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INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)

ISSN NO. 2320-5407

Article DOI: 10.21474/IJAR01/22233
DOI URL: http://dx.doi.org/10.21474/IJAR01/22233

RESEARCH ARTICLE

DESIGN OF DGS INCORPORATED MICROSTRIP WIDE BAND MIMO ANTENNA AT SUB-6 GHZ FOR 5G APPLICATIONS

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Manuscript Info

Manuscript History
Received: 04 September 2025
Final Accepted: 06 October 2025
Published: November 2025

Key words:-
5G, DGS, Incet feed, MIMO, Patch Antenna.

Abstract

During the present day of wireless communique systems, the main concerns are always the need for high data rate,strong channel capacity, and reliability.The current 5G regulations have the guts to provide enormous data transfer rates, rapid transmission, and wide connectivity among devices.For 5G NR n-77,n-78, n-79, and n-48 band applications, a two element defected ground structure (DGS) integrated micro strip wide band MIMO antenna was presented in this communication. In this case, two ground plane rectangular looping slots were used to mimic the DGS. Both antenna patches were fed using the incet approach. This DGS loaded MIMO structure has dimensions of 60 x 35 x 1.6 mm3 in terms of length, width, and height, and it was installed on a FR4 substrate (dielectric constant 4.4). With a core frequency of 3.69gh z, this embedded antenna radiating structure resonated in a broad spectrum that stretched from 3.39ghz to 5.03ghz. The greatest gain was 5.63 dbi, and over 89.3% efficiency was achieved across the wide band. According to the examined results, DG is roughly 10db, ECC is less than 0.1, and isolation is less than -15db. According to the data taken from the suggested antenna, it can cover the 5G NR n-77, n-78, n-79, and n-48 bands with a considerable amount of bandwidth, gain, and efficiency. For 5G mid-band wireless communication systems, the antenna may therefore be a viable option.

Introduction:-

The rapid growth of wireless consumer goods necessitates improving the communication quality of 5G wireless technology. Fast data rates, very low latency, more reliable communication, lower energy usage, D-to-D connectivity, and driverless cars are just a few of the amazing things that 5G promises to bring to the globe. 5G technology has the ability to increase Internet data accessibility and optimize spectrum utilization. The spectrum of 5G technologies is constantly growing because of these amazing qualities. Current heterogeneous wireless networks require operating networks to progressively provide more capacity due to high data transmission rates. Increased internet data access and spectrum utilization resulting from the constant, rapid growth of network traffic are the main challenges facing 5G. Communication devices that operate at frequencies lower than 6 ghz are found to be in high demand. Therefore, to create wireless operational networks that can progressively supply growing capacity, high-gain metallic radiators that can operate below 6 ghz for efficient signal emission and reception are needed [1]. Significant radiation enhancement factors are provided by the use of DGS and MIMO techniques in radiating structure implementations, which provide massive data speeds, respectable channel capacity, and minimal co-channel interference [2]. In order to operate below 6 ghz with notable radiation properties, the researchers in this paper created a wideband sub-6 ghz dual element MIMO radiator.

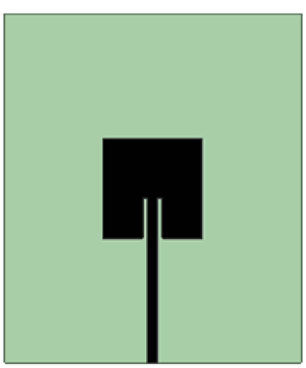
Literature Survey:-

The need for 5G cellular equipment is continuing to grow at an exponential rate [3] [4]. The context of 5G, which demand substantial improvement in the reliability of transmission and ability of channels while avoiding interruptions due to the continuous surge in network traffic and node connection strength, considerable isolated MIMO antennae are necessary to enhance both capacity as well as signal propagating reliability while lowering multiple-path and concurrent channel interference [5]. Higher data transmission speeds and long-distance connectivity are enabled by a radio spectrum for 5G sub-6 ghz. For 5G wireless communications, all nations are deploying the spectrum below 6 ghz to the fullest extent possible [11], and effective MIMO antenna design is underway in this range. The importance of the LTE 42, LTE 43, and LTE 46 channels was demonstrated in the work [3] by Naveen Jaglan et al., 2021, which also introduced single band and multiband MIMO emitters for 5G-smartphones. "Regardless of any external decoupling arrangement, significant isolation can be achieved by the proper design of the MIMO antenna, without indigent the efficiency," he said.

