Review Article

Comprehensive Analysis of Monopole Microstrip Patch Antenna Design

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ABSTRACT

Wireless communication technology has changed our lives during the past two decades. In countless homes and offices, the cordless phones free us from the short leash of handset cords. Mobile phones give us even more freedom to communicate with each other at any time and in any place. Wireless local area network (WLAN) technology provides access to the internet without suffering from managing yards of unsightly and expensive cable. The technical improvements have also enabled a huge number of new services to emerge. Antenna "The eyes and ears in space" is experiencing a various change from earlier long wire type for radio broadcast, communication links to the military applications, aircraft, radars, missiles, space applications in the second half of last century. This scenario is fast changing with the evolution of Cellular mobile personal communication in the form of Global System for Mobile communications (GSM), Code Division Multiple Access (CDMA), Digital Communication System (DCS) 1800 systems, North American dual-mode cellular system Interim Standard (lS)-54, North American IS-95 system, and Japanese Personal Digital Cellular (PDC) system etc. This work explores an extensive survey of literature on wideband monopole square microstrip patch antennas.

KEYWORDS

Patch Antenna, Monopole Square, Microstrip Patch Antenna

1. INTRODUCTION

The antenna is one of the most vital parts, for wireless communication systems. Transmitters and receivers communicate with each other with the help of antennas. As stated in the IEEE standards definition of antennas, the antennas are basically the means of transmitting and receiving radio waves. So, the antenna is the transitional structure between the free space and the guiding space. Antennas act as a transducer which changes the electrical energy to the electromagnetic energy and guide that energy into a particular direction as required by the system. Radio transmitters and receivers are used to send and receive signals in the networks including radio broadcast, point to point communication links and many short-range networks.

Types of Antennas

Classification of antennas on various different ways is as follows: -

a. Based on Aperture

- Wire antennas: These antennas are well known to layman as these antennas can be seen commonly like on automobiles, buildings, ships, aircrafts, spacecrafts etc. There are different shapes of these antennas like straight wire, loop, and helix.
- Aperture antennas: These antennas are more known to the layman in present day than in the past because of the growing demand for more complex form of antennas and also for usage of higher frequencies. Aperture antennas are majorly used in aircrafts and spacecrafts because they can be simply flush-mounted on their upper layer. Also, they can be shielded with an insulator to save them from harsh surrounding conditions [8].
- Microstrip antennas: They have utilization in space applications, government and commercial applications. Microstrip antennas comprise of a metallic patch on a grounded substrate. The metallic patch can be of various configurations such as rectangular, circular etc. These antennas are of low profile, adapted to planar and non-planar surfaces, easy and less expensive to fabricate with the use of modern printed-circuit technology, mechanically durable when installed on hard surfaces and very flexible in terms of impedance, resonant frequency, radiation pattern and polarization.

- Array antennas: In order to get the required radiation patterns, which is not feasible with a single antenna, an assembly of radiating elements is used which is called an array. The arrays should be aligned in such a way that the radiations accumulate to produce maximum radiation in a specific direction or directions and minimum radiations elsewhere as required.

b. Based on Radiation Characteristics

- Directional antennas: They are also called as beam antennas, which transmit and receive in a specific direction. A directional antenna is designed to maximize its radiations in the direction of a particular location or to cover a specific area.
- Omni-directional antennas: These antennas transmit and receive equally well in all horizontal directions in a flat, two-dimensional geometric plane. Omni-directional antennas are used in cellular phones, wireless routers.

c. Based on Polarization

- Circularly polarized antennas: These antennas are able to transmit or receive electric field vectors of any direction. They emit electromagnetic fields in a corkscrew-like fashion and broadcast electromagnetic waves on two planes making one complete revolution in a single wavelength.
- Linearly polarized antenna: These antennas transmit or receive electromagnetic waves in a single plane i.e. either vertical plane or horizontal plane. RFID tag direction must be known to the antenna, the plane of the antenna and its RFID tag must be similar to get a consistent reception.

The main requirement in today's wireless scenario is to reduce the size of the antenna and reduce its power consumption. So, by keeping this in the mind microstrip patch antennas come into the picture.

2. MICROSTRIP PATCH ANTENNA

The microstrip patch antenna comprises of a transmitting fix, substrate and ground plane. The patch stays as the upper layer. The ground plane lies on the base. In the middle of emanating fix and ground plane there lies the substrate. The substrate is made of PEC material. The radiating patch and the feed lines are commonly photograph scratched on dielectric substrate.

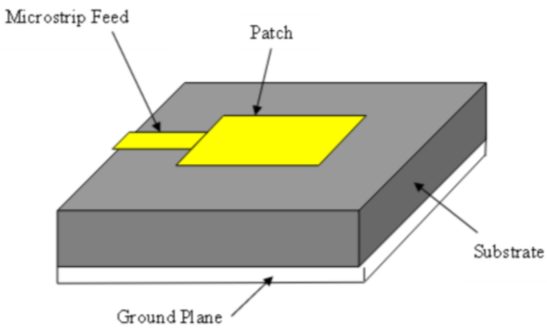

Figure 2.1 Microstrip patch antenna design.

