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# Design of Ultra High Band Pass Filter By Using Di-Electric Resonator

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*Abstract — This paper presents a design of a bandpass filter using combination of a simple transmission line and cylindrical dielectric resonator for wide band application. Four dielectric resonators with same permittivity ($FR_4$ epoxy ) having high permittivity and diameter of 1mm are identified to be contributed to an ultra-wideband bandwidth of the filter. This new approach increases the coupling effect as well as minimizing the insertion loss in the passband. Experimental results from the simulation are closely agreed to the measured values. In order to prove that the new approach contributes more advantages and viable at the desired application band, the return and insertion losses of the filter were analyzed. Bandpass filters play a significant role in wireless communication systems. Transmitted and received signals have to be filtered at a certain center frequency with a specific bandwidth. In designing of microstrip filters, the first step is to carry out an approximated calculation based on using of concentrated components like inductors and capacitors. After getting the specifications required, we realized the filter structure with the parallel-coupled technique. Experimental verification gives comparison, how close the theoretical results and measurements look like.*

**Keywords: Bandpass filter, Dielectric resonator, DGS, Ultra-wideband , Q-factor , Micro-stripline**

## I. INTRODUCTION

Bandpass filter is a passive component which is able to select signals inside a specific bandwidth at a certain center frequency and reject signals in another frequency region, especially in frequency regions, which have the potential to interfere the information signals [1]. A bandpass filter must be used in transmitter and receiver to reject undesired signals [2]. In the previous research we have done the designed and simulated the bandpass filter as in [2] using HFSS software ( version 12). This research, we simulated and fabricated bandpass filter using dielectric resonator and stripline for the radar system and wireless communication at the operating center frequency of 10GHz, bandwidth of 60 MHz. The simulation of bandpass filter in this research using HFSS. Microstrip bandpass filter is one of the most important components in wireless communication systems [3-4].

Unfortunately, without special measures, most of the microstrip BPFs exhibit harmonic responses degrading the system performance. To overcome this problem, various methods have been presented in the past [5-6].

Among the fundamental components of Microwave, bandpass filters are used in many RF/microwave applications and contributes in the overall performance of a communication system. Microwave filters are utilized in broadband wireless applications like satellite and mobile communication systems and WLAN systems. Filters on various materials are available but preferably standard printed patch filter are being used by engineers over higher frequencies, as they can be fabricated easily with low cost. The size is main constrained in front of microstrip filter designers. Numerous researchers have proposed various configurations for reducing filter size and improving filter performance. Some of the filter configurations are using hairpin resonator, ring resonator, step impedance resonator, defected ground structure, and short circuited stub [7]. From the early investigation of ultra-wideband (UWB) technology in 1960s various wireless services grown very fast, and the demand of multi-band microwave communication systems capable of adapting multiple wireless communication platforms have greatly increased. Apart from the various microstrip components the BPFs possessing tunable multi-band characteristics. In the designing of microwave bandpass filters commonly ring resonator are utilized with the benefit of small circuit size and sharp rejection response [8-9].

The main concepts of this paper is Richard's transformation and kuroda's identity(wavelength/8). These two transformation and identity depends on the user of lines for which $x=jz_0$ is width of microstrip to create a microwave stripline for the transmission. A lumped low pass filter can be implemented by using appropriate lines of $Z_0$. So if we need to inductance of L for prototype filter normalized to cut-off frequency $w_c$ =1 and admittance $g_0$. Substitute the value a(wavelength/8) stub $z_0$ = L. The last step of filter design will be scale to scale design to desired $w_c$ and $z_0$ (typically 50 ohms).

