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Ultra-Wideband Bandpass Filter using Microstrip-Coplanar Waveguide (CPW) Structure

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ABSTRACT

In this paper, an ultra-wideband (UWB) bandpass filter (BPF) using Microstrip-coplanar waveguide structure (CPW) is presented. This filter consists of a microstrip line (on top), dielectric substrate (middle) and coplanar waveguide (on conductive ground). The proposed filter has been simulated and measured for UWB bandpass filter. The measured results demonstrate the UWB properties from 1.24 to 11.76 GHz (-10 dB bandwidth) and the potential to be wider.

This paper also introduced another filter structure which works as a dual-band ultra-wideband (UWB) bandpass filter. The dual-band operation was implemented by integrating a stub in the coupled conductors. The resonance of the stub introduces a narrow rejection band in the UWB passband which then results in a dual band filtering. Such a dual-band UWB bandpass filter is strongly required in a practical system in order to avoid the interference between the UWB radio systems and existing radio systems. The rejection band can be easily designed to some specific frequency band by tuning the length of the stub. The measured results demonstrate the ultra-wideband properties from 1.0800 GHz to 5.5157 GHz (-10 dB bandwidth) and rejected performance 5.5157 GHz to 5.6157 GHz (-10 dB bandwidth).

General Terms

Scattering Parameters, Insertion loss , Reflection loss.

Keywords

Ultra-wideband, bandpass filter, dual-band, microstrip line, coplanar waveguide (CPW).

1. INTRODUCTION

The ultra-wideband (UWB) radio system has been receiving great attention from both academy and industry since the Federal Communications Commission (FCC)'s release of the frequency band from 3.1 to 10.6 GHz for commercial communication applications in February 2002 [1-26]. Being a key component, a high performance UWB bandpass filter (BPF) is highly required [2].The ultra-wideband is best for wireless communication.

So it is more useful in future communication links [15]. For examples, a mobile computer user can connect to a digital projector in a conference room in wireless mode and Digital pictures can be transferred to a computer from digital camera without the need of a cable. Beside this, there were two systems in use for wireless technology: traditional “narrowband” systems as well as newer “wideband” systems. There are two main differences between UWB and other “narrowband” or “wideband” systems. First, the bandwidth of UWB systems is more than 1.5GHz. It is clear that in previous technologies, the bandwidth is lesser than the bandwidth used by UWB technology for communication like radio technology, cellular technology etc. Secondly, UWB is typically implemented in a carrier less fashion [10]. Conventional “narrowband” and “wideband” systems use Radio Frequency (RF) carriers to move the signal.

A well designed UWB bandpass filter can be considered to satisfy the following requirements:

- Ultra wide bandwidth: for example from 3.1 GHz to 10.6 GHz according to FCCs spectrum mask [6].
- Low insertion loss [5].
- Good reflection loss.
- Less ripple (necessary for stability) [25].
- Cut-off band performance (strongly required to meet the regulation such as the FCC s spectrum mask) [9].

2. FILTER DESIGN

In this work a UWB filter structure is designed. The proposed filter is shown in Figure 1. The key part of this filter structure is a microstrip-coplanar waveguide (CPW) [9] [15]. As shown in Figure 1, an open-end CPW section is fabricated on the ground of the microstrip line. This provides a very simple and compact filter configuration. The basic section of the filter has two microstrip lines separated with a gap and broadside coupled to one open-end CPW on the ground through the dielectric substrate.

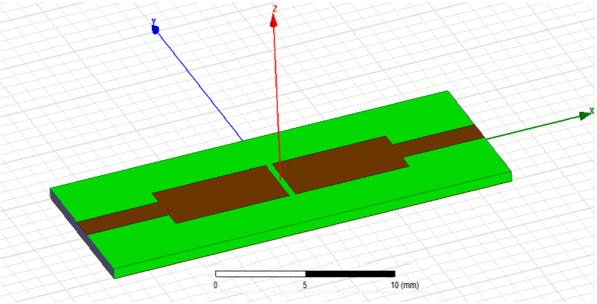


Fig. 1: Proposed UWB bandpass filter using microstrip-coplanar waveguide structure.

The broadside-coupling and the existence of the dielectric substrate make the coupling between the microstrip line and the coplanar waveguide structure very tight. Tight coupling therefore provides a very wide bandpass operation. Figure 2 shows a measured results of the ultra-wideband, from 1.24 GHz to 11.76 GHz (-10 dB bandwidth), very low insertion about 0.45 dB at center frequency 6.5 GHz and also very flat response over the whole band.

