Design of Ultra Wide Band Filter Using Gap Coupled Lines and Elliptic Slot in Ground Plane

D. Packiaraj and M. Ramesh
Central Research Laboratory
Bharat Electronics Limited,
Bangalore, India
dpackiaraj@bel.co.in

***Abstract:* —— This paper presents the design of a ultra wide band filter in microstrip medium, suitable for wireless communications. Filter has been constructed using gap coupled lines and elliptic slot in the ground plane. Elliptic slot in bottom ground plane along with coupled lines in the top layer played an important role in enhancing the bandwidth of the filter. Coupled line parameters and elliptic slot dimensions have been optimized to achieve the desired pass band characteristics. An experimental filter working from 3GHz to 9.5GHz has been developed and tested. Measured results of the ultra wide band filter have been compared against the full wave simulation results and results are in good agreement with each other. Size of the realized filter is 36mm x 30mm.**

Key Words***: filter; elliptic; gap; microstrip; UWB***

I INTRODUCTION

Ultra wide band (UWB) technology is gaining lot of attention in modern wireless communication systems because of its low power and high data rate features. Hence wireless communications have been studied and developed widely which lead to a great demand in developing broad band microwave filters. In recent years, extensive research work has been carried out in the design of broadband filters. UWB filters find numerous applications in various areas such as UWB Radios, Electronic Warfare (EW) systems and Radars. Several papers have reported the design of wide-band band pass filters (BPFs) [1-5] to achieve the desired characteristics. Dual mode ring resonator [1], Tightly coupled lines along with open circuit stubs [2], Circular shaped ring resonator with open circuit stub [3] are some of the topologies reported in literature to realize wideband filters. A compact wide band filter has been designed based on impedance steps and coupled line sections in [4]. Resonators based on defected ground structure are used in [5] to design compact broad band dual band pass filters.

In this paper, another type of UWB microstrip band pass filter is designed using elliptic slot (in ground plane) and coupled lines (top layer) to achieve wide band-pass response and miniaturization. Elliptic slot has been used as the basic element to construct the UWB filter. Rigorous optimization was performed to achieve broadband response. Design of filter is explained in Section II. Experimental results of the designed filter are demonstrated in Section III. Section IV concludes this paper.

II. DESIGN OF ULTRA WIDE BAND FILTER

This filter is designed with the following specifications

Frequency Ban	:3.0GHz to 9.5GHz
Insertion Loss	:<1.5dB
Return loss	:>15dB
Substrate thickness 'h'	: 1.6mm
Substrate permittivity 'ε_r'	: 4.4

Elliptic slot (in ground plane) shown in Fig. 1 has been used along with the gap coupled lines to construct UWB filter in microstrip medium. The proposed UWB filter is shown in Fig. 2.

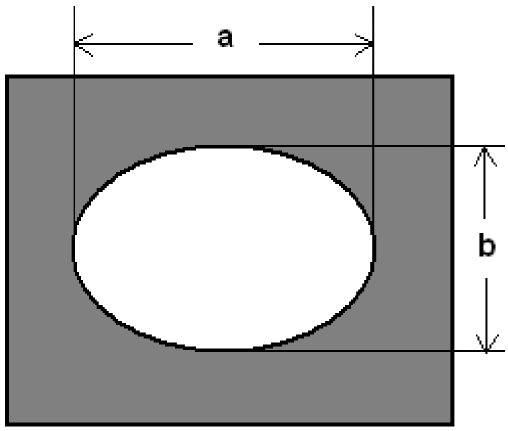

Fig. 1. Elliptic shape slot

This band pass filter is designed to operate from 3GHz to 9.5GHz and is implemented on a microstrip medium having a substrate thickness 'h' of 1.6mm and permittivity 'εr' of 4.4. A 50Ω (width of 'w') transmission lines are printed on the top of the substrate at the input and output. These transmission lines are gap coupled to the 'I' shaped line as shown in Fig. 2. The top and bottom layers of the proposed filter are shown in Fig. 3.