Open- and short-circuit transmission line segments emulate inductive and capacitive behavior of discrete components. Based on:

Set Electrical Length $l = \lambda/8$ so

$$\theta = \beta l = \frac{\pi}{4}\frac{f}{f_o} = \frac{\pi}{4}\Omega$$

Richards Transform is:

$$jX_L = j\omega L = jZ_o\, tan\left(\frac{\pi}{4}\Omega\right) = SZ_o$$

and

$$jB_C = j\omega C = jY_o\, tan\left(\frac{\pi}{4}\Omega\right) = SY_o$$

For $l = \lambda/8$, $S = j1$ for $f = f_o = f_c$

## II DESIGN METHODOLOGY

The dielectric resonator can increase Q-factor in a circuit. The size, location and shape of the dielectric were influencing the matching of the circuit. In this project, three dielectric resonators were excited with a microstrip line in order to obtain the optimum coupling effect. The dielectric resonators offer advantages in increasing the signal transmission performance of RF and microwave devices. The match combination of dielectric resonators and microwave circuit capable to generate additional coupling affect that can be merged together to produce a wideband device as well as increasing the transmitting power and reduce the insertion loss. This combination proficiently produces a low design profile. Since cylindrical shape of dielectric resonators have a flexible radius, *r* , height, *h* and dielectric constant, e due to various sizes can be bought from the market. The applications of these resonators have been used in filters and oscillators [10]. Such shape offers a wide degree of freedom in microwave circuit designs since the ration of r/h could determine the Q-factor for a given dielectric. Thus a height, slender cylindrical DR can be made to resonate at the same frequency as a wide and thin DR.

Defected ground structure on the back of the filter improves the harmonic suppression characterstics of band pass filter[11].This extraction method shows how to design a micro strip high-low pass filter by combining an arrow head shaped defected ground structure with multilayer circuit fabrication techniques[12]. DGS elements have been shown to provide a mean of shrinking the size of passive ckts such as low pass filter.The key is determing the size area of a selected DGS shape by correlating its area to the equivalent circuit. Inductance and capacitance required for a particular filter design as might otherwise be relised by conventional microstip line in addition to the smaller size, they deliver even sharper filter cutoff than conventional microstrip it has a conventional microstrip and stipline technology and can be used creatively in multilayer filter architecture for further saving in circuit real state geometrical resonators. Dielectric resonator (DR) offers a lot advantages in increasing the performance of RF and microwave devices which make it as an ideal Ultra-Wideband Dielectric Resonator Bandpass Filter. It is wireless application; low design profile and wide bandwidth Dielectric resonators are mainly designed to replace resonant cavities in microwave circuits such as filters and oscillators.

Sinusoidally driven resonators having higher Q factors resonate with greater amplitudes (at the resonant frequency) but have a smaller range of frequencies around that frequency for which they resonate; the range of frequencies for which the oscillator resonates is called the bandwidth. Thus, a high Q tuned circuit in a radio receiver would be more difficult to tune, but would have more selectivity; it would do a better job of filtering out signals from other stations that lie nearby on the spectrum. High Q oscillators oscillate with a smaller range of frequencies and are more stable. The dielectric constant is a parameter that reflects the capability of a material to confine a microwave. The higher this parameter means better in term of microwave confinement in the substrate. There is an inversely proportional between size and dielectric constant. A high dielectric constant is required to reduce circuit size of a device. A significant miniaturization can be achieved, thus high quality filters can be realized. The quality factor of oscillators vary substantially from system to system. Systems for which damping is important (such as dampers keeping a door from slamming shut) have $Q = ½$. Clocks, lasers, and other resonating systems that need either strong resonance or high frequency stability need high quality factors. Tuning forks have quality factors around $Q = 1000$. The quality factor of atomic clocks and some high-Q lasers can reach as high as 1011 and higher.

If the receiver coil is at certain distance of a transmitter coil, only fraction of magnetic flux, which is generating by transmitter coil, penetrates the receiver coil and contributes to the power of transmission. the more flux reaches the receiver , the better the coil coupled. The grade of coupling is expressed by K .valued from 0 to 1. If the coupling factor is 1, it expresses perfect coupling .i.e all flux generated penetrates the receiver coil. If coupling factor is 0, then transmitter and receiver coils are independent of each other. The coupling factor determine by the distance between inductor and their relative size and further determine the shape of the coil. and angle between them. If coils are axially aligned ,a displacement caused a decrease of K ,is exemplary arrangement of planer coil with 30mm diameter It shows the measured and calculated coupling factor for parallel coils at different misalignment . Distance at the horizontal axis .Coupling factor in the range of 0.03 to 0.6 are typical negative coupling factor means that receiver captures the magnetic flux from behind.

