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E-Shape Micro strip Band Notched UWB Filter Design using Meander Line Open Stub

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***Abstract*— In this paper an E-shape micro strip structure with meander line is presented. Proposed filter is developed for miniaturized ultra-wide band (UWB) band pass filters. In this paper proposed filter has multiband filtering characteristics and it covers complete UWB band. Meander line concept has been used to produce the band notched characteristic in UWB band applications. Previously, the E-shape micro strip structure with grounded center conductor is analyzed and, an approximate equivalent circuit is presented for its behavior. An advanced version of previously proposed UWB band filter (based on Al_2O_3) is presented with FR-4 material to reduce the overall cost of the primary antenna. Again, multiband (X-band notched) UWB filter with meander line is presented using FR-4 substrate. The approximate dimensions of the filter covering the whole UWB is about 3 mm x 1.5 mm x 0.4 mm. The theoretical and measured responses of the filters show good agreements**.

***Keywords*— E-shape micro strip structure, UWB, microwave filters, Multiband filter**

I. INTRODUCTION

After the declaration by federal communication commission (FCCs) as the unlicensed use of the ultra-wide-band (UWB) in 3.1 GHz to 10.6 GHz with a low power transmission at -41 dB m in February 2002 [1]. It highly appreciated by the academicians and researchers in spite of its few recent set-backs, the UWB technology is still regarded as viable for high-speed wireless communication applications. Since the inception of the UWB standard, challenges have been accepted by the researchers to realize filters for various UWB systems. The UWB band pass filter (BPF) with low insertion loss, high out of band rejection and a flat group delay performance within that band are highly considerable. Several research papers based on UWB band have been studied. Design and development of miniaturized UWB filters with multiband performance can be a challenging task, and various design techniques have already been presented in literature.

A design procedure of UWB filter using a coplanar waveguide (CPW) structure is proposed in [2] and [3]. The presented filters have good selectivity, but suffer from strong spurious responses due to the narrowband wireless communication applications.

Based on quarter-wave length short-circuited micro strip stubs, a compact size UWB filter is discussed in [4]. This filter has a sharp cutoff but poor stop band attenuation, good insertion loss and overall size of 20mm x 18mm. In [5] and [6], a detailed study of UWB filters using stepped-impedance resonators is presented. However, the presented filter design dimensions may not have been meeting the requirements for compact (UWB) systems. A new class of LTCC based UWB filter using stacked slotted loop resonators is presented in [7],but the ground plane in these filters appears on two planes that causing difficulties in fabrication and circuit-board mounting.

In [8] coupled E-shaped micro strip stubs have been exploited to develop compact planar filters covering the UWB band. To relax the fabrication of the small coupling gap between the E-shaped micro strip stubs, in [9] introduces a chip-capacitor to replace the capacitive role of the gap.

The E-shaped structure which is patterned on a grounded dielectric substrate is effectively an E-shape micro strip structure. In spite of the size and fabrication advantages offered by the UWB filters using coupled planar E-shaped structure in [8].

In this paper, the E-shape micro strip structure with meander line is analyzed and compared with the previously proposed UWB filter in [11]. In this paper we have concentrated to reduce the cost of the filter without affecting the behavior of filter presented in [11] with costly dielectric Al_2O_3. Simulation and measurement are used to help with the analysis of the structure.

II. FILTER DESIGN AND ANALYSIS

A. Preliminary Design

In this section, previously proposed UWB filter design [11], using Al_2O_3 substrate is presented in Fig.1. All dimensional information related to UWB filter [11], is summarized in Table-I. To reduce the cost of UWB filter [11], here we have proposed a design of primary UWB filter which is presented inFig.2. The primary UWB filter is designed on FR4 substrate with a thickness of 0.8 mm, with permittivity of 4.4 and loss tangent of 0.02.

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The E-shape primary UWB filter is fed with 50Ω micro strip feed line which is achieved with 0.37 mm width of feed line. FR4 substrate is used to minimize the overall cost of the filter which is greatly reduced in comparison to Al_2O_3 as proposed in [11]. The overall size of primary UWB filter is presented in Table-II.

