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Isolation Improvement in MIMO Antenna using Fractal slots for C & X – Band Applications

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Abstract: A microstrip two port Multiple Input Multiple Output (MIMO) antenna has been designed for C- and X- band applications covering multiple resonances. In this work, partial stepped defected ground has been used to enhance the gain and bandwidth values. These antennas are with a size of 80mm x 40mm x 1.6mm. Corresponding impedance bandwidths are 110MHz, 200MHz, 210MHz, 340MHz, 710MHz and 570MHz at six operating bands of proposed design such as 4.64 – 4.75GHz, 5.84 – 6.04GHz, 9.09 – 9.30GHz, 10.06 – 10.40GHz, 11.12 – 11.83GHz and 13.11 – 13.68GHz respectively. In this paper, the error correlation coefficient (ECC) is less than 0.02 and corresponding diversity gain (DG) values are approximately equals to 10dB. The channel capacity loss (CCL) for MIMO satisfies less than 0.4bits/S/Hz. The proposed structure has been simulated using HFSS software. The parameters of proposed antenna like return loss, radiation pattern; ECC, DG, TARC and CCL are optimized within the bandwidth.

Index Terms **- MIMO, Fractal slots, Multiple resonances, Isolation, ECC, DG, TARC, CCL, MEG, C & X – band Applications**

I. INTRODUCTION

With the adverse development in the communication system there is a huge increase in the cellular communication for this purpose there is a huge demand for the wireless communication. For this purpose, there is a huge demand for long distance communication for this purpose MIMO is the one of the alternatives as it is a Multiple Input Multiple Output. In MIMO it treats the propagation as the multipath and in this the transmission and reception of the signal simultaneously at the same time. By transmitting the streams of data in two or more with the same range in the bandwidth it multiplies the information by the number of streams used in. In the reception part it receives each stream in the identical chains of antenna. The receivers are known that phase offsets of own antenna and it reconstructs its original. It has higher data rate and the reliability is higher without requiring any extra power and the bandwidth. By using the diversity technique, it produces reliability high and by using spatial multiplexing technique it produces high data rate. So, from all the information the MIMO antenna was used in this.

In this paper a MIMO antenna was designed [1] with the size of the antenna as 80 x 120 x 0.76mm^3, with the 2-element dual ultra-wideband with the loop excitation and the defected ground. In this proposed design [2] MIMO was and the isolation is -30 dB in which both the FSS and the slots are used to reduce the radiation in the free space. In this paper [3] in MIMO array antennas from the parameters of scattering calculations for the envelope correlation between two receivers or the transmitter antennas was discussed. In this antenna design [4] MIMO antenna was designed for the mobile terminals of the parasitic elements for reducing the mutual coupling and the channel capacity is a good candidate. In this paper [5] a MIMO antenna with dual band with inverted F shape for the purpose of the WLAN applications high isolation was achieved by building a decoupling structure. In this paper [6] history of MIMO and the techniques used for enabling the next generation standards. In this paper [7] for the purpose of GSM, DCS, and Indoor LTE applications a MIMO antenna was designed which multiband to cancel reactive is coupling neutralizing line is connected. In this paper [8] for the improved performance of MIMO channel capacity MIMO meandered monopole antennas was designed which are operating at LTE 700MHZ band. In this paper [9] an UWB MIMO antenna was designed with a wideband neutralization line for the mutual coupling reduction. In this proposed design [10] compact MIMO antenna was designed which is portable to increase the isolation and bandwidth two long protruding ground stubs are added. In this paper [11] UWB MIMO antenna was designed in this to enhance the isolation achieved through a tree like structure on the ground. In this proposed it is an investigation on the UWB MIMO in the communication system [12] depends up on the channel characterization experimental and measured. In this design [13] a compact MIMO antenna was designed for the applications of the portable UWB systems and characteristics of WLAN band notch a long rectangular strip is protruded to increase the impedance bandwidth and reduce the mutual coupling.

In this paper, FR – 4 materials chosen for antenna design and its thickness is 1.6mm. MIMO antenna is loaded with fractal slots in radiating element and to enhance the gain characteristics, stepped ground is added to this structure. The remaining discussion can be organized into antenna design in section 2, results and discussion of designed antenna in section 3 and finally section 4 ends with conclusion.