Figure1:Dumbled shaped DGS on the ground plane

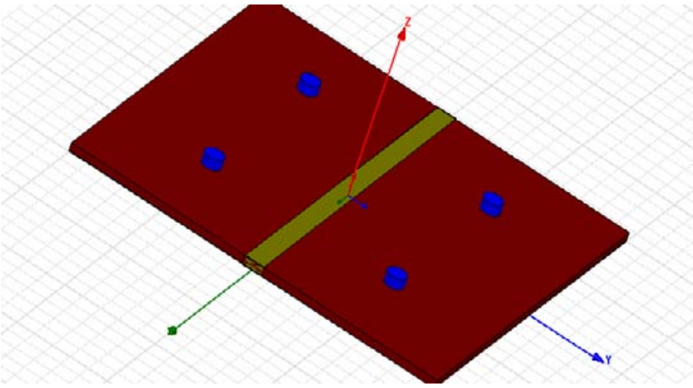


Figure2: Design showing four dielectric resonator with same radius on the strip line and DGS on the ground side.

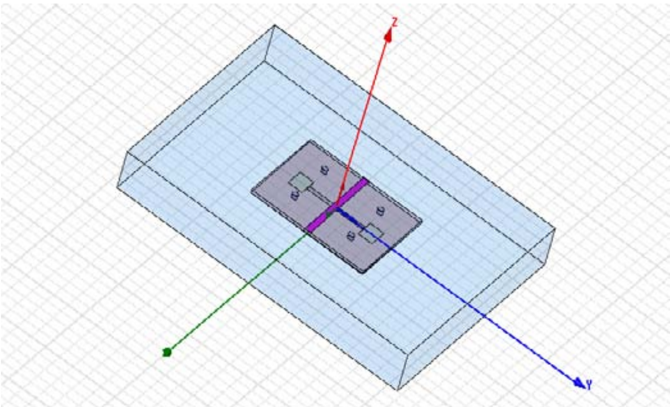
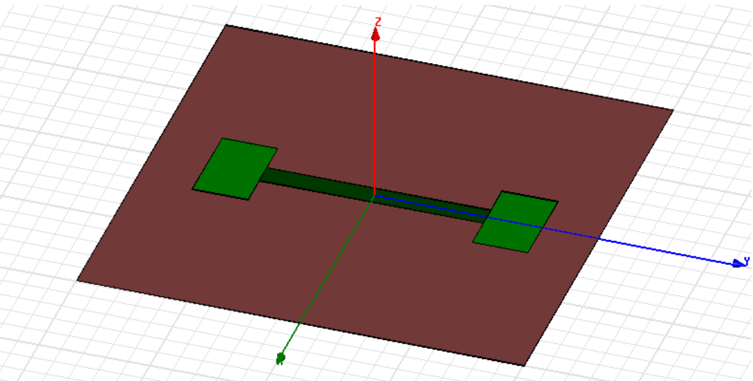


Figure3: Design B.P.F by using dielectric resonators and



microwave strip line with radiation box .

## III RESULT

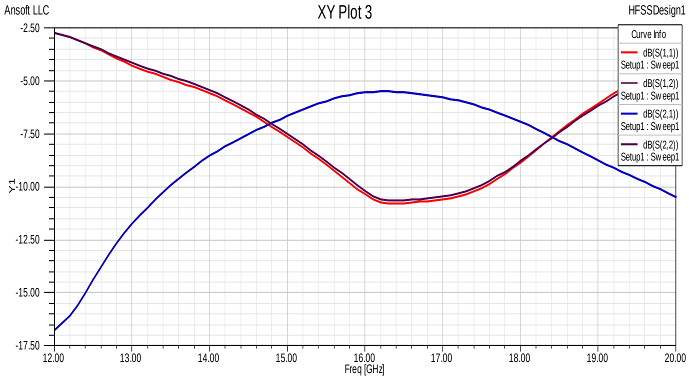



Figure4: Output waveform of Band Pass Filter.

