Multimode Textile Array Antenna for Millimeter Wave Wearable Applications

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Abstract—The development of a multimode textile array antena for wearable applications is discussed in this study. For fabrication, copper sheet and conductive copper materials are employed. Because the body wear antenna is intended to function close to the human body, it should be lightweight and low profile. The performance of the suggested antenna is examined for different textile materials, which serve as its substrate. Additionally, a 1 x 4 antenna array is made to increase gain and bandwidth. According to the results, the designed antenna has high gain and directivity of 14dB and 10dB, respectively. Future 5G wireless devices may employ the frequencies obtained—27.08GHz, 30.16GHz, 38.62GHz, and 45.59GHz—as well as the reflection coefficients—-24.57dB, -13.735dB, -23.61dB, and -10.912dB, respectively. An excellent radiation pattern, good gain of 10.35 dB, and high directivity of 14.206 dB are all shown by the suggested patch antenna. Due to its very low profile, the antenna architecture is easily adaptable to systems where limited space is a major consideration. The antenna may be used for wearable applications and will be efficient for the next 5G applications since it is made of cotton.

Index Terms—Textile array antenna, wearable antenna, mmwave, reflection coefficient, gain and directivity

I. Introduction

Many technologies have been advancing quickly as a result of the tremendous growth in internet users, and wireless communication technology is no exception. Lack of practical frequency, however, is one of the aggravating problems that affect the emerging technology [1]. Researchers were driven to advance wireless communication technology from the 4th generation to the 5th generation by the demand for large data rates. Compared to 4G, 5G provides faster data speeds, reduced latency, more connected devices, and better bandwidth [2]. The design of a tiny antenna structure is becoming more important in today's wireless communication technology as mobile phone sizes continue to shrink. 5G frequencies typically range from 26 GHz to 52 GHz [3]. MIMO and tiny cell technologies are two examples of technologies that have embraced 5G [4]. It has been noted that 5G technology allows for the simultaneous operation of an increasing number of communication devices. A microstrip patch antenna that is compatible with 5G technology has been built in this stage. Microstrip patch antennas have been shown to exhibit similar multiband characteristics, and since they are lightweight and simple to use, they are regarded as the most promising antenna for communication devices [5]. Even when all of the criteria for the antenna have been met, choosing the right substrate is crucial for delivering more efficiency and bandwidth at a lower cost. Therefore, in this advancement, a textile substrate was used in the design of a microstrip patch antenna. An emerging technology employs clothes as a substrate because it can detect data more effectively than textiles [6]. Many other substrates have seen a tonne of study. Finally, we created an antenna with a cotton substrate and a 1.67 [6], [7] dielectric constant. The size of the antenna increases as the permittivity of the dielectric constant decreases, however this has the benefit of increasing efficiency and bandwidth [8].

Wireless communication is made less obstructive by the addition of textile substrate. Mobile phones may benefit the most from this technology because of the lower antenna diameters. MIMO (Multiple Input Multiple Output), which is extensively employed due of its high transmission rate, is one of the most crucial 5G technologies [9]. MIMO technique increases the wireless communication system's capacity by using multiple antennas at both the sending and receiving ends of the signal. The 1*4 array antenna used in this project has been developed to have excellent directivity, high gain, increased signal strength, good signal to noise ratio, and other benefits [10]. Textile antennas were selected to be used in the RF (Radio Frequency) front-end rather of standard materials in order to better integrate the system

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in a vehicle seat cover and thus speed up industrial manufacturing. Both the creation of the novel substrate material and its characterization processes are detailed in detail. The considerations affecting antenna design are then explored. The investigations to test the effectiveness of the textile antennas are presented. These studies included capturing the respiratory signal from six people of different body kinds while they were seated in a car seat. In conclusion, it was possible to show that bio-radar systems could accurately capture important signals utilising textile-based antennas.

The textile substrate in the V-band is described using the open stub method. A unique manufacturing approach is provided for the accurate and reliable construction of millimeter-wave microstrip antennas on textiles. Researching the efficiency, radiation patterns, and antenna reflection coefficient in free space, both with and without bending, as well as on a phantom with uniform skin thickness. The experimental results and the numbers often agree. We believe that this is the first millimeter-wave textile antenna for off-body communications to have been reported in the literature. Both a theoretical and an empirical examination of the recommended antenna array were done. The fundamental components of the proposed design are examined. It offers three band S-parameters with sufficient isolation, dual-polarized radiation with reasonable efficiency and gain values, and three band S-parameters. The results of the PIFAs for the bands' total active reflection coefficient (TARC) and envelope correlation coefficient (ECC) are also not very promising. Additionally, when the user and handset components are present, research is conducted on the radiation characteristics of the MIMO antenna. In addition, a brand-new, easily integrated, small-footprint phased array millimeter-wave (MM-Wave) antenna with end-fire radiation and a broad bandwidth is shown. Due to its excellent performance and straightforward construction, the recommended smartphone antenna array design is a potential choice for emerging multi-mode 5G cellular applications.

