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Dual Feed E-Shaped Multiband Patch Antenna for Microwave Communication Applications

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ABSTRACT

A novel E-shaped multiband patch antenna to support multiple bands of frequencies over the range of 2-20 GHz is designed and analyzed in this paper. The proposed antenna is designed with dual feeding with 50 ohm impedance and simulated using Ansoft HFSS tool. The antenna is a modified form of the conventional E-shaped patch, used to broaden the impedance bandwidth of a basic patch antenna. By letting the two parallel slots of the E patch be unequal, asymmetry is introduced. Antenna is fabricated on FR4 substrate with dielectric constant 4. 4 and thickness 1. 6 mm. The simulated results (Ansoft HFSS) & the measured results (Network Analyzer) are compared & good agreement is observed between them.

Keywords: FR4, HFSS, Multi Band, E-Shaped Patch, Network Analyzer.

INTRODUCTION:-

Microstrip antennas have a planar profile, low cost, and mechanical robustness, while circular polarization can reduce the transmission loss caused by the misalignment between antennas of stationary and mobile terminals [1-4]. For the case of linear polarization, a number of impedance broadening techniques have been extensively investigated and developed in the past. The electric field radiated from a micro strip antenna meets a boundary between two different dielectrics: air and the substrate material. Because of the slight distortion of the field at the boundary, the patch can appear longer in an electrical sense [5-6]. Thus we have an effective patch length.

There is also an effective relative permittivity when performing micro strip antenna analysis. Transmission line method is the easiest method as compared to the rest of the methods [7-8]. This method represents the rectangular micro strip antenna as an array of two radiating slots, separated by a low impedance transmission line of certain length. The below Figure 1 shows a patch antenna from the Transmission Line Model perspective [9-10]. We can observe the fringing at the edges increasing the effective length.

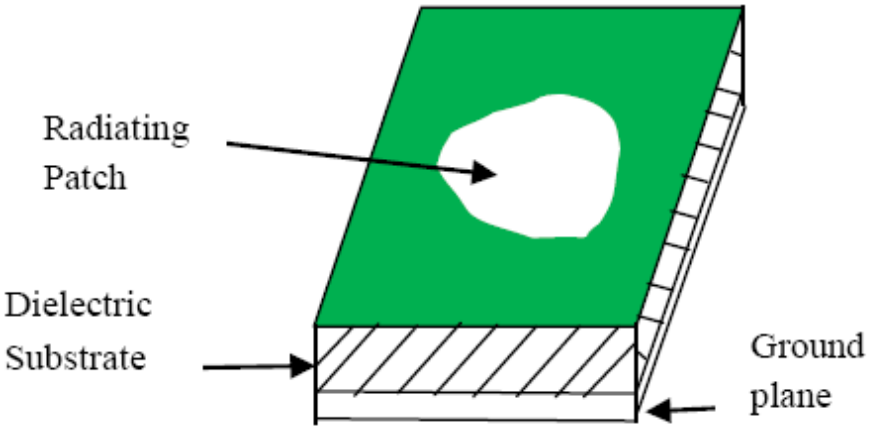


Fig 1: Microstrip antenna configuration

The antenna can be excited by using different feeding techniques like micro strip line, coaxial probe, proximity coupling & aperture coupling. Here, for the proposed antenna deigns we prefer micro strip line feeding, because it is simple for designing & fabrication. When the antenna is excited by the feed line the waves propagates in different directions.