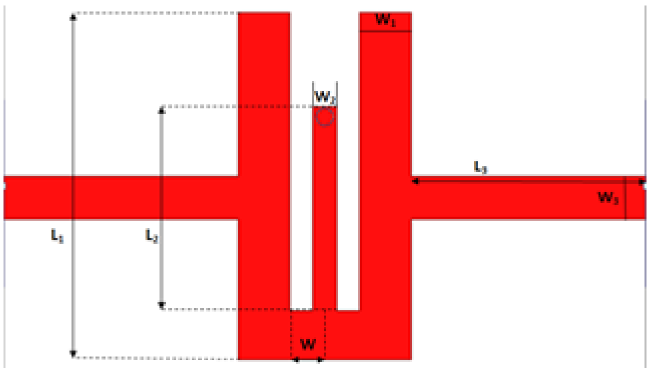

Fig.1. Primary UWB Filter [11]

Table-I
Dimension Summary Of Uwb Filter [11].

L_1	L_2	L_3	W	W_1	W_2	W_3
3.07	1.8	2	0.45	0.44	2	0.37

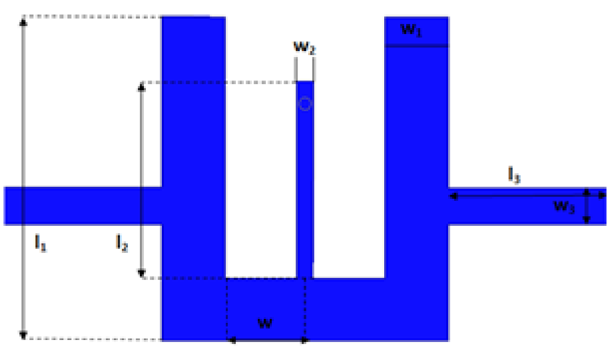

Fig.2. Proposed Primary UWB Filter using FR-4

Table-II
Dimension Summary Of Proposed Primary Uwb Filter

L_1	L_2	L_3	W	W_1	W_2	W_3
4.17	2.54	2	0.8	0.2	0.47	1.28

From Fig.1 and Fig.2 it can be seen that the previously proposed [11] UWB filter design and our primary UWB filter design has similarity and both the designs have the same concepts so one can use the equivalent circuit proposed in [11], to describe the our primary filter. However, values of lumped components for the equivalent circuit may differ by some values. Difference between lumped elements values may be due to the difference in length and width of the both the designs as presented in Table-I and Table-II.

B. Design of Proposed Band Notched UWB Filter

A band notched UWB filter design has been presented in Fig.3 and its optimized dimensions are summarized in Table-III.

From Fig.3 one can see that, there is a meander stub line has been used to produce a band notch for X-band in UWB range.

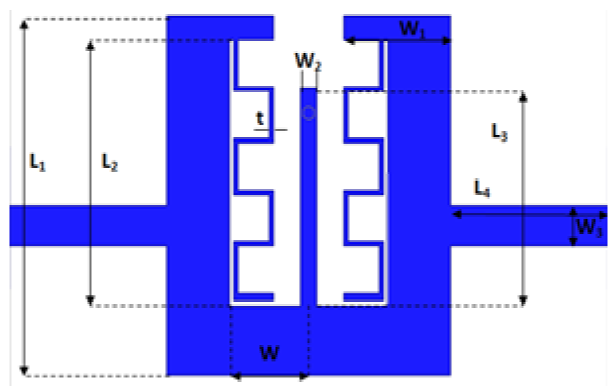

Fig.3. Proposed Band Notched UWB Filter Design

Table-III
Dimension Summary Of Proposed Band Notched Uwb Filter

L_1	L_2	L_3	L_4	W	W_1	W_2	W_3	t
4.17	3	2.4	2.5	1.4	1.35	0.2	0.5	0.08

A fabricated prototype primary UWB Filter and Band Notched UWB Filter has been presented in Fig.4 and Fig.5.

