Design and Implementation of a New Missile-borne Conical Conformal Antenna

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Abstract— In this paper, a conical missile-borne conformal antenna is proposed to meet a specific application. To achieve good omnidirectional circularly polarized (CP) radiation, the proposed antenna array is consisted of four identical CP microstrip antennas, which are distributed around the projectile. Shifter network and optimized patch is used to get CP performance for each antenna. The measured results are in good agreement with the simulation one. The experimental results show that the axial ratio (AR) of element antenna is less than 3 dB and omni-axis ratio is less than 6 dB. The pattern of antenna in the horizontal direction is circular, with un-roundness less than 2 dB and the vertical pattern is "8".

1. INTRODUCTION

Since microstrip antenna with small size, light weight, and low cross-section, in recent years has been widely applied to missiles, aircraft, rockets, satellites and other spacecraft. In engineering applications, microstrip antenna is often conformal with the rotating projectile [1]. Traditional missile conformal microstrip antenna is usually used the patch as a unit to achieve the circular array, but the number of units increases the array size and has a great effect on the aircraft. This is only based on the cylindrical conformal, not suitable for conical one [2, 3]. In telemetry system, in order to avoid the emergency of the phenomenon cannot receive the signal caused by the influence of the flight trajectory and attitude to antenna, we often want to antennas in the horizontal direction is omnidirectional, as compared with its vertical "8" font when mounted on the aircraft [4]. Literature [5] designs a cross dipole antenna, the antenna in the horizontal plane has realized the omnidirectional circular polarized radiation. The literature [6] presents a missile-borne conformal multi-polarization antenna to achieve the request of low elevation gain to missile-borne antenna.

This paper put forward a kind of beidou navigation missile-borne conformal microstrip antenna, for a right-handed circularly polarization, the center frequency of 1.268 GHz. Existing conformal microstrip array antenna are mostly cylindrical conformal microstrip arrays, polarization is vertical polarization. Compared with linear polarization antenna, circular polarization antenna can better accept to wave, reducing polarization loss.

2. ANTENNA DESIGN

The antenna consists of four identical microstrip antenna spacing in projectile around, fed by a four power splitters. Shifter network and optimized patch is used to get CP performance for each antenna.

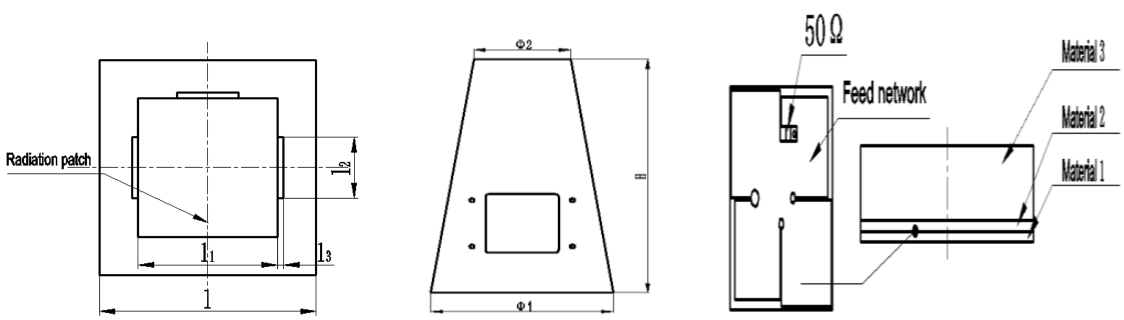


Figure 1: The schematic structure of the antenna.

Specific structure of antenna is shown in Figure 1, open four slots on conical shell, loading a same curvature metal copper on the inner wall, antenna is fixed on the metal copper. As the thickness of the ceramic sheet is large and not easily bent, unlike the conventional conformal antenna is attached directly to the outer wall above the projectile. Bottom diameter of projectile is ϕ_1, the bottom one is ϕ_2, vertebral height is h_1. The antenna section in sequence from the bottom to top as the ground plate, the medium 1, the feed network, the medium 2, the ground plate, medium 3, and the radiating patch. Relative dielectric constant substrate from bottom to top, in turn, is 4.5, 5, 20, height of h_2, h_3, h_4, width of l. Microstrip patch is composed of a square patch and the rectangular patch, the square patch width is l_1, the rectangular patch length is l_2, width is l_3. The specific dimensions are given in Table 1.

Figure 2 shows the influence of the antenna axial ratio when loaded metal projectile. As can be seen from the diagram, when the antenna with metal body conformal, antenna axis ratio change obviously. This is due to the metal projectile are connected to the ground plate, introduces a kind of asymmetry, and worsen the axis ratio. Through simulation optimization, we add a rectangular patch on the surrounding square patch to improve the axial ratio of the antenna. Figure 3 is the optimized axis ratio of antenna. The results show that the optimized axis ratio is less than 3 dB and meet the design requirements.