II. PROPOSED MIMO ANTENNA DESIGN WITH STEPPED DEFECTED GROUND STRUCTURE (DGS)

Proposed antenna has been designed on FR – epoxy glassy material having dielectric constant of 4.4, loss tangent 0.002 and its thickness is 1.6mm.Proposal antenna is three layer structures – patch, substrate and ground. Patch element is printed on one side substrate material and other side is loaded with stepped defected ground structure (DGS). This radiating element is fed by 50 ohm transmission line feed width 3.5mm. Detailed view of structure analysis is shown in figure 2. Figure 2(a) shows the top view of proposed single patch, figure 2(b) shows the enlarged view of slot etched in the patch and figure 2(c) shows the stepped defected ground structure. Table 1 represents the geometrical parameters noted on proposal views. This proposed design has been simulated and analyzed using Electromagnetic (EM) computational High Frequency Structure Simulator (HFSS) tool.

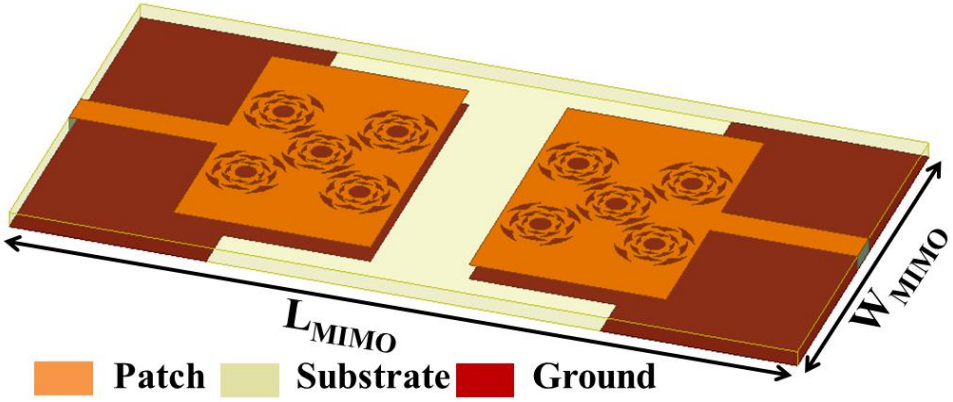


Fig 1. Proposed MIMO antenna design

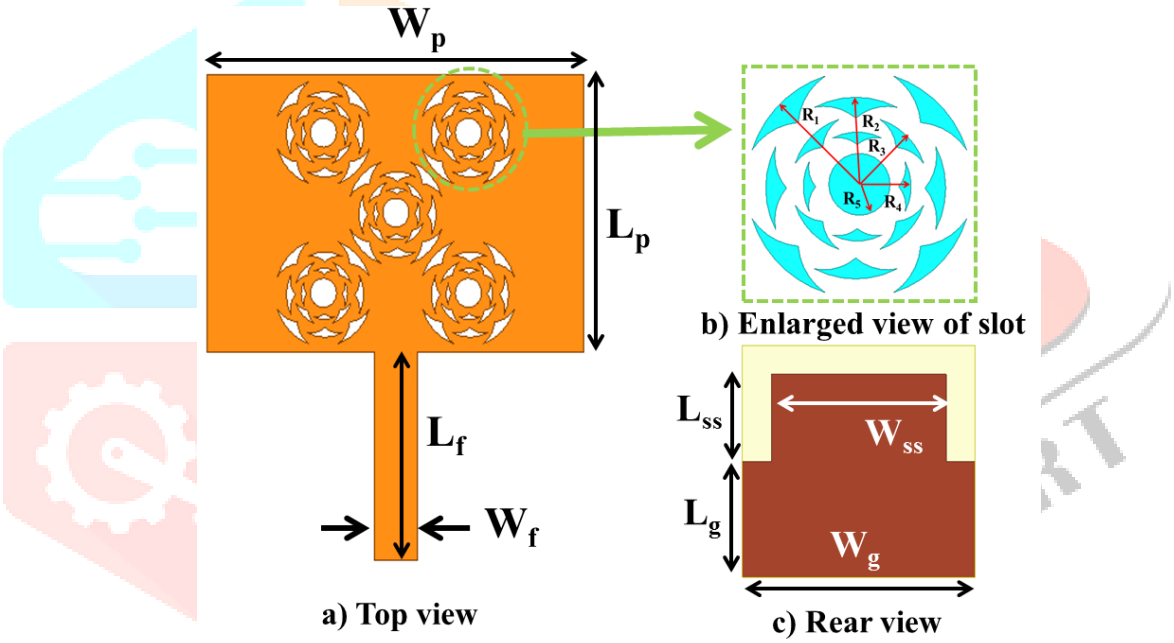


Fig 2. Geometrical representation of single element proposal design with stepped partial ground

