INTEGRATED PRINTED WIDEBAND ANTENNA

WITH L-RESONATOR BAND-STOP FILTERS

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ABSTRACT

A new antenna with a L-resonator band-stop filter is presented. This device integrates an electromagnetic coupled L-resonator band-stop filter with a printed planar monopole antenna. This new device is suitable for creating wideband antenna with narrowband interferer rejection characteristics.

1. INTRODUCTION

The increasing demand for communication systems has call for the design of low-cost and small-size radio frequency and microwave transceivers. One of the design approaches is to integrate different parts of components into a single element such that fewer components are to be used. To realize a high data rate of wireless transmission, it is necessary to use a wideband antenna, and to suppress the interference signals in this band. Band-stop filters have been widely used in many microwave circuits and systems [1-2]. In particular, narrowband reject (or notch) filters have become more and more important in most microwave communications and radar systems as there exist more unwanted signals or interferences at air interfaces. Recently, it has been demonstrated that by etching a proper quarter wavelength slot or slit in the interior of the radiating element [3-4] or by inserting a capacitively coupled resonator at the ground plane layer [5], a single or multiple band-stop function within a wide operating bandwidth can be obtained.

The objective of this paper is to describe a combination of a wideband planar monopole antenna and a L-resonator band-stop filter useful for such applications.

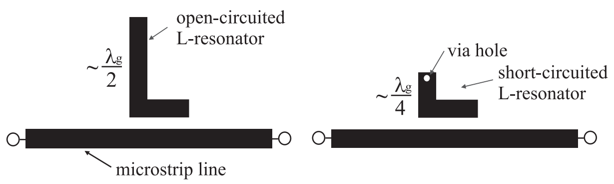

Figure 1. Band-stop filter with shunt-connected L-resonator [1]

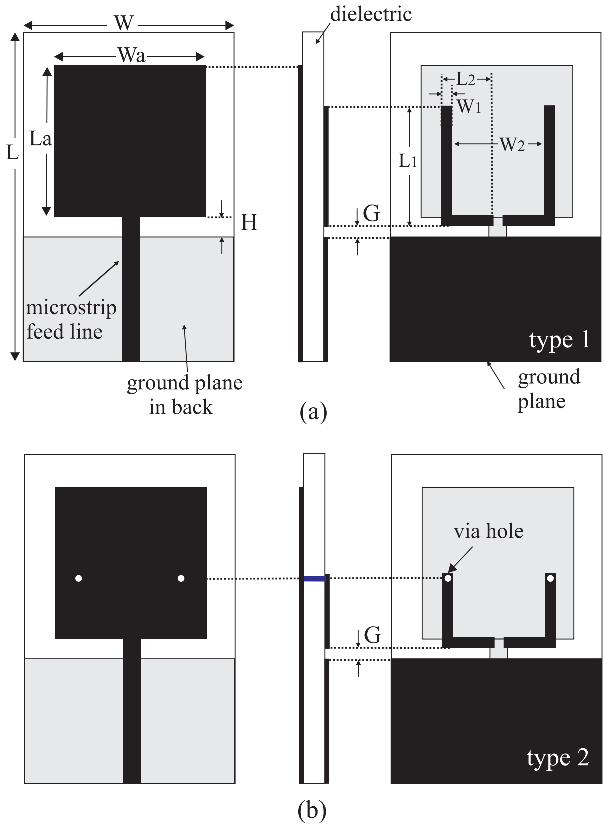

Figure 2. The proposed wideband antenna with L-resonator band-stopfilters : (a) open-circuited resonator (type 1),(b)short-circuited resonator (type 2)

2. DESIGN OF ANTENNA WITH L-SHAPED RESONATOR

Fig. 1 shows the typical configuration for TEM or quasi-TEM narrowband band-stop filter with shunt-connected L-resonator. A main transmission line is electromagnetically coupled to the open-circuited half wavelength resonator or the short-circuited quarter wavelength resonator. Planar monopoles with various radiator shapes such as circular, square, elliptical, pentagonal and hexagonal, have been widely discussed and used [6-8].

