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Design of Wideband Band Stop Filter using Signal Interference Technique

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***Abstract*—A wideband band stop filter based on signal interference technique has been designed. The proposed filter is designed using coupled line and stepped impedance modified pi type transmission line with open circuited stubs in transmission path 1 and path 2 respectively. The proposed filter has been designed at a frequency of 0.9 GHz. The simulated 3dB fractional bandwidth is 0.8GHz and the insertion loss is well below -18dB or -20dB from 0.2 GHz to 2.14 GHz. Using path 2 ABCD parameters of the filter are found and these equations were solved to obtain the position of zeros.**

***Index Terms*— Signal Interference Technique, Coupled Line, Open Circuited Stub, Fractional Bandwidth, Insertion loss and ABCD parameters.**

I. INTRODUCTION

The performance of the wireless system degrades if there is interference from the existing communication systems. In modern high data rate wireless communication applications for effective suppression of spurious signals there is greater demand for compact wideband band stop filters. With the advent in Microwave Integrated Circuits there is demand for such filters. A wideband band stop filter with larger fractional bandwidth and lower insertion loss are essential in GSM, Zigbee, WLAN applications. Several methods [1-6] were reported in designing wideband band stop filters. Rectangular micro strip open loop resonator with stub loaded resonator as building blocks offering tuneable low space occupying wide band stop filter (BSF) for wireless applications was reported [2]. A wideband BPF with an open coupled line in way 1 and transmission line in way 2 offering reduced and sharp selectivity with six transmission zeros dependent on signal interference technique was reported [3]. High selective fifth-order wideband band-pass filters (BPFs) with different transmission zeros based on signal-interaction concepts are proposed in this paper. Transmission ways comprising of a shorted stub and a couple of open coupled lines are utilized to acknowledge signal transmission originating from Port1 to Port2 [4]. The impacts of electromagnetic coupling in parallel-conductor inhomogeneous transmission lines were considered and it was demonstrated that the qualities of different coupled-line circuits implanted in an inhomogeneous dielectric, (for example, the suspended substrate) differ extraordinarily from those in a homogeneous domain [5]. This article presents a triple wideband band pass channel (TWB-BPF) with compact

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size, distinguishable band to band segregation and numerous transmission zeros (TZs). The proposed TWB-BPF depends on a Multi-mode resonator (MMR), driven by the strategy for even and odd mode examination method [6]. A Branch line resonator be composed of shunt stubs and open stubs with multiple independent transmission zeros such that the open stubs length is designed to equal quarter wavelength near the unwanted frequency. A remnant stub is deployed here for establishing coupling between adjacent resonators. At different frequencies zeros can be planned to reduce the objectionable coupling between the stubs [7]. So far in the literature there are multiple topologies that were proposed for wideband band stop filters and yet there is requirement for compact, high selectivity and reduced insertion loss wideband band stop filters for wireless applications.

In this article we are proposing a topology where an open coupled line and stepped impedance modified pi type transmission line with open circuited stubs in transmission path 1 and path 2 respectively. Signal interference technique is used to obtain wideband band stop filter with sharp rejection characteristics.

The takeaways of the proposed work are as follows:

a) A band stop channel with two zeroes and six poles are obtained at an operational frequency of 0.9GHz.
b) 0.8GHz was the 3dB fractional bandwidth of the filter.
c) The insertion loss is well below -18dB or -20dB from 0.2GHz to 2.14GHz.

The design theory with its analysis of proposed wideband band stop filter is presented initially, followed by design procedure and simulation results.

II. Proposed Wideband Band Stop Filter and its Analysis

The Fig.1 below describes the proposed filter design. The filter comprises an open coupled line and stepped impedance modified pi type transmission line with open circuited stubs in transmission path 1 and path 2 respectively. Here Z_E and Zo are even and odd impedances of the coupled line, Z_1 and Z_2 are impedances of first and second transmission lines respectively and Z_s is the impedence of the open circuited stubs. θ_c, θ_1, θ_2 and θ_s are the transmission lines electrical lengths respectively. The two zeroes in the rejection band obtained in the simulated result using Ansoft software are found theoretically, derived and proved to exist.

