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A Novel-Structured Multiple Input Multiple Output (Mimo) Antenna for X-Band Applications

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ABSTRACT: This research suggests a small modified structured Multiple Input Multiple Output (MIMO) structure that is intended for mobile and trafficking applications. The suggested MIMO antenna is created on a Rogers's substrate with a volume dimension of 25x13x0.254mm3, with relative permittivity, dielectric loss tangent, and height values of 2.2, 0.0009, and 0.254 mm, respectively. It operates at X-Band (8-12 GHz) and has above 20dB isolation is attained for the maximum part of the band. Good efficiency values of above 87% are obtained in the entire band due to good impedance matching at the ports. The MIMO performance metrics Envelope Correlation Coefficient (ECC≤0.005), Diversity gain (DG≥9.99 dB). The simulated values are in good agreement.

KEYWORDS: Gain Diversity, Correlation Coefficient, Multiple Input Multiple Output

I. INTRODUCTION:

There will likely be a ten-fold growth in mobile data traffic worldwide between 2016 and 2022, or a projected 45% rise over the next few years. Mobile video streaming and the adoption of the Internet of Things are the key causes of this enormous surge (IoT). Around 18 billion IoT devices will come from this out of a total of 29 billion devices. The ranges from 8GHz to 12GHz are where the primary spectrum bands between 2 GHz and 12 GHz are located. In modern radars, the X band is frequently used. A unique 2x2 Multiple Input Multiple Output (MIMO) antenna for X-Band system has been built and modeled in order to satisfy this challenge and present expectations. This antenna system is a perfect fit for handheld devices like smart phones and tablets because it operates in the 2 to 12 GHz frequency range. Moreover, this band complies with the Federal Communication Commission's (FCC) operational requirements for the X Band. The X Band technology enables wireless communication devices to transfer data over a very broad frequency range while using less power. Other benefits of X Band technology-based products include high data speeds, expanded bandwidth, and low cost. Front-end antennas are crucial components of X-band communication devices. In order to build X-band antennas for mobile devices, a lot of work and study has been done. X-band applications are thought to benefit from planar antennas because of their performance, affordability, and straightforward construction. In order to improve multipath propagation and channel capacity, MIMO antenna systems are widely used in wireless devices. For improved performance at high data rates, wireless systems have recently included X-band and MIMO technology. Reducing the mutual coupling between the radiating parts within lower volumes of small handheld devices is the primary design issue for these types of antenna systems. Increased spacing between the antennas or polarization diversity can be used to accomplish this. As the distance between the antennas is increased, the volume increases, but cross polarized antenna shapes are typically designed with complexity. Radiation pattern variety, spatial diversity, and polarization diversity are some effective strategies for X-band MIMO system implementation. Using two asymmetric "F" type structures with a very compact fractured ground plane, space variety is produced in this paper.

II. MIMO ANTENNA DESIGN AND ANALYSIS:

A 2x2 MIMO antenna for an X-band system was specifically built. A very small fractured ground plane surrounds two asymmetric "F" type components that make up the antenna. 25x13x0.254 mm3 is the total volume of the

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antenna geometry. Using a Rogers substrate (5880), the suggested antenna system was built with relative permittivity, dielectric loss tangent, and height values of 2.2, 0.0009, and 0.254 mm, respectively. CST microwave studio has been used to do a thorough parametric investigation on a single designed antenna element. Table 2 displays the total geometric variables' final values. Because to its wide band properties and improved performance in the S, C, and X bands, the "F" shaped patched monopole design is chosen. The detailed evolution process of the structure is given below. The structure and dimensional parameters of the design are represented in **Fig. 1** and **Table 1** shows the associated dimensional parameter values.

