# A Novel Design of UWB BPF Using CSRR-DGS with Band-Rejection Performance Based on Coupled Wave Canceller SIR with High Skirt Selectivity

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***Abstract*— In this paper offers a novel design of ultra-wide band bandpass filter (UWB BPF) using complementary split ring resonators-defected ground structures (CSRR-DGS) with band rejection efficiency. The high skirt selectivity at both lower and higher cut-off frequencies and the great in-band performance are provided by employment of CSRR and H-shaped DGSs. Also, DGSs is used to enhance the out-of band efficency of the filter. To create a rejection band in the UWB passband, to impede intervention with WLAN band, a stepped impedance resonator (SIR) is implemented adjacent to the low-pass section on wave cancellation method. Moreover, the suggested filter do not involve the use of via-holes which decreases the difficulty of the presented structure. The measurement results for the constructed filter are well consent with simulation results and shows that it complies well the requirements of the FCC with a band-rejection at 5.7 GHz..**

**Keywords— Complementary split ring resonators (CSRR), defected ground structures (DGS), stepped impedance resonator (SIR), ultra-wideband bandpass filter (UWB BPF).**

## I. INTRODUCTION

In recent years, UWB technology has got enormous care, since it is one of promising solutions for high-rate communications in limited area, and many researches have been accomplished in this area. UWB BPF is a key and required component in UWB systems. So, recently different way and structures for the drawing of the UWB BPFs have been introduced [1-4]. Despite all the benefits of the UWB system, mainly due to its intrinsic very widespread spectrum, employing this vast range of frequencies has an unavoidable disadvantage, that is, the interference with other standard narrow-band systems that coexist with UWB system in parts of its defined spectrum (3.1-10.6 GHz), such as WLAN and satellite systems that are working at frequencies close the 5.7 and 8 GHz, respectively [1-2]. As a result, many UWB BPFs with band-rejection have been presented recently [5-9].

## II. FILTER DESIGN AND CONFIGURATION

The layout of the suggested band-rejection UWB BPF with low insertion loss and great harmonic out-of-band suppression upon a very wideband is be obvious in Fig. 1. The ultimate values of the introduced filter layout parameters are tabled in Table I.

