Analysis of Notch in Microstrip Antenna

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Abstract : To enhance the performance, various methods have been applied to design the antenna. Still the scope remains unchanged in antenna research. Antenna has a prime role in wireless communication. In recent years, researchers have focused on improvement of the UWB antennas. UWB has attractive merits compact size, low cost, resistant to severe multipath and jamming, ease of fabrication, and good omnidirectional radiation characteristics. However, the use of the 5.15 to 5.825 GHz frequency band has been limited by IEEE 802.11a for wireless local area network (WLAN) systems. To avoid the interference between the UWB and WLAN systems, a band-notch filter in UWB systems is necessary. However, the use of a filter will increase the complexity of the UWB system. Therefore, a UWB antenna having frequency band-notch characteristic can be an alternative choice to overcome this problem. The effect of notch in the microstrip antenna has been analyzed in this work. The results have been shown for both without notch and with notches.

I. INTRODUCTION

Wireless communication systems are becoming popular Day-by-day. The technologies for wireless communication still need to be improved further to satisfy the higher resolution and data rate requirements. That is why ultra wideband (UWB) communication systems covering from 3.1 GHz to 10.6 GHz released by the FCC in 2002 is currently under development [1]. The ultra-wideband (UWB) technology has given rise to much interest in designing wideband antennas. Wideband antennas have found widespread application in wireless communication industry due to their attractive features like easy fabrication, low cost, linearly and circularly polarized radiation characteristics. Due to these attractive features wideband antennas are used in many wireless applications such as Wi-Fi, Bluetooth, GSM and GPRS. Low profile multiband antennas with sufficient bandwidth coverage fine radiation characteristics fulfill the need of present wireless devices [2].

For many years, various antennas for wideband operation have been studied for communications and radar systems [3], [4]. In UWB communication systems, one of the important issues is to design of a compact antenna while providing wideband characteristic over the whole operating band. Due to their appealing features of wide bandwidth, simple structure, omnidirectional radiation pattern, and ease of construction several wideband configurations, such as circular, square, elliptical, pentagonal, and hexagonal have been proposed for UWB applications [5]–[7]. To obtain various applications, the notches may be introduced in the microstrip antenna. It will serve for different frequency bands.

The paper is organized with five sections. Section I introduced the work where as section-II briefly describes regarding the microstrip antenna. Section-III explains the effect of notch theoretically and section-IV describes its simulation and results. Finally, section-V concludes the work.

II. MICROSTRIP ANTENNA

One of the most exciting developments in antenna is the advent of Microstrip antenna. It is the most popular and adaptable. This is because of all the features including ease of fabrication, good radiation control, and low cost of production. It is constructed from dielectric substrate and patch, metal and that a portion of the metallization layer is responsible for radiation. Microstrip antenna was conceived in the 1950s, and then extensive investigations of the patch antennas followed in the 1970s and resulted in many useful design configurations. Through decades of research, it was identified that the performance and operation of a microstrip antenna are driven mainly by the geometry of the printed patch and the material characteristics of the substrate onto which the antenna is printed. It is one of the important elements in modern wireless communication systems and hence its design optimization are an important aspect of improving the overall performance of the system have been extensively used in many applications due to their low profile, ease of manufacture, and the possibility of integration with other circuits.

In case of microstrip design, the upper conducting layer or "patch" is the source of radiation where electromagnetic energy fringes off the edges of the patch and into the substrate. The lower conducting layer acts as a perfectly reflecting ground plane, bouncing energy back through the substrate and into free space. Physically, the patch is a thin conductor that is an appreciable fraction of a wavelength in extent. The patch which has resonant behavior is responsible to achieve adequate bandwidth. Conventional patch designs yield few percent band widths. In most practical applications, patch antenna is rectangular or circular in shape; however, in general, any geometry is possible. Microstrip antenna should be designed so that its maximum wave pattern is normal to the patch. This is accomplished by proper choice of mode of excitation beneath the patch. With the widely and rapidly development of modern wireless communication systems, multiband and wideband antennas are in high demand. Antennas need to have multiband wideband characteristics in order to be flexible enough to cover multiple communication frequency bands.Microstrip Patch Antennas are capable of producing multi resonances, adaptable for a wide range of wireless. Generally, radiating patch is normally made of conducting material such as copper or gold and can take any possible shape. Figure1 depicts the microstrip patch antenna with dimensional specifications .Parameter 'L', is the length of the patch in the antenna which is the non-radiating edge .Parameters 'W' and 't' are the width of the substrate below the patch and the thickness of the patch. The dielectric medium and the dielectric constant 'εr', determines the coupling of signal. Microstrip Patch Antennas can also have shapes like square, rectangular, circular, triangular, elliptical and fractal designs one of these structures is shown in Fig.1.

