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Design and Analysis of Performance in Microstrip Parallel Coupled Bandpass Filter using DGS

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***Abstract*—This paper presents an analysis and comparison between parallel coupled MicrostripBandpass filter with DGS(Defected Ground Structure) and without DGS. In Electronics,RF and Telecommunication systems filters are the major components. They are used to detect the desired frequency and reject the undesired frequency. Bandpass filters are used in wireless communication systems and also an essential component in RF communication systems. Bandpass filter passes the frequency in the passband and provides attenuation for the frequency outside the passband. Thus Bandpassfilter acts as a frequency selective circuit. Parallel coupled Bandpass filters are used because of less occupied area and large bandwidth.The transmitted and received signals are to be filtered at center frequency. In this proposed prototype we used WIMAX frequency of 3.5GHz as center frequency. The substrate material used here is FR4 material. The bandwidth can be tuned at different frequencies using DGS, which is introduced for compact size and to increase the return loss and reduce the insertion loss. In this paper different shapes of DGS is used and the performance is compared and analyzed. In this paper Advance Design Simulation tool is used for the design and simulation of Microstrip Parallel coupled Bandpass filter.**

Keywords—*WiMax,DGS, Resonator, Insertion loss, Return loss*

I.INTRODUCTION

The recent remarkable growth in the Telecommunication industry is due to the advancement in the filter technology. In Microwave communication system Bandpass filter is the component which is used in both transmitter and receiver. The filter is used in such a way that it has minimum transmission loss. There are many varietiesof filters available. The main advantage of Microstripfilter is its compact size. By comparing end coupledBandpass filter with parallel coupled Bandpass filter, parallel coupled Bandpass filter is advantageous than end coupled Bandpassfilter.Thedemand of Bandpass filter in growing applications, accuracy and standards introduced in modern communication system. The narrow bandwidth and low loss has led to an innovative design of Bandpass filter. Parallel coupled resonator dimensions are calculated theoretically. The filter is integrated with Defected ground structure so that the current distributions over the ground plane are altered and also the resonance properties of the filter are changed.

In this parallel coupled Bandpass filter, the resonators are arranged parallel to each other along half of their wavelength. This parallel arrangement gives relatively large coupling for a given spacing between the resonators.

Microwave filters heavily attenuate the unwanted frequency signal and permit the wanted frequency. In general the performance of the filter is described in terms of insertion loss, return loss, frequency selectivity and so on. Filters are designed to have small insertion loss and high return loss. Return loss implies how much the input signal is reflected. Return loss is defined as the ratio between reflected power and the incident power. Insertion loss implies how much the power is lost in the signal passing through the component. It is defined as the ratio between output power and the input power.

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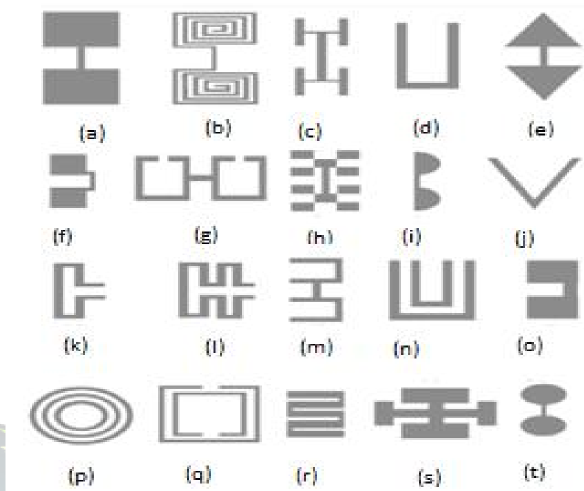
Different kinds of approximations like Butterworth filter and Chebyshev filter are widely used. In this paper Butterworth filter with 3.5GHz WIMAX frequency is used as a center frequency. WIMAX (Worldwide Interoperability for Microwave Access) is an emerging technology. It is a family of wireless communication standards based on the IEEE 802.16 set of standards. WIMAX antenna is expected to have a range of 40 miles with the speed of 70 Mbps or more. As WIMAX can bring the underlying Internet connection needed to service local Wi-Fi networks. Different bands are available for WIMAX applications. The frequencies commonly used are 3.5 and 5.8 GHz for 802.16d and 2.3, 2.5 and 3.5GHz for 802.16e. [4] discussed about Improved Particle Swarm Optimization. The fuzzy filter based on particle swarm optimization is used to remove the high density image impulse noise, which occur during the transmission, data acquisition and processing. The proposed system has a fuzzy filter which has the parallel fuzzy inference mechanism, fuzzy mean process, and a fuzzy composition process.