"Some isolation enhancement techniques, such as extending the ground plane, EBG models, parasitic components, T-shaped slots, etc., may degrade the efficiency in array antennas." The MIMO radiators with notable radiation characteristics were given in the study [3], but the obtained gain did not match the equivalent isotopically radiated power (EIRP). In order to increase gain and bandwidth, DGS integration into antenna technology is becoming more and more significant [6]. MIMO antenna systems were used in the publications [7] and [8], and DGS was used to improve gain, data transfers, and channel capacity. Designing a wide-band significant gain DGS included micro strip MIMO antenna array at sub-6ghz was the driving force behind this project. It is capable of meeting 5G's requirements, which include high data rates, robust channel density, and less concurrent channel interference.

Design Of Proposed Antenna:-

In the current era of wireless communication systems, the main concerns are always the need for high data rate, strong channel capacity, and reliability. These days, there is a greater lack of mobile communication spectrum in bands below 3ghz, which prevents users from using devices with higher connectivity and data speeds. 5G wireless communication: 5G mobile technology standards are brave enough to offer huge device connectivity, low latency communications, and high data rates. Compact yet effective antenna design is necessary for the effective rollout of 5G systems and to accommodate increased bandwidth.

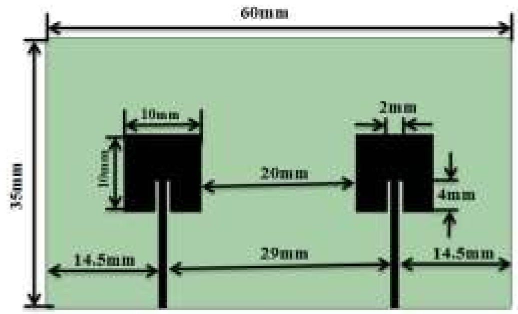


(a) Top view

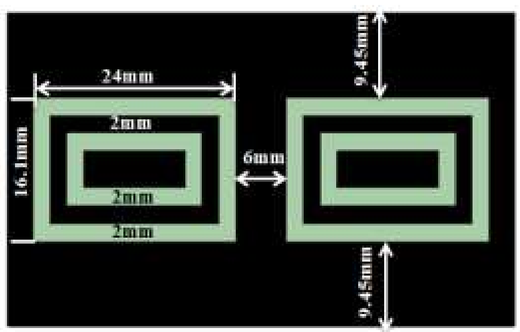
(b) Buttom view

Fig. 1.Single element antenna

For 5G-NR n-77, n-78, n-79, and n-48 applications, a two element defected ground structure (DGS) integrated micro strip wide band MIMO antenna was presented in this communication. Initially, a single element antenna was used to observe the radiation performance, as illustrated in Fig. 1. A dual element MIMO antenna with improved features was then modeled. Here, as illustrated in Fig. 2(b), the DGS was modeled using two rectangular looped slots on the ground plane. The model for the two incet-fed 10 × 10 mm patches is displayed in Fig. 2 (a). This modified MIMO patch structure, which had dimensions of 60 x 35 x 1.6 mm3 in terms of length, breadth, and height, was installed on a FR4. With a core frequency of 3.69GHz, this is functioning in a broad spectrum that stretched from 3.39GHz to 5.03GHz.



