Design and Simulation of Smiley Patch Antenna for 5G Band Application

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Abstract: Fifth Generation (5G) is the most recent version, has been released at high frequencies, often known as millimetre waves. The antenna is a crucial part of wireless communication. In this paper, a Micro- strip patch antenna with partial ground plane structures for 5G mm–wave application is presented. The proposed antenna design on Rogers RT5880 substrates with tangent loss 0.0009, Epsilon 2.2 and thickness 0.8mm. A compact monopole patch antennas resonates at 26 GHz and operating band 24.4-28.2 GHz. The achieved gain 6.93 dB, return loss -25 dB and radiation efficiency 97% at resonance. The proposed antenna is simulated on CST MWS-18 version.

1 INTRODUCTION

A device that emits or receives electromagnetic waves is called an antenna. It acts as an interface between a transmitter/receiver and open space, through the conversion of electrical signals into electromagnetic waves and vice versa facilitating wireless communication. In wireless communication systems such as satellite communication, GPS, cell phones, and radar, a micro strip patch antenna is a popular antenna type. Because of their low profile, lightweight design, and simplicity in manufacturing utilizing printed circuit board (PCB) technology, these antennas are widely used (Balani, 2016), (Kraus, John, et al. , 1973). The components of a typical micro strip patch antenna are a patch, ground plane, feed line, and dielectric substrate. A patch is a radiating element that is usually composed of a conducting substance, such as gold or copper. It is positioned above a substrate that is dielectric (Agrawal, 2020). The antenna's working frequency and efficiency are influenced by the dielectric substrate, which also offers mechanical support. Teflon, Rogers, and FR4 are typical materials. On the other side of the substrate lies, a conducting layer called the Ground Plane. The feed line excites the patch. The fringing fields around the outer edges of a patch antenna cause it to radiate. The patch functions as a resonant cavity that produces electromagnetic waves when it is activated by an RF signal. The patch's size and the substrate's characteristics are the main factors that affect the resonant frequency. Micro strip patch antennas play a key role in 5G wireless networks because of their small size, low weight, simplicity of integration with printed circuit boards (PCBs), and appropriateness for high-frequency operation, especially in millimetre-wave (mm Wave) bands (24 GHz to 40 GHz and beyond). Essential parameters of 5G are high frequency operate in sub 6 GHz and mm wave band, high gain, compact size and wide band width (Agrawal, Neetu, et al. , 2021). This paper covers the design and performance characteristics of a single-band micro strip patch antenna suited for 5G technology. The Rogers 3003 substrate was used to create the micro strip planar antenna, which allowed for excellent efficiency and stable characteristics in the 26 GHz 5G operating spectrum described in the research (Slowik, Nowak, et al. , 2024). In this study, a novel 4x8 micro strip patch array antenna that operates in the 26 GHz range is presented. The suggested antenna is built on a Rogers Duroid RT5880 substrate that is 0.508 mm in height and has a dielectric constant of 2.2. The antenna simulation result exhibit excellent performance with a 1.1 GHz bandwidth, a 21.26 dBi gain, and a small dimension of 110 x 80 mm 2, all of which are highly promising for 5G V2X communications (Band, 2024). This article describes the design of a rectangular micro strip patch antenna operating in the 26 GHz band, as well as the construction of antenna arrays based on this design.

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Beam steering may be accomplished by introducing an appropriate phase difference between the array parts (Ghenjeti, Barrak, et al. , 2023). This research presents a high-gain broadband parasitic micro strip antenna operating at 26 GHz for 5G and Internet of Things applications (Pal, Bandyopadhyay, et al. , 2023). The objective of this research is to improve the antenna's gain and other radiation properties by combining many slot configurations into a single rectangular patch, which is frequently found in other 5G antennas. This antenna operates on 26 and 28 GHz band, most widely used in 5G (Şeker, Güneşer, et al. , 2019). Many MIMO antenna for 5G-band application using PCB technology is presented (Agrawal, Gupta, et al. , 2003), (Agrawal, Gupta, et al. , 2020), (Agrawal, Gupta, et al. , 2022), (Agrawal, Gupta, et al. , 2024).

2 ANTENNA DESIGN

The proposed antenna perspective view is shown in Figure 1 and geometric front view and back view is shown in Figure 2. The physical dimensions is depicted in Table 1. The CST tool optimized the design parameters after they are determined using the standard feed line and circular patch formula. The proposed antenna is design on Rogers's 5880 substrate with a relative permittivity of 2.2 and a loss tangent of 0.0009. The overall circuit board size is 27*38* 0.8 mm^3 to fit inside medium and big touch screen smart phones of today. On the top of Rogers substrate, a circular shape patch with radius of 9.7 mm is inserted and modified micro strip feed line is used with proper impedance matching.

