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MINIATURIZED ULTRA WIDE BAND FILTER WITH EXTENDED STOP BAND

D. Packiaraj, K. J. Vinoy, M. Ramesh, and A. T. Kalghatgi
Central Research Laboratory, Bharat Electronics Limited, Bangalore, India; Corresponding author: dpackiaraj@bel.co.in

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ABSTRACT: *This article reports the design of extended stop band miniaturized ultra wide band (UWB) filter based on short-circuited meandered coupled lines. In addition, rectangular-shaped slots are incorporated in the ground plane beneath the input and output feed lines to improve the stop-band rejection. The proposed filter has been realized in microstrip medium having thickness of 0.78 mm and dielectric constant of 2.17. Experimental results of the developed filter validate the results obtained from circuit models and full-wave simulations. Maximum insertion loss of the experimental filter is 1.1 dB. Group delay variation over the pass band of the filter is within ±0.04 ns. Stop band is extended upto 30 GHz with a stop-band rejection of better than 20 dB. Dimensions of the miniaturized experimented filter are 22 × 22 × 0.78 mm^3.* © 2012 Wiley Periodicals, Inc. Microwave Opt Technol Lett 55:703–705, 2013; View this article online at wileyonlinelibrary.com. DOI 10.1002/mop.27462

Key words: *defected ground structure; filter; meandered coupled line; ultra wide band*

1. INTRODUCTION

Modern wireless communication systems such as ultra wide band (UWB) transceivers require miniaturized low loss, wide pass-band filters with extended stop-band characteristics. Several types of designs have been reported in the literature [1–5] to realize wide band filter. In Ref. 1, microstrip to coplanar waveguide transition structure is used as band pass structure. Band pass filter suitable for UWB communication is realized by embedding individually designed low-pass and high-pass filters in Ref. 2. In Ref. 3, a compact UWB filter is proposed using stub loaded multiple mode resonators. Ring resonator-based configuration is presented in Ref. 4 for the design of UWB filter. Multiple coupled transmission lines with defected ground have been successfully used by the authors to achieve wide band operation [5].

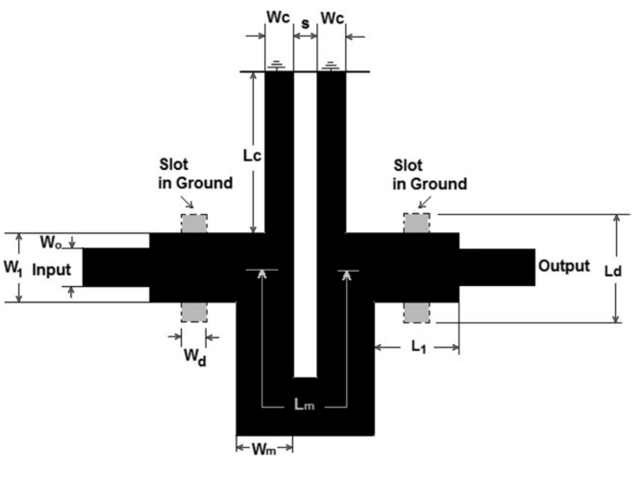

Figure 1 Extended stop band UWB filter

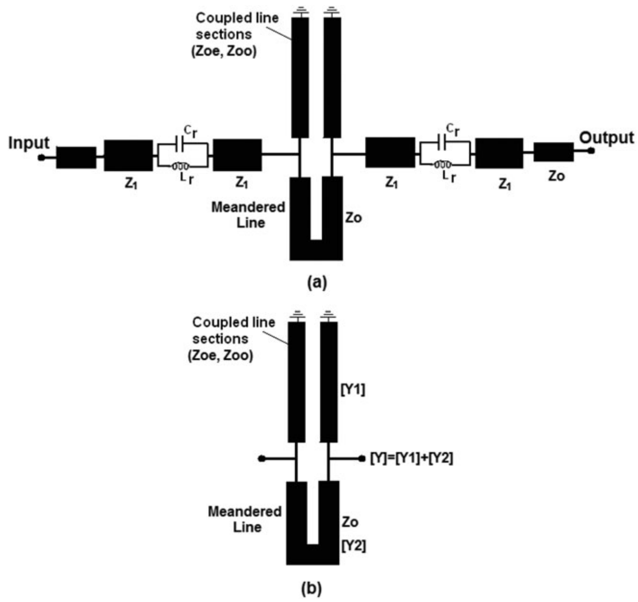

Figure 2 (a) Circuit model of the filter and (b) circuit model of the embedded coupled line section