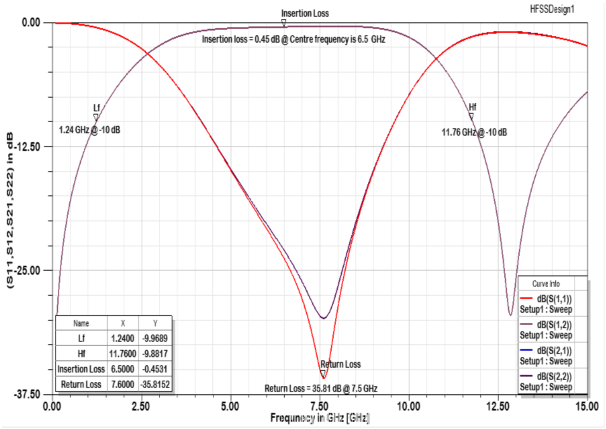
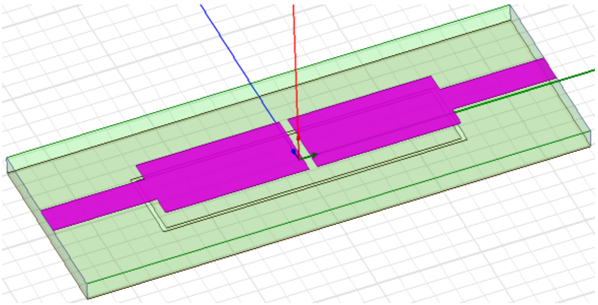


Fig. 2: Z, Y and S matrix result (all scattering parameter in dB) of UWB bandpass filter. This figure shows a measured result of both insertion loss and reflection coefficient (return loss) of our proposed filter.



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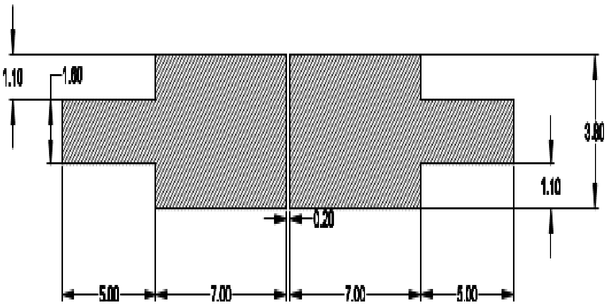
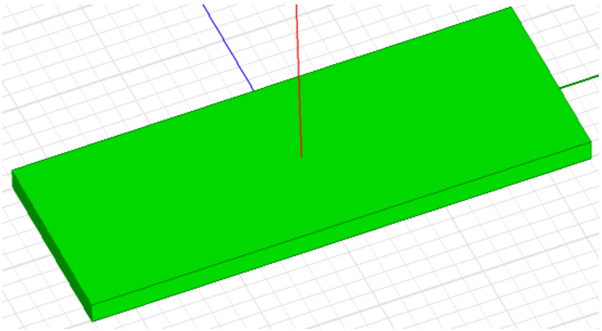


(b)

Fig. 3: (a) Microstrip Line (shown in pink color, thickness of copper is 0.001 mm) of UWB Bandpass Filter.(b) Dimensions of Microstrip line (all dimensions are in mm).



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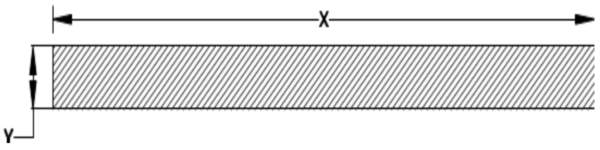
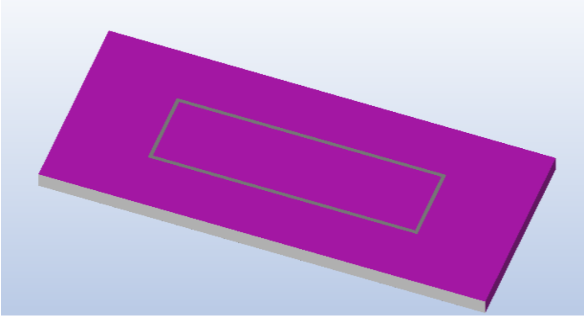


(b)

Fig. 4:(a) Dielectric Substrate (shown in green color, X=24.2 and Y=0.508, relative permittivity εr = 2.2, Dielectric loss tangent tanδ = 0.0009 of UWB Bandpass Filter.(b) Dimensions of dielectric substrate (all dimensions are in mm).