The radiating patch includes two circular slot look like eyes, one rectangular slot as nose and half-moon shape slot as mouth, which look like as smile face. The slotted patch antenna produces desired antenna parameters. At the bottom of substrate, a partial ground plane is made with perfect conductor material instead of full ground gives good results. The ground plane size 27mm* 12.6 mm.

Table 1: Physical dimension of antenna

Parameters	w	l	fw1	fl1
Size (mm)	27	38	2.9	3.3
Parameters	fw2	fl2	gw	gl
Size (mm)	1	9.9	27	12.6

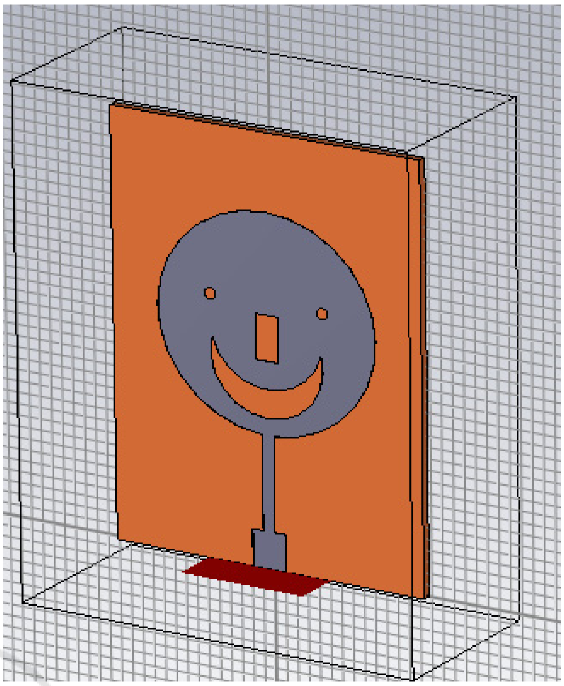
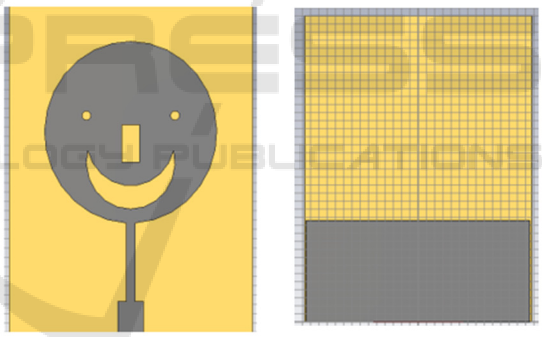


