

Recent Review on Microstrip Patch Antenna for New Technologies

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Abstract: - In today's modern communication, various technologies have been increased. It greatly rises the requirements of wireless communication channel with light weight antennas. The microstrip patch antenna with recent technologies are found to be suitable to fulfill these requirements of RF communication systems. Generally, Microstrip patch Antenna (MPA) comprises of substrate, patch and ground plane. It can be easily fabricated using printed circuit board (PCB) technology. It is also called as 'Printed antenna'. Different feeding techniques like microstrip line, co-axial probe, aperture probe, aperture coupling, proximity coupling can be used as feed to the antenna. Several techniques have been used to improve the performance of the microstrip antenna. Still, the Microstrip Patch Antenna suffers from low gain, low efficiency and narrow bandwidth. Some of the commonly used techniques through which the performance of microstrip patch antenna can be enhanced are slotting, stacking, defected ground, shorting pins, metamaterial loading, etc. In this work, various techniques for designing a MPA were discussed. To understand the limitations of MPA, comparisons of the existing methods were carried out. This paper will serve a basic conceptual idea about MPA for the new researchers.

Keywords: -Microstrip Patch Antenna, 5G technology

I. INTRODUCTION

Wireless communication is emerging drastically to handle the traffic, high capacity and also to provide good quality of service. In order to make the communication more effective, we need to concentrate on the antenna used in the devices. Antenna is designed to radiate or receive electromagnetic waves. Here Microstrip Patch Antenna (MPA), also called 'Printed antenna' plays a vital role. It is compact in size and has several advantages over conventional microwave antenna. It consists of conducting patch on the top side, dielectric substrate with a ground plane on bottom side as shown in Fig. 1. The patch which is used in antenna could be: Square, rectangular, circular, triangular etc. Depending on the patch and materials used, overall performance of the antenna gets varied. Though MPA has more advantages, there are few

disadvantages such as low efficiency, low power handling capability and narrow bandwidth. The MPA design aim is to overcome the disadvantages by using different techniques. Feeding is the important one to excite the antenna to radiate effectively. Selection of substrate places a vital role in the characteristics of the antenna. Usually, substrate with dielectric constant in the range of $2.2 \leq \epsilon_r \leq 12$ is used for MPA [1]. Some of the parameters to be considered for selecting the substrate are dielectric constant, loss tangent, effects of temperature, humidity and aging. Its mechanical requirements are conformability, machinability, solderability, weight, elasticity and also the cost.

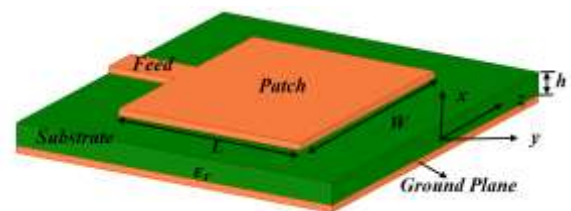


Fig. 1: Microstrip Patch Antenna

Recent 5g Technologies:

Antenna design for 5G applications has scope for recent research since it is an emerging technology which provides the high capacity and faster communication to the user. On October 22nd 2013, Federal Communication Commission (FCC 15138) proposed for wireless broadband frequencies of 28GHz, 37GHz, 39GHz and 64-71 GHz for 5G applications [2]. In mobile phones, antenna used need to be compact in size [3]. In order to reduce the size of the antenna within the handheld devices, miniaturization techniques such as slotting, stacking, modifications in ground, etc., are playing an important role [4]. There are lot of research papers available for particular applications [5,6]

II. APPLICATIONS

Fig. 2 shows the application on Microstrip Patch Antenna in several areas. Because of easy fabrication and other features, it is used in various applications. Global Positioning System (GPS) is useful to find the position accurately and to land the

vehicles. Radio Frequency Identification (RFID) operates in frequency between 30 Hz to 8 GHz and used as a tag, reader and transceiver. WiMAX frequency is achieved with Microstrip Patch Antenna with IEEE standard as IEEE 802.16. It requires the frequency ranges from 2 GHz to 66 GHz. Radio, Detection and Ranging (RADAR) used to detect the moving object. It needs more directivity. Telemedicine has the capability of antenna integration with clothes. In this, antenna sends health parameters such as heart rate, blood pressure, glucose level etc. Rectenna is a special type of antenna that is able to convert directly microwave energy into DC power. There are lots of applications in MPA other than the mentioned applications.

