COMPACT FREQUENCY-NOTCHED WIDEBAND PLANAR MONOPOLE ANTENNA WITH AN L-SHAPE GROUND PLANE

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ABSTRACT: *A wideband planar monopole antenna with an L-shape ground plane is presented. The antenna also has a frequency-notching characteristic. By etching a half-wavelength U-shaped slot in the interior of the radiation element, the frequency-notching characteristic has been created. This paper presents the design and experimental results of the proposed antenna. Moreover, the study also investigates the tuning effects of the geometry parameters on the impedance matching.* © 2005 Wiley Periodicals, Inc. Microwave Opt Technol Lett 46: 340–343, 2005; Published online in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/mop.20981

Key words: *antennas; planar-monopole antenna; frequency-notched wideband antennas; UWB antennas; L-shape ground plane*

1. INTRODUCTION

Ultra-wideband antennas are becoming very attractive for future software-defined and reconfigurable wireless systems. Planar monopole and dipole antennas show good promise for use in UWB systems. Despite the FCC's approval for UWB operation over 3.1 to 10.6 GHz, it may be necessary to notch out portions of the band in order to avoid interference with existing wireless networking technologies such as GPS and wireless LAN systems.

As communication devices have become smaller and more compact, due to the greater integration and functionality of electronics and smaller printed-circuit-board configurations, the antenna has become a significantly larger part of the overall package volume. Finding space for the antenna without compromising its performance characteristics is increasingly demanding.

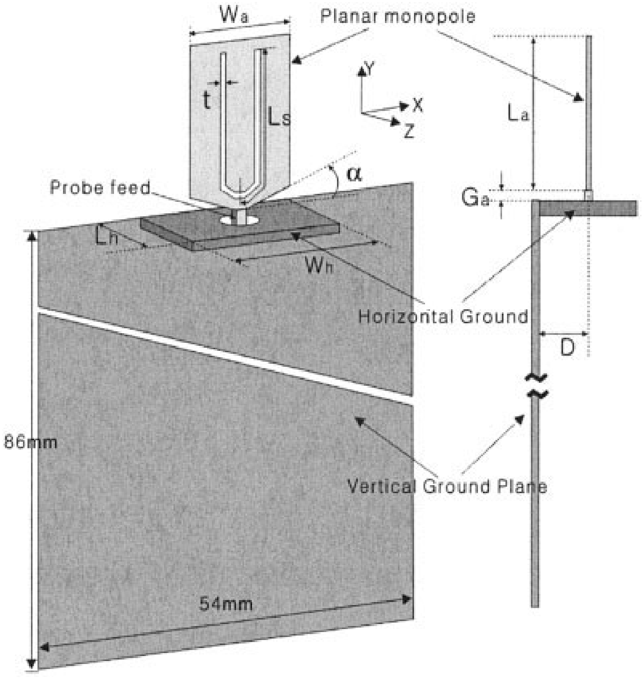

Figure 1 Geometry of the proposed wideband planar monopole antenna with L-shape ground

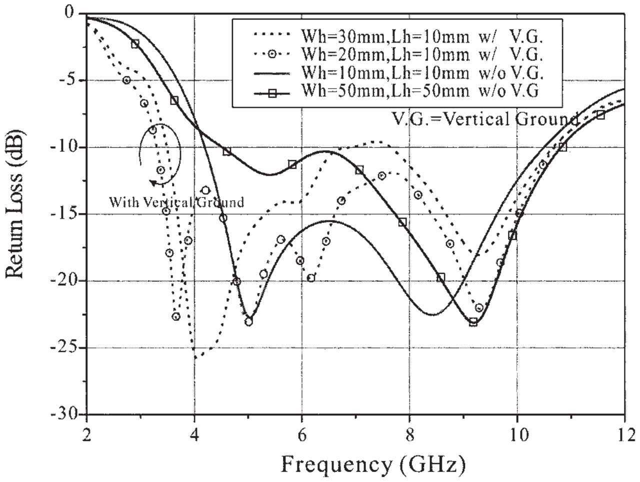

Figure 2 Return losses for the planar antenna with/without vertical ground

In this paper, we present a method to achieve frequency-notching characteristics in ultra-wideband planar monopole antenna using an L-shape ground plane. The design mainly consists of an ultra-wideband planar monopole antenna and an L-shape ground plane to meet the needs for ultra-wideband operation and antenna-size reduction. Also, both the notch frequency and notch bandwidth can be adjustable by varying the geometry parameters of the etched U-shape slot.