(a) Top view



b) Bottum view

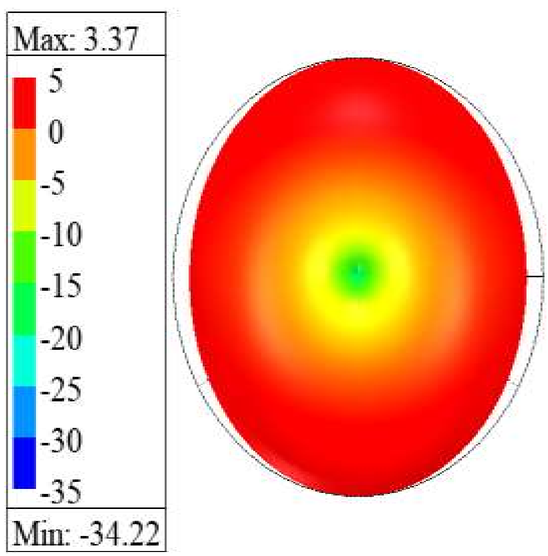


Fig. 4. Gain at central frequency of single element antenna

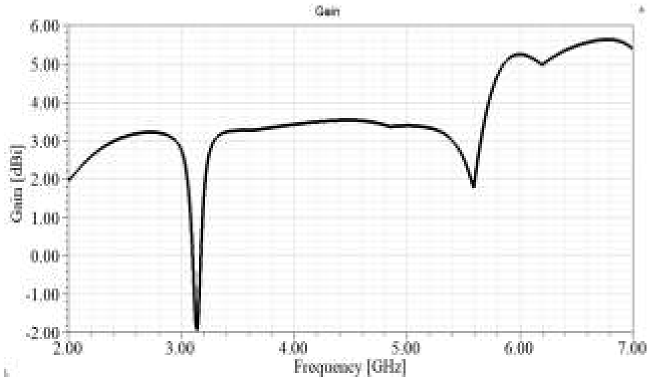


Fig. 5. Gain of single element antenna over the sweep

As previously mentioned, the suggested antenna had a wide band resonance, with a central frequency of 3.69GHz and a range of 3.32-4.95GHz. The 3D gain polar plot at 3.69GHz in Figure 4 shows the peak gain of 3.35dBi that was recorded at this core frequency. The highest gain achieved over the resonant band is 3.6 dBi. The gain plot of the suggested antenna design, displayed in Figure 5, illustrates this. Above the band, a radiation effectiveness of above 70% was noted. It can be seen in Fig. 6's return efficiency plot of the suggested antenna configuration.

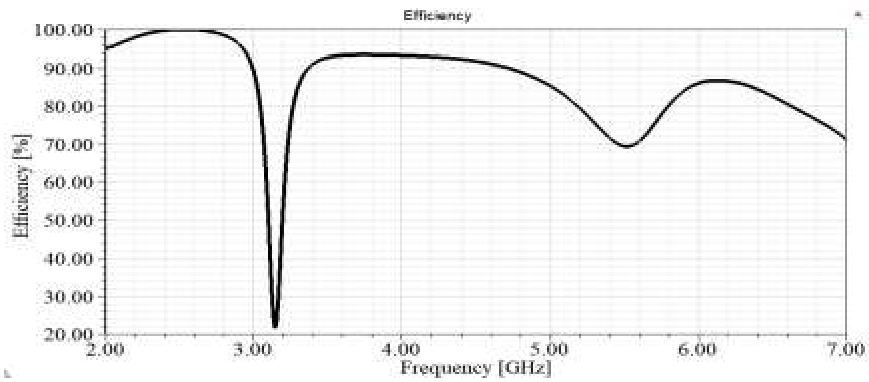


Fig. 6. Efficiency of single element antenna over the sweep

Fig. 7 displayed the 2D E-plane and H-plane radiation patterns. With better results than a single element antenna, the principle planes Co and Cross polarizations are calculated at center frequency and displayed in Fig. 8 and 9. Low cross polarization was noted here in contrast to co-polarization. Thus, the suggested antenna works well for both sending and receiving.