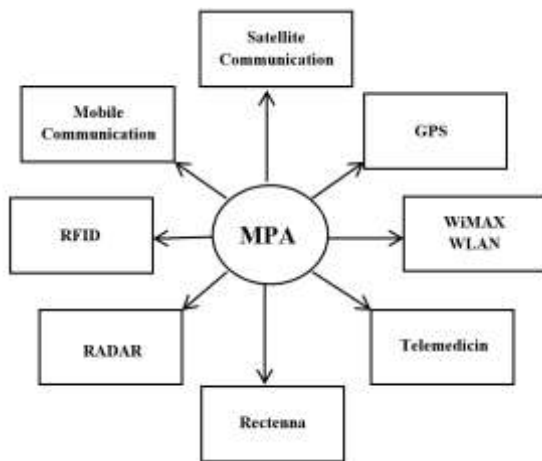


Fig. 2: Applications of Microstrip Patch Antenna

Fig. 3 presents the overview of design of a microstrip patch antenna. The design process consists of steps to choose the substrate material, dimensions of the ground plane, shape of the patches and types of feeding. A slight difference in loss tangent and dielectric constant of substrate leads to a very large changes in the output. So proper value of dielectric and loss tangent need to be chosen. RT Duroid and FR4 are the widely used substrates. Below the substrate part or sometimes above the substrate, ground plane was chosen by the length six times larger than the length of the patches and the width six times larger than the width of the patch. This was the optimized length and width of the ground plane. To design the patch in the antenna, different shapes have been considered. As from the survey, different techniques were used for the patch design. At last feeding can be done using any of the four standard methods or any other novel method.

IV. Feeding Techniques

A feed is a conductor that is connected with an antenna to provide excitation. It is mandatory to have the proper impedance matching between the feed and the antenna for the efficient radiation of electromagnetic (EM) waves. There are different methods available to feed an antenna. They are classified into two categories: Contacting and Non-Contacting. In the contacting methods, the RF (Radio Frequency) power is directly fed to the antenna using connecting conductor like microstrip line feed.

Other than this, Edge feed, Meanderline feed, Branchline feed and CPW (Co-Planar Waveguide) feed are some of the available other feeding methods in this category. In non-contacting methods, the RF power is not directly fed to the

radiating patch. The power is transferred to the path from the feed line through electromagnetic coupling. The most commonly used non-contacting feed methods are aperture and proximity coupled feed. Some of the frequently used feeding techniques for MPA have been reproduced in Fig. 1.3 which were given by the author Balanis [7]. These are designed using HFSS (High Frequency Structure Simulator) 2019 R2 and the brief explanation is given as follows [8].

Microstrip Feed

In this type of feeding technique, a microstrip transmission line of suitable dimension can be used as a feed and it is directly connected to the radiating patch or via QWT (Quarter-Wave Transformer) line. Inset feed is a kind of microstrip feed which has a cut at the two sides of the feed in deep into the patch as shown in Fig. 3 (a). It is made to achieve the good impedance matching by adjusting the length of the feed into the patch. It is simple in structure and easy to fabricate.

Co-axial Feed

The co-axial feeding technique is a non-planar feeding technique. The inner conductor of the co-axial connector is extended through the substrate which is connected to the radiating patch and the outer conductor is connected to the ground plane as shown in Fig. 3 (b). The feeding probe is located at the point where the antenna impedance is 50 Ω . It is also simple

III. FLOW CHART

1. SUBSTRATE: Different types of some commonly used substrates

S.No	Substrates	Dielectric constant	Loss tangent
1.	RT-Duroid	2.2	0.0009
2.	Polyflon	2.32	0.0005
3.	Roger 4350	3.48	0.004
4.	FR-4	4.4	0.018

2. GROUND PLANE: Optimized dimensions for choosing the size of the ground plane is given by,

$$L_g = 6H + L$$

$$W_g = 6H + W$$

3. PATCH: From the literature survey various techniques were used to design a patch as follows

1. Using different shapes of patch
2. Introducing parasitic elements
3. Etching different shapes of slots
4. Antenna array, etc.

