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Design and Implementation of a Microstrip Band-Stop Filter for Microwave Applications

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Abstract

Performance of Microwave system may be degraded since the interference may be exist due to the presence of signals from other existing wireless communication systems. Currently, the major interference are in-band signal from 802.lla WLAN system which occupies the 5-6 GHz spectrum and signals from 802.11*b* WLAN system covering 2.4-2.48 frequency band. This paper presents the design of a modified L-shaped resonator bandstop filter for Microwave applications. The applicability of the proposed design method is demonstrated by a conventional 2.45 GHz L-shaped bandstop filter with -60 dB attenuation, which was extended to include a modified L-shaped resonator's design and result discussion. Methods of increasing bandwidth such as changing L-resonator width and cascading of filters are presented. The filters have been simulated using ADS design software and implemented on FR4 substrate.

Keywords: L-resonator; Bandstop filters; Microstrip resonator; Microwave system; ADS

1. Introduction

Federal Communications Commission (FCC) released the 3.1-10.6GHz spectrum with an indoor emission limit of -41 dBm/MHz for Ultra wideband communication (UWB) in 2002. Ultra Wideband (UWB) technology has attracted a lot of interest in the research community and in industry. It offers the potential for high data rates, low-power transmissions, low cost, excellent range resolution (geolocation) capabilities, and robustness to multipath fading. One of the main research focus was to capitalize on the low transmission power of UWB pulses in communications, thereby catalyzing UWB transceiver

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research. The simpler transceiver circuitry required in this system, compared to more complicated structures in narrowband transceivers, have also been seen as another promising, as small-sized devices can be manufactured at a lower price. One of the transceiver components that have received much research attention due to this is the filter. Various researchers have carried out investigations on different aspects of filters, which includes the band pass UWB filters, filters with tunability and switch ability features, and transmission zeroing at pass band. Much attention have also been paid to notching out signal reception in the ISM spectrum range of 5-6 GHz. These works have focused on implementing the notch filters using various means such as parasitic patches, coupled line structures, defected ground structures (OGS), split ring resonators (SRR), photonic band gap (PBG) and etc. Less have been done in notching out the WLAN 802.11*b* spectrum range for application in UWB. This work is an effort to design and examine an L-resonator band stop filter which was designed to have attenuation of at least -60 dB between 2.4 GHz and 2.5 GHz. L-resonator band stop filter presented in this paper used an EM-simulation method to obtain the reactance slope parameters required for designing the filter. L-resonator band stop filter with 2.45 GHz center frequency, and discuss about the findings. The methods for obtaining larger bandwidth by parametric study and cascading of multi staged filters.

2. **Narrowband L-resonator bandstop Filter design**

The filters designed were then implemented on a FR4 substrate, with a dielectric constant of 5.4, loss tangent of 0.035 and substrate height of 1.6 mm. Based on the design specifications, the order of filter can be determined from [10]. Through this method, a bandstop Microwave filter of the 9th order filter was required.

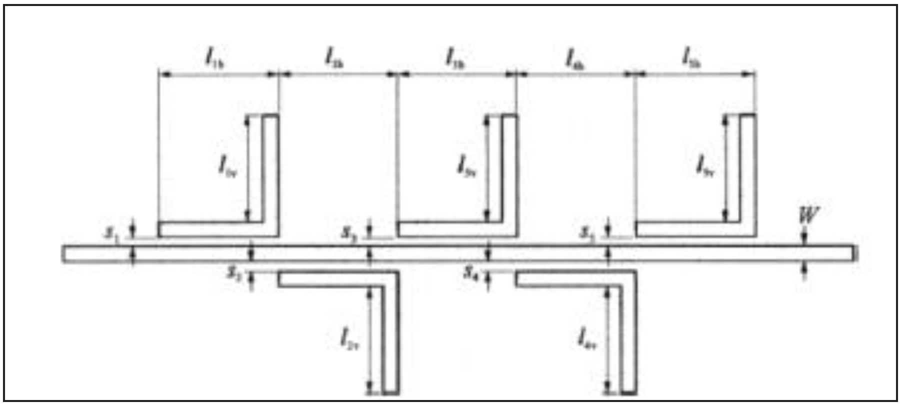

Figure 1: L-Resonator Bandstop Filter

As seen from Figure 1, each L-shaped resonator was designed to be half wavelength, while *L,* and *L;* was each quarter wavelength. The resulting in *L,* and *L;* to be both 15 mm in length. For simplicity, width of the main line and L-resonators were assumed to be 2.6 mm based on a 50 Ohm line dimension.

