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Design and Analysis of a Band Pass Filter on a Silicon Substrate

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Abstract: A UWB bandpass filter has been presented in this study. The filter has been designed on a silicon substrate with Perfect Electric Conductor (PEC) microstrip parallel-coupled stub resonators. The filter comprises of Wave port, Infinite Ground Plane and 1 GHz bandwidth with centre frequency, f_0 being 1.5 GHz ranges from 0.6-2.4 GHz. The filter has been designed and verified by HFSS simulation.

Key words: UWB, bandpass filter, microstrip and HFSS, PEC, Bangladesh

INTRODUCTION

The Federal Communication Commission (FCC) authorized the commercial use of the UWB technology in February, 2002. Wireless communication utilizing UWB signals has obtained great attention among industry groups, academia and standardization and regulation bodies (FCC, 2002). The microstrip bandpass filter cascaded by two stages fork-form resonators with a 3-dB fractional bandwidth of 128% (from 1.0-4.6 GHz) is designed, fabricated and tested (Chen and Zhang, 2007). Microstrip planar dual band bandpass filter by using novel feed scheme structure consists of two sets of half-wavelength resonators (Chun-Yueh *et al*., 2010). A ring resonator with a stub was proposed which shows a bandwidth of 86.6% (Ishida and Araki, 2004). The bandwidth of the passband for a bandpass filters was extended from 40-70% (Kuo and Shih, 2002).

The design and fabrication of the compact narrow band pass filter based on the Complementary Split-Ring Resonators (CSRRs) have been presented (Choi *et al*., 2009). UWB BPFs have been fabricated with FR4 PCB substrate ε_r 4.4 h, 2.4 mm; RT/duroid 5880 substrate ε_r, 2.2 h, 25 mils; duroid 5880 substrate ε_r 2.2 h, 0.38 mm and duroid 5880 substrate ε_r 2.2 h, 0.254 mm, respectively (Chen and Zhang, 2007; Chun-Yueh *et al*., 2010; Ishida and Araki, 2004; Choi *et al*., 2009). The MMR has two identical high-impedance sections with a length of quarter guided wavelength at two sides and a low-impedance section with a length of half guided wavelength in the middle. The geometry of CPW MMR can be varied (Wang and Zhu, 2005). Microstrip MMR based UWB bandpass filters are further optimized with improvement in the rejection of the upper stopband can be done by introducing interdigital microstrip coupled lines at the two sides of the MMR (Cai *et al*., 2006). There are a good number of new structures (FCC, 2002; Chen and Zhang, 2007; Chun-Yueh *et al*., 2010; Ishida and Araki, 2004; Kuo and Shih, 2002; Choi *et al*., 2009; Wang and Zhu, 2005; Cai *et al*., 2006) proposed that cover wide range of fractional bandwidth upto 128% and large return loss but none of these have zero insertion loss.

MATERIALS AND METHODS

Description: Figure 1 illustrates a general structure of parallel-coupled microstrip bandpass filters that use half-wavelength line resonators. In Fig. 2, it has shown that they are positioned so that adjacent resonators are parallel to each other along half of their length. This parallel arrangement gives relatively large coupling for a given spacing between resonators and thus, this filter structure is particularly convenient for constructing filters having a wider bandwidth as compared to the structure for the end coupled microstrip filters described in the last section (Hong and Lancaster, 2001). The design equations for this type of filter are given by:

$$\frac{J_{01}}{Y_0} = \sqrt{\frac{\pi FBW}{2g_0g_1}} \qquad (1)$$

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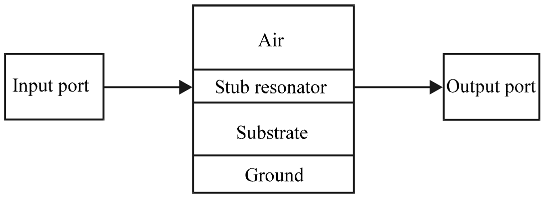

Fig. 1: The block diagram of the proposed bandpass filter

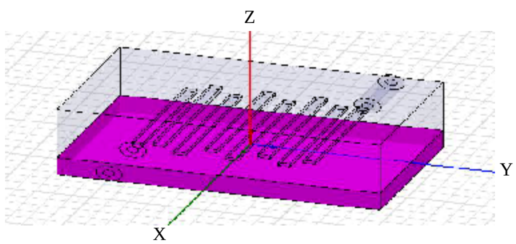

Fig. 2: The HFSS layout of the proposed bandpass filter

$$\frac{J_{j,j+1}}{Y_0}=\frac{\pi FBW}{2}\frac{1}{\sqrt{g_j g_{j+1}}} \quad (2)$$

$$(\text{For } j = 1 \text{ to } n-1)$$

$$\frac{J_{n,n+1}}{Y_0}=\sqrt{\frac{\pi FBW}{2g_n g_{n+1}}} \quad (3)$$

Where:

$g_o, g_1 \cdots g_n$ = The element of a ladder-type lowpass prototype with a normalized cutoff $\Omega c = 1$

FBW = The fractional bandwidth of bandpass filter

$J_{j,j+1}$ = The characteristic admittances of J-inverters

Y_0 = The characteristic admittance of the terminating lines (Matthaei *et al*., 1980)

RESULTS AND DISCUSSION

The main goal of present study is to design the bandpass filter having less area, excellent transmission loss (S21), low reflection loss (S11) at the pass band and wide bandwidth (Fig. 3).

