The Simulation Design of a Low-Side Lobe Level High Gain and Broadband Microstrip Patch Antenna Array

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***Abstract* - A microstrip patch antenna array with low-side lobe level, high gain and broadband is presented in this paper. A microstrip patch with one parasitical patch is proposed as a radiation element, and the antenna array is composed of 8×8 radiation elements. Then Chebyshev current distribution is used to design the feeding network on H-plane. The simulated results by CST Microwave Studio software indicate that the antenna array working in Ku band has the center frequency of 17.5 GHz and relative bandwidth of 9.3%. Also, the gain is 20dBi and the first side lobe is -20dB. Hence, this antenna array can be utilized in automotive collision avoidance radars systems.**

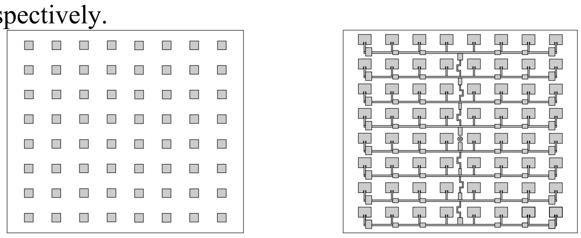
***Index Terms* — broadband, low-side lobe level, high gain, microstrip patch antenna array.**

1. Introduction

In the research field of collision avoidance radars systems, the antennas which have low-side lobe high gain and broadband characteristics are required. In recent years, many new types of low-side lobe and high gain antennas have been presented [1-3]. However the working frequency bands (from1.1% to3%) of these antennas are relatively narrow, that will lead the performances of the radar systems unstable in complex environment. Thus, improving bandwidth is more significant. A strategy of loading parasitical patch can increase the relative bandwidth up to 30% [4-5]. In this paper, a microstrip patch antenna array working in Ku band is proposed, which is loaded parasitical patches to obtain the relative bandwidth of 9.3%. And the side lobe level is less than -20dB through using Chebyshev distribution feeding network, moreover, the gain attained by 8×8 radiation elements is over 20dBi. Finally, the detail simulated results are described in the following content.

2. Antenna Structure

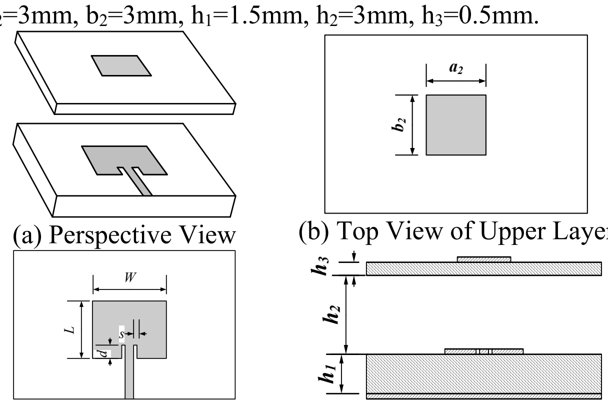
A sketch of the proposed antenna array is shown in Fig.1. This antenna array consists of two printed circuit boards and is fed at the center of the lower layer by coaxial line. Then the port impedance used for Chebyshev current distribution is determined by the width and height ratio of microstrip, moreover, using bended microstrip lines achieves same phase between those adjacent fed patches in the same rows. The relative permittivity of fed patches dielectric substrate and parasitical patches dielectric substrate are 4.4 and 2.2 respectively.



(a) Upper layer (b) Lower layer.

Fig. 1. Configuration of the proposed antenna array.

Fig.2 shows the Perspective View, top view and side view of one isolated radiation element, and the structure parameters are: W=4.4mm, L=3.45mm, s=0.2mm, d=0.8mm, a_2=3mm, b_2=3mm, h_1=1.5mm, h_2=3mm, h_3=0.5mm.



(a) Perspective View (b) Top View of Upper Layer

(c) Top View of Lower Layer (d) Side View

Fig. 2. Configuration of the radiation element.