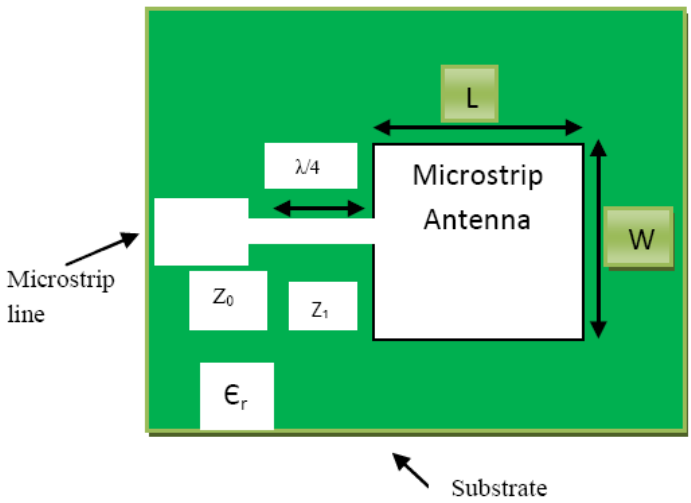


Fig:2: Microstrip Line feed configuration

The most effective technique to obtain the multiband characteristics is by cutting the slots at different positions. To reduce the size of antenna substrates are chosen with the higher value of the dielectric constant. So, here for the proposed design we choose FR4substrate (€= 4. 4). FR-4 is the primary insulating backbone for many rigid printed circuit boards (PCBs) produced. FR-4 copper-clad sheets are fabricated with circuitry interconnections etched into copper layers to produce printed circuit boards.

Antenna Design and Geometry

The model used here is the E-shaped patch antenna, to obtain the multiple band frequencies. At first we design the rectangular patch on an Fr4 substrate with a thickness of 1. 6 mm & later we move for E-shaped slot. But, in this design we had used the dual feeding to the antenna. Even though the antenna is provided with the dual feed it remains still single layered and single patch. Here, the advantage of using the dual feed antenna is to obtain dual polarisation. So, by providing feeding to the patch from two perpendicular ports we can obtain multiband & multi polarization. So, this technique is very useful for the modern wireless technology.

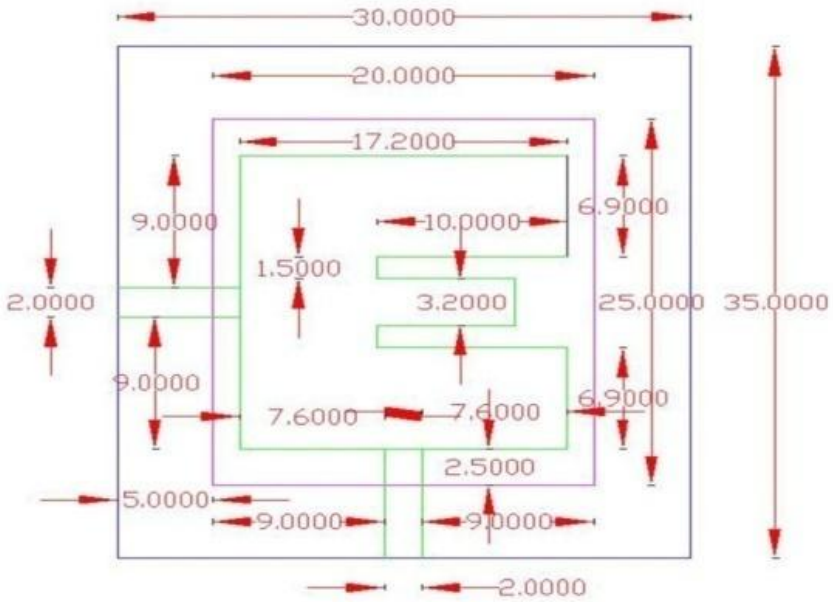


Fig 3 Antenna Geometry

The substrate is Fr4 (permittivity =4. 4) and the substrate thickness is 1. 6mm. Here, the wave port width is chosen as 2mm to provide 50ohm impedance matching with the input signal. The two wave ports are arranged in perpendicular to each other. The design is simulated using HFSS. A good antenna might have a return loss value

of-10dB as 90% of the signal is absorbed and 10% is reflected back. The proposed antenna is giving the excellent return loss curve in the specified frequency range.