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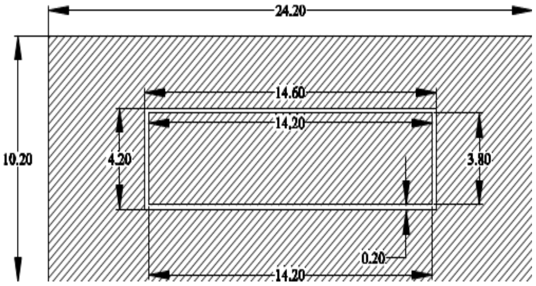


(b)

Fig. 5: (a) Coplanar Waveguide structure (shown in pink color, thickness of copper is 0.001 mm) of UWB Bandpass Filter. (b) Dimensions of coplanar waveguide structure (all dimensions are in mm)

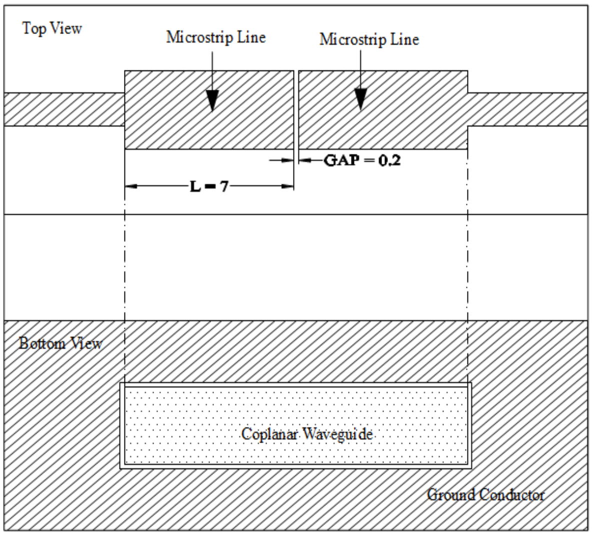


Fig. 6: The topology of the microstrip coplanar-waveguide based bandpass filter and its key parameters, with the units shown in millimeters.

Secondly, this paper also introduced a more functional bandpass filter that can not only operate over wideband but can also have capability to reject some frequency band which the existing radio system are using [2] [8] [19] [24]. Such filter is strongly required in a practical radio system in order to avoid the interference between existing radio systems which are usually using a narrow frequency band.

Such filters as dual-band UWB bandpass filter which has one rejection frequency band, or multi-band UWB bandpass filter when it has more than two rejection frequency bands, in this paper. A simple structure to realize the dual-band filter is shown in Figure 7, where a stub is integrated with the coupled microstrip conductors. The resonance of the stub introduces a narrow rejection band in the UWB passband which then results in a dual-band filtering operation. The rejection band can be easily designed to some specific frequency band by tuning the length of the stub.

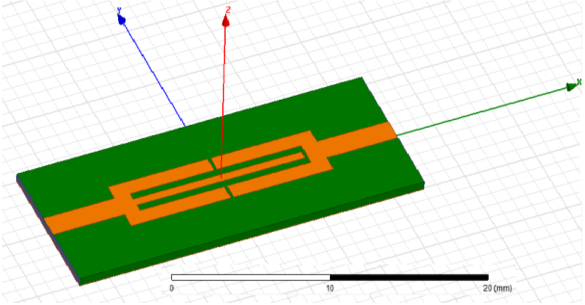
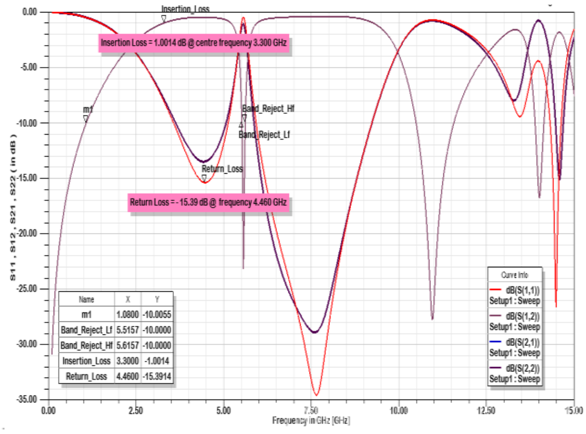
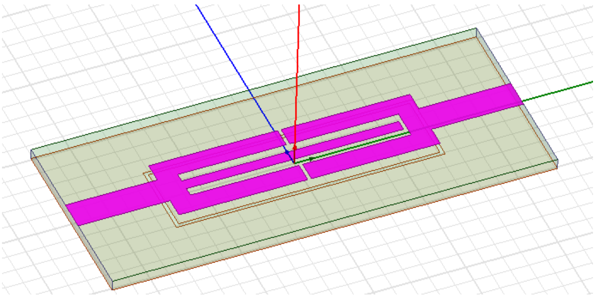


