APPROACHES IN ANTENNA DESIGN TECHNIQUE FOR 5G MEASUREMENT AND HETEROGENEOUS NETWORKS

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ABSTRACT

The next generation of wireless systems will be a heterogeneous mix of several communication technologies, such as millimeter wave (mmWave) communication, terahertz (THz) communication, and visible light communication (VLC), in addition to evolved versions of existing systems, which are interconnected. Complementation and cooperation are expected. A number of wireless systems are emerging as candidate technologies to meet the needs of next-generation communication systems to provide connectivity not only in the traditional sense, but also in the rapidly emerging field of Internet of Things (IoT) are necessary. The overall dimension of the patch antenna is 2.9 × 3.5 mm, two rectangular U-slots in conjunction with the H-slots were loaded into the radiator to increase the antenna bandwidth. The antenna is designed and simulated and the analysis was done at CST Studio. The antenna achieves a maximum reflectance coefficient of about -42.648731 dB at 50 GHz, with a very wide bandwidth of about 25 GHz and a realization of 9.83 dB. 5G will support significantly faster mobile broadband speeds, lower latency and reliable communications as well as enabling the full potential of the Internet of Things (IoT). This paper presents the design, simulation, development and measurement research work on antenna design techniques for 5G measurement and heterogeneous networks. As the demand for high-speed wireless communication grows, many modulation techniques in the frequency, temporal, and spatial domains, such as orthogonal frequency division multiplexing (OFDM), time division multiple access (TDMA), space division multiple access (SDMA), and Multi-input multiple-output (MIMO) is being developed.

Keyword: - *DB, Ghz,* TDMA, MIMO, IoT, VLC, THz etc.

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1. INTRODUCTION

5G will support significantly faster mobile broadband speeds and wider data transfers, as well as enable the full potential of the Internet of Things (IoT). Mobile handsets face various applications such as virtual reality, industrial internet and smart cities. While 5G applications will use higher frequency bands, including the millimeter-wave region, to enable wider bandwidth and higher data rates, they must also consider traditional bands. Wide bandwidth and the need for beamforming, beam steering and multiple beams are significant challenges for 5G systems. This provides the impetus for a new breed of handset design that puts new design drivers over antenna design. Low-profile efficient antennas that ensure reliable and interference-free communication are required, but demands for increased power, larger bandwidth, higher gain, and insensitivity to the presence of a human user further complicate the antenna and propagation aspects. This requires new ideas and innovative solutions in antenna design that can operate in single- and multiple-input and multiple-output (MIMO) arrangements. In the past few years, economic and social development has been greatly influenced by advances in the field of mobile communications. As a result, 5G technology has emerged as a foundation for the future 2020 generation. 5G technology is an emerging technology with evolutionary and revolutionary services. It is the next generation of technology providing ultra high data rates, very low latency, high capacity and good quality of service. It is noteworthy that 5G technology will provide new opportunities to overcome the traditional barriers of development. As 5G technology supports IoT, it leverages a major social change in the fields of education, industry, healthcare and other social sectors. 5G technology is expected to unlock a broader IoT ecosystem in which multiple devices will be connected and a network can meet communication needs by maintaining a trade-off between latency, cost and speed. 3GPP standards are constantly changing. 3GPP oversees an organized release of new functionality and is responsible for new releases of standards according to the planned schedule. With the potential of 5G, much of the industry in the region will be expanding artificial intelligence as seen in augmented and virtual reality (AR/VR) systems, and autonomous driving. On the other hand the Internet of Things (IoT) which is fueling the need for large-scale connectivity of devices, and also the need for ultra-reliable, ultra-low-latency connectivity over Internet Protocol (IP) [2], [3](Fitri, Communication, Wireless, & 2017, nd) (Nasimuddin & Chen, 2009) (Liu, Ackermans, Propagation, 2009, & 2009, nd). With application diversity in next generation wireless broadband, a robust system that can fit across industries, schools, home, cars, personal communication is essential. Patch antenna meeting all relevant requirements like light weight, low cost, easy to manufacture and simple geometry are considered. In addition to the ease of circuit assimilation with wireless mobile devices in array form or single unit, the low profile micro-strip patch antenna is an important element in modern wireless broadband communications compared to its traditional microwave antenna counterpart. Good resonance mode, bandwidth, and polarization can be achieved through proper mode and patch selection (Muhammad, Yaro, & Alhassan, 2018; Yu & Kamarudin, 2016) (Yahya, Olimat, & Abdel-Razek, 2012) (Sun , Fang, Liu, & Zheng, 2012).

