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CPW Feed Flag shaped Array Antenna on Common Ground for UWB MIMO and IOT Applications

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Abstract: *An UWB MIMO (Multi Input Multi Output) antenna with two notch bands suitable for IOT (Internet of Things) applications is designed in HFSS simulation software and obtained results are presented. To enhance isolation between two CPW feed flag shaped patch antennas etched on common ground is provided with two SRRs (split ring resonators) on either side of feed line, contains a gap between feed line edge to SRR edge of 0.5mm. SRRs also responsible for formation of two notch bands first one is from 5GHz to 8GHz(C-Band) and second one is from 10.4GHz to 10.7GHz (X-Band). Constant peak gain of 4.2dB and radiation efficiency of 89% is maintained throughout the UWB region. Finally simulated results are compared with experimental results, which proves that MIMO diversity antenna is best suitable for IOT applications.*

Index Terms: *Ultra-wide band antenna (UWB), MIMO antenna.*

I. INTRODUCTION

Most of wireless communication systems adopted nowadays suffering from non line of sight, multi path signal fading problems, which effects the communication link results poor signal reception. MIMO antenna technology is showing solution and minimizing above problems by enhancing system capacity.

The improvement in usage of smart devices and also connected IOT devices demanding a compact printed antennas. However, due to issue of space in portable devices accommodation of number of antennas is a challenging task. Also multiple operating frequencies, Power supply to feeds ports of multiple antennas cause electromagnetic interference (EMI) results mutual coupling between devices. So it is very much essential to design an efficient MIMO antenna with less separation and minimal mutual coupling, and also transfer 7.4GHz of data (within the range of 3-10GHz) with very less power[2-6]. In [7,8], some designs suitable for IoT applications are specified which including sensor-based information gathering, remote wireless communication, control system etc. These applications uses RF (radio frequency) waves for short distance communication with high transmission capacity. Various UWB antennas are reported in [9-12]. A hexagon-like MIMO antenna with UWB range of 3GHz-11GHz and ports isolation of 20dB is presented in[9].

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A-shaped dielectric resonator MIMO antenna with UWB of 3.24GHz to 6GHz and port isolation of greater than 20dB is presented in [10-12]. To reduce EMI in UWB range as per the standards of wireless communication. MIMO antenna with notch band characteristics is proposed. In [13] two port MIMO antenna with dual notch characteristics is proposed. Single notch UWB MIMO antenna is proposed in [14-18].

Moreover, for the profitable usage of MIMO technology in the design of antennas, the mutual coupling, envelope correlation coefficient (ECC) and losses in the channels should to be less with large amount of isolation among the radiating elements.

LP	**WP**	**LF**	**WF**	**LG1**	**LG2**	**WG1**	**WG2**	**W**
8.95	**6.4**	**14**	**1.2**	**10.5**	**1**	**7**	**2**	**0.8**
L	**L1**	**W1**	**L2**	**W2**	**W3**	**W4**	**W5**	**-**
0.5	**2**	**1.6**	**3**	**0.5**	**0.4**	**0.5**	**0.8**	**-**

Table 1: Parameters of proposed UWB antenna (mm).

II. ANTENNA DESIGN

Propose antenna has 32mm × 24 mm × 0.8mm dimensions, printed on on FR-4 epoxy substrate material. It required an antenna to operate at frequency of wireless network within UWB range, so SRRs are added on the patch ground to notch band of frequencies in some regions so that required bands for IoT applications can achieve. This avoids EMI during working and consumes less power with higher data rates. .

