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Design of a MIMO Antenna with Novel Rejection Features

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Abstract :

Today's MIMO antenna designers receive a strong demand from customers which require an antenna with certain band utility and certain other bands which are to be notched rejected ; for which many researchers proposed many novel ideas including strips, meta structures to suppress unwanted bands prevailing due to mutual coupling even though the original intended design did not include those frequencies. The current research is carried out to assimilate and put forth all novel ideas emerged so far in the MIMO antenna design. The proposed dual port antenna is simulated for vital antenna parameters which includes return loss. gain pattern An FEM based antenna simulator is used for designing and freezing the design outline. The proposed antenna Dimension are 24.45mm*44.45mm*1.6mm. We present a low profile miniaturized dual port cpw fed triple band notched MIMO antenna with high isolation in this paper.

Keywords: *MIMO, Isolation,CPW*

I. Introduction

In the present day scenario emerging wireless technologies system there is a demand in low profile antennas which can be easily integrated with devices with advanced data transmission rate. The crucial problem experienced by the high data rate system is multipath fading which happens due to reflection and deflection of the of the signals in the free space.[1] This forced the researchers to focus their attention towards MIMO antennas. MIMO technique gives a compromising solution for the multipath fading and hence there is increase in data rata, band ranging without maximizing the transmitting power. also MIMO systems are feasible solutions in the sense that they exhibit a less channel capacity and a much reliable system. Still there exists a problem due to the availability of less space in all portable devices which demanded for size reduction to avoid mutual coupling; as a system experience mutual coupling results in out flow of signal leakage which directly affects the efficiency of the antenna. When we target for higher frequencies communication we use high di-electric constants materials which in turn increase the mutual coupling effect paving way for excitation of surface waves hence it becomes mandatory to design an antenna with low profile less mutual coupling removing the unwanted bands .This could be done by the following ways the researchers proposed. By altering the structure radiating like slot etched on ground plane [3], without decoupling structure [4] polygon shaped structured added with L shaped structure in the radiator [5] slotted meander-line resonator (SMLR) [6] and making space between the elements and introducing Structures Various

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techniques also deployed under this category like Defected ground structure[7] , metallic strip[8] neutralization line[10] decoupling network etc are used which is reported in the literatures metallic strip [10] protruding ground plane, coupling parasitic element ,electronic band gap materials [11] defected ground structure [13] patterned grounds [14], stub loading[15], frequency selective surface [16] h type resonator [17] Metamaterial [18] and feeding also plays important role in designing such antennas offset micro strip fed [19] CPW [20][21] from CPW fed MIMO are better in the results in general. We propose to design a miniaturized good isolation a dual port CPW fed triple notched MIMO antenna

II. Proposed antenna configuration

Fig.1 depicts the designed radiating structure and attributes of the proposed antenna, optimal parameters related to the structure are listed in the Table 1. Radiating patch layers are designed as described in the [22][23]. The Proposed design is such a way that two symmetric antennas were placed orthogonal to each other, both the antenna are fed by coplanar wave guide the patch is etched over the RT DUROID 5880 substrate whose electrical property i.e. Dielectric constant is 2.2 and loss tangent is 0.009 The dimension of the antenna is 44.45mm*24.45mm*1.6 mm antenna which is aimed to operate in the ultra wide band range and to support higher frequencies. A flexible substrate is chosen (RT Duroid substrate) in the design. Since the commonly available FR4 like substrates exhibit less efficiency in the ultra wide band operation. The simulated result of the antenna is enumerated in the Fig.2 which shows the actual result of the antenna and after isolation enhanced.

