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REVIEW ON UWB ANTENNA DESIGN WITH BAND STOP FUNCTION BY IMPLEMENTING PARASITIC PATCH METHOD

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Abstract
In this review paper, a survey is conducted on different band notching techniques used in UWB antennas. Then by using one of the methods we have proposed, a novel, compact, printed rectangular slot antenna with band-notch function for ultra-wideband (UWB) applications. In rectangular slot antenna to increase the impedance bandwidth and to achieve UWB coverage, we have introduced an inverted T-shaped conductor supported plane inside the rectangular slot on another side of the substrate. Additionally, by using a coupled rotated C-shaped strip around the inverted T-shaped conductor backed plane, frequency notched band performance can be achieved. The antenna has compact dimensions of 21×26.5 mm².

Keywords:
Inverted T-Shaped, Rectangular Slot Antenna, Rotated C-Shaped Conductor-Backed Plane, CST, EBG, UWB Application

1. INTRODUCTION

One of the key issues in ultra-wideband (UWB) communication systems is a small antenna design to provide wideband characteristics over the whole operating band. Subsequently, some of the printed microstrip antennas with different geometries have been experimentally characterized similar to printed wide slot antennas which are fed by a microstrip line similar fork tuning, T-shaped microstrip line fed wide slot antenna, and three offset shaped microstrip line fed slot antenna [1]-[3]. For the improvements in the impedance bandwidth, other techniques have been investigated like triangular-shaped tuning stub [4], a square-ring radiating patch has a pair of T-shaped strips protrude inside with a coupled shaped strip and a ground plane with a protruded strip [5]. The wireless local area network experiences interference due to the frequency range for UWB systems which is operating in 5.15GHz - 5.35GHz and 5.725GHz - 5.825GHz bands. The characteristics of the antenna with band-notch can be used to reject frequency band, 5.15GHz - 5.825GHz can be designed by implementing slotted parasitic patch on the bottom layer of the antenna [6], and inverted U strip parasitic patch is attached to the elliptical slot plane, to overcome said problem [7] [14]-[17].

A novel and compact microstrip fed slot a rectangular slot antenna for UWB applications with band-notched characteristics and additional resonance for UWB applications have presented. The ground plane with rotated C-shaped and inverted T-shaped conductor backed plane that can achieve a fractional bandwidth of more than 110%. The insertion of an inverted T-shaped conductor supported plane inside the slot on the ground plane is proposed, much wider impedance BW can be produced with more resonance excited, particularly at the higher frequencies. To generate a single band-notch function, for the first time, we use a rotated C-shaped parasitic structure around the inverted T-shaped conductor backed plane. This structure has an ordinary square radiating stub configuration. Better VSWR and radiation pattern characteristics can be obtained at the frequency band of interest.

2. DIFFERENT BAND NOTCH TECHNIQUES USED IN UWB ANTENNA

UWB applications can co-occur with other narrowband communication standards which uses the same spectrum due to the restriction of power level which may leads to a severe interference between the UWB systems and a narrowband like WLAN (5.15 - 5.35GHz and 5.725 - 5.825GHz bands) and WiMAX (3.4 - 3.69GHz band). To solve this, we can integrate the UWB antenna with band-notch characteristics. Some of these methods are characterized as follows:

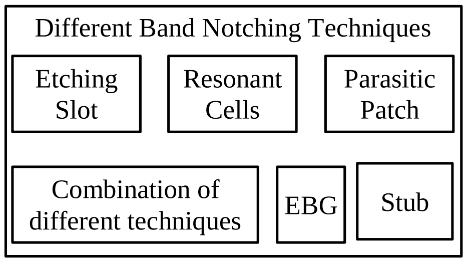


Fig.1. Band notching techniques

2.1 RESONANT CELLS

Lin et al. [9] have proposed two printed UWB compact monopole antennas with tri-band notched characteristics. By introducing small capacitive-loaded loop (CLL) resonators, the notch filters are achieved. Printed top-loaded CLL-based monopoles and 50Ω microstrip feed lines served as directly driven elements of the antenna.

