

Design and Analysis of Compact UWB BPF Using Parallel Coupled Microstrip Line With DGS

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Abstract

This paper presents design and analysis of a simple and compact ultra-wideband (UWB) band-pass-filter using parallel-coupled micro strip line with DGS. A two poles filter is designed by a parallel couple micro strip line. A rectangular defective ground plane is used to enhance coupling between lines i.e. better return loss in UWB range. Simulation of this proposed filter is carried out on CST MWS software, and fabricated using microwave laminate GML 1000 of dielectric constant 3.2 and height 0.762mm with loss tangent 0.001. Measured results are compared with simulation results with good agreement. The electrical equivalent model of this filter is also presented in this paper. The equivalent model of this filter is verified by comparing the frequency response of equivalent circuit of the filter and simulated frequency response of this filter.

Index terms— multi-mode resonator (MMR), fractional bandwidth (FBW), ultra-wide band (UWB), band pass filter (BPF), parallel-coupled micro strip line (PCML), defective parallel-coupled micro strip line with DGS. A two poles filter is designed by a parallel couple micro strip line. A rectangular defective ground plane is used to enhance coupling between lines i.e. better return loss in UWB range. Simulation of this proposed filter is carried out on CST MWS software, and fabricated using microwave laminate GML 1000 of dielectric constant 3.2 and height 0.762mm with loss tangent 0.001. Measured results are compared with simulation results with good agreement. The electrical equivalent model of this filter is also presented in this paper. The equivalent model of this filter is verified by comparing the frequency response of equivalent circuit of the filter and simulated frequency response of this filter. In 2002, Federal Communication Commission (FCC) released Ultra wide band (UWB) system from 3.1 GHz to 10.6 GHz for the use of indoor and hand-held systems. Ultra-wideband (UWB) band pass filters play a key role in the development of UWB systems [1]. After the release of UWB, there were lot of challenges to design such a band pass filters with a pass band of the frequency range (3.1 GHz -10.6 GHz), and a fractional bandwidth of 110% for conventional filter design. Initially broad band filters were designed, and covered only 30 to 40 % of UWB not the whole UWB [2]. In [3][4][5][6] many researcher reported various techniques, like aperture compensation, micro strip-coplanar waveguide structure design, ground plane aperture technique and multiple mode resonator were used to design UWB filters. Many new techniques [8][9][10][11][12][13], like U-shaped Slot Coupling [8], asymmetric parallel-coupled lines [9], right/left handed transmission line [10], differential-mode wide band BPF using two stage branch-line structure with open circuited stubs [11], tunable harmonic stepped impedance resonators [12] and parallel coupled line micro strip structure [13] were used to design the UWB filter.

The synthesis of UWB filter has been carried out by various approaches presented in [14][15].

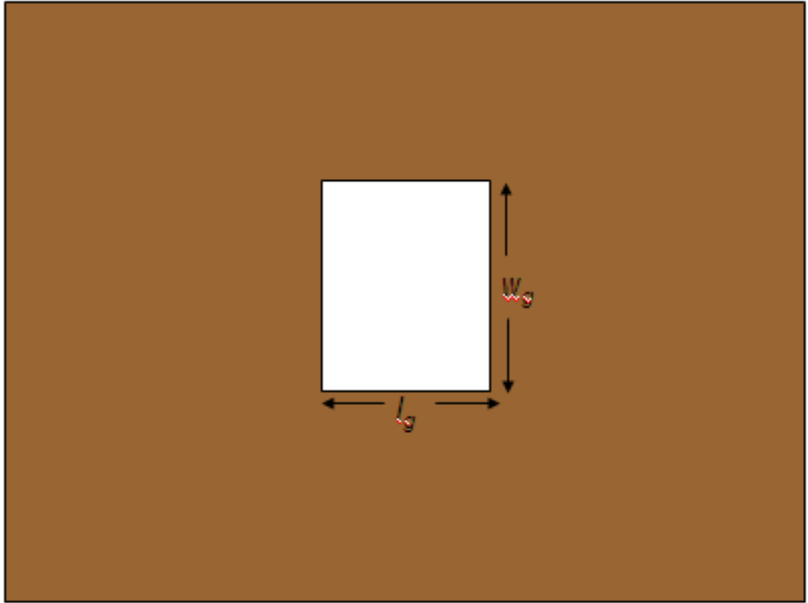
The transfer function of the proposed UWB was synthesized having two short circuited stubs with two stages of stepped impedance resonators (SIRs) [14]. In [15], series multi conductor transmission lines (MTLs) and shunt MTL were used to design various UWB filters and a new approach was presented to synthesis the transfer function of UWB filter.