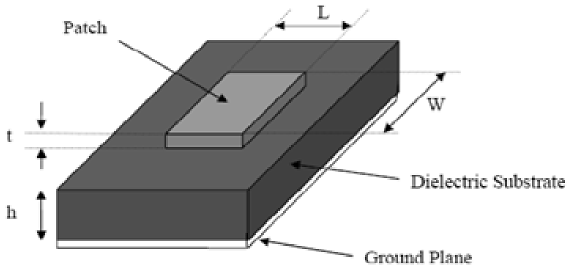

Figure1. Microstrip Patch Antenna

To reduce the size of MPA, substrate with higher dielectric constants are used which are less efficient and result in narrow bandwidth. A thick dielectric substrate with low dielectric constant provides larger bandwidth, better radiation and greater efficiency. But such configuration leads to a larger antenna size. Hence a trade-off must be realized between the antenna performance and antenna dimensions.[8]

A microstrip patch antenna consists of a radiating patch on one side of a dielectric substrate which has a ground plane on the other side as shown in Figure 1. The patch is generally made of conducting material such as copper or gold and can take any possible shape. The radiating patch and the feed lines are usually photoetched on the dielectric substrate. Arrays of antennas can be photoetched on the substrate, along with their feeding networks.

In recent years, microstrip antennas have been one of the most innovative topics in antenna theory and design. The basic idea of microstrip antenna came from utilizing printed circuit technology not only for the circuit component and transmission lines, but also for the radiating elements of an electronic system. They are used in a wide range of modern microwave applications because of their simplicity and compatibility with the printed - circuit technology. A microstrip antenna, in its simplest form, consists of a rectangular shape (or other shapes such as circular, triangular, etc.) on top of a substrate backed by a ground plane [9]. Microstrip antennas have a great demand for commercial applications such as mobile and satellite communications. But the disadvantage is that microstrip antennas suffer from low bandwidth. Research has been done over the years to develop bandwidth enhancement techniques. These techniques include use of substrates with more thickness and less dielectric constant [10], and stacked patches [11]. By using stacked patches, bandwidth can be increased, but this would add complexity in fabrication. A simple method to achieve bandwidth enhancement in a microstrip antenna is embedding a slot in the patch in which the radiating patch includes a pair of step-slots [12]. It results the notice at specific frequency.

III. MICROSTRIP ANTENNA WITH NOTCH

The basic component of a factors constant, replicas of transmission line in communication system is an antenna [13], ground plane are placed, as stacking makes the overall particularly patch antennas have rapidly design bulkier, difficult to produce and alignment in multiacclaimed a lot of interest due to their layers is another major issue encountered in case of applicability in satellite, missile and mobile stacking so varying ground plane seems to be a better communication systems [14]. As mobile devices have option. very inadequate room for antenna installation, therefore it is desired to integrate most of the wireless Antenna Design and Structure. The basic circuits are analyzed as follows [15].

Analysis of Rectangular Patch Antenna A simple rectangular microstrip patch antenna can be considered as a parallel combination of resistance, inductance and capacitance as shown in Fig.2.

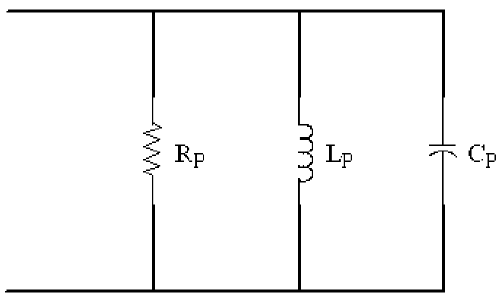

Fig. 2. Equivalent circuit of the rectangular patch

The notch is loaded along one side of the rectangular patch; this causes an additional series capacitance and inductance as shown in Fig.3.