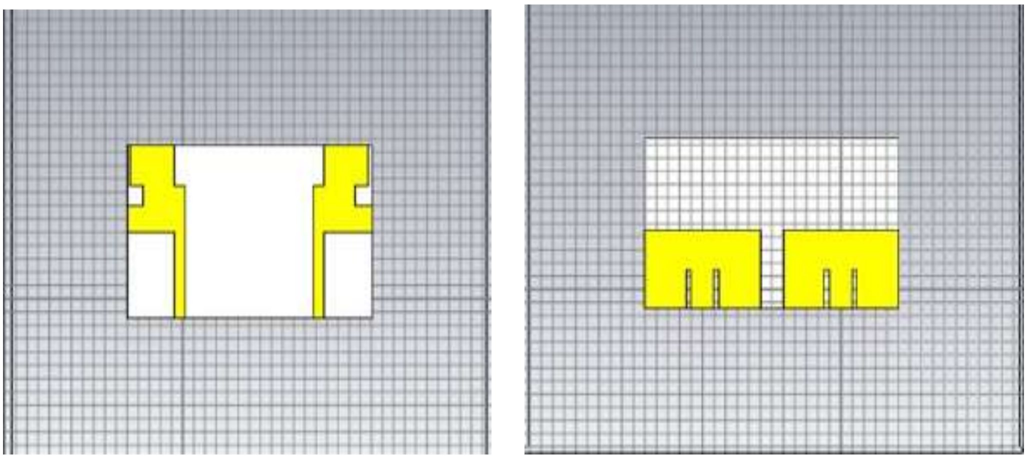

Figure 1: Patch and Ground

Table 1: Proposed MIMO Antenna Parameters with Values.

Parameter	**L**	**W**	L_1	L_2	**Ls**
Value (mm)	13.01	21.40	3.5	2	6
Parameter	L_f	L_g	W_1	W_2	W_3
Value (mm)	6.5	6	5.2	3.7	0.4
Parameter	**H**	**Wf**	**Wg1**	**Wg2**	**Ws**
Value (mm)	0.9	0.4	10	1.72	0.6

The single F-shaped patch's total measurements have been tuned to produce the X-band characteristics. The same plane has reciprocated a second F-shaped patch in order to integrate a 2 2 MIMO antenna array. The input impedance of 50 is resonant at both antenna ports. A spacing of 13.9 mm, which corresponds to a half wavelength at the operating frequency's upper limit, has been carefully chosen to minimise coupling between the two radiating elements. In addition, a very small ground plane with dimensions of 10 3 mm2 has been included, which is a compact fragmented ground plane. At the resonant frequency band, the fractured ground plane was helpful in achieving the desired port impedance.

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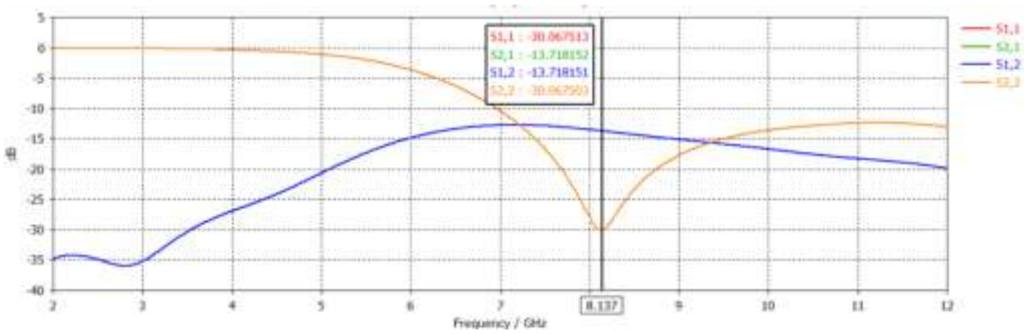
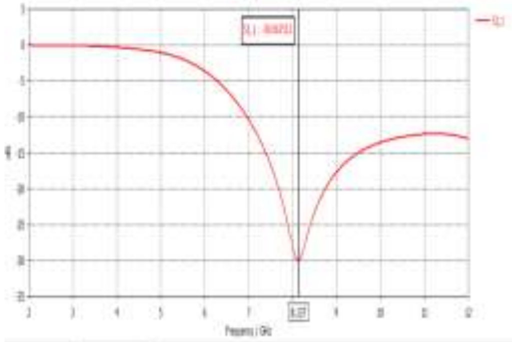


Figure 2: S-parameters



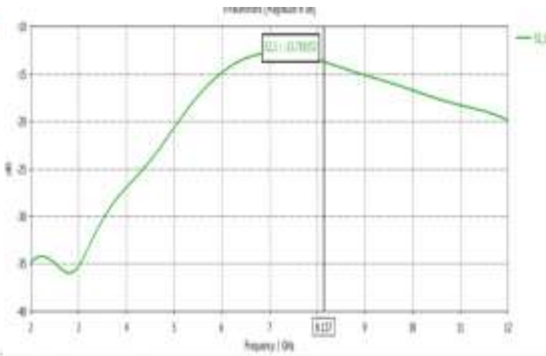


Figure 3: Evolution Results of S11

Figure 4: Evolution Results of S21

III. RESULTS AND DISCUSSIONS:

(i) S-Parameters: The relationships between ports in an electrical system's scattering parameters describe the input-output interactions. A network must be described in terms of waves rather than voltage or current, especially at high frequency. Thus, power waves are used in S-parameters. The measured S-parameter values are checked with simulated ones and these are represented in **Fig. 2**. Both are in good agreement except for a small deviation at mid-band frequencies.

