DESIGN OF MULTI BAND MIMO ANTENNA FOR VARIOUS INDOOR APPLICATIONS

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ABSTRACT: A new planar multiband multiple-input multiple-output (MIMO) antenna is introduced, which is both innovative and very compact. Two symmetriescal radiating components, linked by a neutralising line to eliminate reactive coupling, make up the suggested antenna. The radiating element, which consists of a folded monopole and a bevelled rectangular metal patch, is intended to operate at several frequencies, including GSM 900 MHz, DCS 1800 MHz, LTE-E 2300 MHz, and LTE-D 2600 MHz. A set of 50 coplanar waveguide (CPW) transmission wires feed the antenna that is being given. The mutual coupling is reduced by engraving four apertures onto the ground plane. All of the observed parameters—impedance matching, isolation, peak gain, and radiation patterns—are satisfactory for the suggested antenna. The diversity gain (DG) and radiation efficiency (RE) at the service frequencies are satisfactory. Three different antenna feed systems are covered in the Ericsson indoor experiment. The suggested antenna performs well in terms of download and upload speeds, as well as Long Term Evolution (LTE) reference signal receiving power (RSRP).

Keywords: Multiband, multiple-input–multiple-output (MIMO) antenna, Long Term Evolution (LTE), indoor, antenna feed system

Introduction:

When looking to expand the capacity of a system, one option is to implement MIMO (Multiple Input and Multiple Output) antenna systems. These systems offer high bandwidth, reduce fading caused by multipath effects, and improve spectral efficiency and reliability. Thanks to the addition of a number of antennas to the transceiver, which transmits and receives power via multiple antennas, exceptionally high data rates are obtained in MIMO antenna systems.Various MIMO antenna configurations have been covered in the literature [1–5]. The multi-input and multi-output antenna design is very critical for portable devices.

tiny and will have little signal connection with one another. Coupling effects provide the greatest challenge to MIMO antenna designers. To fit in a small system, the radiating elements of a multiple-input multiple-output (MIMO) antenna must be near to each other; as a result, the energy emitted from each element will interfere with each other, leading to far field coupling [6-8]. Especially in bands like lower wide bands, this impact will significantly degrade system performance. Improving the inter-radiating element distance is an effective strategy for dampening coupling effects[9, 10].To reduce the inner gap between the radiating components while maintaining optimum performance, decoupling structures may be employed between the radiators. There are a number of methods that have been suggested by antenna engineers to increase the separation of antenna components using EBS and DGS structures [11, 12]. There are two subtypes of decoupling techniques based on operating principles. One kind uses metamaterials[13–14] and structures with a defective ground to reduce currents among radiating components. By efficiently dampening surface waves, metamaterials increase isolation between antennas; structures with defective ground may achieve a high degree of isolation; and metamaterials with single or multiple[15–16] opening slots can function as band stop filters. A second approach to achieve isolation is to introduce a second coupling channel that mimics the first one[17–20].

Inserting components like parasitic elements, decoupling networks, and neutralisation lines between the radiating elements can also improve isolation [21–24].In the case of two closely placed antennas, a bandwidth that is off by less than 5%, and an isolation of 20 dB.As an efficient means of achieving high isolation, decoupling networks make use of suspended lines and lumped elements as their active components. Using second-order coupling resonators is another approach to achieve isolation for 20 dB and 10% bandwidth. Several works of literature with three linear neutralisation actualized with dual radiating elements [26-28] and the usage of onlylines to reduce mutual coupling by 20 dB and bandwidth by 10% are examples of alternatives to networks for decoupling and neutralisation, respectively, [25]. However, techniques like decoupling structures are still challenging, and isolation levels are poor—not even close to -15 dB. A folded neutralisation approach may be used in antennas with a separation of 0.3 λ0 to enhance the isolation bandwidth.Nevertheless, it is not feasible to build it for use with two or more closely placed antennas that are less than 0.1λ0 apart.