2. ANTENNA TYPES

Another important method of classification may be based on antenna types as shown in Figure 3. According to the literature, the different types of antennas suitable for 5G applications are as follows:

• Monopole antenna: It consists of a straight microstrip line of length /4, where is the wavelength of the antenna's resonant operating frequency. As found in the literature, several modifications were proposed that change the basic structure to new shapes such as conical, spiral and other according to the applications and requirements [16], [23].

• Dipole antenna: It consists of two straight microstrip lines, each of length /4 and feeding is provided between the two microstrip lines, therefore, the total length of the dipole antenna is /2 [17], [24] occurs.

• Magneto-Electric (ME) Dipole Antenna: It consists of a planar electric dipole and vertically shorted planar magnetic dipole. The feeding is provided to the magnetic dipole from the bottom side of the substrate [18], [25], [26].

• Loop Antenna: It consists of a circular, rectangular, square or any other shape of a ring. The radius of the loop antenna is smaller than wavelength [8], [27].

• Antipodal Vivaldi Antenna (AVA): It consists of two conductors on both sides of the substrate and they are mirror images of each other. The upper conductor acts as a radiator whereas bottom conductor acts as a ground [12], [28]–[30], [34].

• Fractal Antenna: It consists of a repetition of the same structure multiple times. It is designed by using an iterative mathematical rule. The fractal antenna can be of different shapes like rectangle, circle, star, triangle, and leaf [20], [31].

• Inverted F Antenna (IFA): It consists of a microstrip line with one bend and feeding is given to the straight part of the microstrip line. The feed point is near to the bent part and hence the overall look of an antenna is of inverted F type [21], [32].

• Planar Inverted F Antenna (PIFA): It consists of the patch antenna and ground plane which are connected by using shorting pin and feeding is provided from the bottom side of the substrate. As it resonates at quarter wavelength, it requires less space [22], [33].

3. Research Methodology

In this section, the methodology for the design of the proposed antenna is presented. The rectangular microstrip patch antenna is a commonly adopted shape in the design of wideband antennas capable of operating in the microwave and millimeter wave frequency bands that is considered in this paper. Structure of proposed antenna on rectangular microstrip patch operating at 60GHz for 5G mobile application. The front view of the antenna consists of a rectangular radiator of approximately 2.9 × 3.5 mm in dimension which is fed through a 50 feed line probe of approximately 2.15 × 0.41 mm in dimension. On the rear sight, there is a ground plane of approximately 7.5 × 8 mm in dimensions with a substrate between it (the ground plane) and the radiator. The Rogers RT5880 which has a dielectric constant of 2.2, loss tangent 0.0009, and a copper thickness of 0.003 mm is used because of its light weight and high efficiency.

Table 1.1: Dimension of the Proposed Antenna

Parameter	wg	lg	Wp	Lp	Wf	Lf	lfx
Dimension (mm)	10	8.5	4.5	3.9	0.41	3.15	0.3
Parameter	lfy	Hx	Hy	Ex	Ey	D	h
Dimension (mm)	0.3	3.4	3.5	2.5	2.35	0.4	0.004

4. Result Analysis

4.1 Simulation

The antennas were modeled and simulated using the Computer Simulation Technology (CST) microwave commercial software program and each layer of the proposed design was assigned with its respective physical and electrical properties. The result of return loss, VSWR (voltage standing wave ratio), gain and radiation pattern of the single patch element obtained are shown in Fig. 1.1 to Fig. 1.2. |S11| At 60 GHz the parameter approximately -41.65 dB is taken as the base value which is optimal for mobile communication as shown in Figure 1.1. An acceptable level of VSWR for wireless applications should be a ratio of 2:1 and Figure 1.3 provides a good VSWR ratio of 1.8:1. The antenna achieved a high gain of 8.82dB at 60 GHz which is considered excellent in the context of a compact microstrip patch antenna as shown in Figure 1.3. The radiation pattern at phi = 0° and theta = 90 is presented in Figure 1.4, and a nearly omnidirectional pattern of the proposed antenna is obtained with a small back lobe. Table 1.2. Summarizes the discovery of the results of the design.

