Compact Lowpass Filter Design by using Triangle Shape DGS

Amit Kumar singh[1] Prashant Jain[2]

[1, 2] (Department of Electronics & Telecommunication, Jabalpur Engineering College Jabalpur- 482011, India)

Abstract

Most communication system contains an RF front end which performs signal processing with RF filters. Micro strip filters are a low cost means of doing this. Micro strip filters play various roles in wireless or mobile communication systems. There is an increasing demand for newer microwave and millimetre-wave systems to meet the emerging telecommunication challenges with respect to size, performance and cost. This paper describes a compact array of triangular shaped defected ground structure (DGS) is proposed. The dimensions of proposed compact filter are about and have very high sharpness factor (0.911). A traditional single triangular DGS structure is also design, analyzed and simulated for comparison purpose. For the design and simulation, IE3D simulation tool is used.

Keywords-Low-Pass Filter, Photonic band Gap (PBG), Defected ground structure (DGS), triangular shape and Sharpness factor.

I. INTRODUCTION

Emerging applications such as modern wireless communications are often met only by high performance and compact filtering structures. Several of such filters have been reported using generic structures called the defected-ground structures (DGS). Since DGS cells have inherently resonant properties, they have been used in filtering circuits to improve the stop and pass band characteristics. In recent years, periodic or non periodic arrays such defected ground structure (DGS) for planar transmission lines can be applied to wide frequency ranges including the microwave frequencies. The /transmission lines combined with the periodic structures have a finite pass and rejection band like low pass filters (LPF), while the standard transmission lines show only the simple transmission characteristics over broadband. The DGS component can provide size reduction, bandwidth enhancement and has capability of harmonics and spurious suppression. However these designs suffer from some disadvantage such as the fabrication difficulties associated high impedance lines and the appearance of spurious bands. In order to overcome these disadvantages a method has been proposed [1-2] which uses DGS resonators and compensated micro strip line to design the desired LPF. Many passive and active microwave circuits have been developed by using DGS or PBG (Photonic band-gap) patterns to suppress harmonics and realize the compact size [7-9]. Also, the lumped-element filter design generally works well at low frequencies, but two problems arise at microwave frequencies. First, lumped elements such as inductors and capacitors are generally available only for limited range of values and are difficult to implement at microwave frequencies, and hence must be approximated with distributed components. In addition, distance between filter components is not negligible [10].

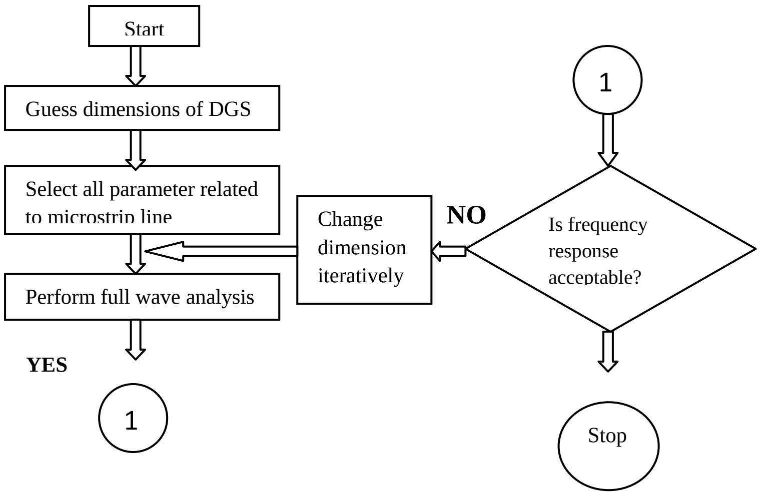

Fig 1. Conventional design and analysis method of DGS [12].

II. MICROSTRIP LINE WITH DGS

The triangular headed DGS slot shown in Figure2 (a) is taken in the ground plane of a 50Ω microstrip line on substrate ξ_r =4.4having thickness h=0.6mm. L-C equivalent circuit is also shown in figure 2(b). The triangular headed DGS has sharper cut off and better rejection in the stop band. The inductance and capacitance of the DGS slot are computed from the following expressions.