4. FEEDING: Different types of feeding techniques which are used in MPAA are as follows

1. Coaxial probe feed
2. Microstrip feed
3. Aperture coupling
4. Proximity coupling

Fig. 3: Overview of Microstrip Patch Antenna design

in structure and easy to fabricate. But the disadvantage is narrow bandwidth.

Proximity Feed

Proximity feeding technique is a non-contacting feeding technique. Here the power transfer from the feed to the patch takes place through electromagnetic field coupling. It consists

of two dielectric substrates and the feed line is placed between the substrates as shown in Fig. 3 (c). The edge of the feed line is located at a point where the antenna input impedance is 50 Ω . The advantage is that it eliminates the spurious radiation and provides higher bandwidth. But it is slightly difficult to fabricate because of the two dielectric substrates.

Aperture Coupled Feed

Aperture coupled feeding technique is also a non-contacting feeding technique. It consists of two substrate layers and a ground plane is placed in-between the substrates. Radiating patch is placed at the top of the layer 1 and a feed is placed at the bottom of the layer 2. A slot is created at the ground plane to make an electromagnetic coupling between the patch and the feed as shown in Fig. 3 (d). This type of construction minimizes the spurious radiation and provides higher bandwidth. Similar to proximity coupled feeding technique, it has difficulties in fabrication due to two substrate layers.

CPW Feed

A Co-Planar Waveguide (CPW) is one type of planar transmission lines which has both ground and signal line on the same layer. It consists of three metal lines on the top of the

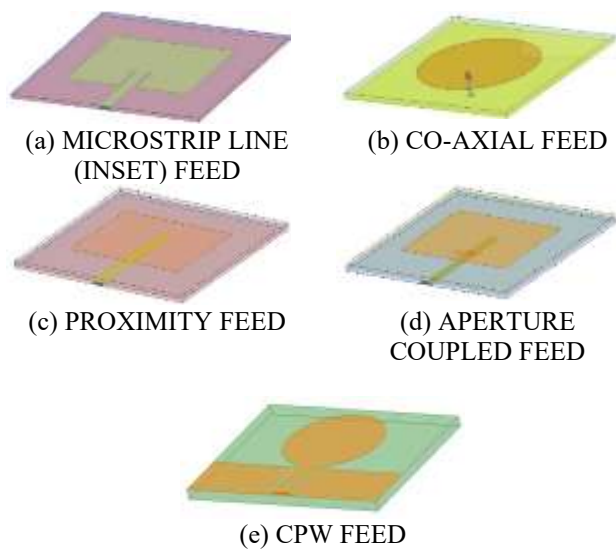


Fig. 3 Different types of Feeding Techniques

substrate as shown in Fig. 3 (e). The metal at two outer sides is acting as a ground and a metal in between the ground acts as a signal path. It is also used as a feed to the patch antenna. The advantage of CPW feed is that it provides wider bandwidth and good impedance matching.

IV. LITERATURE REVIEW

Various Shapes of Patches

K.Alameddine et al., described a new technique for bandwidth enhancement. Rectangular and triangular patches were used for proposed design that can be used in DCS, PCS, UMTS, and WLAN [9]. MHD Amen Summakieh and Mastaneh Mokayef presented 5G wireless application using proximity feeding technique the matching between radiating patch and feedline. The proposed antenna exhibited increased directivity and bandwidth [10]. Sumathi et al. presented a star shaped antenna for dual band operation which is suitable for satellite applications [11].

Slotting

Mandar P. Joshi and Vitthal J. Gond presented a dual band single feed circularly polarized square microstrip patch antenna using FR4 substrate with square shaped and L-shaped slots etched inside the patch [12]. Som Pal Gangwar and Kapil presented a design of microstrip patch antenna with five circular slots for wideband applications in frequency range from 1.91 GHz to 6.19 GHz [13]. Zaheer A. Dayo et al. presented a compact multiband planar bowtie slot antenna with fillet triangular-shaped slots, and a chamfered metallic ground plane [14].