Fig. 7: Proposed dual-band ultra-wideband bandpass filter with an integrated stub using microstrip coplanar waveguide structure.



Name	X	Y
m1	1.0800	-10.0055
Band_Reject_Lf	5.5157	-10.0000
Band_Reject_Hf	5.6157	-10.0000
Insertion_Loss	3.3000	-1.0014
Return_Loss	4.4600	-15.3914

Fig. 8: Z, Y and S matrix result (all scattering parameter in dB) of dual-band UWB bandpass filter. This figure shows the measured result of Insertion loss and Reflection Cofficient (return Loss) of our Proposed Filter.



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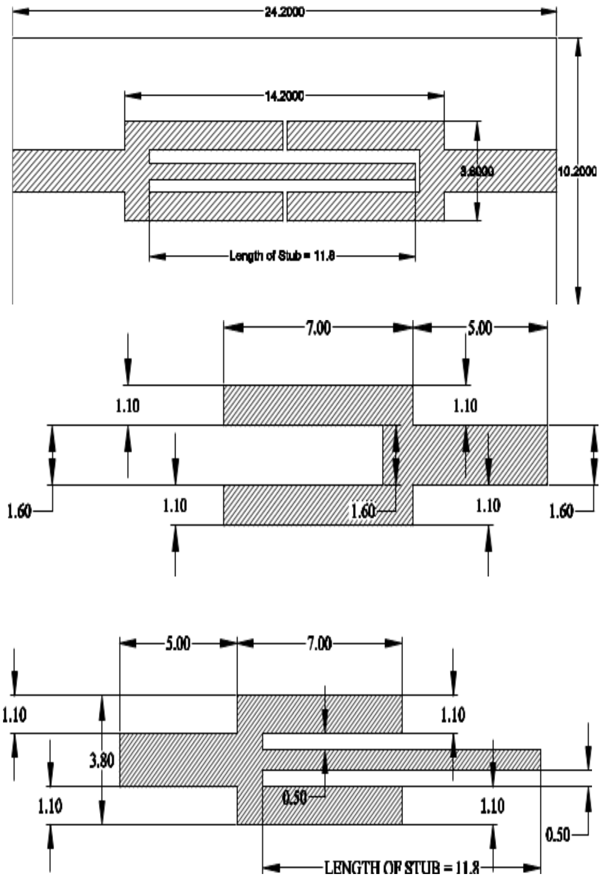
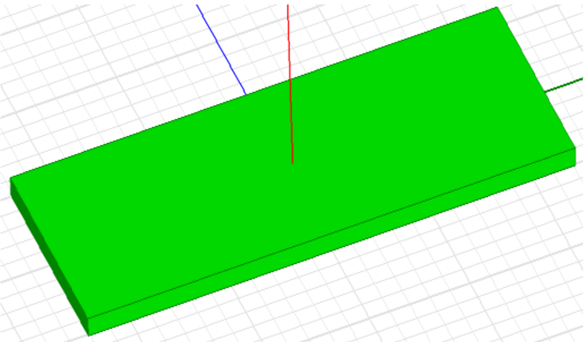


(b)

Fig. 9:(a) Microstrip Line with stub (shown in pink color, thickness of copper is 0.001 mm) of UWB Bandpass Filter. (b) Dimensions of microstrip line with stub(all dimensions are in mm).



