Research article **Available online www.ijsrr.org** **ISSN: 2279–0543**

International Journal of Scientific Research and Reviews

LPF using Defected Ground Structure and Microstrip-line

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ABSTRACT

This paper describes the design of a LPF that is using DGS. The analysis of the rectangular shaped defected ground structure (RS-DGS) and the application of the structure on some microwave devices.In this paper, a microstrip transmission line combined with a new U-headed dumb-bell defected ground structure (DGS) is investigated. The proposed DGS of three U-shape slots connected by a thin transverse slot is placed in the ground plane of a microstrip line. A three-cell DGS microstrip line yields a better lowpass filtering characteristics. The simulation is carried out by CST microwave studio. The equivalent circuit for the DGS and its corresponding L-C parameters are extracted by using its S parameters response (EM simulation) and a simple circuit analysis method. The proposed periodic defected ground structure (DGS) provides the excellent cutoff and stopband characteristics. Observed results show good agreement with the theoretical results. The results are validated by using CST.

KEYWORDS : Defected ground structure (DGS), bandpass filter, coupler, LPF, microstrip, EM simulation.

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INTRODUCTION:

The low pass filter is designed using high and low impedance transmission line sections. The low pass filter prototype element values are calculated for chebyshev response. These lumped element values are translated into distributed element values using standard formulas. The filter is designed in the microstrip configuration, but with air cavities under the inductive lines. The purpose of introducing cavities under the inductive line is to reduce the effective dielectric constant, such that the line widths are convenient to fabricate. Radio frequency (RF) and microwave wireless applications demand compact planar low pass filters (LPFs), for suppression of noise and interference. Based on the idea of photonic band-gap structure, defected ground structure was firstly proposed by J.I. Park et al. in 1999[1], which is realized by etching defected patterns on the metallic ground plane under the microstrip line. It has found its applications in planar circuits such as filters[1 - 3], amplifiers[4] and power dividers[5]. It represents slow-wave and band-stop characteristics by changing the equivalent inductance and the equivalent capacitance of the transmission line.DGS components are the dominant technology which can provide size reduction and has capability of harmonics. The DGS can be applied to various kinds of components such as lowpass filters (LPFs) and bandpass filters (BPFs) as well as RF phase shifters.

The basic microwave lowpass filter (LPF) is implemented either by all stunt stubs or by series connected high-low (Hi-Lo) stepped-impedance microstrip line sections. However, these designs suffer from some disadvantages such as the fabrication difficulties associated with the high

impedance lines and the appearance of spurious bands.In order to overcome these disadvantages, a method has been proposed in [8,9] , which uses both DGS resonators and a compensated microstrip line to design the desired LPF. A method to design lowpass filters (LPF) using defected ground structure (DGS) and compensated microstrip line is presented[7].

Using the extracted equivalent elements of DGS and capacitive microstrip line, an LPF having no open stub, high impedance line, or cross-junction element, is designed. Only three DGS patterns and one broad microstrip line comprise the LPF. Simple structure, small size (half of a conventional LPF), less discontinuities, and high power handling capability are obtained through the proposed LPF.

I.A. Filter design by insertion loss method:

A filter response is defined by its insertion loss or power loss ratio as:-

$$P_{LR} = \frac{SourcePower}{LoadPower} = \frac{P_{IN}}{P_{OUT}} = \frac{1}{1-|\Gamma(\omega)|^2} \quad (1)$$

As we know that $|\Gamma(\omega)|^2$ is an even function of ω; therefore it can be expressed as a polynomial in ω. Thus we can write

$$|\Gamma(\omega)|^2 = M(\omega^2)/(M(\omega^2)+N(\omega^2)) \qquad (2)$$

Where M and N are real polynomials in ω^2. Substituting this form in above equation we have:

$$P_{LR} = 1+(M(\omega^2)/N(\omega^2)) \qquad (3)$$

Thus for a filter to be physically realizable its power loss ratio must be of the form as given in above equation. Notice that specifying the power loss ratio simultaneously constrains the reflection coefficient, $\Gamma(\omega)$.