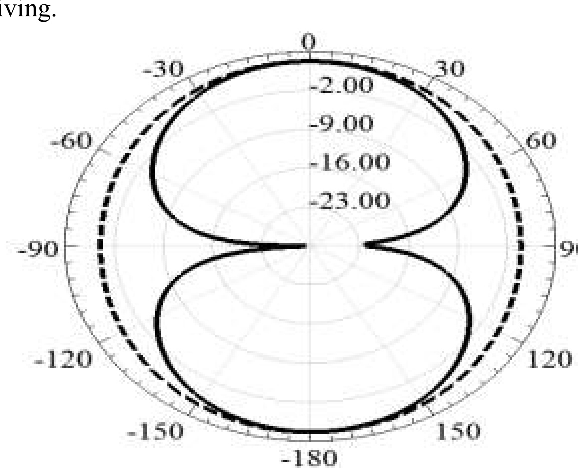


Fig. 7. Principle Plane Patterns at central frequency of single element antenna

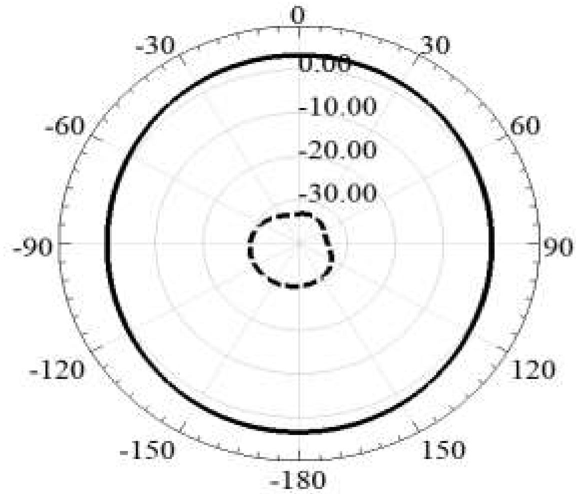


Fig. 8. H Plane Co & Cross polarizations at central frequency of single element antenna

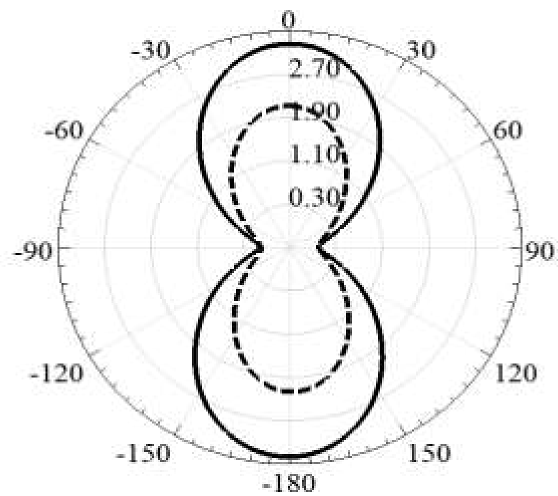


Fig. 9. E Plane Co & Cross polarizations at central frequency of single element antenna

With a core frequency of 3.69 GHz, the suggested DGS loaded micro strip wide band MIMO antenna resonated in the 3.39 GHz–5.03 GHz band. That is, the 5G NR n-77, n-78, n-79, and n-48 bands can be covered by this antenna. It is shown in Fig. 10's return losses plot of the suggested antenna design.

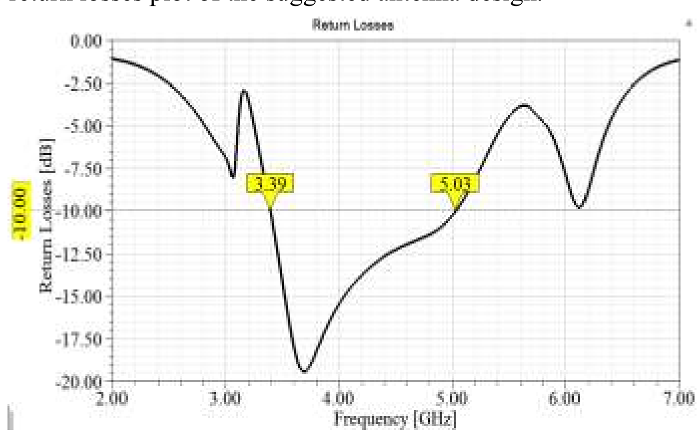


Fig. 10. Reflection Coefficient plot of Proposed MIMO Antenna over the sweep

The ratio of standing waves to voltage was less than two for both resonated bands. Figure 11 shows the proposed antenna's VSWR.