Table 1. Geometrical parameters of proposed design (All parameters are measured in mm)

L_{MIMO}	W_{MIMO}	L_p	W_p	L_f	W_f	L_{ss}	W_{ss}
80	40	20	30	15	3.5	15	30
L_g	W_g	R_1	R_2	R_3	R_4	R_5	
20	40	3.85	3.08	2.31	1.85	1.05	

III. RESULTS AND DISCUSSION

In this section, performance of proposed antenna design has been computed and analyzed interms of S – parameters such as reflection coefficient (S11), insertion loss (S12), Voltage standing wave ratio (VSWR), group delay and radiation pattern. Multiple Input Multiple Output (MIMO) antenna characterized interms of envelope correlation coefficient (ECC), diversity gain (DG), total active reflection coefficient (TARC), channel capacity loss (CCL) and Mean effective gain (MEG).

3.1 Electrical characteristics of proposed antenna design

Reflection coefficient characteristics of proposed antenna are represented in figure 3. Due to the fractal slots etched on patch element, this proposed antenna achieves multiple resonances. Resonant frequencies of proposed design are 4.69GHz, 5.95GHz, 9.22GHz, 10.24GHz, 11.50GHz and 13.42GHz. Corresponding impedance bandwidths are 110MHz, 200MHz, 210MHz, 340MHz, 710MHz and 570MHz at six operating bands of proposed design such as 4.64 – 4.75GHz, 5.84 – 6.04GHz, 9.09 – 9.30GHz, 10.06 – 10.40GHz, 11.12 – 11.83GHz and 13.11 – 13.68GHz respectively. Reflection coefficients at resonant frequencies are -14.80dB, -15.69dB, -12.35dB, -13.44dB, -22.15dB and -12.27dB respectively. Figure 4 shows the insertion loss characteristics of proposed antenna design. From figure 4, we observe that the mutual coupling between two antenna elements is good, it's total spectrum is less than -20dB.

