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Design and Implementation of T-junction Triangular Microstrip Patch Antenna Array for Wireless Applications

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***Abstract*— This paper describes 2 x 2 triangular microstrip patch antenna using T-junction with quarter wave transformer. By regulating the distance in patch antenna and adjusting feed position, bandwidth can be obtained and by using an array, directivity is enhanced. The requirement of large bandwidth, high directivity, and minimum size leads to the design of 2 x 2 triangular microstrip patch antenna array feeding with T-junction network operate at 5.5 GHz. An antenna designed on an FR4 substrate that had a dielectric constant (ε_r) 4.4, a loss tangent 0.02 and thickness of 1.6 mm. Simulated results showed that designed antenna has directivity 12.91 dB and bandwidth 173 MHz with VSWR 1.07 using T-junction feeding network. The proposed 2 x 2 triangular array has the benefit of light weight, simplicity of fabrication, single layer structure, and high directivity.**

Keyword - Bandwidth, Corporate feeding, Return Loss, T-junction, VSWR.

I. INTRODUCTION

Microstrip patch antennas [1] are popularly used in communication system due to its simplicity of fabrication, small size, lightweight and less cost. But conventional microstrip antenna impedance bandwidth is not more than 2% - 5% percent. Bandwidth increases with increasing height of substrate (h) or with small dielectric constant. If the height of substrate further increases $0.1\lambda_0$, degrades the antenna performance. Also, single microstrip antenna has low directivity. A number of methods to overcome such problems by use of array technique, modified patch shape [2]. Geometries like rectangular and circular are frequently used but the triangular patch has the benefit of less metal area of a patch than other configurations. The directivity can be increased by constructing antenna array of microstrip patch antenna. Basically, to distribute the energy into the different antenna element, feeding configurations are used [3].

A number of approaches to design and investigation of microstrip patch antenna array according to feeding technique, series fed microstrip antenna array [4, 5]. Sometimes multilayer configurations are used for feeding the array [6], [8], [9]. Configurations like shared aperture dual frequency array [7], array with hybrid feeds using combination of aperture coupled and proximity feed line [10], corporate feed rectangular microstrip patch array [11] and much more have been stated. If the physical width of the microstrip line is large and arrays with more elements, increases the size and fabrication cost.

In this paper, we proposed a 2 x 2 triangular microstrip patch antenna array with T-junction feeding network with quarter wave transformer for impedance matching. Initially, 2 x 1 rectangular microstrip patch antenna array and 2 x 1 triangular microstrip patch antenna array are designed and simulated. Simulation results illustrate better directivity for 2 x 1 triangular microstrip patch antenna array. Therefore, 2 x 2 triangular microstrip patch antenna array with T-junction feeding network with quarter transformer is designed, simulated, fabricated and tested using Vector Network Analyser (VNA). Simulation and measured results are examined.

II. THE CONFIGURATION OF THE BASIC STRUCTURE

Initially, 2 x 1 rectangular microstrip patch antenna array and 2 x 1 triangular microstrip patch antenna array are designed. Inter-element spacing between two elements is adjusted.

Figure 1(a) and figure 2 (a) shows 2 x 1 rectangular and 2 x 1 triangular microstrip patch antenna array designed using ANSYS HFSS respectively. Figure 1(b) and figure 2 (b) shows dimensional parameters of 2 x 1 rectangular and 2 x 1 triangular microstrip patch antenna array respectively, illustrated using AUTOCAD. Simulation of these antenna arrays was done using HFSS software.

Figure 3 and Figure 4 shows simulated return loss and VSWR for 2 x 1 rectangular (S11 = -22.99 dB, VSWR = 1.15) and 2 x 1 triangular (S11 = -27.61 dB, VSWR = 1.08) microstrip patch antenna array. Figure 5 shows simulated directivity for 2 x 1 rectangular (4.62 dB) and 2 x 1 triangular (7.35 dB) microstrip patch antenna array.

