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Performance Analysis of a Defected Ground Structure (DGS) Band-pass Filter for Wireless Application

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Abstract: Defected ground structure (DGS) is of increasing importance in band pass filter applications and designed for getting the specified parameters. they'll be used to design compact filters keeping the performances higher than standard filters. DGS is accomplished by introducing a shape defected on a ground plane therefore can disturb the shielded current distribution looking on the shape and dimension of the defect .The disturbance at the shielded current distribution can influence the input resistivity and therefore the current flow of the antenna. Also twin band pass channel and low pass filters, can be planned with new metal strips stacked defected ground structure (DGS). it had been determined that in correlation with the conventional DMS, this may display lower resonant frequency and more extensive stop band.

Keywords: Band-pass Filter, Coupled resonator, Defected ground Structure (DGS)

I. INTRODUCTION

A faulty soil structure (DGS) is a very popular method to reduce the size of microwave components due to its simple structural design. DGS has been used under the microstrip line to achieve band stop characteristics and to suppress harmonic modes and mutual coupling. After the successful introduction of DGS in the field of filters, today the DGS is in great demand for a variety of applications. The compact geometric slots incorporated in the ground floor of microwave circuits are called Defective Soil Structure (DGS). A single defect (unit cell) or a series of periodic and periodic defect configurations can be included in DGS. Therefore, the periodic and / or periodic defects recorded in the ground plane by the microwave flat circuits are called DGS.

Defects in the ground plane disturb the current distribution of the ground plane; this disturbance alters the characteristics of a transmission line (or of any structure) by adding some parameters (slot resistance, slot capacity, and slot inductance) to the line parameters (line resistance, line capacity, and line inductance)

On the idea of DGS, defected microstrip structure (DMS) may also be used that is simpler than DGS. Defected microstrip structure (DMS) is created by etching bound slot patterns within the microstrip line, and it exhibits the properties of slow-wave, rejecting microwaves in bound frequencies that are like the defected ground structure (DGS) however without any manipulation of the bottom plane. DMS is a lot of simply integrated with different microwave circuits, and it's an effectively reduced circuit size compared with DGS.

This paper presents basic description of a DGS system, their potential advantages, design of filters and the resonators used in DGS. The paper also discusses some previous works and research carried out for enhancement in performances of filters by various authors.

II. ADVANTAGES OF DGS IN MICROSTRIP FILTERS

The microstrip filters used with DGS have numerous advantages like it will improves bandwidth, suppress harmonics and improves sharpnes.

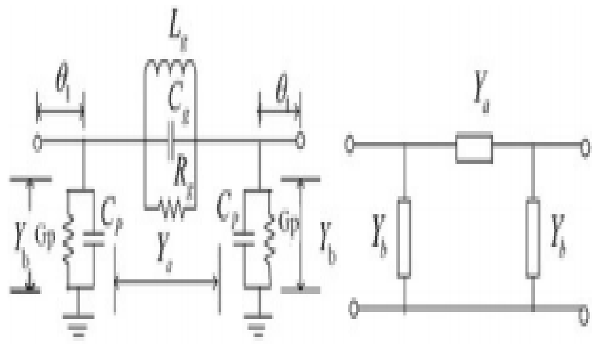

Figure 1 : RLC circuit modeling of unit DGS cell

a) Size reduction techniques in microstrip filter with DGS

For microstrip line with DGS, electrical length is given by:

$\theta = \beta l = \sqrt{\varepsilon_{eff}}\, k_o\, l$

Here, is microstrip line electrical length, is the propagation constant, l is the length of line, eff is effective permittivity of the microstrip line, and ko is the wave number.

As the DGS is introduced in the ground plane of the microstrip line, the effective inductance and capacitance will change and these in turn will change the resonant frequency of the microstrip line. For keeping the resonant frequency at its initial value, we have to compensate for the length of the transmission line.

b) Bandwidth enhancement in microstrip filter with DGS

Owing to the incorporation of DGS, there will be variation in inductance and capacitance. The quality factor will also change due to change in inductance and capacitance. The quality factor can be written as:

$$Q = \frac{f_o}{BW}$$

Here, fo is the resonating frequency, BW is the bandwidth of operating devices, and Q is the quality factor.