In this paper a design and analysis of a compact UWB filter is presented. In section 2, design and development of the UWB filter using single PCML and DGS is demonstrated. The electrical analysis of the filter is mentioned in section 3. Finally paper is concluded in section 4.

The layout of the proposed structure is shown in Fig. 1 which consist a quarter wavelength parallel coupled micro strip line (PCML) with a rectangular shaped DGS. The designed structure of filter is optimized by using CST Microwave Studio software on the microwave laminate GML 1000 of dielectric constant 3.2, height $h = 0.762$ mm and loss tangent 0.001. The design parameters of the proposed filter are mentioned in TABLE ??.

1 Design of UWB Filter

Keywords: multi-mode resonator (MMR), fractional bandwidth (FBW), ultra-wide band (UWB), band pass filter (BPF), parallel-coupled micro strip line (PCML), defective ground plane structure (dgs). The optimized structure of this filter is fabricated using conventional microwave integrated circuits (MIC) technology, the photograph of the fabricated filter is shown in Fig. ?. The frequency response (S11 & S21) of this fabricated filter is measured on Agilent Tech. E5071C ENA Vector Network Analyzer. The measured frequency response is compared with simulated frequency response which is in close approximation, and it is shown in Fig. ? (a). It is observed from the frequency response of the fabricated filter, that the pass band of this filter exists from 3.1 GHz to 10.9 GHz, insertion loss (S21) of -0.5 dB and return loss (S11) better than 10 dB. The group delay is also measured and compared with simulation value, and it is observed that this filter having a flat group delay of value 0.35 ns approximately, which is shown in Fig. ? (b). A slight mismatch in the results is due to imperfection in fabrication process, quality of substrate and SMA connectors. The surface current distribution at center of the frequency 6.85 GHz is shown in Fig. ? (c). $\frac{1}{\sqrt{2}} \approx 0.7071$, $\frac{1}{\sqrt{3}} \approx 0.57735$, $\frac{1}{\sqrt{5}} \approx 0.44721$, $\frac{1}{\sqrt{7}} \approx 0.37796$, $\frac{1}{\sqrt{11}} \approx 0.30151$, $\frac{1}{\sqrt{13}} \approx 0.27735$, $\frac{1}{\sqrt{17}} \approx 0.24254$, $\frac{1}{\sqrt{19}} \approx 0.22361$, $\frac{1}{\sqrt{23}} \approx 0.20458$, $\frac{1}{\sqrt{29}} \approx 0.18383$, $\frac{1}{\sqrt{31}} \approx 0.17741$, $\frac{1}{\sqrt{37}} \approx 0.16442$, $\frac{1}{\sqrt{41}} \approx 0.15617$, $\frac{1}{\sqrt{43}} \approx 0.15119$, $\frac{1}{\sqrt{47}} \approx 0.14494$, $\frac{1}{\sqrt{53}} \approx 0.13842$, $\frac{1}{\sqrt{59}} \approx 0.13201$, $\frac{1}{\sqrt{61}} \approx 0.12909$, $\frac{1}{\sqrt{67}} \approx 0.12370$, $\frac{1}{\sqrt{71}} \approx 0.11904$, $\frac{1}{\sqrt{73}} \approx 0.11736$, $\frac{1}{\sqrt{79}} \approx 0.11256$, $\frac{1}{\sqrt{83}} \approx 0.10940$, $\frac{1}{\sqrt{89}} \approx 0.10630$, $\frac{1}{\sqrt{97}} \approx 0.10206$, $\frac{1}{\sqrt{101}} 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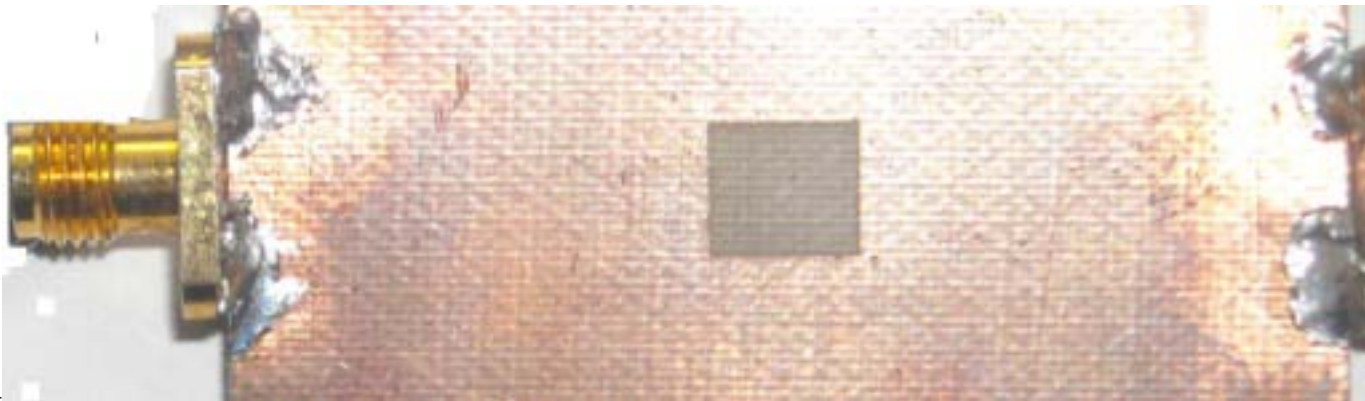
1