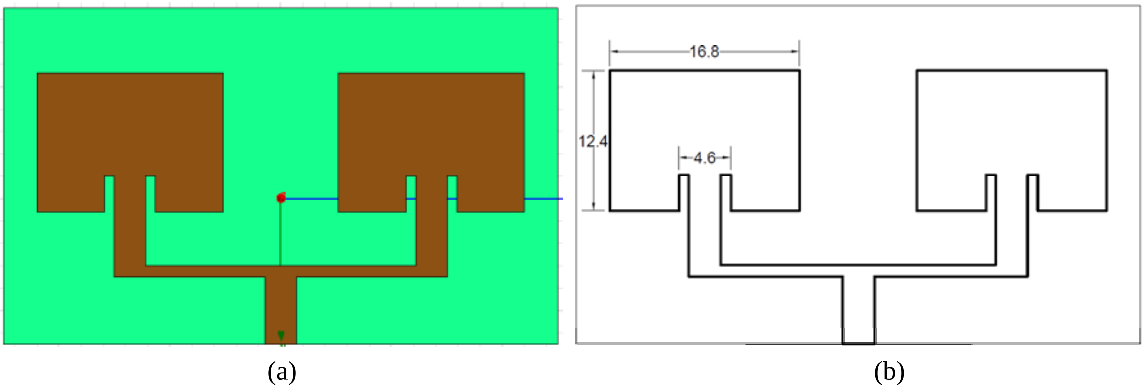


Fig. 1. 2 x 1 rectangular microstrip patch antenna array (a) HFSS, (b) AUTOCAD - all dimensions are in mm.

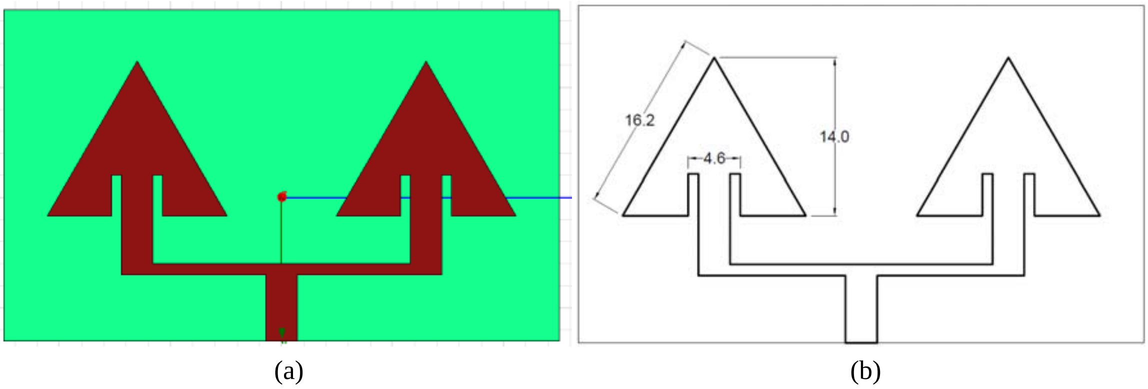


Fig. 2. 2 x 1 triangular microstrip patch antenna array (a) HFSS, (b) AUTOCAD - all dimensions are in mm.

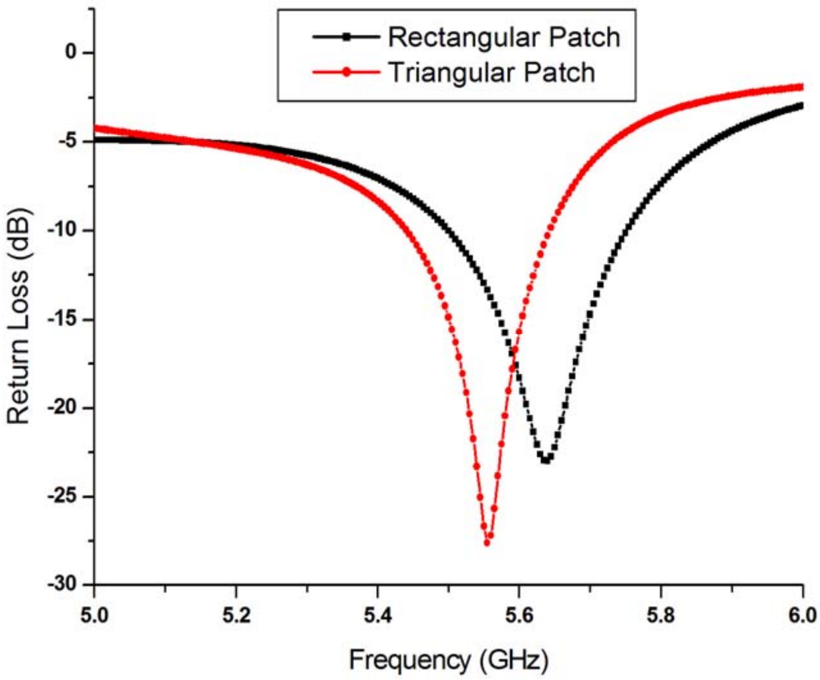


Fig. 3. Return loss for 2 x 1 rectangular and triangular microstrip patch antenna array