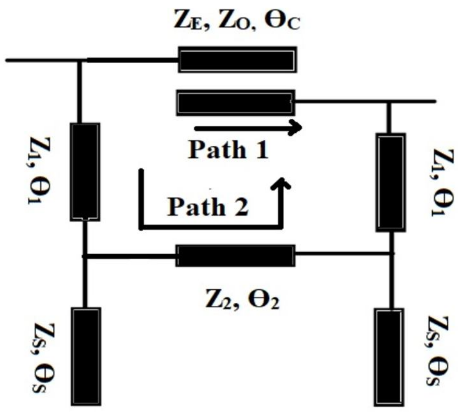

Fig. 1. Proposed Filter Topology

A. Design Equations

In the proposed filter design ABCD Parameters of the transmission lines along path2 are given as:

$$m1 = \begin{pmatrix} \cos\theta 1 & jz\,sin\,\theta 1 \\ \frac{j}{Z}\,sin\,\theta 1 & \cos\theta 1 \end{pmatrix} \rightarrow (1)$$

$$m2 = \begin{pmatrix} 1 & 0 \\ \frac{j}{Zs}\,tan\,\theta 2 & 1 \end{pmatrix} \rightarrow (2)$$

$$m2 = \begin{pmatrix} \cos\theta 2 & jz\,sin\,\theta 2 \\ \frac{j}{Z}\,sin\,\theta 2 & \cos\theta 2 \end{pmatrix} \rightarrow (3)$$

$$m1 = \begin{pmatrix} \cos\theta 1 & jz \sin\theta 1 \\ \frac{j}{Z}\sin\theta 1 & \cos\theta 1 \end{pmatrix} \rightarrow (4)$$

$$m2 = \begin{pmatrix} 1 & 0 \\ \frac{j}{Zs}\tan\theta 2 & 1 \end{pmatrix} \rightarrow (5)$$

B== $-jsin^3\theta\left[\frac{2Z1Z2}{Zs}+\frac{2Z1^2}{Zs}+\frac{Z1^2}{Z2}\right]+jcos^2\theta sin\theta(2Z1+Z2)+j\frac{Z1^2Z2}{Zs^2}sin\theta\ tan^2\theta \rightarrow (6)$

Let the variables be x1, x2, x3 where

$$x1 = -jsin^3\theta\left[\frac{2Z1Z2}{Zs}+\frac{2Z1^2}{Zs}+\frac{Z1^2}{Z2}\right] \rightarrow (7)$$

$$x2 = jcos^2\theta sin\theta(2Z1+Z2) \rightarrow (8)$$

$$x3 = j\frac{Z1^2Z2}{Zs^2}sin\theta\ tan^2\theta \rightarrow (9)$$

$$y_{21} = \frac{-1}{B} \rightarrow (10)$$

Equating (10) to Zero

$$\frac{2(Ze-Zo)\ cosec\ \theta}{(Ze-Zo)^2-4ZeZo\ cosec^2\theta}+\frac{1}{(x1sin\theta cos^2\theta - x2sin^3\theta + x3sin^3\theta tan^2\theta)} = 0 \rightarrow (11)$$

$$2x1(Ze-Zo)cos^4\theta\ sin^2\theta - 2x2(Ze-Zo)sin^4\theta cos^2\theta + 2x(Ze-Zo)sin^4\theta + (Ze-Zo)^2sin^2\theta cos^2\theta - 4ZeZo\ cos^2\theta = 0 \rightarrow (12)$$

