Research Article

A Review Paper on Microstrip Patch Antenna (MPA) for 5G Wireless Technology

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Abstract: In earlier days larger size antennas were used but due to technological development these larger size antennas were replaced by compact antennas. Microstrip patch antennas have low profile configuration, light weight, easy to fabricate, smaller in dimension and low cast. There is tremendous growth in mobile users in recent years. They need more features on their mobile phone such as high-data-rate speed, reduced traffic, more efficient telecommunication, and real-time applications. The fifth-generation (5G) technology better QoS, high bandwidth, and reduced delay or latency. In this paper, a review is done for microstrip patch antenna along with 5G technology and studied of measurements of various antenna design parameters

Keywords: Microstrip patch antenna (MPA), Array, 5G-technology, Wireless communication, Feeding techniques, Polarization, Millimeter-wave

1. Introduction

Wireless communication may be defined as a communication without any physical medium. Wireless technology provides increased efficiency, better coverage, flexibility, reduced cost [1]. The recent decayed-years rapidly development in the field of wireless communication as well as telecommunication 5G-technology increased the demand for design a compact antenna and more gain outputs. The term antenna is one of the more-important elements components of the communications. The antenna or aerial is defined as "a means of radiating or receiving radio waves" [2]. The antennas act as an interface for EM-energy, translation between unguided or free-space and guided intermediate [3]. Microstrip-comb line antenna is most suitable for applications where compact antenna design require its configuration is shown in Figure 1(a) and Figure 1(b) for Element with matching circuit.

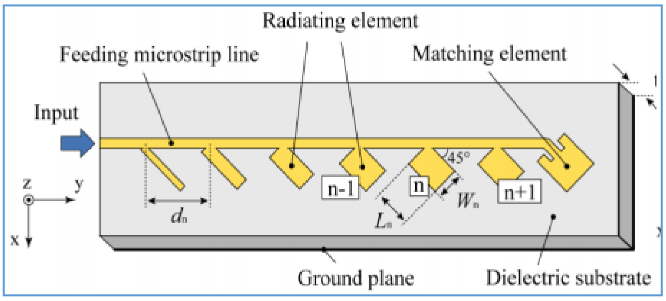

Fig 1: Microstrip comb-line antenna [4]

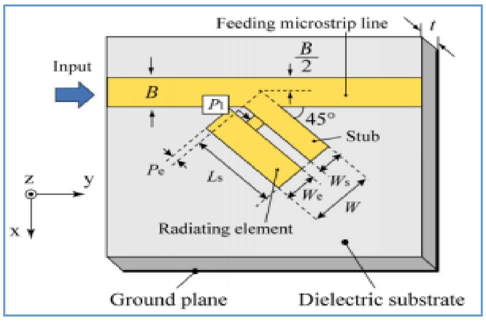

Fig. 1(b) Element with matching circuit [4]

Patch may be rectangular, square, circular, dipole, triangular and elliptical in shape. They also termed as printed antenna or simply Microstrip antenna. The various shapes are shown in figure 2. MPA are widely used in the micro-wave frequency ranging between 300 MHz-300 GHz.

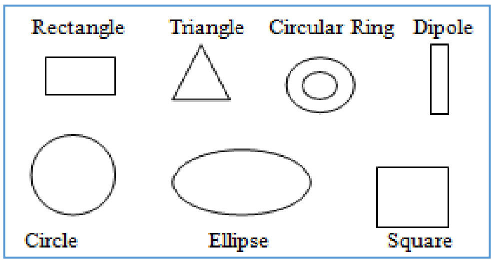

Fig 2: Shapes of microstrip-patch antenna

5G Promises faster data rate, higher connection density, much lower latency, high resolution, high bandwidth and high power [5, 6]. Automation, cloud computing ant IoT requires huge amount of data transfer at high speeds will be provided by 5G [7]. 5G assigned the spectrum from 30GHz to 300 GHz for short distance communication [8, 9]. Some of the plans for 5G technology include the device-to-device and millimeter wave communication, minimum power consumption, improvement of coverage of wireless system, reliable and secure way of communication [10-12]. In 5G researchers are being made on development of wwww, dynamic adhoc wireless networks (DAWN).

2. Literature Review

Energy efficiency plays an important role in 5G small cellular networks. It is more than 50% of power of the energy is consumed. Transmission power also plays an important role. Hence it is considers together transmission and computation power of 5G cell network [13].

There is a various number of dielectric substrate available for Microstrip patch antenna (MPA). Material selection for dielectric substrate in microstrip patch antenna can be considered in three classes of wireless communication namely millimeter-wave applications, mobile base stations applications, and mobile phone miniaturization applications. Di-electric material selection procedure using Ashby's chart approach of different material indices studied. "The Ashby's selection-chart shows that 0.75MgAl2O4–0.25TiO2 material for millimeter waves applications, Ca[(L1/3Nb2/3)0.85Ti0.15]O32d for mobile base station applications, and (Ba0.95Ca0.05)O– Sm2O3–4.5TiO2 ceramic for mobile phone miniaturization applications by Choudhary et al. [14].