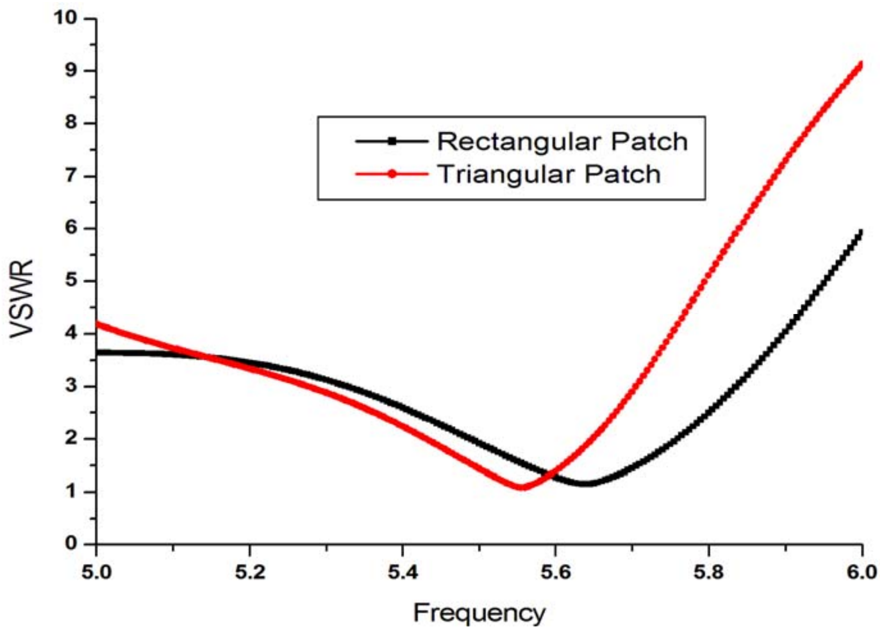


Fig. 4. VSWR for 2 x 1 rectangular and triangular microstrip patch antenna array

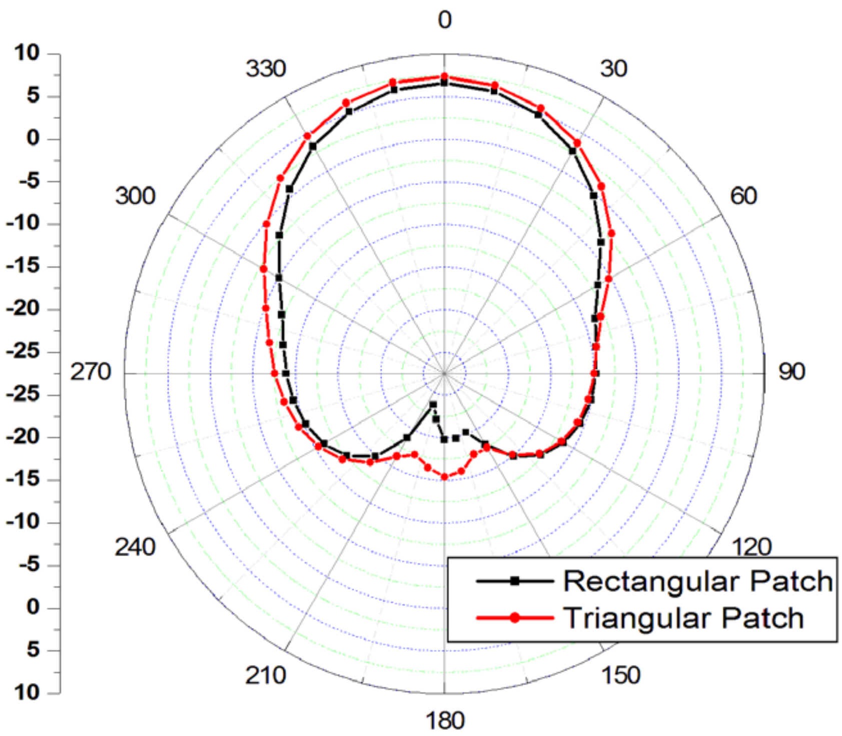


Fig. 5. Radiation pattern for 2 x 1 rectangular and triangular microstrip patch antenna array