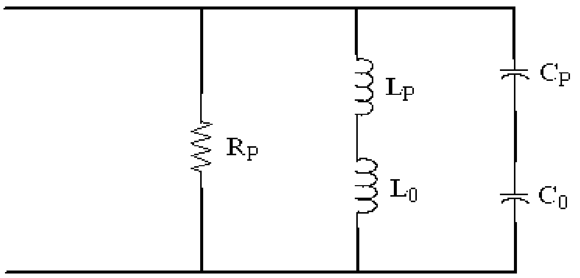

Fig. 3. Equivalent circuit of notch loaded patch antenna

For Ultra Wideband (UWB) applications, a suitable UWB antenna is required to provide satisfactory performance over the whole FCC defined frequency band from 3.1 GHz to 10.6 GHz [16], including return loss less than 10 dB or VSWR below 2. WiMAX (3.3 – 3.7 GHz) and WLAN (5.15 – 5.825 GHz) band-notched function is necessary for a good candidate UWB antenna to prevent interference between the existing operating bands applied to UWB radio systems [17].Many UWB antennas with band-notched function has been reported in recent years, which mainly use partial ground plane and a slot or parasitic elements [18-25]. (a) WiMAX (3.5GHz) (b) WLAN (5.2GHz) (c) Bluetooth (2.45GHz) (d) 10GHz.

IV. SIMULATION RESULT

DESIGN ANALYSIS OF ANTENNA WITH A NOTCH

An RMP antenna with a notch designs for bandwidth enhancement of the antenna. For designing of this RMP antenna transmission line model is used. An inset fed microstrip rectangular patch antenna is designed to match the patch with 50Ω microstrip transmission line. The designed microstrip patch antenna structure is shown in Fig.4 The substrate used is FR-4 epoxy having dielectric constant = 4.4 and height h=1.58mm. The operating frequency is 2.4GHz. The inset depth and gap width are varied to get the desired results. The width and length of the notch are 14mm and 2mm. effect of the notch on physical parameters of an RMP antenna.

Fig.4. A RMP Antenna with a Notch

In Fig.5 two vertical slots are placed on the patch having the length Ls and width Ws for providing different surface current paths so as to produce multi resonant modes. The two slots are kept at a distance of 2 mm from the vertical and horizontal edges of the radiating patch.

However, major disadvantage of patch antenna is narrow bandwidth. There are many methods to overcome this problem such as increasing the height of the substrate, and introducing parasitic elements or modifying the shape of the patch. In this paper E-shaped micro strip patch antenna is designed and analyzed. If two parallel slots are incorporated into the patch, the bandwidth increases . A wide band E-shaped antenna with U-shape slot in its feed is designed to cover 1GHz-12GHz range of frequencies. A broad band radiation pattern is achieved. There are different types of slot loaded antennas such as U-slot, V-slot, E-shape and H-shape. In this paper U-slot is inserted in E-shaped antenna’s feed to achieve wide bandwidth. The parameters are analyzed by changing the position, length, width of the slot .

Often microstrip antennas are referred to as patch antennas. The radiating elements and the feed lines are habitually photo etched on the dielectric substrate. The radiating patch may be square, rectangular, thin strip, circular, elliptical, triangular or constituting any other configuration. Square, rectangular, thin strip and circular microstrip patch configurations are the most common because of their ease of analysis, fabrication, and their attractive radiation characteristics, especially the low cross-polarization radiation. There are many configurations that can be used to feed microstrip antennas. It was observed that with a decrease in notch width, the resonant frequency shifts away from 10 GHz notch width is decreased from W/10 to W/40.

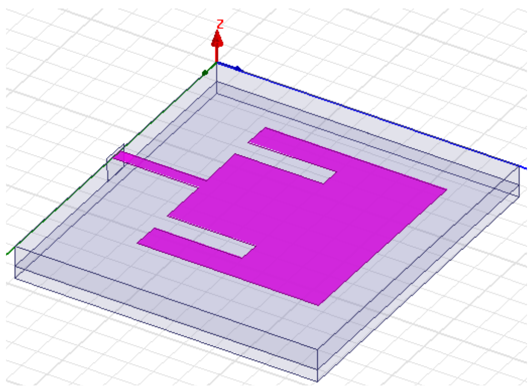

Fig. 5. E-shaped antenna without U-slot

When the height of the slit is properly chosen, wideband characteristic can be achieved. The height of the feed gap between the main patch and the ground is also an important parameter to control the impedance bandwidth.