3. Simulation Analysis

One isolated radiation element is used to research the mechanism of the antenna array by CST Microwave Studio®. Fig. 3 shows the simulated result of metal surface current on the element, as the figure shown, the maximum current is located in the margin of length side, then according to Fig. 4 drawing the surface margin current densities of the fed and parasitical patches combined with the reflection coefficients of a radiation element, the currents are resonance in 17.02GHz and 21.79GHz respectively, in addition, one element working frequency range is just between those two resonance frequencies, that is the mechanism of improving antenna bandwidth namely irregular resonance formed by multi-resonance units.

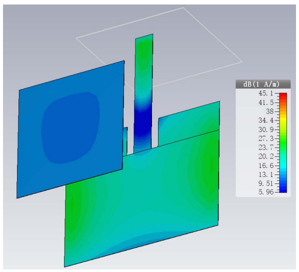


Fig. 3. Simulated result of metal surface current on the element.

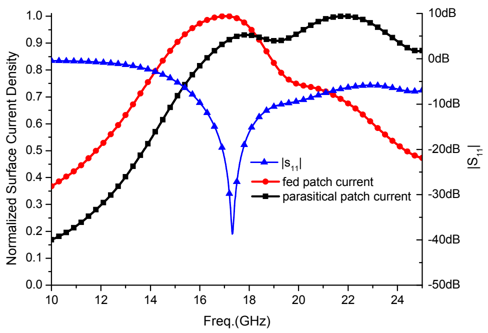


Fig. 4. Surface margin current densities of the fed and parasitical patches combined with reflection coefficients of a radiation element.

4. Simulation Results

The antenna array shown as Fig.1 has been constructed in CST Microwave Studio® and then the simulated results including reflection coefficient, gains and radiation patterns are shown in Fig.5- Fig.7. It can be seen that the antenna array achieves the bandwidth from 16.54GHz to 18.16GHz for $|S_{11}|$<-10dB ultimately, moreover, the gain is up to 20dBi, the side lobe level is -20dB and main lobe beam width are 20.2°and 20.1°of E-plane and H-plane respectively. The simulated results indicate that the bandwidth of antenna array is wider than the isolated element that is because of the coupling between adjacent fed lines and between adjacent radiation elements.

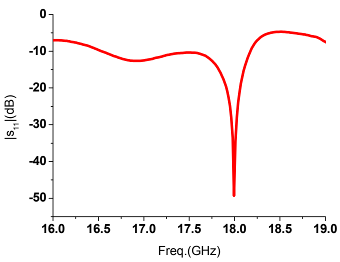


Fig. 5. Simulated reflection coefficient of proposed antenna array.

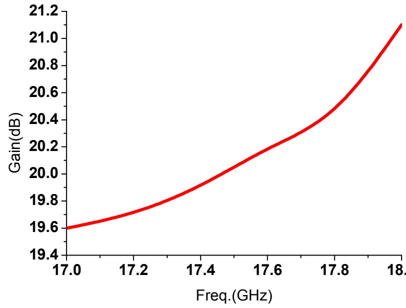


Fig. 6. Simulated gain of proposed antenna array.

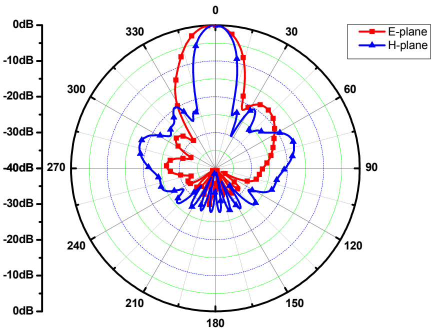


Fig. 7. Simulated radiation patterns of proposed antenna array at 17.5GHz.

5. Conclusion

In this paper, a method of loading parasitical patches is proposed to realize a microstrip patch antenna array with low-side lobe level, high gain and broadband for Ku band. This antenna array has small dimension, low profile and light weight which can be exploited in collision avoidance radars systems.

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