II.DEFECTED GROUND STRUCTURE:

DGS is one of the techniques for obtaining high performance microwave filter. DGS acts as parallel LC resonator which resonates at certain frequencies depending on their dimensions and shapes. DGS cells are etched in ground plane of microstrip under coupled lines. Here DGS cells are put under the three coupled lines. The placement of DGS along the transmission line introduces changes in the propagation of the wave along the line. The DGSelements do not affect the odd mode transmission, but slows down the even mode, which must propagate around the edges of the DGS slot. The filtering characteristics of DGS can be applied to antennas, reducing mutual coupling between antenna array elements, or reducing unwanted responses. Different shapes of DGS are shown in Fig.1. In this paper three DGS structures are used and its performance are analyzed and compared.



(a)dumbbell-shape (b)spiral-shape (c)H-shape (d)U-shape
(e)arrow-head-dumbbell (f)square heads connected with U slots
(g)open loop dumbbell (h)fractal (i)half-circle (j) V-shape
(k)meander lines (l)U-head dumbbell (m)double equilateral U
(n)square slots connected with narrow slot at edge
(p)concentric ring shape(q)split ring resonator
(r)interdigital (s)cross shape(t)circular head dumbbell

Fig.1 Different shapes of DGS

III.PARALLEL COUPLED MICROSTRIP BANDPASSFILTER

Microstrip is a type of electrical transmission line which can be fabricated using printed circuit board technology, and is used to convey microwave frequency signals. It consists of a conducting strip separated from a ground plane by a dielectric layer known as substrate. It has certain advantages like good reliability, wider bandwidth, good reproducibility, small size and easy fabrication.The parallel coupling methods have certain merits over end coupling, such that length and loss are greatly reduced. In the design parallel coupled Microstrip filter the strips are arranged parallelly, which are close to each other so that they are coupled due to certain coupling factors. The parallel arrangement gives relatively large coupling between the resonators and thus the filter structure is particularly convenient for constructing filters with large bandwidth. Fig.2 illustrates a general structure of Microstrip Parallel coupled Bandpass filter which uses half wavelength line resonators.

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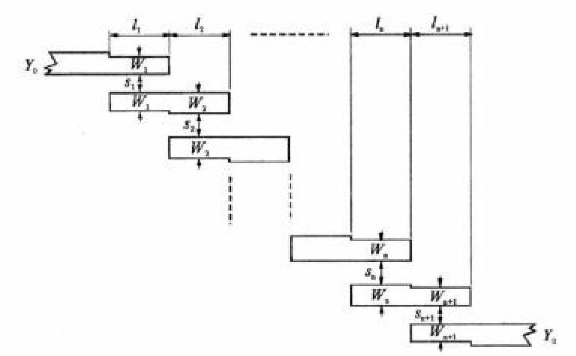

Fig.2 Microstrip parallel coupled bandpass filter

IV.DESIGN OF BANDPASS FILTER

The physical parameters proposed for the Bandpass filter of order 3 is that it has a center frequency of 3.5GHz, Characteristic Impedance of 70Ohm. It uses Butterworth filter approximation. The resonator length is given as 20.4mm and feedwidth of 1.4mm. The design calculations are given below.