Let us consider R1, R2, R3, R4, R5 where

$$R1 = 2x1\ (ze-z0)\ cos^4\theta\ sin^2\theta \rightarrow (13)$$

$$\text{R2}=x2\ (ze-z0)\ sin^4\theta\ cos^2\theta \rightarrow (14)$$

$$\text{R3}= 2x3(ze-z0)\ sin^4\theta \rightarrow (15)$$

$$\text{R4}= (ze-z0)^2\ sin^2\theta\ cos^2\theta \rightarrow (16)$$

$$\text{R5}= 4\ Ze\ Zo\ cos^2\theta \rightarrow (17)$$

Replacing R Values in Equation (12)

$$R1\ cos^4\theta\ (1-\ cos^2\theta)\ - R2\ (1-\ cos^2\theta)^2 cos^2\theta + R3\ (1-\ cos^2\theta)^2(1-cos\ \theta)\ +\ R4\ cos^2\theta(1 - cos^2\theta) - R5\ cos^2\theta\ =\ 0 \rightarrow (18)$$

$$cos^6\theta\ (-R1-R2-R3)\ + cos^4\theta\ (\ R1+2R2+\ 3R3R4) + cos^2\theta\ (-R2-3R3\ +\ R4-R5)\ +\ R3 = 0 \rightarrow (19)$$

MATLAB Coding was done to obtain roots, out of which only one is a real root (θ_1) using which position of two zeros were found.

The frequencies at which zeros exists are obtained by Equation (20) where i = 2, f_0 = 0.9 GHz and θ_2 = 180 − θ_1

$$\text{f}_\text{i} = \frac{\theta_i}{90} \times f_0 \rightarrow (20)$$

Two zeros are therefore proved to be residing at 0.67 GHz and 1.12 GHz respectively in coincidence with the simulation results.

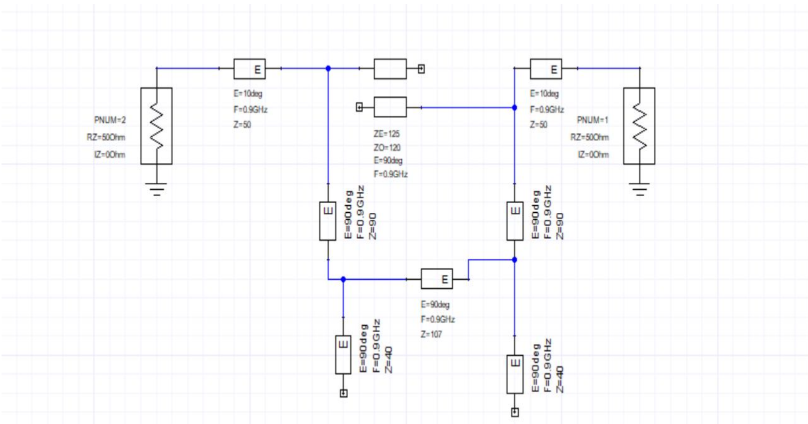

Fig. 2. Snapshot of Ansoft Circuit Schematic for the proposed topology where Z_E=125 Ω, Z_o=120 Ω, Z_1=90 Ω, Z_2=107 Ω, Z_s=40 Ω

III. Filter Design and Results

The circuit simulation of the proposed model was performed using Ansoft designer SV and was reported in Fig.3. After the circuit simulation a 3D model has been constructed in HFSS to perform full wave simulations. The proposed filter's 3D model is exhibited in Fig. 4. Optimization has been performed to get the perfect results. Data tables of both the results have been collected to plot in the same graph using MATLAB so that both the results can be compared and was reported in Fig.5. In comparison it was found that both circuit simulation graph and full wave simulation graph are in good agreement.

