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Wide band Microstrip Patch Antenna Array with Parasitic Element for Automotive Radar Applications

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Abstract

In this paper a low cost array of 6 patch elements for 24 GHz is designed for automotive radar applications. Antenna array is made up of FR-4 material having dielectric constant of 4.4 that makes it very cost effective. This antenna has the complete dimension of 55X30X0.8 mm^3. This antenna array covers a wide frequency range 22.65- 25.33 GHz. Antenna array has the gain of 7.3dBi at the frequency of 24 GHz. A single parasitic element is used to enhance the property of the antenna array.

Index terms:- Patch antenna array, Automotive radar , FR-4 , Low cost

1. Introduction

Now a day's automotive technology plays major role in automobile industry. Automotive industry has focused largely on automotive vehicles, and demand for automotive radars has risen significantly in recent years. In many automotive applications such as Rear Collision Warming, Blind Spot Detection, Side Impact etc. the short range radars have often been used. This basic requirement for short range radar is its moderate gain. Generally two bands 24 GHz and 77 GHz are used by automotive industries in US and Europe for short range radar.

There are many antenna system used in the applications of automotive radar application like reflector antenna, lens antenna and planar antennas [1]. There are many literature [2-7] present for the planar grid antennas used in the automotive radar applications. The Microstrip Comb antenna Array (MCAA) and Phase antenna array are the best alternatives for low-cost ARS. Kraus initially proposed the grid antenna array concept in 1964. MGAA has a planar structure with many rectangular loops. For millimeter-wave applications, MGAA is the ideal choice. The MGAA developed Comb Array antenna, which is ARS-compatible. [2]- [5] discuss several grid antenna arrays, and [5] defines a grid array that eventually converts into a comb antenna array. [6] Explained phased array antenna.

Grid array antennas with increased bandwidth have been designed for automobile radar applications in [2], [3]. The ultra-wideband has been obtained in [2] by filling a circular disc with capacitive loading on the short radiating elements. As the equivalent capacitance grew, the Q-factor fall, and as the Q-factor decreased, the bandwidth increased. The feed is located at the structure's centre. From 16.5 to 28.5 GHz, the impedance bandwidth is available.

In [3] an asteroid-shaped unit cell was constructed, with the two requirements of uniform size and amplitude tapered GAA taken into account. The impedance bandwidth rose as the current route lengthened due to the asteroid form unit cell. To minimise the side-lobe level, the amplitude was tapered at a tapering rate of 0.271 from the array's centre. [4] Proposed a meandered grid antenna array that decreases the antenna's size by using meandering. For further size reduction and gain bandwidth increase, a slanted meandering structure was adopted. Multiple resonances have been formed in a single loop due to the employment of variable dimension radiating elements, and the final structure has a steady gain with 96 percent radiating efficiency, 3dB elevation beamwidth of 5^0.

A microstrip grid antenna with excellent gain and low side-lobe level was designed in [5]. Then there's the on-amplitude tapered MGAA, which has a high gain of 20.6dB at 24.5GHz. To suppress the side-lobe level structure, the Taylor synthesis method was utilised to turn the side-lobe level structure into amplitude tapered MGAA. At 24.47GHz, amplitude tapered MGAA has a maximum gain of 19.85dBi. It features a -24dB low side level. To avoid a matched load and reflection cancellation structure, MGAA has been modified to MCAA.
A ten-element patch array was designed in [6], and the elements were fed using a series-parallel feeding method. Microstrip transformers were utilised in the structure for impedance matching, and the patch and microstrip transformers were tilted at 45^0 to provide a symmetrical structure. A few microstrip patches are clipped at the corners to increase bandwidth. A patch array can be used as both a transmitter and a receiver. The transmitter antenna array was set up as a single column with a 3dB splitter, while the receiving antenna array was set up as a three-antenna column.

In this paper, a low cost antenna array of single feed is designed with the gain of 7.3dBi. . This antenna is useful for automobile application.

2. Antenna Configuration

The proposed antenna array for 24 GHz is shown in Fig. 1.

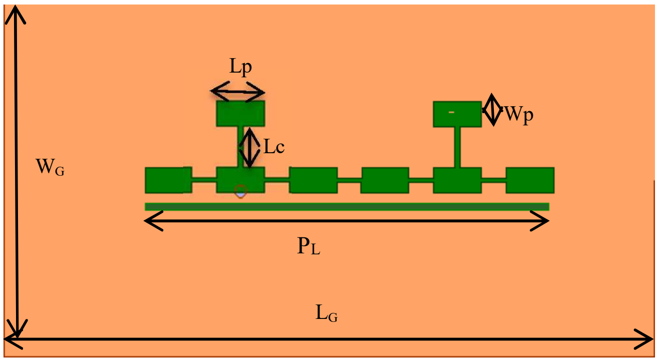

Figure 1. Geometry of Proposed Antenna

This antenna array has 8 same type of elements connected in series. These elements have same separation with each other and 2 elements are connected in parallel having same dimensions but the separation may change.
This antenna array is designed by using Glass exopy FR-4 material of dielectric constant 4.4 and thickness of 0.8 mm. This antenna array has single feeding point at the edge of one patch.
A singe parasitic element of dimension of 35X0.5 mm^2 is used to improve the performance of the antenna array.
The optimized dimension of the antenna array is given in the table I.