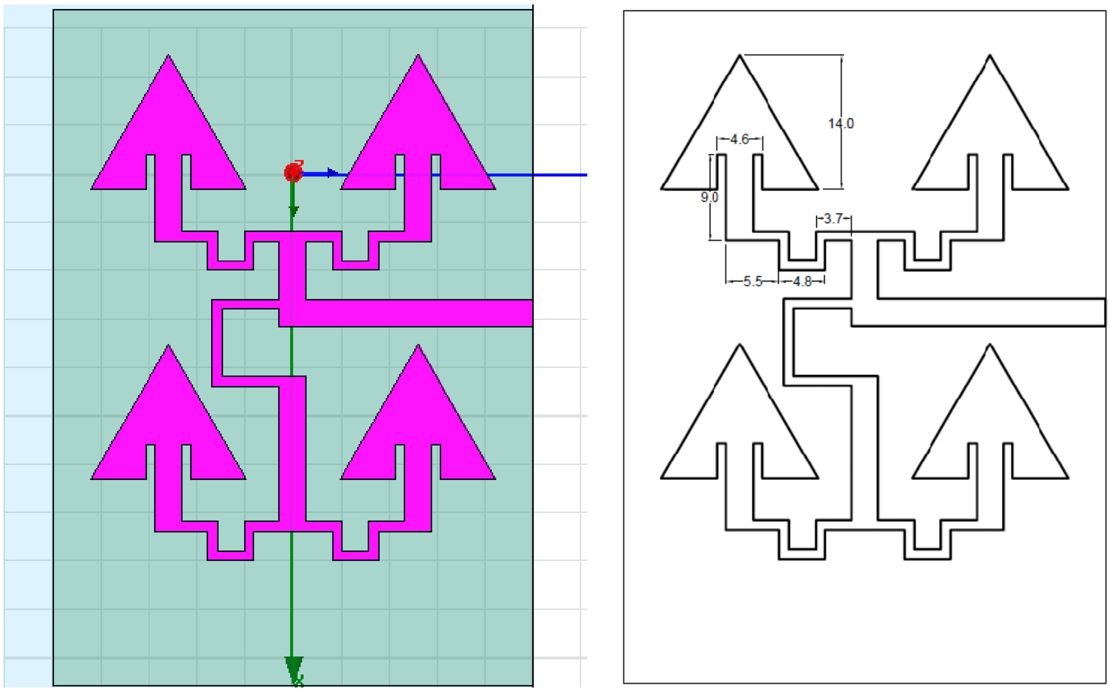
TABLE I. Comparison Of Simulation Results For 2 X 1 Rectangular And 2 X 1 Triangular Microstrip Patch Antenna Array

Parameter	**2 x 1 Rectangular MPAA**	**2 x 1 Triangular MPAA**
Frequency	5.5GHz	5.55GHz
Return Loss	- 22.99 dB	-27.61 dB
VSWR	1.15	1.08
Directivity	4.62 dB	7.35 dB
Bandwidth	250 MHz	205 MHz

Above simulation results from Table I shows return loss is -27.61 dB, bandwidth of 205 MHz and directivity 7.35 dB for 2 x 1 triangular microstrip patch antenna array which is 2.73 dB more than 2 x 1 rectangular microstrip patch antenna array. But bandwidth gets reduced by 45 MHz. To enhance directivity, four elements are positioned in an array, but it influences the bandwidth. By regulating patch antenna spacing and adjusting feed position, can achieve bandwidth. In designed array, impedance tuning configuration is used to enhance directivity without affecting bandwidth.

III.Proposed Antenna Array Design

Simple T-junction feeding configuration is used for impedance matching with quarter wave transformer. Energy gets divided into different paths by T-junction. The design of proposed 2 x 2 triangular microstrip patch antenna array is shown in Figure 6 (a) and (b).



(a) (b)

Fig. 6. 2 x 2 triangular microstrip patch antenna array (a) HFSS, (b) AUTOCAD - all dimensions are in mm.

Results shown in figure 7 and 8 are simulated return loss and VSWR which is -30.34 dB and 1.07 respectively, the bandwidth of 173 MHz. Figure 9 shows directivity of 12.91 dB for proposed 2 x 2 triangular microstrip patch antenna array with T-junction which is 5.56 dB more than 2 x 1 triangular microstrip patch antenna array. Simulation results illustrate the improvement in directivity. Figure 10 shows the E-field distribution for proposed antenna array. It shows that electric field uniformly distributed in the region of the patch.