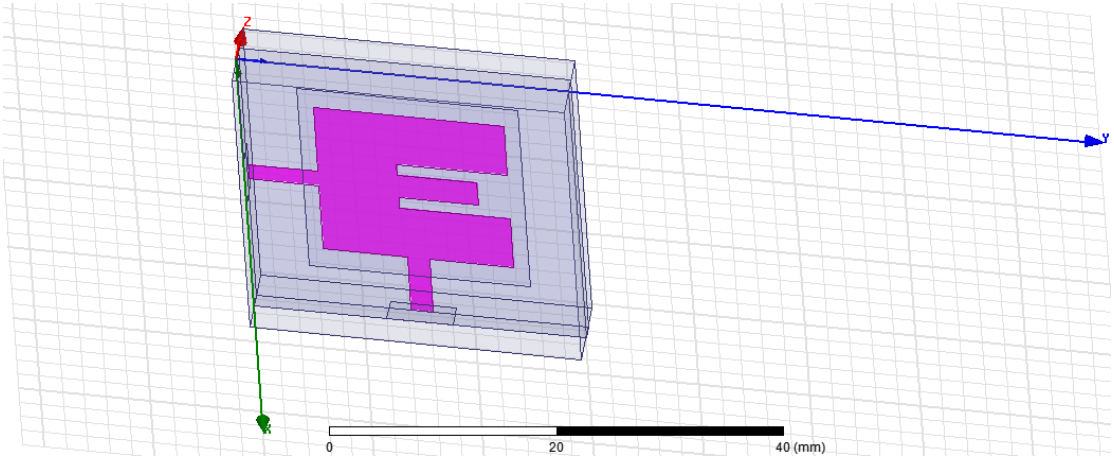


Fig. 4. Design model of proposed antenna in HFSS

The simulated S-Parameters results obtained are shown below. The input impedance at the feed of the antenna is

$$Z = R+jX = \frac{V}{I} = \frac{-E_{avt}}{I}.$$

Where E_{av} is the average value of the electric field at the feed point and I is the total current. The input impedance is complex and involves a resistive and reactive part. The resistive and reactive components vary as a function of frequency and are symmetric around the resonant frequency.

The band width of an antenna is the range of frequencies within which the performance of the antenna with respect to some characteristic conforms to a specified standard. If the antenna impedance is matched to the transmission line at resonance, the mismatch off resonance is related to the voltage standing wave ratio. The value of VSWR which can be tolerated then defines the bandwidth of the antenna. If this value is less than s, the usable bandwidth of the antenna is related to the total Q-factor by

