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DESIGN OF PATCH ANTENNA AND ARRAY FOR WIRELESS COMMUNICATION

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ABSTRACT

The antenna is used to receive RF/Microwave signal. In this work, the design and simulation of the rectangular microstrip patch antenna and arrays are carried out at 10GHz frequency for low-profile wireless communication applications. Initially a single rectangular edge feed microstrip patch antenna is designed at 10GHz frequency using an electromagnetic software. The antenna design parameters are optimized using the above electromagnetic simulation software. Rectangular microstrip array of 1×4 is designed using feed network at the same frequency. The inter-element spacing of the antenna is $0.75\lambda_0$. The antenna radiation parameters such as return loss, gain, directivity, efficiency and 3D radiation patterns are obtained for single patch and array. The antenna radiation parameters are compared for the and arrays. From the simulation results, it is observed that the gain and beam width of the antenna array are increased and decreased respectively for the increase in elements in the array.

Keywords: Microstrip Patch Antenna, 10 Ghz, Electromagnetic Simulation Software, Gain, Directivity.

I. INTRODUCTION

Microstrip antenna was introduced from microstrip circuit technology and has inherited many characteristics such as low radiating efficiency and narrow bandwidth that are undesirable for a radiator. However, they offered many desirable features in terms of small size, low profile, ease of integration with circuits and forming arrays. Consequently, research has been focused to improve their performance as radiators. Modern mobile communication systems are increasingly employing phased array at base stations to expand the base station customer capacity and reduce interference among adjacent stations. In the wireless industry, such antennas are typically referred as smart or adaptive antenna. Reflector, horn and microstrip array antenna are widely used in microwave applications. In this work, the rectangular microstrip patch antenna array is designed and simulated at 10 GHz frequency for X-band applications. The design parameters of single antenna and 1×4 antenna array are optimized using an electromagnetic software. The antenna parameters such as return loss, gain, efficiency, directivity, and radiation pattern are obtained using the electromagnetic simulator for the antenna and array.

II. METHODOLOGY

Rectangular Patch Antenna

Design section of a single microstrip antenna consists of patch, quarter wave transformer and feed line. A rectangular patch antenna is designed at 10 GHz frequency. A 50Ω surface mount adapter connector is used to connect the feed line to the coaxial cable. The feed line is fed to the patch through a matching network which is a quarter-wave transformer. Fig.1. shows the patch antenna with quarter-wave transformer. The dimensions are calculated based on the transmission line model. The length and width of the patch are calculated using equations (1) and (2).

$$L = 0.49\frac{\lambda}{\sqrt{\varepsilon_r}} \qquad (1)$$

$$W = \sqrt{\frac{90\frac{\varepsilon_r^2}{\varepsilon_r - 1}}{Z_A}}\, L \qquad (2)$$

$$Z_1 = \sqrt{Z_o R_{in}} \qquad (3)$$

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The impedance of the quarter wave line is calculated using equation (3). Z_1 is the transformer characteristic impedance. Z_0 is the characteristic impedance of the transmission line and $R_{in}$is the edge resistance at resonance. The obtained values for the parameters are illustrated in Fig.1 and Table 1.

1x4 Patch Antenna Array

The array antenna is used to increase the directivity. So the received power will be increased. In this proposed work, 1X4 patch antenna array is designed at 10 GHz frequency. The array calculation consists of two parts. The first is the patch calculation and the second is for 50 Ω, 35 Ω and 112 Ω transmission lines. Similarly the patch dimensions are obtained through equations (1) and (2) same as a single patch. The impedance of the quarter wave line transformer is calculated using equation (3). The obtained values for the line parameters are illustrated in the Table 2 and Fig 2.