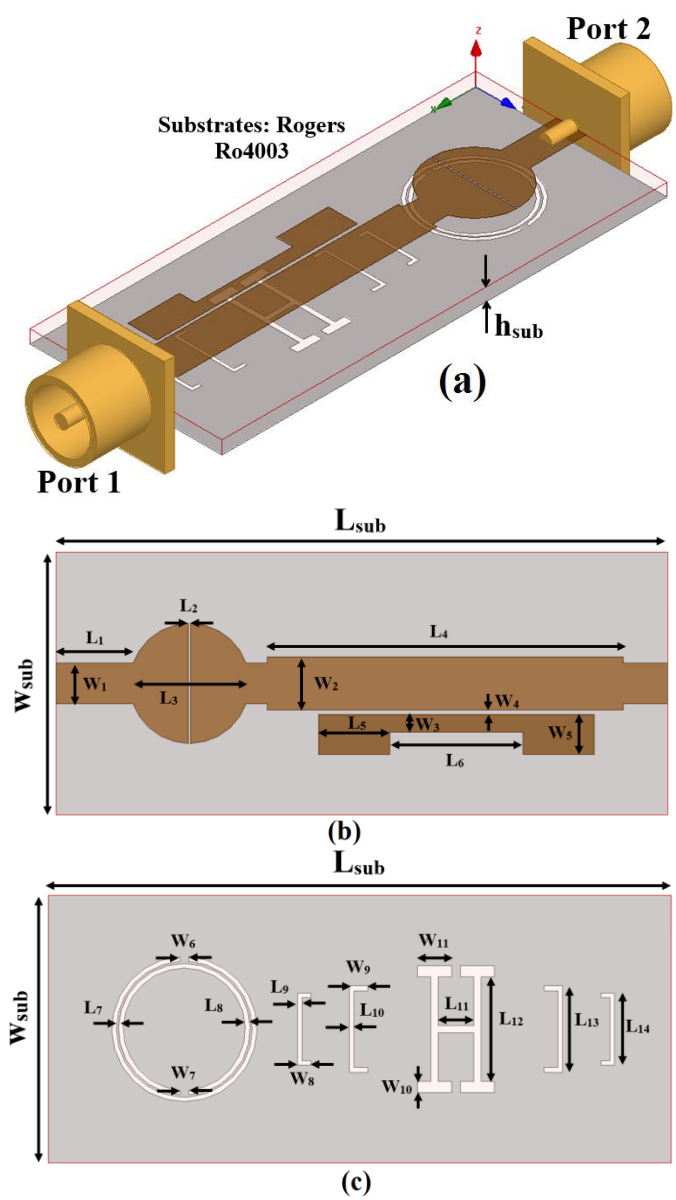


Fig. 1. The Layout of the suggested band-rejection UWB BPF: (a) side direction, (b) top direction, (c) bottom direction

TABLE I: The final values of design parameters

| Param. | mm | Param. | mm | Param. | mm |
|---|---|---|---|---|---|
| **$W_{sub}$** | **11.8** | $W_9$ | 0.8 | $L_6$ | 6 |
| $W_1$ | 1.8 | $W_{10}$ | 0.5 | $L_7$ | 0.1 |
| $W_2$ | 2.4 | $W_{11}$ | 1.5 | $L_8$ | 0.2 |
| $W_3$ | 0.8 | **$L_{sub}$** | **27.5** | $L_9$ | 0.2 |
| $W_4$ | 0.2 | $L_1$ | 3.5 | $L_{10}$ | 0.2 |
| $W_5$ | 1.8 | $L_2$ | 0.1 | $L_{11}$ | 1.6 |
| $W_6$ | 0.4 | $L_3$ | 5.4 | $L_{12}$ | 4.6 |
| $W_7$ | 0.4 | $L_4$ | 16 | $L_{13}$ | 3.8 |
| $W_8$ | 0.6 | $L_5$ | 3.2 | $L_{14}$ | 3.2 |

The suggested UWB BPF is designed on the method of cascading low-pass filter (LPF) and high-pass filter (HPF) together [8-11]. Moreover, the offered filter do not involve the usage of via-holes despite [8-10] which reduces the elaboration and expense of the presented structure. The HPF is composed of CSRR is etched in the ground plane as DGS whereas the couplings are engraved on the top of the half-circle head microstrip transmission line (TL). The stopband produced by CSRR can be changed to a thin-width passband by etching a gap, on the traditional microstrip line with uniform width [11]. The gap supplies a negative permeability and a left hand (LH) transmission band is generated. The T-type equivalent circuit-model of this structure, as suggested in [12], is displayed in Fig. 2(a). The out of band rejection level increases with the increasing gap width ($L_2$). The thin-width passband signifies that the structure is an asymmetric composite right/left hand (CRLH) TL [13].

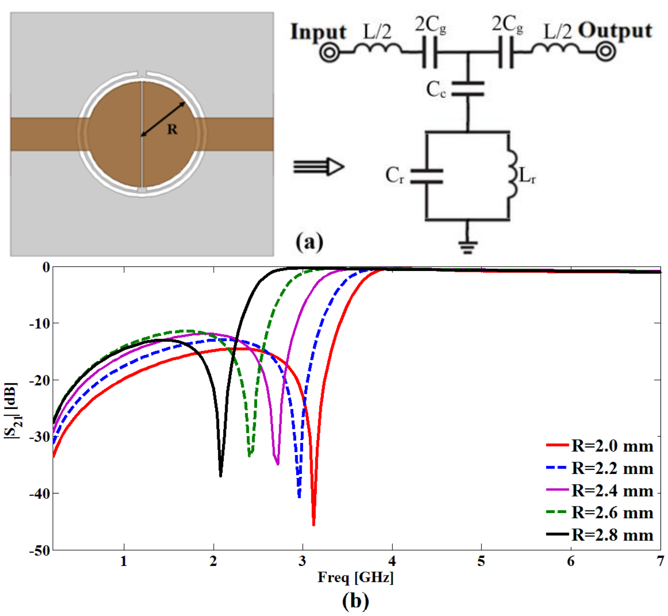


Fig. 2. (a) Equivalent circuit-model of the unit cell half-circle head microstrip TL with CSRR-DGS, (b) Effect of variation in radius of the half-circle TL on transmission response (R in part (a)).

