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Study on Designing An Ultrawide Microstrip Antenna using Band-Notched Characteristics-Review

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Abstract— **In the present day scenario of growing wireless communications, demand for compact, low-profile, ultrawide band (UWB), multiple functionality, pure polarization, and low cost antennas have arisen remarkably. Due to which, research studies in the field of microstrip patch antennas have drastically increased in the past few years. In this report, design and analysis of two UWB microstrip antennas with notched band characteristics are presented. The first design consists of a semi-circular disc with a dual stepped triangular patch. The second antenna design has dual notched band characteristics. It consists of a mirrored E-shaped structure inscribed inside a circular ring radiator.**

Keywords—Microstrip antenna, ultrawide band, WLAN, WiMAX, band-notched, circular patch antenna.

1. INTRODUCTION (WIRELESS COMMUNICATION)

Wireless communication is the transfer of the data between two or more points which are indirectly connected to each other. The term “Wireless” came into general usage to refer to a radio transmitter or receiver constituting its use in wireless communication such as in mobile networks and mobile broadband internet. It also refers to any type of application that is employed without using wires. It includes different types of duplex radios and cellular phones that are mobile and portable. Other examples of wireless communication are global positioning system (GPS), cordless computer peripherals, satellite television etc. [1].
Wireless communication is the fastest growing division of the communications industry. These communication systems play very critical role in our everyday life. During the last few years, a number of enhancements have been noticed in the field of wireless mobile technologies. There has been a surge of research activities in this area. This is due to a several factors. First, there has been an increase in demand for tether less connectivity wireless data applications. Second, the progress in VLSI technology has enabled small-area and low-power implementation of sophisticated signal processing algorithms and coding techniques. Third, the success of second- generation (2G) digital wireless standards, especially, the IS-95 code division multiple access (CDMA) standard, provides a concrete example that good ideas from communication theory can have a major impact in practice [2].

Wireless systems allow long range communications that are difficult or inconceivable to employ with the use of wires. The most common usage of wireless systems is to connect the wireless device data communication users who travel to different locations. Other important use of wireless networks is to connect mobile networks through antennas using satellite communication. Radio frequency (RF) communication, microwave communication, infrared communication, short range electromagnetic induction communication, ultrasonic short range communication etc. Categorization of wireless mobile communication system on the basis of various generations it has gone through is presented here.

- *First Generation*

The first generation wireless communication technology was analog i.e. voice based communication system. It used analog frequency modulation technique to send the voice signals. The available frequency channels were shared by the users by using frequency division multiple access (FDMA) technique.

- *Second Generation*

The second generation of mobile communication technology is digital. Digital cellular services are extremely used world-wide. This technology also shows increased capacity because voice signals can be multiplexed in a more efficient manner. It gives the various services such as WAP (internet on small devices), digital voice call and short messaging service (SMS).

Global system for mobile (GSM), time division multiple access (TDMA) and code division multiple access (CDMA) are examples of second generation wireless standards [3].

- *Third Generation*

The third generation of wireless mobile communication technology provides pretty high speed wireless communication to accommodate more useful services like data, video, multimedia and voice. Enhanced data rates for GSM evolution (EDGE), high speed packet access (HSPA) and universal mobile telecommunications system (UMTS) are the various standards which are used in third generation wireless technology. 3G systems have improved features for multimedia communications i.e. digital data, voice c0mmunication,etc.

- *Fourth Generation*

The fourth generation wireless communication system is expected to provide the data transmission rate of 20 Mbps by implementing OFDM (orthogonal frequency division multiplexing) technique and for better allocation of network resources to multiple clients by using multiple carriers simultaneously.

The third generation networks are based on both packet-switching and circuit-switching networks, but the fourth generation networks will be exploiting only packet switching and may connect all the users anywhere around the globe [3].

- *Fifth Generation*

Fifth generation is to be a new technology that will deliver all the possible applications, by using only one universal device, and interconnecting most of the already existing communication infrastructures. The fifth generation principal is to be a re-configurable, multi-technology principal. Cognitive radio (CR), software defined radio (SDR)-configurability enabler, reconfigurable-interoperability between several types of wireless access network, adaptive coupling reconfigurable integration, nanotechnology and Cloud computing are main challenges for the development of the fifth generation communication systems [6].

2. TYPES OF ANTENNAS

Classification of antennas on the basis of 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*:. 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 [8].

3. MICROSTRIP PATCH ANTENNAS:

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.

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. The radiating patch, the feed line and the ground plane are generally engraved by a photomechanical process on the substrate.