A magnitude plot as shown in Figure 2 was simulated using ADS software. Space of the coupled line *(CLinJ)* was varied to obtain a set of measured reactance slope parameter values, using the simulated $S_{21}(dB)$ magnitude plot from the circuit setup. Figure 2 shows the resulting simulated $S_{21}(dB)$ magnitude plot.

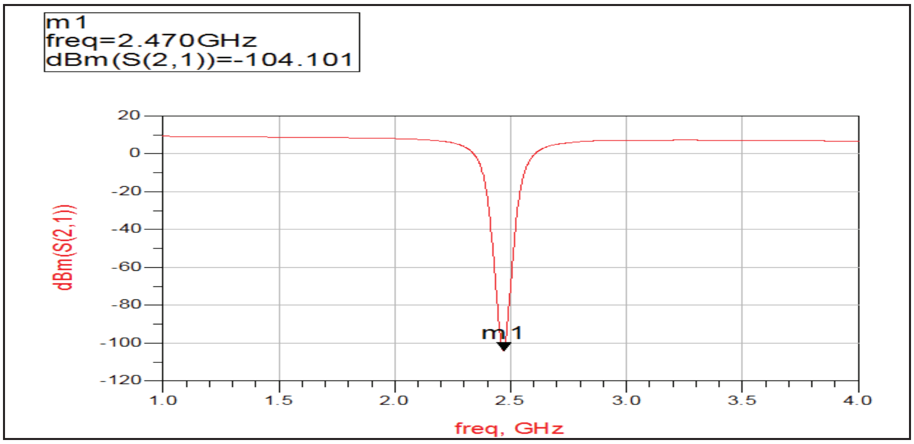

Figure 2: Simulated S_{21} magnitude plot

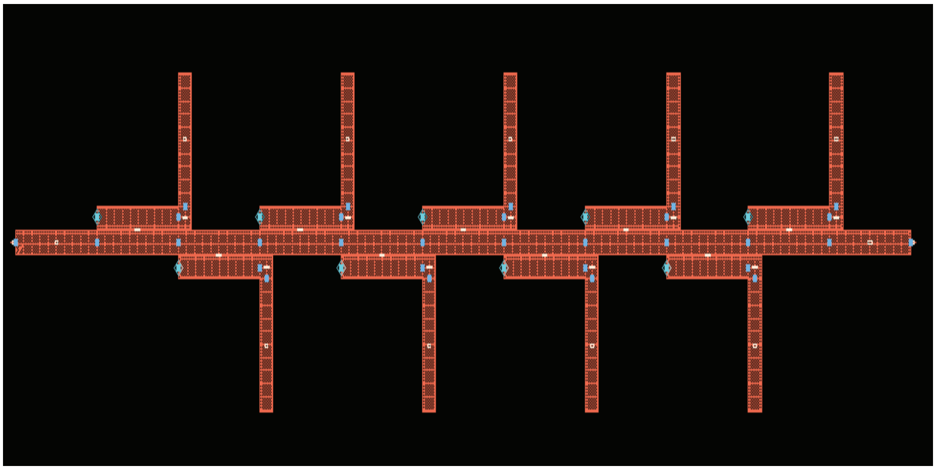

Figure 3: Layout of modified L-resonator band stop filter

3. Result and Discussion

Figure 3 shows the layout dimension of the L-resonator bandstop filter designed using ADS. Nine elements were included as part of the filter structure, and were swept using different spacing. These spaces were associated with the reactance slope parameters, and were obtained based on the method discussed in Section 2. Based on the Figure 3, the center frequency of simulation definitely success at 2.45 GHz but the measurement result was slightly increased to 2.57 GHz. This variation was caused by various fabrication imperfections such as dimensional inaccuracies and port to line transition losses.

4. Modified L-Resonator Bandstop Filter Design

In order to obtain a larger bandwidth the width of *L-R*esonator was reduced. L-resonator width of 1.8mm, 2.2mm, 2.6mm, 3.0mm and 3.4mm. In order to increase the notch bandwidth, two 9th-order filters were cascaded together.

The first and second stage filters were designed to have the same specifications with a cut-off frequency of 2.45 GHz and 3dB-bandwidth of 0.57 GHz. As the impedances were matched, cascading the filters produced a near to zero center frequency to shift. The notch bandwidth was successfully increased by cascading of filters but it was still insufficient to meet the design specification. Two 9th-order L-resonator filters having different stop band frequency were cascaded.

