NOVEL COMPACT SIZE BANDSTOP FILTER WITH SHORTED-STUB LOADED RING RESONATOR

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ABSTRACT: *A planar compact bandstop filter (BSF) and a miniaturized resonator structure are presented along with its analytical equation to obtain resonance. The resonator is miniaturized by means of a shorted-stub which is loaded to a closed-loop resonator. Design and implementation of a 2.1 GHz BSF with 6% fractional bandwidth is presented.* © 2011 Wiley Periodicals, Inc. Microwave Opt Technol Lett 53:2766–2768, 2011; View this article online at wileyonlinelibrary.com. DOI 10.1002/mop.26439

Key words: *bandstop filters; microwave filters; compact filters; narrow-band filters; microstrip resonators*

1. INTRODUCTION

Recent advances in the field of modern RF/microwave communication systems have increased the demand for miniaturized components. In RF and microwave systems, active devices, such as oscillators and mixers, are systematically followed by bandpass/bandstop filters to remove harmonics and other spurious signals. On the other hand, microstrip filters have the advantages of low-cost, low-weight, and ease of implementation. In this context, numerous efforts have been conducted to reduce the size of microstrip bandstop filters (BSF) [1–10].

Circuits with resonators coupled to main transmission line (TL) are widely accepted for narrow band BSF. Figure 1(a) and (b) shows two typical configurations [8]. In Figure 1(a) the main TL is electrically coupled to half-wavelength open resonators spaced a quarter guided wavelength, whereas in Figure 1(b), the main TL is magnetically coupled with CLRs spaced a quarter guided wavelength. Evidently, the size of the resonator is very important for the size of the filter; in this context miniaturized resonator are desired for compact filters.

In this work, a bandstop filter is presented based on a new miniaturized microstrip resonator which is eight times smaller than a conventional closed loop resonator. Analytical equations for the resonant frequency are presented. A 2.1 GHz filter with 6% fractional bandwidth is presented showing good agreement between simulation and experimental results.

2. SHORTED-STUB LOADED RING RESONATOR

The proposed resonator and its equivalent circuit are shown in Figure 2(a) and (b), respectively. The equivalent circuit of the proposed resonator consists of two subcircuits. Subcircuit1 is a two port network composed by two TLs with length $L/2$ connected in parallel. Subcircuit2 is a grounded TL with length $L/4$ and impedance Z_0.

The Y-parameter matrix of subcircuit1 is given in Eq. (1)

$$Y=\begin{bmatrix} \frac{-2j}{Z_0}\cot 2\theta & \frac{2j}{Z_0}\csc 2\theta \\ \frac{2j}{Z_0}\csc 2\theta & \frac{-2j}{Z_0}\cot 2\theta \end{bmatrix} \tag{1}$$

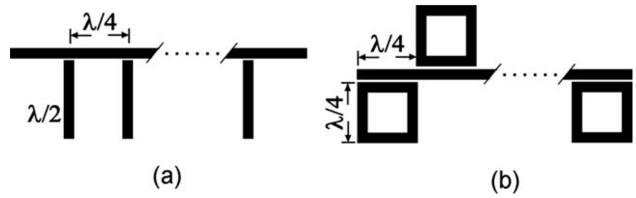

Figure 1 Typical configuration for narrow-band stopfilters using (a) half-wavelength and (b) closed loop resonators

where

$$\theta = \beta L/4 \tag{2}$$

and β is the propagation constant.

The input impedance looking into subcircuit2 is given in Eq. (3)

$$Z_s = jZ_0 \tan\left(\beta\frac{L}{4}\right) \tag{3}$$

It is well-known that when a two-port network is loaded with an impedance Z_L at port2, then the input impedance looking into port1 is given in Eq. (4)

$$Z_{inr} = \frac{1 + Z_L Y_{22}}{Z_L(Y_{11}Y_{22} - Y_{12}Y_{21}) + Y_{22}} \tag{4}$$

At resonance, the denominator of Z_{inr} is equal to zero, which gives Eq. (5)

$$Z_L\left(\frac{2}{Z_0}\right)^2 + Y_{22} = 0 \tag{5}$$

For the proposed resonator, Z_L is the input impedance looking into subcircuit2. Therefore, $Z_L = Z_s$. Using Eqs. (1)–(3) to solve (5) it can be found that resonance (f_o) occurs when:

$$\Theta = 0.42 \text{ radians} = 24 \text{ deg} \tag{6}$$

Based on Eq. (6) the proposed resonator may be readily designed. On the other hand, the fundamental resonant frequency is given by:

$$f_0 = \frac{0.42}{\pi L}\frac{2c}{\sqrt{\varepsilon_{eff}}} \tag{7}$$

where, c is the speed of the light in free space, ε_{eff} is the static effective relative dielectric constant, and L is the length of the ring resonator of subcircuit1.