A wide passband can be got making a symetrical CRLH TL. Here, it is realized by improving the end section of the feed lines, in the figure of half-circle heads as shown in Fig. 1(b). HPF cut off frequency is mainly specified by the CSRR dimensions ($C_r$ and $L_r$). Due to this improvement, coupling capacitance ($C_c$) and gap capacitance ($C_g$) increases in comparison with uniform width microstrip line. Increment $C_c$ decreases HPF cut of frequency and wider passband is gained [11-13]. The high skirt selectivity at lower cut-off frequency is achieved by the transmission zero (TZ) which is created by the half-circle head microstrip TL with CSRR-DGS. Fig. 2(b) shows the transmission response for various values of the half-circle TL (R in Fig. 2(a)). As it is obvious, when the values of R increases, the TZ decreases, and the cut-off frequency decreases gently, and passband can be fine-adjusted effectively by modifying this parameter. The aforesaid HPF has the main pass band 3.09 to 11.25 GHz with some higher order harmonics which degrades the upper stop band efficiency. To suppress the harmonic passband in HPF an elliptical LPF is realized with cutoff frequency 11.7 GHz.

A novel high skirt LPF is offered, which includes of C-shaped DGSs at two sides of the H-shaped DGS for symmetrical defected structure and a widened TL on top. The dimensions of the C-shaped slots can be modified until tuned the placement of its resonances and TZs toward UWB spectrum and spurious high order pass-band, respectively. By properly tuning the TZs of the DGS, the out-of-band performance of the filter can be improved and the unwanted pass-band at higher frequencies can be effectively suppressed [8-10]. An H-shaped DGS, as displayed in Fig. 1(c), is more compressed in shape. This form has a steep transition from pass to stopband, and great stopband efficiency with high attenuation level more than 28 dB. Finally, both the HPF and LPF are cascaded to get UWB BPF efficiency with wide stop-band and steep rejection skirt at the lower and upper frequency band. Fig. 2 shows the BPF and their simulated frequency responses of the suggested UWB BPF without rejection band.

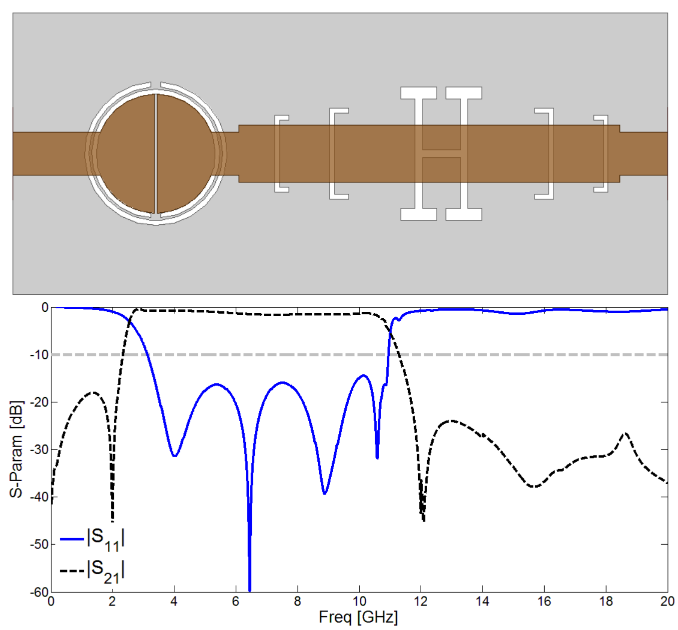


Fig. 3. Layout and frequency responses of UWB BPF without rejection band.

A SIR adjacent to the low-pass section is employed in order to make a narrow band-rejection function at WLAN frequencies. The resonant modes of SIR happens while the input admittance will be zero [1]. The main advantage of the coupled SIR is that the transmission response magnitude and frequency position in rejection band can be simply specified by adjusting the size of coupled SIRs. Also, since the distortion of the filter specifications, introduced by the external SIR at nonresonance frequencies, can be omitted, the offered UWB notch filter can be accomplished by the design of UWB BPF and external SIR respectively. The aspect behind this favorable band rejection function is also based on the wave cancellation theory which is realised through creating a new coupling signal path [6-10].