Figure 1: Fig. 1 :



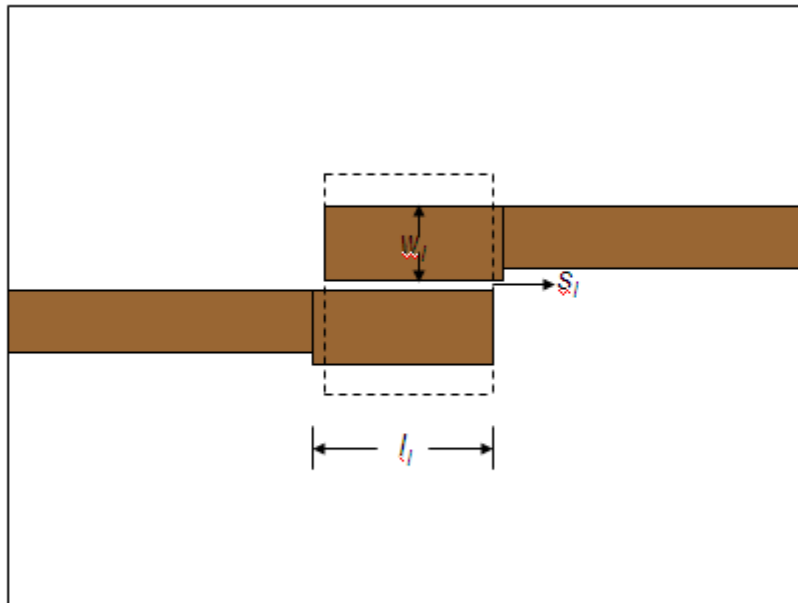
23

Figure 2: Fig. 2 :Fig. 3 :



34

Figure 3: Fig. 3 :Fig. 4 :



5

Figure 4: Fig. 5 :

