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Parasitic Om Inspired Octagon Microstrip 5g Antenna At N-260 And N-261 Bands

K. Naga Raju[1], R. Sujatha[2], T. Praveen kumar[3]

Department of Electronics and Communication Engineering, Bapatla Engineering College, Bapatla, Andhra Pradesh, India.

Abstract: - The demand for high data rate, good channel capacity, and reliability is always the primary area of concern in the modern era of wireless communication systems. The 5G mm-wave technology standards have the guts to deliver high data rates, low latency communications, and massive device connectivity. In this communication, a compact millimetre wave dual band parasitic om inspired octagon microstrip antenna was presented for 5G applications. Here, the radiating patch was modelled by incorporating om shaped parasite and fed using strip feeding technique. This printed radiating structure was mounted on one side of Rogers RT/duroid substrate (dielectric constant 2.2) with in dimensions of 6.8 x 6.8 x 0.8 mm^3 with respect to length, width and height. Plane metal ground with a rectangular slot was filled on bottom side of substrate. This embedded radiating structure was resonated in dual mm-wave wide bands, 27.24GHz-28.88GHz and 36.38GHz-38.14GHz. The 7.73 dBi and 6.55dBi were the maximum gains obtained over the both bands respectively. The efficiency greater than 80% was observed over both operating bands. The evaluated results show that, the proposed antenna capable to operate in the 5G NR n-260 and n-261 bands with significant bandwidth, gain and efficiency. Thus the antenna can be considered as a potential candidate for 5G mm-wave wireless communication systems.

***Keywords**: Parasitic, 5G, Dual Band, Partial Ground plane, mm-wave frequencies.*

1. Introduction

The demand for high data rate, good channel capacity, and reliability is always the primary area of concern in the modern era of wireless communication systems. The Compact designs of antennas made it possible for them to resonate at higher frequencies, thus to enable the devices to attain higher data rates as compared to 4G technology. In order to support higher bandwidth 5G require high frequency range (millimetre waves) [1].

Previous researchers introduced lot of antenna design techniques to enhance the radiation. Though that techniques used in antenna design, there improvement in one antenna property is frequently accompanied by decline in its other property performances. For example increased substrate thickness in [2] to enhance band width, but increases of substrate thickness and height of antenna can degrade antenna efficiency, since more input power will be wasted, due to that insufficient power will be delivered by antenna [3].

A slot antenna consists of a metal surface, usually a flat plate, with one or more holes or slots cut out. When the plate is driven as an antenna by an applied radio frequency current, the slot radiates electromagnetic waves in a way similar to a dipole antenna. The shape and size of the slot, as well as the driving frequency, determine the radiation pattern. Slot antennas are usually used at UHF and microwave frequencies at which wavelengths are small enough that the plate and slot are conveniently small. At these frequencies, the radio waves are often conducted by a waveguide, and the antenna consists of slots in the waveguide; this is called a slotted waveguide antenna. Multiple slots act as a directive array antenna and can emit a narrow fan-shaped beam of microwaves. They are used in standard laboratory microwave sources used for research, UHF television transmitting antennas, antennas on missiles and aircraft, sector antennas for cellular base stations, and particularly marine radar antennas. A slot antenna's main advantages are its size, design simplicity, and convenient adaptation to mass production using either waveguide or PC board technology.

During the last decade, progress in wireless mobile communications with higher data rates is reported. The hunger for endless users joining the network with high rates of information being sent and received has been the driving force behind the boom of the auspicious Fifth-Generation (5G) technology. The data rates have massively exploded to reach 100 times nowadays and as expected, 1000 times by 2030 [5]. The 30-300 GHz Millimeter-wave spectrum is anticipated to be dominant because of its high rate of data transmission to ful ll the needs of the proliferation of 5G applications [6]-[9]. The frequency bands of interest for the fifth generation are 28 GHz, 38 GHz, 60 GHz, and 73 GHz [10].The Federal Communications Commission (FCC) has allocated unlicensed bands in the range 59-64 GHz for high speed communications and short range communication [11]. The International Telecommunications Union (ITU) has allocated certain bands for mobile communication in the fifth generation at 28, 38, 60, and 73 GHz [12].