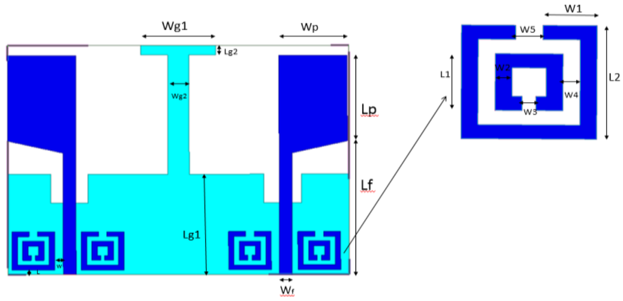

Fig. 1 Geometry of the proposed antenna (top side, bottom side)

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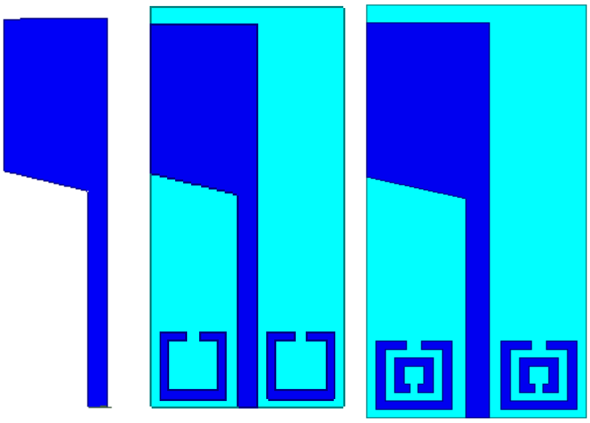
A. Design procedure

Proposed structures is modeled and simulated in HFSS. The complete architecture is implemented in three iterations.



(a) (b) (b)

Fig. 2 Antenna iterations.
[a] First iteration; [b]Second iteration;

Monopole flag shaped antenna is designed during first iteration. Single SRR is added on either side to feed line initially, later double SRR is added during second iteration. In third iteration, ground is attached and T shaped stub is joined to ground to improve isolation.

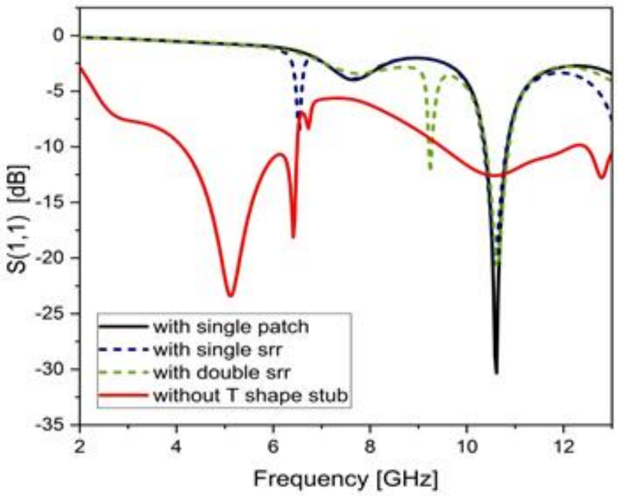


Fig. 3 Simulated return loss characteristics of proposed antenna at all three iterations.

Third iteration is shown in Fig 4(b), where T shaped stub is joined to ground and also ground plane is etched by a small amount of ground underneath the patch feed, which enhances the isolation between two ports.

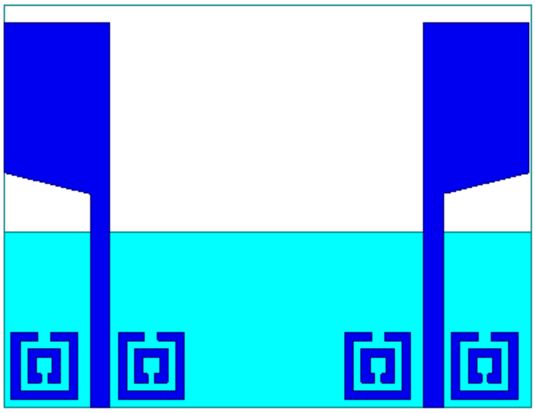


Fig. 4(a) Proposed antenna absence of T stub.