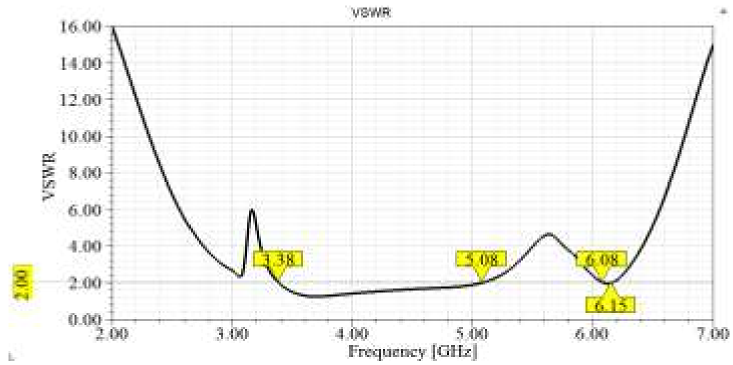


Fig. 11. VSWR plot of Proposed MIMO Antenna over the sweep

The highest gain achieved over the resonant band is 6.2 dBi. The gain plot of the suggested antenna design, displayed in Fig. 12, illustrates this. Over the band, a radiation effectiveness of over 89.3% was noted. It can be seen in Fig. 13's return efficiency plot of the suggested antenna configuration.

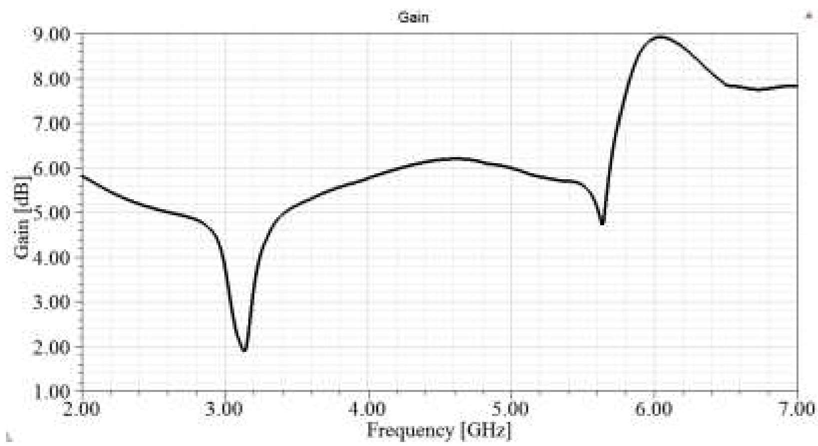


Fig. 12. Gain plot of Proposed MIMO Antenna over the sweep

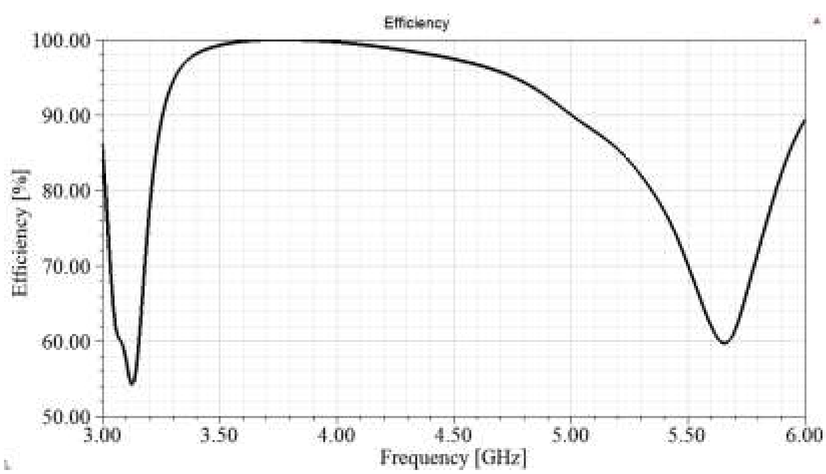


Fig. 13. Efficiency plot of Proposed MIMO Antenna over the sweep

As previously mentioned, the suggested antenna had a wide band resonance, with a center frequency of 3.69GHz and a range of 3.39-5.03GHz. Figure 14 shows the 3D gain polar plot at 3.69GHz, which shows the peak gain of 5.63dBi at this core frequency. Fig. 15 displayed the 2D E-plane and H-plane radiation patterns.