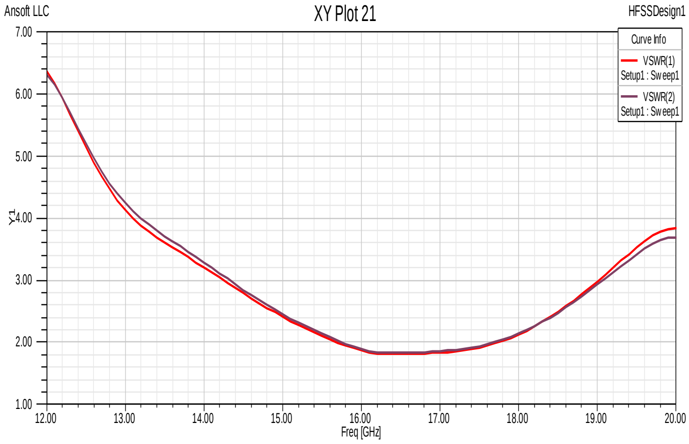



Figure5: Shows Voltage Standing Wave ratio at port 1 & port 2

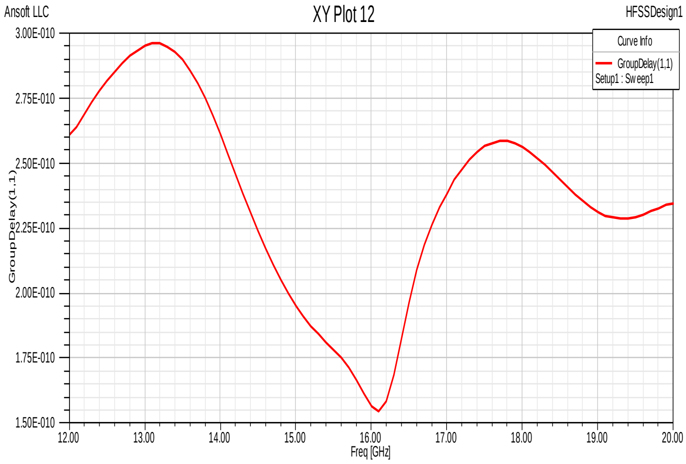



Figure5: Shows Group Delay at $S_{11}$

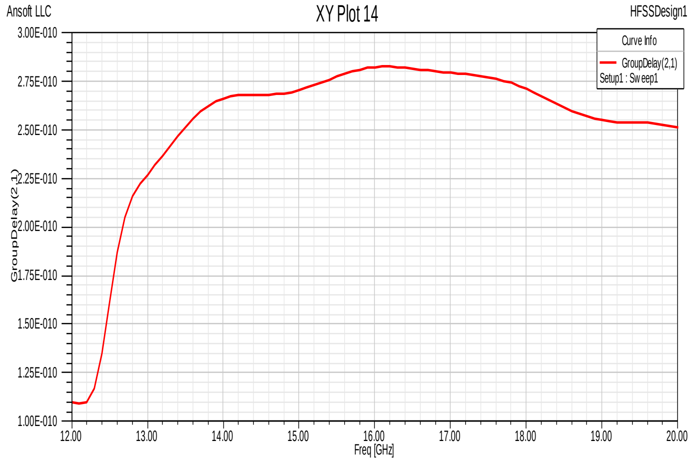



Figure5: Group Delay at $S_{21}$

IV CONCLUSION

A bandpass filter was designed to operate at starting frequency of 12 GHz, without tuning the dielectric resonator.If dielectric resonator tuned than it will give more accurate pass band response by utilizing DGS Structure along with it, very small ripple at the passband insertion loss and able to operate with a wide bandwidth upto 20GHz or more . The structure of the filter is simple for ease fabrication process. The measurement values are closely agreed to the simulation results by HFSS. A new technique for designing micro-strip BPFs suitable for the UWB wireless communications is proposed. The BPF is designed with a composite structure by embedding an HPF and an LPF to each other. Although the high-pass and low-pass structures in a composite BPF are perturbed by each other, the entire design shows a satisfactory band-pass characteristic over a wide bandwidth.

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