III. MODELING AND ANALYSIS

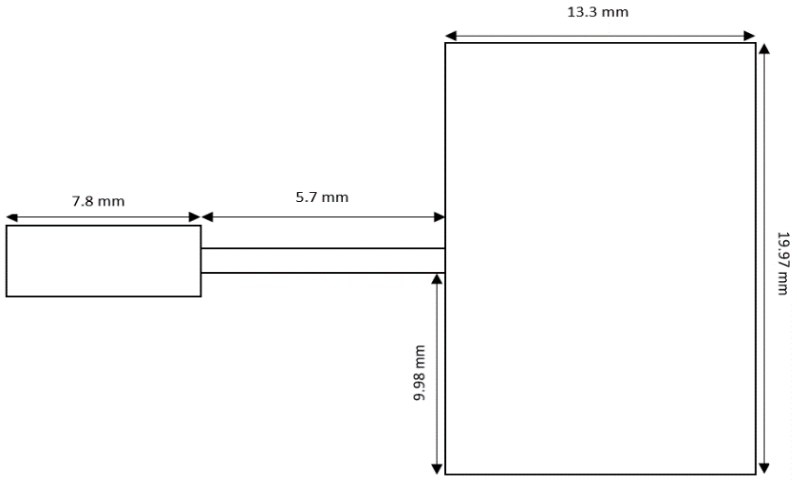

Figure 1: Patch Antenna

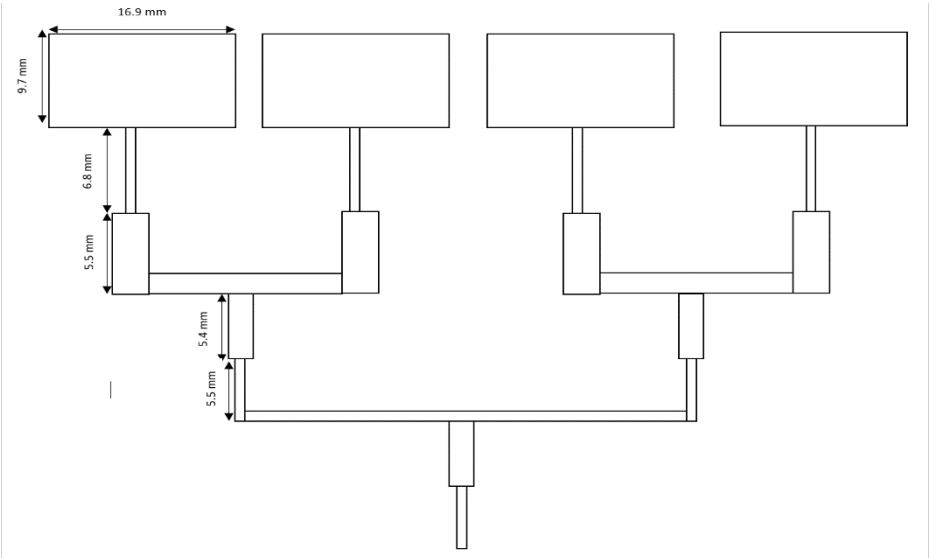

Figure 2: 1x4 Patch Antenna Array

IV. RESULTS AND DISCUSSION

Table 1. Dimensions of Rectangular Patch Antenna

Patch	
Width W	13.3 mm
Length L	19.97 mm
λ/4 Transformer	
Width W	0.8 mm

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Length L	5.7 mm
50 ΩFeedline	
Width W	2.75 mm
Length L	7.8 mm

Table 2. Dimensions of 1x4 Patch Antenna Array

Patch	
Width W	13.3 mm
Length L	19.97 mm
112 Ω λ/4 Transformer	
Width W	0.8 mm
Length L	5.7 mm
50 Ω Feedline	
Width W	2.75 mm
Length L	7.8 mm
35 Ω Feedline	
Width W	2.75 mm
Length L	7.8 mm

Table 3. Comparison of Antenna parameters

SN.	Model Type	Seismic Zone	Displacement
1	Gain	7.05 dBi	12.54 dBi
2	Directivity	7.52 dBi	12.79 dBi
3	Efficiency	89.83%	94.46%
4	Effective Angle	2.22 Steradians	0.66 Steradians

V. CONCLUSION

The comparison of antenna parameters for single rectangular patch antenna and 1X4 rectangular patch antenna array is shown in Table 3. From the tabulation values, it is observed that directivity, gain and efficiency are increased and also effective angle, is decreased for the array. So the simulated array obeys the antenna theory. The designed array may be suitable for wireless communication applications.

VI. REFERENCES

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