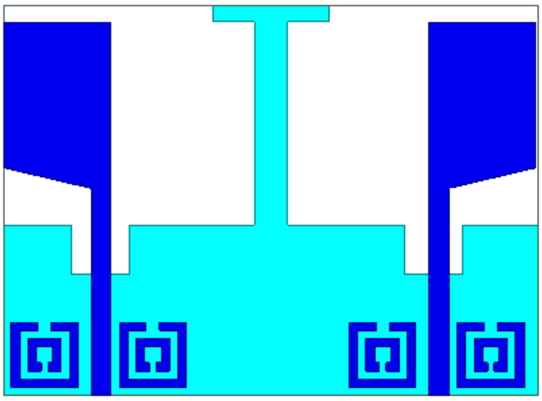


Fig. 4(b) Proposed antenna with T stub. (Third iteration).

B. T-Shaped ground stub

The influence of T stub joined to ground is improving the matching and isolation as shown in figure 5.

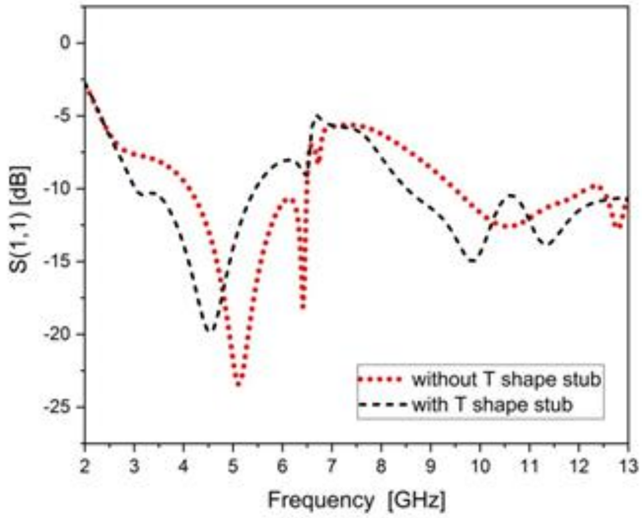


Fig. 5. Influence of T stub on reflection coefficient characteristics.

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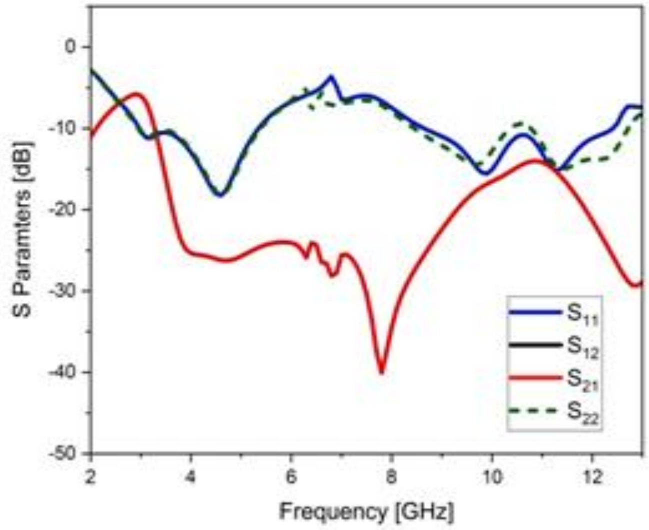
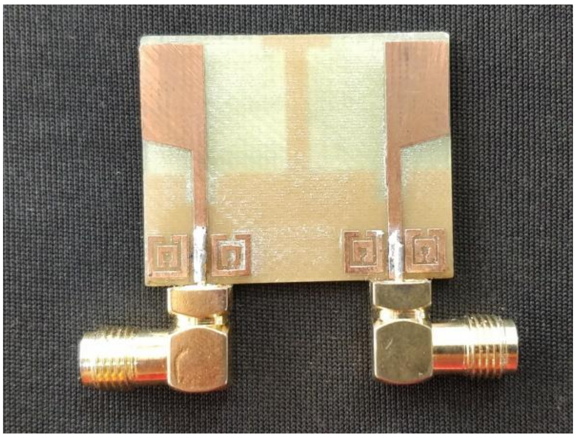