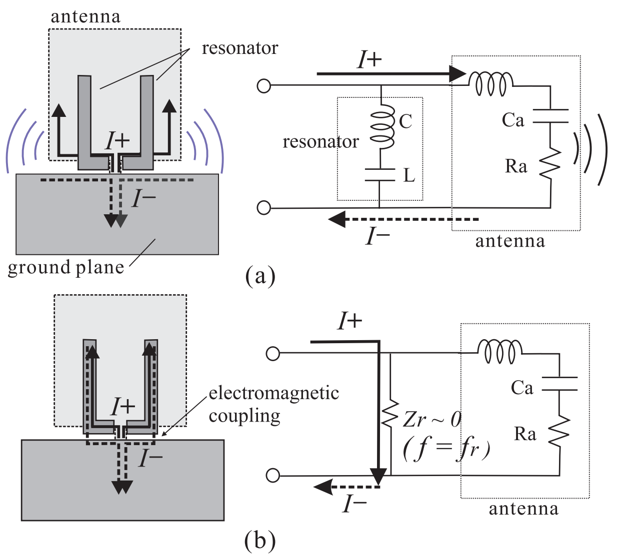

Figure 3. Conceptual equivalent lumped-element circuit model of the antenna-filter device with type 1

These broadband monopoles feature wide operating bandwidths, satisfactory radiation properties, simple structure and easy of fabrication. However they are not planar structure because their ground planes are perpendicular to the radiators. As a result, they are not suitable for integration with printed circuit board. This drawback limits practical applications of these broad band antenna with filter.

Fig. 2 shows the geometry of the proposed wideband antenna with L-resonator band-stop filter. A planar monopole with a rectangular patch size, 18×20 mm^2, and a 50 ohms microstrip feed line are printed on the same side of the dielectric substrate (in this study, the Teflon substrate of thickness 0.76mm and the relative permittivity 3.5 was used). L (=45mm) and W (=28mm) denote the length and the width of the dielectric substrate, respectively. On the other side of the substrate, the conducting ground plane with a length of Lg (=22.5mm) only covers the section of the microstrip feed line. H is the height of the feed gap between the feed point and the ground plane. H is constant at 2.5mm in this study. Also, the L-resonator band-stop element is introduced on the opposite side of the dielectric substrate and is coupled to the ground part (or imaging part) of the main planar monopole antenna. G is the height of the coupling gap between the resonator and the ground plane. W_1 denote the width of the resonator, and the length of the resonator is $L_1 + L_2$. The addition of an electromagnetic coupled L-resonator element makes a band-stop characteristic.

The conceptual equivalent lumped-element circuit model for the proposed antenna-filter is given in Fig. 3.