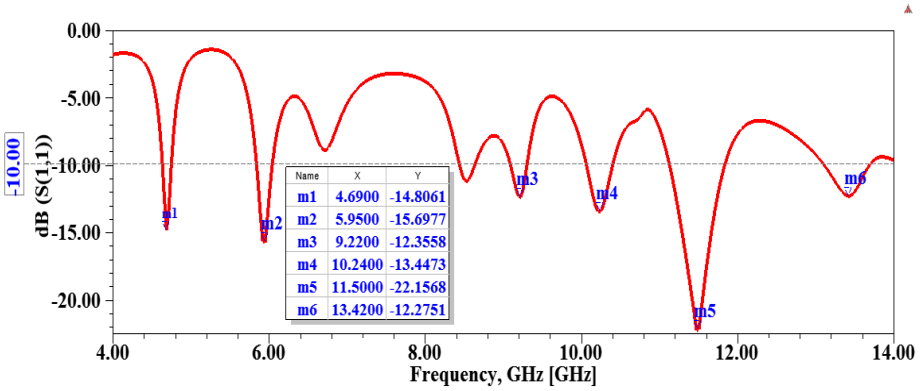


Fig 3. Reflection coefficient characteristics of proposed MIMO antenna design

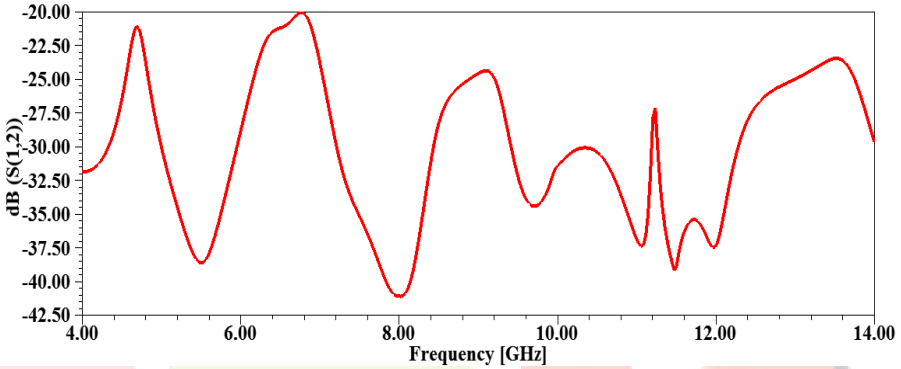


Fig 4. Insertion loss characteristics of proposed MIMO antenna design

Figure 5 shows the VSWR characteristics of proposed two element MIMO antenna with stepped partial ground. This plot signifies that the impedance matching condition at resonant frequencies. Obtained VSWR values at resonant frequencies are 1.44, 1.39, 1.63, 1.54, 1.16 and 1.64 respectively. Figure 6 shows the group delay plot of suggested antenna design.

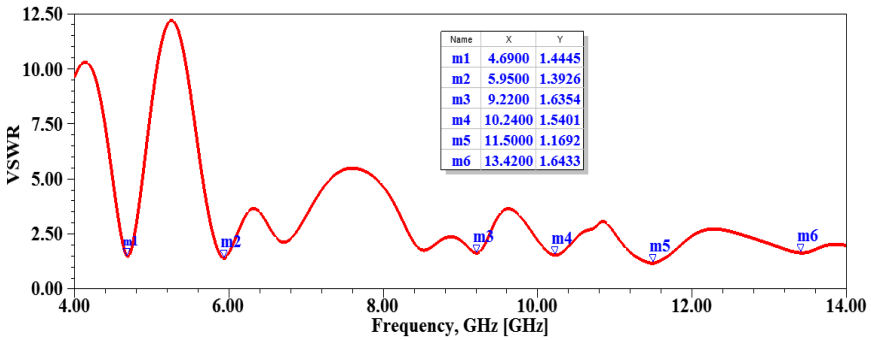


Fig 5. VSWR characteristics of proposed MIMO antenna with partial ground

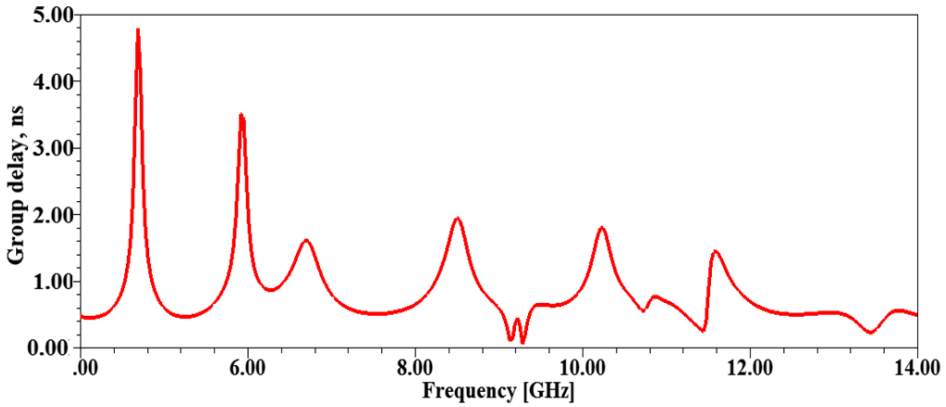
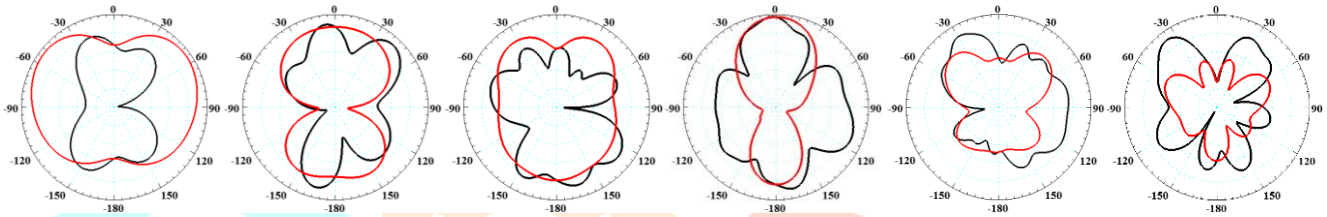


Fig 6. Group delay plot of proposed MIMO antenna with stepped DGS

3.2 Far - field characteristics of proposed antenna design

Another important parameter in the antenna design is realized peak gain. Gain values achieved at resonant frequencies are 1.28dBi, 1.78dBi, 3.41dBi, 4.37dBi, 3.98dBi and 4.29dBi respectively. Figure 7 shows the radiation pattern representation of suggested antenna at resonant frequencies. Red colour plot in characteristic demonstrates elevation plane (E - plane) and black colour plot in characteristic suggests azimuthal plane (H - plane).