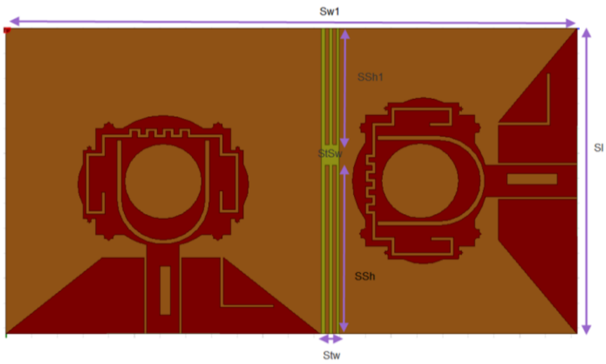

Fig.1 Layout of the proposed antenna

S. No	Parameter	Value (mm)
1	Strip width	1.4
2	Strip length	24.45
3	Upper side slot length	9.3
4	Lower side slot length	13.5
5	Slot width	0.3
6	Width of the substrate	44.45
7	Length of the substrate	24.45
8	Thickness	1.6

Table 1.optimal parameters

III. Simulation and discussions

By utilizing FEM based software the proposed antenna is designed. Antenna is intended to work over the ultra wide band region with three major interfering Wimax, WILAN and X band to make the antenna more reliable and also to work for the higher data rate antenna is further designed as MIMO. S parameter of the proposed variant is illustrated in the Fig. 2 where actual results of the UWB Notched antenna achieved isolation

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results. MIMO is presented with tuned VSWR values. The Fig.3 shows compensating limit less than 2 over the complete operating region. while designing MIMO mutual coupling between the elements make the antenna performances degraded, hence isolation is more important Fig. 4 shows the without any isolation element due to mutual coupling WIMAX band is missing , so to achieve remove the mutual coupling between the two radiating elements and to reduce the size of the antenna two major steps are carried out , foremost thing is radiating elements are kept orthogonal with other which reduces the size of the structure , after that a conducting strip is introduced between two elements over which Four slots were First to slots were introduced with the size of 0.3mm*13.5mm which gives better isolation This lead to the notch value increased which is shown in the Fig.5 comparing to the desired value , hence two more slots were introduced in the upper side of the strip and parametrically analysed. distance 9.3mm is found to be optimal and also the bandwidth is increased in the lower side, to incorporate another applications parametric analysis of isolation slot is shown in the Fig.6 , but extra notch is obtained .Hence both the upper and lower side of the strip slots were engraved and those slots were further parametrically varied to get optimal results. Figure illustrates the parametric analyse of the variation of the slot and its optimal value, Fig.7 shows the complete S parameters of the proposed antenna.