$C= 5fc/\pi(f_0^2 - fc^2)$ pF…………………..(1)

$L= 250/C(\pi f_0)^2$ nH……………………...(2)

Where fc is the cut off frequency and fo is the pole frequency. At the frequency below the pole frequency i.e. the resonance frequency of the LC circuit, the LC circuit behaves as an inductor. And above this frequency this behaves as a capacitor.

III. HI- LOW DESIGN

Usually the LPF is implemented either by all shunt stubs or by the series connected high-low (Hi-Lo) stepped-impedance microstrip line sections, A relatively easy way to implement low-pass filters in microstrip or stripline is to use alternating sections of very high and very low characteristic impedance lines. Such filters are usually referred to as stepped-impedance, or Hi-Low-Z, filters, and are popular because they are easier to design and take up less space than a similar low-pass filter using stubs. Because of approximations involved, however, their electrical performance is not as good, so the use of such filters is usually limited to applications where a sharp cut-off is not required. Part of this length is due to the implementation of inductors using long thin lines. To overcome this limitation we decided to implement the inductors using DGS elements.

IV. DESIGN AND SIMULATION

There are many shapes of DGS has been discussed. The triangular DGS elements have been shown to have the sharpest responses among several DGS shapes. In order to design an array, we start with conventional single triangular DGS structure and then proceeds towards array of the same. The proposed design is shown in Fig.4 and corresponding simulated result is shown in Fig.5

V. FORMULA'S

Sharpness factor = fcl/f_0............. (3)

Band width BW = fcu-fcl.............(4)

Where fcl, and fcu is the -3dB lower and upper cut off frequency respectively. fo is resonant frequency.

VI. DESIGN PARAMETER OF SINGLE TRIANGULAR DGS AND ITS FREQUENCY RESPONSE

Width of strip = 2.4 mm, length of strip = 13.0 mm
Height and base of triangular shaped DGS = 3.615
Substrate thickness = 1.6 and ϵr =4.4.
Calculated values of various parameters using frequency response curve are as follows. fcl= 7.2GHz , fcu=14.8GHz, f_0=9.8 GHz, Stop band =7.58 GHz, Sharpness factor = 0.77