The authors Md. WAW et al. [15] were proposed, a dipole antenna using polydimethylsiloxane–glass microsphere (PDMS-GM) substrate offers a lower-permittivity of 1.85 against 2.7 of pure PDMS. This operating frequency range 19 GHz-45 GHz with a bandwidth of about 28 GHz.

Tighezza M et al. [16] was proposed the wideband flexible microstrip patch antenna with polyethylene terephthalate thickness 0.125mm, and 60×75mm2 dimension It operates in the frequency range 7GHz-13GHz, provides an Omni-directional radiation pattern having the gain of 5 dBi.

A 15GHz high-gain compact grid-array-antenna (GAA) using FR4 substrate, 23 radiating element, and antenna dimension 49mm×58mm×1.6mm, coaxial feeding technique. The resultant shows the impedance BW of 14% (2.1GHz) from 13.8-15.9 GHz and obtained the output gain is 14.4dBi at 15.9GHz [17].

Zhu S, and et al. [18] was proposed a novel antipodal Vivaldi antenna using eight antenna elements, 28.823×60×0.787 mm antenna size having impedance BW of 24.75-28.5 GHz, multiple notch structures to remove mutual coupling for millimeter-wave applications are presented. It covers the 5G frequency band 24.75-27.5 GHz and 27.5-28.35 GHz. The Antipodal Vivaldi antenna coupling reduced gain of 6.96dB-to-11.32 dB in the 24.75GHz-to-28.35GHz band.

The 30.5GHz Ka-band was designed by Liu D and et al. [19]. It achieves 0.8 GHz input match bandwidth and < 3-dBi gain. A dual-polarized slot coupled feeding technique 1×3 microstrip-antenna-array stable active element pattern using copper pillars is presented by Wang Y and Du Z [20]. It provides impedance bandwidth for VSWR < 2 is 520 MHz (1.69–2.21 GHz).

A 28GHz compact Omni-directional circularly polarized for device-to-device communication were fabricated on Rogers 5880 substrate and author Liu D and et al. was proposed for 5G cellular systems [21].

Lin W and et al. [22] was a rectangular dielectric resonator antenna with a modified feeding technique using RT/Duroid 5880 substrate (εr = 2.2 and $\tan\delta$ = 0.0009) are presented. It provides a coefficient of reflection response is from range 27.0-29.1 GHz, impedance BW is 2.1 GHz and output gain is obtained 12.1 dB.

A optimized 4×4 microstrip patch antenna array in 28-38GHz frequency range with corporate feed network is presented by Md. KR and Md. AM (2017)[23].

Lee B and Yoon Y (2017) was proposed a 60GHz 4 ×4 circularly polarized broadband MPA array using an edge-coupled parasitic patch structure and novel series sequential rotation feeding network for high data rate wireless PAN [24].

A beam-switching conformal three-antenna array of 16 patches-E (elements) in each array linear polarization for 59.9GHz (61GHz resonant frequency) is designed [25].

The two compact planar microstrip patch antennas (each 2×2 elements) operating in the 60 GHz frequency band are presented by Biglarbegian B and et al. [26] which is based on the PHY-layer specifications of ECMA 387 standards for wireless applications.

There are many papers are review related to antenna design and its radiation paten related. There is some summarized description is below.

The author Yao Y and et al have been proposed the 4×4 high-gain (Ghig) circularly polarized wide-band antenna is presented [27]. A 28 GHz Radial-Line-Slot-Array-Antenna has been designed using circular, linear, and elliptical polarization. It was proposed by Maina I and et al. [28]. The slotted meander line resonator has been designed to the isolation in MPA array by Gulam Nabi Alsath M et al. [29]. The MPA with 6-different shapes such as square, elliptical, rectangular, circular, hexagonal, and pentagonal are proposed by Sidhu Sumanpreet Kaur and Siva J S with “Rogers RT/duroid 5880 material” having dielectric const. of 2.2, and thickness 3.2 [30].

The different compact Circular Patch Antennas (CPA) using Slots and Defected Ground Structure designed to achieve compactness. The Antenna-AA, Antenna-BB, Antenna-CC, Antenna-DD, Antenna-EE, Antenna-FF provide 42.44%, 9.7%,15.27%, 53.67%, 73.17% and 90.34% of compactness respectively [31].