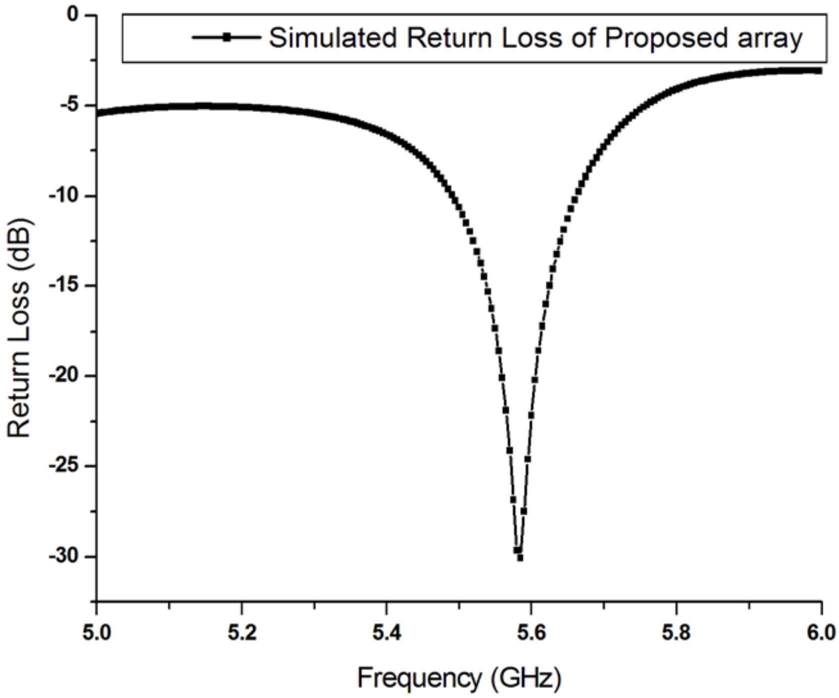


Fig. 7. Return loss for proposed 2 x 2 triangular microstrip patch antenna array

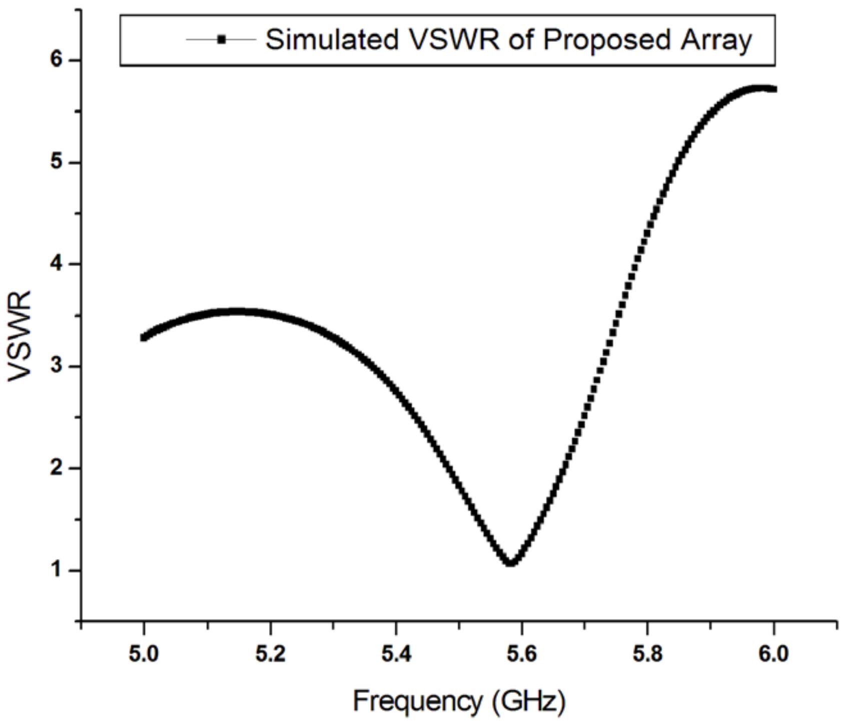


Fig. 8. VSWR for proposed 2 x 2 triangular microstrip patch antenna array

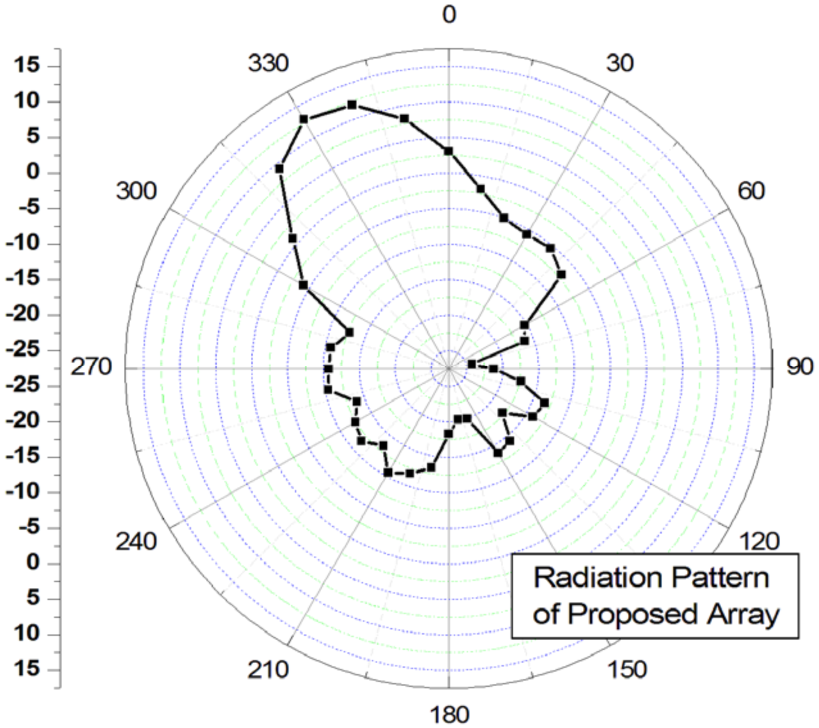


Fig.9. Radiation pattern for proposed 2 x 2 triangular microstrip patch antenna array