Photonic Band Gap

Ritesh Kumar et. al., proposed a high gain novel microstrip patch antenna using polyimide substrate based on photonic crystal for terahertz spectral band applications [15]. Zhang et al. presented the properties of PBG for two-dimensional plasma dielectric crystals using transverse magnetic waves [16]. Mukhopadhyay et al. proposed an Electronic Bandgap structure to the antenna to reduce the interconnection problems. It provides high efficiency and enhanced bandwidth with proper impedance matching [17].

Defected Ground Structure

Deepak and Abhilasha presented two different methods to improve the performance such as slot cutting for frequency tuning and concept of defective ground structure to avoid ripples and obtained improved return loss [18]. Smrity Dwivedi has presented a new Defected Ground Structure (DGS) consisting of double I-shaped slot in ground for Bandwidth enhancement of the Microstrip Patch Antenna (MPA) [19]. Vishal Das et al. presented a wideband planar antenna with defected ground structure. It offered the THz applications [20].

Conducting Strips

Ahmad Emadeddin et al., presented a novel parasitic configuration to reduce the mutual coupling between two adjacent microstrip patch antennas. It was achieved by introducing several shorted dipole between patch antennas [21]. Asieh Habashi et al., presented two different designs of folded split-ring resonators (FSRRs), composed of single and double rows, etched into the ground plane for more reduction of mutual coupling more than 30 dB [22]. Yang et al. proposed a miniaturized circularly polarized antenna with four shorting pins. It provides the resonant frequency of 1.268 GHz for BeiDou Satellite Navigation System (BDS) applications [23].

Array

Muhammad Kamran Ishfaq et al., proposed 8 element series fed arrays with mixed standing wave and travelling wave behaviour to increase the gain [24]. W.Roh et al., presented mm-wave beamforming prototype antenna at a carrier frequency [25]. Touko et al. proposed a 2 x 2 array of patch antenna for satellite communication [26].

Stacked

Ankita Katyal and Ananjan Basu presented a broadband microstrip patch antenna using stacked configuration. The antenna comprises of two parasitic patches above the driven patch. It was proposed to increase the bandwidth with unidirectional radiation pattern [27]. Hossein Malekpoor and Mehdi Hamidkhani presented a compact multiband stacked

circular patch antenna which consists of folded-patch with V – shaped slot and two stacked circular patches. It gives the resonance at three different frequencies such as 3.85 GHz, 5.57 GHz and 10.22 GHz. This antenna covers wideband which is suitable for WiMAX and WLAN applications [28].

Miniaturization

D.D.Ahire and G.K Kharate proposed a corner rounded Ultra-Wideband rectangular microstrip patch antenna using FR4 substrate to achieve increased gain [29]. S. Imran Hussain Shah and Shahid Bashir proposed an antenna consists of four horizontal slots of various lengths in the patch and U-shaped and L shaped slot in the ground and obtained gain in the range of 3.5 dBi to 6.6 dBi [30]. Devesh et al. proposed a miniaturized fractal microstrip patch antenna using a hexagonal Sierpinski gasket structure. Its overall dimension is 50 x 50 x 1.6 mm³. It provided the hexa-band at 3.46 GHz, 8.28 GHz, 12.26 GHz, 17.21 GHz, 23.40 GHz and 26.01 GHz with its 4th iterations [31].

Fractal

Tanweer Ali et al. presented a miniaturized UWB antenna based on Sierpinski square slots. The antenna has a compact dimension of 28 x 28 x 1.6 mm³. It achieved the UWB band from 3.41 GHz to 15.37 GHz at its 2nd iterations [32]. Ashwini Kumar and Amar Partap presented a Modified Hilbert Curve Fractal antenna for multiband applications. It offered the resonant frequencies at 0.315 GHz, 1.94 GHz 2.95 GHz and 3.22 GHz at its 2nd iterations. It covered the radiolocation in Ultra High Frequency (UHF) and Aeronautical Radio Navigation Service (ARNS) in C – band, X – band and Ku – band as defined by International Telecommunication Union (ITU) [33].