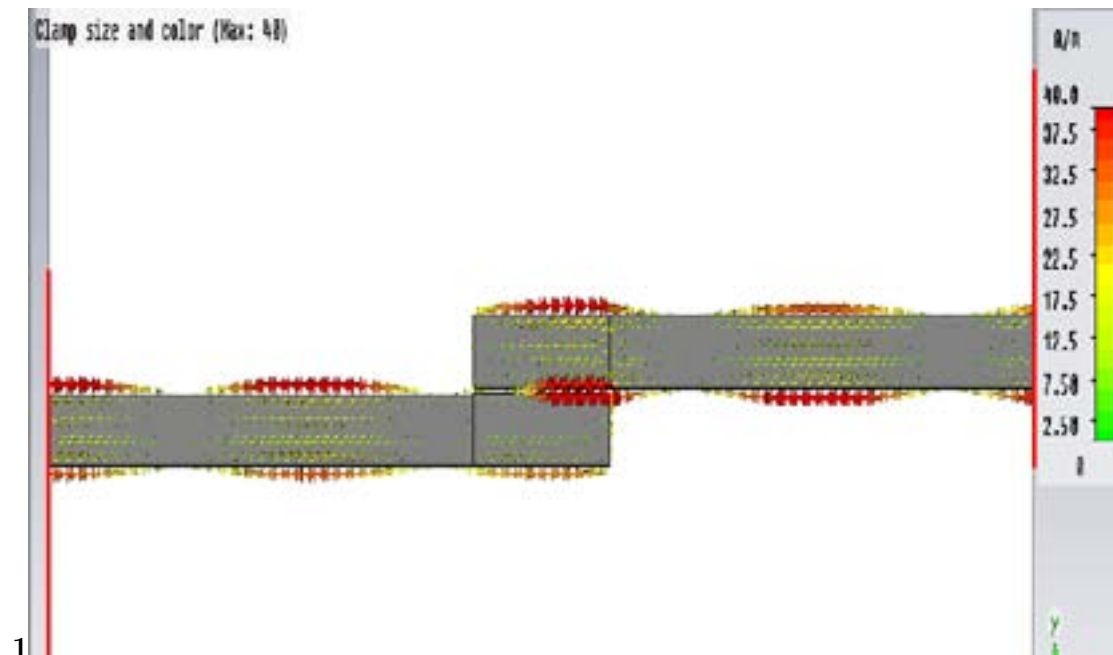


Figure 5: 1 -

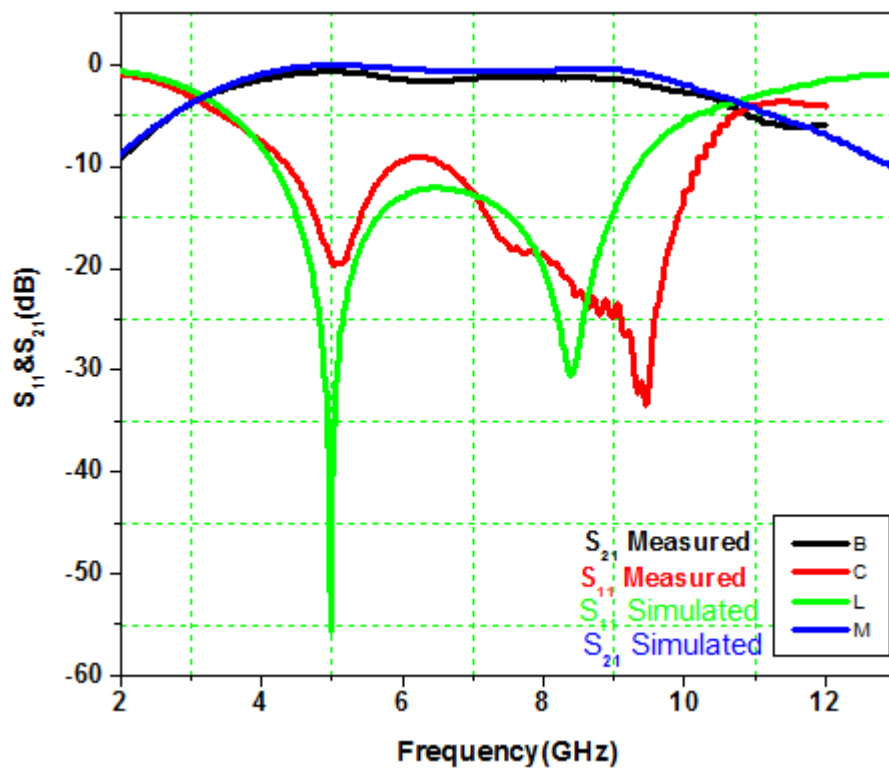


Figure 6:

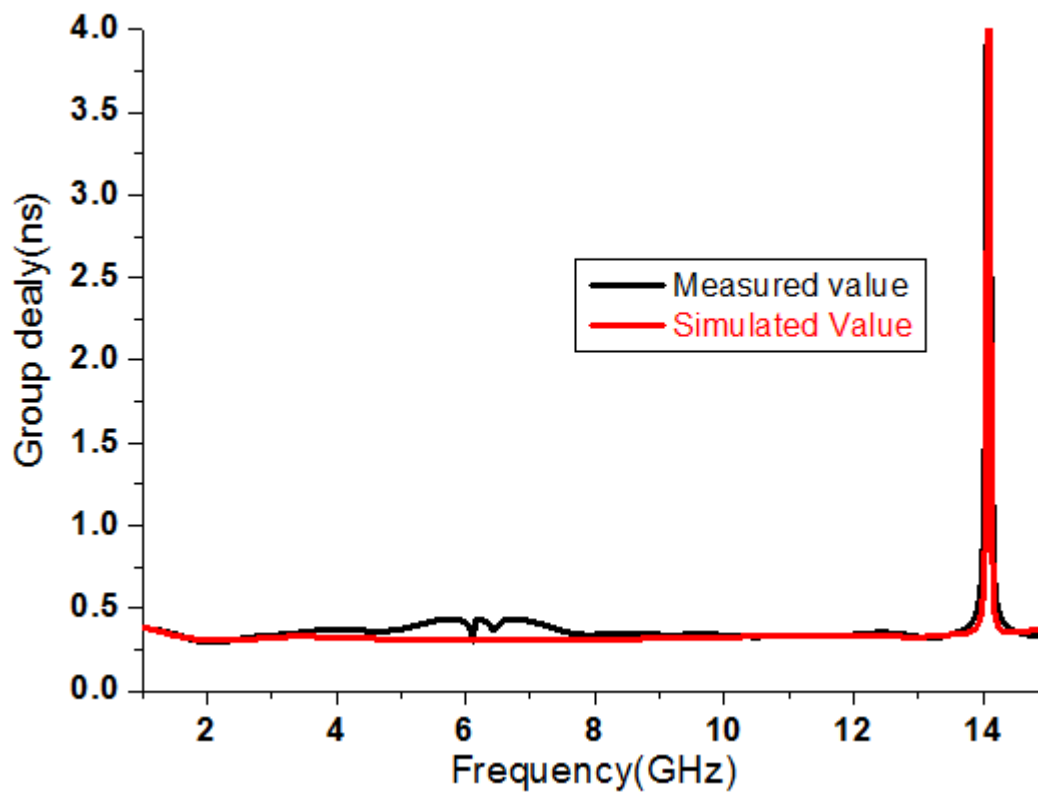
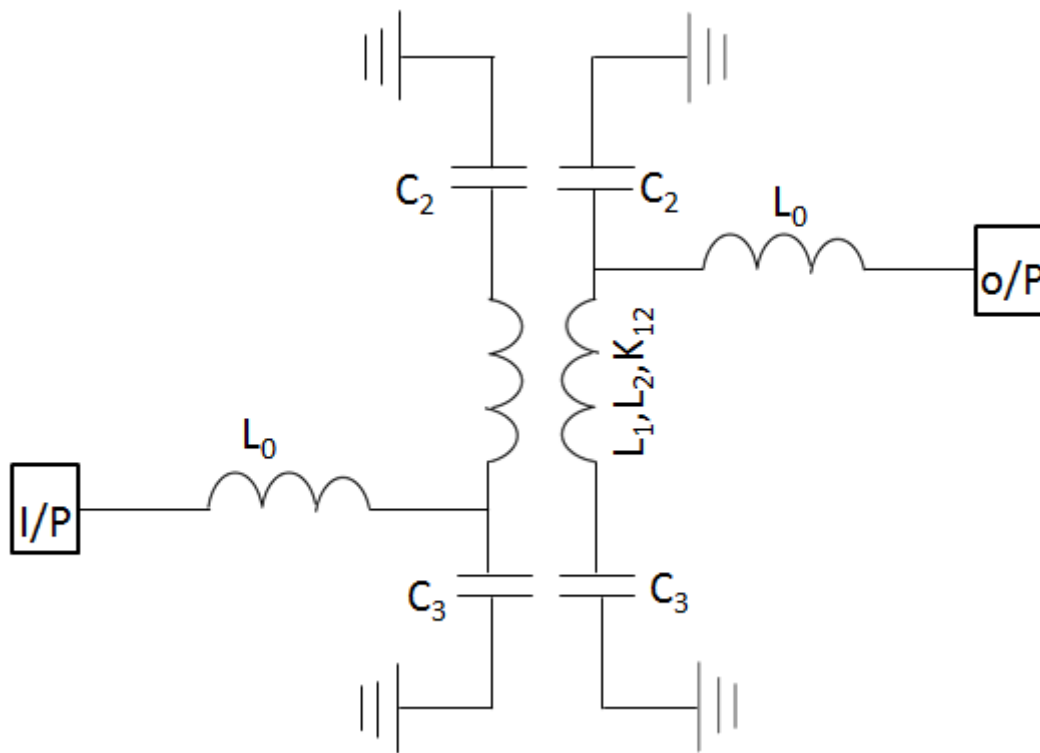


Figure 7: ?