## III. RESULTS AND DISCUSSIONS

The filter substrate is RO4003 with $\varepsilon_r$ of 3.55, thickness of 0.8 mm, and tanδ of 0.0027. The fabricated prototype of the suggested UWB BPF Using cell half-circle head microstrip TL with CSRR-DGS is displayed in Fig. 4. The frequency response obtained from full wave simulation [14] and measurement of the UWB BPF is presented in Fig. 5. The prototype has a wide passband from 3.09 to 10.68 GHz with insertion loss less than 1.05 dB. Measured return loss parameter all over the passband is better than 13.1 dB. The attenuation is more than 15 dB at the center of band rejection at 5.70 GHz. The FBW of the rejection band is about 18% at 5.70 GHz. As well as, the smooth group delay is attained except at the rejection-band with utmost variation of less than 0.2 ns. The suggested filter also shows a wide upper stop band given up to 20 GHz with attenuation more than 18 dB.

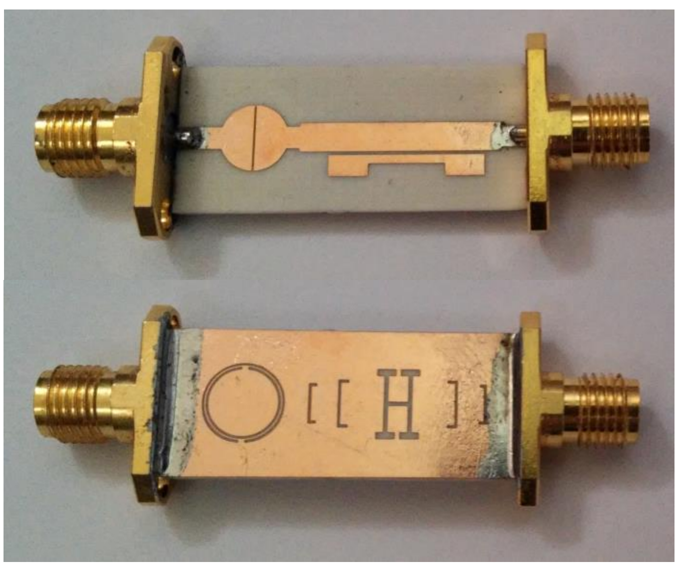

Fig. 4. The picture of the constructed filter: (a) top direction, (b) bottom direction

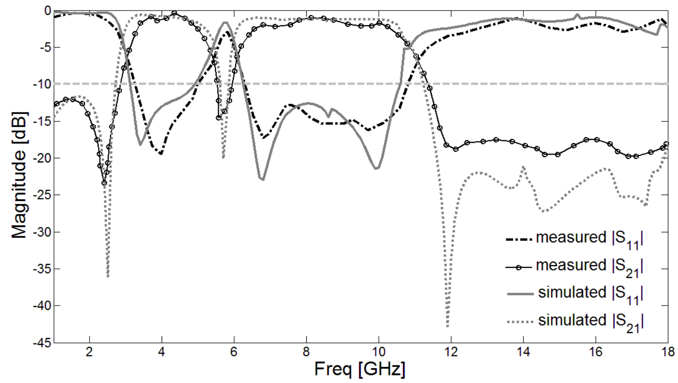


Fig. 5. Simulated and measurement frequency responses of UWB BPF CSRR-DGS with band-rejection

## IV. CONCLUSION

A novel compact UWB BPF with band-rejection performance using SIR beside the main microstrip line based on wave cancellation method was presented and discussed. The high skirt selectivity at both lower and higher cut-off frequencies and the great in-band performance are provided by employment of half-circle head microstrip TL with CSRR- and H-shaped DGSs. Moreover, the suggested filter does not involve the use of via-holes which reduces the complexity and cost of the presented structure. The main advantages of the offered structure that make the presented filter design a good nominated for UWB pplications are its high skirt selectivity at both lower and higher cut-off frequencies and good in/out of band performances while providing band-rejection function.

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