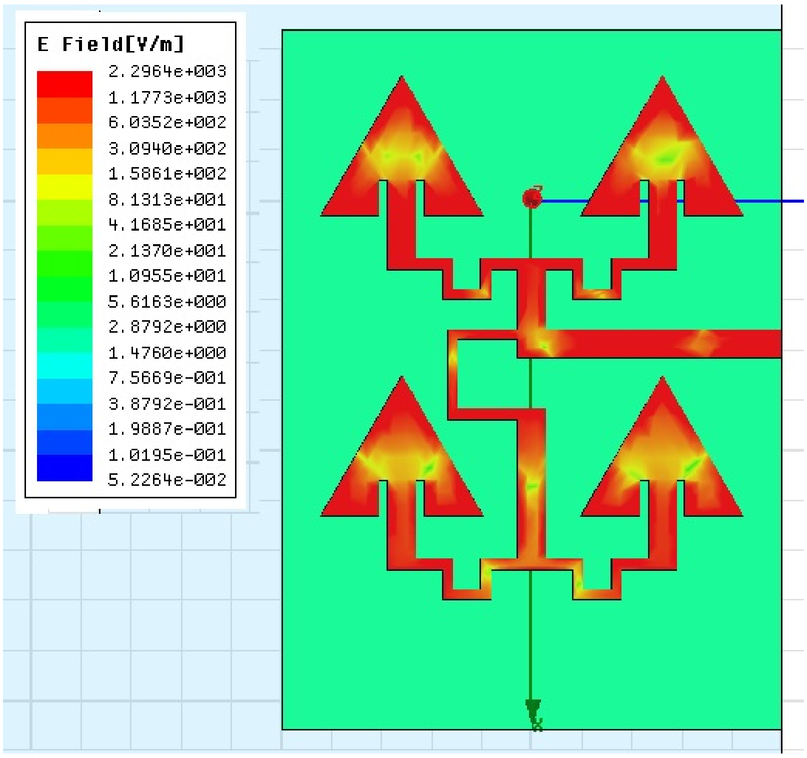


Fig.10. E-field Distribution for proposed 2 x 2 triangular microstrip patch antenna array

Figure 11 shows smith chart of proposed antenna array. Loop size is controlled by the gap between two patches [2], [12]. There is good impedance matching between patch and feed network, as smith chart arc passing very close to value1.

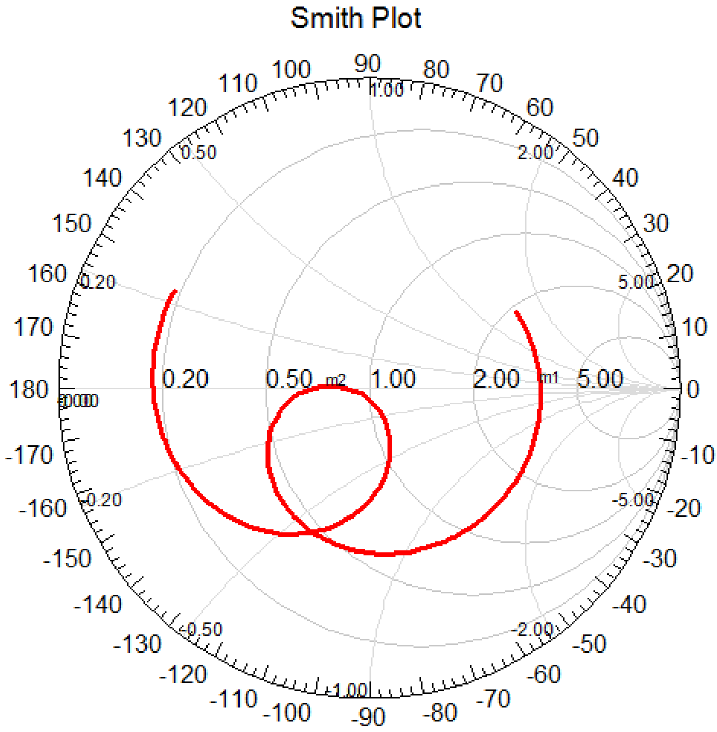


Fig. 11. Smith chart for proposed 2 x 2 triangular microstrip patch antenna array

IV. PERFORMANCE OF PROPOSED ANTENNA ARRAY

For validation of simulation results, proposed antenna is fabricated as per design specifications are illustrated in Table 2. The performance of same is tested using VNA.