The band-notch properties in the WiMAX (3.3 - 3.6GHz), lower WLAN (5.15 - 5.35GHz) and higher WLAN (5.725 - 5.825GHz) bands achieved by incorporating three CLL elements close to the feed line. A 27×34 mm² sheet of Rogers Duroid 5880 are the constraints for each antenna system. One designed with three additional CLL elements and the other achieved with only two [9].

The properties of UWB antenna like broadband matched impedance values and stable radiation patterns for all radiating frequencies shown by comparisons between the simulation and measurement results [9].

2.2 PARASITIC PATCH

Choi et al. [10] proposed a compact UWB antenna for laptop applications with a band-notch function. The band-notch function is better understood by implementing a half-wavelength parasitic element printed on the rear side of the substrate. The impedance bandwidth of the antenna is 3.1GHz ~ 11.4GHz (114%) with a notched frequency from 5.05 to 5.90GHz (with VSWR less than 2). The antenna has a relatively good omnidirectional pattern, with an average gain of -3dBi ~ -1.2dBi over the ultra-wideband frequency band excluding for the notched frequency band. The performance is confirmed by simulation and measurement results. The measured efficiency of an antenna ranges between 55% and 72%, excluding the notched band [10].

2.3 STUB

Li et al. [11] numerically presented an ultra-wideband monopole antenna coplanar waveguide with feeding for circular ring along two notches. It has been observed that, the impedance bandwidth of the loop antenna can be extended by employing two arc-shaped tapered cuts in the CPW ground plane. Two stop frequency bands are obtained, with an insertion of three microstrip slot stubs at the inner of the designed circular ring patch. Two notched bands can be controlled with as adjustment of the width and the length of the microstrip slot stubs. Simulation results show the proposed antenna can be utilized for C-band satellite communications which have characteristics like, compact size of 30×22.4mm², an impedance bandwidth ranging from 2.7GHz to 9.3GHz for voltage standing-wave ratio (VSWR) less than 2, without two-notch band frequency 3.9GHz - 4.9GHz and 6.0GHz - 7.8GHz. The proposed antenna has implemented and optimized by using HFSS [11].

2.4 ELECTROMAGNETIC BAND GAP

Peng and Ruan [12] proposed a new way of the design for the ultra-wideband planar monopole antenna by the rejection of individual bands within the passband. The proposed approach utilizes mushroom-type Electromagnetic Band Gap (EBG) structure which is an effective way for band-notched designs which has many advantages like, stable radiation patterns, notch-band width controllable capacity, notch-frequency tunability, and efficient dual-notch design. In this, many design examples are represented using conventional mushroom-type EBG and edge-located mushroom-type EBG. The approaches exhibit excellent bandstop characteristics to reject the wireless local-area network interference bands (5.2GHz and 5.8GHz bands). Apart from this, the bases leading to the disagreements between the simulations and measurements were deliberated. In existence of the EBG has little effect on the radiation patterns. Thus, the design approach is very efficient [12].

2.5 COMBINATION OF DIFFERENT TECHNIQUES

Liao et al. [13] proposed a semi-circle aperture in ultra-wideband (UWB) antenna for triple band-notched characteristics. The tri-band rejected filtering properties in the WiMAX/WLAN achieved by the process of etching a complementary split-ring resonator on the front side inside circular stub, in each side of the ground plane employing an interrogation-shaped defected ground structure and by adding a pair symmetrically for open-circuit stubs at the edge of the slot. Results show the designed antenna with impedance bandwidth of 2.6 - 12GHz for VSWR < 2 and with compact dimension size of 24×30mm² has better omnidirectional radiation patterns in the H-plane except for three frequency stop-bands of 3.3GHz - 4GHz, 5.15GHz - 5.4GHz, and 5.8GHz - 6.1GHz. The said antenna is simulated using CST Microwave Studio (based on the finite integration technique (FIT)). VSWR measurement of the antenna is carried out with a network analyzer Agilent N5230A [13].

3. COMPARATIVE STUDY

By studying all the referenced papers, a comparative study is done which is presented in Table.1. Various band-notch techniques are used in UWB antenna design and the comparison is done based on passband minimum VSWR, rejected bands (GHz), stopband maximum VSWR, highest gain (dBi), and dimensions of antenna (mm²).