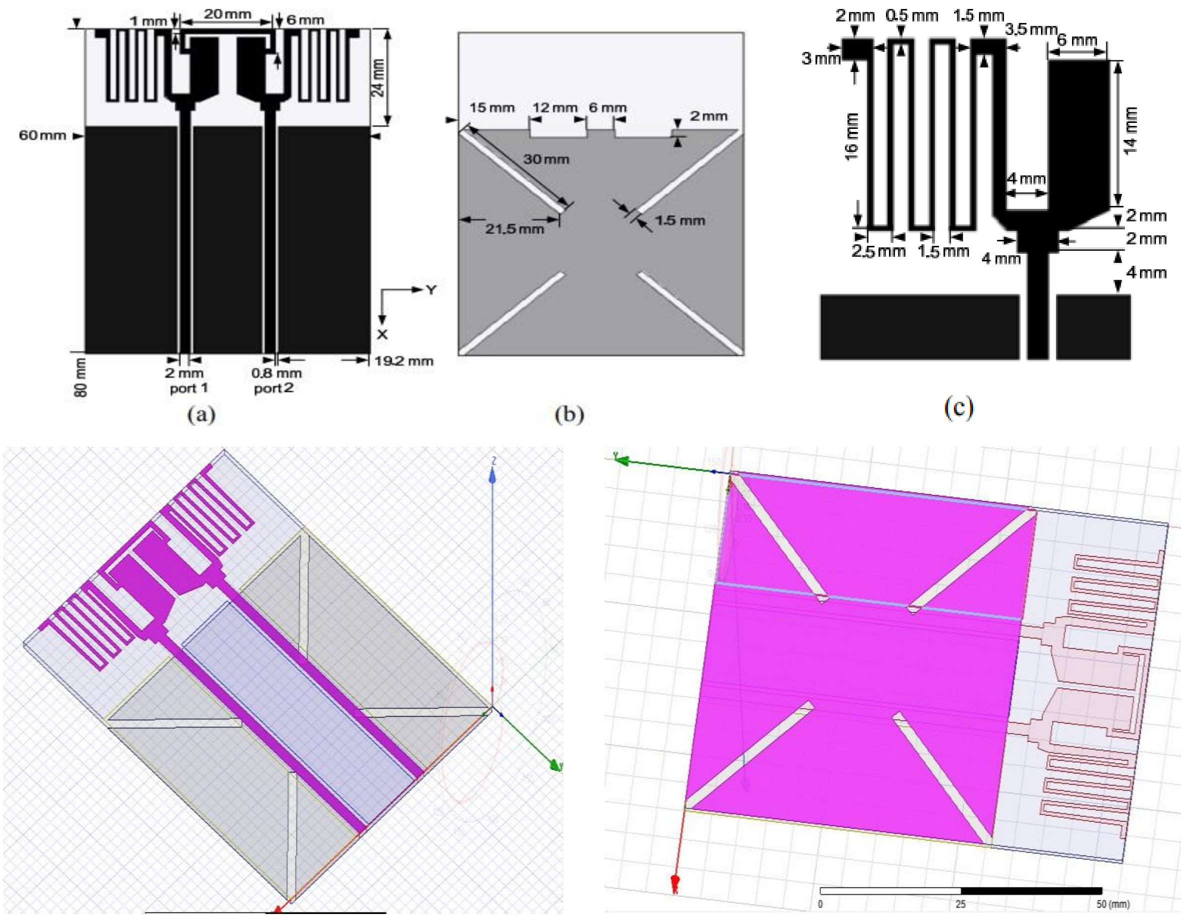
At 30 dB, the levels of isolation are not achievable. Although the neutralisation lines and decoupling networks may reach a small size, none of the aforementioned technologies are flexible enough to meet the needs of all possible applications [29–34]. The following are some of the ways in which this work contributes: • The Multi-band MIMO antenna described in this article has a neutralisation link and slits that connect two antennas that share a coplanar waveguide feed.
• Several indoor applications, including as LTE, W-LAN, and WiMax, have shown acceptable total active reflection coefficient and envelope correlation coefficient values, as well as satisfactory impedance matching and diversity gain.