Figure 12 shows fabricated designed antenna array. Return loss and VSWR of presented antenna array are measured using VNA and comparison of simulated and measured results are shown in Figure 13 (a) & (b). The measured bandwidth ranges from 5.459 GHz to 5.645 GHz with core frequency 5.58 GHz.

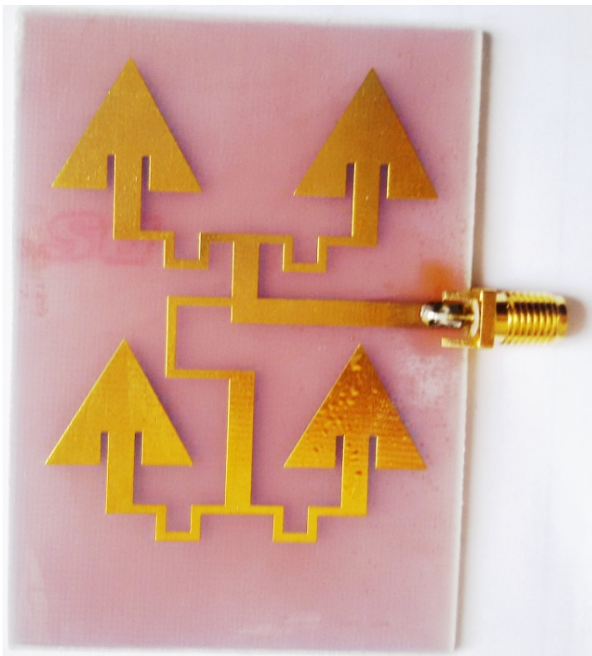
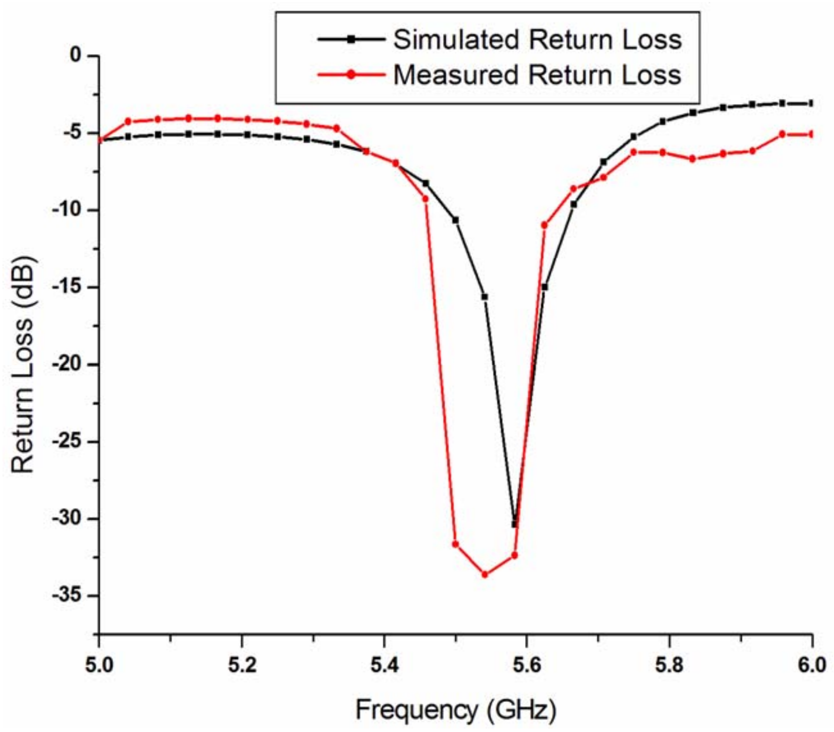
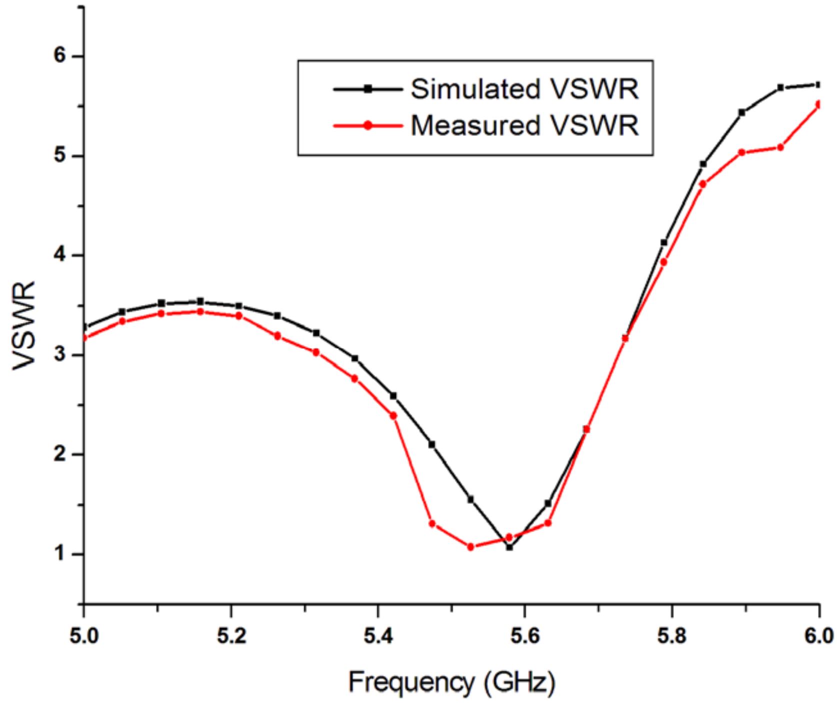