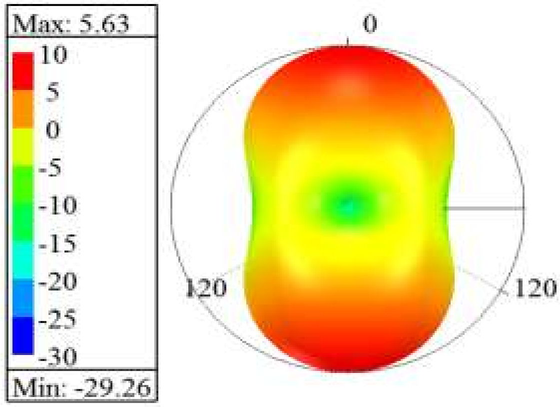


Fig. 14. 3D Gain plot of Proposed Antenna at 3.69GHz

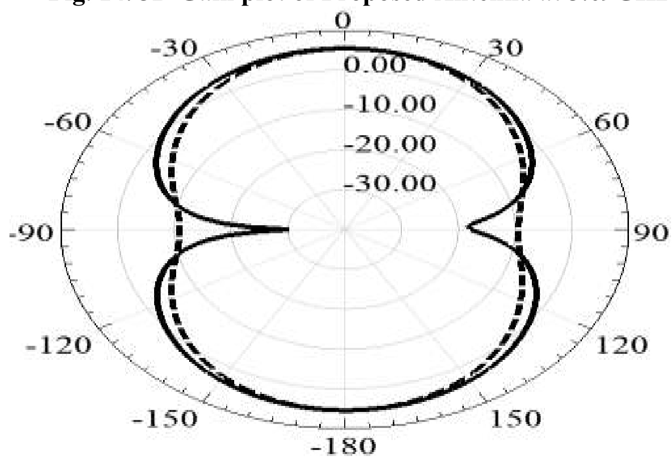


Fig. 15. 2D principle plane patterns of Proposed MIMO Antenna at 3.69GHz

The primary planes With better results than a single element antenna, Co and Cross polarizations are calculated at the center frequency and displayed in Figures 16 and 17. Low cross polarization was noted here in contrast to co-polarization. Thus, the suggested antenna works well for both sending and receiving.