$$B = \frac{1}{Q}\frac{S-1}{\sqrt{S}} = \frac{VSWR-1}{\sqrt{VSWR}.Q_T}$$

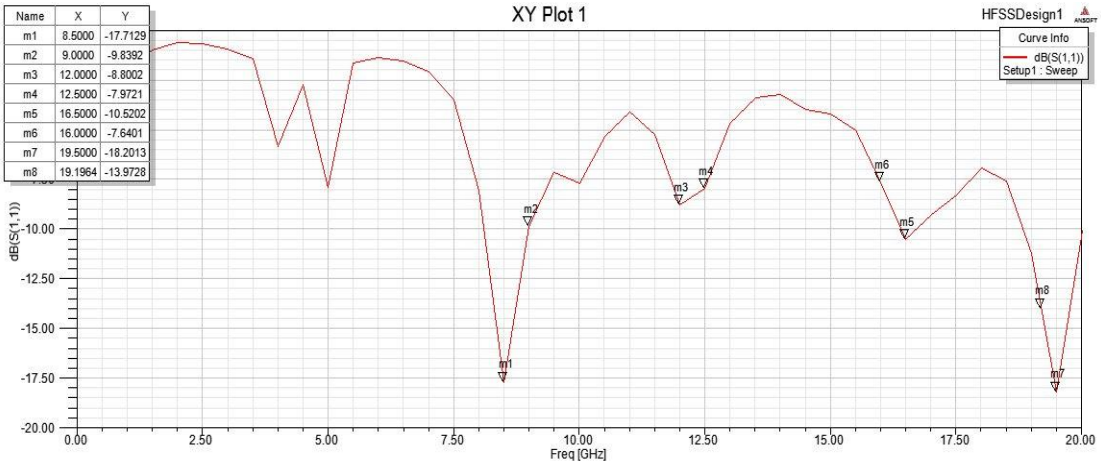


Fig. 5:S11 plot of E-Shaped Patch Antenna

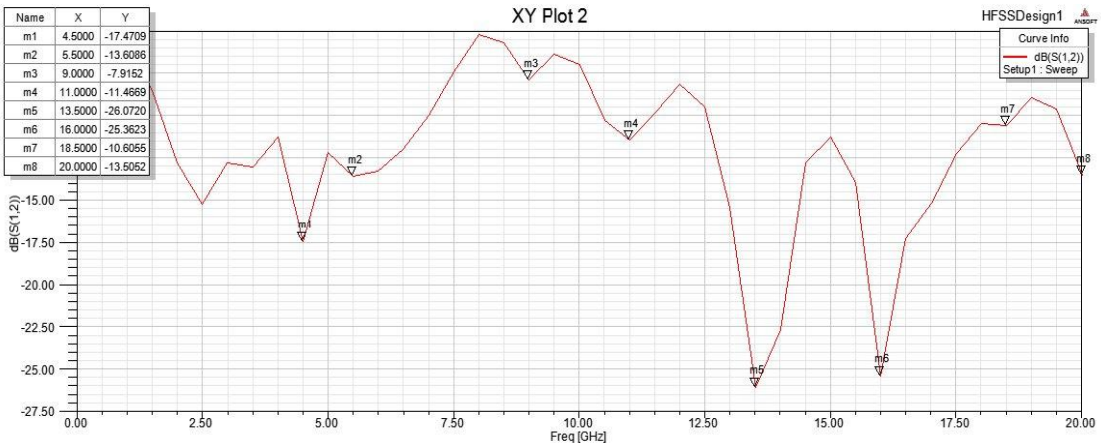


Fig. 6:S12 curve of E-Shaped Patch Antenna

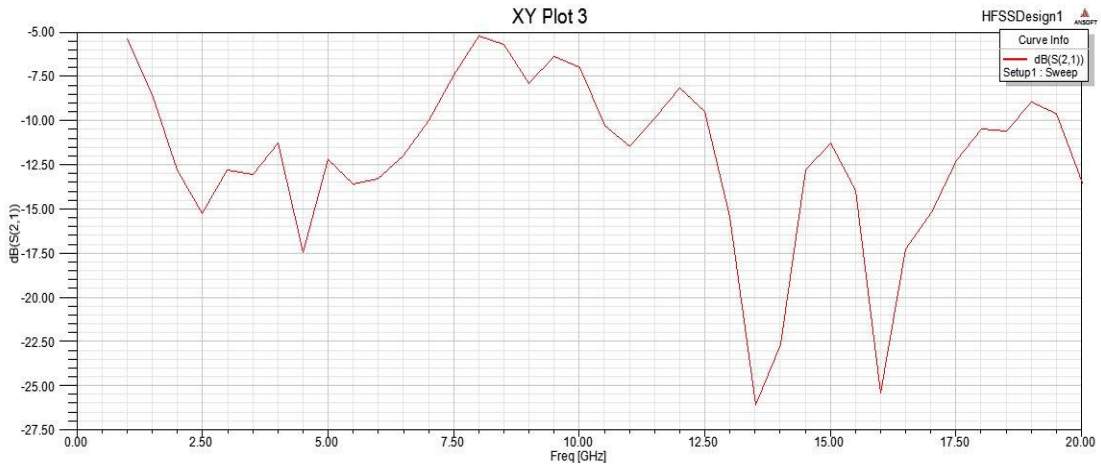


Fig. 7:S21 plot of E-Shaped Patch Antenna

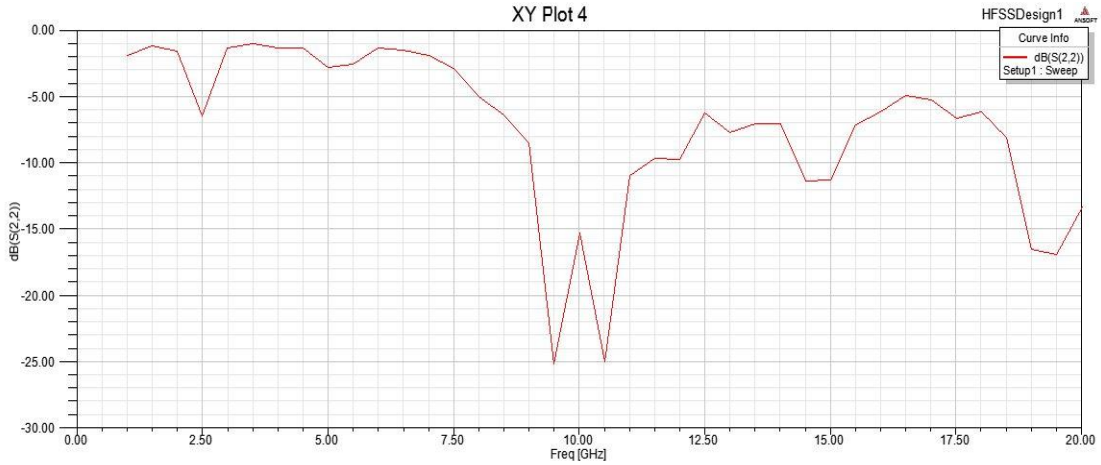
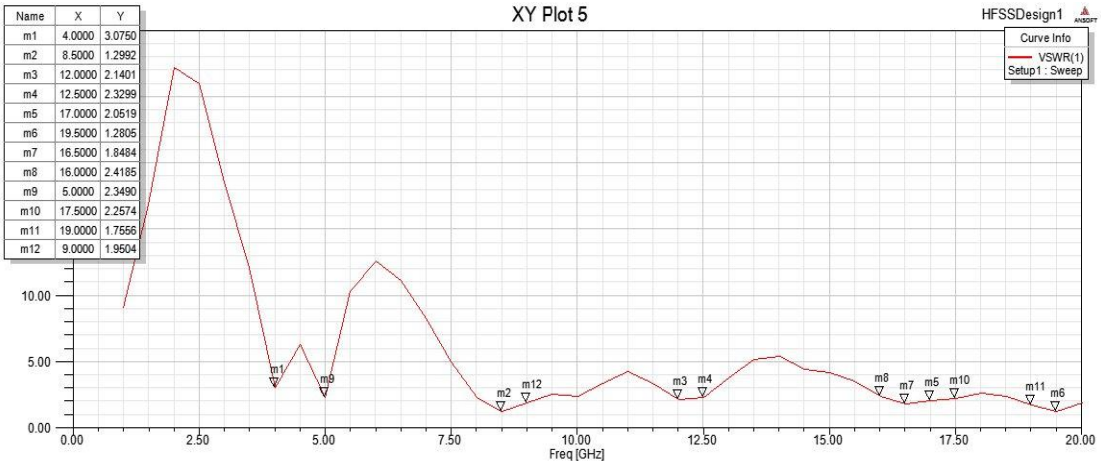


Fig. 8:S22 plot of E-Shaped Patch Antenna



Name	X	Y
m1	4.0000	3.0750
m2	8.5000	1.2992
m3	12.0000	2.1401
m4	12.5000	2.3299
m5	17.0000	2.0519
m6	19.5000	1.2805
m7	16.5000	1.8484
m8	16.0000	2.4185
m9	5.0000	2.3490
m10	17.5000	2.2574
m11	19.0000	1.7556
m12	9.0000	1.9504

Fig. 9: VSWR plot of E-Shaped Patch Antenna

The S-parameters are calculated. The antenna supports eight band of frequencies i. e. at 5Ghz, 8. 5Ghz, 9. 1Ghz, 12Ghz, 16Ghz, 19Ghz. The frequencies which have a low return loss and the VSWR in the range between 2:1 is chosen. The Radiation Patterns for the proposed design are shown below. For each mode, there are two orthogonal planes in the far field region. One designated as E-plane and the other designated as H-plane. The far zone electric field lies in the E-plane and the far zone magnetic field lies in the H-plane. The patterns in these planes are referred to as the E and H plane patterns respectively.

