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Review Paper on a Compact UWB Band Pass filter with DG Structure

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Abstract

In This paper reviews various designing methodology and analysis of a simple and compact ultra-wideband (UWB) band-pass-filter using defected ground plane structure (DGS) technique to achieve high data rate in mobile radio communication system by keeping a low cost and small size of band pass filter (BPF) with multi-band and high performance. A multiple type of defective ground planes structure are used to enhance coupling between lines i.e. modified and better results in return loss as well as other parameter in UWB range(3.1 to 10.6 GHz) as per every successive research and development. The purpose of this paper is to discuss some researcher's DGS pattern & set of techniques to meet the challenge of designing Multi Band/UWB band pass filters(BPF).

Keywords: Multiple-mode resonator ; Ultra-wideband; Band pass filter**;** defected ground

1. Introduction

In 2002, Federal Communication Commission (FCC) released Ultra wide band (UWB) system from 3.1 GHzto 10.6 GHz for the use of indoor and hand-held systems as shown in Figure 1. Ultra-wideband (UWB) band pass filters play a key role in the development of UWB systems [1]. After the release of UWB, It attracts researcher from both industry and academia due to its various advantages like low power consumption, high data rate & large transmission capacity. There were lot of challenges to design such a band pass filters with a pass band of the frequency range (3.1 GHz - 10.6 GHz), and a fractional bandwidth of 110% for conventional filter design. Initially broad band filters were designed, and covered only 30 to 40 % of UWB not the whole UWB [2].UWB filters should not only have low insertion loss, better return loss and good selectivity but also good out-of-band rejection performance to provide undisrupted service across different networks as well as to achieve high-data-rate access at any moment from any place. In addition, a compact size and easily-implemented structures are also demanded. So there are various techniques have been implemented to design filters in order to improve their S-parameters and minimization of their sizes. One of them is to use a defective ground structure (DGS). The DGS is a deliberately etched cascaded structure defect on the ground plane. There are various DGS shapes that have been observed such as square, rectangular, circular, dumbbell, concentric ring, spiral, L-shaped, U-shaped and V-shaped, hairpin, hexagonal, cross-shaped, arrow head slot and inter-digital DGS [3]-[7] as shown in Figure 2.Defected Ground Structure (DGS) firstly and used the term "DGS" in describing a single dumbbell shape defect. The DGS can be described as a simplified form of EBG structure, which also exhibits a band-stop property. DGS extended its horizon and opened a door to microwave researchers of a wide range of applications. Various novel DGSs have been proposed and lot of applications have been explored extensively in microwave engineering.

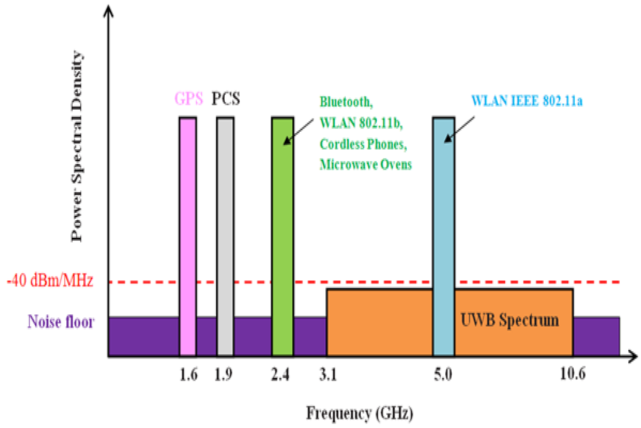

Figure 1.FCC Frequency Mask for UWB Applications

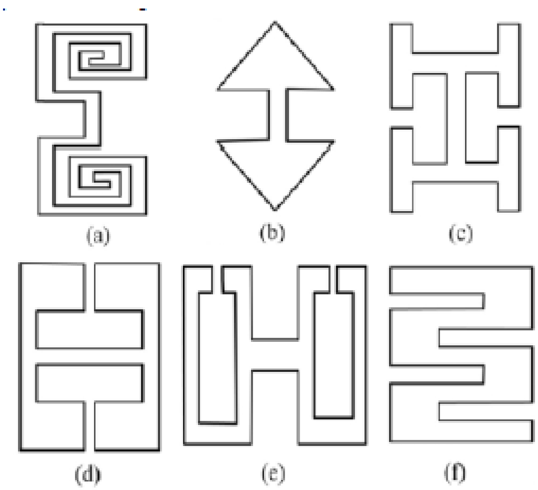

Figure 2 Various DGS shapes (a) Spiral head (b)Arrow-head (c) H-shaped (d) a square open loop with slots in the middle (e) Open loop dumbbell (f) Inter-digital DGS [7]