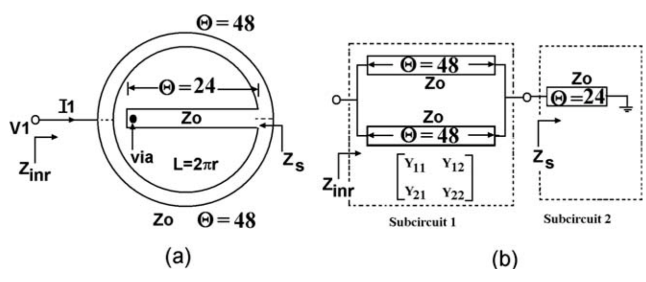

Figure 2 Schematic of (a) proposed resonator and (b) equivalent circuit

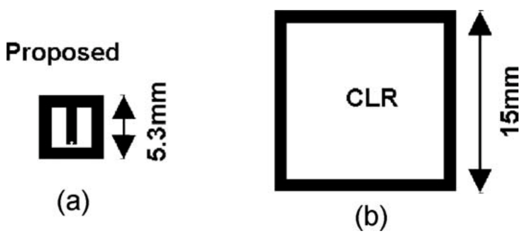

Figure 3 (a) Proposed resonator and (b) CLR resonator designed at 2.1 GHz

3. A 3-POLE BANDSTOP FILTER

A 2.1-GHz resonator was designed using the RT-Duroid 6010 substrate ($\varepsilon_r = 10.8$ and $h = 1.27$ mm). In Figure 3(a) dimensions of the resonator are given. It can be seen that the area of the proposed resonator is $0.0371\lambda \times 0.0371\lambda$ ($=5.3 \times 5.3$ mm^2). With the aid of an electromagnetic simulator the resonant frequency was verified and the unloaded Q factor was calculated, giving a value of $Q_u = 110$. For comparison, in Figure 3(b), a 2.1 GHz conventional CLR was designed; occupying an area of $0.105\lambda \times 0.105\lambda$ ($=15 \times 15$ mm^2) which is eight times larger than the proposed resonator.

On the basis of the novel resonator, a three-pole ($n = 3$) Chebyshev bandstop with ripple of 0.01 dB is having a fractional bandwidth FBW = 6%. The design starts using the reactance slope parameter expression Eq. (8) suggested in Ref. 11

$$\frac{x_i}{Z_0} = \frac{g_0}{g_i\,\Omega_C\,\mathrm{FBW}} \tag{8}$$

where, g_i is the ith element of low-pass prototype, $Z_0 = 50\ \Omega$, Ω_c is the angular cutoff frequency, FBW is the fractional bandwidth, and x_i/Z_0 is the normalized reactance slope parameter for the ith resonator. In our design, FBW = 0.06 which gives the following low-pass prototype parameters: $\Omega_c = 1$ and $g_0 = g_4 = 1.0$, $g_1 = g_3 = 0.6292$, and $g_2 = 0.9703$ therefore, $x_1/Z_0 = 26.489$, $x_2/Z_0 = 17.18$, and $x_3/Z_0 = 26.489$.

In order to extract the slope parameter from the filter layout, full wave simulations are carried out where a resonator is coupled to a 50 Ω transmission. Then, the spacing (s) between the line and resonator are varied and normalized reactance is obtained from Eq. (9).

$$\frac{x_s}{Z_0} = \frac{f_0}{2\ \Delta f_{3\mathrm{dB}}} \tag{9}$$

In Eq. (9) f_0 and $\Delta f_{3\ \mathrm{dB}}$ are the resonant frequency and the 3 dB bandwidth which are obtained from the S_{21} parameter. For different spacings, a plot of normalized reactance versus the spacing is obtained as shown in Figure 4 and then required spacings are chosen. For our design, the required spacings are $s_1 = s_3 = 0.230$ mm and $s_2 = 0.114$ mm.