ANALYSIS OF THE PROPOSED DGS CELL:

The equivalent capacitance Cp and equivalent inductance Lp can be obtained follows:

$$L_P = 250/C_P(\pi f_0)^2 \text{ nH} \qquad (4)$$

$$C_p = 5f_c/\pi(f_0^2 - f_c^2) \text{ pF} \qquad (5)$$

Where

L_p = Equivalent Inductance

C_p = Equivalent Capacitance

F_c = Cutoff Frequency

F_0 = Center Frequency

For a line with air above the substrate and the effective dielectric constant has values in the range of $1 < \varepsilon_{reff} < \varepsilon_r$. For most applications where the dielectric constant of the substrate is

much greater than unity $\varepsilon_r >> 1$, the value of ε_{reff} will be closer to the value of the actual dielectric constant ε_r the effective dielectric constant is also a function of frequency.

The initial values (at low frequencies) of the effective dielectric constant are referred to as the *static values*, and they are given by

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{-1/2} \qquad (6)$$

For given dimension of microstrip line, the characteristic is given as :-

$$Z_o = 60/\sqrt{\varepsilon_{eff}}\ \ln[(8h/W) + (W/4h)] \qquad (7) \qquad \text{for } W/h \le 1$$

$$Zo = 120/\{\sqrt{\varepsilon_{eff}}[W/h + 1.393 + .667\ln(W/h + 1.444)]\} \qquad (8) \qquad \text{for } W/h > 1$$

Fig.1: Microstripline used in design

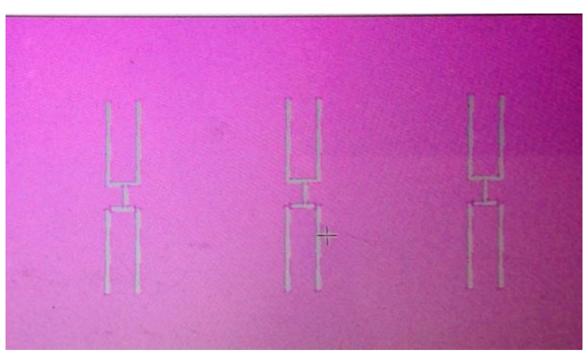


Fig.2: Design of DGS

SIMULATION RESULT:

Fig.: shows the simulated result of the proposed work. The result is realized as given in the table:

Table No.1: Output of Simulation

Characteristics	Return1	Return2
Frequency	5.503GHz	5.513GHz
Attenuation	62.582dB	51.183dB

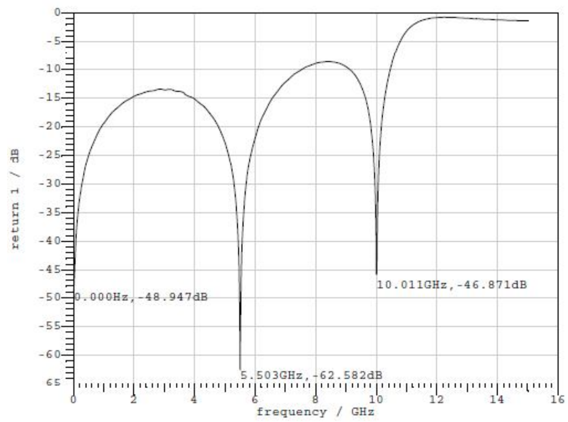


Fig.3:Return1 (dB) vs Frequency (GHz)

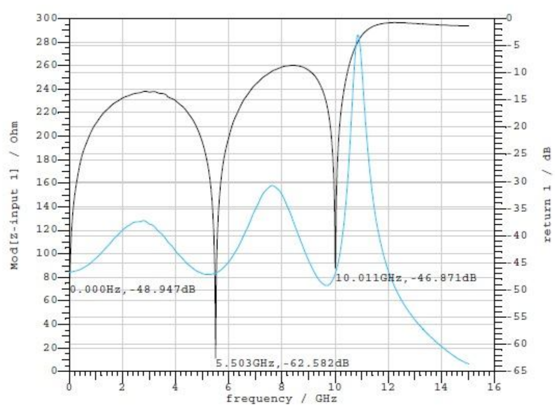


Fig.4: Mod[z-input1]/ohm & return1 /dB vs Frequency(GHz)