II. Related Work

Fei Wang and Zhaoyun Duan's "High isolation millimeter-wave wideband MIMO antenna for 5G communication" [11]. The proposed method uses a millimetre wave wideband antenna and operates between 24GHz and 39GHz. The greatest gain achieved is 7.5dB with a 0.4 mm spacing between the antenna and the transmission coefficient is -20dB. Design of a Microstrip Patch Antenna for 5G Applications by T. Kiran, N. Mounisha, Ch. Mythily, D. Akhil, and T. V. B. Phani Kumar. [12] This research includes designing a microstrip patch antenna with a compact configuration of 11 mm by 8 mm by 0.5 mm for use in future 5G applications. The Rogers RT/duroid 5880 is the material utilised in this approach. The electrical indicator is 2.2 and has a 0.5 mm thickness. This microstrip patch antenna reverberates in frequencies ranging from 28 GHz to 50 GHz. It has a gain of 2.6 dB, while the Reflection Coefficient for a frequency range of 28 GHz and 50 GHz is 21 dB and 31 dB, respectively. "A Small Microstrip Patch Antenna for Future 5G Applications" was written by Shivangi Verma, Leena Mahajan, Rajeshkumar, Hardeep Singh Saini, and Navin Kumar. [13]

This paper proposes the design of a low-profile microstrip patch antenna for 5G devices that has a compressed structure of 20mm20mm1.6mm and is best suited for handheld devices [14]. The FR4 substrate is used in the proposed antenna design. The proposed design offers a gain of 4.46dB and a thickness of 1.6mm. The proposed design resonates at a frequency of 10.15GHz. For use in 5G communication applications, this article presented a novel dual-band, dual-polarized array antenna operating at 28 GHz and 38 GHz. The lower band spans the range of 27.48 to 28.50 GHz, while the higher band spans the range of 36.94 to 40.43 GHz. The increase is bigger than 14 dB from 37GHz to 40GHz and 6dB from 27.5GHz to 28.35GHz. The losses in the return signal are lower than -20 dB. The technology utilised in this approach, 2.2 "High Isolation Millimeter-Wave Wideband MIMO Antenna for 5G Communication" by Fei Wang and ZhaoyunDuan, is one of low loss organic substrates with dielectric icons [15] The aforementioned approach is the design of a millimeter-wave wideband antenna that is offered for use in applications for the fifth generation. The antenna employs a Rogers 4003C substrate with a 3.4 relative permittivity. The functioning of the frequency band spans the range of 24 GHz to 39 GHz. Within just 0.4 mm of gap between antenna components, the transmission efficiency is sub 20 dB. The suggested antenna's total size is 14mm x 14 mm x 0.8mm.

By Leeladhar Malviya, Ajay Parmar, Deepak Solanki, Parul Gupta, and Priyanshi Malviya, "Highly Isolated Inset-Feed 28 GHz MIMO-Antenna Array for 5G Wireless Applications" [16] This technique employs a Rogers RT-Duroid 5880 as the base station and proposes a 2X8 MIMO-antenna array with a base station size of 23.61 X 55.18 Xmm2. The frequency range extends from 27.49 to 29.42 GHz, and the gain at the dominant frequency of 28.0 GHz is 11.33dB. Each patch uses an inset-feed for matching impedance and is linked to a 100Ω microstripline. The efficiency of radiation is 88.58 percent, with a Reflection Coefficient that is lower than 48 dB [17]-[25].

The flow of the paper is design the antenna, simulate the structure in software and analysis the parameters of the antenna structure.

III. Antenna Design Methodology

The figure below depicts the proposed antenna geometry. When developing the suggested antenna, several factors like the substrate's thickness (0.29 millimetre) and dielectric constant (r = 2.077) are taken

into account. Cotton is employed as the textile substrate material. Illumined port is used in this arrangement to excite the antenna. The suggested structure operates in the 27GHz to 46GHz frequency range for future 5G communications. In the literature, formula is used to compute the patch dimensions for rectangular patch antennas are shown in Fig. 1.