A microstrip patch antenna with liquid crystal polymer as the substrate is studied for a coordinated RF front-end system. Different feeding techniques and properties of the different substrates are also compared [32] and an Ultra Wide Band antenna was proposed by Kumar A and Singh MK [33]. Other high gain antennas such as rectangular microstrip patch antenna [34], wideband microstrip patch antenna [35] are proposed. A single feed dual-band (28 and 38GHz) monolayer circular polarized L-shaped slotted patch antenna is designed. It provides a small frequency ratio (1.35). [36]

A wideband circularly polarized patch antenna [37-38], E-shaped microstrip patch antenna [39], 60GHz Microstrip antenna array with rectangular patch [40], T-slotted microstrip antenna [41], U-slot MPA [42], 8×8 rectangular patch antenna array [43], coaxially fed U-slot rectangular patch antenna has been proposed and designed by [44]. A beam Steerable 28 GHz Array Antenna using Branch Line Coupler has been designed [45]. A compact dual-band (10.15 and 28GHz) patch antenna has been designed by Jandi Y and et al. [46]. An 8-element dual-band (28and 38 GHz) Microstrip patch antenna arrays have been designed by Rafique U and et al. [47]. A 28GHz 16-element rectangular patch Microstrip linear antenna array was designed by Saada Md. [48]. A high gain MPA for terahertz (THz) spectral band applications has been designed by Kushwahaa R K and et al. [49].

3. Antenna design and theory

Micro strip patch antenna depends on a number of factors such as substratum, dimensions of Ls×Ws, material, dielectric constant, Tangent loss, height width and substratum dimensions.[50] Dimensional formula for Microstrip patch antenna are as follows: [51]

With of path is calculated using following mathematical equation Eq. (1)

$$W = \frac{1}{2f_0\sqrt{\mu_0\epsilon_0}}\sqrt{\frac{2}{\varepsilon_r+1}} = \frac{c}{2f_0}\sqrt{\frac{2}{\varepsilon_r+1}} \qquad (1)$$

Effective length is calculated by following equation Eq. (2)

$$L_{eff} = \frac{c}{2f_0\sqrt{\epsilon_{reff}}} \qquad (2)$$

The length extension can be calculated as equation in Eq. (3)

$$\triangle L = 0.412h\frac{(\epsilon_{reff}+0.3)(\frac{W}{h}+0.264)}{(\epsilon_{reff}-0.258)(\frac{W}{h}+0.8)} \qquad (3)$$

4. Feeding Methods for Microstrip patch antenna

Microstrip antenna can be fed in a number of ways. The feedline is a conducting strip of smaller width as compared to the width of patch. In contacting feed the radio-frequency power/energy is directly fed to radiating-patch with the help of microstripline or coaxial line. Microstrip feedline is easy to fabricate and feed can be etched on the same substrate which provide the planar structure.centre feed, offset feed and inset feed are the different types of microstrip feed line. Coaxial feed line also termed as probe feed [52].

In non contacting fed EM coupling is done to transfer the power between the feedline and the radiating patch using aperture coupling or proximity coupling. Aperture coupled feed is also termed as electromagnetic coupling scheme. Proximity coupled feed also called indirect feed. It removes the ground plane .it is easy to manufacture. It has low spurious radiation [53]. Comparisons between above discussed feeding techniques are summarized in table I.

TABLE I. Comparison between Microstrip patch Antenna using Feeding-method

Parameter	**Feeding-Method**			
	Coaxial	**Microstripline**	**Aperture coupling (AC)**	**Proximity coupling (PC)**
Fabrication	Convenient		Arduous	
Impedance-Matching	Simple		Difficult	
Spurious Radiation	Low	High	Low	
Modeling	Arduous	Effortless	Effortless	
Bandwidth (BW)	Narrow 2.5%			High 13%
Reliability	Poor	Better	Good	Good

5. Applications of Microstrip patch antenna

It is popular in wireless communication due to its low profile structure.

They are compatible with the embedded antenna in handheld wireless devices like mobile phones and pagers.

It is used in satellite communication.

It is used in missiles.

It has widespread use in the microwave and millimeter-wave systems.

These are used in airborne and spacecraft systems.

It is used in phased array radars where less than a few percent bandwidths are tolerable.

These are used in global positioning systems (GPS) applications such as asset tracking of vehicles and marine.

6. Conclusion

This paper presents a theoretical and experimental survey on Microstrip patch antenna and Microstrip patch antenna array with different substrates for 5G. Here we studied the frequency band from 5GHz-60GHZ. Some papers also discussed in THz frequency range. We also studied different shaped microstrip patch antennas like rectangular, circular, square, E, T, U with different methods of contact and non contact feeding techniques using different polarization techniques. We studied various parameters like radiation pattern, compact structure (Dimensions), Gain, Efficiency, impedance bandwidth, voltage standing wave ratio (VSWR), reflection coefficient, axial ratio, Envelope correlation coefficient (ECC) and return loss but mainly concentration on Gain, Efficiency, Compact structure (Dimensions)..

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