2. Literature Review

Saito, H. Harada, and A. Nishikata (2003): This paper presents a band pass filter for Ultra wide hand (UWB) communication systems and fundamental transmission Characteristics. The Federal Communication Commission (FCC) authorized the commercial use of the UWB technology in February 2002. Where, the frequency range of the spectrum mask in an indoor environment is from 3.1GHz to 10.6GHz. To transmit digital information on the maximum of 1 Gbps using this range, the band pass filter with the same pass band and is indispensable.

Ishida and Araki (2004): In this paper, a device was developed using a new Ring Filter. The Ring Filter is compact, with low insertion loss, sharp rejection and a constant group delay within the UWB pass band. The Ring Filter is made to control the attenuation pole frequency by adjusting both the ring and the stub impedance.

Wang, Zhu and Menzel (2005): A novel ultra-wideband (UWB) band pass filter (BPF) is presented using the hybrid micro-strip and coplanar waveguide (CPW) structure. A CPW non uniform resonator or multiple-mode resonator (MMR) is constructed to produce its first three resonant modes occurring around the lower end, center, and higher end of the UWB band.

Yang, M. R. Jin, J. Geng, X. Huang, and G. Xiao (2007): A compact planar micro-strip ultra-wideband (UWB) band pass filter (BPF) is presented in this paper. The proposed UWB filter is realised by cascading a high pass filter (HPF) and a low pass filter (LPF). The designed five-pole HPF consists of inter-digital capacitors & short-circuited stubs as well as the LPF is realised mainly based on a non-uniform defected ground structure array in the ground.

M.-H. Weng, C.-T. Liauh, H.-W. Wu and S. R. Vargas (2009): In this paper, a compact ultra-wideband band pass filter (BPF) mainly consists of conventional stepped impedance resonator (SIR) as the multiple-mode resonator (MMR) and two enhanced coupled input/output lines. The measured 3 dB fractional bandwidth of 113.8% and narrow notched band with 25 dB rejection is achieved.

A. Kumar and M. V. Kartikeyan (2011): A compact wide-band band pass micro strip filter with T-shaped DGS studied with inter-digital capacitance in 50 ohm conducting line is proposed. Using this DGS structure, forward transmission coefficient (S21) is -0.08 dB and reflection coefficient (S11) is -22 dB at the center frequency 5.4 GHz with the wide bandwidth of 2 GHz.

Z.-J. Shang, Guo, Cao, B. Wei, Zhang, Y. Heng, Suo& X.-K. Song (2013): This letter presents a superconducting ultra-wideband (UWB) band pass filter (BPF) with sharp rejection skirts and miniaturized size using multiple-mode resonator (MMR). The modified SIR generates three resonant modes within 3.1–10.6 GHz UWB range. Interdigital coupled-lines are used for the external couplings to enhance the coupling strength.

Dharmendra Jhariya, Amit Ranjan Azad, Akhilesh Mohan &Manoran-jan Sinha (2015): In this paper, a compact ultra-wideband (UWB) band pass filter (BPF) with notched band is proposed. The basic quintuple mode UWB band pass filter is based on stub loaded multi-mode resonator (MMR) and two inter digital coupled lines. The design BPF has pass band insertion loss of 1.6 dB, return loss greater than 12 dB and fractional bandwidth of 110 %.

M. Kavosi, J. Nourinia, Ch. Ghobadi, A. Bazdar&B. Mohammadi (2017): In this paper a new design of ring resonator band pass filter (BPF) with enhanced out of band efficiency and double band notch operation for ultra-wideband (UWB) applications is designed. The employed multi-mode resonator (MMR) is excited by two cross-form coupled lines (CFCLs) at two sides to attain quadruplet-mode UWB BPF performance.