6

Figure 8: Fig. 6 :

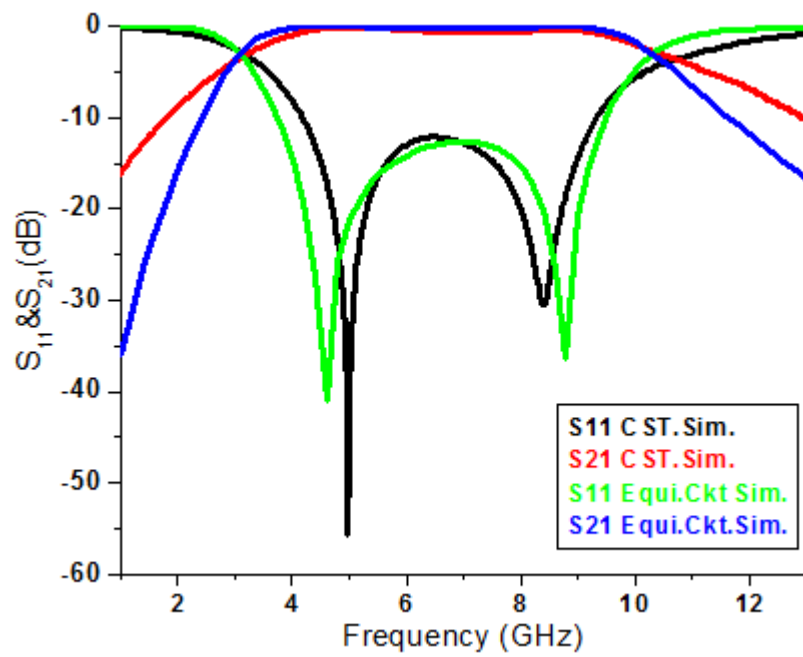


Figure 9:

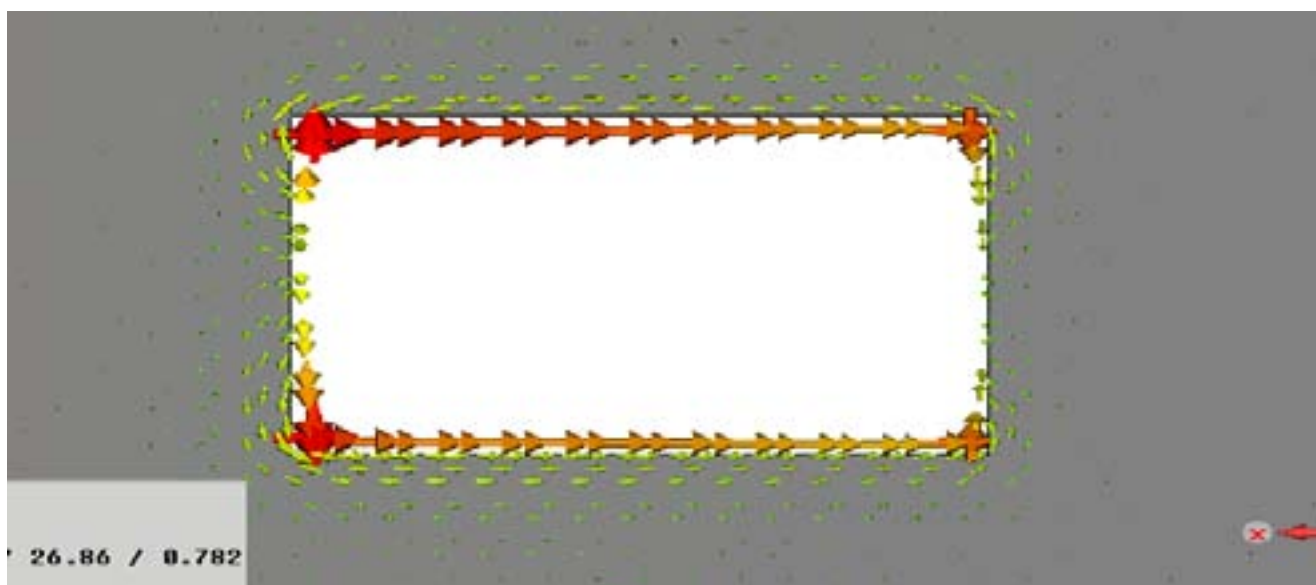


Figure 10:

[Bin] , Li Bin .