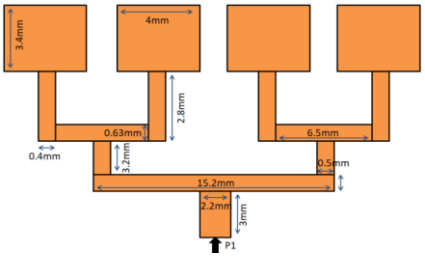


Fig. 1. Geometry of the antenna.

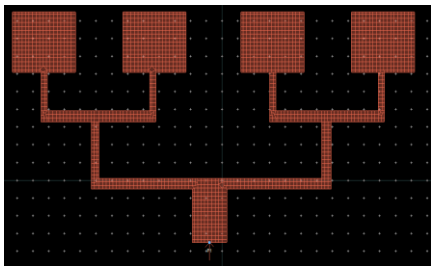


Fig. 2. Antenna idesign.

Fig. 2 depicts the design and simulation of the proposed patch antenna using the commercially available simulation programme known as ADS (Advanced Design System). Because surface waves have a greater impact on solid substrates than they do on textile substrates, the primary utility of a textile substrate is to reduce them. Because there is an air gap in textile substrates, which are porous materials, the surface waves are negated. The antenna's flexibility is another crucial aspect. It is only conceivable with textile substrates because as an antenna's flexibility rises, so do its directivity and Reflection Coefficient.

High gain is another feature of this antenna. Gain is increased by increasing the number of antennas. The suggested antenna is thus an array antenna. A 1*4 array antenna is suggested here. To lessen mutual interference, each array was spaced apart by 0.5 lamda. The next section describes a number of simulation findings related to the suggested antenna design.

IV. Results and Idiscussion

The reflection coefficient is also known as the Reflection Coefficient and is indicated by the symbol (S11). Because the Reflection Coefficient of an antenna is the ratio of incoming power to that of reflected power, the performance of an antenna typically relies on a good reflection coefficient or a Reflection Coefficient of at least 10 dB or larger. Consider that nothing has radiated since all of the power has been reflected from the antenna when the reflection coefficient is 0 dB is shown in Fig. 3.

As can be observed in Fig. 4, the Reflection Coefficient values are -24.57 dB, -13.735 dB, -23.611 dB, and -10.912 dB. It has been determined that with this high bandwidth and excellent Reflection Coefficient, one is able to stream ultra-quality data, such as 4K/8K films, without any interruption.

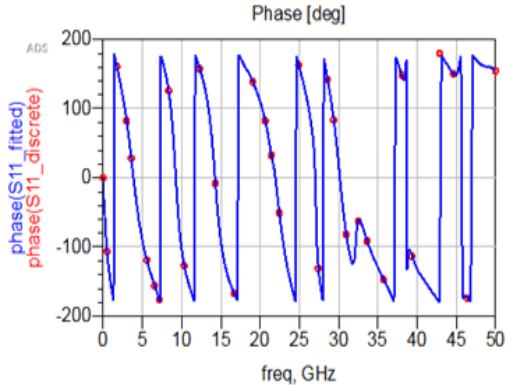


Fig. 3. Phase graph of the proposed antenna.

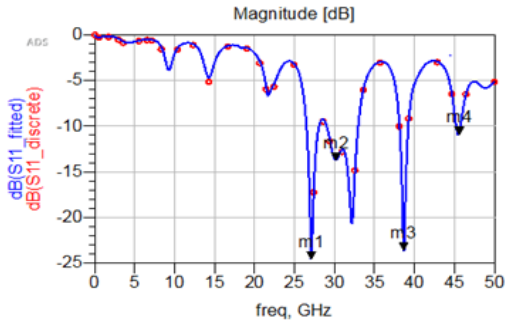


Fig. 4. Reflection coefficient of the proposed antenna.

Table I: Comparision of Proposed Antenna for Various Substrate

Colour	Substrate	Dielectric constant	Loss tangent	Thick ness	Reflection coefficient
Red	Cotton	2.077	0.0314	0.29m m	-26.966dB
Blue	Jean	1.73	0.077	3.5m m	-10.01dB
Green	Nylon	3.6	0.0083	0.082 mm	-19.02 dB

The standing wave ratio for voltage is also expressed in terms of standing wave ratio. This ratio should be in the range of 1 to 2 VSWR for microstrip patch antenna designs utilised in 5G applications. This ratio is consistently seen as a true and positive real number. Greater the match, the higher the VSWR value.