If the quality factor decreases, bandwidth will increase but circuit performance is degraded because of increased losses. Therefore, there is a tradeoff between the value of L and C in such a manner that the performance of the filters is not reduced. The inductance and capacitance depend on the lattice dimensions and slot gap of the DGS

c) Enhancement of sharpness in microstrip filter with DGS

The combination of both DB-DGS and SP-DGS improves sharpness of the filter. The sharpness of the filter depends on the length of the connecting slot that connects the square heads of DB-DGS. By employing both DB-DGS and SP-DGS, the characteristics of the sharp transition knee and wide stopband can be obtained. The sharpness of the filter can be expressed as:

$$\text{Sharpness Factor} = \frac{f_{CL}}{f_0}$$

Where f_{CL} is 3-dB lower cut-off frequency and fo is the resonance frequency.

III. RESONATORS IN DGS

A space in the ground plane energized by a 50 Ω line (Fig.2-a) carries on as a parallel resonator. It tends to be demonstrated by a LC circuit [1], [3].

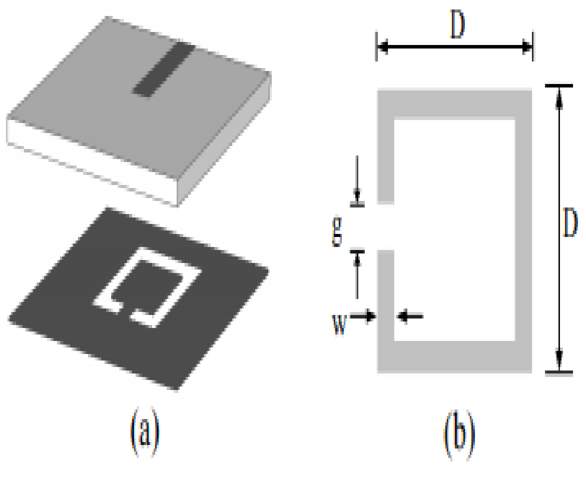

Figure 2: DGS resonator configuration

The slot can take any resonant shape. Fig. 2 demonstrates a DGS resonator setup. The resonator resembles a folded half wavelength resonator. One of the benefits of this setup is that the magnetic and electric fields are focused close to the hole g and the opposite side, separately. Both positive and negative coupling coefficients can be acknowledged effectively.

IV. FILTERS

Lowpass filters (LPFs) are important components that are widely used to suppress harmonics and spurious signals in modern wireless communication systems. To improve the performance of the filter and realize the compact physical dimensions of circuits, defected ground structure (DGS) is introduced.

Filters are two-port systems which are utilized to shift the amplitude (or) phase attributes of a signal in accordance with frequency and they give transmission inside the passband and lessening in the stopband of the filters. The objective of filter configuration is to get a perfect characteristics requisites inside an acceptable tolerance. Filters are utilized in all frequency ranges and they are sorted into four kinds, Low pass filters (LPF), High pass filters (HPF), Band pass filters (BPF), Band stop filters (BSF). Frequency, Bandwidth, Return loss, Insertion loss, and Group delay are the different parameters of the filters. Filters discover their application in numerous spots, for example, in Communication frameworks, Satellite frameworks, Mobile and cell systems, Radar systems, and so forth.

Amongst all these different filters, a band-pass filter is that the one that enables to pass the frequencies inside a particular range and rejects frequencies outside that range. it's employed in wireless transmitters and receivers. In transmitter, it's used to limit the bandwidth of the output and in receiver it permits signals inside a specific range of frequencies and forbid the unwanted frequencies passing through. An example of analogue bandpass filter is an RLC circuit, this may be enforced by the combination of a low-pass and high-pass filter. For eg, the equivalent circuit of bandpass filter and it’s response is shown in figure 3and 4.