From the Figure 4 we can see that, 3 dB beam width of a single antenna is 100°, to achieve the omni-directional circularly polarized antenna needs at least 4 element microstrip antenna array.

Table 1: The size parameters.

Parameters	ϕ_1	ϕ_2	h_1	h_2	h_3
Value (mm)	107.7	65.8	110	1	1
Parameters	h_4	l	l_1	l_2	l_3
Value (mm)	7	35	11.6	5.4	2

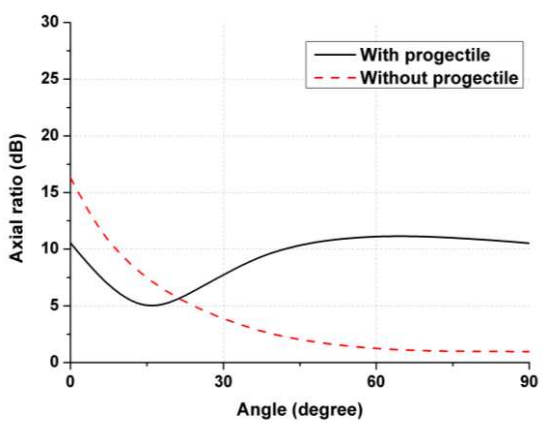


Figure 2: Projectile impact on antenna.

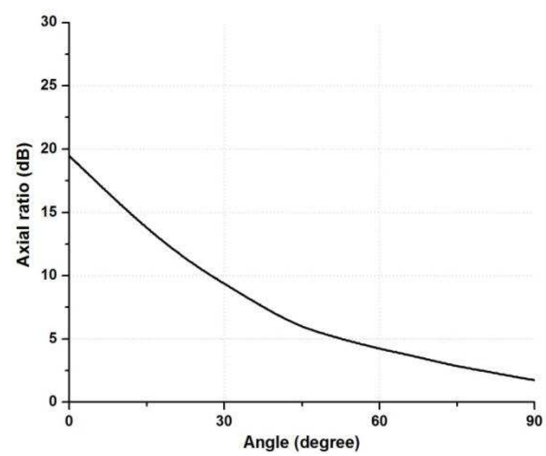


Figure 3: The optimized axial ratio.

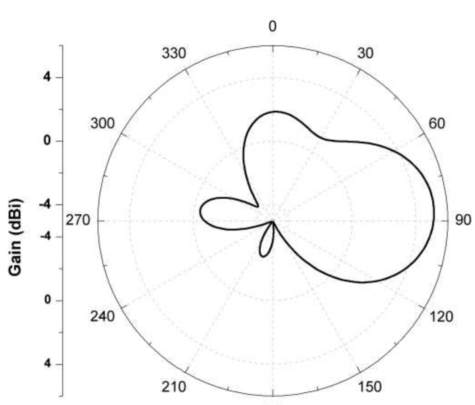


Figure 4: Single antenna horizontal pattern.

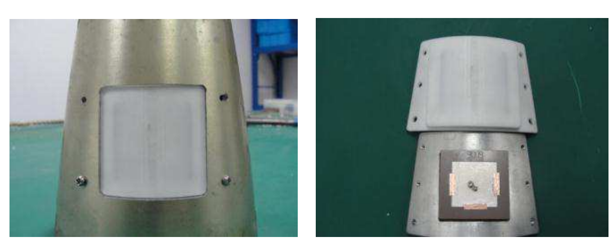


Figure 5: Physical picture of antenna.

3. RESULTS AND DISCUSSIONS

Through the above theoretical analysis, produced a physical antenna, shown in Figure 5.

Measured the antenna VSWR by vector network analyzer, The simulation and experimental results is shown in Figure 6. The isolation resistor in the feed network has broadened the Measured the antenna VSWR by vector network analyzer, The simulation and experimental results is shown in Figure 6. The isolation resistor in the feed network has broadened the bandwidth of the antenna impedance. Measured results from the chart shows that the impedance bandwidth of the antenna for the 1.18 GHz $\sim$ 1.36 GHz, the relative bandwidth is 28.3%. Figure 7 shows antenna axial ratio in the horizontal plane with the direction change curve. We can learn from the diagram, antenna in the main direction of each axis ratio is smaller than 3 dB, Omni axial ratio is less than 6 dB, and the 3 dB axial ratio bandwidth is 1.257 $\sim$ 1.276 GHz, circular polarization performance is very good.

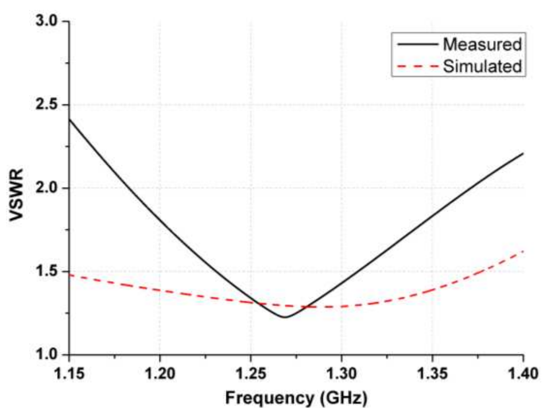


Figure 6: Measured chart of VSWR.