Table.1. Comparative Study

Technique	Passband min VSWR	Rejected bands (GHz)	Stopband max VSWR	Highest gain (dBi)	Dimensions of antenna (mm²)
Etching Slot [8]	< 2	5.000 ~ 6.000	9	-	16×29
Resonant cells [9]	1	3.300 ~ 3.600 5.150 ~ 5.350 5.725 ~ 5.820	10.1	5	27×34
Parasitic patch [10]	< 2	5.030 ~ 5.940	5.5	4	20×20
Stub [11]	< 2	3.900 ~ 4.900 6.000 ~ 7.800	-	-	30×22.4
EBG [12]	1	5.200 ~5.720 5.990 ~6.230	>6	-	38×40
Combination of different techniques [13]	1.1	3.300 ~ 4.000 5.150 ~ 5.400 5.800 ~ 6.100	>10	5	24×30

4. COMPARATIVE ANALYSIS

In the comparative analysis (Table.2) we get the advantages and disadvantages of different band notching techniques. The Table.2 shows the comparative analysis of different band notching techniques used in UWB antennas

Table.2. Comparative Analysis

Technique	Observation
Slots	• Very small antenna size. • by adjusting slot dimension and position notched band can be easily tuned
Resonant cells	• Multiple band notches and reconfigurable designs are easily possible. • Complicated structures and it is difficult to control the notch band.
Parasitic patch	• Very small antenna size. • Widely used technique. • The notched band tuning possible.
Stub	• Relatively complex technique.
EBG	• The efficient technique, with a better rejection quality.
Combination of different techniques	• The hybrid combination of more than one technique is a smart approach that combines the advantages and compensates for the disadvantages of various techniques into a single design.

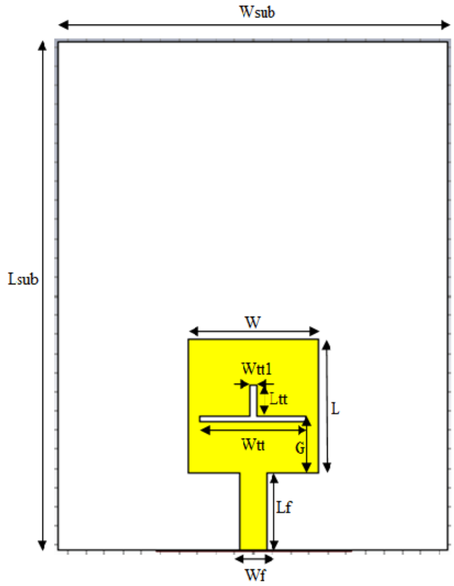
5. PROBLEM FORMULATION

One of the key issues in UWB communication systems is designing a small antenna to provide wideband characteristics over the whole operating band. The frequency range for UWB systems can cause interference to WLAN operating in bands of 5.15GHz - 5.35GHz and 5.725GHz - 5.825GHz. The UWB antenna with band-notched characteristics is proposed to overcome the problem. Recent communication systems need a single antenna to cover large channel capacity, small size. This antenna design can easily include all these features. The high-speed data rate, broad bandwidth and excellent technology are some of the most promising solutions for better development in the field of wireless communication.

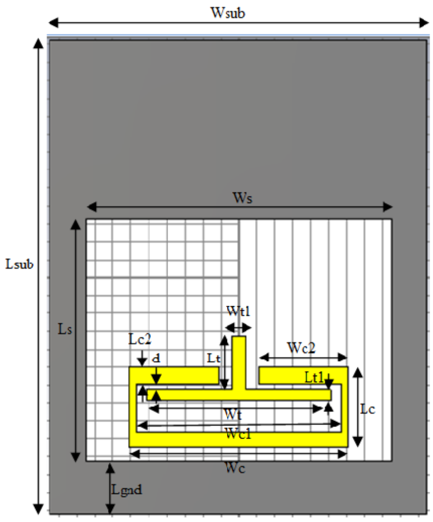
6. ANTENNA DESIGN

The Fig.2 shows the design of a rectangular slot antenna is printed on the FR4 substrate, fed with a 50Ω microstrip line, with thickness 0.8mm, loss tangent 0.018 and permittivity 4.4. The antenna has a 50Ω microstrip feedline and a ground plane with a rectangular slot and a square radiating stub. The square radiating stub has a length L and width W. as shown in Fig.2, the radiating stub is connected to a feed line of length L_f and width W_f. A conducting ground plane with a rectangular slot placed on the other side of the substrate. The proposed antenna connected through a 50Ω SMA connector for signal transmission. In this proposed antenna, an inverted T-shaped is rotated.