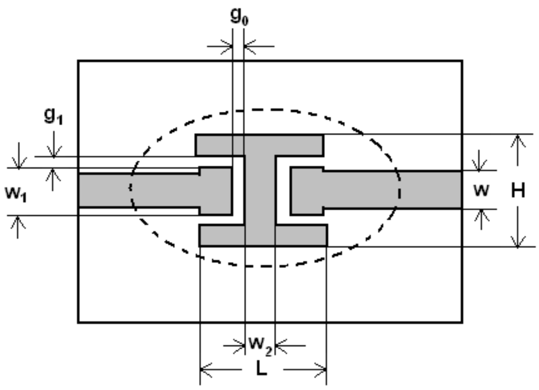

Fig. 2. UWB Filter

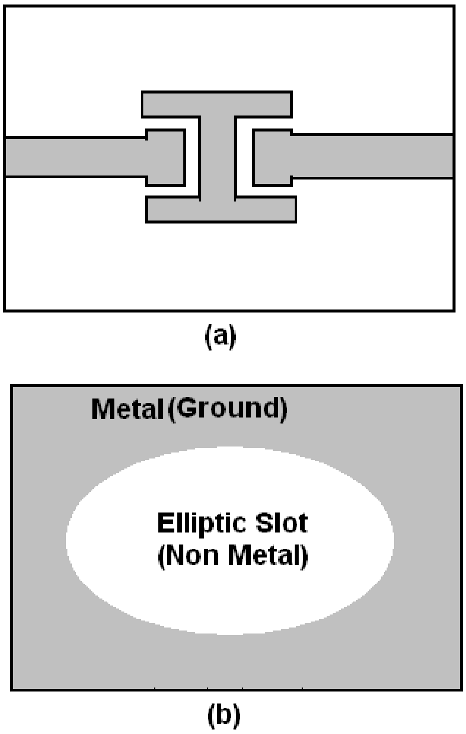

Fig. 3. a) Top Layer, b) Bottom Layer

Elliptical shaped slot shown in Fig.1 is created in the bottom ground plane of the microstrip medium. This slot aids in achieving tight coupling between the lines for achieving wide bandwidth. Parametric optimization has been done in simulator "Microwave CST" [6] to arrive at the optimized dimensions for the slot and coupled lines. The optimized UWB filter dimensions are given in Table I. The simulated characteristics of the UWB filter are shown in Fig. 4. Simulations show that the filter has good response over the desired frequency range 3.0GHz to 9.5GHz. To understand the effect of elliptic shaped slot in the ground plane, simulation study was carried out without elliptic slot. Fig . 5 shows the simulation results of filter without elliptic slot in the ground plane. It is understood that the bandwidth of the filter is from 5.7GHz to 7GHz whereas the proposed UWB filter passes the frequency from 3GHz to 9.5GHz. Hence elliptic shaped slot in the ground plane of the filter played vital role in achieving wide ultra wide bandwidth in the filter's characteristics.

TABLE I. Dimensions of UWB Filter

Dimensions	Values(mm)
a	16
b	10
g0	0.2
g1	0.3
w	3
w1	3.4
w2	3
H	6
L	10

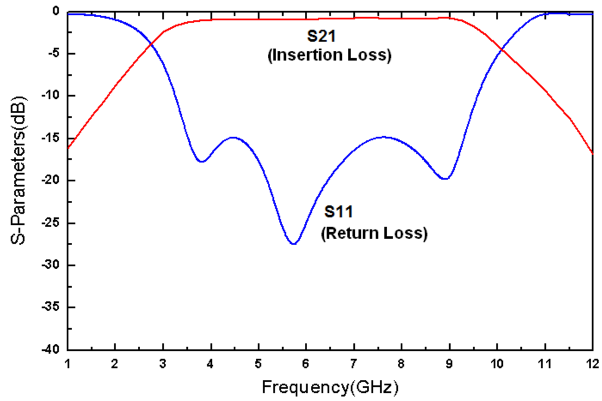

Fig. 4. Simulated results of proposed UWB Filter

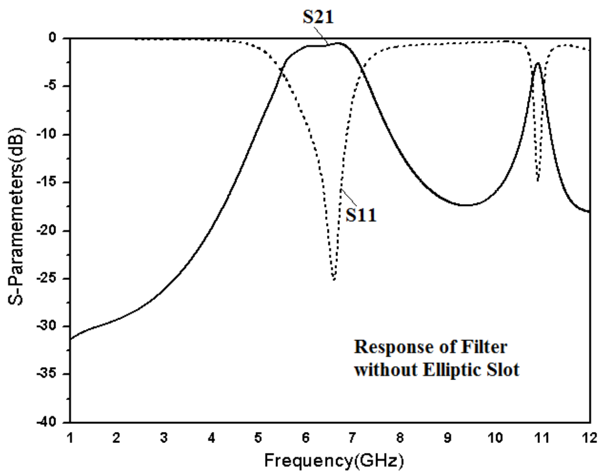

Fig. 5. Simulated results of filter without Elliptic shaped Slot

III. EXPERIMENTAL RESULTS

The above optimized filter has been fabricated using standard printed circuit board fabrication process. Fig. 6 shows the experimental prototype UWB filter. The input and output feed lines are designed with line impedance of 50Ω. Dimensions of the filter are 36 × 30 × 1.6 mm^3. The filter is tested using vector network analyzer Agilent N5230A. Fig. 7 show that measured results and fullwave simulation using IE3D are in good agreement. Measurements show slight expansion in bandwidth i.e. from 2.85GHz to 9.6GHz and this may be due to fabrication tolerances in realizing the coupling gaps (go, g1). The maximum measured insertion loss is 1.4dB and minimum return loss is 13dB. The measured group delay characteristics of the UWB filter is shown in Fig. 8 and the measured group delay is constant within ±0.2ns.