In literature (FCC, 2002; Chen and Zhang, 2007; Chun-Yueh *et al*., 2010; Ishida and Araki, 2004; Kuo and Shih, 2002; Choi *et al*., 2009; Wang and Zhu, 2005; Cai *et al*., 2006), bandpass filters of several structures with different dielectric strengths have been proposed. In this research, the design process was analytical and simulation, $\lambda g/2$ parallel-coupled stub resonators was used to realize a passband from 0.6-2.4 GHz and centre frequency, f_0 1.5 GHz with bandwidth of 1.0 GHz. The current study was observed with silicon substrate (Relative dielectric constant ε_r = 11.9,

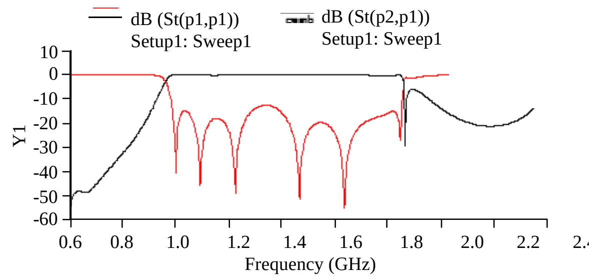

Fig. 3: S11 and S21 parameter of the UWB bandpass filter

substrate height, h = 325 miles, filter dimension = 50.8 mm ×86.36 inm), Perfect Electric Conductor (PEC) microstrip width = 3.175 mm, length = 46.177 mm, thickness = 1.524 mm, air (dimension = 50.8 mm×86.36 mm×23.495 mm/ (Rad1) boundary) and infinite ground plane having feed probe based waveport (dimension = 50.8×86.36 mm/ Ground (PerfE1) boundary) technique. The port (wave port (1.524×19.05 mm) has been designed in the air out side of substrate that would save lots of silicon. The complete design has been analyzed and studied by HFSS simulation.

CONCLUSION

The designed bandpass filter has been simulated by using High Frequency Structure Simulator (HFSS). The XY plot shows the performance of the bandpass filter which has been developed using $\lambda g/2$ parallel-coupled stub resonator. It has zero insertion loss, maximum of 1 GHz Bandwidth and >12 dB reflection loss.

REFERENCES

Cai, P., Z. Ma, X. Guan, Y. Kobayashi, T. Anada and G. Hagiwara, 2006. Synthesis and realization of novel ultra-wideband bandpass filters using 3/4 wavelength parallel-coupled line resonators. Proceedings of the Asia-Pacific Microwave Conference, December 12-15, 2006, Yokohama, pp: 159-162.

Chen, H. and Y.X. Zhang, 2007. A novel and compact UWB bandpass filter using microstrip fork-form resonators. Prog. Electromagnet. Res., 77: 273-280.

Choi, D.M., D.O. Kim and C.Y. Kim, 2009. Design of a compact narrow band pass filter using the rectangular CSRRs. PIERS online, 5: 456-460.

Chun-Yueh, H., X. Yong-Xiang and Y. Ru-Yuan, 2010. High selective dual-band bandpass filter design with novel feed scheme. Proceedings of the World Congress on Engineering, June 30-July 2, 2010, London, UK.

FCC, 2002. First Report and Order in the matter of revision of part 15 of the commission's rule regarding Ultra-wideband transmission system. FCC ET Docket, pp: 98-153.

Hong, J.S. and M.J. Lancaster, 2001. Microstrip Filters for RF/Microwave Application. 1st Edn., John Wiley and Sons Inc., New York.

Ishida, H. and K. Araki, 2004. A Design of tunable UWB Filters, International Microwave Symposium. Fort Worth, Texas, USA.

Kuo, J.T. and E. Shih, 2002. Wideband bandpass filter design with three-line microstrip structures. Microw. Antennas Propag., 149: 243-247.

Matthaei, G., L. Young and E.M.T. Jones, 1980. Microwave Filters, Impedance-Matching Networks and Coupling Structures. Artech House, Norwood, MA.

Wang, H. and L. Zhu, 2005. Ultra-wideband bandpass filter using back-to-back microstrip-to-CPW transition structure. Electron. Lett., 41: 1337-1338.