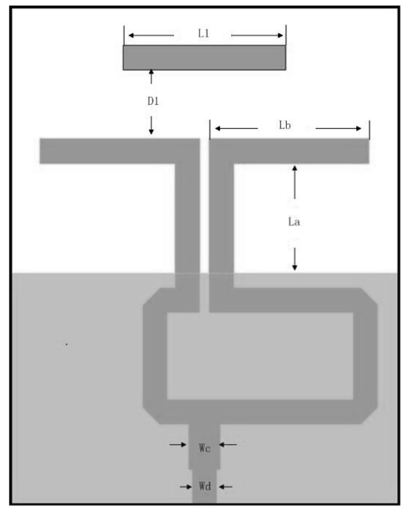

Figure 1.. Schematic of microstrip Yagi antenna

a microstrip Yagi antenna as Figure 1 shows. Compared to traditional Yagi antenna, it has lots of advantages such as small size, light weight, low profile, and flat structure. It has the advantages what traditional Yagi antenna has, and also can be made into the structure which can conformal on cylinder, satellites and other supporters.

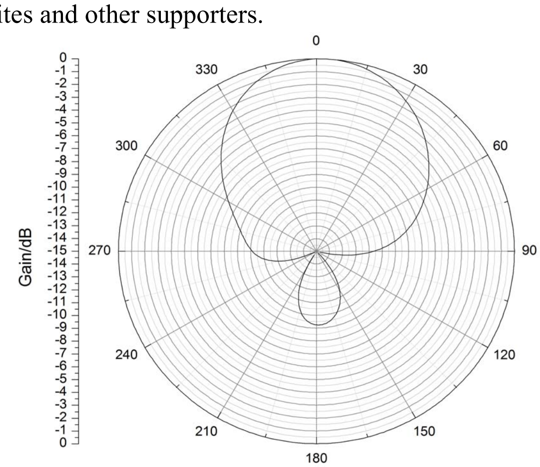

Figure 2..Radiation pattern of microstrip Yagi antenna when f=5.2GHz

Generally, the more directors antenna has, the higher gain antenna will have, but its bandwidth will decrease, in order to meet the requirements of wideband antenna, we use the structure of one director. Central frequency of antenna is 5.2GHz; ε_r of the substrate material is 2.65. The antenna consists of a printed dipole directors and a driver dipole fed by a broadband microstrip-to-coplanar strips (CPS) transition. The work band and matching performance of microstrip Yagi antenna is mainly depending on the driver dipole and reflector. The work frequency is depending on the length of the dipole director, and the S parameter s is depending on the gap of the coplanar stripline and La. The metallization on the bottom plane is a truncated microstrip ground, which serves as the reflector element for the antenna. The feature of this antenna design is the use of the truncated ground plane on the backside of the microstrip substrate as its reflecting element. This results in a very compact and simple structure that can be easily integrated with any microstrip based RF circuitry [4]. The optimization results we get finally are: thickness of substrate h=0.8mm, ε_r=2.65, Wd=2.2mm, Wc=2.9mm, La=8.9mm, Lb=14.1mm, L1=14.4mm, D1=6mm.

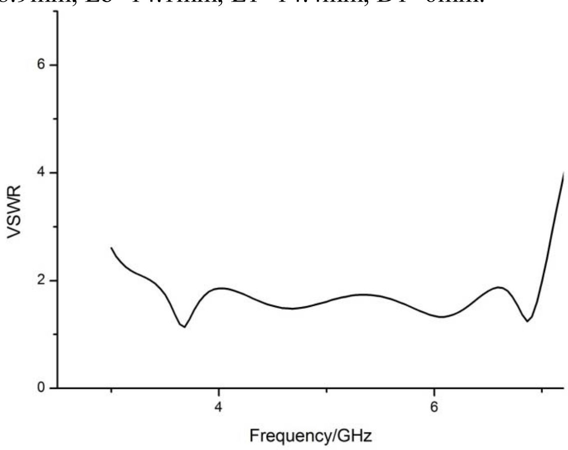

Figure 3.. VSWR of Yagi antenna

From Figure 3 we can get that: the central frequency of antenna is 5.2GHz, work band is 3.35GHz-7GHz, relative bandwidth is 70%, almost meet our design expectation.