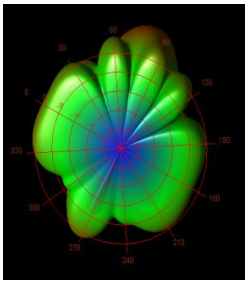


Fig. 5. Radiation iPattern of the proposed antenna.

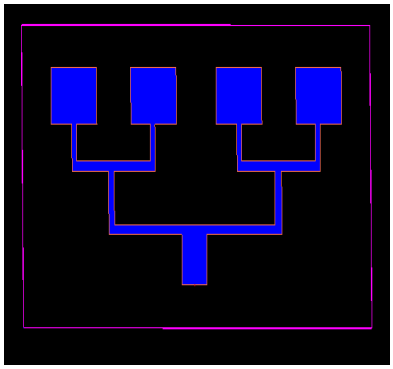


Fig. 6. 3D View of the proposed antenna.

High gain is very much required for 5G wireless system because the radiation patterns indicates the quantity of power radiated by antenna. The below Fig. 5 shows the imovement of electric charges on the patch which creates ithe current densities on the patch surface which igives good radiation to antenna. The comparison of proposed antenna for various substrates is shown in Table I. The 3D view of the proposed structure is shown in Fig. 6. The antenna parameters of the proposed structure are shown in Fig. 7. The directivity and gain of the proposed structure is shown in Fig. 8.

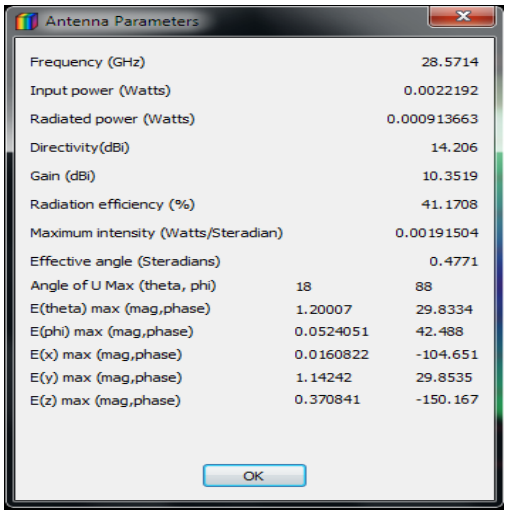


Fig. 7. Antenna parameters of the proposed antenna.