1. AntennaGeometry:

The Fig.1 represents the geomemultical structure of CPW layered MIMO antenna iterations 1and 2 which has radiating elements in square shape. The antenna is fabricated on FR4 substrate with 4.4 dielecmultic values and 0.02 loss tangent with dimensions of L×W×h. The patch on the substrate is intended by square with split ring resonator and CPW loaded at the ground with a sharp pencil like shape feed line with 50 Ohm impedance is incorporated. Fig. 1(a) shows the geometryandconfigurationoftheproposedantenna.Itwasfabricatedona60×80×0.8mm3FR4 epoxy substrate with dielecmultic constant εr =4.4 and loss tangent tanδ=0.02. The antenna consists of two symmemultical radiating elements. The coplanar waveguide (CPW) transmission lines of 50 Ω feed the radiating elements connected by a 1 mm wide shorting line. The shorting line takes the role of neutralizing the currents from two elements to increase their isolation. As shown in Fig. 1(b), four 30 mm long slits and two 2×12 mm2 rectangles are cut from the backside of the ground plane for reducing the mutual coupling and slightly improving the impedance matching. In Fig. 1(c), the left folded monopole of the radiating element provides the 900 MHz, 1800 MHz and 2300 MHz resonant path, while the right beveled rectangular metal patch is the 2600 MHz resonant path. Hence, the overall operating frequency bands of each radiating element are achieved as GSM 900 MHz,DCS 1800 MHz, LTE-E 2300 MHz and LTE- D 2600 MHz.

Fromtheequation1theresonantfrequencyiscalculated.

$$fr = \frac{144}{Lg+P\,l+Pg+\frac{A1}{2\Pi Lg\sqrt{\varepsilon r\ eff}}+\frac{A2}{2\Pi P\,l\sqrt{\varepsilon reff}}} \text{ ---- (1)}$$



(d) (e)

Fig.1: Geomemulties of the proposed multi band MIMO antenna.(a) Front view.(b) Rearview. (c)Detailed view (d)&(e) isometric view design

Where Lg represents the ground plane length, PL is the patch length, Pg is the gap among the ground and patch, A1denotes the area of the ground plane, A2denotes patch area, Ɛreff denotes the dielecmultic value effective where is Ɛreff = (Ɛr+1)/2. To recover the isolation among the 2 ports the L-shaped long slots are designed in the structure. In the ground plane two slots which acts as ƛ/4 resonators are included to achieve band at WLAN frequency. The

Fig. 1 shows the dimensions and structure of the designed antenna which its parameters. The length and width of the proposed antenna is 60×80×0.8 mm3 with the thickness of 0.8 mm^3. Addition of neutralising link, this links the two radiating elements and cancel the mutual coupling between elements and

Etching four slits and two small rectangles into the ground plane which yields good isolation in all the serving frequencies

2. AnalysisandResults:

TheprojectedCPW layeredMIMOantennaiterations1and2exhibitstwooperational frequency bands conferred, and two operational frequencies was designed, and simulated results are taken byusing the HFSS software. The resonant frequencies area with return loss less than -10dB with the 2.1GHz to 5 GHz and 6GHz to 12 GHz bands shown in the Fig. 4 and 5. The fabricated antenna results are measured by using network vector analyzer with anechoic chamber. The designed antennas performance with simulated and measured results gives good performance when both are compared. The Fig.4 shows the simulated and measured results of the designed antennaiteration 1 with thereflection coefficient plotted in it. TheFig.5 shows thesimulated and measured results of the designed antenna iteration 2 with the reflection coefficient plotted in it. The measured reflection coefficient operates at certain frequencies are 2.1GHz to 5 GHz. The mutual coupling at the resonant frequencies 2GHz to 5 GHz is 5dB and -20dB.