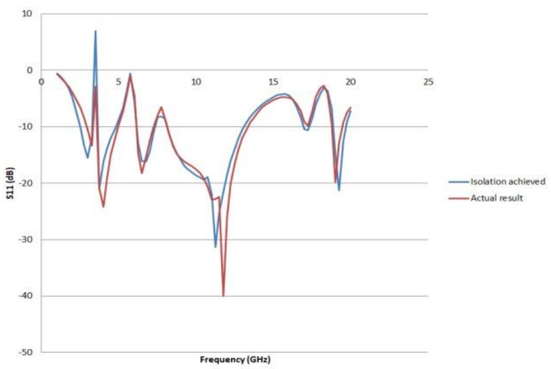

Fig.2 Simulated results

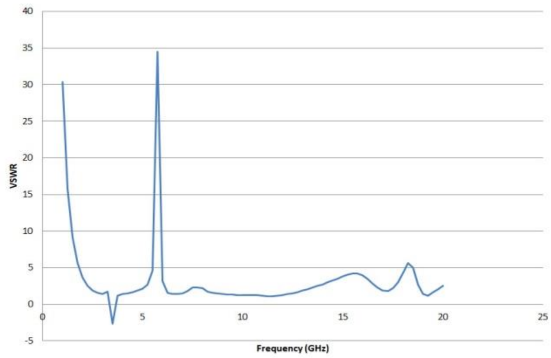

Fig.3 VSWR

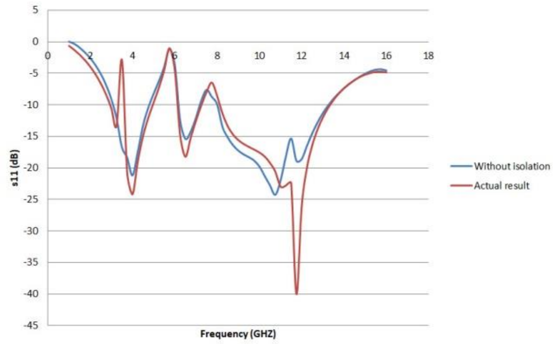

Fig.4 without isolation element

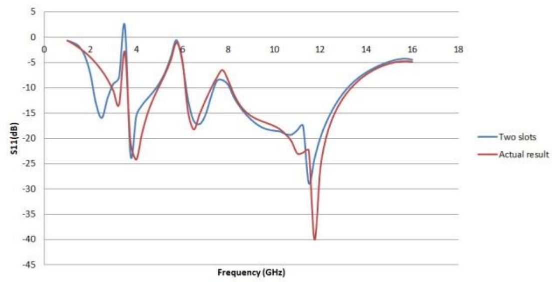

Fig.5 With two slots in the down side

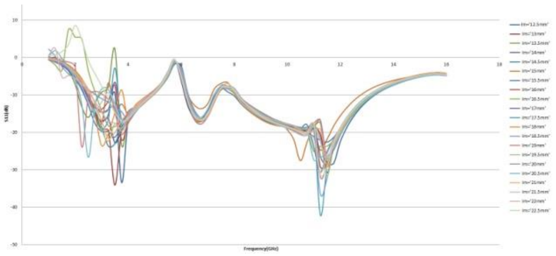

Fig.6 Parametric analysis of the isolation slot

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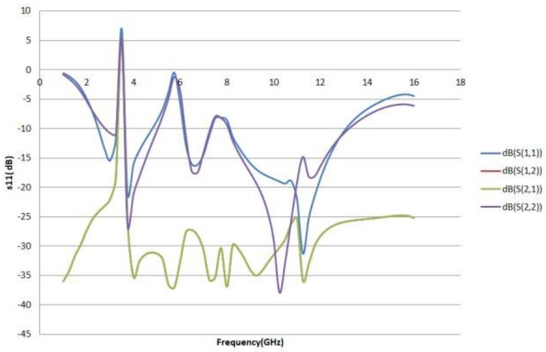

Fig.7 S parameters of the proposed antenna

IV . Isolation analysis

Surface current

Further to investigate more about the isolation characteristics of the antenna current distribution of the antenna is analysed. Which is enumerated in the Fig.8 to 11, the current flow over the patch with strip current is induced on the first radiating patch and also in the conductor strip which displays better isolation between two antennas and suppressed surface waves to travel towards the adjacent element which march towards to the desired output enhanced isolation