Step 1: Calculation of Resonator length (RL1)

$$\lambda = \frac{c}{f} \dots\dots\dots\dots\dots(1)$$

Resonator length,

$$RL1 = \frac{\lambda}{2 * \sqrt{4.4}} \dots\dots(2)$$

Similarly we need to calculate for RL2 and RL3,

Step 2: Calculation of feed length (FL):-

$$FL = \frac{\lambda}{4 * \sqrt{4.4}} \dots\dots\dots(3)$$

Step 3: Calculation of Feed width (w_f)-

The equation of Characteristic Impedance:

$$z_0 = \begin{cases} \frac{60}{\sqrt{\varepsilon_e}} ln\left(\frac{8h}{w} + \frac{w}{4h}\right) for\ {}^{w}/_{h} \le 1 \\ \frac{120\pi}{\sqrt{\varepsilon_e}\left[{}^{w}/_{h} + 1.393 + 0.667ln\left({}^{w}/_{h} + 1.444\right)\right]} for\ {}^{w}/_{h} \ge 1 \end{cases} \dots\dots(4)$$

z_0=Impedance

h = height of substrate

W= width of strip

Generally Feed width =0.7 mm for 70 Ohm

Step 4: Calculate the substrate length (Ls)

$$Ls = \frac{\lambda}{4} \dots\dots\dots\dots(5)$$

The Fig.3 shows the layout of the Parallel coupled microstripbandpass filter having the length RL1,RL2 and RL3 as calculated by using the equations. Let Rg be the gap measured as per 3rd order Butterworth filter.

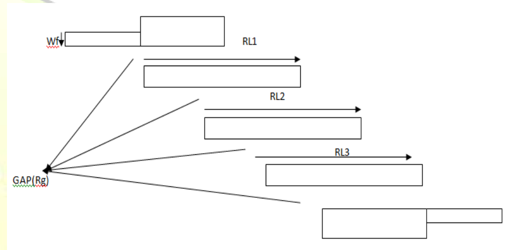

Fig.3Layout of the filter without DGS

The Fig.4 shows the layout of the parallelcoupledmicrostripbandpass filter by using rectangular headed DGS structure between the resonators.
The dimensions of the dumbbell are shown below:
W=2.2mm,h=2.7mm and w=1.1mm and h=3.7mm.

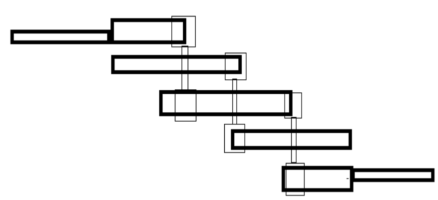

Fig .4 Layout of the filter with rectangular headed DGS

The Fig.5 shows the layout of the ParallelcoupledMicrostripBandpass filter by using hexagon shaped DGS structure between the resonators.

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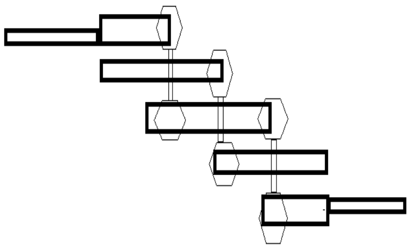

Fig.5 Layout of the filter with hexagon shaped DGS

The Fig.6 shows the layout of the ParallelcoupledMicrostripBandpass filter by using triangle shaped DGS structure between the resonators.

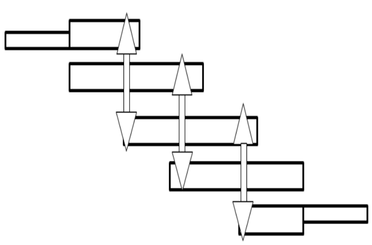

Fig.6 Layout of the filter with triangle shaped DGS

V. SIMULATION RESULTS AND DISCUSSIONS.

The MicrostripBandpass filter with and without DGS are simulated and its performance are analyzed at frequency 3.5GHz. From the output of Fig.7 the simulated result shows high Insertion loss.WhenDGS (rectangular headed) is introduced to the layout the Insertion loss is found to be reduced to -3dB and there is an increase in return loss of -34dB, the simulated response is shown in Fig.8. It is seen that when the number of DGS is increased the Insertion loss is reduced gradually. The Fig.9 shows the simulated result for the hexagon shaped DGS and it also shows that Insertion loss is reduced and Return loss is increased when the number of DGS is increased.The Fig.10 shows the simulated response of the filter with triangle shaped DGS with minimum insertion loss of -1.5dB and return loss of -18dB.