In this article, a short-circuited meandered coupled line and defected ground structure (DGS) has been proposed to construct a compact UWB filter. Figure 1 shows the proposed structure of compact filter. Cross coupling between the input and output through short-circuited coupled lines improves the selectivity. Rectangular slots are incorporated in the ground plane beneath the input and output feed lines for widening the stop-band region of the filter. The article is organized as follows. Analysis of the filter based on circuit model is presented in Section 2. Results from the circuit model are compared against the results from Mentor graphics IE3D planar simulator [6]. In Section 3, experimental results of UWB filter are compared against the simulation results. Section 4 concludes this article.

2. DESIGN

The filter is designed over 3.1–10.6 GHz suitable for UWB systems and high data rate transceiver systems. This filter is implemented in a microstrip medium having a substrate thickness "h" of 0.78 mm and permittivity "ε_r" of 2.17. The filter has input and output feed lines (with defected ground) connected to a short-circuited quarter wave coupled lines. A meandered transmission line is also connected across input and output. Combination of all these ensures spurious-free filter response up to the 30 GHz.

2.1. Circuit Analysis

As shown in Figure 2(a), for the sake of analysis the entire filter is split into three sections: (i) DGS, (ii) short-circuited coupled lines, and (iii) meandered coupled lines. The coupled line section is characterized in terms of even and odd mode parameters. Analysis of the coupled line sections are shown in Figure 2(b).

Short-circuited coupled line sections can be characterized using impedance "Y" parameters given by [7]

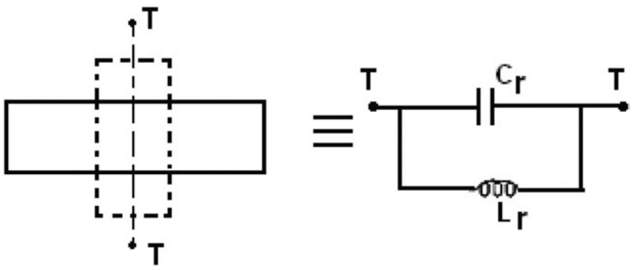

Figure 3 DGS and its equivalent

TABLE 1 Dimensions of DGS Section

Line width "W_1"	4.5 mm
Dimensions of DGS slot	$L_d = 5.7$ mm and $W_d = 1$ mm
Length "L_1"	4.8 mm

TABLE 2 Equivalent Lumped Elements

Inductance "L_r"	0.85 nH
Capacitance "C_r"	0.0458 pF

$$Y_{11} = Y_{22} = -j(Y_{oe}\cot(\theta_e) + Y_{oo}\cot(\theta_o)) \tag{1a}$$

$$Y_{12} = j(Y_{oo}\cot(\theta_o) - Y_{oe}\cot(\theta_e)) \tag{1b}$$

$$Y_{21} = -j(Y_{oo}\cot(\theta_o) - Y_{oe}\cot(\theta_e)) \tag{1c}$$

where Y_{oe} and Y_{oo} are even and odd mode admittances, respectively. θ_e and θ_o are even and odd mode phase velocities, respectively. The ground plane beneath the microstrip line is defected with rectangular shaped slots as shown in Figure 1. The DGS exhibits band notch characteristics. Resonant frequency "ω_o" and lower 3 dB frequency "ω_1" can be obtained from any commercial EM simulator. Equivalent circuit of DGS is shown in Figure 3. Element values of the equivalent circuit approximating the DGS for the frequencies below the lower 3 dB frequency "ω_1" can be obtained using the equations [8].

$$L_r = \frac{1}{\omega_1}\sqrt{\frac{1}{p^2} - 4Z_O^2\left(1 - \frac{\omega_1^2}{\omega_O^2}\right)^2} \tag{2}$$