We adopt the design strategy of keeping the return loss minimum at the resonant frequencies as close as possible and striving to achieve -10dB return loss over the impedance bandwidth. Our design procedure is based on the existing literature and analysis of the notch width discussed earlier and the goal of this procedure is to provide a good result. In practice, the dielectric constants of the material are not free variables, since discrete values depend on the dielectric material used.

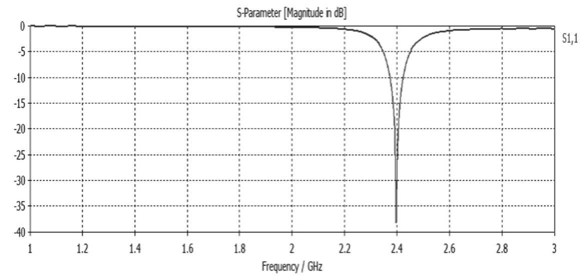

Fig.6. S (Return Loss) Parameter plot of RMP antenna

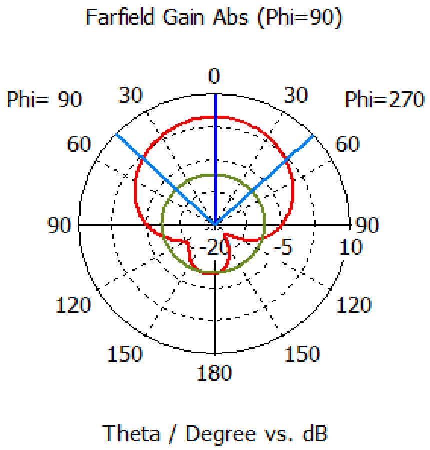

Fig.7. Far Field Polar Plot of Gain of RMP Antenna

Results shown from Fig.6 through Fig.9 for return loss and fulfield radiation pattern. For different notches the antenna has been designed, analyzed and produced the following results.

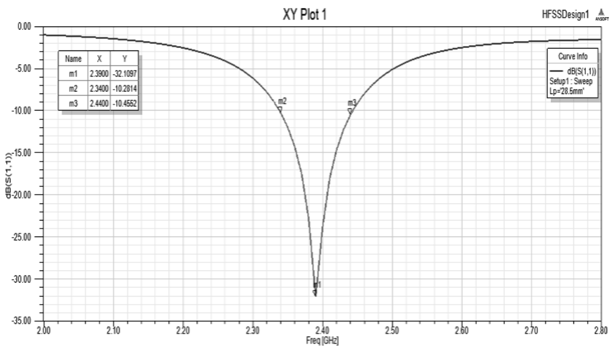

Fig. 8. S Plot of RMP Antenna for εr=4.4

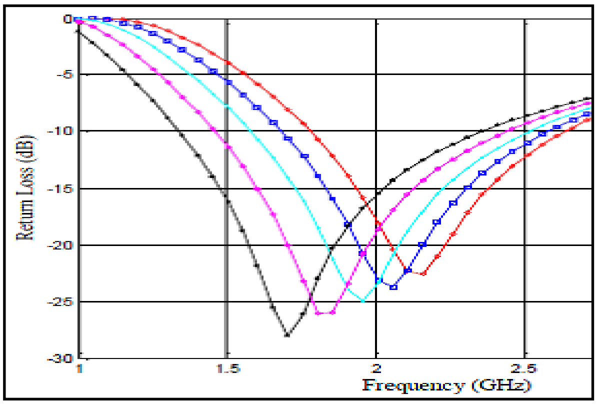

Fig.9 Variation of return loss with frequency for different notch length and width.

V. CONCLUSION

A novel UWB microstrip-fed monopole antenna with bandnotch characteristic has been designed. A narrow slit is used to improve the VSWR performance of the antenna. Band-notch characteristic is achieved by inserting a modified inverted U-slot. The notch frequency can be controlled by changing the length of the U-slot. The proposed antenna has the frequency band of 3 GHz to over 11 GHz for VSWR less than 2.0.

In this design, it is suitable for UWB applications from 3.1 to 10.6 GHz while support Bluetooth frequency (2.45GHz) and provides a two frequency notch at WiMAX (3.5GHz) and WLAN (5.2)GHz in order to prevent interference with other UWB applications. The antenna is simple, low cost and compact in size. The measured results indicate that the modified antenna provides a near omnidirectional radiation pattern over the operating frequency band and a high VSWR and low gain at the notch frequencies

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