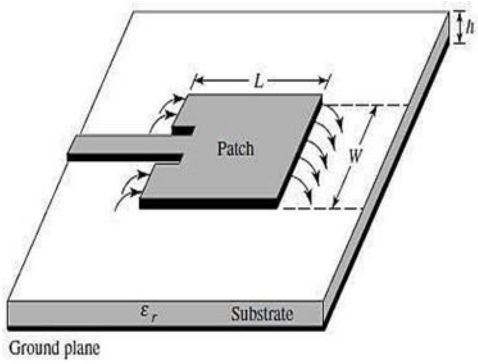


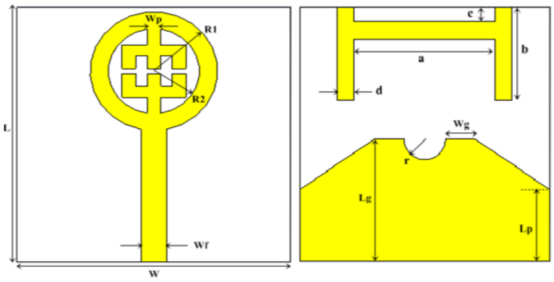
Fig 1:Top view of microstrip antenna

ULTRAWIDE BAND (UWB) MICROSTRIP ANTENNAS

After years of research studies on ultrawide band wireless communication systems, a large number of applications have been found in short range and high speed wireless systems. In 2002, the Federal Communication Commission (FCC) in United States allocated the band in the range from 3.1 to 10.6 GHz having the equivalent isotropically radiated power (EIRP) less than -41.3dBm/MHz for unlicensed radio communication in UWB applications.

In the ultrawide band frequency range there exist other wireless narrowband standards like wireless local area network (WLAN) having frequency bands from 5.15 to 5.35 GHz and 5.725 to 5.825 GHz, Worldwide Interoperability for Microwave Access (WiMAX) having frequency band from 3.3 to 3.6 GHz, and other C-band systems having range from 3.7 to 4.2 GHz, which tends to cause undesired interference with the functioning of UWB systems.

FABRICATED ANTENNA DESIGN



(a) (b)

Fig 2: Antenna design for dual notched bands (a) top view (b) bottom view

To create two rejection bands an H-shaped parasitic element is etched on the bottom side of the substrate above the ground plane. Dimensions of the parasitic element are; a = 17 mm, b = 11 mm, c= 1.7 mm and d = 2mm.

4. METHODOLOGY

- A printed patch antenna has been designed for UWB applications with notched band characteristics. In the design, a semi-circular patch is used and a dual stepped triangular patch is mounted upon it. These steps are made to enhance the bandwidth of the antenna. A partial ground plane is used in the design which also incorporates in bandwidth enhancement. To create a stop band to avoid interference from WLAN band, a slot has been cut in the shape of a circular arc on the circular patch.

- A printed monopole antenna has been designed for UWB systems with dual notched band characteristics. In the design, a trapezoidal shaped ground plane having a semi-circular notch has been used to obtain ultrawide bandwidth. To obtain dual notched band characteristics a mirrored E-shaped structure is inscribed inside a circular ring patch and an H-shaped parasitic element is etched above the ground plane on the bottom side of the antenna.

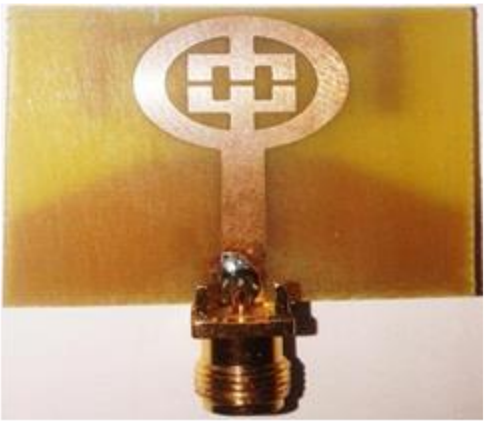


Fig 3: Design of the fabricated antenna (top view)

Fabrication of an antenna involves a process called printed circuit board (PCB) designing. Steps of PCB designing process:-

- Layout of the antenna is designed on a designing tool named OrCAD and its print is taken on a transparent paper to develop the negative of the design.

- A copper sheet is cut according to the dimensions of the substrate using a PCB cutter.

- Copper sheet is dipped in the photo resistive solution and then it is kept in the oven for drying for 10 to 15 minutes.

- The printed paper and the copper sheet are put under the ultraviolet (UV) rays to get the print of the design on the copper sheet.

- The PCB is washed in the etching solution which contains ferric chloride and it is washed afterwards.