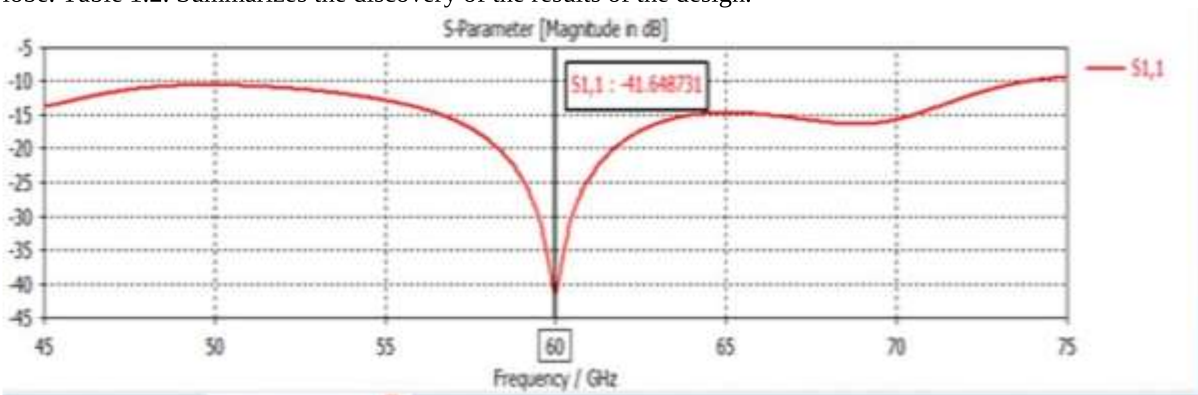

Figure 1.1: Reflection Coefficient Magnitude against Frequency for Design Antenna

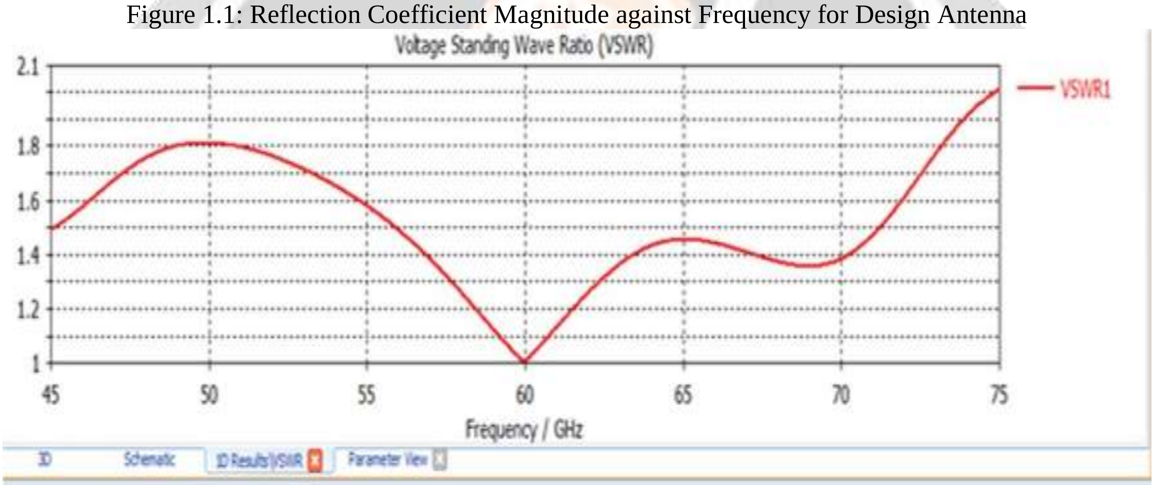

Figure 1.2. VSWR curve of proposed antenna

Fifth generation (5G) is the current hot topic of the world's leading telecommunications companies. The compact design of the antennas made it possible for them to resonate at higher frequencies, thus enabling the devices to receive higher data rates than 4G technology. The data rate of 5G technology is expected to be 50.0 Gbps for low mobility users and 5.0 Gbps for high mobility users. On the other hand, the International Telecommunication Union aims for 5G to be 3 times more spectral efficient than Long Term Growth (LTE). The paper has carefully studied the effect of 5G antennas on antenna size, shape/type of substrate, gain, efficiency, and isolation etc. Also, patch antenna, various array with magneto and multiple input multiple output (MIMO) electric-dipole, microstrip grid array antenna, folded dipole, series-fed array, connected antenna array, MIMO are studied. The paper also covers the existing technology i.e. 4G LTE and their isolation enhancement approaches. Many designs used reflector plates to reduce the back lobe radiation problem in MIMO/array antennas to increase the front-to-back ratio. Gain in 5G antennas can be increased by using baluns, parasitic elements as directors, multiple notch structures, three identical slot sub-arrays, etc. Contains mathematical equations for multi-element/port antennas to model designed antennas. The main issue associated with planar antennas is the existence of surface waves that adversely affect and deteriorate the radiation pattern of the antenna [22]. Surface waves occur when electromagnetic energy is radiated across the antenna's substrate. Performance improvement techniques for patch antennas are mainly based on restricting the propagation of these surface waves in the antennas. In addition, there are some techniques that restrict the propagation of antenna-generated electromagnetic waves in unwanted directions, thereby increasing the antenna's direction and gain. Photonic bandgap (PBG)/electromagnetic bandgap (EBG) structures, defected ground structures (DGS) and frequency selective superstrate (FSS) structures are discussed in this section of the paper Performance Enhancement Techniques.