(a) 4.69GHz (b) 5.95GHz (c) 9.22GHz (d) 10.24GHz (e) 11.50GHz (f) 13.42GHz

Fig 7. Elevation and Azimuthal plane characteristics of designed two element MIMO antenna with partial stepped DGS

3.3 MIMO Antenna characteristics

3.3.1 Envelope Correlation Coefficient (ECC)

The mutual coupling between two antennas can be determined with a parameter of error correlation coefficient (ECC). The ideal value of ECC is 0 but practically it is acceptable value is 0.5 for uncorrelated MIMO antennas [14]. Figure 8 shows the envelope correlation characteristics of designed MIMO antenna with partial ground.

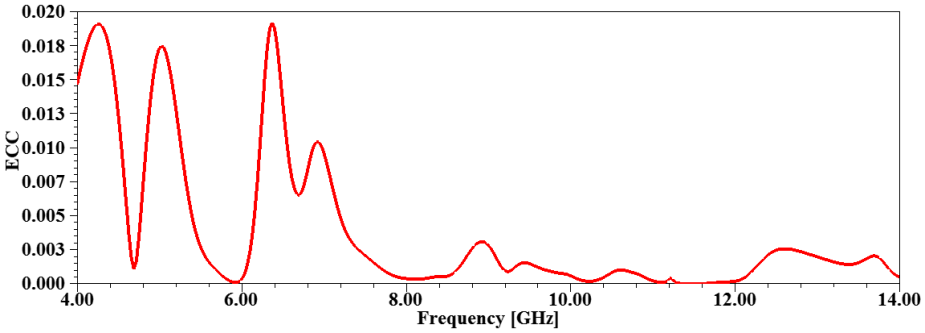


Fig 8. ECC characteristics of proposed MIMO antenna

3.3.2 Diversity Gain (DG)

Figure 9 shows represents the Diversity gain characteristics of suggested two element multiple input multiple output (MIMO) antenna with partial ground designed of approximately 10dB over all frequency ranges on FR – 4 epoxy substrate material having dielectric constant of 4.4.

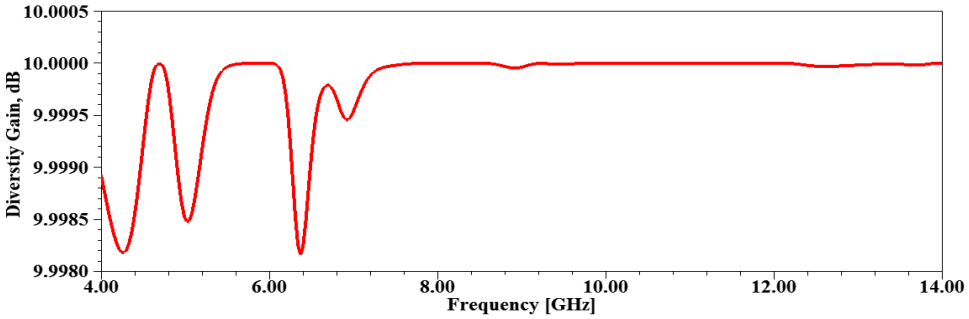


Fig 9. Diversity plot of proposed antenna

3.3.3 Total Active Reflection Coefficient (TARC)

One more parameter consider in the MIMO antennas is total active reflection coefficient (TARC). It is defined as square root of ratio of reflected power to accepted power [14]. Figure 10 shows the TARC characteristics of MIMO antenna.