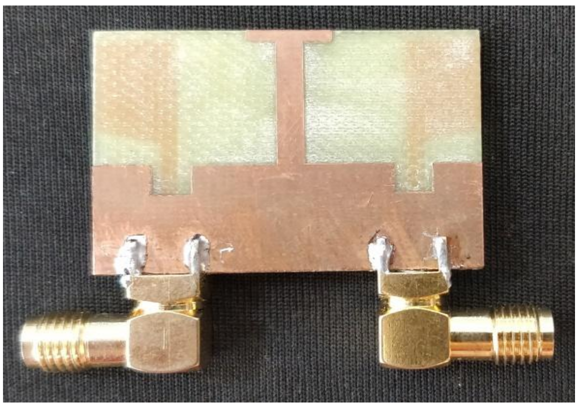
Fig. 6. S parametrers of the proposed antenna.

III. RESULTS AND DISCUSSION

To validate the simulated results, proposed antenna is fabricated using PCB technology and measured for for results.



(a) Top face of antenna.



(b). Bottom face of antenna.
Fig. 7: Fabricated antenna using PCB technology.

The measured and simulated results are almost identical, During UWB (that is 3GHz - 12GHz) peak gain is ranging from -2dB and 6 dB.

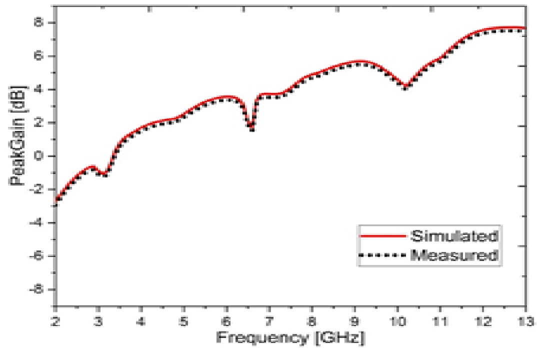


Fig. 8. Peak gain verses frequency.

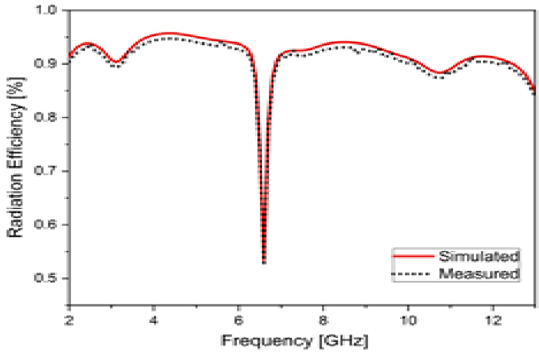


Fig. 9. Reflection verses frequency.

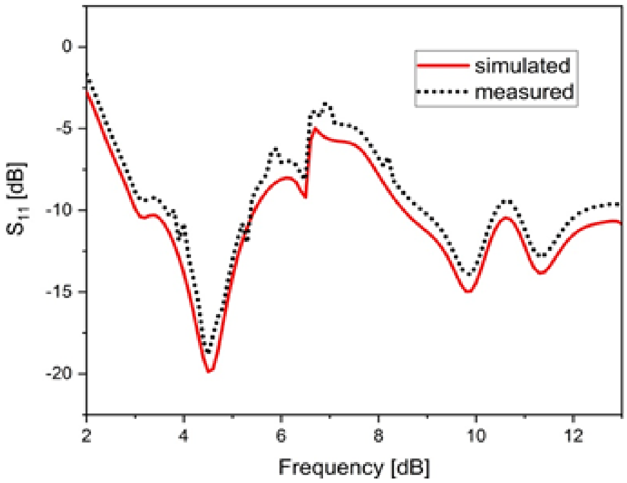


Fig. 10. Measured verses simulated results.