When designing the antenna, we should first deign the balun, driver dipole and reflector to make the antenna working within specified frequency band, mainly by adjusting the parameter La and Lb. It is worth mentioning here that we should make the length of two balun arms differ by λ/2 so that it can feed the driver dipole. Then we can improve the gain of antenna as high as possible by optimizing other parameters.

III. CONFORMAL ANTENNA ARRAYS

The antenna we design in the precious section is a planar antenna; its section height is only 0.8mm, so it's easier attached on the cylindrical vectors. From paper [5] we can know, when simulating the conformal antenna, supporter cylinder can be replaced by polyhedron approximately. Here is schematic diagram of the antenna array. In Figure 4, there are totally 12 antenna units, every three antenna units form a group. In a real application, we can increase or decrease the number of units according to the size of cylinder. In this paper, we stimulate an monopulse antenna consists of eight units.

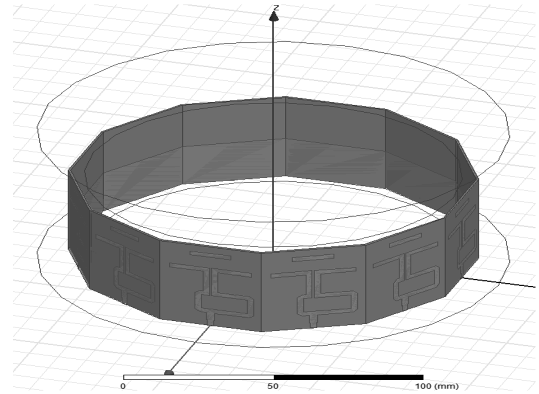

Figure 4.. Schematic diagram of antenna array

Simulated in HFSS, we can get VSWR of antenna.

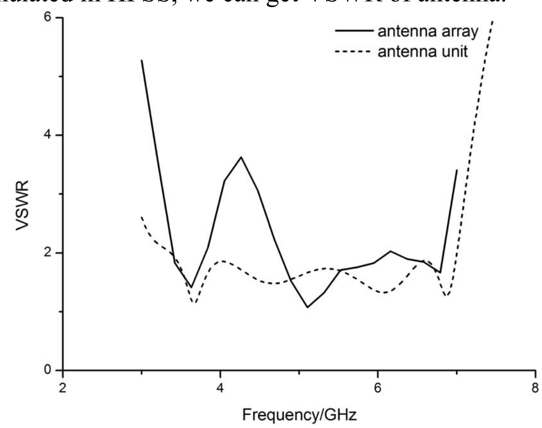

Figure 5..VSWR of antenna array

From Figure 5 we can get that when frequency range from 4.7GHz to 6.8GHz, the VSWR of antenna array is below 2, relative bandwidth of antenna is about 47.3%, decreased compared to single antenna when frequency is about 4GHz，this shows the antenna we designed is a broadband antenna.

Following is the sum beam, azimuth difference beam and elevation difference beam of antenna.

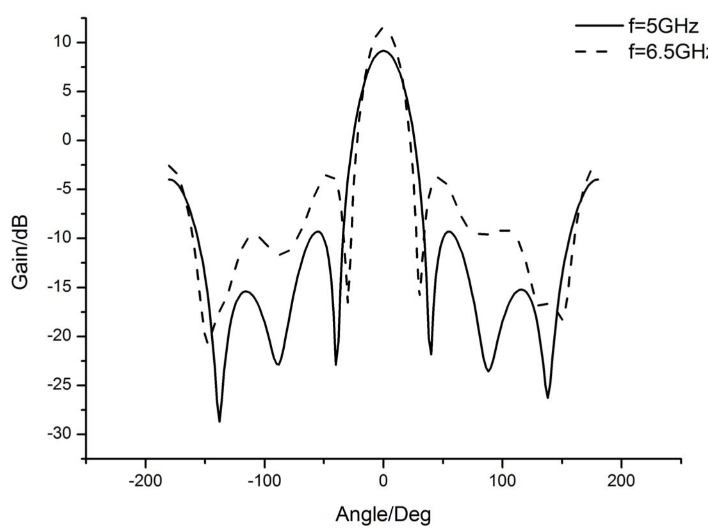

Figure 6.. The sum beam of antenna array

From Figure 6 we can know the gain of antenna towards the main radiation direction is about 10dB.