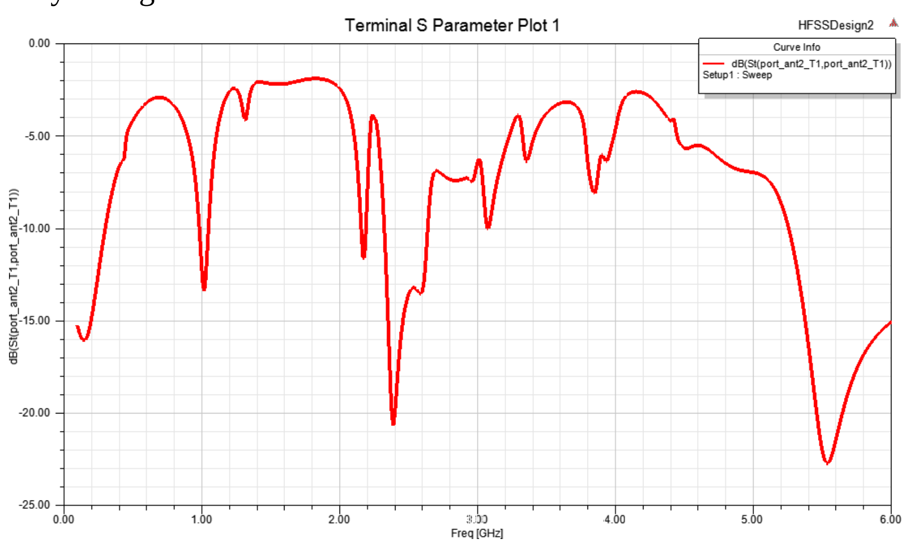


Figure2:Resultsofreturnlossplot

In figure 2, the return loss characteristics of proposed multi band MIMO antenna with various substate materials is depicted. The substrate material choosed for the analysis are arlon, FR4 and RTduroid 5880. From the figure it is clearly observed that the proposed structure is having very good impedance matching when FR4 is used as substrate when compared with arlon and RTduroid.In figure 2, the return loss characteristics of the proposed multi band MIMO antenna isdepictedfromthatitisclearlyseenthatproposedantennawithoutthecomplementarysplit ring resonator can operate in the same multiple bands with some decent impedance matching, when the Complementaryrings are etched the impedance matchingat the higher band is reduced and when the complementary ring is converted in to complementary split ring resonator the proposed multi band MIMO antenna can able to achieve very good impedance matching at the higher bands.

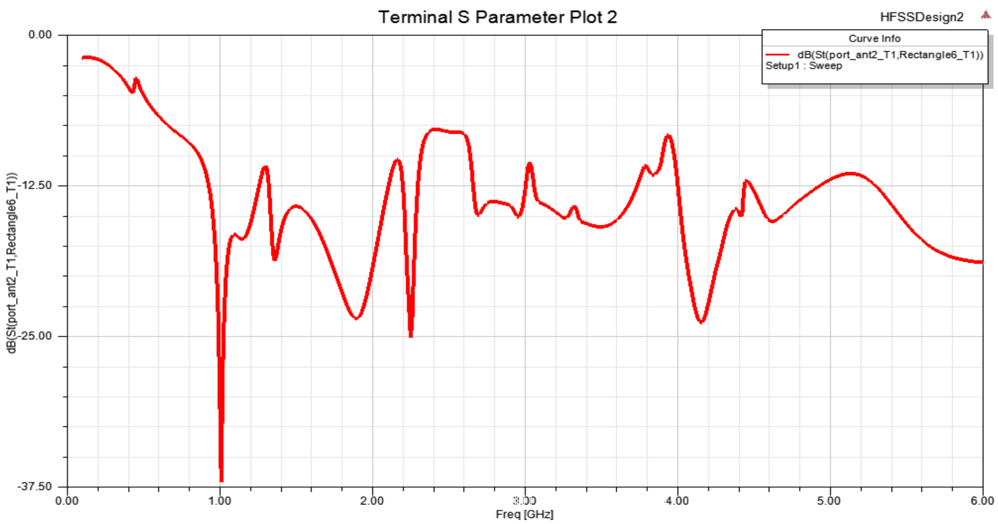


Figure3: Results of isolation plot

Infigure3, the isolation performance of the proposed multiband MIMO antenna is depicted. From the figure it is observed that the isolation level is maintained at the lover band and at thehigherbandtheisolationisgreaterthan20dBin thehigherbandsaftertheinclusionofthe CSRR at the radiating element.To analyze the working mechanism of the neutralizing line and fourslits,Fig.3showsthesimulated|S21|ofMIMOantennaswithdifferentdecoupling configurations.Itcanbeobservedthattheisolationisdeterioratedseriouslyintheoperating bands,whenMIMOantennawithoutneutralizing lineandfourslits.Theisolationisgreatly improvedintheDCS1800MHzandLTE-E2300MHzbandswhenMIMOantennawith neutralizingline.Moreover,thecouplingcanbefurtherdecreasedintheGSM900MHzand LTE-D 2600 MHz bands when MIMO antenna with four slits etched into the back ground plane. Infigure4,the3Dradiationpatternispresented;itisobservedthatthemaximumradiation intensityisperpendiculartotheantennaaxis.Fromthefigureitisobservedthatmostofthe surfacecurrentisalteredbecauseoftheinclusionofcomplementarysplitringresonator.Itis notedthatmostofthesurfacecurrentisaccumulatednearthethreecomplementarysplitring resonators.Asobserved,theradiationefficienciesare85%to95%highintheoperating frequencybands.Whenoneportisexcitedandthe otherportisterminatedbya50Ωload,the measuredradiationpatternsoftheantennaony-zplaneandx-yplaneforfourdifferent frequencies 900, 1800, 2300 and 2600 MHz.