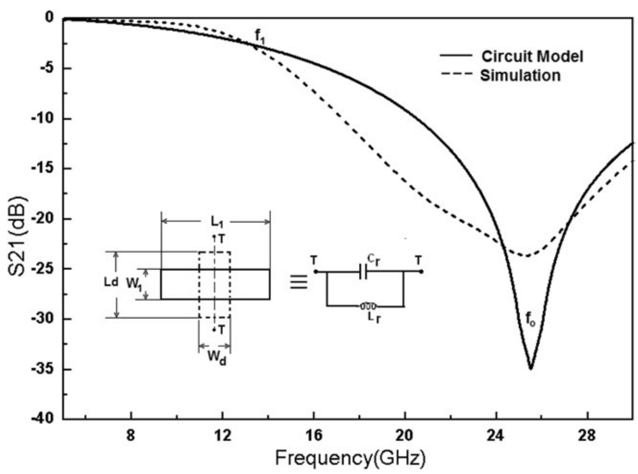

Figure 4 Response of line with DGS

TABLE 3 Geometrical Parameters of Filter

Substrate thickness "h"	0.78 mm
Substrate permittivity "ε_r"	2.17
Length of coupled lines "L_c"	7 mm
Width of coupled line "W_c"	1 mm
Spacing "s"	0.8 mm
Feed line width "W_o"	2.4 mm
Meandered line width "W_m"	2.2 mm

TABLE 4 Electrical Parameters of Filter

Even and odd mode impedances (Z_{oe}, Z_{oo}) of coupled line and meandered line sections	(63,50) Ω
Line impedance (Z_o)	50 Ω
Line impedance (Z_1)	32 Ω
Input and output impedances	50 Ω

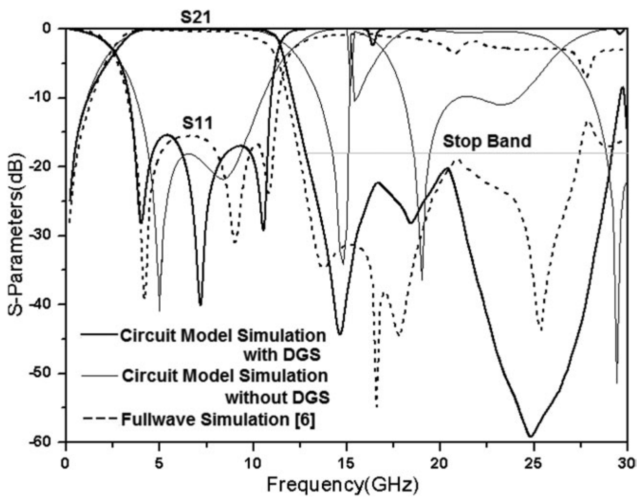

Figure 5 Simulation results of filter

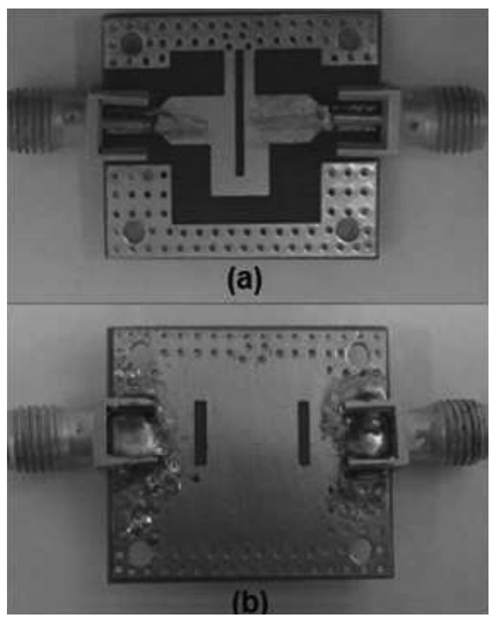

Figure 6 Photograph of the assembled UWB filter

$$C_r = \frac{1}{L_r \omega_O^2} \quad (3)$$

$$p = \frac{1}{\sqrt{2}.2Z_O\left(1 - \frac{\omega_1^2}{\omega_O^2}\right)} \quad (4)$$

where Z_o is the characteristic impedance of the system into which the unit cell's response is evaluated.

DGS section with the dimensions given in Table 1 has been used in the present design. Corresponding equivalent lumped element values of the unit cell are given in Table 2. Simulation results of the unit cell from EM simulation and circuit model are shown in Figure 4.

Geometrical parameters of the filter are given in Table 3. Electrical parameters of the filter are listed in Table 4. Analytical results (using MATLAB) were obtained by cascading individual ABCD matrices of three sections. Reflection and transmission parameters are extracted from the overall transmission matrix. Analytical results are compared against full-wave simulation results in Figure 5 and a close agreement between them can be observed. It can be noticed from Figure 5 that DGS improves the stop-band rejection characteristics of the filter better than 20 dB.