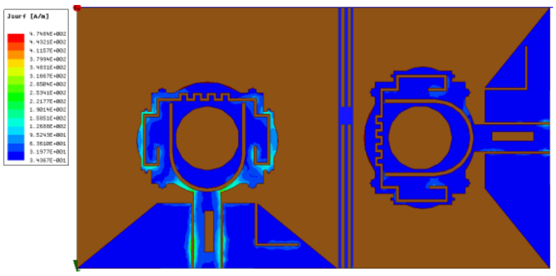

Fig.8 Surface Current density at 3 GHz

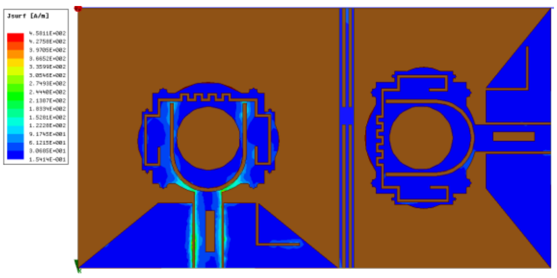

Fig.9 Surface Current density at 3.75GHz

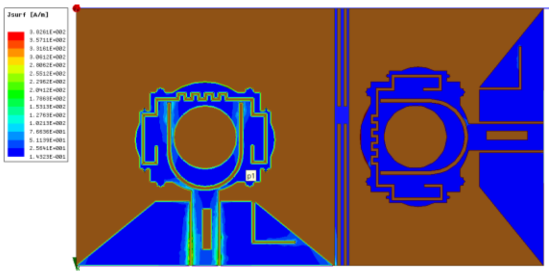

Fig.10 Surface Current density at 6.5GHz

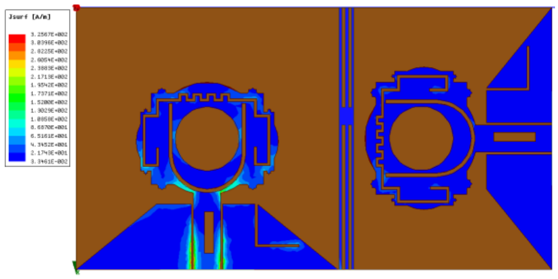

Fig.11 Surface Current density at 11.25GHz

Radiation performance

Radiation characteristics at the primary planes XY and XZ is shown in the Fig. 12 to 19 to radiation characteristics shows a stable pattern in the form of Figure of eight as like the monopole radiation pattern

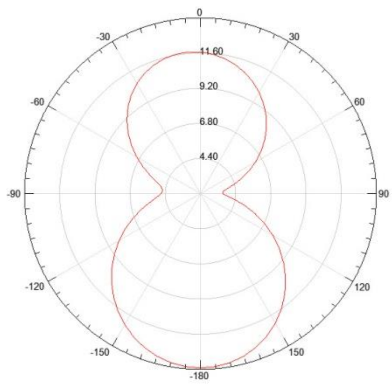

Fig.12 simulated radiation E plane at 3 GHz

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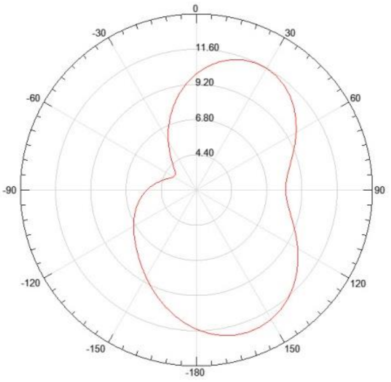