Antenna design in the mm-wave range poses a set of challenges to the antenna community. Bandwidth augmentation and size reduction are dominant design attentions for the applied utilization of printed antennas. For new RF designs the antenna elements should have low profile, dual or multiple bands of operations, low cost, modest planar design, and squeezed size [13]. Mobile phones are restricted by a very limited space which necessitates the designers to reduce the antenna size with good performance.

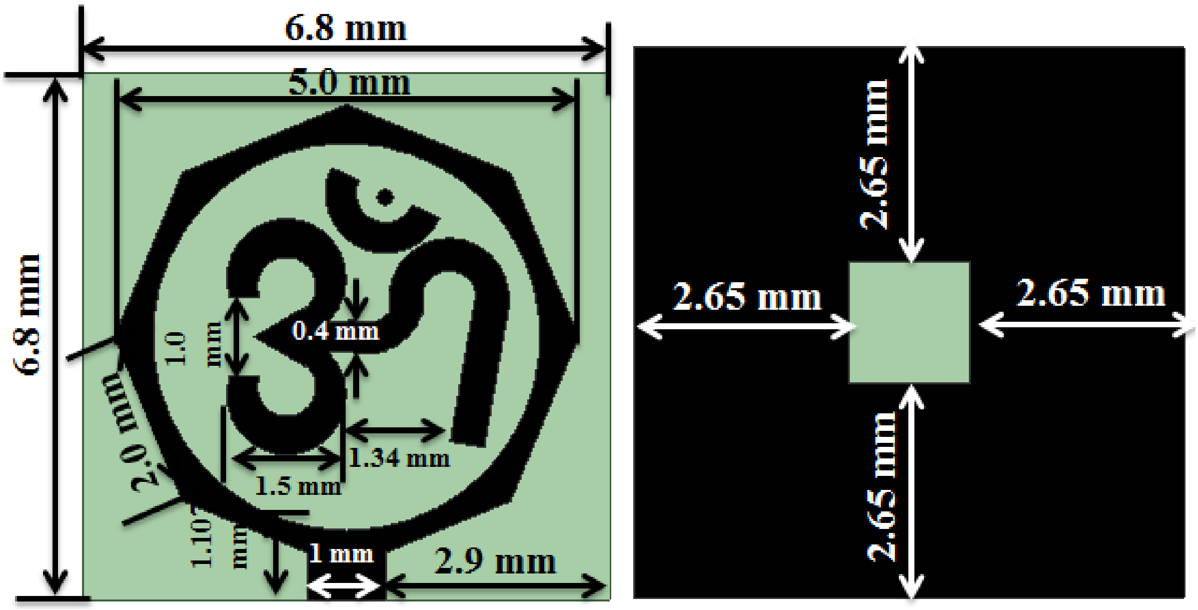
Recently, a lot of antennas designed to be employed in mobile phones for fifth generation are provided. Several planar mm-wave antennas with single band are reported in [14]-[17]. Printed mm-wave antennas with dual-band are reported in [18]-[20]. In [18] the designed dual-band antenna achieves a bandwidth of 3% at 28 GHz and 1.9% at 38 GHz. A reconfigurable dual band antenna with ideal switching concept is introduced in [19] but it was not suitable for practical implementation. In [20], narrow bandwidth dual-band antenna at 37.5/47.8 GHz is proposed.

In this communication, a parasitic om inspired dual band mm-wave microstrip antenna was presented for 5G NR n-260, and n-261 band applications. The antenna was modeled using modified om shaped slotted octagonal patch, rectangular slotted square looped ground plane with in dimensions of 6.8 x 6.8 x 0.8 mm^3 with respect to length, width and height. The modified rectangular patch was etched on Rogers RT/duroid substrate (dielectric constant 2.2), this antenna was grounded by 6.8 x 6.8 mm^2 dimensioned plane metal with 1.5 x 1.5 mm^2 dimensioned rectangular slot. This embedded antenna radiating structure was resonated in two mm-wave bands, the first band was 27.24 GHz - 28.88 GHz band with central frequency 28.06 GHz and second one was 36.38GHz-38.14GHz with central frequency 37.3 GHz.

