Design of Microstrip Antenna With Notch Filter for UWB Application

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Abstract
UWB antennas are also necessary for the rejection of an interference with existing wireless networking technologies. This is due to the fact that UWB transmitters should not cause any electromagnetic interference on nearby communication system such as wireless local area network (WLAN) applications. Two types of UWB antennas with band-notched studied and designed. Initially, a square notch on the top of the ground provides the mechanism to enhance the impedance bandwidth of the proposed antenna. The proposed filter structure uses a single patch without coupling gaps. This filter has two transmission zeros on both sides of the passband. The effect on the filter's performance by changing filter parameters is studied. The results show that this new filter can provide a low insertion loss and reduce uncertainty in fabrication. It also makes miniaturization easy. Next to it, a novel microstrip antenna with a frequency band-filter characteristic for UWB applications is proposed and investigated. Having a triangle-shaped slot on the patch, a frequency-notched characteristics is obtained. The proposed slot topology, when used for antenna design, demonstrates a much less ohmic loss, and thus, higher efficiency than standard microstrip structures. The designed antenna satisfies the voltage standing wave ratio (VSWR) requirement of less than 2.0 in the frequency band between 4.2 and 6 GHz while showing the band rejection performance in the frequency band from 2 to 12 GHz. This technique is suitable for creating ultra-wideband (UWB) antenna with narrow frequency notched characteristics.

Keywords
UWB, Microstrip Antenna, Notch Filter, WLAN, VSWR

I. Introduction

Ultra Wide Band (UWB) technology is the basis of different methods of wireless communications. According to the Shannon-Hartley theorem, the main benefit of the UWB system is that it is channel capacity corresponds to the bandwidth. The UWB can handle a large capacity of hundreds of Mbps because of it is ultra-wide frequency bandwidth. In addition, UWB systems function at exceedingly low levels of power transmission. Hence, it is able to offer an extremely safe and dependable communications system because of the low energy density. Moreover, the impulse radio UWB is cheap and simple because of the baseband character of the signal transmission [1-2].

Microstrip bandstop filters are widely utilized to block interfered signals and suppress spurious harmonics because of easy fabrication and low weight. The bandstop filters utilizing shunt open-circuited stubs suffer from slow roll-off and comparatively large size. Alternatively, microstrip bandstop filters have been developed by utilizing the defected ground structure (DGS) [3-5]. Whereas, there is a back radiation problem which is common for the DGS and additional metallic plane must be appropriately put underneath the ground of microstrip components at the cost of increased weight and inevitable complexity. Recently, signal interference technique was introduced to design wide stopband bandstop filters with high selectivity, but the given filters suffer from large dimension, especially the extended width [6-7].

We discuss how MicroStripes can efficiently model a microstrip spur line band stop filter, which is integrated in a 50 Ω microstrip feed line. The filter is then incorporated into a simple patch antenna design, which results in the creation of a dual band antenna.

Antennas are the indispensable elements of the UWB wireless communication device, and they play a vital part in the advancement of present day communication systems. Modern UWB antennas should feature a small and compact size to be suitable for portable devices.

Microstrip planar antennas are very appropriate for UWB application because of attractive advantageous features of low profile, inexpensive, light weight, ease of fabrication, and conformability. Moreover, planar antennas can achieve wide operating band and exhibit omnidirectional radiation patterns. Different types of planar antennas with different geometries are widely investigated as they exhibit the fundamental features of UWBtechnology [8-10]. Different techniques, optimization algorithm, and use of metamaterial have also been reported to design UWB antennas [11-13]. Slot antennas that possess relatively highermagnetic fields are also reported to be very suitable for UWB application since they tend not to couple strongly with nearby objects [14-17].

II. Characterazation of notch UWB Antenna

In the UWB band pass filter, a open circuited stub is incorporated for designing a notch at the desired frequency.

The variation in length and width of this stub affect the notch frequency and the insertion loss |S21|. It is observed that decreasing the stub length the notch frequency increases with slight variation in the value of insertion loss S21, while notch frequency shifted towards lower side on increasing the stub length.

The length of the slot etched from the ground plane near of the feed line can be given as the notch.

$$f_{notch} = \frac{c}{4L.\sqrt{\varepsilon_{eff}}} \quad (1)$$

Where L is the total length of the slot, c is the velocity of light and εeff is the effective dielectric constant. This is approximately found as below.

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} \quad (2)$$

The antenna is called a square ring due to square ring lock and a WLAN band is notched from UWB using the slot cut-out of the ground. The antenna design software package, called Ansoft HFSS 13.0 has been used to develop and simulate this antenna.