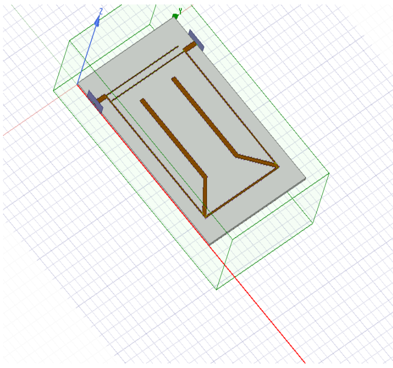

Fig. 3. Simulated Results of S-Parameters

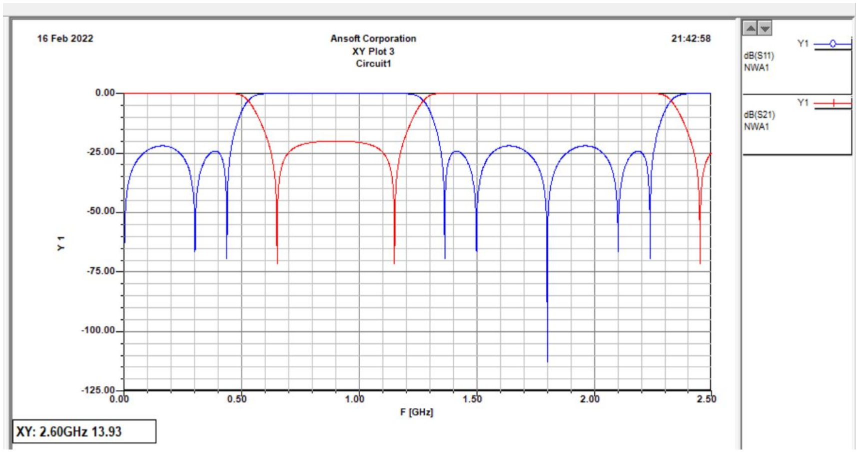

Fig. 4. 3D Model of Proposed Wideband band stop filter

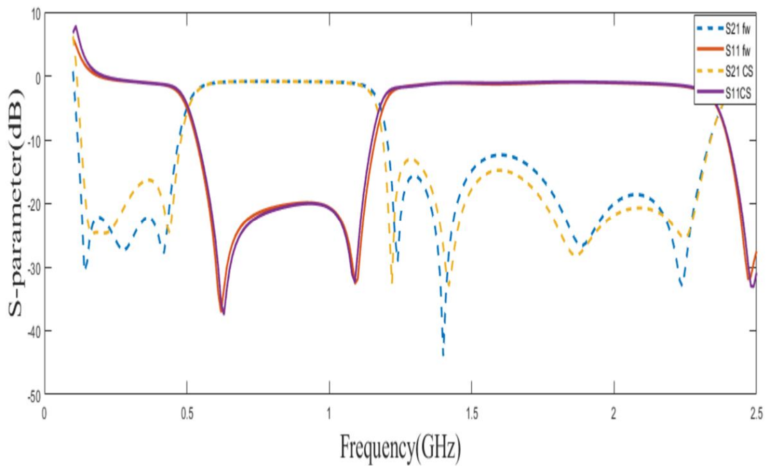

Fig. 5. Comparison of Full Wave and Circuit Simulation Results

IV. CONCLUSIONS

A compact filter response is recorded with a wideband band stop channel configuration utilizing micro strip transmission lines with open circuit stubs dependent on signal interference scheme. The claimed model utilizes in path 1 an open coupled line and in path 2 a transmission line. Due to the superposition of two transmission ways a band stop channel with two zeroes and six poles were obtained at an operational frequency of 0.9GHz. The location of obtained two transmission zeros with in the rejection band at 0.67GHz and 1.12 GHz respectively were analysed and proved using design equations. Theoretical analysis and simulated analysis were approved and was seen that they were in great understanding.

The proposed channel configuration has to be manufactured on a Teslin sheet utilizing an adhesive copper sheet. The future work involves generating a Dxf file using the 3D model in HFSS. Using this fabrication has to be been done on a Teslin sheet by pasting adhesive copper sheet on the design. Two connectors are to be connected on both the sides making a connection between ground plane and the design .These connectors should be used for measuring and obtaining results. Measurements has to be done using a device called VNA(Vector Network Analyser) where two ports of the device are to be connected to the two connectors. Before measuring the results Calibration of VNA should be performed. Various bending effects on the fabricated prototype can then be carried out on the fabricated model.

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