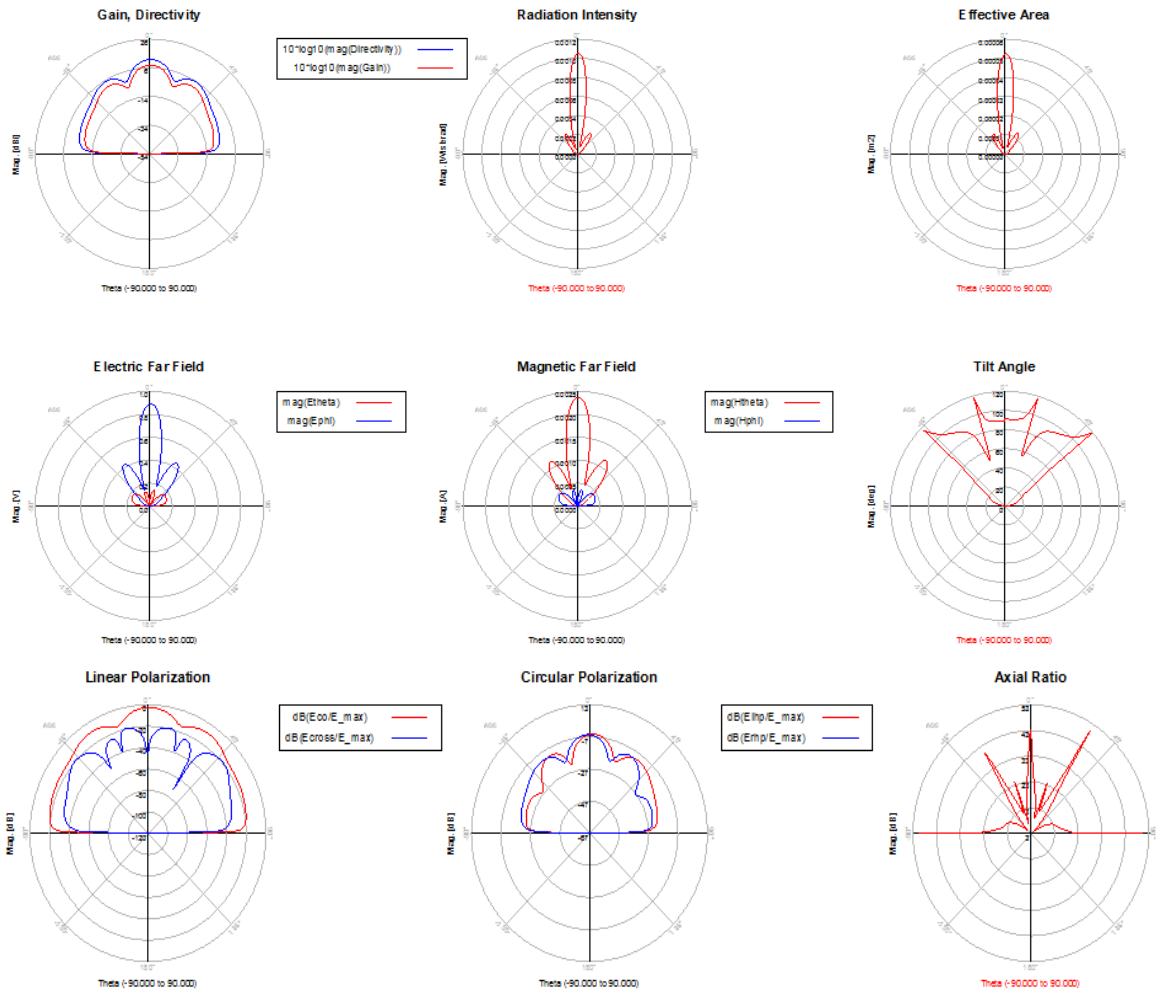


Fig. 8. Directivity graph of the proposed antenna.

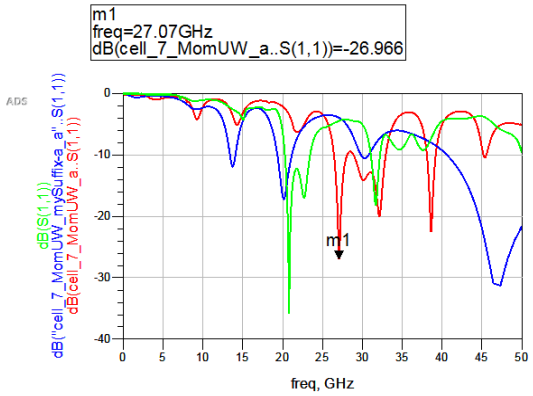


Fig. 9. Comparison with other substrates.

As mentioned above, the comparison between cotton, jean and nylon substrates, only cotton substrate meet the required conditions, so cotton is choosed as a textile substrate for the proposed antenna is shown in Fig. 9. The fabrication antenna is shown in Fig. 10.

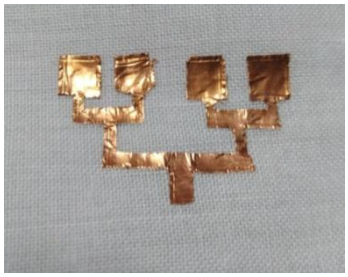


Fig. 10. Fabricated antenna.

V. Conclusion

A microstrip patch array antenna has been suggested for the 5G wireless standard in this paper. With the outstanding growth of mobile data, technologies are moving from 4G (Fourth generation) to 5G Fifth generation. Future 5G wireless devices may employ the frequencies obtained 27.08GHz, 30.16GHz, 38.62GHz, and 45.59GHz as well as the Reflection Coefficient obtained -24.57dB, -13.735dB, -23.61dB, and -10.912dB, respectively. The suggested patch antenna exhibits an excellent radiation pattern, good gain of 10.35dB, and an excellent directivity of 14.206 dB. The antenna construction is very low-profile and may be readily fitted into systems where space is a key concern. Given that the material is cotton, the antenna may also be utilised for wearable applications and will be effective for the next 5G applications.

Conflict of Interest

The authors declare no conflict of interest.

Author Contribution

P.Ramya conducted the research and analysed the data; B.Deepa simulated the antenna; R.Nirmala anlaysed the various paper; Malathi Murugesan simulated the antenna and analysed; K.Rama Abirami the Editing and Anlaysis of the antenna; S.Kannadhasan the simulated analysis and comparison with others

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