For the TM_{01} mode, the contributions to the far fields are from the magnetic surface current densities on the side walls containing the radiating edges. The directions of the magnetic currents that the E-plane is the y-z plane (Φ=90º) and the H-plane is the x-z plane (Φ=0º). For the TM_{10} mode, the E-plane is the x-z plane (Φ=0º) and the H-plane is the y-z plane (Φ=90º)

$$E_\theta(r,\theta,\phi) = -2wh\left(\frac{E_0}{\eta_0}\right)\cos\phi(1-T^{TM}(\theta))\cos\left(k_x\frac{L}{2}\right)\sin c\left(k_y\frac{w}{2}\right)\tan c(k_{z1}h)$$

$$E_\phi(r,\theta,\phi) = 2wh\left(\frac{E_0}{\eta_0}\right)(\cos\theta\sin\phi)(1-T^{TE}(\theta))\cos\left(k_x\frac{L}{2}\right)\sin c\left(k_y\frac{w}{2}\right)\tan c(k_{z1}h)$$

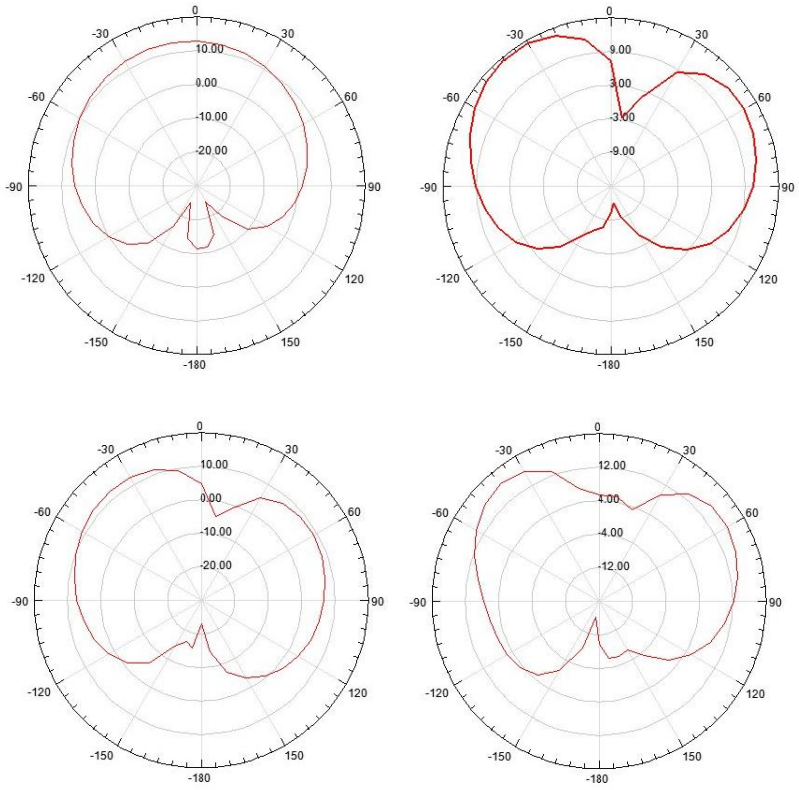


Fig 10. Antenna Radiation Pattern at different resonant frequencies

The 3 dimensional polar plots of the proposed design at resonant frequencies are shown below

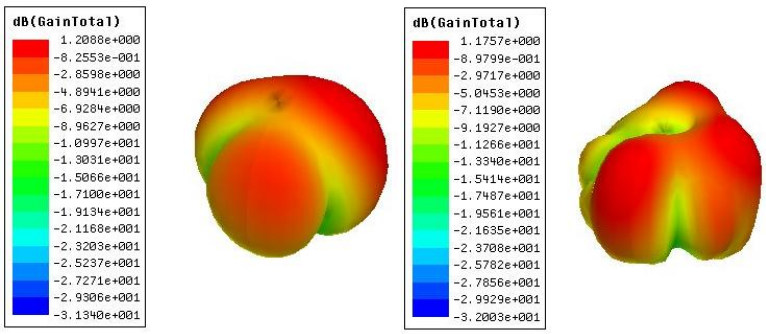


Fig 11. 3D Radiation Pattern of the E-shaped patch antenna

The proposed E-Shaped Micro strip antenna design is fabricated using photolithographic process. The Photo of the fabricated antenna is shown below

Fig. 12 Photo of fabricated antenna

The antenna is tested using Network Analyser & the measured results are obtained.

