A Novel H-Shaped Microstrip Patch Antenna Array for Automotive Radar Applications

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Abstract

In this paper a 1X3 H- shaped antenna array is designed for 24 GHz band automotive radar applications. This antenna array is designed using RT-Duroid 5880 having standard thickness of 0.381 mm. Beamwidth of antenna system is reduced to 40^0 in H-plane by using 1X3 H - shaped array as compare to the single patch antenna. The gain of the antenna is 8.39dBi that make it suitable for short range radar applications.

Index terms:- H-shaped Patch antenna array, Automotive radar , RT-Duroid 5880 , 3 -dB beamwidth

1. Introduction

Automotive radar has become increasingly popular in advanced driver assistance systems. Wider beamwidth and moderate gain are required for mid and short range antennas used in automotive radar systems.

There are many literature [1]-[4] are presented for antennas used in automotive radar applications. A ten-element patch array was designed in [1], 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.

Wide beam antennas, such as fan shape and high gain array antennas, are described in [2]. There have been two different constructions realised. A conventional patch antenna has a 3dB beamwidth of roughly 90^0 and a maximum gain of 7dBi, however the described antenna arrays have higher gain and beamwidth thanks to parasitic loops in one array structure and mushroom-like structures in the other. When parasitic loops are utilised in a 1x8 array, the gain increases to 12.2 dBi and the beamwidth increases to 130^0 in the E plane and 12^0 in the H plane, respectively. When the parasitic mushroom structure is used, the gain decreases slightly but 3 dB beamwidth became 150^0 and 10^0 in the E plane and H plane, respectively. There used to be three layers in the array.

In [3], the design of a switch antenna array for FMCW radar that includes one transmitting antenna, four receiving antennas, and an SP4T switch. The single antenna has a 2 dBi gain and a 100^0 dB beamwidth. A plano-convex lens antenna was employed from the patch antenna's centre to achieve the better power gain. A phased array antenna incorporating RF MEMS was realised in [4]. It was scaled for long-range radar applications using a Rotman lens. In order to achieve the requisite beam width, 24 antenna columns in the azimuth plane were used in the W band.

2. Antenna Configuration

The proposed H shaped antenna array geometry is shown in the figure1.

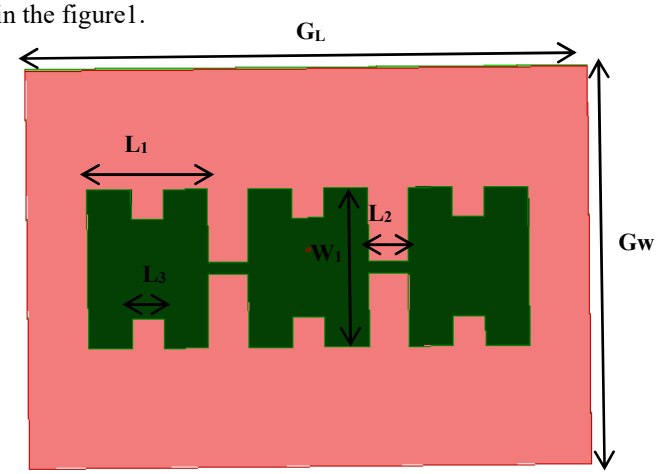


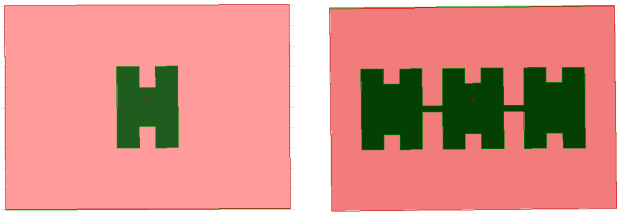
Figure1. Proposed 1X3 H- shaped antenna array

Table I shows the dimensions of proposed antenna array after optimization.

Table I Optimized Dimensions of antenna array

Parameter	Dimension(mm)	Parameter	Dimension(mm)
G_L	14	L_2	1
G_W	10	L_3	0.8
L_1	3	W_1	4

To enhance the properties of designed antenna such as gain , beamwidth and impedance matching addition Two H-shaped patches are used that makes an array . It is shown in fig.2.



Antenna I Antenna II

Figure.2 Evolution of antenna array

3. Result and Discussion

To analyze this antenna array Ansys HFSS (Version15.1)[5] is used. Various parameter such as return loss ,3-D radiation pattern, 2-D radiation pattern , 3-dB Beamwidth and current distribution etc. are calculated.

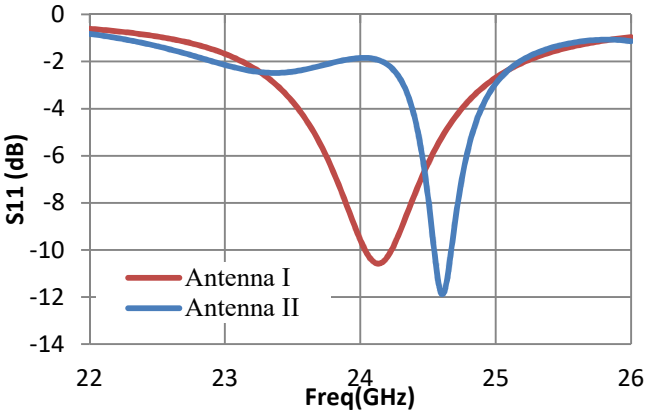


Figure3. Return loss (S_{11}) of antenna I and antenna II

Fig .3 shows the return loss S_{11} of antenna I and Antenna II . It shows that return loss characteristics is improved by using antenna array.

