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Compact Ultra-Wideband Bandpass Filter Employing Rectangular Slits and Circular Impedance Stepped Stubs with Improved Performances

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***Abstract**:*
In this paper, a Compact Ultra-Wideband Bandpass filter is being designed using circular impedance stepped stubs along with a rectangular slit which provides an efficient and improved bandwidth for ultra wideband applications.Due to the implementation of rectangular slit within each of the circular stub radius,the frequency obtained at the output changes.Infact the simulation of this design is being carried out using MICROWAVE CST STUDIO. The simulation gives us three resonance mode centered on 7.0836GHz,8.1451GHz and 15.024 GHz.For 0 dB attenuation sidebands forms 6.6624GHz to 7.2158GHz frequencies and at -5 dB attenuation the lowest side bands produces certain frequencies ranging from 6.9651GHz to 7.2158GHz,7.912GHz to 8.364GHz,14.828 to 15.218GHz. All these frequency set corresponds to Microwave frequency spectrum lying in the X and Ku band respectively .The output obtained will be having insertion lossless and return loss noise free characteristics,which will enable the filter to perform efficiently for both indoor and outdoor performances.

***Key words:** Bandpass filter (BPF),Microwave CST Studio, Ultra wideband(UWB)*

1. Introduction

Ultra wideband is also known as Ultraband or ÜWB.UWB uses low energy level for short range,high bandwidth communications using radio spectrum.Its based on very short pulse signals typically of sub nanoseconds.UWB exhibits extreme broad bandwidth larger than 20% or 500MHz.UWB has an unique ultrawide frequency bandwidth.It can achieve huge capacity as high as hundreds of MBPs or even several GBPs within a distance of 1-10 meters.One of the important challenges faced in UWB communication is the design of antenna to achieve the required bandwidth criterias.Inorder to maintain the required bandwidth for UWB,a constant group delay should be maintained.Group delay is the derivative of unwrapped phase of an antenna.If the phase is linear throughout the frequency range,Group delay is constant for a particular frequency range.It helps to indicate how well a UWB pulse will be transmitted and to what degree it may be distorted or dispersed.Antennas required to have non dispersive characteristics in time and frequency,providing a narrow,pulse duration to enhance a high data throughput.For designing of UWb antennas which focuses on microsrip,slots and planar antennas with different matching techniques to improve bandwidth ratio without the loss of its radiation pattern properties.A Bandpass filter is typically designed to meet the UWB communication requirements.Hence a microwave filter is designed inorder to meet high frequency applications since LC filters,Crsytal oscillators etc can’t meet high frequency applications.Even stability of the circuit is also very less for LC filters.Hence for UWB high frequency applications we have to implement microwave filter structure.It can be interconnected as PCBs and can be aligned very easily.

In this paper a BPF is designed employing a circular impedance stepped stubs with a rectangular slit.In the previous paper [1],a planar Bandpass filter is being designed using Broadside structure with circular impedance stepped stubs ,that covers a frequency range from 3.1GHz to 10.6GHz range.In this paper this structure is being modified to provide two sets of frequency ranges at the output.At -5dB attenuation the frequency set will be from 8.146GHz to 8.584GHz and 14.41GHz to 14.686GHz range. This range of frequencies will cover the microwave frequency bands Ku and X bands.Thus this operational frequency range will enable this structure to be applied for all Ku band and X band applications like Radar communications,backhaul (broadcasting applications) and satellite communications.The Microwave frequencies set is being noted in Figure 1.Our desired output will be lying in the SHF (Super High Frequency)region in Microwave spectrum as below.

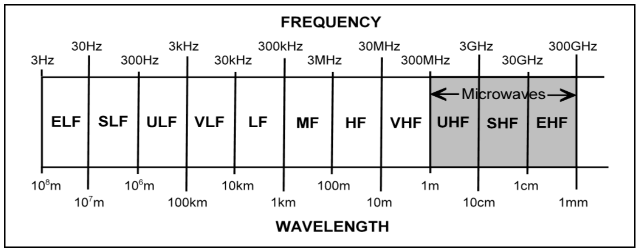

Figure 1: Microwaves in Electromagnetic Spectrum(300MHz-300GHz)

The simulation is being performed using Microwave CST tool. CST MICROWAVE STUDIO (CST MWS) is the leading edge tool for the fast and accurate 3D simulation of high frequency devices and market leader in Time Domain simulation. It enables the fast and accurate analysis of antennas, filters, couplers, planar and multi-layer structures and SI and EMC effects etc.Here mainly Transient Solver simulation is being performed for steady state response.Some advantages of using CST tool here is that,it can be used for autocorrecting frequency range,hiding or unhiding the history list and far field monitoring purposes.