III. Antenna Design

A. Rectangular Microstrip Patch Antenna

Basic Rectangular Microstrip Patch Antenna consists of simple Coplanar Microstrip Patch Antenna with no any modifications in patch or ground shape. Hereafter termed as simple RMSA. Design and dimensions are described in brief in the next section. Micro strip patch antenna radiate primarily because of the fringing fields between the patch edge and the ground plane. For a rectangular patch, the length L of the patch is usually $0.3333\lambda 0 < L < 0.5\ \lambda 0$, where λ0 is the free space wavelength (λ0=0.125). The patch is selected to be very thin such that $t << \lambda 0$ (where t is the thickness of the patch). The height h of the dielectric substrate is usually $0.003\ \lambda 0 \leq h \leq 0.05\ \lambda 0$. The dielectric constant of the substrate is typically in the range $1.2 \leq \varepsilon r \leq 12$. The Micro strip patch is designed such that its pattern maximum is normal to the patch (broadside radiator). This is accomplished through proper choice of the mode of excitation beneath the patch. The feed is chosen as microstrip line feed and explained as follows.

IV. Microstrip Line Feed

A Micro strip line is a simple conducting strip which is directly connects to the radiating patch. Micro strip lines are easy in fabrication, matching by means of controlling the position of the microstrip line. In this type of feed technique, a conducting strip is connected directly to the edge of the Micro-strip patch. The conducting strip is made smaller in width as compared to the patch. Advantage is that the feed can be etched on the same substrate to provide a planar structure. A rectangular patch with microstrip line feed is shown in Fig. 1.

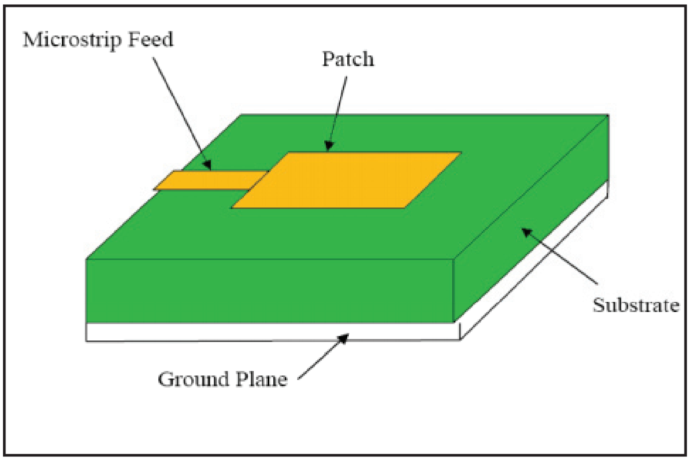

Fig. 1: Micro Strip Line Feed

A. Triangular Microstrip Patch Antenna

The geometry of the proposed antenna is as shown in the Fig. 2. It typically consists of a square piece of substrate coated on both surfaces with copper. The side dimension of the square substrate is 26mm. Cross shaped conducting surface typically acts as a radiating stub which is formed by removing the remaining region on the surface. The radiating surface is excited with a microstrip line feed that runs from the cross shape to the end of the substrate on one side. The width of the strip line forming the feed line as well as the radiator is 3mm. A triangular region of side 22.6mm is removed to form a slotted section in the ground plane of the monopole. This technique generally reduces the extended surface area of the conductor. The horizontal arm of the stub appears to be starting at a distance of 2mm when measured from the base of the equilateral triangular. This can be observed when both the surfaces are superimposed.

The height of the substrate is 0.762mm with a relative permittivity of 2.17 to represent RT-Duroid material. The antenna geometry is simulated in CST and solved using the efficient time-domain solver embedded in it. The simulated microstrip line feed has a terminal end where the corresponding port is defined.

The port observes an impedance of 50Ω due the coupled (simulated) transmission line. In order to achieve proper impedance matching, the length of the feed line is determined to be 11mm keeping the width constant at 3mm. This way a uniform distribution of the current on the cross shaped area can be expected. The length of the feed line can be easily determined simple mathematics for microstrip line or otherwise performing parametric sweep with impedance. The unique feature of CST in switching from orthodox rectangular meshing to tetrahedron ensures efficient technique to realize any shaped geometry. The adaptive nature of the meshing phenomenon decreases several complexed calculations required for efficient solving.

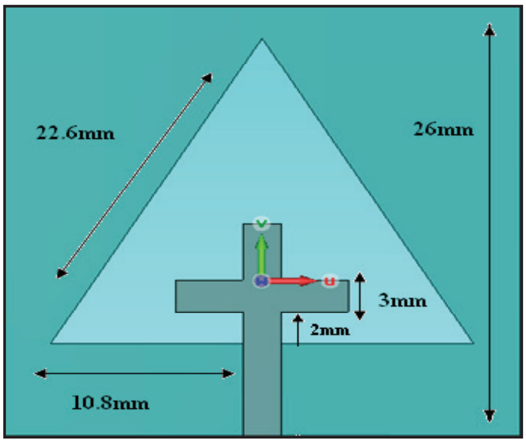

Fig. 2: Geometry of the Antenna

Also the curve takes a maximum dip at 4.3167 GHz. The entire 1.7 GHz band between the frequency range identified can be considered as the bandwidth of the antenna while observing maximum gain at the dip.