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Fig.4. Fabricated Prototype of Proposed Primary UWB Filter Design

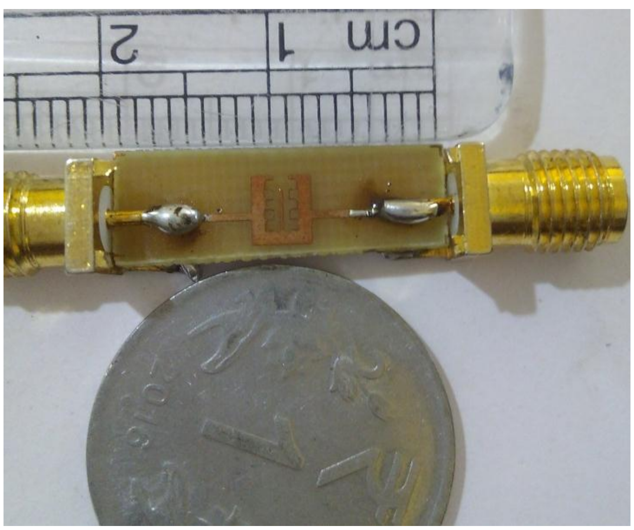

Fig.5. Fabricated Prototype of Proposed Band Notched UWB Filter Design

From Fig.6 one can see that results of the reference [11] results and proposed primary UWB Filter are approximately same, while both the design has E-shape of micro strip concept being used. In such case we can say that equivalent circuit used for the UWB filter [11], may also be applicable for our proposed UWB filter. However it may be possible that the lumped element value change by a range.

Our major concern was to reduce the cost of the UWB antenna, so from Fig. 6, we can see that both filters have similar result while reference filter is made from the Al_2O_3 and proposed UWB filter is made from the FR-4 substrate, we know that Al_2O_3 is more costly than FR-4, later one is more easily available too. The size of proposed UWB filter is bigger than reference filter due to the dielectric constant of the Al_2O_3 that is 9.8 while FR-4 has low dielectric constant of 4.4.

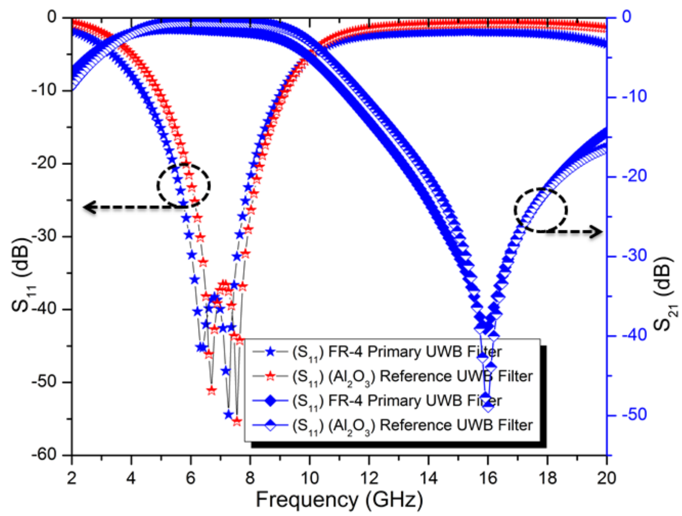

Fig.6: Comparison of Reference [11] UWB Filter and Proposed Primary UWB Filter.

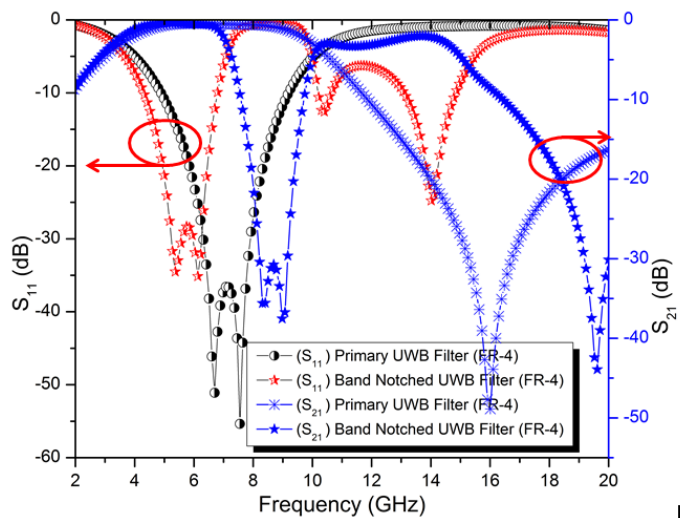

Fig.7: Comparison Proposed Primary UWB Filter and Band Notched UWB Filter.

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Comparison of proposed UWB filter and proposed band notched UWB filter is presented in Fig.7. From Fig.7 one can see that the proposed band notched UWB filter covers complete UWB range from 3.1 – 10.6 GHz with a notch at X-band satellite communication band that is from 7.25 – 8.35 GHz. Except X-band for satellite communication (uplink and downlink) filter operates over 3-16 GHz.

