UWB BPF Built With Compact Structure Comprised of Microstrip and Coplanar Waveguide

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Abstract—Filters are the key components in communication system. Compactness of filters is an important design constraint. Due to limitations in design methods for filters at low frequency, several newer techniques for filter design at higher frequency are invented. Hybrid microstrip coplanar waveguide technique among these techniques gives a way to design a compact filter structure meeting the required (UWB) specifications. In this paper, a filter based on hybrid microstrip coplanar waveguide structure is designed. The passive elements are realized using the microstrip, coplanar waveguide (CPW) and transitions between microstrip and CPW. Multiple Mode Resonator (MMR) is formed on the CPW structured at bottom side of a substrate. The microstrip resonators are structured at top side of the common substrate. The designed filter gives five transmission poles making the design five pole UWB BPF. The fractional bandwidth obtained is 109%.

Keywords— Microstrip, Coplanar waveguide (CPW), Bandpass Filter, Electromagnetic coupling, scattering parameters.

I. INTRODUCTION

Federal Communication Commission (FCC) sanctioned the unlicensed use of frequency band starting from 3.1 GHz to 10.6 GHz as Ultra-wideband (UWB) in Feb. 2002. This band gives a spectrum of about 7500 MHz. Since then, researchers are tryimg to develop a bandpass filter which shows a good performance in UWB band. There are several advantages of UWB such as maximum bandwidth for transmission and reception of signals, low power values while communication, high speed wireless data transmission, coexistence, avoids unauthorized access of UWB signals etc.

Ultra-wideband (UWB) technology finds many applications such as imaging system, ground penetrating radar, Communications and Measurements, Vehicular radar, wall imaging, Surveillance and medical systems. The term fractional bandwidth denoted as B_f is used to define the UWB performance of designed UWB devices. For UWB band, the fractional bandwidth seems to be 110% which is more as compared to other existing systems. Systems Fractional bandwidth is defined as:

$$B_f = 2\left[\frac{(f_h - f_l)}{(f_h + f_l)}\right]$$

where f_h and f_l are the higher and lower 3 dB bandwidth, respectively. In [4], several UWB filter techniques are given. A broadband is achieved using hybrid structure of microstrip and CPW in [5].In [5], Input port is at top microstrip and output port is taken at bottom CPW. Electromagnetic coupling between microstrip & CPW plays important role in getting broad band. In [6], by adjusting the bottom CPW slots and appropriate coupling between microstrip & CPW, a five pole filter structure is designed. In [7], a broadside coupled structure is used to design UWB bandpass filter. A three & five pole compact UWB bandpass filter is designed with the help of quasilumped elements in [8]. Combination of short circuited CPW quarter wavelength resonator at bottom & parallel coupled microstrip at top is used to design a simple UWB bandpass filter in [9]. In [10], a four pole UWB bandpass filter using CPW split mode resonator at bottom and coupled microstrip at top is designed.

II. SCHEMATIC OF UWB BANDPASS FILTER

In this work, a novel MMR-predicated UWB BPF, as illustrated in Fig. 1, is proposed and implemented utilizing the hybrid microstrip/CPW structures.

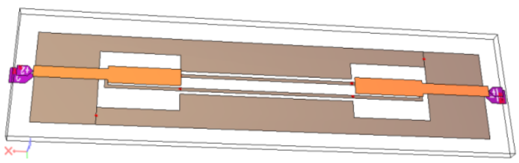

Fig. 1 3D schematic of UWB BPF

In this way, a CPW non uniform or MMR is composed on the ground plane to exhilarate and allocate the first three resonant modes occurring around the lower end, center and higher cessation of the concerned UWB passband. Meanwhile, a surface-to-surface [10] or broad-side [6] coupled microstrip/CPW structure is characterized, aiming to allocate its coupling peak with enhanced extent around the UWB's center or 6.85 GHz. This proposed UWB filter can address the two problematic issues which subsist in the initial UWB filter [7], i.e., a deficiently tight coupling degree between two side-to-side coupled microstrip lines and parasitic radiation loss from a wide divest conductor or patch in the central part of the MMR on the microstrip line. In this design, this UWB filter is composed on the

RT/Duroid 6010 with relative dielectric constant of 10.8 and thickness of 0.635 mm, and its performance is optimized via IE3D. Both presaged and quantified results exhibit a good UWB passband with five transmission poles, maximum insertion loss of 0.5 dB, and maximum group delay variation of 0.30 ns within the entire UWB passband.

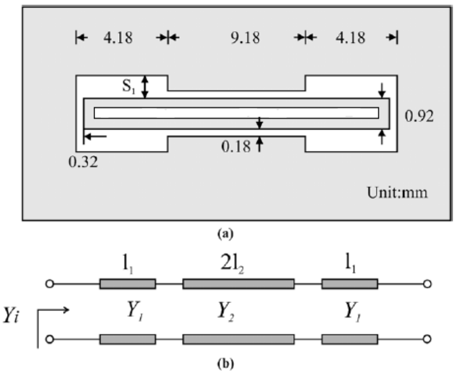

Fig. 2 Proposed MMR on coplanar waveguide. (a) Layout. (b) Equivalent transmission line network.