Table I . Optimized dimension of proposed antenna array

Parameter	Dimension(mm)	Pw	0.75
W_G	30	P_L	34
L_G	55	L_C	3.5
Lp	4	Wp	2.1

3. Result and Discussion

This antenna is simulated with the help of Ansys HFSS (Version 15.1) . Various parameters those are important for designing of automotive radar application antenna are evaluated. These parameters are return loss, VSWR, Gain of the antenna array, current distribution on the surface of antenna etc.

Fig.2 shows the effect of parasitic element in the performance of antenna array.

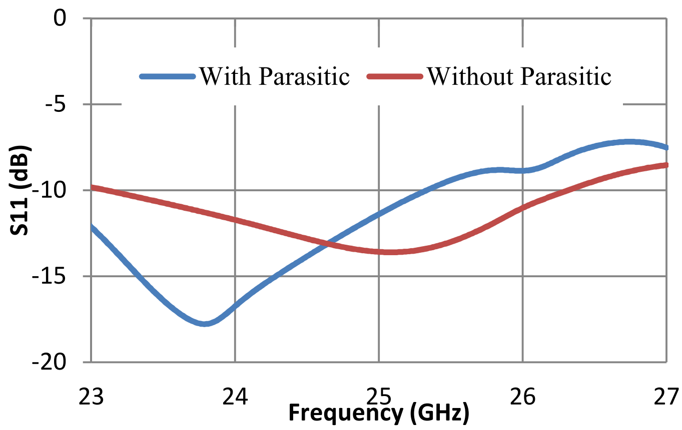

Figure.2 Effect of parasitic element on S_{11}

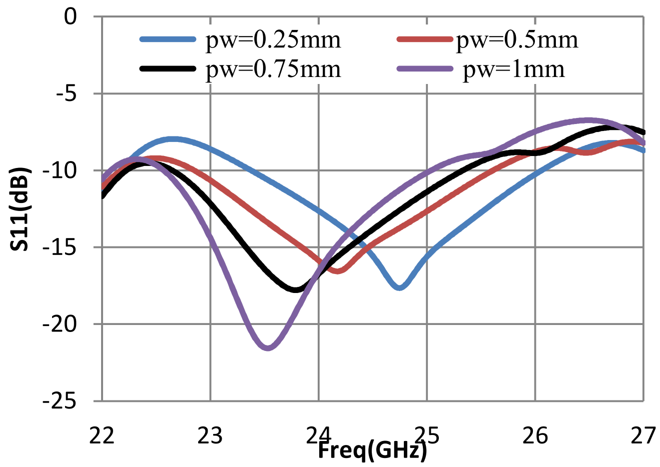

Figure3. Variation of S11 with respect to parasitic element width (P_W)

Fig.3 shows the variation of return loss *(S_{11})* with respect to the parasitic element width. It shows that the width plays an important role. As the width of the parasitic element increases the resonant frequency may vary from higher to lower side of frequency. For operation Pw =0.75 mm is consider for getting best result.

Fig .4 shows the 3-D radiation pattern of the antenna array at the frequency of 24 GHz. It shows that the radiation pattern is broad side radiation pattern and this antenna array has the gain of 7.3 dBi at the bore sight direction. This range of gain is used for the short range automotive radar system.

Fig. 5 shows the current distribution at 24GHz. It shows that current also flow in the parasitic element and responsible for the improvement in the antenna array performance.

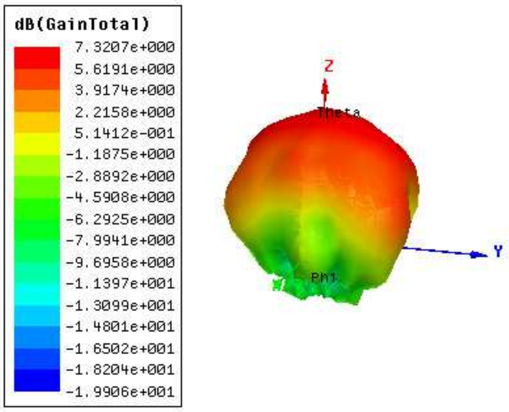

Figure 4. 3-D Radiation pattern at frequency of 24GHz

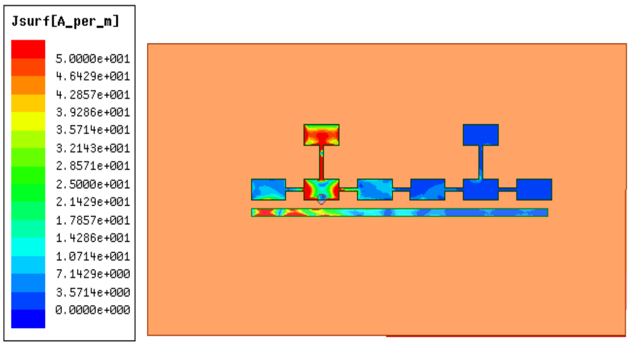

Figure 5. Current distribution at 24 GHz

4. Conclusion

In this paper a single fed series antenna array is designed using FR-4 substrate. A single parasitic element is used to improve the performance of the antenna array. This antenna array covers the frequency range of 22.65- 25.33 GHz. This range covers the 24 GHz and this antenna is suitable for automotive radar applications. This antenna array has the gain of 7.3 dBi. This moderate gain is suitable for short range radar application.

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