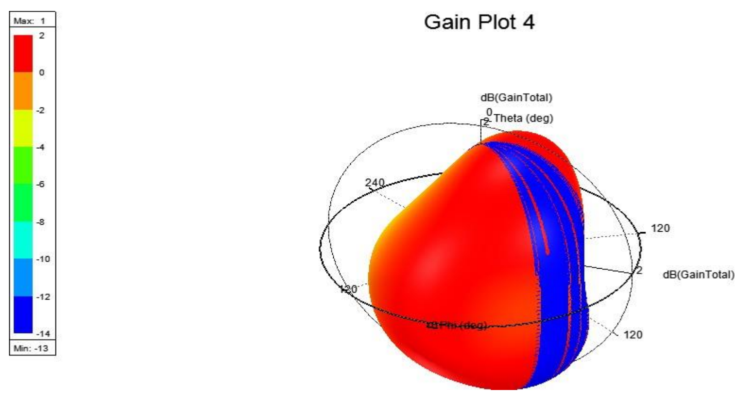


Figure4:Resultsofgainplot(3D)

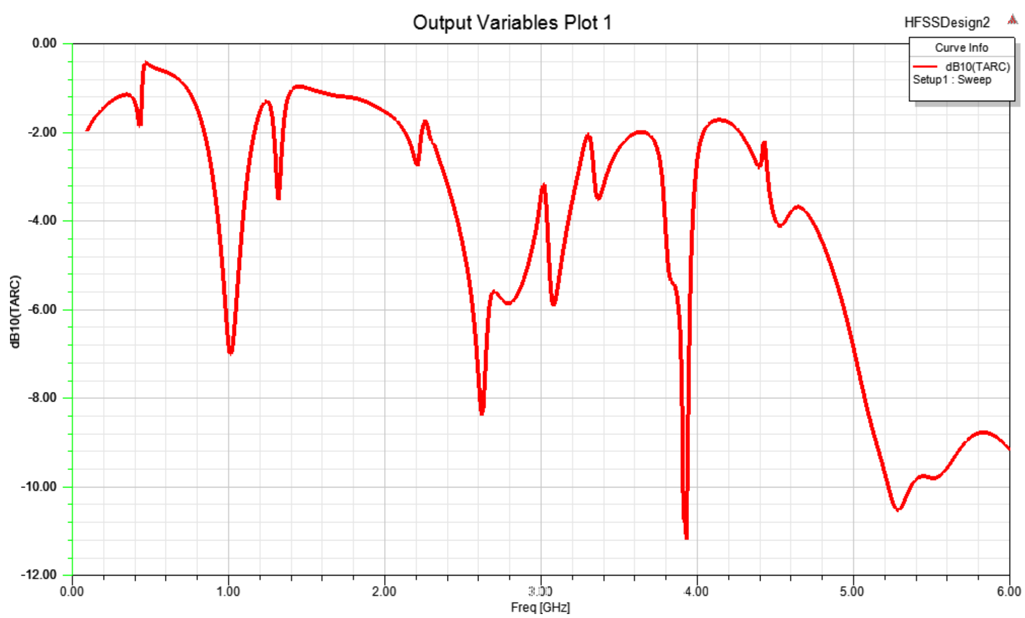


Figure5: results of TARC plot

By energizing two indistinguish able antennas with by placing front to front position of in the fields as far, the ninterruption was taken down and displayed of proposed model antenna in Fig5. Right now, port1 was energized then port2 was ended with 50Ω impedance and when port2 was energized then port1 was ended with 50Ω impedance. Group delay is flat in the measured operating bands. Sharp edges are observed at the bands in the TARC graph.