Let's start to construct and characterize a CPW MMR and a surface-to-surface microstrip/CPW coupling structure [10]. As shown in Fig. 2(a), the proposed open-ended MMR resonator on CPW is composed of one central CPW with narrowslot width or low impedance and two identical CPWs with wide slot width or high impedance at two sides under the fine-tuned divest width. Fig. 2(b) depicts its equipollent transmission line topology with three cascaded sections. To determine the frequencies of the three resonant modes, the input admittance (Y_i) at one of the open ends, looking into the MMR, must be zero, $Y_i = 0$. Thus, all those resonant frequencies can be solved from a transcendental equation.

As shown in Fig. 2(a), there is rectangular shaped ring structure which is a customized form of central stripof conventional CPW. Due to this ring structure, the parasitic radiation loss gets minimized to a substantial level. The three sections in this MMR are selected in such a way that the middle section has about one half guided-wavelength i.e. 9.18 mm and the two side sections have about one quarter guided-wavelength i.e. 4.18 mm at 6.85 GHz (UWB's center), respectively. As S_1 is widened, the first resonant frequency f_1 quickly increases at the beginning and then becomes saturated around 4.12–4.16 GHz. On the other hand, the second and third ones, f_2 and f_3 seem quasilinearly decreased with S_1 in the small and large degree of deviation, respectively. To achieve a UWB passband covering 3.1 to 10.6 GHz, the first three frequencies are targeted to be equally spaced in the UWB band with the locations above 3.1 GHz, near 6.85 GHz, and below 10.6 GHz. According to this criteria, the three frequencies of 4.12, 6.84, and 9.55 GHz under S_1 = 0.98 mm.

Fig. 3(a) shows a top microstrip structure and Fig. 3(b) shows bottom CPW. In this structure, the upper microstrip conductor is vertically coupled with the central divest conductor of the lower CPW on ground plane via electromagnetic coupling. Its coupling comportment can be characterized in terms of an equipollent coalesced J-inverter network as illustrated in Fig. 3(b). The J-inverter admittance in fact represents the coupling extent and its maximum peak is congruously allocated near 6.85 GHz by culling the coupling length proximate to quaerter wavelength in Fig. 3(a). Fig. 4 is the frequency-dependent-parameters of this coupling structure under different slot widths S1. As S1 is widened, the J-admittance peak is observed to elevate up significantly as studied in. Plus, the two quarter-wavelength resonators the two transmission poles can be exhilarated in the two sides of 6.85 GHz when 1.60 mm. As a result, a five-pole UWB BPF can be expected to be constructed utilizing the above resonator and coupling elements.

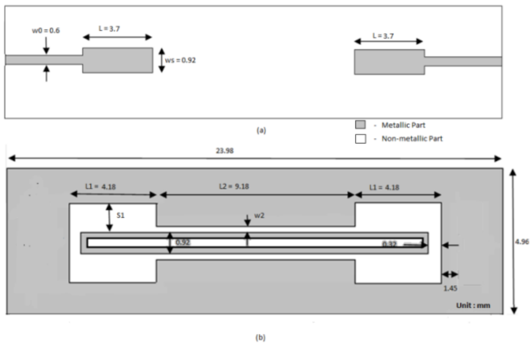

Fig. 3 Dimensions of UWB BPF (a)Top Microstrip (b) Bottom CPW

III. SIMULATION RESULT

The structure is simulated using Mentor Graphics IE3D electromagnetic simulator. The simulator uses method of moments to analyse the structure. IE3D is a full wave simulation and optimization package for the analysis and design of 3D & planar microwave circuits. Basically, it solves the Maxwell's equations in an integral form. The simulated results are shown in Fig. 3.1.

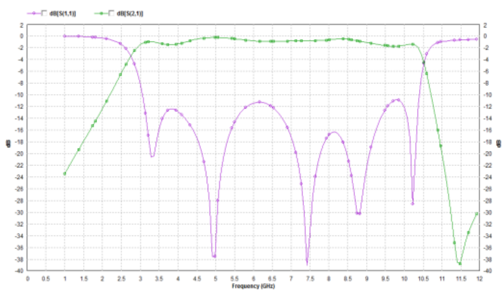

Fig. 3 Simulation Results

While simulating the structure, the ground is considered as a finite ground so differential port is applied to the structure. The insertion loss i.e. S_{21} is almost to a 0-dB line that means loss due to introduction of filter in application circuit is very less or say negligible. The return loss i.e. S_{11} is less than -10 dB. So, very less amount of power is reflecting back to the ports and proper transmission of signal from input to output port takes place.

IV. CONCLUSIONS

The designed UWB BPF shows optimum performance within ultra-wide band. A very less insertion loss of nearly 0.2 dB in UWB. Return loss is less than -10 dB at every frequency point in UWB. The size of designed filter is 23.98 x 4.96 mm^2 . This filter structure will be a good candidate for UWB devices.

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