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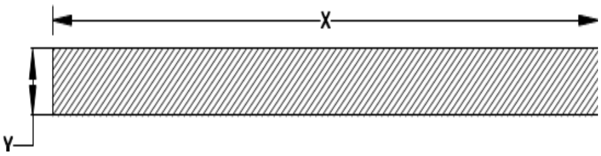

(b)

Fig. 10: (a)Dielectric Substrate (relative permittivity εr=2.2, Dielectric loss tangent tanδ = 0.0009, X=24.2 andY=0.508) of UWB Bandpass Filter.(b) Dimensions of dielectric substrate (all dimensions are in mm).

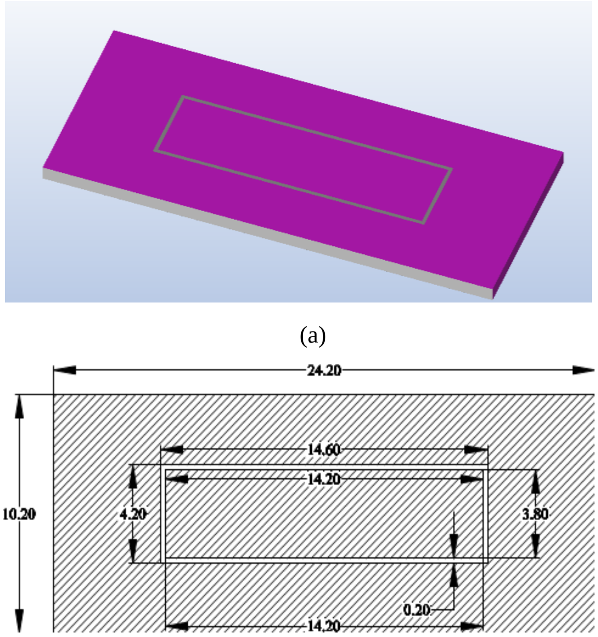
(a)

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Fig. 11: (a)Coplanar Waveguide structure (shown in pink color, thickness of copper is 0.001 mm) of UWB Bandpass Filter.(b)Dimensions of coplanar waveguide structure (all dimensions are in mm).

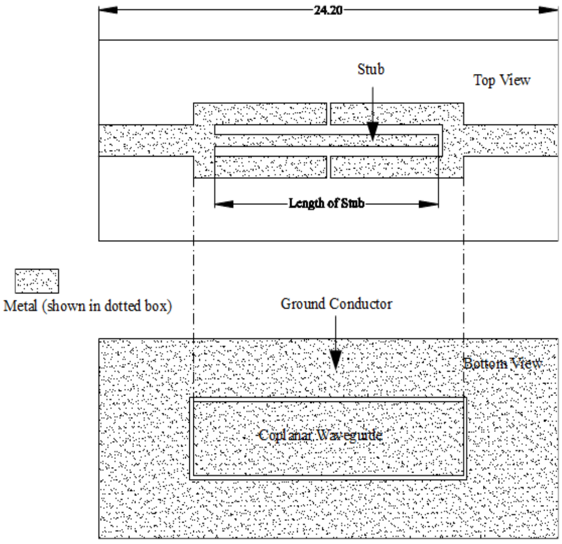

Fig. 12: The topology of the microstrip coplanar-waveguide with stub based bandpass filter and its key parameters, with the units shown in millimeters.

3. SIMULATION AND MEASURED RESULTS

The S-parameter is obtained from Z, Y and S matrix of HFSS software. To examine the bandwidth characteristic then only S21 or S12 parameter is required. HFSS is a high-performance full-wave electromagnetic (EM) field simulator for arbitrary 3D volumetric passive device modeling that takes advantage of the familiar. The default parameters of the ultra-wideband bandpass filter using microstrip-coplanar waveguide (CPW) structure and the dimensions are shown in Figure 3, Figure 4 and Figure 5 and Figure 6. Figure 2 shows simulation results of the S12 parameter (or response) of bandpass filter.

Fig. 2: shows a measured result of both insertion loss and reflection coefficient (return loss) of our proposed filter. From this graph, one can see the ultra-wideband, from 1.24 to 11.76 GHz (at -10 dB bandwidth), Return loss is 35.81 dB at frequency 7.5 GHz, very low insertion loss about 0.45 dB at center frequency is 6.5 GHz and also very flat over the whole band.

- Bandwidth:1.24 to 11.76 GHz (-10 dB bandwidth)
- Insertion loss = 0.45 dB at center frequency 6.5 GHz.
- Return loss= 35.81 dB at 7.5 GHz.
- Very flat over the whole band.