The width w_2 of shunt stub in proposed UWB filter as shown in Fig.2 can be varied over a range of values and accordingly response of filter can be tune. A tuning process of width of shunt stub is done and results are presented in Fig.8.From the Fig.8 it can be seen that at w_2= 0.2 mm the response of proposed UWB filter has approximately same result as in reference filter using Al_2O_3 substrate.

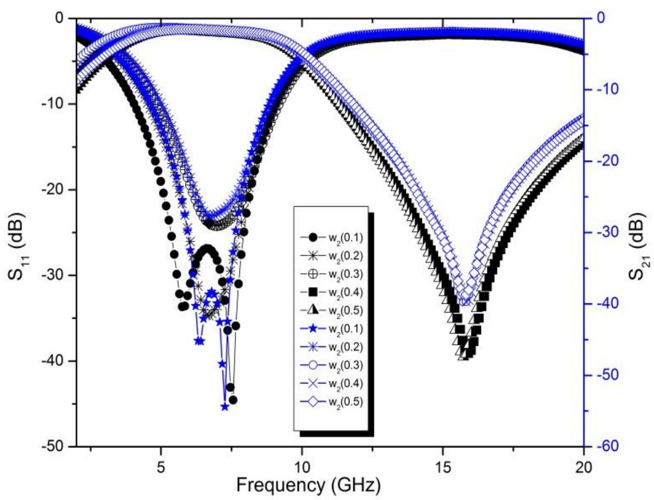

Fig.8: Parametric Variation in Proposed Primary UWB Filter.

The width W_2 of shunt stub in proposed band notched UWB filter as shown in Fig.3 can be varied over a range of values and accordingly response of filter can be tune. A tuning process of width of shunt stub is done and results are presented in Fig.9.

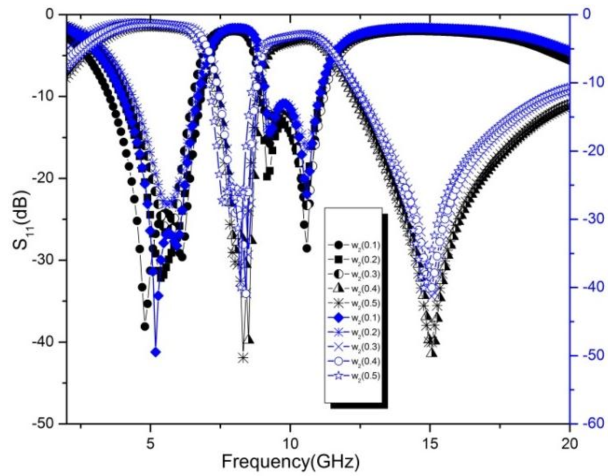

Fig.9: Parametric Variation in Proposed Band Notched UWB Filter.

A comparison between various filters like, reference [11] UWB filter using Al_2O_3, proposed UWB filter and proposed band notched filter has been presented in Fig.10.

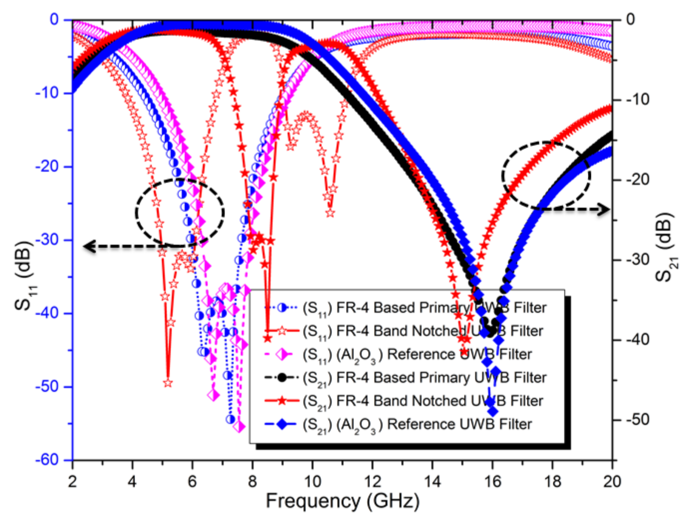

Fig.10: Comparison of Reference [11] Filter, Proposed Primary UWB Filter and Proposed Band Notched UWB Filter.