(ii) Radiation Performance: Far-field refers to a field that is located outside of the antenna's range. The radiation influence is strong in this area, hence the additional name of radiation field. Many antenna characteristics, including antenna directivity and radiation pattern, are only taken into account in this area.

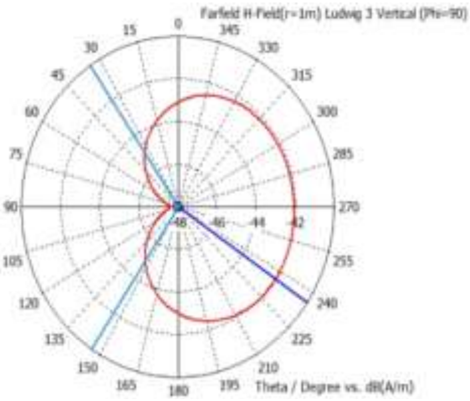


Figure 5: H-field at 8. 14GHz

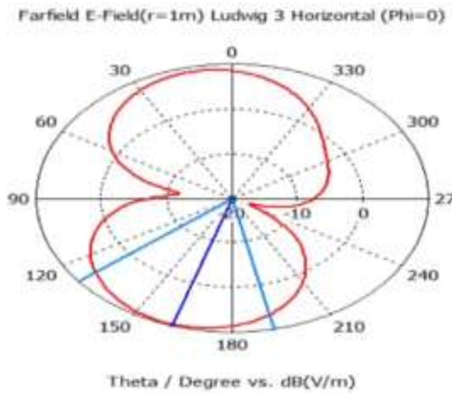


Figure 6: E- field at 8.14GHz

(iii) MIMO Performance: For analysis of the diversity performance of any MIMO structure, the MIMO diversity metrics ECC and DG are significant.. The ECC is represented here using S-parameters and it is represented in **equation (1)**. Fig.7 demonstrates the contrast between ECC

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values for simulation and measurement. The diversity gain (DG) is calculated using the ECC parameter and these are represented in **equation (2)**. Fig.8 illustrates a comparison of measured and simulated DG. The suggested MIMO antenna's ECC and DG values are below 0.005 and above 9.99 dB throughout the entire band, respectively.

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

$$\mathrm{DG} = 10\sqrt{1 - \mathrm{ECC}^2} \quad (2)$$

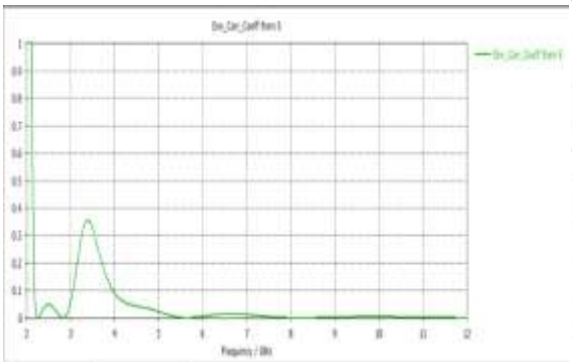

Figure 7: ECC Results.

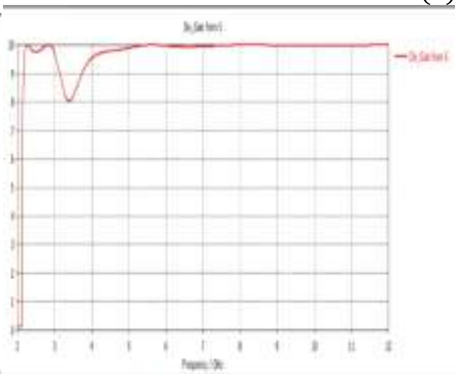

Figure 8: DG Results.