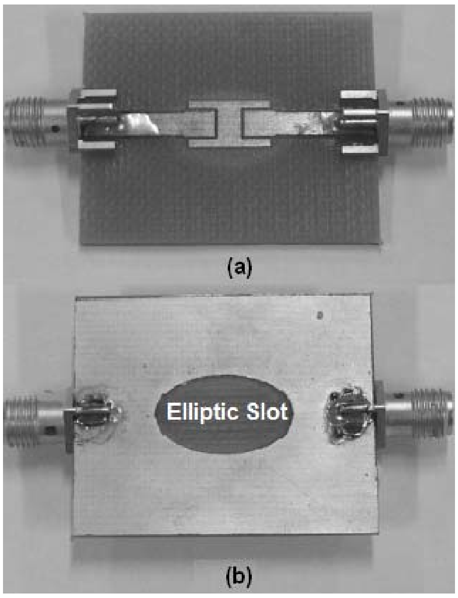

Fig. 6. Photograph of the UWB filter

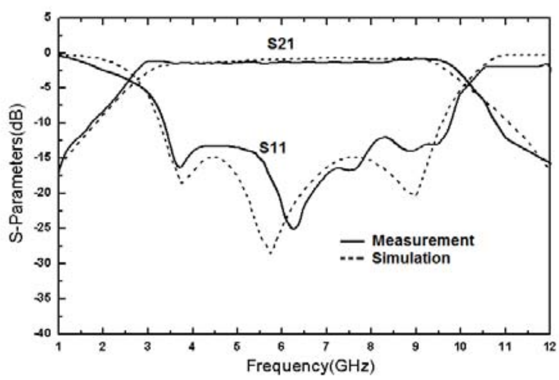

Fig. 7. Measured results of UWB filter

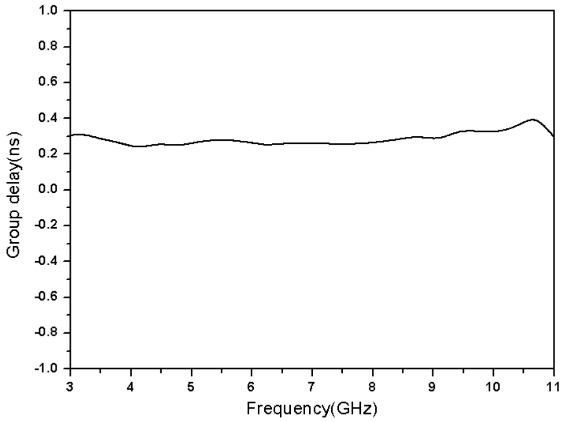

Fig. 8. Measured Group delay

IV. CONCLUSIONS

An UWB filter operating from 3.0GHz to 9.5GHz using coupled lines and elliptic slot in the ground plane has been designed for broadband communication devices. The elliptic slot in the ground plane was used to enhance the bandwidth of the filter. The filter has been developed and tested. The measured maximum insertion loss is 1.4dB and return loss is better than 13dB over the band.

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BIO DATA OF AUTHORS

Dr. D. PACKIARAJ is currently a Member of Senior Research Staff in Central Research Laboratory of Bharat Electronics Limited, Bangalore. He obtained Bachelor of Engineering degree in Electronics and Communication from Madurai Kamaraj University in 2000 and Master of Engineering degree in Communication Systems from National Institute of Technology, Trichirappali in 2002. He received Doctor of Philosophy (Ph.D) from Institute of Science (IISc), Bangalore in the area of Microwaves in 2013. He has received BEL's prestigious Research and Development award for the year 2011 for his significant contribution for the project IRLM for Akash systems. He has received BEL's Innovative contribution award for the year 2012 for his contribution as a team member for the project Smart antenna for wireless applications. He received IETE-IRSI Young Scientist award from IETE in 2014. He has authored about eighty (80) research papers in reputed international journals and conferences. His area of interest includes analysis and design of microwave filters, diplexers and transceiver systems.

M. RAMESH is currently a Member of Senior Research Staff in Central Research Laboratory of Bharat Electronics Limited, Bangalore. He obtained Bachelor of Engineering degree from Andhra University Visakhapatnam in 1990 and Master of Technology degree from Indian Institute of Technology Kharagpur in 1993. He is a co-inventor of one Indian patent and one US patent in the area of microwave components for phased array antennas. He has more than 90 research papers in reputed international journals and conferences. He has received BEL's Innovative contribution award for the year 2012 for his contribution as a team member for the project Smart antenna for wireless applications. His areas of interest include Microwave circuits and antennas.