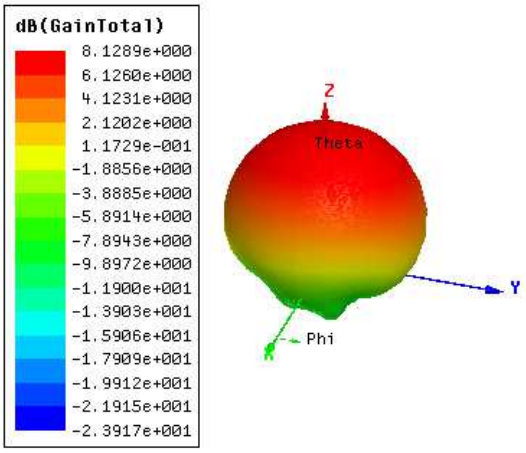


Figure 3(a). 3-D Radiation pattern of antenna I

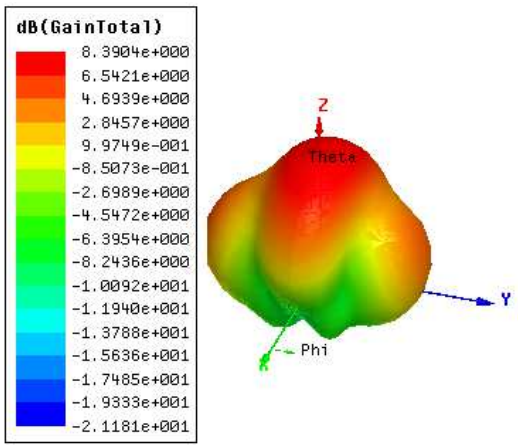


Figure 3(b). 3-D Radiation pattern of antenna II

Fig.3 (a) and (b) show the 3-D radiation pattern of antenna I and antenna II and Fig 4 (a) and (b) show the 2-D normalized gain graph of the proposed antenna. It shows that the -3-dB Beamwidth of the single patch antenna (Antenna I) is approximately 70^0 in E –Plane and 80^0 in H-plane . -3dB beamwidth of the 1X3 H antenna array (Antenna II) shows 80^0 in E-plane and 40^0 in H-plane. Antenna II reduces the H-plane -3 -dB beamwidth approximately half of the single patch (Antenna I) by using the array combination.

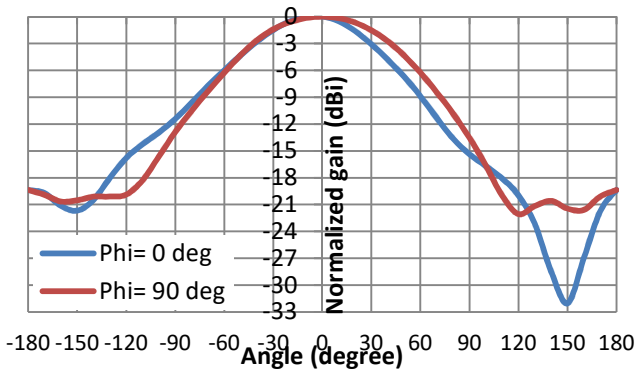


Figure 4(a). 2-D Radiation pattern of antenna I

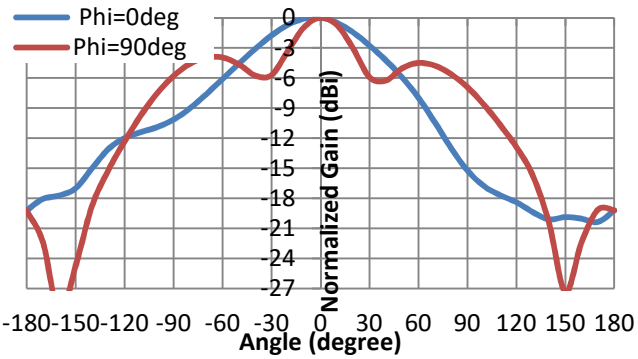


Figure 4(b). 2-D Radiation pattern of antenna II

Fig. 5 shows the current distribution of the antenna II. It shows that current distributed in the all three patches and this array reduces the 3 dB beamwidth in H-Plane.

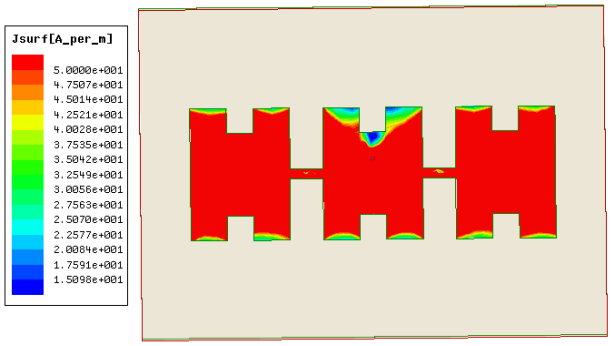


Figure 5. Current distribution of the proposed antenna II

4. Conclusion

In this paper, 1X3 H –shaped antenna array has proposed by using RT-Duroid 5880 materia having thickness of 0.381 mm. This covers the frequency range from 24.54-24.68GHz. With the help of antenna array 3-dB beamwidth is reduced approximately 50 percent of the single patch antenna . This antenna array has 8.39dBi gain and this antenna array is suitable for automotive radar applications.

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