The bandpass characteristics changes with gap (B) as a parameter while keeping L = 7 mm. This indicates that one can improve the sharpness of the bandpass skirt by using a narrower gap.

Secondly, the dual-band operation was implemented by integrating a stub in the coupled conductors. The resonance of the stub introduces a narrow rejection band in the UWB passband which then results in a dual-band filtering. Such a dual-band UWB bandpass filter is strongly required in practical systems in order to avoid the interference between the UWB radio system and existing radio systems. The rejection band can be easily designed to some specific frequency band by tuning the length of the stub.

Fig. 8: shows a measured result of both insertion loss and reflection coefficient (return loss) of our proposed filter. The measured results demonstrate the ultra-wideband properties from 1.0800 GHz to 5.5157 GHz (-10 dB bandwidth) and rejected performance 5.5157 GHz to 5.6157 GHz (-10 dB bandwidth).From this graph, very low insertion loss about 1.0014 dB at frequency 3.300 GHz , Return loss is 15.3914 dB at frequency 4.460 GHz and also flat pass-band.

- Bandwidth (band-pass):1.0800 to 5.5157 GHz (-10 dB bandwidth)
- Bandwidth (band-rejected):5.5157 GHz to 5.6157 GHz (-10 dB bandwidth)
- Insertion loss = 1.0014 dB at center frequency 3.300 GHz.
- Return Loss = - 15.3914 dB at frequency 4.460 GHz

According to this graph (see in Figure 8), one can see that the rejection frequency band can be relatively easily adjusted to some specified frequency by simply changing the length of the stub.

4. CONCLUSION

In this paper, a UWB bandpass filter using a coupled microstrip-coplanar waveguide structure is designed. The filter structure is very simple and can be compact, since the CPW is fabricated on the ground of the microstrip line. The proposed filter exhibited excellent bandpass performance, low insertion loss in the operation band. Combining the proposed wideband bandpass filters with different physical dimensions was used to ultra-wideband bandpass filter.

Secondly, in this paper a dual-band ultra-wideband (UWB) bandpass filter is also designed. The dual-band operation was implemented by integrating a stub in the coupled conductors. The resonance of the stub introduces a narrow rejection band in the UWB passband which then results in a dual-band filtering. Such a dual-band UWB bandpass filter is strongly required in practical systems in order to avoid the interference between the UWB radio system and existing radio systems.

Compared to the existing notched band filter designs in the literature the proposed filter has simple structure, compact size, high performance, and easy fabrication.

5. REFERENCES

[1] J. C. Adams, W. Gregorwich, L. Capots and D. Liccardo, “Ultra- wideband for navigation and communications,” Aerospace Conference, IEEE Proceedings. , vol. 2, pp. 785-792, Mar. 2001.

[2] Binyan Yao, Yonggang Zhou and Qunsheng Cao, “A ultra-wideband bandpass filter with multi notched bands using microstrip/coplanar waveguide,” Antennas, Propagation and EM Theory ISAPE, pp. 637-640, Nov. 2008.

[3] MarjanMokhtaari, Jens Bornemann and SmainAmari, “Dual-band stepped-impedance filters for ultra-wideband applications,” Proceedings of the 37th European Microwave Conference, pp. 779-782, Oct. 2007.

[4] C. L. Hsu, Fu Chieh Hsu and J. K. Kuo, “Microstripbandpass filters for ultra-wideband wireless communications,” Microwave Symposium Digest, IEEE MTT-S International, pp. 1-4, June 2005.

[5] C. Y. Hsu, C. Y. Chen and C. H. Huang, “A UWB filter using a dual-mode ring resonator with spurious pass band suppression,” Microwave Journal , pp. 130-136, Nov 2005.

[6] W. Cheng, X.H. Wang, Y. Tuo, Y.F. Bai, and X.W. Shi, “MMR helps tune ultra- wideband bandpass filter,” Microwaves & RF, Vol. 50, No. 3, pp. 26-30, Mar. 2011.

[7] S. Devkumar and C. K. Chakrabarty, “Using lowpass and highpass filters to form ultra-wideband bandpass filter,” Telecommunication Technologies and 2nd Malaysia Conference on Photonics, pp. 162-165, Aug. 2008.

[8] X. Guo, Y. Xu and W. Wang “Miniaturized Planar Ultra-Wideband Bandpass Filter with Notched Band,” Journal of Computer and Communications, Vol. 3, pp. 100-105, Mar. 2015.