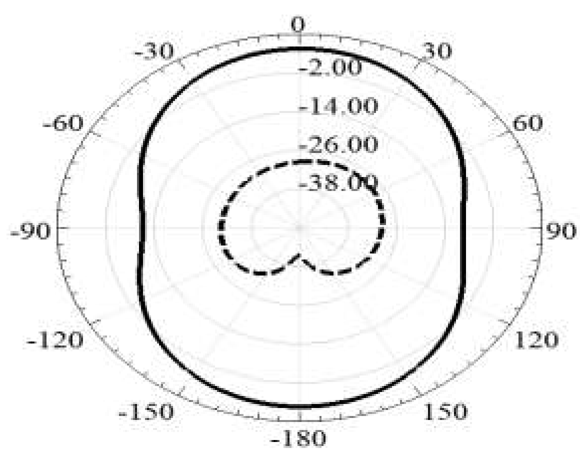


Fig. 16. 2D H plane Co & Cross polarizations of Proposed MIMO Antenna at 3.69GHz

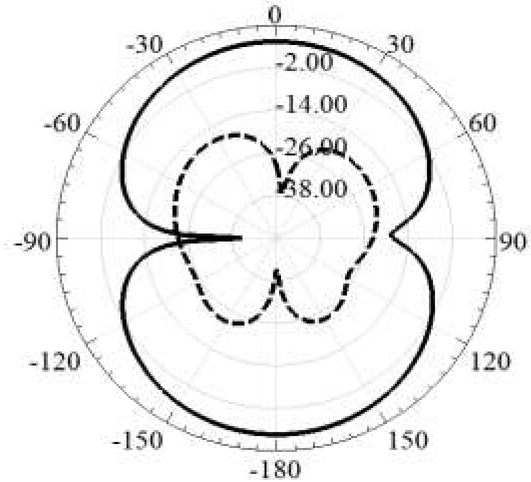


Fig. 17. 2D E plane Co & Cross polarizations of Proposed MIMO Antenna at 3.69GHz

Additionally, the suggested MIMO antenna's isolation, ECC, and diversity gain are noted. Figure 18 illustrates that the suggested MIMO antenna structure's isolation was less than -15 dB, which is suggestible. Figures 19 and 20 demonstrate that the Envelop Correlation Coefficient (ECC) was less than -0.1 and the Diversity Gain (DG) was greater than 9.9dB, respectively. Regarding the properties of MIMO antennas, these findings are suggestive.