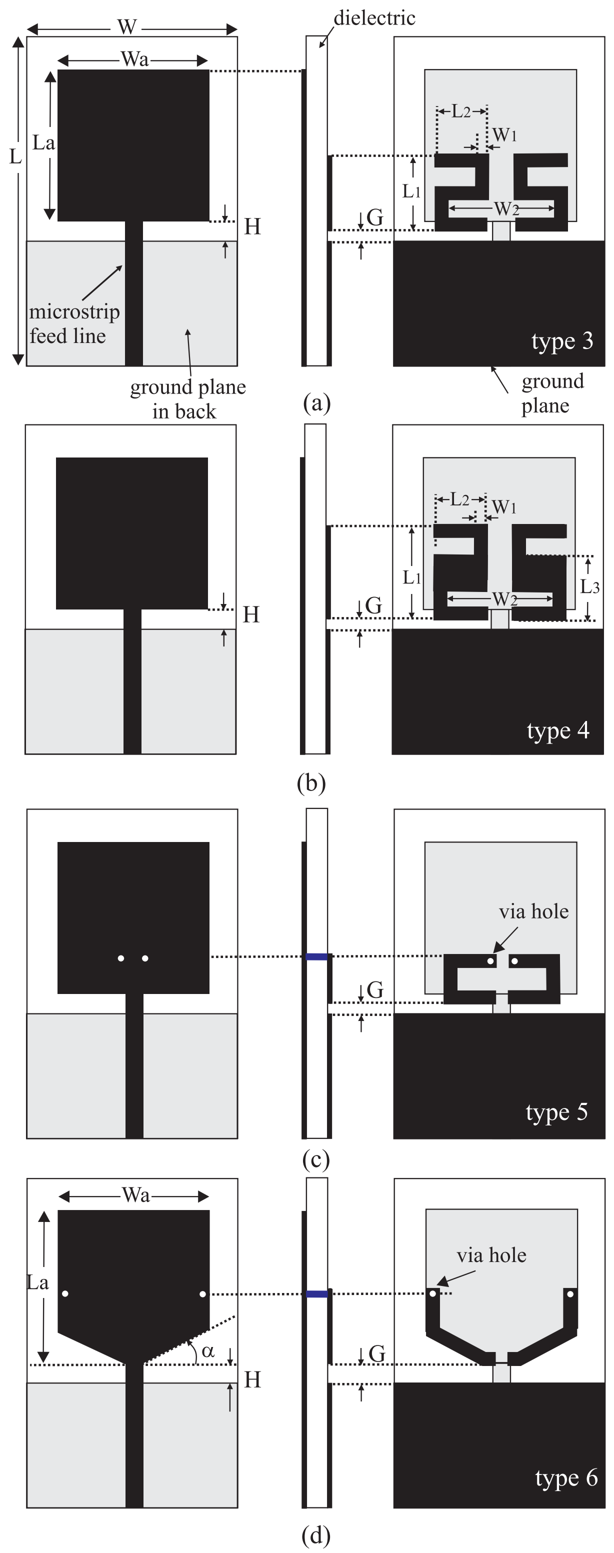

Figure 4. The planar monopole antenna with band-stop filters : (a) open-circuited mender line resonator(type 3), (b) open-circuited step-impedance meander line resonator (type 4), (c) short-circuited meander line resonator (type 5), (d) short-circuited line resonator (type 6)

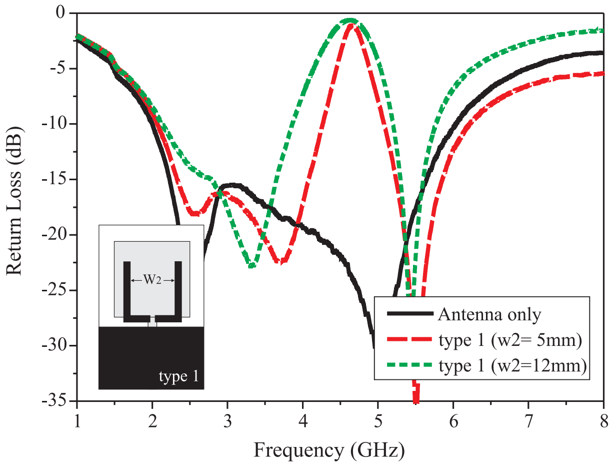

Figure 5. Measured return loss against frequency of type 1 with W1=1mm, W2=5mm, L1=18mm ,L2=3mm and W1=1mm, W2=12mm, L1=18mm,L2=3.5mm.

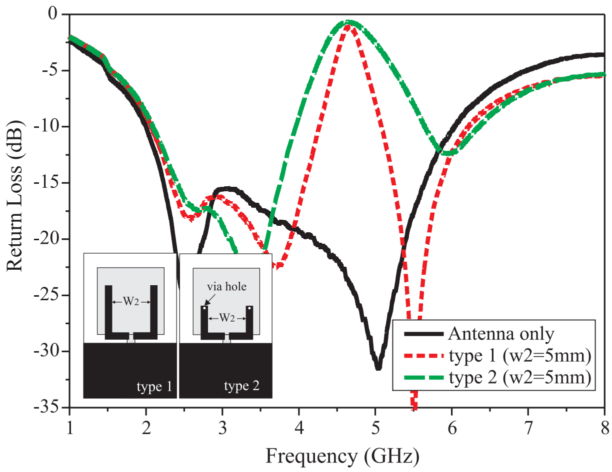

Figure 6. Measured return loss against frequency with type 1(W1=1mm, W2=5mm, L1=18mm, L2=3mm) and type 2 (W1=1mm,W2=5mm, L1=8mm,L2=3mm)

The electromagnetically coupled open-circuited half wavelength resonator is modeled by a lumped capacitor in series with a transmission line inductor which is less than a half wavelength $\lambda_g/2$ long at the resonance frequency (f_r).