[Eck et al. (2009)] ‘A Differential-Mode Wideband Band pass Filter on Micro strip Line for UWB Application’. Beng Eck , Lei Lim , Zhu . *IEEE Microwave and Wireless Components Letters* Oct. 2009. (19) .

[Mokhtaari et al. ()] ‘A Modified Design Approach for Compact Ultra-Wideband Micro strip Filters’. M Mokhtaari , J Bornemann , S Amari . *International Journal of RF & Microwave CAE* 2010. 20 (1) p. .

[Li et al. (2005)] ‘An ultra-wideband band pass filter using broadside-coupled micro stripcoplanar waveguide structure’. K Li , D Kurita , T Matsui . *IEEE MTT-S, Int. Dig* June 2005. p. .

[Zhu et al. ()] ‘Aperture compensation technique for Innovative design of ultra-broadband micro strip band pass filter’. L Zhu , H Bu , K Wu . *IEEE MTT-S Int. Dig* 2000. 1 p. .

[Shaman and Hong (2007)] ‘Asymmetric Parallel-Coupled Lines for Notch Implementation in UWB References Références Referencias Design and Analysis of Compact Uwb Bpf Using Parallel Coupled Microstrip Line With Dgs © 2017 Global Journals Inc. (US) Filters’. H Shaman , J Hong . *IEEE Microwave and Wireless Components Letters* July 2007. 17 (7) p. .

[Zhu et al. ()] ‘Broadband and compact multi-pole micro strip band pass filters using ground plane aperture technique’. L Zhu , H Bu , K Wu . *IEEE proc. Microwave Antennas Propag* 2002. 149 (1) p. .

[Menzel et al. (2003)] ‘On the design of novel compact broad-band planar filters’. W Menzel , L Zhu , K Wu , F Bogelsack . *IEEE Transaction on Microwave Theory Technology* Feb. 2003. 51 (2) p. .

[Thirumalaivas An K And Nakkeeran ()] ‘Parallel Coupled Micro strip Band pass Filter for Short Range UWB Applications’. R Thirumalaivas An K And Nakkeeran . *Computational Intelligence and Information Technology Communications in Computer and Information Science* 2011. (250) .

[Yang et al. (2006)] ‘Planar Micro strip UWB Band pass Filter Using U-shaped Slot Coupling Structure’. G M Yang , R H Jin , J P Geng . *Electronic Letters* December 2006. 42 (25) .

[Revision of Part 15 of the Commission’s Rules Regarding Ultrawideband Transmission Systems ET-Docket 98-153 (2002)] ‘Revision of Part 15 of the Commission’s Rules Regarding Ultrawideband Transmission Systems’. *ET-Docket 98-153*, April 2002. p. . (Tech. Rep) (Federal Communications Commission)

[Sánchez-Martínez et al. (2015)] ‘Synthesis and Design of High-Selectivity Wide band Quasi-Elliptic Band pass Filters Using Multi conductor Transmission Lines’. Juan José Sánchez-Martínez , Enrique Márquez-Segura , Stepan Lucyszyn . *IEEE Transactions on Microwave Theory and Techniques* Jan. 2015. 63 (1) .

[Chen et al. (2010)] ‘Synthesis of compact UWB band pass filter with improved performances” *Microwave and Optical Technology Letters*, Chun-Ping Chen , Hiroshige Nihei , Zhewang Ma , Tetsuo Anada . March 2010.

[Xu-Ping ()] ‘Ultra wideband filter design based on right/left-handed transmission line” *Antennas, Propagation and EM Theory*, Li Xu-Ping . 2008. 2008. (ISAPE)

[Zhu et al. (2005)] ‘Ultra-wideband (UWB) band pass filters using multiple-mode resonator’. L Zhu , S Sun , W Menzel . *IEEE Microwave and Wireless Components Letters* November 2005. 15 (11) p. .

[Kuo and Shih (2002)] ‘Wideband band pass filter design with three-line micro strip structures’. J T Kuo , E Shih . *IEEE proc. Microwave Antennas Propag* October/December 2002. 149 (5) p. .