Fig. 13 Photo of fabricated antenna testing using Network analyser

The practical results obtained (using Network Analyser) are shown below.

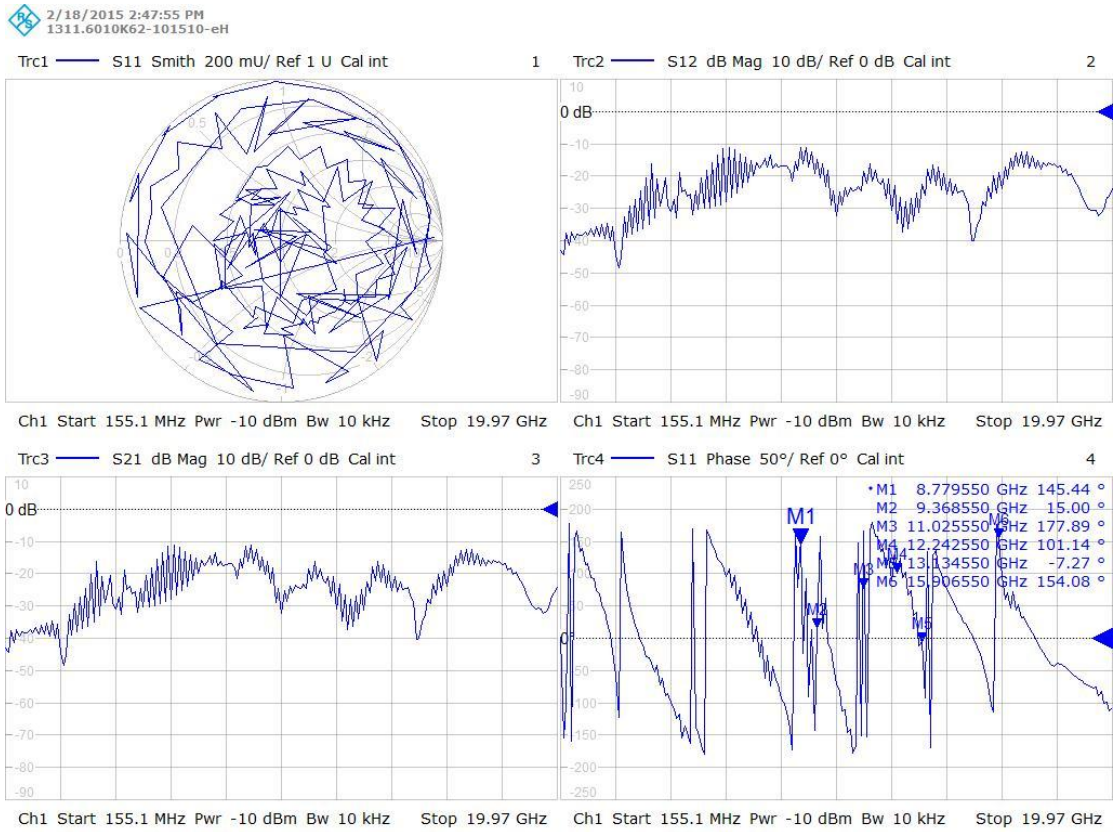


Fig 14. Measured Results

The practical Results are observed. All the S-matrix parameters are observed both theoretically & practically. The antenna supports six bands of frequencies. The frequencies observed practically are at 8. 7Ghz, 9. 3Ghz, 11. 02 Ghz, 12. 24Ghz, 13. 13Ghz, 15. 95Ghz.

Conclusion:

The patch antenna that supports multiple frequencies which comes under the category of different wireless applications is designed. The model explained in this paper supports six frequency bands. These antenna models designed & fabricated on FR4 substrate with a less cost are very useful for the modern wireless communication industry. The simulated Results and the measured results are observed a good agreement observed between them.

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