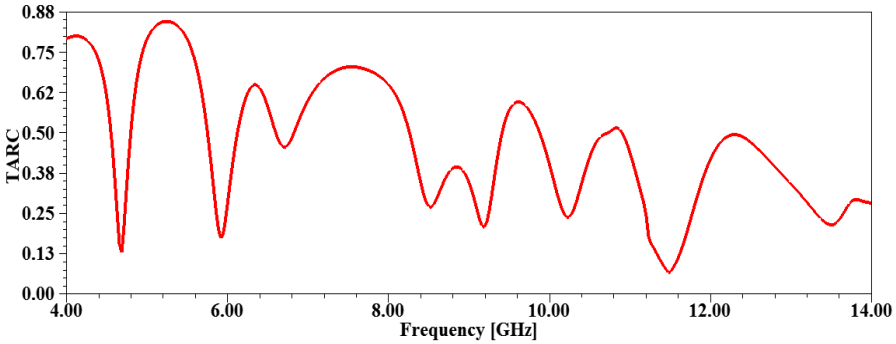


Fig 10. TARC characteristics of designed MIMO antenna

3.3.4 Channel Capacity Loss (CCL)

Figure 11 shows the Channel capacity loss (CCL) of MIMO antennas. The proposed antenna obtains acceptable values (ideally CCL values should be less than 0.4 bits/S/Hz in the operating band) [14].

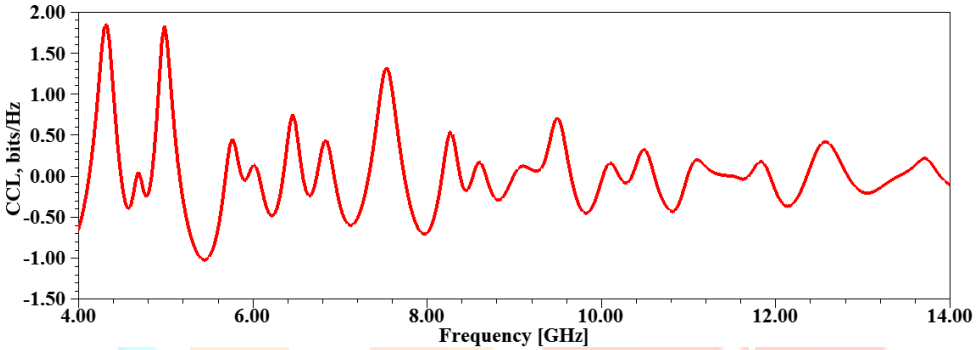


Fig 11. Channel capacity loss plot of proposed antenna with partial ground

3.3.5 Mean Effective Gain (MEG)

Mean effective gain characteristics of proposed MIMO antenna with partial ground. Ideal values of MIMO antenna are -3dB ≤ MEG ≤ -12dB. From figure 12, observe that at all resonant frequencies obtained are in the limited range.

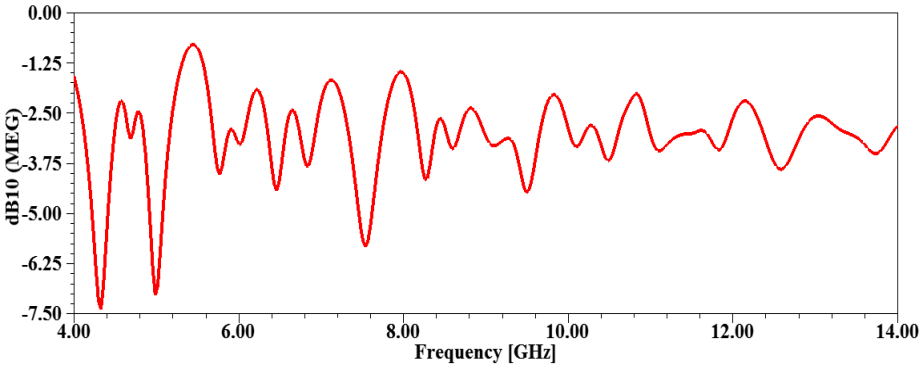


Fig 12. Mean effective gain characteristics of proposed MIMO antenna design

IV. CONCLUSION

In this paper, a two element MIMO antenna with stepped ground structure has been designed and simulated on FR – 4 material within compact size of 80mm x 40mm. Multiple resonances are obtained at 4.69GHz, 5.95GHz, 9.22GHz, 10.24GHz, 11.50GHz and 13.42GHz due to the fractal slots etched in the radiating element of proposed design. Mutual coupling between two antennas is less than -20dB, which signifies that there is no deviation in between performance of two antennas. MIMO antenna parameters such as ECC, DG, TARC, CCL and MEG are illustrated in this paper. These characteristics shows the good agreement between two elements that's why it is well suitable for C – band (4 – 8GHz) and X – band (8 - 12) applications.

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