Figure 1.3. Simulated 3D radiation pattern (a) theta = 0^o (b) theta = 90^o

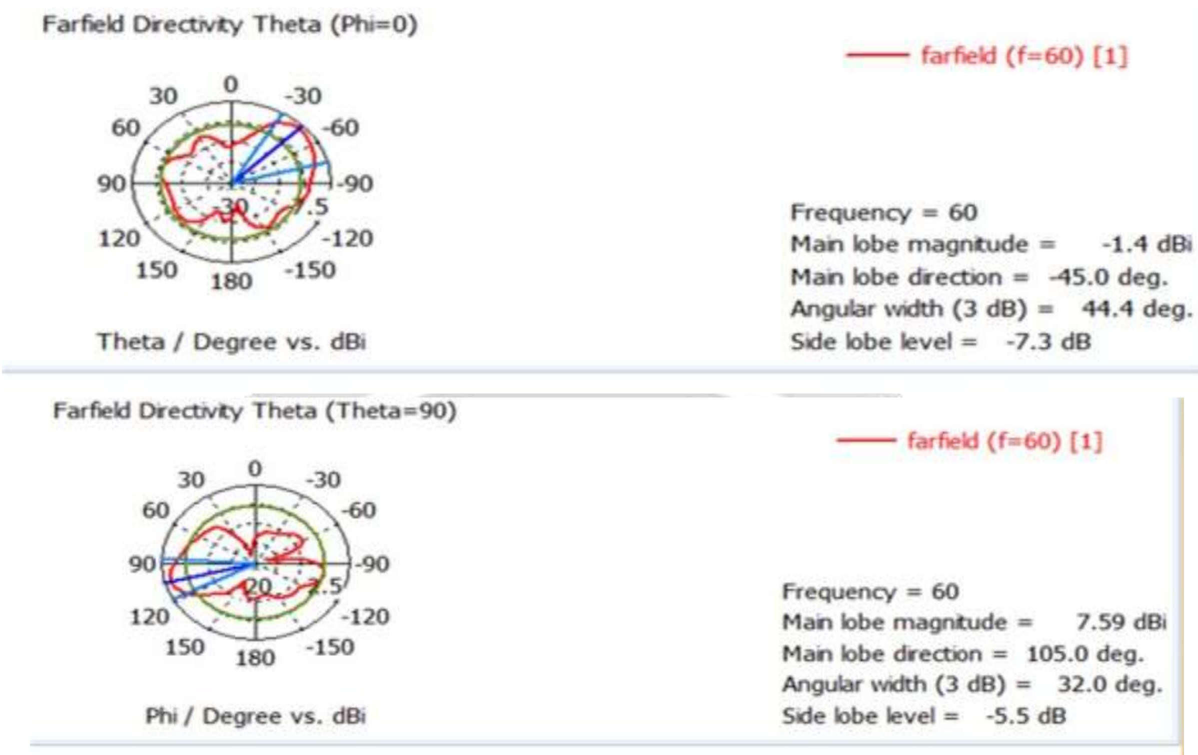

Table 1.2. Summary of the simulated results.

Antenna parameter	|S11| at 50 GHz	VSWR	Realized Gain (dB)	Bandwidth (GHz)
Specification Detail	42.64dB	2.8:2	9.83	25

5. Conclusion

In this paper, a rectangular microstrip patch antenna is proposed and designed for 5G mmWave wireless communication. The antenna resonates at 50 GHz, with a return loss of approximately -42.64 dB, the bandwidth achieved at the -10 dB reference point is approximately 20 GHz (40 - 68 GHz) for wideband applications. With an omnidirectional radiation pattern the actual gain of the antenna is 9.83dB. Antenna integration can be done in devices where space is a major concern and could be used in future 5G wireless devices. Patch antennas are an ideal choice for portable wireless applications due to their small size, planar geometry, low cost, easy design, etc. However, they suffer from significant limitations, especially when used at very high RF frequencies such as the 28 GHz and 38 GHz mmW signals. These limitations include low gain and low directivity, narrow bandwidth, and the existence of surface waves. Some contemporary and prominent performance enhancement techniques for patch antennas operating at mmW frequency are discussed in this paper. These techniques are photonic bandgap (PBG)/electromagnetic bandgap (EBG), defected ground structure (DGS) and frequency selective superstrate (FSS) structure. The paper presents the operating principles of these techniques, their work done by researchers using these techniques, and contemporary antenna system designs. The paper also discusses two major antenna feeding techniques, namely microstrip feedlines and surface integrated waveguides (SIWs).

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