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A Review on Band Notch Techniques For UWB Antenna Design

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Abstract

Federal Communication Commission has allocated a 3.1 GHz - 10.6 GHz frequency band for commercial ultra-wideband communication systems. Microstrip patch antennas are now used in mobile phones, defense equipment, wireless wearable devices, and other places. The Ultra-wideband technology has a wide range of applications in huge data transmission across a wide bandwidth, especially greater than 500 MHz and short-range communications due to its low energy levels. Different structures are used to get the triple-notch characteristics and multiband operations that are needed. The paper presents a review of band-notch techniques for UWB antenna and its application over traditional antennas.

Keywords: Band notch techniques, Ultra-Wideband antenna, Electromagnetic bandgap (EBG), WLAN, 5G.

I. INTRODUCTION

A stopband is formed by constructing a thin and periodic pattern of small metal patches on dielectric substrates to block electromagnetic waves of certain frequency bands in an electromagnetic band-gap (EBG) structure. As a result, the UWB antenna's notching improves its dependability. Microstrip lines can have resonant cells placed into them, and split rings can be employed for band rejection. Some researchers used parasitic devices connected to the radiator to achieve band-notched capabilities [1]. Antennas are the major energy source in most communication systems. It is challenging to build an antenna with small dimensions, correct radiations, great impedance matching, and affordable prices. Microstrip patch antennas are an attractive choice for use in ultra-wideband (UWB) applications due to their ability to be easily integrated with other electrical components, as well as their lightweight and flat designs [2]. While constructing UWB antennas, there is already interference in the 5.15–6.84 GHz range from WLANs (IEEE802.11a, HIPERLAN/2), X-band satellite transmission 7.94–8.49 GHz, and 5G sub-6GHz 3.4–3.9 GHz [3]. Rejecting the interference at the UWB system is the best and most economical solution to this problem. With a bandwidth of 1 GHz, traditional notch approaches cannot filter very large interference bands. More consideration is being given to those who design UWB antennas with excellent rejection capabilities. To successfully eliminate interference generated by unwanted bands in practice, the employment of a rectangular notch with high selectivity is required. Some rectangular antennas are designed to exclude undesired bands with great selectivity. Without restricting the bandwidth between the two channels to exclude WLAN, typical notch bands at frequencies (5.2 - 5.8) GHz were achieved [4]. An antenna with a rectangular notch band was created by adding EBG structures to the WLAN band. By using stepped slots as its radiator, notching features were accomplished at WLAN and satellite downlink bands. In the UWB spectrum, it's crucial to construct multiple band-rejecting antennas. To avoid interference, a triple rectangular notch band microstrip patch antenna comprising two EBG and one SRR antenna was created.

II. THE NEED FOR OPERATIONAL BANDS UWB ANTENNA WITH TRIPLE-BAND NOTCH

There are numerous ways to create ultra-wideband antennas. These include UWB antennas for wearable applications, fractal UWB antennas, planar wideband antennas, multiband UWB antennas with band-notch capabilities, and UWB antennas inspired by metamaterials [5]. The microstrip antennas are less expensive, easier to make, and have a low profile. These microstrip antennas are subject to the constraints of having a constrained bandwidth, hence certain designs are needed to achieve a higher bandwidth ratio. To

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achieve a higher bandwidth ratio, several researchers have created a variety of antenna types over the years [6].

Numerous fractal UWB antennas are now being developed for wireless components to reap the benefits of lower size. One of the key concerns that arose was the difficulty in designing these sorts of UWB antennas due to interference issues with other adjacent systems that operate at a frequency that falls within the coverage region of the UWB antennas [7]. Antennas that are utilized for band rejection of specific bands have been built in a way similar to that of UWB antennas. Slots, frequency-selective surfaces, meander lines, resonator structures, electromagnetic bandgap structures, and other techniques can be used to create these antennas with notch characteristics [8]. These antennas can reject either a single band or several bands. The effectiveness of the processes that were used directly affects how accurately the bands are rejected.

III. ANTENNA ANALYSIS

The proposed UWB band notch antenna model for 2.4 GHz with 3D radiation pattern and Simulated S_{11} Gain shown in the below figure. The maximum gain achieved by the antenna is 3.39 dB.