2. Proposed Bandpass Filter Design

In this paper a compact ultra wideband bandpass filter is implemented using circular impedance stepped stubs with rectangular slits.Firststep is to design an Bandpass filter based on components selection.The designing is being performed initially upon LC filter circuits.This lumped elements used in LC filter can be converted into distributed elements.This give rise to transmission line structures.The proposed model can be as explained in the below figure 2

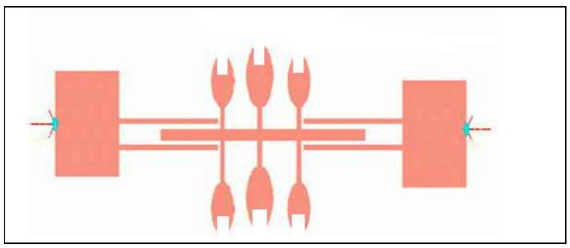
Figure 2: Proposed bandpass filter design

The proposed model contains a Substrate made up of FR-4(loss less) material of about length b=19.5mm,relative dielectric permittivity εr =4.6,height of substrate l= 8mm ,width of the material w=0.2mm, and the thickness of the substrate h=1.6mm.The input and output section includes two ports of each $Z0C$ =50 ohms and $Z0L$ =100 ohms impedances.The filter is being designed with rectangular slit within three pairs of circular impedance stepped stubs in shunt with respect to an high impedance microstrip lines.The distance between any two circular patches is about 1.73mm.

The filter is formed by attaching intercoupled digital lines and the length of coupled lines at both ends corresponding to even mode impedance and odd mode impedance can be deducted using matlab coding.As per trial and rule method,the even and odd mode values can be matched and it can be estimated to about 4.8mm.This intercoupled digital lines is made upof PEC material .The length of the microstrip line is about 9mm.The structure is well grounded also to provide maximum efficient output.The microstip line is having a radius of 0.6mm at the center and a common radius of 0.5mm.A rectangular slit of length 0.8mm and breadth 0.6mm is fabricated out from each portion of circular stub radius.Thus this rectangular slit is curved out from three pairs of circular impedance stepped stubs.The input is fed to the port network and three modes of resonant frequencies are obtained at the output which can be used for various microwave Ku band and X band applications.Basically we provide input frequencies ranging from 0-16GHz.

3. Simulation and Results

A Bandpass filter is designed for UWB communications which can allow almost three sets of passbands ranging from 6GHz to 15GHz, which can be used for a wide variety of ultra wideband applications like satellite communications,radar etc.The filter output can be analysed using The Insertion loss plot(s22) and the Return loss plot(s11).This can be represented as shown below in figure 3 and figure 4.

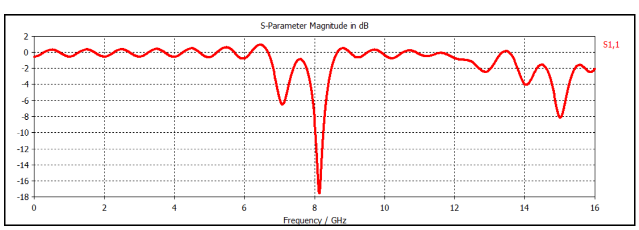

Figure 3: Return Loss plot

From this Return Loss graph, we infer that three resonance mode operation can be obtained.These bands corresponds to 3 sets of frequencies corresponding to 7.0836GHz at -6.495dB attenuation,8.1451GHz at -17.559dB attenuation.At 0 dB attenuation side bands produces frequencies from range 6.6624GHz to 8.6462GHz.At 5dB attenuation the lower sidebands produces three sets of frequencies starting from 6.96GHz to 7.215Ghz,7.91GHz to 8.36GHz and 14.82Ghz to 15.21GHz.All these frequencies corresponds or mapps to microwave frequency band ranging from 6 to 15 GHz which belongs Ku and X bands respectively.Minimum return loss for lowest side band is obtained at -17.566dB at 8.1451GHz.

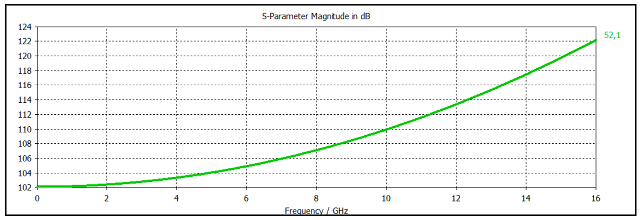

Figure 4: Insertion loss plot

The insertion loss plot provides noisless output and provides a sharp response for all UWB communications.

4. Conclusion

Compact ultra-wideband bandpass filter is being implemented using rectangular slit embedded within circular impedance stepped stubs produces certain microwave frequencies ranging from 6GHz-15GHz,which can be used for various indoor and outdoor applications.The output produces insertion losseless and returnloss noise free sharp band of frequencies lying in Ku and X band,which can be utilised for many applications like satellite communications ,most notably for fixed and broadcast services,and for specific applications such as NASA's tracking data relay satellite used for both space shuttle and ISS communications and also used for high resolution imaging radars.

5. References

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