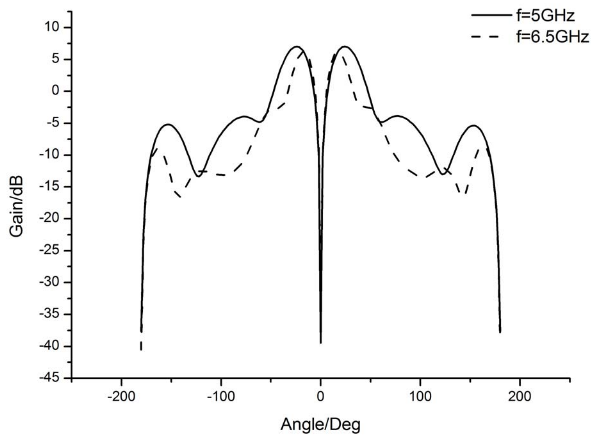

Figure 7.. The elevation difference beam of antenna array

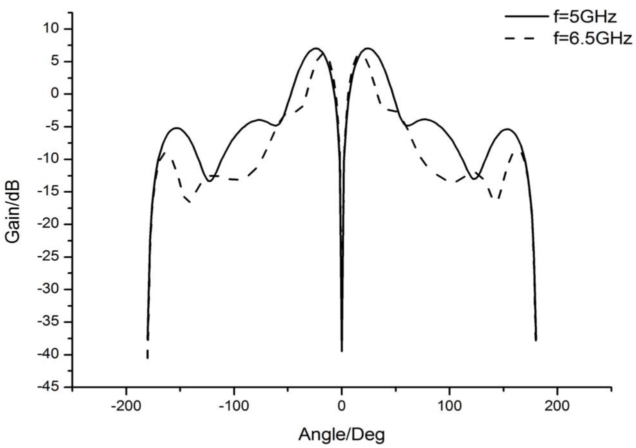

Figure 8.. The azimuth difference beam of antenna array

From Figure 7 and Figure 8 we can know that the elevation difference beam and azimuth difference beam of antenna is the same, it is not difficult to understand because our antenna is a symmetric antenna structure.

IV. CONCLUSION

In this paper, our work is manly focus on the broadband conformal monopulse antenna. As an antenna, microstrip Yagi antenna has the characteristics of low profile and end-fire, so we selected it as the fundamental antenna unit. First, we design a microstrip Yagi antenna which only have one dipole director, its central frequency is 5.2GHz, relative bandwidth is about 70%. Next, we attach the antenna on a cylindrical supporter and simulate the performance of antenna in HFSS. Compared to antenna unit, bandwidth of the antenna arrays decreased to about 47.3%. We also have simulated the performance of antenna as a monopulse antenna; sum and difference beam of antenna is given. Next step we will take measures to further improve the bandwidth of the antenna.

REFERENCES

[1] Joy An Lebaric. Ultra-Wideband Conformal Helmet Antenna. Us Ground Troop Helmet, 2000(3).

[2] Robert E. Munson Ball Aerospace. Conformal Antenna for Smart Cars. IEEE. Pro.1994, 29(3):325-331.

[3] Robert E. Munson. Conformal Microstrip Antennas and Microstrip Phased Antennas. IEEE Transaction on Antenna and Propagation. Communications 1974 (1):74-78.

[4] Pei Y Qin. A Reconfigurable Quasi-Yagi Folded Dipole Antenna. IEEE. Pro.2009.

[5] Josefsson L,Person P.Conformal Array Antenna Theory and Design [M] .Wiley-IEEE Press,2006.