Fig.12. Fabricated proposed 2 x 2 triangular microstrip patch antenna array



(a)



(b)

Fig. 13. Comparison of Simulated and Measured (a) Return loss and (b) VSWR of proposed 2 x 2 triangular microstrip patch antenna array

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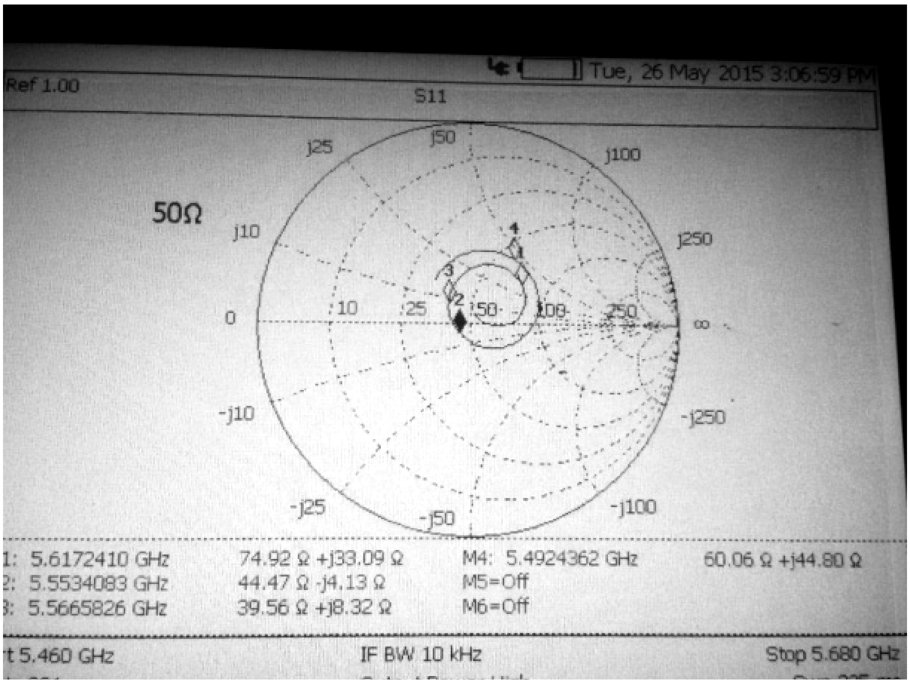

Fig. 14. Smith Chart of fabricated proposed 2 x 2 triangular microstrip patch antenna array

Smith chart of proposed antenna arrays shown in figure 14. The side length of patch determines loop position on a smith chart. The distance between two patches affects the size of the loop [2], [5], [7].

TABLE II. Parametric Analysis of Simulated and Measured Results of presented Antenna Array

Parameters	Simulated	Measured
Frequency	5.58 GHz	5.55 GHz
Return Loss	- 30.349 dB	-32.349 dB
VSWR	1.07	1.17
Bandwidth	173 MHz	186 MHz
Impedance	50.90Ω	44.47Ω

Experimental results slightly differ from simulated results due to fabrication issues as soldering, dielectric material, and loss tangent.

V. CONCLUSION

Simple 2 x 1 triangular microstrip patch antenna array and proposed 2 x 2 triangular microstrip patch antenna array using T-junction was presented. Fabrication results show little variation between resonance frequency because of variation in the ε_r of the dielectric material with a length of the material. But result shows clearly good matching and radiation characteristics.

Proposed antenna design has returned loss -30.349dB and VSWR 1.07 in the simulation. Fabricated antenna shows return loss -32.349 dB and VSWR 1.17. The directivity of proposed antenna in the simulation is 12.91 dB which is more than 5.56 dB. Measured directivity obtained for fabricated antenna array is 11.28 dB.

The geometry applied for simulation model and fabricated array with the modified feeding of T-junction gives the good performance antenna characteristics.

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