A C-shaped conductor backed plane placed under the radiating stub and which are also symmetrical to the longitudinal direction. Based on electromagnet coupling theory (ECT), in the broadband characteristics of this antenna, electromagnetic coupling effects can be adjusted by the conductor-backed plane, between the patch and the ground plane for the improvement of its impedance bandwidth without any cost of size [5]. This phenomenon occurs because, with the use of a conductor-backed plane structure on the other side of the substrate, more coupling is introduced between the bottom edge of the rectangular patch and the ground plane [2]. Also by inserting the inverted T-shaped conductor backed plane of suitable dimensions, it is found that much-enhanced impedance bandwidth achieved for the proposed antenna.



(a) Front View



(b) Back View

Fig.2. Geometry of proposed slot antenna

As in Fig.2, the rotated C-shaped conductor-backed plane is placed around the inverted T-shaped conductor backed plane and symmetrical to the longitudinal direction. It perturbs the resonant response and also acts as a parasitic one-wave resonant structure electrically coupled to the inverted T-shaped conductor backed plane. The current flow is more dominant around the parasitic element at the band stop frequency, and the current flow oppositely directed between the parasitic element and the inverted T-shaped conductor backed plane. Therefore, the required high attenuation is produced at notch frequency. The inverted T-shaped slot is etched in the front view of the square radiating stub is shown in the Fig.3, using this BW of the antenna can be adjusted. The dimensions of design parameters for the proposed microstrip antenna for ultra-wideband applications are as mentioned in the Table.3.

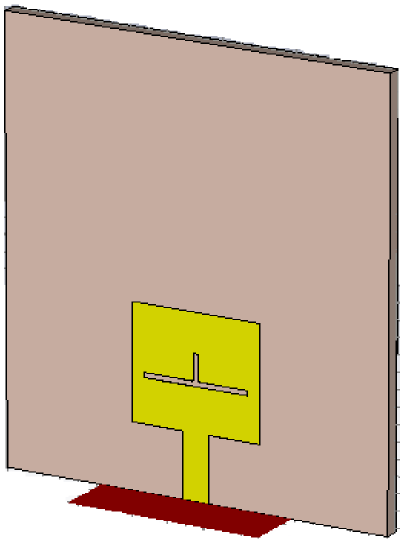


Fig.3. Perspective view

Table.3. Design Parameters

Parameter	Value (mm)	Parameter	Value (mm)
W_{sub}	21	W_{c1}	11.4
L_{sub}	26.5	W_{c2}	5
W_s	17	L_{c2}	1
L_s	13.5	W_t	10.25
W	7	L_t	3
L	7	W_{t1}	0.8
W_f	1.5	L_{t1}	0.6
L_f	4	D	0.25
L_{gnd}	3	H	0.8
W_c	12.2	M_t	0.01
L_c	4.5	W_{tt}	5.68
L_{tt}	1.6	L_{tt1}	0.3
W_{tt1}	0.3	G	2.7

7. CONCLUSION

In this paper, we have surveyed the past research works which mainly focuses on different band notching techniques used in UWB antenna designing. By using one the methods mentioned above a new compact printed slot antenna (PSA) proposed for UWB applications with bandstop function. By inserting the inverted T-shaped conductor backed plane of suitable dimensions on the etched rectangle on the ground plane we can increase the impedance bandwidth. Then by adding a rotated C-shaped parasitic element around the inverted T-shaped conductor backed plane band rejection performance in the frequency band of WLAN operating in 5.15 - 5.35GHz and 5.725 - 5.825GHz bands can achieve. The proposed antenna designed in CST simulator software by using the parasitic patch method for the band rejection.

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