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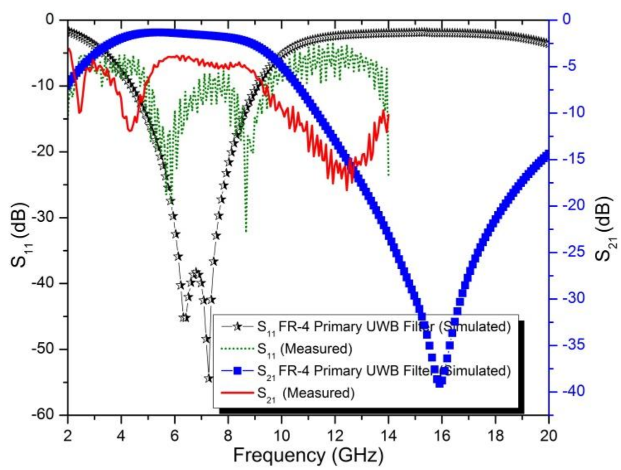
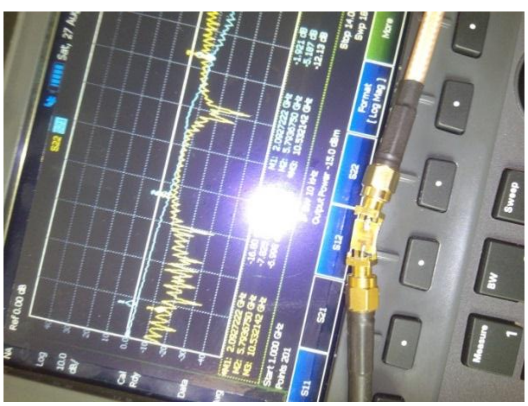
III. Results And Discussions

The measurement of the proposed filter was performed with Key sight vector network analyzer for S_{11} (dB) and S_{21} (dB). Measured results show good agreement with the simulated results. The discrepancy between measured and simulated results is due to the simulation error, cable & connector losses during measurement, not proper calibration of cable used for measurements and tolerance in fabrication. A simulated and measured result of proposed Primary UWB filter is presented in Fig.10. While simulated and measured result of the proposed band notched UWB filter is presented in Fig.11.

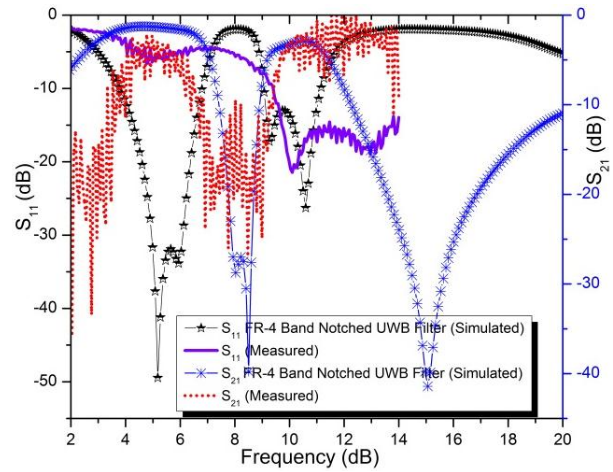


(a) Simulated and Measured result of Primary UWB Filter



(b) Measurement Setup for the Proposed Primary UWB Filter

Fig.10: Comparison of Proposed Primary UWB Filter Simulated and Measured Results



(a) Simulated and Measured result of Proposed Band notched UWB Filter

(b) Measurement Setup for Proposed Band Notched UWB Filter

Fig.11: Comparison of Proposed Band Notched UWB Filter Simulated and Measured Results

IV. Conclusions

Initially reference filter is reproduced for better understanding and comparison, and then a primary UWB filter is designed with FR-4 substrate to reduce the cost of the reference antenna successfully. To make filter more effective and useful another filter with band notching characteristic for X-band satellite communication (Uplink and Downlink) has been successfully proposed. Primary UWB filter and Proposed Band notched UWB filter has been measured and compared with their simulated results.

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Due to not perfect cable loss calibration we are getting not exact result as presented in simulation. However maximum time proposed filter measured result follow the simulated results. So here we have successfully designed a primary UWB filter and same time using a meander line stub proposed a Band Notched UWB Filter design which can be useful to notch the X-band satellite communication band during the UWB applications to minimize the interference due to the narrow band wireless communications in UWB spectrum.

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