3. EXPERIMENTAL RESULTS

The filter is fabricated using standard printed circuit board fabrication technique. Figure 6 shows the photograph of assembled UWB filter. Experimental results of designed filter are compared against the full-wave simulation results in Figure 7. Comparison shows a good agreement between them confirming the expected UWB and wide stop-band rejection characteristics. Experimental results conformed the extension of stop band upto 30 GHz with a rejection of better than 20 dB. The second harmonic (13.7 GHz) has been suppressed to a level of 25 dB. Measured group delay over the pass band is constant to within ±0.04 ns. Figure 8 shows the measured group delay. Filter is compact and measures dimensions of is 22 × 22 × 0.78 mm^3.

4. CONCLUSION

Using short-circuited meandered coupled lines along with the defected ground, a compact UWB filter with extended stop band was designed and analyzed in this article. An experimental filter while exhibiting 1.1 dB insertion loss and 13.5 dB return loss over the pass band of 3.1–10.6 GHz achieved a stop-band rejection of better than 20 dB upto 30 GHz. Overall dimensions of the compact filter are 22 × 22 × 0.78 mm^3.

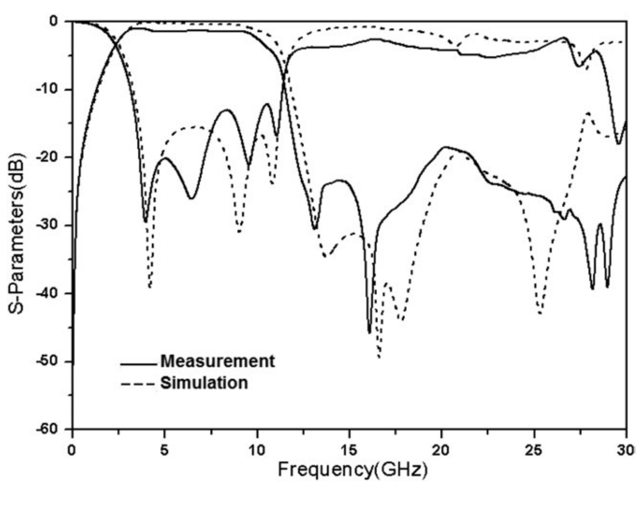

Figure 7 Measured results of UWB filter

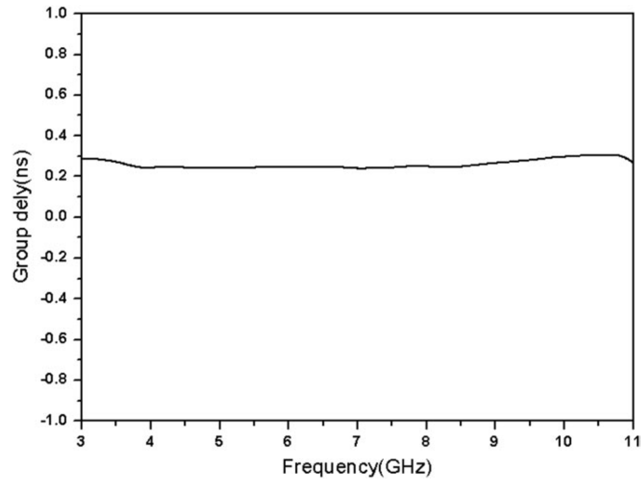

Figure 8 Measured group delay

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MODULATION ACCURACY OF BINARY PHASE-SHIFT KEYING SIGNAL BROADCAST AFTER INJECTION LOCKING OF A RESONANT TUNNELING DIODE MICROWAVE OSCILLATOR

Horacio I. Cantú,[1] Bruno Romeira,[1] Jose M. L. Figueiredo,[1] Anthony E. Kelly,[2] and Charles N. Ironside[2]
[1] Departamento de Física, CEOT, Universidade do Algarve, Campus de Gambelas, 8005-139 Faro, Portugal; Corresponding author: hiquirino@ualg.pt
[2] School of Engineering, University of Glasgow, Rankine Building, G12 8LT, United Kingdom

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ABSTRACT: *Injection of a binary phase-shift keyed signal to a resonant tunneling diode (RTD)-based microwave oscillator is presented in this article. The locked signal is broadcast through a wireless*