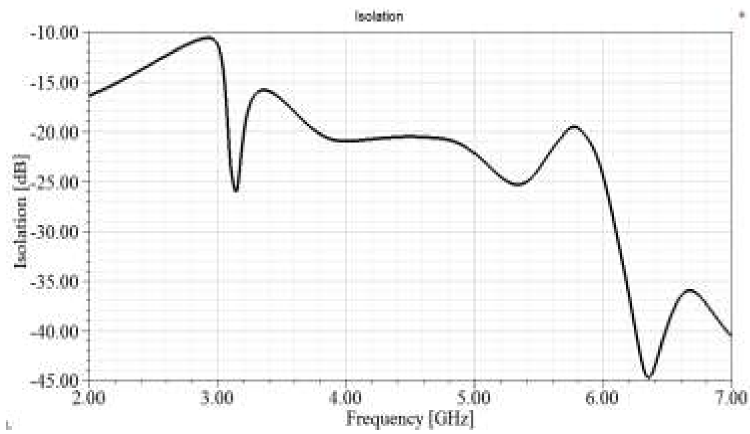


Fig. 18. Isolation of Proposed MIMO Antenna Structure

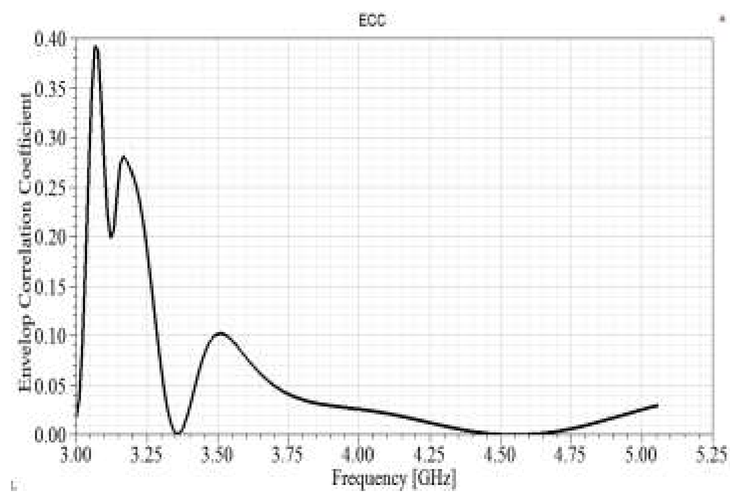


Fig. 19. ECC of Proposed MIMO Antenna Structure

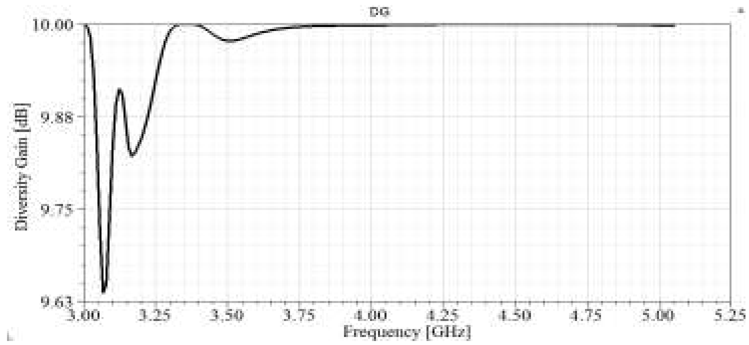


Fig. 20. DG of Proposed MIMO Antenna Structure

Table I lists the results that were extracted from the simulation of the suggested MIMO antenna. According to the data taken from the suggested antenna, it can cover the 5G NR n-77, n-78, n-79, and n-48 bands with a considerable amount of bandwidth, gain, and efficiency. For 5G mid-band wireless communication systems, the antenna may therefore be a viable option.

Table I. Rresults Of Proposed Antenna

Radiation Parameter	Obtained result
Resonant Frequency Band	3.39GHz-5.03GHz
Central Resonant Frequency	3.69GHz
Return Losses at CRF	-19.38 dB
Band width	1.64 GHz
Gain at CRF	5.63 dBi
Maximum gain	6.2 dBi
Efficiency	>89.3 %
Isolation	<15dB
ECC	<0.1
DG	>9.9dB

Table Ii. Rresults Of Proposed Antenna

Reference	Dimensions (mm x mm x mm)	Resonated Freq. band (GHz)	Isolation (dB)	ECC	Max. Efficiency (%)
[9]	37λ × 3.17 λ × 0.579 λ	6.1–7.2	<-8dB	-	*65*
[10]	0.21 λ × 9.34 λ × 0.748 λ	6.2–6.8	<-3dB	-	*78.5*
[11]	1.05 λ × 1.05 λ × 0.02 λ	3.08–7.75	<-15.5	< 0.004	*84*
[12]	1.16 λ x 2.5 λ x 0.013 λ	3.1–3.85 4.8–6	<-17	<0.06	*75*
[13]	5.18 λ x3.45 λ x0.018 λ	3.45-3.55	<-14.9	<0.12	*64*
[14]	3.3 λ x1.65 λ x0.03 λ	2.4-3.1 5.1-5.8	<-25	<0.3	-
[15]	2.17 λ x4.02 λ x0.018 λ	3.4-3.65	<-35	<0.0001	*90*
[4]	0.35 λ x2.42 λ x0.028 λ	3.42-3.57 4.86-5.74	<-16	<0.1	81.14 99.12
This Work	0.73 λ x 0.43 λ x0.019 λ	3.39-5.03	<-15	<0.1	99.5

Table II lists the comparisons between the results of the state-of-the-art findings from the literature survey and the extracted results from the simulation of the suggested MIMO antenna. The extracted results from simulation of proposed MIMO antenna are listed in Table II. According to the data taken from the suggested aerial, it covered the 5G NR n-77, n-78, n-79, and n-48 with a considerable amount of bandwidth, gain, and efficiency. For 5G mid-band wireless communication systems, the aerial may therefore be a viable option.

Conclusion:-

In this communication, a two element defected ground structure (DGS) incorporated micro strip wide band MIMO emitter was presented for 5G NR n-77, n-78, n-79 and n-48 applications. Here, the DGS was modeled using two rectangular looped slots on ground plane. Incet feeding technique was employed to both antenna patches. This DGS loaded MIMO structure was mounted on FR4 material with in dimensions of 60 x 35 x 1.6mm3. This embedded antenna radiating structure was resonated in a wide band, ranging from 3.39GHz-5.03GHz with central frequency 3.69GHz. The 5.63 dBi was the maximum gain and greater than 89.3% efficiency was obtained over the wide band. The evaluation results show that isolation <-15dB, ECC <0.1 and DG approximately to 10dB. According to the data taken from the suggested aerial, it covered the 5G NR n-77, n-78, n-79, and n-48 with a considerable amount of bandwidth, gain, and efficiency. For 5G mid-band wireless communication systems, the aerial may therefore be a viable option.

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