Radiation pattern taken on the xy cut for 00 azimuthal angle is given and the corresponding field distribution overlapped with the antenna is also observed. In both the cases the distribution follows the template radiation pattern of a patch antenna.

V. Result and Discussion

Fig. 4 and 5 results shown for rectangular microstrip antenna (RMSA). The geometry of the proposed filter with five quarter-wave open circuited stubs is as shown in the Fig. 3. The design procedure involves in two broad steps of calculating the characteristic impedance of each system and further optimizing in CST. The final design topology is made consistent to achieve the desired characteristics of notch filter whose centre frequency is 3.7 GHz with 20% approximate bandwidth. The return loss for triangular microstrip antenna is shown in Fig. 6 and the corresponding radiation pattern is shown in Fig. 7.

The proposed antenna design along with the notch filter is as shown in the Fig. 8. The filter is placed between the feed terminal and the corresponding radiator. The top and the bottom views are shown in Fig. 2.

The ground is formed by etching a triangular portion of the conducting layer and the respective layer under the notch stubs. The simulated S11 plot for the designed antenna with proposed filter is as shown in Fig. 8. Clearly the plot shows rejection to a band of frequencies by producing high degree of S11 which account for maximum return loss.

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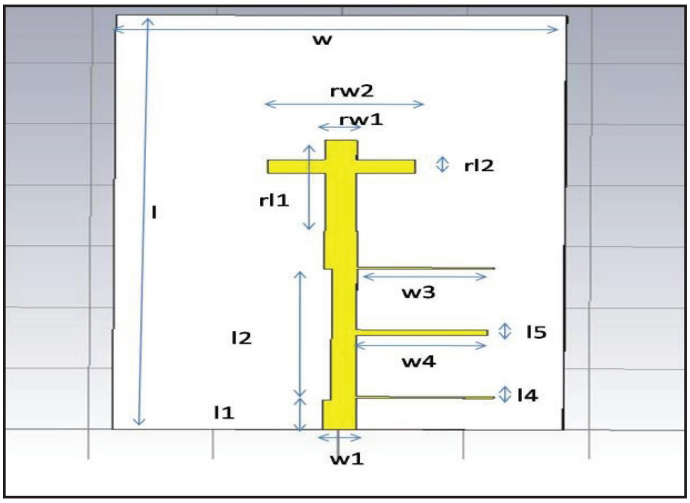