A. Surface current distribution

The concept of mutual coupling can be further explained by using surface current distribution method. Figure 11 is showing E field, figure 12 is showing H field, figure 13 is showing J field at three frequencies that is 4.8GHz, 9.2GHz, 11.7GHz. It is evident from the figures that less mutual coupling and high degree of isolation is achieved by placement of SRRs and T-shaped stub.

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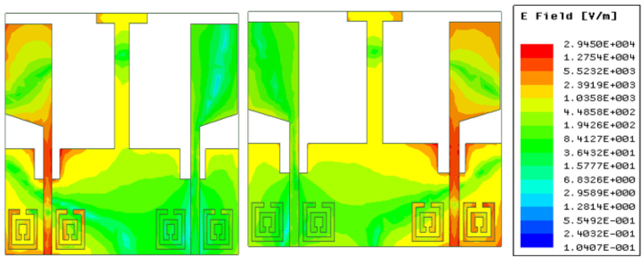
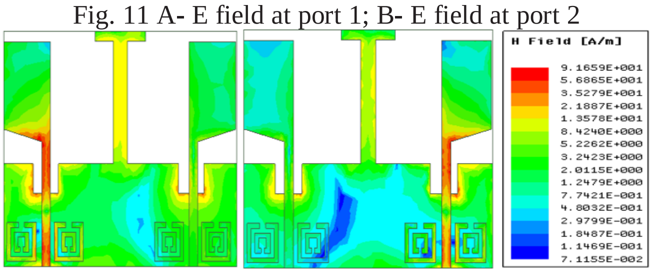


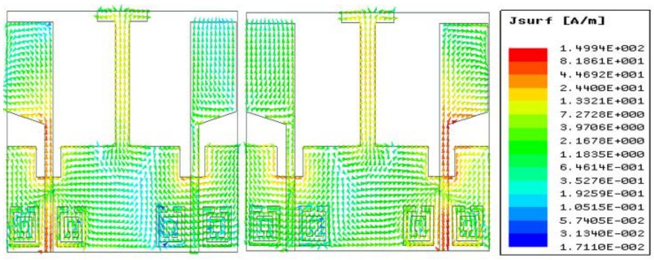
(A) (B)

Fig. 11 A- E field at port 1; B- E field at port 2



(A) (B)

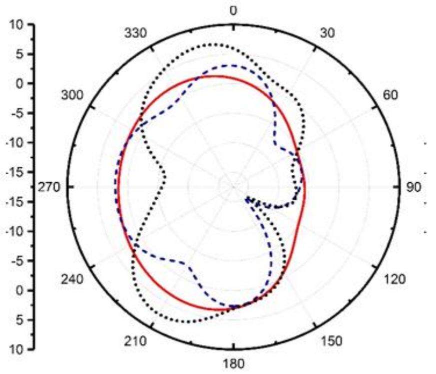
Fig. 12. A- H field at port1; B-H field at port 2



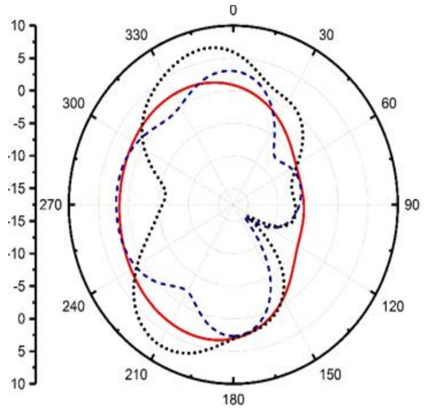
(A) (B)