Figure 1: Perspective view



a) Front view b) Back View

Figure 2: Geometric views of proposed design

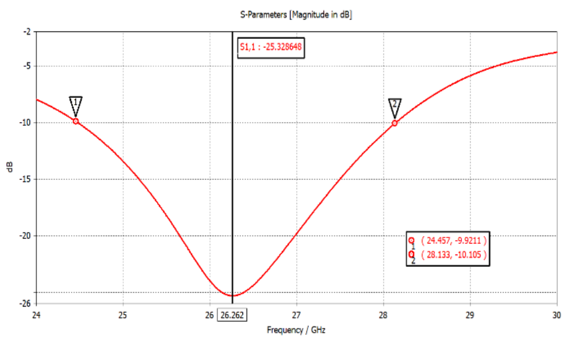


Figure 3: Return Loss (S_{11}) of proposed antenna

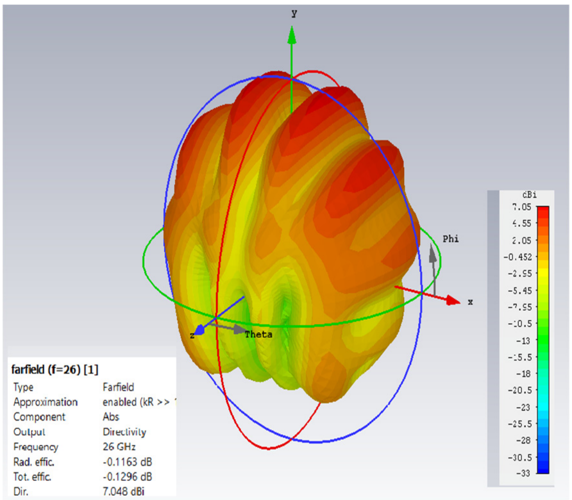


Figure 4: Directivity of proposed antenna

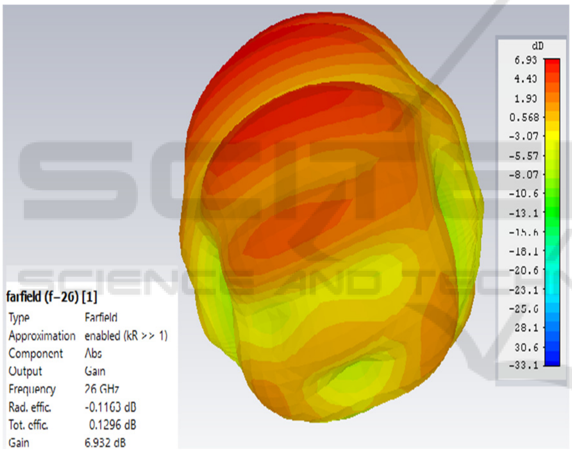


Figure 5: Gain of proposed antenna

3 SIMULATED RESULTS

The proposed antenna result like return loss (S_{11}), gain and directivity, are all simulated using CST (Computer Simulation Tool). Figure 3 shows the return loss of Smile shape micro strip Patch Aantenna (MSPA).

The simulationn result of return loss is -25 dB at 26 GHz resonance frequency, the impedance bandwidth is 3.8 GHZ, and operating band range is 24.4-28.2GHz. The proposed antenna has directivity 7.05dB as shown Figure 4 and maximum gain 6.98 dB as shown in Figure 5.

4 COMPARATIVE STUDY OF PROPOSED ANTENNA

The proposed antenna is designed for 5G application. Several antennas have been mentioned in the literature, which resonates at 26 GHz mm wave band. In terms of impedance bandwidth, return loss, gain and directivity performance parameters of proposed antenna, are compared with existing antennas including application and its type. Table 2 shows a comparison of 5G antenna resonates at 26 GHz based on enhanced performance with modern literature. In terms of impedance bandwidth, proposed antenna has wide band almost 3.8GHz as compared to all reported antenna except antenna design using DGS. The gain of proposed antenna is better than antenna design referenced (Oliveira, Goncalves, et al. , 2021), (Taweel, et al. , 2018) and has directivity 7.05 dB is better than referenced antenna (Oliveira, Goncalves, et al. , 2021).The return loss is 25 dB at resonance which is better than antenna design (Oliveira, Goncalves, et al. , 2021). Directivity parameter are not given most of designs like (Aziz, , et al. , 2003), (Al-Taweel, et al. , 2018), (Ghenjeti, Barrak, et al. , 2023). Impedance bandwidth is not given in (Saha, Mandal, et al. , 2024) antenna designs and gain is not mentioned in (Saha, Mandal, et al. , 2024) antenna design. However, proposed antenna has included all-important parameters. The proposed antenna has wide bandwidth, suitable gain, return loss and directivity as per standard, which is important for 5G antenna.

5 CONCLUSIONS

An optimzed modified single band high bandwidth micros tip patch antenna that is appropriate for 5G wireless communication is presented in this study. This study introduces a circular patch antenna that resembles an emoji and uses several slots with a modified feed line. High gain, increased directivity, and improved return loss make the smiley antenna ideal for 5G networks.

Table 2: Comparison of proposed antenna with existing antenna

Ref.	Frequency (GHZ)	Impedance Bandwidth	Return Loss (dB)	Gain	Directivity	Antenna Type	Application
(Ghenjeti, Barrak, et al. , 2023)	26	1.26	26.08	7.9	--	Rectangular microstrip antenna	5G V2X communications.
(Oliveira, Goncalves , et al. , 2021)	26	2.49	-21.44	4.18	3.44	Quarter circular slot rectangular patch antenna	Quarter circular slot
	26.0 25.9	3.591 3.888	-20.53 -44.51 (with DGS)	5.37 5.88	7.13 (with DGS)	Half-moon shape antenna	5G or high frequency band application
(Saha, Mandal, et al. , 2024)	26.6	-	-17	-	7.9	Antenna using MEMS	5G or high frequency band application
(Aziz, et al. , 2003)	26	3.54	-33.4	10	--	Rectangular patch	high quality online education and 5G application
(Al-Taweel, et al. , 2018)	26	-	25.6	5.74	-,	Wang shaped antenna	wireless communication, mobile robotics application,
proposed	26	3.8	25	6.93	7.05	Slotted smile circular patch antenna	high-quality online education and other 5G applications

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