(iv) VSWR: Voltage Standing Wave Ratio or Standing Wave Ratio is the abbreviation for VSWR (SWR). VSWR is a result of the reflection coefficient, which expresses the power reflected from the antenna. If s11, reflection coefficient, or return loss are used to determine the reflection coefficient, the following formula can be used to determine the VSWR:

$$VSWR = \frac{1 + |\Gamma|}{1 - |\Gamma|}$$

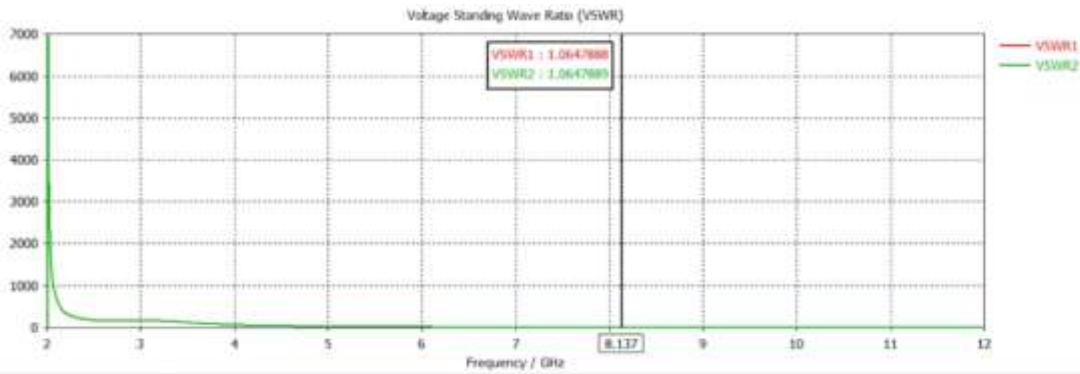

Figure 9: VSWR

(v) REFERENCE IMPEDENCE: S characteristics are determined by reference impedance, a numerical value. You require the reference impedance if you have S-Parameters and want to know information about voltages and currents (or vice versa).

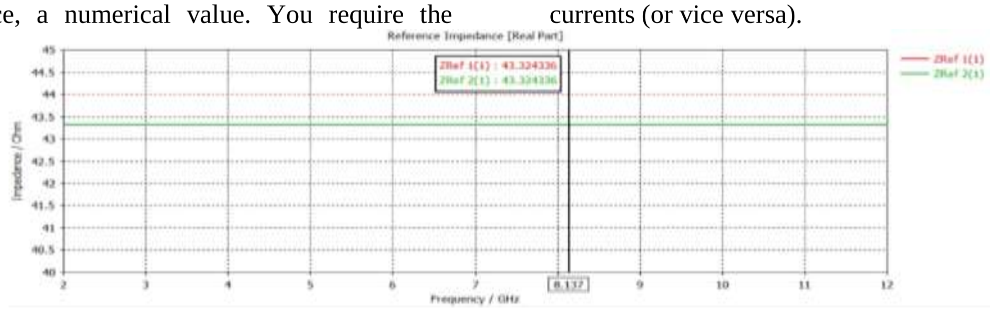

Figure 10: REFERENCE IMPEDENCE

(vi) EFFICIENCY: Antenna efficiency is the ratio of the power given to the antenna (Ps) to the power supplied by the antenna (Prad). A perfect antenna is 100% efficient, meaning it transmits all of the power applied to it. But in reality, a decent antenna only transmits between 50 and 60 percent of the power that is applied to it.

$$Antenna\ Efficiency = \frac{P_{RAD}}{P_T}\ \%$$

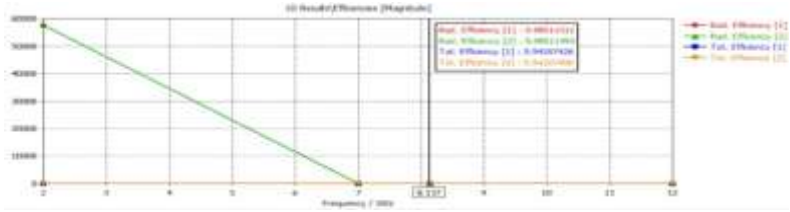

Figure 11: EFFICIENCY

IV. CONCLUSIONS:

The presented work deals with the Novel-structured MIMO Antenna for X-Band Applications. The antenna's operating range is 8 to 12 GHz, with isolation of more than 20 dB for the vast majority of the band. The construction is created and developed on a 25 x 13 mm^2 Rogers's substrate. Efficiency (86%), peak gain (2.5-4.6 dBi), and field patterns are used to examine the radiation performance of the suggested MIMO antenna. Bore sight patterns are attained with properly designed parameter values. The MIMO diversity metric are ECC and DG values are simulated. Because of its compactness, the suggested MIMO antenna is the best suitable portable for Mobile Trafficking Applications.

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