A 24GHz Millimeter Wave Microstrip Antenna Array for Automotive Radar

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Abstract-In this paper, a 24GHz millimeter wave microstrip antenna array is proposed, which consists of 6×8 elements and the feeding network. The simulation result indicates that the VSWR is lower than 1.5 from 24GHz to 24.25GHz and the maximum gain is 20.56dBi. The power radio in both E-plane and H-plane follows the exponential distribution for lower sidelobe level (SLL). The half power beamwidth (HBPW) in the H-plane is 12.2° and the SLL is -19.1dB. In the E-plane, the HBPW is 19.2° and the SLL is -18dB. The proposed antenna has advantages of high gain and low SLL, which proves the antenna applicable in automotive radar.

Index Terms—millimeter wave, microstrip antenna array, exponential distribution, automotive radar

I. INTRODUCTION

With the sustained development of economy and construction of roads, the number of motor vehicle is increasing year by year, which meantime leads to the frequent occurrence of traffic accidents. In order to protect the property and personal safety of the car drivers, the vehicle should be equipped with an auxiliary equipment to avoid obstacles [1]. The automotive radar came into being, which can detect the information of obstacles around the car and give feedback to the system. The driver can be warned when it’s dangerous, so as to reduce the accident rate. In recent years, millimeter wave radar have been widely used because of its excellent performance of high resolution and high penetrating force. Besides, it is not sensitive to severe weather conditions such as fog and heavy rain. Consequently, it has a strong applicability [2].

Nowadays, the common working frequencies of vehicle-mounted anti-collision radar are 24GHz, 77GHz and 79GHz [3]. The 77GHz and 79GHz antennas have high frequency and short wavelength, so the radar size is small and its application prospect is very broad. However, radar antennas in high frequency band have high requirements for fabricating accuracy. Under the limited technological conditions, radar antennas in low frequency band have better performance [4].

As a two-dimensional planar antenna, microstrip antenna has the characteristics of low profile, light weight and easy fabrication. According to different scenes, the antenna is usually required to have low sidelobe, high gain, strong directivity, and the formation of fixed oblique beam, etc. It is difficult for a single microstrip antenna to meet the requirements of a certain scene, so it is necessary to form microstrip array antenna in a certain distribution [5]. Compared with single microstrip antenna, the gain and directivity of array antenna are greatly increased.

In this paper, a 24GHz millimeter wave microstrip antenna array for automotive radar is proposed. The array includes 6×8 elements and the feeding network which makes the power radio follow the exponential distribution for lower SLL. The results show the designed antenna is a good candidate for automotive collision avoidance radar.

II. DESIGN PROCESS

A. Feeding Network

In this work, the feeding network is firstly designed, which plays a very important role in antenna array. To be specific, it is not only conducive to independence matching, but also provides the required excitation amplitude and phase for each element. Figure 1 shows the feeding structure of 4 elements in a linear array, which consists of microstrip lines and quarter-wavelength independence converters. Besides, the independence of microstrip line $Z_1$ is 50$\Omega$, while the independence of the junction of two microstrip lines $Z_2$ is 25$\Omega$.

$$Z_0 = \sqrt{Z_1Z_2}$$  \hspace{1cm} (1)

According equation (1), the independence of converter $Z_0$ can be calculated. With the structure, the power radio of port 1-4 follows the exponential distribution so as to lower the SLL. Additionally, the spacing of two adjacent ports is one wavelength to realize uniform phase.

![Figure 1. Structure of feeding network.](image)

The model in Ansoft HFSS software is designed for verifying the performance of the designed feeding network. The S parameters and phase parameters are shown in Figure 2(a) and (b). It can be seen that the phase of each port is approximately equal and the power radio satisfy the exponential distribution, which makes the feeding structure suitable for proposed antenna array.
B. 6×8 Antenna array

The proposed antenna is shown in Figure 3. Considered the transmit cost, the Rogers4350 is selected to be the substrate. Its relative permittivity is 3.66 and the dielectric loss tangent is 0.004. The overall size of the 6×8 antenna array is 50mm×59mm×0.254mm and the thickness of a metal layer is 0.035mm. The size of each microstrip antenna is equal to half waveguide wavelength at center frequency. Besides, the spacing of adjacent element is approximately one waveguide wavelength along both x and y axis, which ensure the excitation phases of elements are uniform to achieve same radiation direction.

III. CONCLUSION

In this paper, a 6×8 microstrip antenna array operating at 24GHz is proposed. The bandwidth of VSWR<1.5 is 24GHz-24.25GHz and the maximum gain is 20.56dBi. Additionally, the SLLs of radiation pattern in both E-plane and H-plane are -18dB and -19.1dB, respectively.

REFERENCES