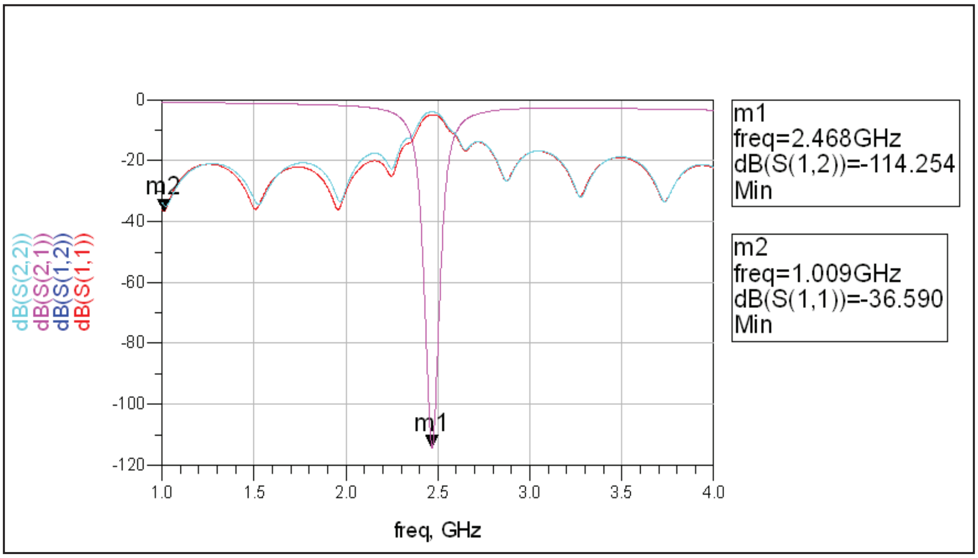

Figure 4: Simulation of S-Parameters L-Resonator Filter

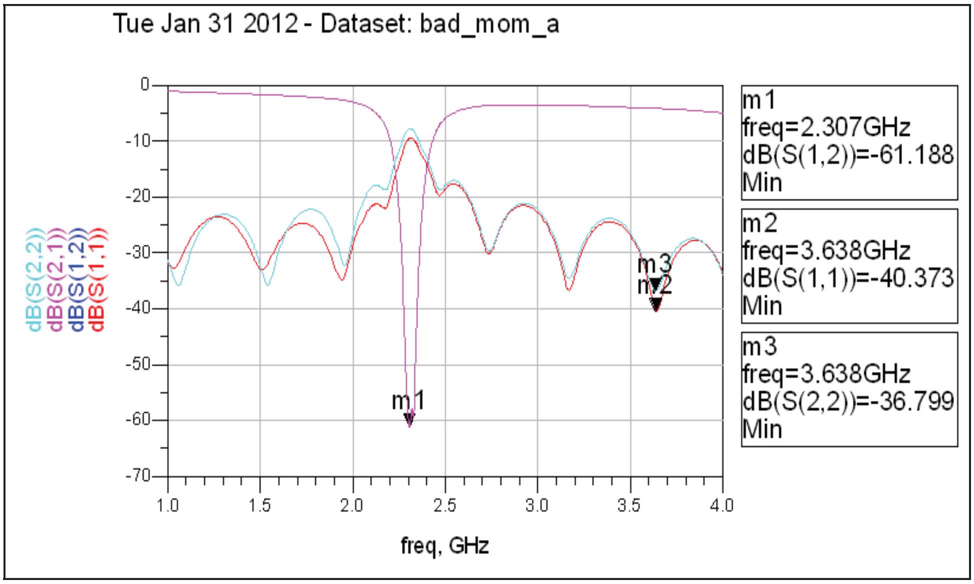

Figure 5: Layout Output

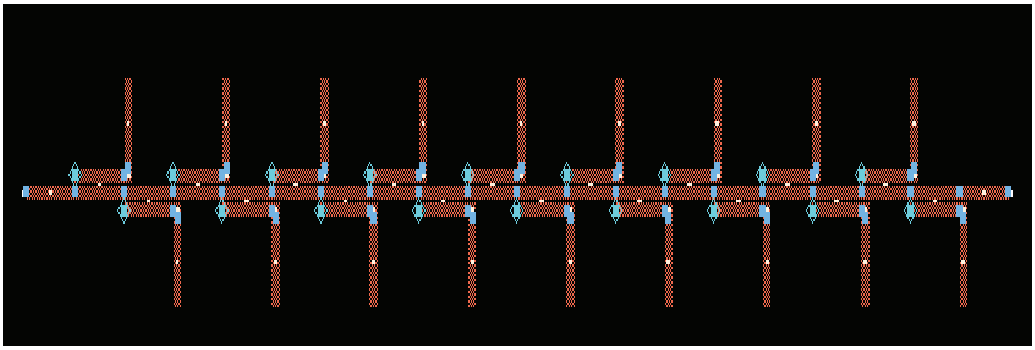

Figure 6: Layout of 2nd Stage modified L-resonator band stop filter

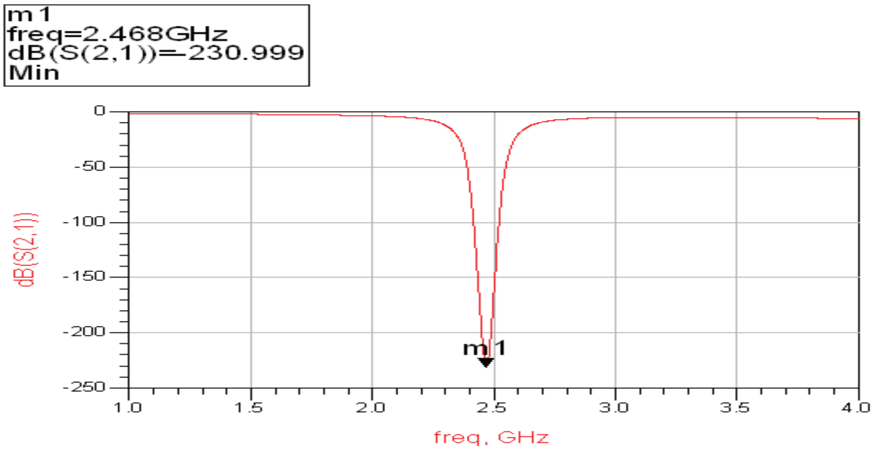

Figure 7: Simulated 2nd Stage S_{21} magnitude plot

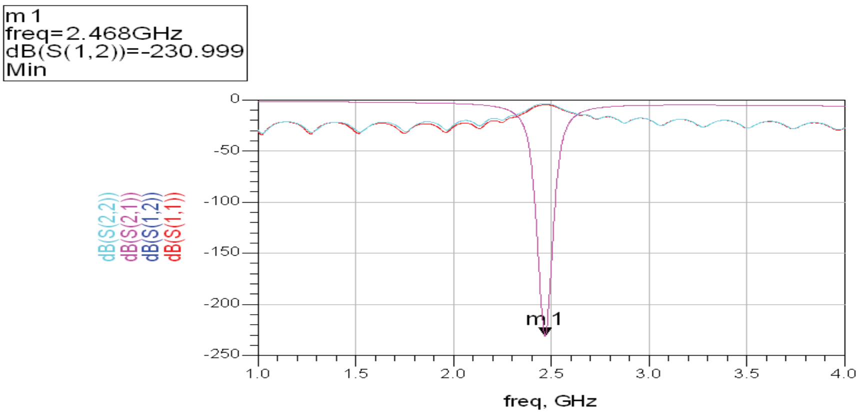

Figure 8: Simulation of 2nd Stage S-Parameters L-Resonator Filter

The bandwidth for the 1st stage and 2nd stage was designed to be 0.55 GHz and 0.56 GHz. The resulting cascaded structure produced an increased bandwidth of 0.71 GHz .

Methods of changing width and cascading different filter structures have produced the same effects on S_{21} center frequency which was about 5 %. However, the cascading method has been proven to be more effective in increasing the bandwidth, up to 6.3 %. On the other hand, the width varying method has produced an improvement of up to 5 %. However, one important point to note is that the width varying method have emerged as a more practical method as it can be easily implemented on an electromagnetic simulator and therefore saves cost.

5. Conclusion

A new, modified L-shaped resonator bandstop filter that was implemented for Microwave applications is presented. Two methods to tune its bandwidth and center frequency of the filter have been identified, which are the width varying method and the cascading method. A bandwidth improvement of up to 6% has been verified using the cascading method, through simulation and measurement carried out in this work.

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