The radiating patch is generally is square, rectangular, circular, triangular and roundabout. If there should be an occurrence of rectangular patch, the length L of the patch is commonly lies between 0.3333λo to 0.5 λo, where λo is the free-space wavelength. It has by and large the thickness of t where t<< λo. The thickness h of the substrate is for the most part 0.05 λo ≥ h ≥ 0.003 λo the scope of the dielectric steady of the substrate by and large lies in the middle of 2.2 to 12. For better radiation properties, a thick dielectric substrate is taken which is having a low dielectric steady is appealing since it gives better productivity. So, to achieve higher transmission capacity of antenna various techniques are reported by many authors. Henceforth, design must be analyzed for the antenna execution.

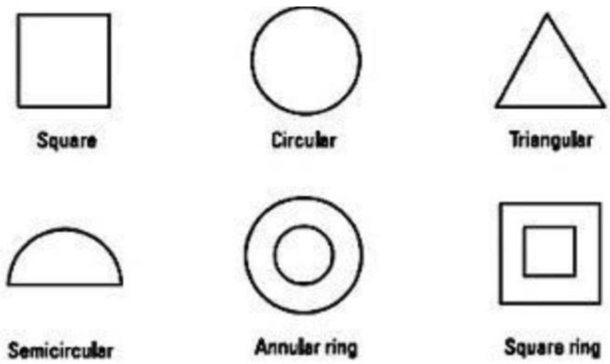

Figure 2.2 Distinct faces of microstrip patches.

3. LITERATURE REVIEW

Sr. No.	Title	Author	Year	Approach
1	A Broadband Microstrip Antenna with Stable Gain	Bo Cheng and Zhengwei Du	2020	Author reported a FR4 substrate having dielectric constant 4.4 is used
2	A WLAN notched wideband monopole antenna for ultra wideband communication applications	A. Utsav, A. Kumar and R. K. Badhai,	2017	Author reported the prototype of proposed antenna is designed on FR-4 dielectric material with a very small size as 0.35λ0 × 0.3λ0 × 0.0166λ0
3	A novel wideband monopole antenna loading parasitical patches,	L. Meng, W. Wang, J. Gao and Y. Liu,	2017	Author reported a microstrip-fed monopole antenna and two parasitical patches

4	A compact ultra-wideband monopole antenna for breast cancer detection,	A. I. Afifi, A. B. Abdel-Rahman, A. Allam and A. S. A. El-Hameed,	2016	Author reported a very compact UWB monopole antenna with large bandwidth, for breast cancer detection is designed and fabricated
5	Body coupled wideband monopole antenna	M. Tømmer, K. G. Kjelgård and T. S. Lande,	2016	Author reported a planar body coupled wideband monopole antenna for medical imaging and sensing applications
6	Single Band-Notched UWB Square Monopole Antenna with Double U-slot and Key Shaped Slot,	A. Sudhakar, M. Satyanarayana, M. S. Prakash and S. K. Sharma	2015	Author reported a compact printed monopole ultra-wideband (UWB) antenna with single band-notched characteristics
7	Small monopole antenna with corner modified patch for UWB applications	S. Kundu, M. Kundu and K. Mandal,	2014	Author reported a new form of the microstrip-fed UWB printed monopole antenna with corner modified radiating plane

Bo Cheng and Zhengwei Du, [1] proposed and investigated a low-profile, broadband microstrip antenna with consistent gain. The proposed antenna's radiating patch is shorted by two rows of shorting pins and three slots separate it into six parts. A microstrip line feeds the antenna through a slit created in the ground. Two resonance modes with broadside radiation are excited at the same time. With a profile of 0.06 0 (0 is the centre operating wavelength in free space), the suggested antenna achieves a broad operating band of 4.05-5.86 GHz and a relative bandwidth of 36.5%. It has a very steady gain of 5.7-6.5 dBi and stable radiation patterns in the operational band.

A. Utsav, A. Kumar and R. K. Badhai, [2] A compact ultra-wide band planar monopole antenna with double I shaped slots on the ground plane for notched band characteristics in the 5 GHz WLAN band are presented in this investigation. The prototype of proposed antenna is designed on FR-4 dielectric material with a very small size as $0.35\lambda 0 \times 0.3\lambda 0 \times 0.0166\lambda 0$ ($\lambda 0$ is the wavelength at the lowest operating frequency of the antenna). The proposed antenna having a bandwidth of 42% in the range from 3 GHz to 4.5 GHz, before the notch, and 79% from 6.4 GHz to 13 GHz after the notch. The proposed antenna obtained the good impedance matching in the pass band and good isolation for stop band; it also exhibits good antenna gain and efficiency. The proposed design is suitable for various communication purposes, Navigation purposes and Radar technology with a stop notch band at WLAN range.