2. DESIGN AND ANALYSIS

The demand for high data rate, good channel capacity, and reliability is always the primary area of concern in the modern era of wireless communication systems. Present days mobile communication spectrum, below 3GHz bands is faces more shortage and not able to serve people with more device connectivity and data speed. 5G wireless communication: The 5th generation mobile technology standards have the guts to deliver high data rates, low latency communications, and massive device connectivity. For the efficient deployment of the 5G systems and in order to support higher bandwidth requires the design of compact yet efficient antennas at mm wave frequencies [27]-[33].

In this communication, an parasitic om incorporated microstrip dual band antenna was presented for 5G NR n-260 and n-261 band applications. Here, the radiating patch was modeled by incorporating om parasite on patch and fed using strip feeding technique. This printed rediating structure was mounted on one side of Rogers RT/duroid substrate (dielectric constant 2.2) with in dimensions of 6.8 x 6.8 x 0.8mm^3 with respect to length, width and height as shown in Fig. 1 (a). Planed metal ground was filled on bottom side of substrate as shown in Fig. 1 (b). This embedded antenna radiating structure was resonated in dual bands, ranging from 27.24GHz-28.88GHz with central frequency 27.54GHz and 36.38GHz-38.14GHz with central frequency 37.3GHz. Strip line feeding technique was employed to the patch.



(a) Top view (b) Bottom view

Fig. 1.Prototype of proposed design with dimensions

Using HFSS software the antenna was designed according to the proposed dimensions. The proposed antenna was operated in dual wide millimeter wave bands. It offers some advantages; low cost, high flexibility, harmless to human body and resistive towards environmental effects. The dimensions of proposed antenna were as shown in Fig. 1 and Table I.

TABLE I. OPTIMIZED DIMENSIONS OF PROPOSED ANTENNA

Parameter	**Alias Used**	**Size in mm**
Length of substrate	Lsub	6.8
Width of substrate	Wsub	6.8
Hight of substrate	Hsub	0.8
Length of Ground	Lg	6.8
Width of Ground	Wg	6.8
Width of feed line	Wtl	1.0

3. RESULTS AND DISCUSSION

The proposed parasitic om microstrip dual band antenna was resonated in the bands 27.24GHz-28.88GHz with central frequency 27.54GHz and 36.38GHz-38.14GHz with central frequency 37.3GHz. That is this antenna capable to operate in 5G NR n-260 and n-261 bands. It can observe in return losses plot of proposed antenna design, which was shown in Fig.2.

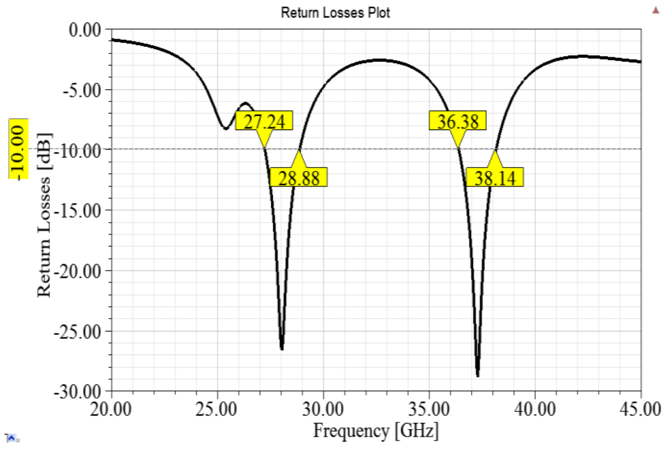


Fig. 2.Return Loss plot of Proposed Antenna

At both resonated bands, the voltage to standing wave ratio was less than 2. The VSWR of proposed antenna were given in Fig. 3.