3. RESULTS AND DISCUSSION

The simulation are performed using the CST Microwave Studio package which utilizes the finite integration technique for electromagnetic computation. Fig. 4 shows the proposed wideband antenna with various electromagnetic coupled resonators, such as open-circuited meander line, open-circuited step-impedance meander line and short-circuited meander line.

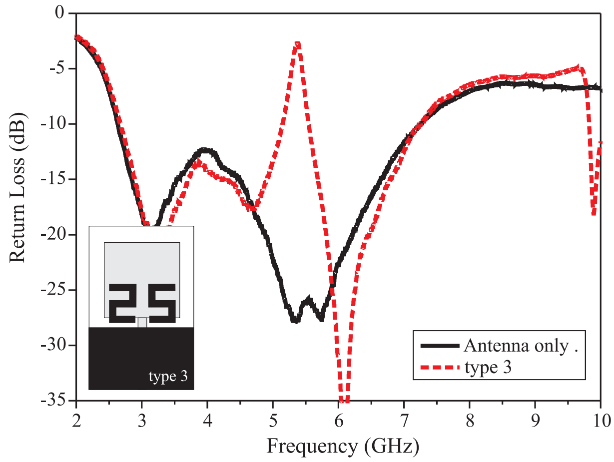

Figure 7. Measured return loss against frequency with type3(W1=0.5mm,L1=3.5mm,L2=6mm,W2=14mm)

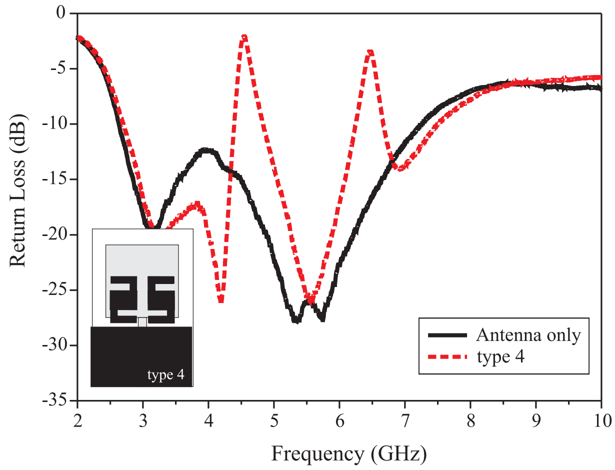

Figure 8. Measured return loss against frequency with type4 (W1=0.5mm, L1=10mm, L2=6mm, L3=7mm, W2=14mm)

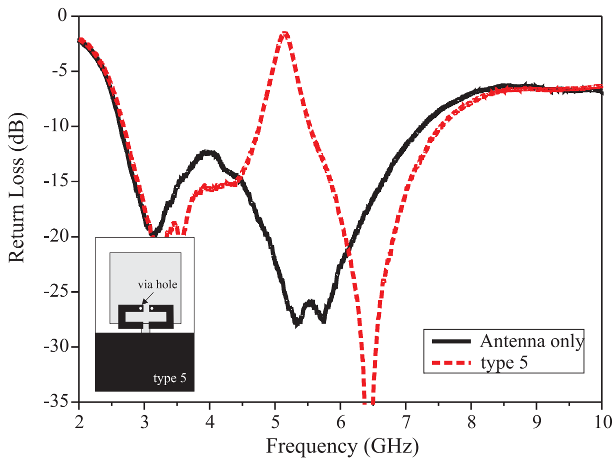

Figure 9. Measured return loss against frequency with type 5 (W1=0.5mm, L1=2mm, L2=6mm, W2=14mm)

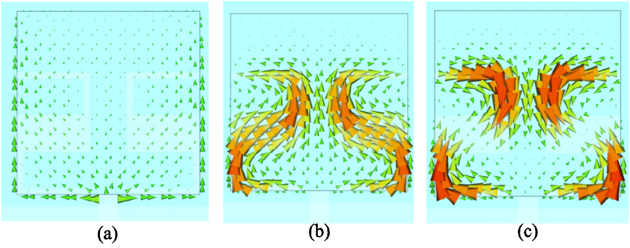

Figure 10. Simulated results of notch characteristics of type 4 ; (a)surface current at 3GHz passband, (b) surface current at 4.34GHz notch band, and (c) surface current at 6.31GHz notch band