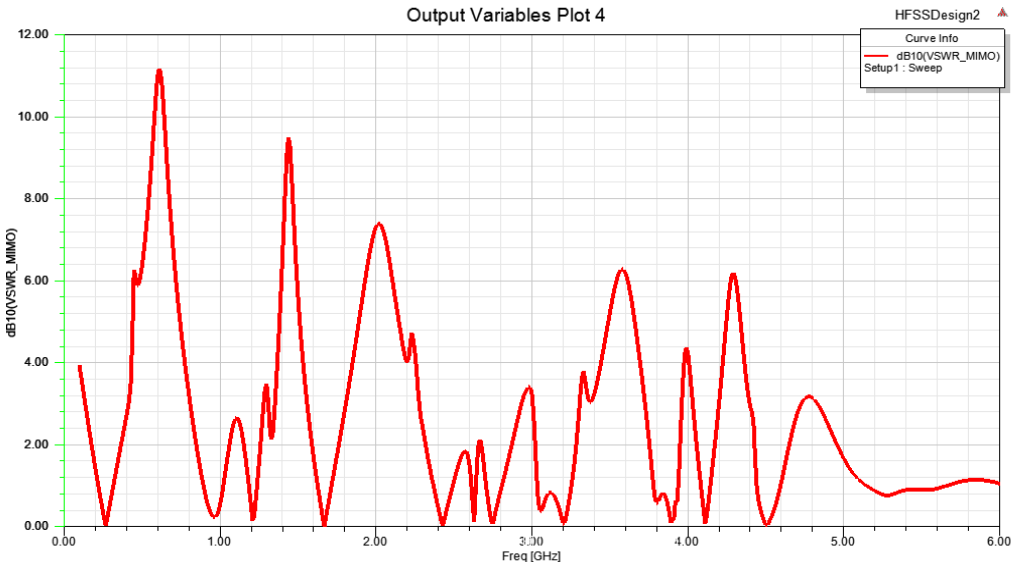


Figure6: RESULTS OF VSWR PLOT

In figure 6, the simulated VSWR plot is depicted from which it is observed that the value of VSWR is less than 2 in the operating ranges 2.01 GHz to 2.69 GHz which is used for ISM application, 3.54 GHz to 4.26 GHz which is used for WiMAX and UAV application and GSM 900 MHz, DCS 1800 MHz, LTE-E 2300 MHz and LTE-D 2600 MHz applications respectively.

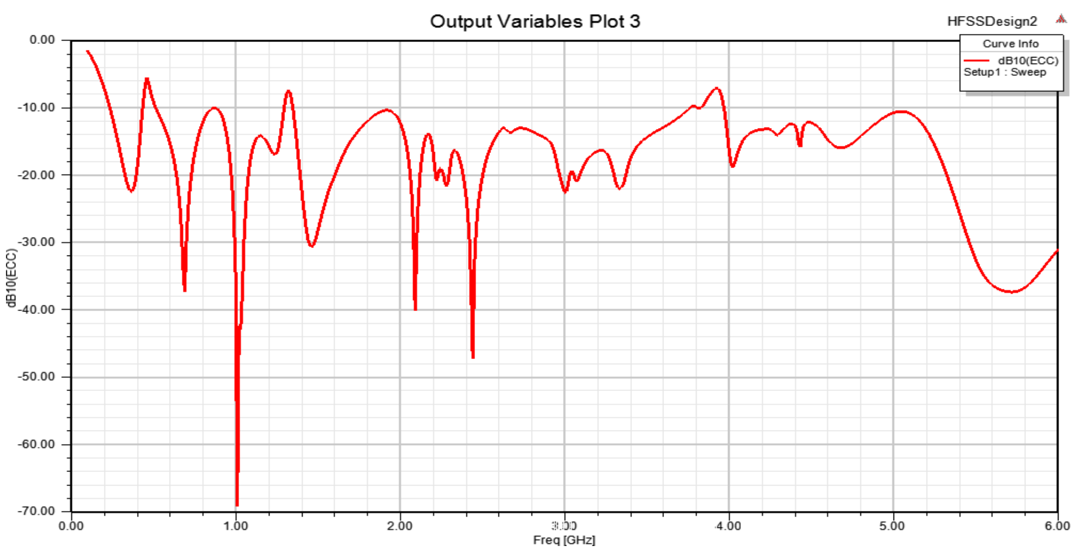


Figure7:RESULTSOFECCPLOT

$$Ecc = \frac{|S_{11}S_{12} + S_{21}S_{22}|}{(1-(|S_{11}|^2 + |S_{21}|^2))(1-(|S_{22}|^2 + |S_{12}|^2))} \quad (2)$$

$$\text{Diversity Gain} = 10\sqrt{1-ECC^2} \quad (3)$$

To assess the performance in diversity Envelope relationship coefficient (ECC) parameter is used. The below equations 2 and 3 are the ECC and diversity gain values obtained from the reflection coefficients of the designed iterations of the antenna. By minimizing the standards of ECC, the radiation pattern sover lapping canbe decreased. The proposed MIMO antenna iteration 1 and 2 ECC graph is shown inFig.7.TheacceptablevalueoftheECCis0.5 andtheECCatthe operating band is obtained about 0.02 at the average when there is notch in the bands.