Fig. 3: Geometry of the Proposed Filter

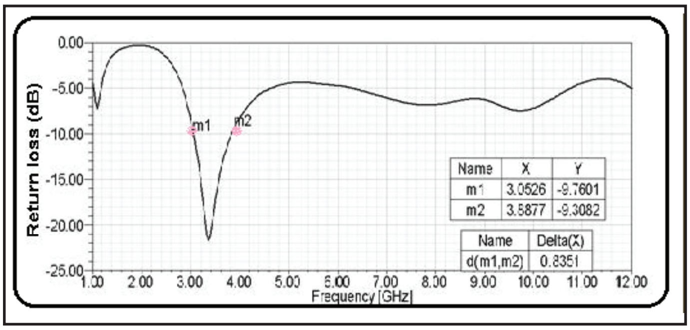

Fig. 4: Return Loss vs. Frequency for Simple RMSA

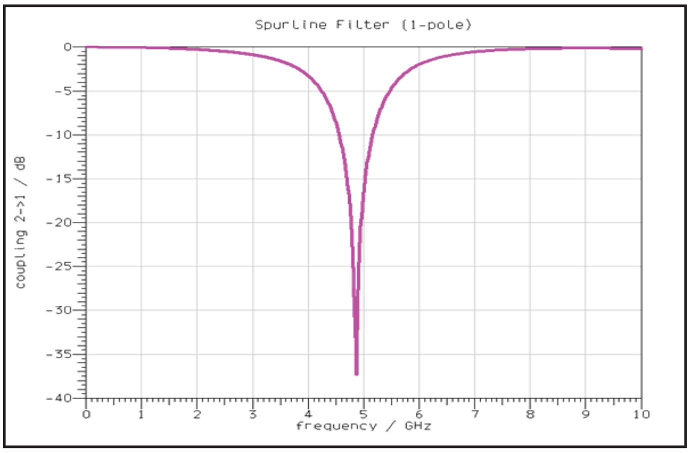

Fig. 5: Modelled return-loss for the Spur Line Filter

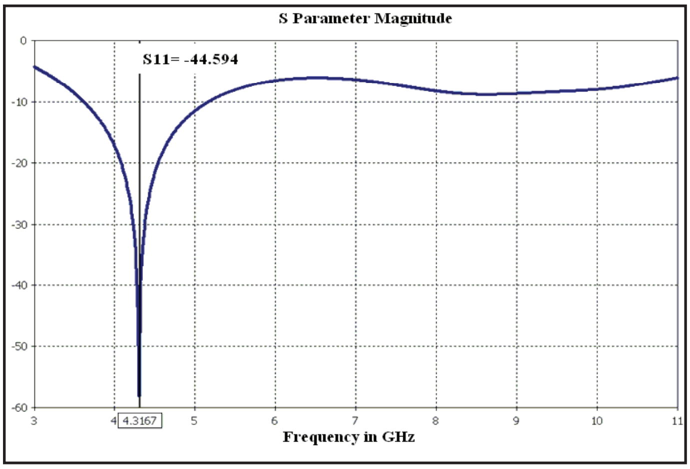

Fig. 6: Return Loss vs. Frequency for simple Triangular MSA

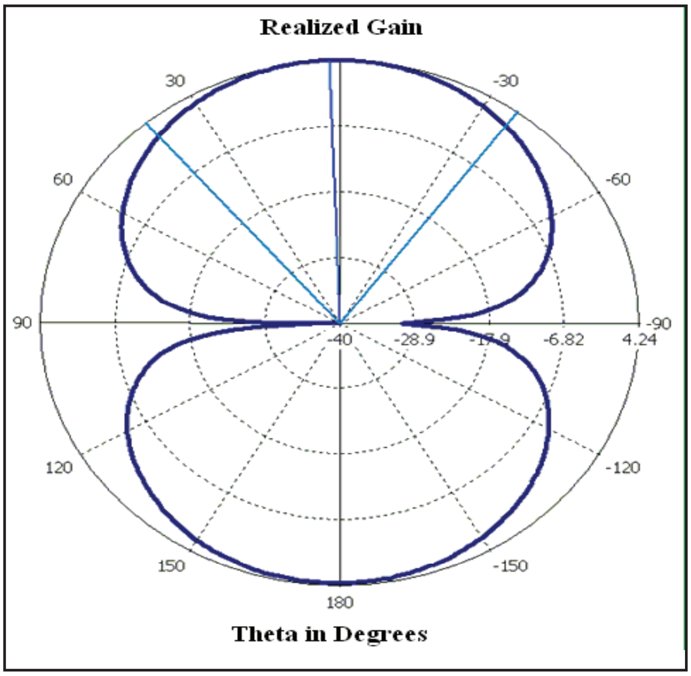

Fig. 7: Radiation Pattern for TriangularMSA

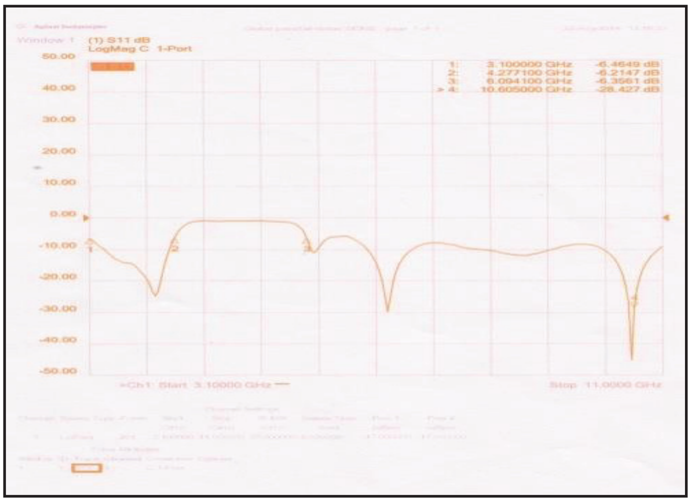
Fig. 8: Return Loss of the proposed Antenna

VI. Conclusion

A simple, compact UWB antenna with triangular slot and cross structure feed line is implemented. It has shown consistent gain characteristics as well as VSWR value of 2:1 in the UWB range. The triangular slot reduced the physical surface area of the patch. The cross feed line parameters have shown a considerable change in the resonant characteristics and its optimized value is presented in this work. Further notch band characteristics can be studied by designing a filter with desired notch frequencies. The antenna is operating from 2-12 GHz and the notch are found from 4.2-6 GHz which has a bandwidth of 1.8 GHz frequency. The designed antenna satisfied the UWB frequency band requirements except 4.2-6 GHz for HIPERLAN/2, IEEE 802.11a and C-band applications.

The bandwidth of miniaturized slot antennas can be improved more effectively if we understand the causes of their narrow bandwidth. The radiation conductance of a slot antenna is an equivalent quantity, whose dissipated power models the radiated power from the antenna. The need for antenna miniaturization stems from the fact that most mobile platforms have a limited space for all of the required antennas in ever increasing wireless systems.

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