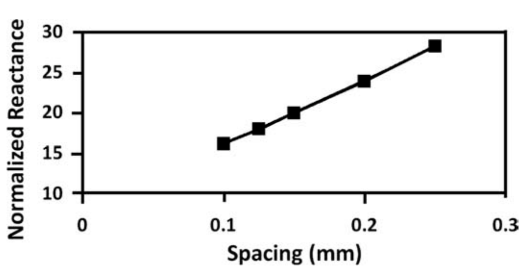

Figure 4 Normalized reactance versus spacing

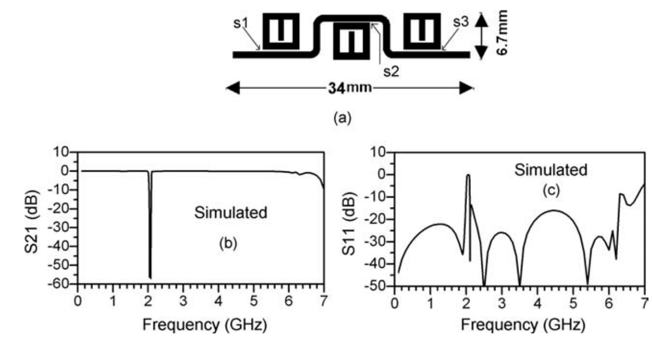

Figure 5 (a) Proposed three-pole miniaturized BSF, (b) simulated S_{21}, and (c) simulated S_{11}

Finally, the filter is implemented, by cascading the three resonators by 90° 50 Ω TLs as shown in Figure 5(a). Simulated scattering parameters of the BSF filter are shown in Figure 5(b) and (c). From this figure, it can be observed that the central frequency is 2.1 GHz, the attenuation in the stopband is better than 25 dB, and the bandwidth is 6%.

4. EXPERIMENTAL RESULTS

Figure 6(a) shows the photograph of the fabricated microstrip bandstop filter. Measurements were performed using the Agilent PNA Series microwave Vector Network Analyzer (E8361A). Measured results of the filter are illustrated in Figure 6(b) and (c). The central frequency is 2.1 GHz and the measured bandwidth is 5%. It can be seen that the stopband attenuation is better than 25 dB.

5. CONCLUSION

In this work, a novel compact microwave band stop filter at 2.1 GHz with 6% fractional bandwidth was proposed. The filter is based on a new miniaturized microstrip resonator which is eight times smaller than a conventional closed loop resonator. Analytical equations for the resonant frequency were presented. Moreover, a three-pole Chebyshev bandstop filter was realized and measured which shows good agreement between simulations and experiments.

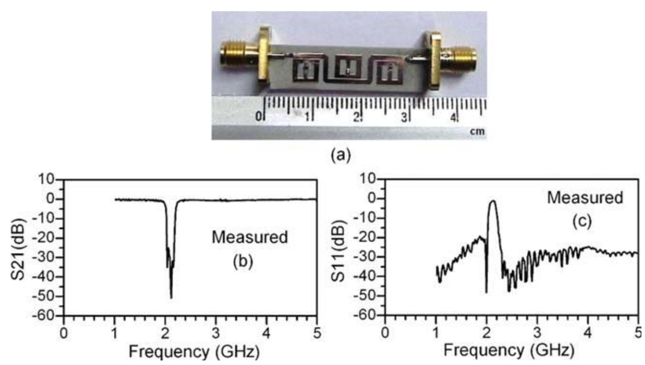

Figure 6 (a) Photograph of the fabricated microstrip bandstop filter, (b) measured S_{21}, and (c) measured S_{11}. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com]

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REFERENCES

1. A. Görür and C. Karpuz, Reduced-size wideband bandstop filter using two open-circuited shunt stubs spaced by a double-length transmission-line element, Int J RF Microw Comput Aided Eng 15 (2005), 79–85.
2. R.-Y. Yang, M.-H. Weng, C.-Y. Hung, H.-J. Chen, and M.-P. Houng, Novel compact microstrip interdigital bandstopfilters, IEEE Trans Ultrason Ferroelectrics Frequency Control 51 (2004), 1022–1025.
3. W.-H. Tu and K. Chang, Compact microstrip bandstop filter using open stub and spurline, IEEE Microw Wireless Compon Lett 15 (2005), 268–270.
4. M.-Y. Hsieh and S.-M. Wang, Compact and wideband microstrip bandstop filter, IEEE Microw Wireless Compon Lett 15 (2005), 472–474.
5. W.-H. Tu and K. Chang, Compact second harmonic suppressed bandstop and bandpass filters using open stubs, IEEE Trans Microw Theor Tech 54 (2006), 2497–2502.
6. H. Lim, J.-H. Lee, S.-H. Lim, D.-H. Shin, and N.-H. Myung, A novel compact microstrip bandstop filter based on spiral resonators, Proceedings of Asia-Pacific Microwave Conference APMC, Thailand, 2007,1–4.
7. S. Fallahzadeh and M. Tayarani, A compact microstrip bandstop filter, Prog Electromagn Res Lett 11 (2009), 167–172.
8. J.-S. Hong and M.J. Lancaster, Microstrip filters for RF/microwave applications, Wiley series in microwave and optical engineering. New York, Wiley & Sons, 2001.
9. C.-Ch. Yu and K. Chang, Transmission-line analysis of a capacitively coupled microstrip-ring resonator, IEEE Trans Microw Theor Tech 45 (1997), 2018–2024.
10. L.-H. Hsieh and K. Chang, Compact, low insertion-loss, sharp-rejection, and wide-band microstrip bandpass filters, IEEE Trans Microw Theor Tech, 51 (2003), 1241–1246.
11. B.-B. Zabdiel, Ll.-G. Ignacio, P.-C. Lluis, and C.-Ch. Alonso, Microstrip switchable bandstop filter using PIN diodes with precise frequency and bandwidth control, Proceedings of 38th European Microwave Conference, Amsterdam, Holland, 2008, 1707–17010.