Metamaterial

Boopathi Rani and Shashi Pandey proposed the design of dual band antenna using metamaterial structures of square closed ring resonator and square split ring resonator. It was designed for the resonant frequencies of 2.45 GHz and 3.5 GHz which are suitable for the applications of WLAN and WiMAX [34]. Pandeewari proposed a MSRR based CPW-fed antenna for RFID application. It was designed on FR4 substrate material. Metamaterial unit cell was designed at the resonant frequency of 5.8 GHz and implemented using MSRR (Multiple Split Ring Resonator) as a radiating element of the antenna [35]. Rajasri et al proposed a decogan shaped metamaterial-inspired antenna for vehicular applications such as GPS (Global Positioning System), LTE (Long-Term Evolution), UMTS (Universal Mobile Telecommunication System), WLAN (Wireless Local Area Network), Wi-Fi (Wireless Fidelity), INSAT (Indian National Satellite), etc [36].

Substrate Integrated Waveguide technology

Muhammad proposed a broadband SIW antenna for high gain applications. The antenna consists of square shaped patch with dimensions of 5.2 x 5.2 mm². By putting via-through-holes along the four sides of the truncated patch, an SIW cavity is achieved [37]. Arvind Kumar and S. Raghavan presented a review on the design of SIW antennas. It provides with design rules of vias, SIW arrays, leaky wave antenna, horn antennas [38]. Muntoni et al. proposed a wearable antenna with SIW technology. The antenna functions in the UHF frequency band, at 867 MHz, and shows compact size, minimal manufacturing complexity and very low production cost [39].

V. COMPARATIVE ANALYSIS

Table 1 provides the comparison of different existing antennas with its proposed techniques.

Table 1: Comparative analysis of various types of microstrip patch antenna

Ref.	ANTENNA TYPE	TECHNIQUES	RESULTS
[3]	Octagonal shaped CPW-fed	Metamaterial-inspired	It was designed for the resonant frequencies of 1.7 GHz, 3.4 GHz and 4.5 GHz.
[12]	Dual Band single feed circularly polarized MPA	A square and L-shaped slot was etched on the patch	Suitable for WLAN (2.4 – 2.48 GHz) and WiMAX (5.25 – 5.85 GHz)
[15]	Polymide substrate structure	Photonic Band Gap was used	Gain:7.94 dB Directivity: 8.63 dBi Bandwidth:36.23 GHz
[18]	Miniaturized microstrip patch antenna	Defective Ground Structure	Return loss: -21.069 dB Directivity: 4.07 dBi VSWR: 1.5
[21]	Mutual coupling between two adjacent MPA	Introduced five narrow conducting strips of different lengths in between two MPA	41 dB mutual coupling reduction.
[24]	8x8 phased series fed patch antenna array	Inset feed	Used for 5G mobile station antenna. Operation at 27.9 to 28.4 GHz. Gain: 24.25 dBi.
[27]	A broad band and compact stacked MPA	Two parasitic patches above the patch. Inserted a vertical slot in the direction of feed.	Achieved minimum volume with good bandwidth and radiation properties.
[29]	Ultra-Wideband monopole rectangular MPA	Made lower corners of rectangular into round corner.	Bandwidth: 9.16GHz Gain: 3.02 dBi.
[40]	E-shaped Fractal Patch Antenna (EFPA)	Various iterations of E-shaped fractal.	It covers GSM850/900, GSM1800/1900/UMTS and LTE2300/2500
[41]	Wideband patch antenna	Electromagnetically coupled feeding technique	Increase the bandwidth. Used in DCS, PCS, UMTS, WLAN and IMT-2000.

VI. CONCLUSIONS

In this paper, the literature review of Microstrip Patch Antennas which were designed using various techniques are studied. Gain and bandwidth are the important parameter for Microstrip Patch Antenna. These antennas are playing a vital role in mobile applications. Emerging 5G technology need MPA for the effective utilization of the proposed spectrum. Among various frequencies, 38 GHz is the common frequency which is used for the analysis of 5G technology. The combinations of techniques which are studied in this paper can be applied in antenna design for the performance improvement.

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