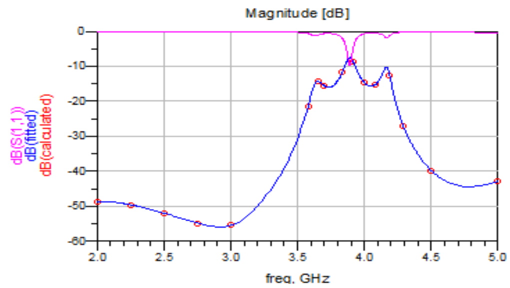

Fig.7 Microstripbandpassfilterwithout DGS

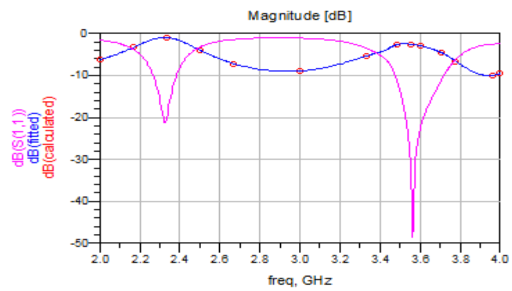

Fig.8Microstripbandpassfilter with rectangular headed DGS

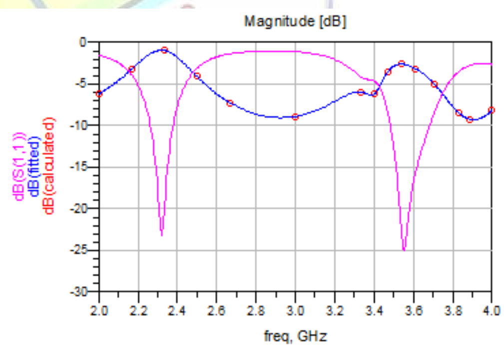

Fig.9Microstripbandpassfilter with hexagon shaped DGS

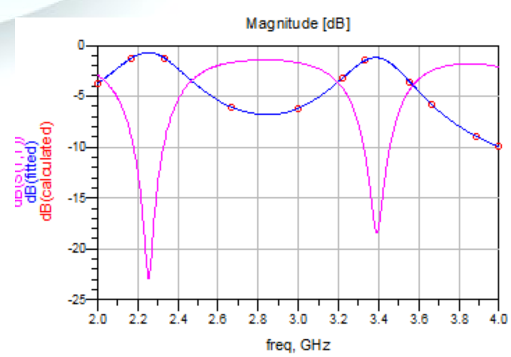

Fig.10Microstripbandpassfilter with triangle shaped DGS

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TABULATION

The below tabular column (TABLE1.1) shows the parallel coupled microstripbandpass filter with using DGS and without using DGS. The insertion loss and return loss are related and tabulated as given below.

TABLE 1.1

PARALLEL COUPLED MICROSTRIP BANDPASS FILTER	INSERTION LOSS (dB)	RETURN LOSS (dB)
FILTER WITHOUT DGS	-8	-10
FILTER WITH DGS(1rectangular headed-DGS)	-3	-34
FILTER WITH DGS(2rectangular headed -DGS)	-2.5	-37
FILTER WITH DGS(3rectangular headed -DGS)	-2	-48
FILTER WITH DGS(3hexagon shaped-DGS)	-2.5	-25
FILTER WITH DGS(3triangle shaped -DGS)	-1.5	-18

VI.CONCLUSION

This paper clearly reveals the design of Microstrip parallel coupled Bandpass filter. The theoretical calculation done is in close agreement with the simulationresults.The design and simulation is done using ADS (Advanced Design System)tool.It is also possible to generate the layout using ADS tool and fabricate the same.

At first comparison is done for the parallel coupled MicrostripBandpass filter without DGS and withDGS.The response of the filter without DGS has high insertion loss,but in the response of the filter with DGS it is seen that the insertion loss is greatly reduced.The designed filter is efficient and has high performance.Furthermore it is easy to fabricate,also this design is simple and flexible in nature.The proposed system is effective,reliable and compact filter design is obtained.The designed parallel coupled MicrostripBandpass filter operates at a center frequency of 3.5GHz,which falls under WIMAX-Band application.

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