[9] Hang Wang, Lei Zhu and W. Menzel, “Ultra-Wideband bandpass filter with hybrid microstrip/CPW structure,” IEEE Microwave And Wireless Components Letters, Vol. 15, No. 12, pp. 844 – 846, Dec. 2005.

[10] J. S. Hong, and M. J. Lancaster, “Microstrip filters for RF/microwave applications,” Ed. New York: Wiley, 2001.

[11] H. Ishida and K. Araki, “Design and analysis of ultra-wideband band pass filter,” IEEE Topical Conference on Wireless Communication Technology, pp. 457-458, Oct. 2003.

[12] Jia Yuan Yin, JianRen, Hao Chi Zhang, Bai Cao Pan and Tie Jun Cui, “Broadband frequency-selective spoof surface plasmonpolaritons on ultrathin metallic structure,” Scientific Report, Vol. 5, pp. 1-5, Feb. 2015.

[13] T. N. Kuo, C. H. Wang and C. H. Chen “A compact ultra-wideband bandpass filter based on split-mode resonator,” Microwave And Wireless Components Letters, Vol. 17, No. 12, pp. 852-854, Dec. 2007.

[14] Lahaie, I.J., “Ultra-wideband Radar,” Proceedings of SPIE-The International Society for Optical Engineering, Vol. 1631, pp. 22-23, 1992.

[15] K. Li, K. Daisuke and M. Toshiaki, “An ultra-wideband bandpass filter using broadside-coupled microstrip-coplanar waveguide structure,” Microwave Symposium Digest, IEEE MTT-S International, June 2005.

[16] I. T. Tang, D. B. Lin , C. M. Li and Min Yuan Chiu, “Ultra-Wideband bandpass filter using hybrid microstrip-defected-ground structure,” Microwave and Optical Technology Letters, Vol. 50, No. 12, pp. 3085-3089, Sept. 2008.

[17] P. Mondal, M. K. Mandal and A. Chakrabarty, “Compact ultra wideband bandpass filter with improved upper stopband,” IEEE Microwave And Wireless Components Letters, Vol. 17, No. 9, pp. 643-645, Sept. 2007.

[18] M. Mokhtaari, J. Bornemann and S. Amari, “Folded compact ultra- wideband stepped-impedance resonator filters,” pp. 747-750, June 2007.

[19] M. Mirzaee, “A novel small ultra-wideband bandpass filter including narrow notched band utilizing folded-t-shaped stepped impedance resonator (sir),” Progress In Electromagnetics Research C, Vol. 22, pp. 85-96, 2011.

[20] M. S. Razalli, A. Ismail, M. A. Mahdi, and M. N. bin Hamidon, “Novel compact "via-less" ultra-wide band filter utilizing capacitive microstrip patch,” Progress In Electromagnetics Research, Vol. 91, pp. 213-227, 2009.

[21] L. Zhu, S. Sun and W. Menzel, “Ultra-Wideband (UWB) bandpass filters using multiple- mode resonator,” IEEE Microwave Wireless Components Letters, Vol. 11, No. 11, pp. 796-798, Nov. 2005.

[22] V. K. Sharma and M. Kumar, “Design of Microstrip UWB bandpass Filter using Multiple Mode Resonator,” American Journal of Engineering Research (AJER), Vol. 03, No. 10, pp. 169-177, 2014.

[23] C. G. Tan and K. M. Lum, “Ultra-Wideband bandpass filter using symmetrical step-impedance resonators,” PIERS Proceedings, pp. 1488-1490, Aug. 2012.

[24] S. W. Wong and L. Zhu, “Quadruple-Mode UWB Bandpass Filter with Improved Out-of-Band Rejection,” IEEE Microwave Wireless Components, Vol. 19, No. 3, pp. 152-154, Feb. 2009.

[25] W. Haimeng and Q. Weiping, “Compact ultra-wideband bandpass filters using microstrip-coplanar-waveguide simplified structure,” Communication Systems, ICCS 11th IEEE Singapore International Conference, pp. 626-629, Nov. 2008.

[26] Z. Y. Xiao et al., “Design of compact ultra- wideband filter using stepped impedance dual-mode resonator,” Signals Systems and Electronics (ISSSE) ,Vol. 2,pp. 1-4, Sept. 2010.