MODIFIED DUAL MONOPOLE ANTENNA FOR WLAN OPERATION

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ABSTRACT: *A novel and simple design of a coplanar waveguide-fed folded dual monopole antenna with dual-band frequency operation for a wireless local area network (WLAN) application is proposed. The obtained impedance bandwidths reach about 37.3% for the 2.4 GHz and 15.5% for the 5.8 GHz band, meeting the required bandwidth specifications of the IEEE 802.11a/b/g standards. The peak antenna gains for the operating frequencies across dual WLAN bands are measured to be 6.30 and 5.16 dBi, respectively.* © 2011 Wiley Periodicals, Inc. Microwave Opt Technol Lett 53:2768–2770, 2011; View this article online at wileyonlinelibrary.com. DOI 10.1002/mop.26428

Key words: *dual monopole; dual band; WLAN; antenna*

1. INTRODUCTION

Dual and multifrequency band operation of antennas has received much attention due to the tremendous growth in wireless communication technology. Wireless local area network (WLAN) is an important application of wireless communication technology that takes advantage of license-free industrial, scientific, and medical bands and especially for the IEEE 802.11a/b/g WLAN standards in the 2.4 GHz (2400–2484 MHz), 5.2 GHz (5150–5350 MHz), and 5.8 GHz (5725–5825 MHz) band [1–3].

Developing efficient dual-band antennas is essential to the integration of these bands for use in one device. The printed monopole antenna is a good candidate for wireless communication due to its simple structure, omni-directional radiation characteristic, low profile, and being lightweight [4–6].

This letter proposes a folded dual monopole antenna with good radiation characteristics to enhance the bandwidths to cover all the 2.4/5.2/5.8-GHz WLAN bands. The proposed antenna comprises two symmetric strip arms of planar monopole elements with identical dimensions. The details of the antenna design are described, and the prototypes of the proposed monopole antenna for WLAN operation in the 2.4 and 5.8 GHz are presented and discussed.

2. ANTENNA DESIGN

Figure 1 shows the geometry of the proposed coplanar waveguide (CPW)-fed dual monopole antenna to achieve dual band frequency operation. The proposed antenna is fabricated on a 1.52-mm thick Teflon substrate of relative permittivity 3.5 and loss tangent 0.0018. Two finite ground planes with the same width GW and length GL, are situated symmetrically on each side of the CPW feeding line. A CPW-fed line designed with a fixed signal strip thickness $w_1 = 3$ mm and a gap distance of $g_1 = 0.2$ between the single strip is selected for the CPW characteristic impedance of 50 Ω. The antenna consists of symmetrical strip lines that have a uniform width of 3 mm for the design convenience.

The HFSS is used for the numerical analysis required, and to obtain the appropriate geometrical parameters in Figure 1, to investigate the performance of the proposed antenna

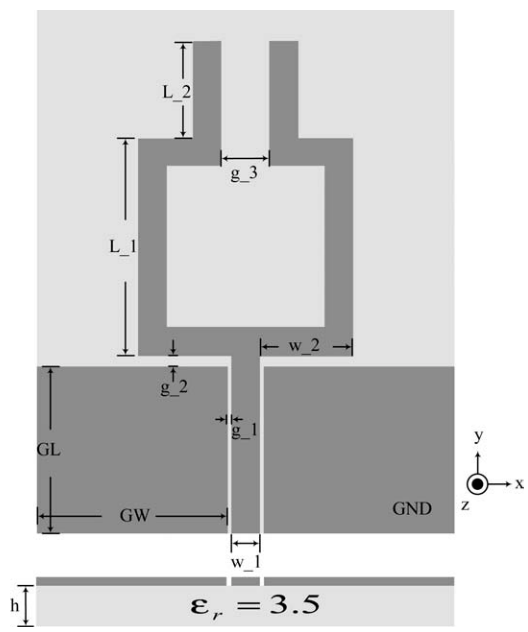

Figure 1 Geometry of the proposed antenna