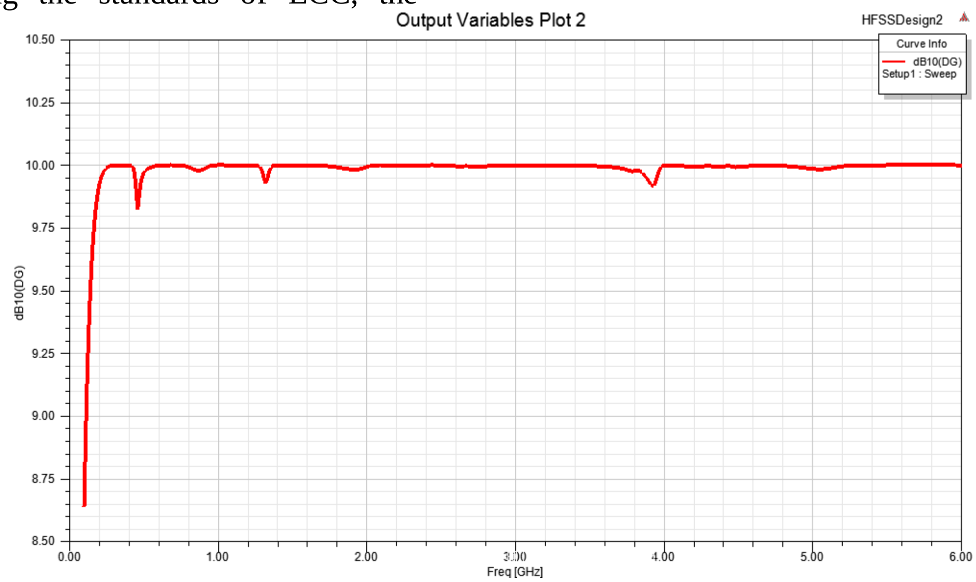


Figure8: RESULTS OF DG PLOT

The Fig. 8 shows the diversity gain of the designed antenna. he gain vs frequency graph is presented which clearly show the proposed tri band MIMO antenna is having a reasonable gaininall theoperatingbands 2.01 GHz to 2.69 GHzwhich is usedforISMapplication,3.54 GHz to 4.26 GHz which is used for WiMAX and UAV application. The maximum gain of the proposed tri band MIMO antenna is 6 dBi.

Table1:Resultsanalysisofdifferentmethods

Name	TARC	DiversityGain	ECC
MIMO ANTENNA WITHOUT NEUTRALISATIONLINKANDSLITS	-2.4dB	8.35dB	0.81
MIMO ANTENNA WITH NEUTRALISATIONLINKANDSLITS	-7.4dB	9.75dB	0.24

Conclusion: An enhanced multi-band MIMO antenna with slits and a neutralisation connection is shown in this study. The antenna's characteristics include Total Active Reflectivity Coefficient (TARC), Envelope Correlation, and others.

High Frequency Structure Simulator (HFSS) software is used to model ECC and DG.To lessen the coupling mutual impact between the radiating components, we provide a meta-material based two-multiple-input multiple-output (MIMO) antenna with CPW loading and FSS for gain improvement. This study proposes a new small MIMO antenna for indoor multiband applications.A multi-band antenna element is achieved by folding a monopole and using a bevelled rectangular metal pattern. By using a neutralising line and cutting four slits in the back ground plane, a high isolation of |S21| -30 dB in the working bands is accomplished. Presented below are the findings on s-parameters, peak gains, and radiation patterns. Research has been focused on the diversity performance metrics of radiation efficiency and diversity gain. In addition, LTE base stations with three different antenna feed methods are built to assess the performance of the proposed MIMO antenna in a real-life LTE indoor application. Indoor GSM, DCS, and LTE use cases might benefit from the suggested antenna.

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