Fig.13 simulated radiation E plane at 3.75 GHz

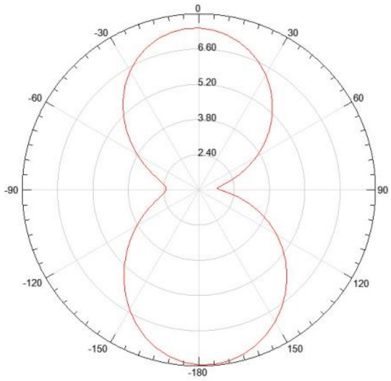

Fig.14 simulated radiation E plane at 6.5 GHz

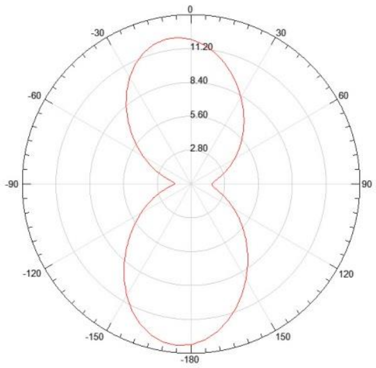

Fig.15 simulated radiation E plane at 11.5 GHz

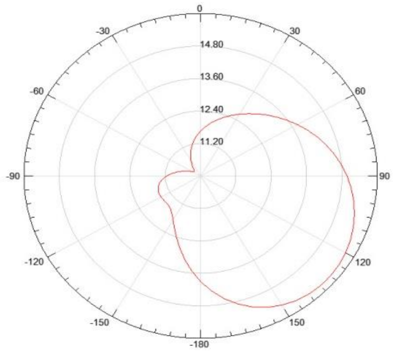

Fig. 16 simulated radiation pattern H plane at 3 GHz

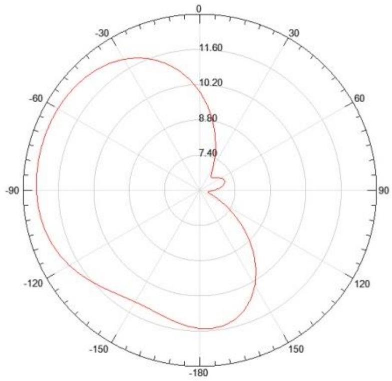

Fig. 17 simulated radiation pattern H plane at 3.75GHz

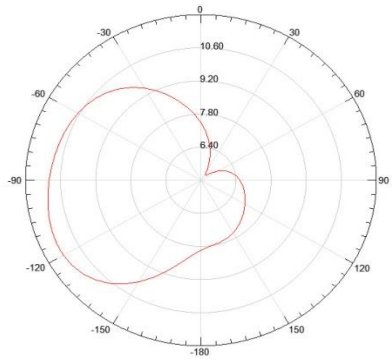

Fig.18 simulated radiation pattern H plane at 6.5 GHz

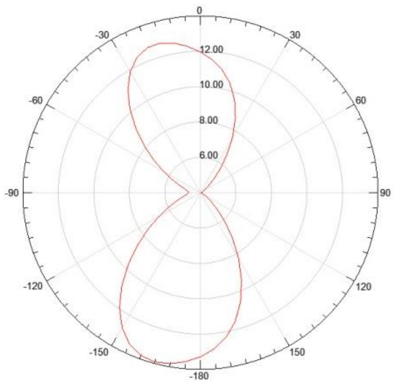

Fig.19 simulated radiation pattern H plane at 11.5GHz

V. Diversity properties

ECC (Envelope Correlation Coefficient) and DG (Diversity Gain)

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ECC is one of the significant parameter to be analysed while designing an MIMO antenna which indicated how much both the antennas are correlated dependency of the radiation pattern between two radiating elements usually correlation between the two elements is reduced when they kept orthogonal to each other hence we introduced isolation structure, hence the correlation value will be increased. ECC is calculated by utilizing radiation parameters and also scattering parameters calculating by means of radiation pattern is a tough process comparing scattering parameters usage provided considering the antennas to be lossless in nature scattering parameter based method is represented by the equation 1 [21] of the antenna practical verge of the ECC value is less than 0.5 here that criteria is satisfied is depicted in the Fig.20 show casing value diversity gain is represented by the equation and our antenna show around which is in preferable range is shown in the Fig.21

$$\rho_e = |S_{11}{}^* s_{12} + s_{21}{}^* s_{22}|^2 \div (1-|s_{11}|^2 - |s_{21}|^2)(1-|s_{11}|^2 - |s_{12}|^2) \text{ ----1}$$