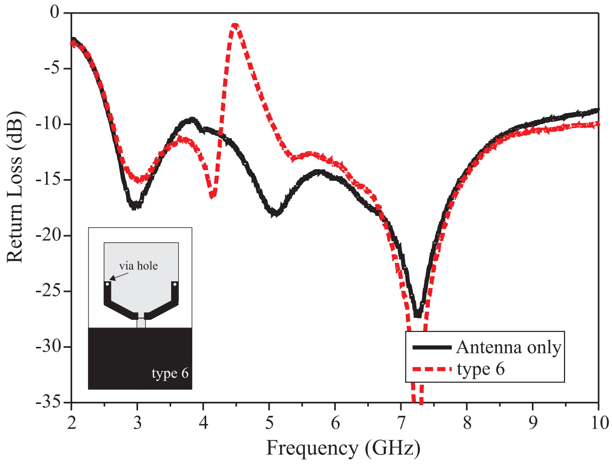

Figure 11. Measured return loss against frequency with type 6

The frequency notched characteristic of the antenna was investigated experimentally. Fig. 5 shows the measured return loss for the cases with different distance W_2. It is clear that by increasing W_2, the notch bandwidth can be increased significantly. Fig. 6 shows the measured return loss for the cases with open-circuited resonator and short-circuited resonator. In the case of short-circuited resonator, the notch bandwidth is affected by the parasitic inductance of the via hole. Fig.7 shows the measured return loss of the wideband monopole antenna with the open-circuited meander line resonator. Fig.8 show the measured return loss of the wideband monopole antenna with the open-circuited step impedance meander line resonator. It shows the dual-band notch characteristic. Fig. 9 shows the measured return loss of type 5. Fig.10 shows the simulated surface current of type 4. At the 3.0 GHz pass band, the currents are concentrated at the bottom of antenna patch. But, at the notch band of 4.34GHz and 6.31GHz, the currents are concentrated at the step impedance resonator, then the field is not radiated. Fig. 11 shows the measured return loss of type 6.

4. CONCLUSION

In this paper, we proposed the planar monopole antenna with L-resonators. By inserting the L-resonator at the ground plane, the notch-band characteristics are created.

REFERENCES

[1] H.C.Bell, "L-Resonator Bandstop Filters", *IEEE Trans. Microwave Theory Tech.*, vol.44, no.12, pp. 2669-2672,Dec.,1996.

[2] C.Nguyen and K.Chang, "On the Analysis and Design of Spurline Bandstop Filters", *IEEE Trans. Microwave Theory Tech.*, vol.33, no.12, pp.1416-1421, Dec.,1985.

[3] W.S.Lee, D.Z.Kim, K.J.Kim and J.W.Yu, "Wideband Planar Monopole Antenna with Dual Band-Notched Characteristics", *IEEE Trans. Microwave Theory Tech.*, vol.54,no.6,pp.2800-2806,Jun.,2006.

[4] W.S.Lee, W.G.Lim, and J.W.Yu, "Multiple Band-Notched Planar Monopole Antenna for Multiband Wireless Systems", *IEEE Microwave and Components Letters*, vol.15, no.9, pp.576-578, Sept.,2005.

[5] W.S.Lee, J.H.Kim and J.W.Yu, "Capacitively Coupled Band-Stop Filter with An Integrated Antenna", *Proc in IEEE MTT-S, Int. Microwave Symp*, pp.2019-2022,Jun.,2006.

[6] M.J.Ammann, and Z.N.Chen "Wideband monopole antennnas for multiband wireless systems", *IEEE Antennas Propag. Mag* ,vol.45, no.2, pp. 146-150,2003.

[7] N.P.Agrawall, G.Kumar and K.P.Ray, "Wideband planar monopole antennnas", *IEEE Trans. Antennas Propag.*, vol.46, no.2, pp.294-295,1998.

[8] Z.N.Chen, M.Y.W.Chia, M.J.Ammann, "Optimization and comparision of broadband monopoles", *IEE Proc. Microw. Antennas Propag.*,vol.150, no.6, pp. 429-435, 2003.