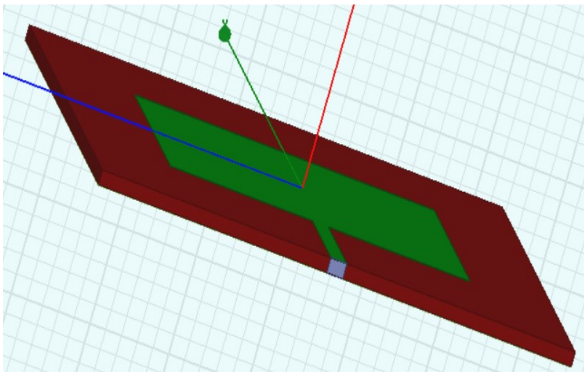

Figure 1. Antenna model

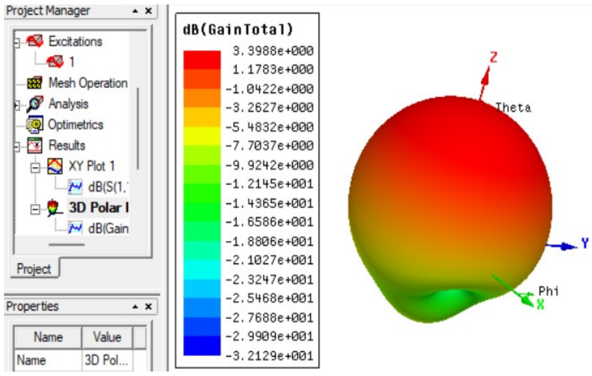

Figure 2. 3D Radiation Pattern

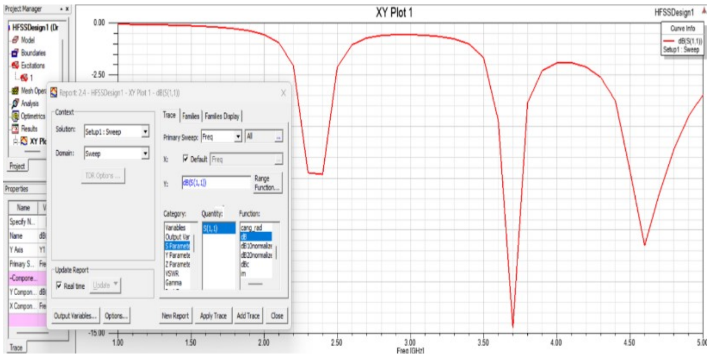

Figure 3. The Simulated S_{11} of UWB Antenna

IV. RESEARCH APPROACH

The primary goal of our research and analysis is to provide an overview of the triple-band notch with various operational bands UWB antenna employing various notching approaches. In the present review, the analysis is done based on the following categories.

1. Band-notch UWB antenna using notching techniques.
2. High-gain compact UWB antenna.
3. The impedance bandwidth of the antenna.

V. REVIEW AND DISCUSSION

We have undergone several research articles based on the operational bands and notching techniques, Some of them in brief are discussed previously. Now, we are going to carry forward certain terminologies described by different researchers.

VI. NOTCHING TECHNIQUES USED FOR ANTENNAS.

The most commonly used notching techniques

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are as follows:

a. SRR: An SRR, or split-ring resonator, is a structure that is created on purpose and is typical of metamaterials. It's crucial to get the right magnetic response in a range of metamaterials that operate at up to 200 terahertz in frequency. [2,5,7,8,11,13].
b. Rectangular slot: Rectangular microstrip antennas composed of a rectangular patch are known as microstrip patch antennas. A ground plane is put on one side, and a typical section of the dielectric substrate and a patch of any planar or non-planar geometry are applied on the other [3].
c. Stepped Slot: At its radiator, stepped slots can be employed to achieve ultra-wideband functioning. By setting up the stepped slot to the right size and feeding it in at the right place, several resonant modes can be produced. This makes it possible for the modes to change seamlessly from one to the other, resulting in a much larger bandwidth [12].
d. EBG: EBG structures produce a thin, periodic pattern of tiny metal patches across dielectric surfaces to block electromagnetic radiation [2,4,6,10,13].
e. U slot: Wide impedance bandwidths are well-known benefits of U-shaped slot patch antennas. In this study, a microstrip patch antenna has been built, optimized, and simulated for WiMAX/WLAN applications [4,13].
f. Meander Slot: A meander antenna is an extension of the basic folding antenna and has resonance frequencies that are significantly lower than those of a single-element antenna with the same length. The radiation efficiency of a meander line antenna is relatively high when compared to more conventional half- or quarter-wavelength antennas [1,4].
g. Etched Slot: One of the common ways to create a notched band is to etch slots of various shapes onto the radiator or the ground. Another strategy is to place folded parasitic strips next to the radiator. The proximity of the stepped slot to the short-ended half-wavelength split ring slot permitted the development of a notched band that could cover the WLAN.
h. Parasitic Strips: By adding two parasitic strips to the radiator, the antenna may successfully create a dual notched band for both lower and higher WLAN [9].