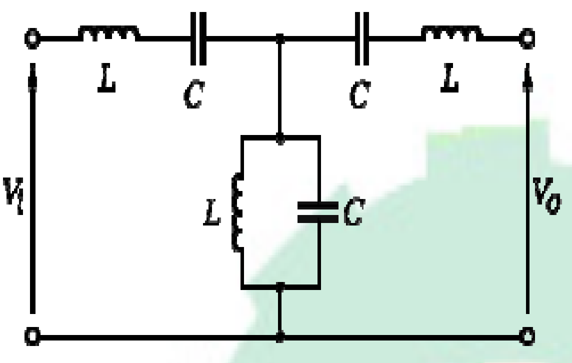

Figure 3: Band pass filter circuit

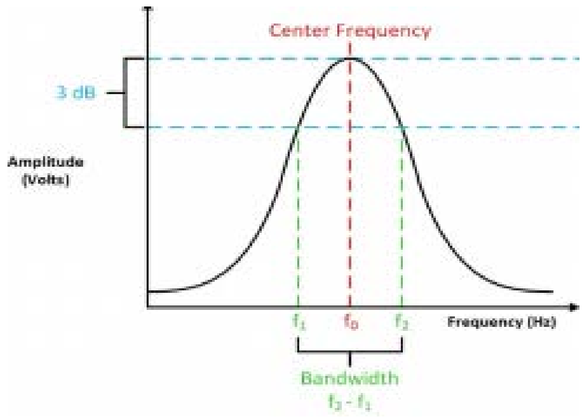

Figure 4: Frequency response of bandpass filter

V. PREVIOUS WORKS

Mohamed K Rashad et.al "Compact High Selective DGS Band-Pass Filters for WLAN Applications" (2017)

In this paper, smaller size band pass filters are proposed and are intended for WLAN applications. The coupled DGS resonators are viewed as the fundamental block of proposed band pass filters. The three proposed filters are planned by utilizing the same defected ground structure shape, yet with various feed line designs. The first design is band pass without transmission zero, the second is with one transmission zero, and the last one is band pass with two transmission zeros. In general, the three band pass filters are designed to operate from 5 GHz to 6 GHz. Insertion loss = < 0.5 dB and central frequency= 5.5 GHz.

Z. Chen et.al "Compact Lowpass Filter with Wide Stopband Using G-shaped Defected Microstrip Structure" (2014)

A defected microstrip structure (DMS) for LPF with G-shaped is proposed in this paper. It is made out of one CSRR and one associating slot. If we campare it with an open square ring-DMS (COSR-DMS), the proposed G-shape DMS can give progressively useful bandgap property. A lowpass filter with - 3dB cutoff frequency at 5.01 GHz utilizing G-molded DMS units is structured and created. The LPF which is designed displays sharp cutoff frequency response, low insertion loss, and great stopband execution. Transition band = 0.28 GHz, stopband width = 20GHz and attenuation = 20 dB

Farah Shazuani Mahmud, "Tuneable Dualmode Narrowband Bandstop Filter Using Loaded Microstrip Resonator" (2016)

Novel tuneable double mode narrowband bandstop filter utilizing loaded microstrip resonator is introduced. The filter is structured by utilizing coupled line coupling with the microstrip resonator. There is two diverse pair of loaded resonator that creates a double band bandstop filter. The dual band bandstop resonance frequency can be tuned freely by altering the resonator width and length. To accomplish high selectivity of the bandstop filter reaction, defected ground structure (DGS) is connected in the filter design. The tapped lines structure (TLS) are utilized to suppress second harmonic frequency. The double band bandstop filter is resonant at 2.4 GHz with 200 MHz of bandwidth and 5.8 GHz with 300 MHz of bandwidth.

VI. CONCLUSION

It can be concluded that compact size, sharp cutoff frequency and excellent bandpass performance are the indicators of a filter with a good potential application in the mobile communication system. The microwave Bandpass filter passes the frequencies within certain range and rejects the frequency outside the range. Based on resonance characteristics, the tuning of the resonant frequency can be done over a wide range by adjusting its structure parameters.

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