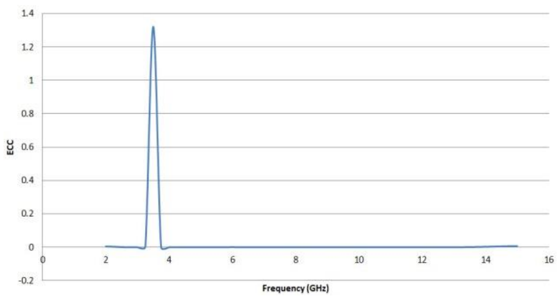

Fig.20 ECC

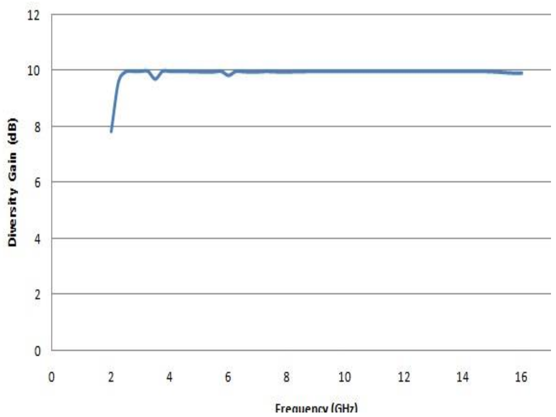

Fig.21 Diversity gain

Group delay

Group delay which Figure out the performance of the radiating element mainly about transmitting signal distortion and signal phase response group delay is mathematically expressed as which is shown in the Fig.22

$$\text{Group Delay} = -\Delta\Upsilon/\Delta\xi \text{ -----3}$$

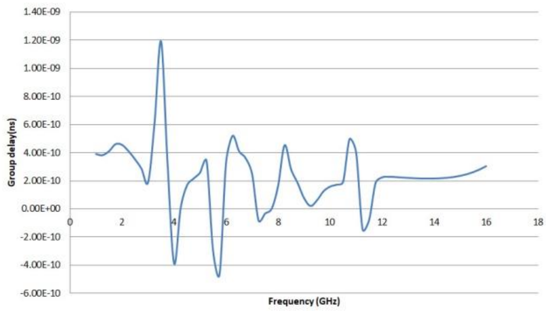

Fig.22 Group delay

Gain

Gain is also increased which is shown in the Fig.23 good increase in gain is observed and exhibit a peak gain of 5.2 dB

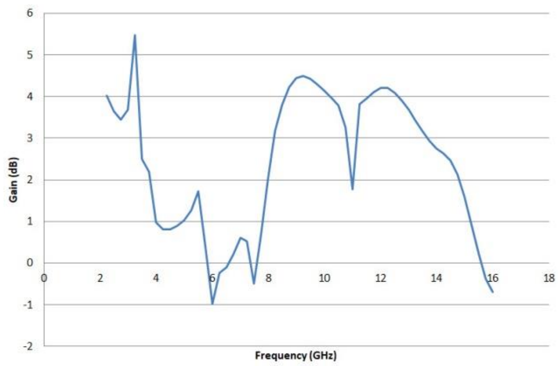

Fig. 23 Gain of the proposed antenna

TARC (Total Active Reflection Coefficient)

Another authoritative parameter to predict the performance of the MIMO antenna is TARC. Which is calculated by means of the reflection co efficient of the antenna which is under the -10 dB over the operating band is sown in the Fig.24

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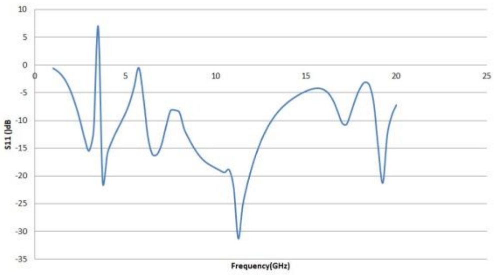

Fig. 24 Total active reflection co efficient

Analysis and incorporation of features in the proposed design

To achieve miniaturization of the antenna two patches were kept orthogonal to each other and to enhance the isolation between elements a conducting strip is introduced over which four slots were engraved to slots from the upper side of the strip and two slots from the lower side of the strip size of the slots were parametrically analysed, by utilizing the aforementioned decoupling structure isolation value improved Conducting strip with slot act as the barrier to propagation of surface wave to exited the adjacent antenna and results in the better resolution.

VI. Conclusions

In this paper a compact dual port MIMO antenna with good isolation characteristics is presented. The proposed system is low profile having good isolation characteristics m the design scheme implements adequate reduction in mutual coupling The ECC, diversity gain are promising. and the antenna finds its application over the ultra wide band region. Further antenna can be designed for four ports with enhanced isolation miniaturization and increased gain.

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