In the review paper, we looked at several notching methods. The notching methods employed by the researchers are listed below, and they are grouped using a pie chart.

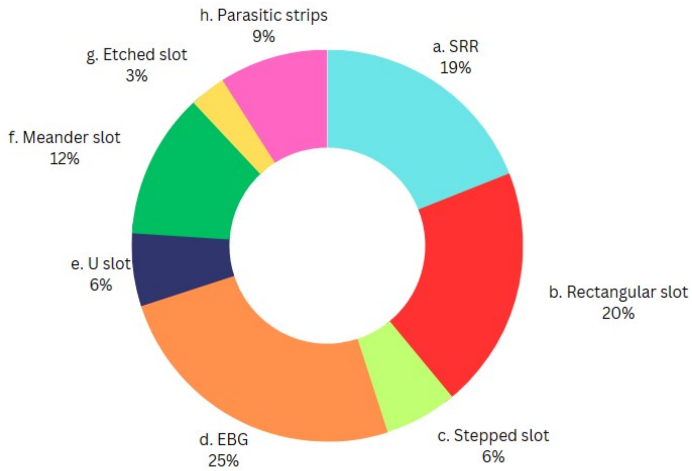

Figure 4: Notching Techniques used for Antenna

From Figure 1. It has been noted that the researchers rejected several bands using various notching methods. Many researchers favor slip ring resonators, meander slots, and electromagnetic band gap structures for notching.

VII. THE PERFORMANCE COMPARISON OF THE LITERATURE.

The UWB antenna described in this review paper has two notch bands that can be switched while adjusting the main frequency. Here, the switchable

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and adjustable features of the band-notched UWB antennas are combined. The EBG structure has been primarily employed by researchers to notch frequencies. For classifying things and creating the new antenna, this knowledge is helpful. We found that there is a need to improve notching and tuning precision since the current research approach requires a more thorough examination after researching various notching strategies such as Electromagnetic band gap (EBG) structure, Slip ring resonator, and Meander slots. We require a technique to increase accuracy to achieve the antenna's compactness, improved gain, correct tuning, and quad-band capabilities.

Table 1. Lists the various types of notching techniques utilized by various researchers.

Reference Antennas	Notching Techniques	Antenna Size (mm)	Notch Bands	Notch Bands (GHz)
[01]	Meander Slot	40×38×1.6	3	3.29 – 4.83, 5.15 – 6.84, 7.94 – 8.49
[02]	SRR and EBG	20×26×1.52	3	3.4–3.9, 5.15–5.825, 7.25–7.75
[03]	Rectangular slots	26×30×1.6	2	5.18–5.82, 7.25–8.39
[04]	Meander line EBG and U slots	34.9×31.3×1.6	4	2.53–3.15, 3.23–3.68, 3.92–4.30, 5.49–6.19
[05]	Slots and SRR	54 x 47 x 1	3	2.23-2.45, 3.26-3.48, 5.54-5.88
[06]	EBG_s	24x24x1.6	3	3.3-4.0, 5.1-5.8, 7.2-7.8
[07]	SRR	40 X 30 X 0.78	4	3.39-3.82, 50.13-5.40, 5.71-5.91, 7.5-8.61
[08]	Slots and SRR	41.5×32×1.6	4	3.3–3.7, 5.15–5.35, 5.725–5.825, 7.25–7.75
[09]	Parasitic Strips	30 x 22 x 3	3	3.26-3.71, 5.15-5.37, 5.78-5.95
[10]	EBG_s	50 x 42 x 1.6	3	3.3-3.8, 5.15-5.82, 7.1-7.9
[11]	SRR on the feed line	50 x 50 x 1.57	2	5.15-5.82, 6.2-6.9
[12]	Stepped Slot	28 x 18 x 0.8	2	5.1-6.0, 7.83-8.47
[13]	EBG, U slot, SRR	25 × 25× 1.6	2	5.94–7.5, 8.02–10.46

Table 1: The Performance Comparison Chart

VIII. Conclusion

In this paper, to prevent narrowband interference, many UWB antenna types using band-notch techniques have been researched and reported. By using an EBG structure, a slip ring resonator, and meander slots, UWB antennas with a notch band have been produced. The EBG structure has been employed by the majority of researchers to lower electromagnetic noise in electronic equipment.

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