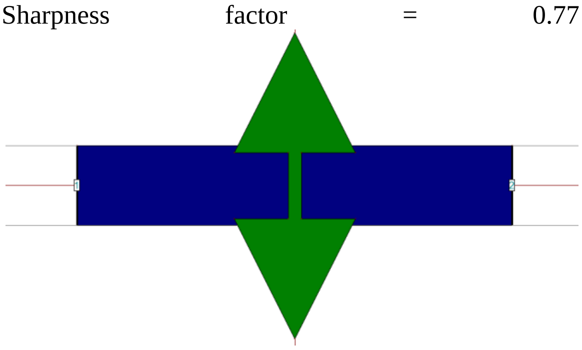

Fig 2(a). Single triangular DGS

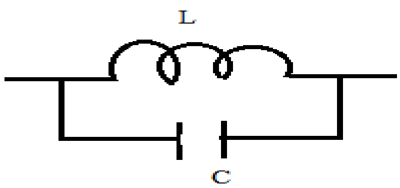

Fig 2(b). L-C Equivalent circuit for Single triangular DGS

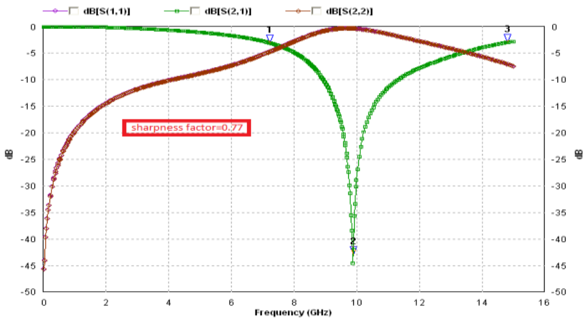

Fig 3. Frequency response of traditional LPF having triangular DGS

VII. LOW PASS FILTER USING THREE TRIANGULAR (PROPOSED LPF)

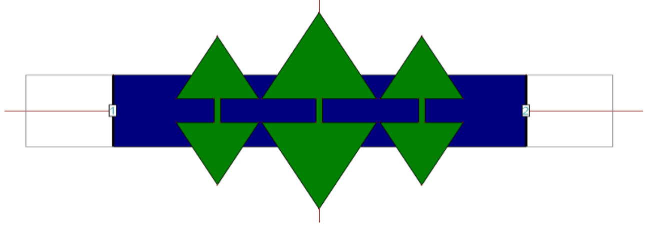

Fig 4. Proposed array of three triangular DGS

This DGS array consists of three triangular DGS. By using so many iterations [15], the resonant frequency shifted to 9.1GHZ and also reduces the size of the DGS [16]. Thus by using etching geometry and size reduction techniques [17], we get the final design of DGS array. The design is shown in Fig.4 and corresponding simulated result is shown in Fig.5.

Design parameter of proposed LPF and its frequency response

Width of strip =3.0mm, length of strip = 13 mm
Height and base of centre triangle DGS = 4.15mm
Height and base of Left and right triangle DGS =3.1mm
Substrate thickness =1.6 and ϵr =4.4
Calculated values of various parameters using frequency response curve are as follows fcl=9.1667GHz, fcu=20GHz, f_0=10.0667GHz, Stop Band (corresponding to -20 dB) = 7.5GHz, Sharpness factor = 0.911,

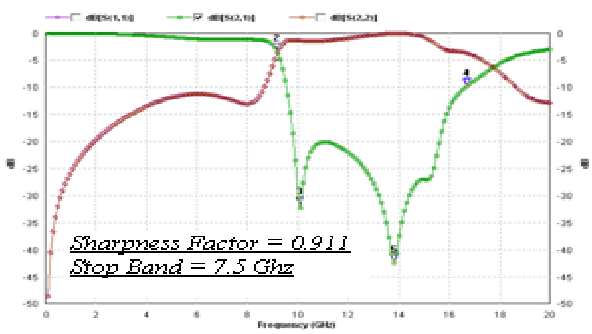

Fig 5. Frequency response of proposed LPF having array of three triangular DGS

VIII. INVESTIGATION OF FREQUENCY RESPONSE AND PERFORMANCE BY USING VSWR CURVE

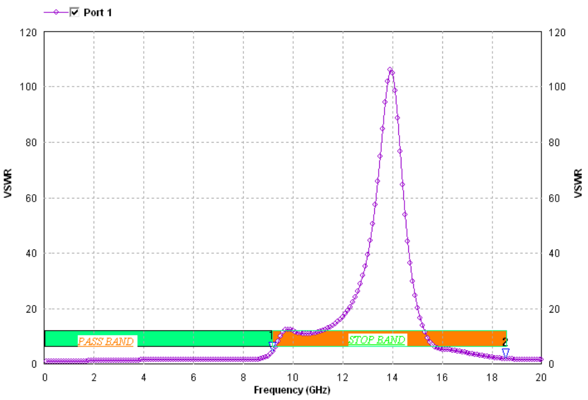

Fig 6. VSWR parameter of proposed LPF

Thus from the observation of frequency response it is clear that for the same resonant frequency 10.1GHz, the array of DGS has more sharpness factor, wide stop bandwidth and less area of the etched DGS than the conventional single triangular DGS - LPF. For illustration the level of suppression in band-stop region, the VSWR parameter is shown in Fig.6 as can be seen, the VSWR value is very low till pass band region and sharply increased at resonant frequency and then gradually decreases after that. This shows that even high power harmonics can be completely rejected after the resonant frequency.

IX. CONCLUSION

In this paper, triangular shape micro strip low pass filter is designed. The proposed array of DGS LPF design is much better than the same conventional type of DGS LPF because it has better frequency response and much better sharpness factor. Also, unlike conventional low pass filter it does not have any undesired harmonics due to presence of high low impedance micro strip line. It is expected that the broadened width of micro strip line would provide an improved high power-handling capability. This filter provides us to achieve better sharpness factor with the conventional filter. This filter has wider stop band of 7.5 Ghz. We can improve the frequency response for this low pass filter by varying the design shapes and dimensions of DGS.

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