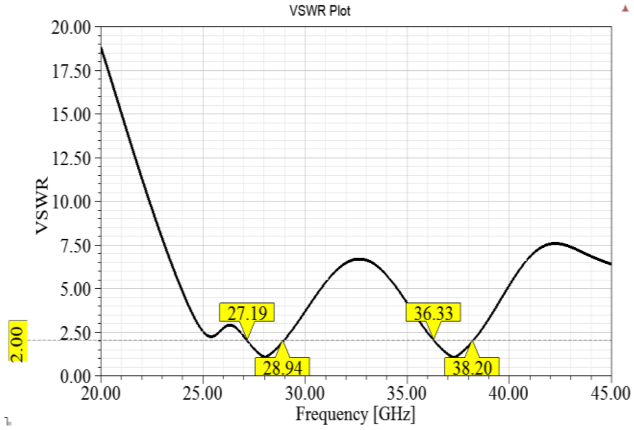


Fig. 3.VSWR plot of Proposed Antenna

The 7.73 dBi and 6.55 are the maximum gains obtained over the both resonated bands respectively. It can observe in Gain plot of proposed antenna design, which was shown in Fig. 4. Greater than 80% radiation efficiency was observed over the both resonated bands respectively. It can observe in return efficiency plot of proposed antenna design, which was shown in Fig. 5

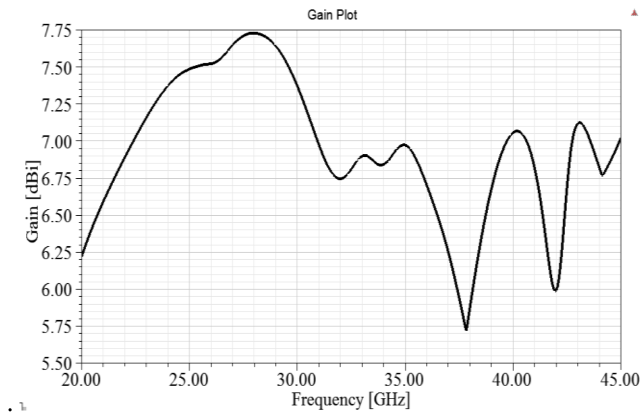


Fig. 4.Gain plot of Proposed Antenna

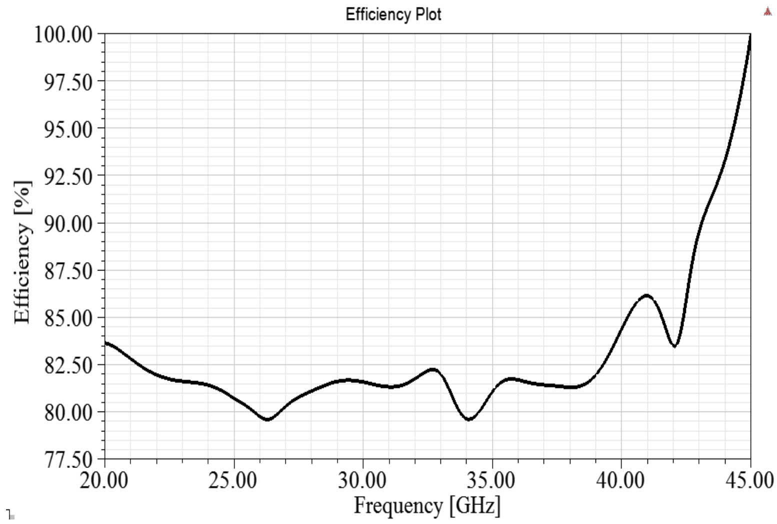
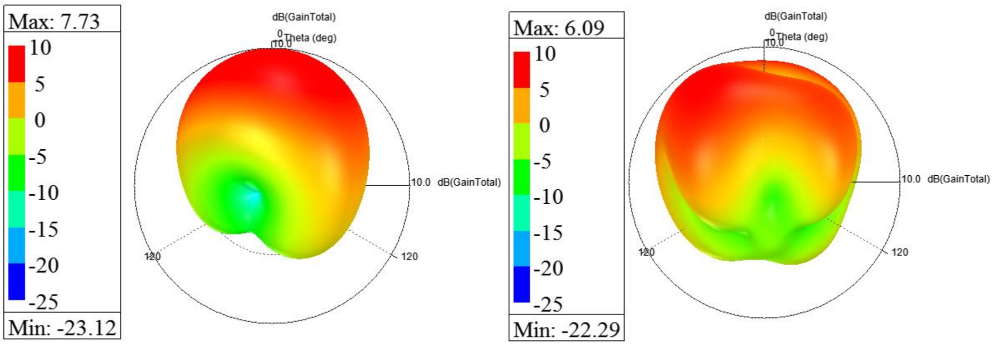