L. Meng, W. Wang, J. Gao and Y. Liu, [3] A novel wideband monopole antenna employing parasitical patches is presented in this investigation. The proposed antenna consists of a microstrip-fed monopole antenna and two parasitical patches. In this exploration, utilize a stepped microstrip-fed structure to improve the impedance matching of the antenna to achieve a wide bandwidth. Furthermore, loading the parasitic patches can significantly improve broadband characteristics. A prototype antenna is manufactured using TLF-35A substrate. The measured bandwidth of the antenna goes from 2.66 GHz up to 5.48 GHz (69.3%) and has a peak gain of 2.15 dBi.

A. I. Afifi, A. B. Abdel-Rahman, A. Allam and A. S. A. El-Hameed, [4] In this manuscript, a very compact UWB monopole antenna with large bandwidth, for breast cancer detection is designed and fabricated. The designed antenna has a size 10.2 mm×15.5 mm and operates over a frequency range from 4.23 GHz up to more than 14 GHz. The proposed antenna shows a sufficient variation of transmission response, displays good omnidirectional radiation patterns, gain level reaching to 5.17 dB, radiation efficiency above 85% over the operating band, high fidelity reaching to 0.965 and the maximum variation in a group delay is 0.25 ns. The proposed design achieves the specifications of the element to use in an antenna array for breast cancer detection.

M. Tømmer, K. G. Kjelgård and T. S. Lande, [5] In this exploration a planar body coupled wideband monopole antenna for medical imaging and sensing applications is presented. With a dielectric spacer between the monopole and body, a high degree of body coupling and low matching sensitivity is achieved. The antenna is a staircase monopole with a -10dB reflection bandwidth of 2.5-7 GHz measured on the forehead, breast bone and calf muscle. Antenna size is only 20×20 mm. Measurements of the antenna coupled to the body surface indicate significant improvements using a low-loss dielectric spacer with permittivity matching the body. The wide bandwidth, high body coupling and low sensitivity to varying body dielectric properties makes this antenna a suitable candidate for microwave medical imaging and body sensing applications.

A. Sudhakar, M. Satyanarayana, M. S. Prakash and S. K. Sharma, [6] A compact printed monopole ultra-wideband (UWB) antenna with single band-notched characteristics of size 18mm× 12mm on FR4 substrate is proposed. The proposed antenna consists of a pair of slits and two U slots with a key shaped slot combined with one of the U slot. This provides a wide band width from 4.4 to 11.7 GHz with single band frequency notch from 5.2 to 5.8 GHz to avoid interference of UWB band with the existing systems. In this exploration variation of frequency notched characteristics are discussed by combining the key shaped slot with U slots. The design parameters and the performance of the proposed antenna are analyzed by using HFSS. The antenna displays a good omnidirectional radiation pattern since it has square radiating patch. The measured and simulated results are in good agreement.

S. Kundu, M. Kundu and K. Mandal,[7] A new form of the microstrip-fed UWB printed monopole antenna with corner modified radiating plane is proposed. Four slots with same arc radius are introduced on the four corners of the square patch, which provides a wide usable fractional bandwidth of more than 122% (3.1-12.85 GHz). The proposed antenna is simple and small in size as it is designed onto an inexpensive FR4 substrate with an overall dimension of 18 × 25 mm2. In this work the effects of slots insertion, slot radius variation and gap variation between patch and ground plane are studied with the help of simulated results. Simulated results obtained for this antenna show that it exhibits good radiation behavior within the UWB frequency range.

4. PROBLEM FORMULATION

The applications in today's wireless communication systems generally require miniaturization of antennas in order to reduce the size of mobile devices. Therefore, reduction of size and bandwidth improvement, both are becoming significant design features for practical implementation of microstrip antennas. Due to this, there has been a surge in research studies to attain small size and large bandwidth of microstrip antennas. Remarkable advancements in the designing of small sized microstrip antennas with ultrawide bandwidth, multi-frequency bands, dual- polarization and gain enhancements have been seen over the last few years. Microstrip patch antennas generally have a conducting patch mounted on the top of a grounded dielectric substrate, and have low power consumption, light weight, ease of fabrication, and compatibility to mounting interface. Since, microstrip antennas have small frequency bandwidth comparatively; bandwidth improvement is usually required for practical applications. Basically, a microstrip patch antenna includes a radiating patch on the upper side of a substrate which is made of a dielectric material, on the bottom side of the substrate there is a metallic ground plane. The patch is generally made of conducting material like copper or gold and can be of any feasible structure.

5. CONCLUSION

This exploration analysis presents an extensive survey of literature of designs of microstrip patch antennas for various frequency band applications are discussed. The technical improvements have also enabled a large number of new services to emerge. The first-generation (1G) mobile communication technology only allowed analog voice communication while the second-generation (2G) technology realized digital voice communication. Currently, the third-generation (3G) technology can provide video telephony, internet access, video/music download services as well as digital voice services. The main objective of investigation phase is to gain good understanding of wide band antenna technology and microstrip line calculations.

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