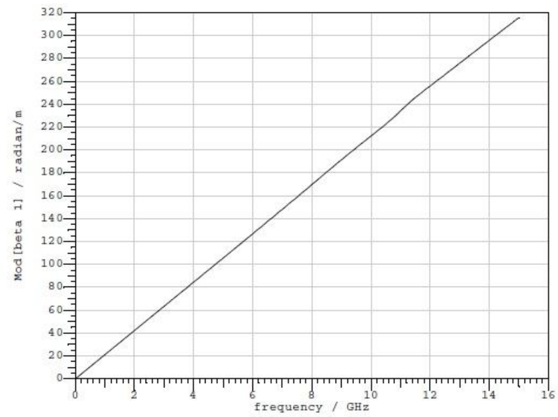
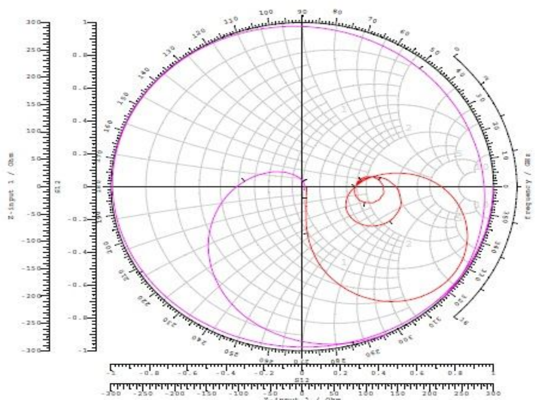
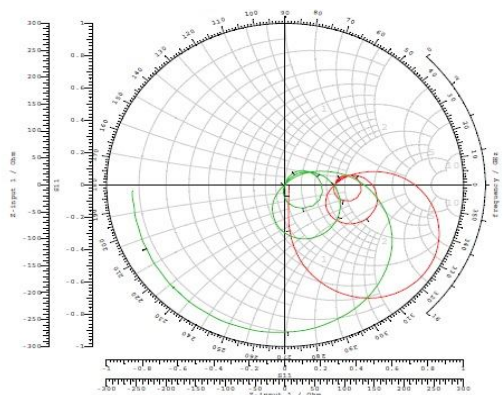


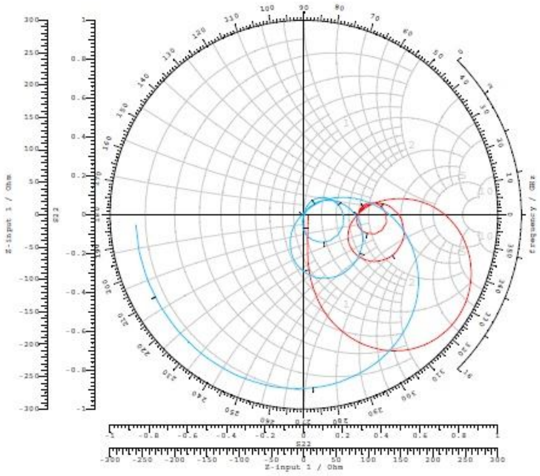
Fig.5: Mod [beta1](radian/m) vs Frequency(GHz)



(a)



(b)



(c)

Fig.6: Various Smith Chart for S-parameters

CONCLUSION

A new concept of a compact LPF using three U-DGSs has been proposed. This lowpass filter is not only of compact size, but also offers control of the cutoff frequency and transmission zero. To verify the performance, the fabrication, simulation and measurement of the filter was done. The measurements show a good consistency with the simulations. Therefore, it is expected that the proposed structures with its compact size, simple circuitry and large stopband characteristics will be used for applications in various integrated microwave circuits as well as other types of filters. The microstrip lowpass filters show advantages of high performance, low cost, and easy fabrication. Measured results are in good agreement with simulated results. **A** new LPF using only three DGS patterns and compensated microstrip line is proposed. No open stubs, high irnpedances lines, and cross-junction are required. This makes the proposed LPF suitable for high power application.

The advantages of this LPF are:

1. Suppressing higher harmonic.
2. Achieving broader stopband responses.
3. Improving the stop and pass band characteristics.
4. Better frequency responses in the passband.
5. Fewer losses in passband.
6. A very sharp transition response.

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