Habiba, H., Prashanth, T., Keerthipriya, S., Sayeed, L., & Sandhya, R. (2017): A compact full mode SIW UWB band pass filter using novel input/output transmission-line-structure is proposed in this paper. This wide band SIW resonator can be evolved from a conventional SIW transmission line or a two-conductor transmission line. This filter has wide passband of 3 - 8GHz with return loss of nearly -20dB.

3. Comparative Study of PBG, EBG & DGS

3.1 Photonic Band Gap (PBG): Photonic Band Gap (PBG) structures are periodic structures etched on the ground plane and have the ability to control the propagation of electromagnetic waves. Periodic structures effects the current distribution of the structure. The periodic structures can influence on the propagation of electromagnetic waves and radiation characteristics. The PBG have the periodic defects, which can be treated as a resonant cavity and affect the propagation of the electromagnetic waves.PBG forms free mode inside the forbidden band gap and provides a stop band at certain frequency. PBG has been reported for improving the directivity of antennas, surface wave's suppression, and harmonics suppression [15].

3.2 Electromagnetic Band Gap (EBG) Structure: The EBG technique is based on the PBG phenomena and also realized by periodical structures. In [16], EBG has been introduced as high-impedance surface or PBG surface. These structures are compact and result in high gain, low profile and high efficiency antennas. EBG has been created an interest in the field of antenna. EBG structures suppress the surface wave current hence increase the antenna efficiency. The surface waves decrease the antenna efficiency. Surface wave suppression using EBG technique improves the antenna performance by increasing the antenna efficiency and antenna gain [17].

3.3 Defected Ground Structure (DGS): The compact geometrical slots embedded on the ground plane of microwave circuits are referred to as Defected Ground Structure (DGS). A single dumb bell defect (unit cell) as shown in figure 3.

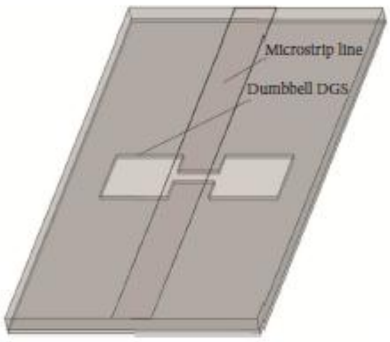

Figure 3.Dumbell DGS Unit

or a number of periodic and a periodic defects configurations may be comprised in DGS. Thus, periodic and/or a periodic defects etched on the ground plane of planar microwave circuits are referred to as DGS. The comparison between PBG, EBG, and DGS is depicted in Table 1.

Table 1: Comparison of PBG, EBG andDGS.

Factors	PBG	EBG	DGS
Definition	PBGstructures are periodic structures etched on the ground plane and have the ability to control the propagation of electromagnetic waves.	The EBG technique is based onthe PBGphenomena and alsorealized by periodical structuresbut compact in size.	Single or few compact geometrical slots embedded on the ground plane of microwave circuits are referred to as Defected Ground Structure (DGS).
Geometry	Periodic etched structure	Periodic etched structure	One or few etched structures
Parameter extraction	Very difficult	Very difficult	Relatively simple
Size	Large	Smaller than PBG and largerthan DGS	Much more compact than PBG and EBG

Fabrication	Difficult	Difficult	Easy

4. Objective of Research

One of the primary objectives is to improve return loss and selectivity of UWB band pass filter by using periodic DGSs for planar microwave circuits which are earning major attraction of microwave researchers. By using periodic structure phenomena higher slow wave rate with greater degree of miniaturization is achieved. Repetition of single defect with a finite spacing is referred to as periodic structure. By cascading the defects (resonant cells) in the ground plane, the return loss level and bandwidth is improved depending on the number of periods. The major purpose of using DGS patterns is easy to design and fabricate to get higher precision as well as easy to realize its equivalent circuit.

5. Conclusions

In this paper, the evolution of UWB BPF with various DGS is presented as well as comparative approach among photonic band gap (PBG), electronic band gap (EBG) and defected ground structure. The key role of DGS in the field of microwave engineering is described with different shapes of DGS, as result of which, miniaturization, multiband performance, bandwidth enhancement and gain enhancement etc. A dumb bell shaped DGS was designed in the ground plane underneath a micro strip line for creating a filter response. It perturbs the electromagnetic fields around the defect and trapped electric fields give rise to the capacitive effect, while the surface currents around a defect cause an inductive effect. This, in turn, results in resonant characteristics of a DGS, causing an effect of filters.

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