5. RESULTS

- *Return Loss (S11)*

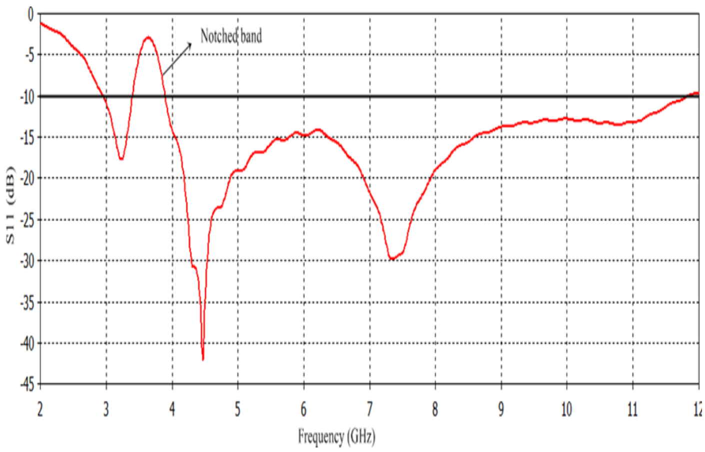


Fig 4: Return loss (S11) curve showing single notched band.

The simulations are performed using CST Microwave Studio package [41]. The simulated return loss (S11 in dB) plot for the antenna is shown in Fig. 4.2. It can be observed from the plot that -10 dB impedance bandwidth of the antenna is from 2.9 to 11.8 GHz, giving a total bandwidth of 8.9 GHz, which is an ultrawide bandwidth. A notched band is generated from 3.4 GHz to 3.9 GHz due to the presence of mirrored E-shaped structure inside the patch. This rejection band is created to mitigate the interference from the WiMAX band with center frequency 3.5 GHz

- *Gain Of The Antenna*

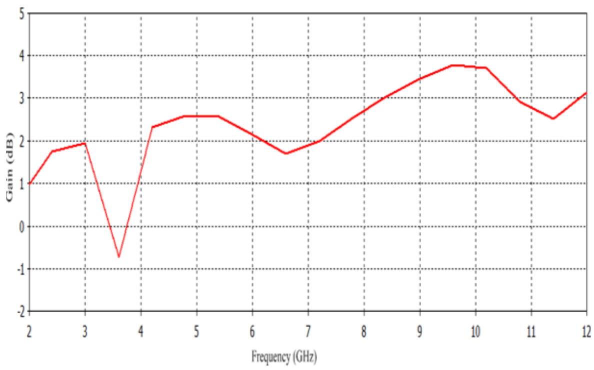


Fig 5: Antenna gain (in dB) versus frequency plot

From the antenna gain versus frequency plot (Fig. 4.4), it can be observed that the gain is increasing with the increase in frequency. Highest gain obtained is 3.8 dB at 9.6 GHz. For the notched band (3.4 GHz to 3.9 GHz), there is a drop in the gain up to -0.7 dB.

The reason for the creation of this rejection band by using the E-shaped elements is that the direction of flow of the current in the circular ring radiator and the E-shaped elements becomes opposite to each other, thereby cancelling out the resultant radiation field vector.

- *Return Loss Of The Antenna:*

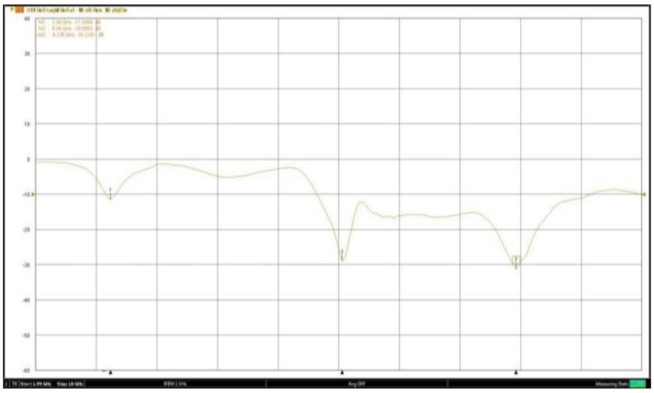


Fig 6: Measured return loss of the antenna.

Measured return loss (S11 in dB) versus frequency plot is shown in Fig. 5.3. -10 dB return loss impedance bandwidth of the antenna is 8 GHz, ranges from 3.2 to 11.2 GHz. A stop band is generated by the antenna from 3.4 to 6.6 GHz for rejecting WiMAX, WLAN and C bands. Minimum return loss is -31 dB at 9.9 GHz. This stop band is due to the inclusion of the mirrored E-shaped structure inside the circular ring radiator and the H-shaped parasitic element above the ground plane of the antenna.

6. FUTURE SCOPE

Various methods like cutting a pair of U-shaped slots and a C-shaped slot [44], including an inverted T-shaped element [45], a loaded arc shaped stub (LAS) [46] etc. can be used to create adjustable multiple notched bands. Metamaterials (MTMs) can be used for miniaturization of the antenna design [47]. Different techniques from electromagnetic band-gap (EBG) antennas, Fabry-Perot antennas (FPA) and resonant cavity antennas, LWAs can be used for directivity enhancement and spurious radiation reduction

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