Fig. 13. A- J field at port 1 ; B- J field at port 2

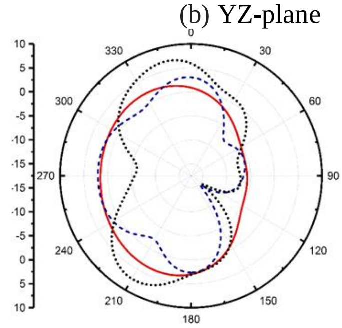
B. Radiation Pattern



(a) XY-plane



(b) YZ-plane

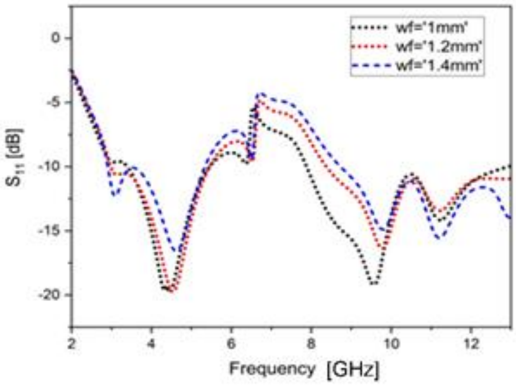


(c) ZX-plane

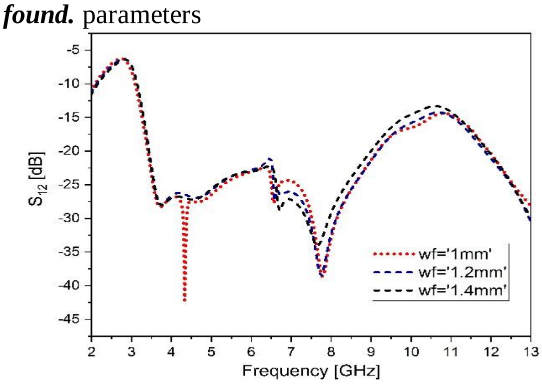
Fig. 14 Radiation patterns.

C. PARAMETRIC ANALYSIS

To understand the influence of each parameter on working characteristics of antenna is understood by using parametric analysis and also exact design values can be determined.

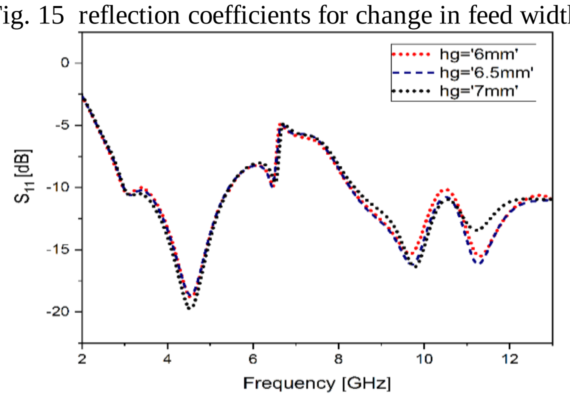


(a) ***Error! Reference source not found.*** parameters



(b)S12 parameters

Fig. 15 reflection coefficients for change in feed width



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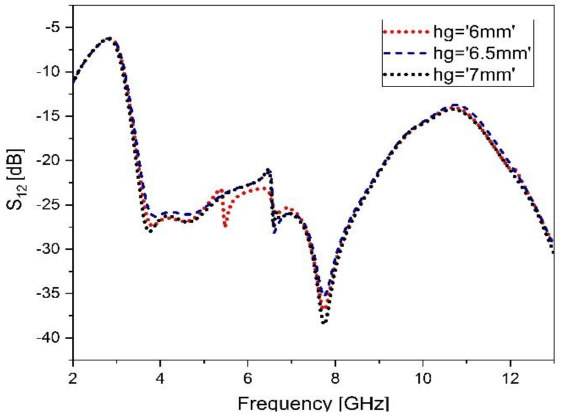
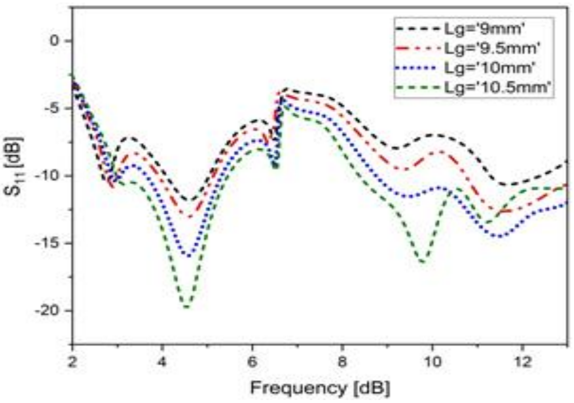
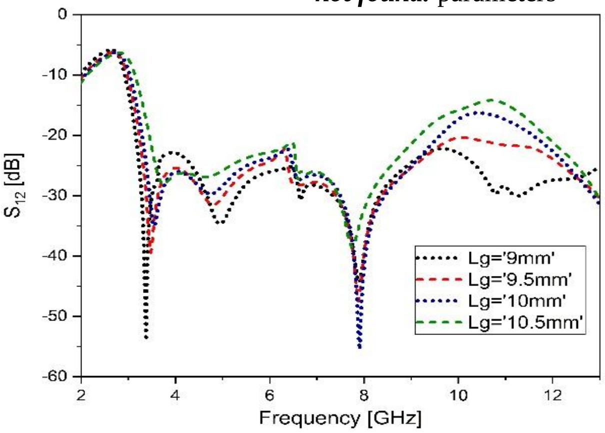