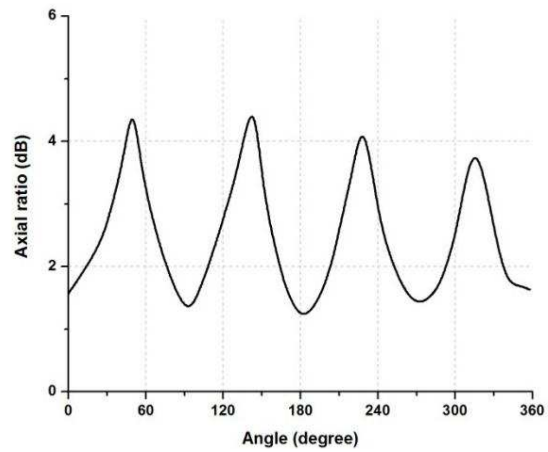
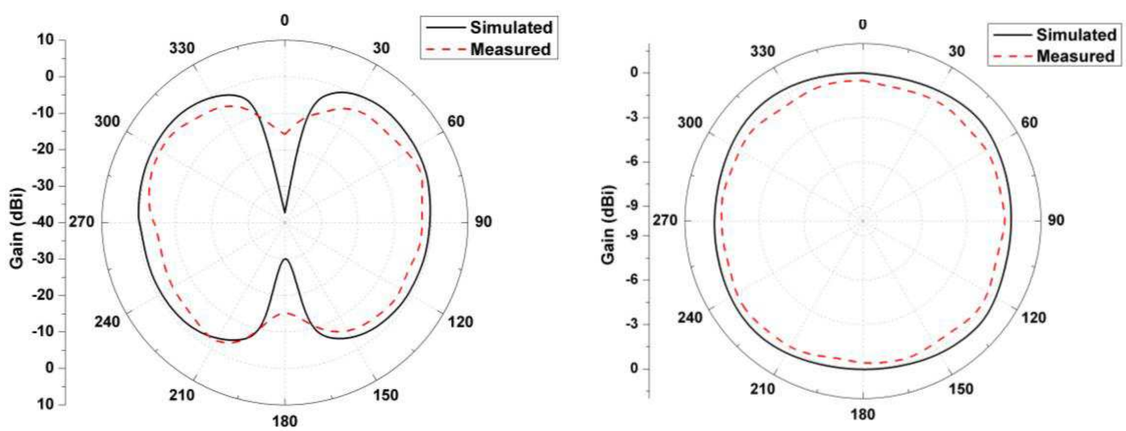


Figure 7: Measured chart of AR.

Figure 8 shows the simulation and measured antenna pattern in the E plane and H plane. As seen from Figures 8(a) and 8(b), antenna vertical pattern is "8", zero depth is about -20 dB, horizontal pattern un-roundness is less than 3 dB, achieved omnidirectional radiation.



(a) (b)

Figure 8: Comparison between simulated and measured patten. (a) Vertical pattern of antenna. (b) Horizontal pattern of antenna.

4. CONCLUSION

In this paper, we put forward a kind of beidou navigation missile cone conformal microstrip antenna, the antenna in the horizontal plane has realized the omnidirectional circular polarized radiation. Created object on the basis of simulation and measured results show that the antenna performance indicators in accordance with the simulation analysis. Good omnidirectional antenna radiation characteristics ensure the projectile receive signal during the flight can be stabilized. The antenna structure is compact, low profile, good performance, has a broad application prospect in the field of engineering.

ACKNOWLEDGMENT

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REFERENCES

1. Sim, C. Y. D. and T. Y. Han, "GPS antenna design with slotted ground plane," *Microwave and Optical Technology Letters*, Vol. 50, No. 3, 2008.
2. Josefsson, L. and P. Persson, *Conformal Array Antenna Theory and Design*, Hoboken, New Jersey, 2006.
3. Barrie, D., "Conformal consensus," *Aviation Week* & *Space Technology*, Vol. 165, No. 17, 51, 2006.
4. Jayakunar, J., "A comformal cylindrical microstrip array for producing omnidirectional radiation pattern," *IEEE Trans. AP*, Vol. 34, 1258–1261, 1989.
5. Morrow, J. and D. Polarization, "Adjustable omnidirectional dipole array," *IEEE Antennas and Wireless Propagation Letters*, Vol. 2, 223–225, 2003.
6. Foschini, G. J. and M. J. Gans, "On limits of wireless communicationsin afading enviromnent when using multiple antennas," *Wireless Personal Comnmnicafions*, Vol. 6, No. 3, 311–355, 1998.