Fig. 5.Efficiency plot of Proposed Antenna

It was already stated that the proposed antenna was resonated in two mm-wave bands, the first band was 27.24GHz-28.88GHz band with central frequency 27.54GHz and second one was 36.38GHz-38.14GHz with central frequency 37.3GHz. The peak gain observed at first band central frequency 28.06GHz was 7.73dBi, which was given in 3D gain polar plot at 28.06GHz in Fig. 6. (a).



(a) (b)

Fig. 6.3D Gain plot of Proposed Antenna at (a) 25.44GHz (b) 40.89GHz

Similarly the peak gain observed at second band central frequency 37.3GHz was 6.09dBi, which was given in 3D gain polar plot at 37.3GHz in Fig. 6 (b).

From the results extracted from proposed antenna, it was found that, the antenna capable to cover 5G NR n-260 and n-261 bands with significant bandwidth, gain and efficiency. Thus the antenna can be considered as a potential candidate for 5G mm-wave wireless communication systems.

TABLE II. RESULTS OF PROPOSED ANTENNA

Radiation Parameter	**Obtained result**
Resonant Frequency Bands	27.24GHz-28.88GHz
	36.38GHz-38.14GHz
Central Resonant Frequencies	28.06GHz
	37.3 GHz
Return Losses at	-26.5 dB

28.06GHz	
Return Losses at 37.3GHz	-28.7 dB
Band width over first band	1.64 GHz
Bandwidth over second band	1.76 GHz
Gain at 28.06GHz	7.73 dBi
Gain at 37.3GHz	6.09 dBi
Maximum gain over first band	7.73 dBi
Maximum gain over second band	6.55 dBi
Efficiency	>80 %

Finally the results obtained from proposed antenna were compared with the results of the previous related works presented in the literature. These comparisons show the significance of proposed antenna over previous works and listed in table III.

TABLE III. COMPARATIVE RESULTS OF PROPOSED ANTENNA WITH THE RESULTS OF THE PREVIOUS RELATED WORKS PRESENTED IN THE LITERATURE

Ref. No.	freq. (GHz)	Band width (GHz)	Max. Gain (dBi)	Efficiency (%)
[4]	28	1.23	6.6	>80
	38	1.06	5.86	
[21]	28	1.55	1.27	>75
	38	1.1	1.83	
[22]	28	0.45	5.2	-
	38	2.2	5.9	
[23]	28	-	5.2	-
	38		5.0	
[24]	28	2.6	7.7	-
	38	2.5	9.4	
[25]	28	-	7.9	-
	38		6.9	
[26]	28	1.47	5.1	>88
	38	4	5.7	
This work	28	1.64	7.73	>80%
	38	1.76	6.55	

4. Conclusion

In this communication, a compact millimetre wave dual band parasitic om inspired octagon patch antenna was presented for 5G applications. Here, the radiating patch was modelled by incorporating om and fed using strip feeding technique. This printed radiating structure was mounted on one side of Rogers RT/duroid substrate (dielectric constant 2.2) with in dimensions of 6.8 mm x 6.8 mm x 0.8mm with respect to length, width and height. Plane metal ground with a rectangular slot was filled on bottom side of substrate. This embedded radiating structure was resonated in dual mm-wave wide bands, 27.24GHz-28.88GHz and 36.38GHz-38.14GHz. The 7.73 dBi and 6.55dBi were the maximum gains obtained over the both bands respectively. The efficiency greater than 80% was observed over both operating bands. The evaluated results show that, the proposed antenna capable to operate in the 5G NR n-260 and n-261 bands with significant bandwidth, gain and efficiency. Thus the antenna can be considered as a potential candidate for 5G mm-wave wireless communication systems.

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