(b)S12 parameters

Fig. 16 reflection coefficients for change in height of ground.



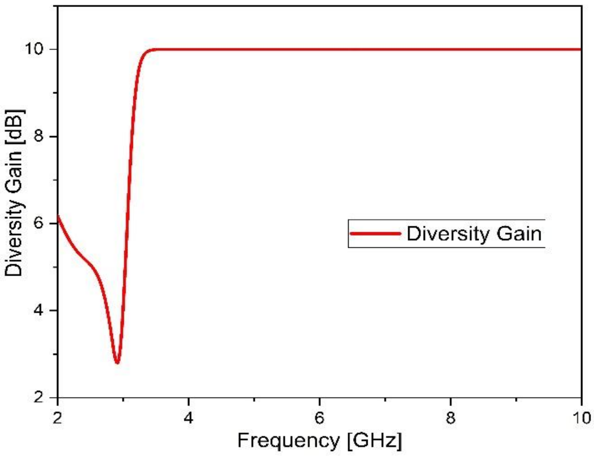
(a) ***Error! Reference source not found.*** parameters



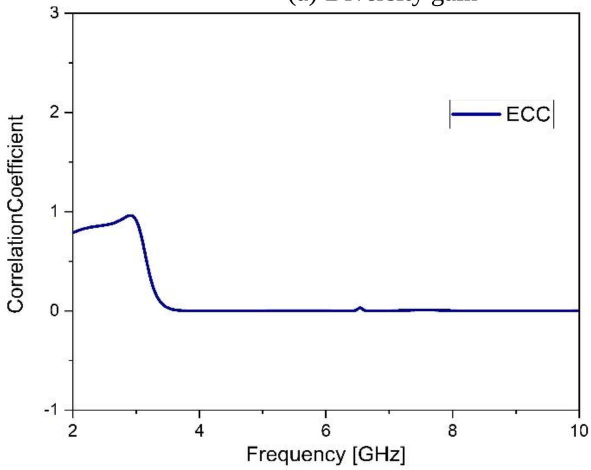
(b) S12 parameters

Fig. 17 reflection coefficients for change in length of the ground

D. MIMO Performance



(a) Diversity gain



(b) ECC

Fig. 18 MIMO Performance

IV. CONCLUSION

CPW feed UWB dual band-notch MIMO antenna for IoT applications is designed in HFSS and obtained results are discussed in comparison with measured results. The SRRs are on the surface of antenna are enhancing the impedance band width and T-shaped stub joined to ground is providing good isolation between MIMO antennas. Both simulated and measured results are showing that proposed antenna is well works within UWB (3.1 GHz to 10.6 GHz) range except at two notch bands, that is 5.43 GHz - 8.54 GHz (C-band) and 10.4 GHz - 10.7 GHz (super extended X-band). .

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