2. ANTENNA DESIGN

The configuration of the proposed antenna is shown in Figure 1. The ground plane, which has an inverted L-shape, consists of a horizontal and vertical part. A probe is adopted to excite the antenna in this design. The SMA connector passes through the hole on the center of the horizontal ground plane, and connects with the center of the bottom edge of the monopole. Many new planar monopole-antenna designs for achieving a wideband characteristic, which depend on the antenna size $W_a \times L_a$,

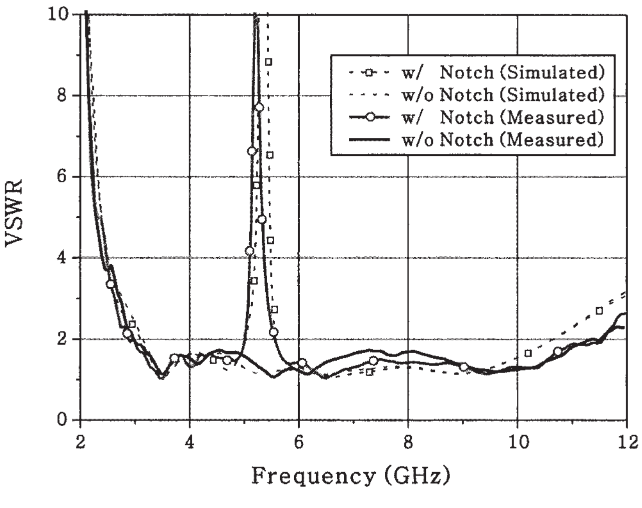

Figure 3 Simulated and measured VSWR vs. frequency

feeding gap G_a, bevel angle α, and horizontal ground size $W_h \times L_h$, have been reported [1–7]. The frequency corresponding to the lower edge of the bandwidth was found to be dependent on the antenna size and ground size, but the upper edge of the bandwidth was found to be dependent on the feeding gap and bevel angle.

The proposed antenna is mounted on a vertical ground plane of the PCMCIA card size 54 × 86 mm^2. The vertical ground causes significant effects on the lower-edge frequency, as shown in Figure 2. The antenna parameters W_a, L_a, W_h, L_h, G_a, D, are set to be 10, 15, 15, 10, 1.0, and 5 mm, respectively, and α is 18°. With the proper bevel angle and L-shape ground in the planar monopole, wideband impedance matching can be obtained. Throughout this study, the antennas are designed to operate over the band of 3.1 to 10.6 GHz and generate the frequency-notch characteristic at 5.25 GHz.

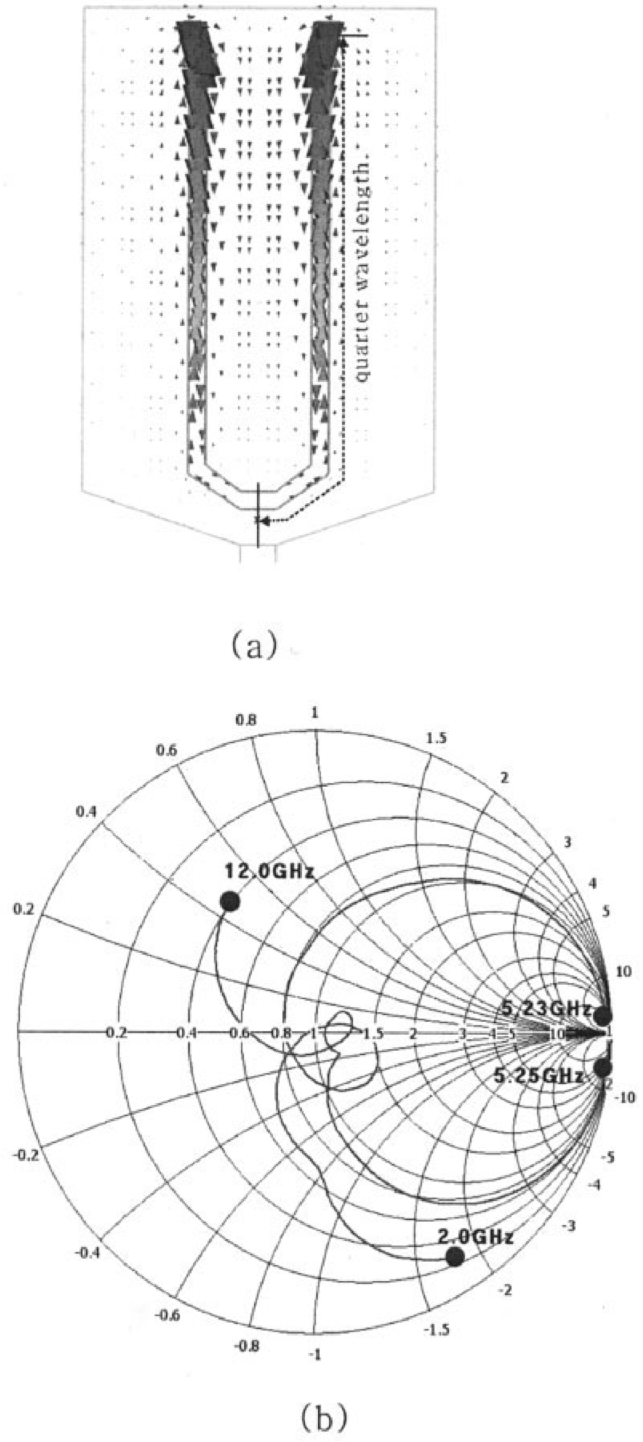

Figure 4 Simulated results of notch characteristics: (a) surface current at 5.25 GHz; (b) S_{11} at the antenna feeding point

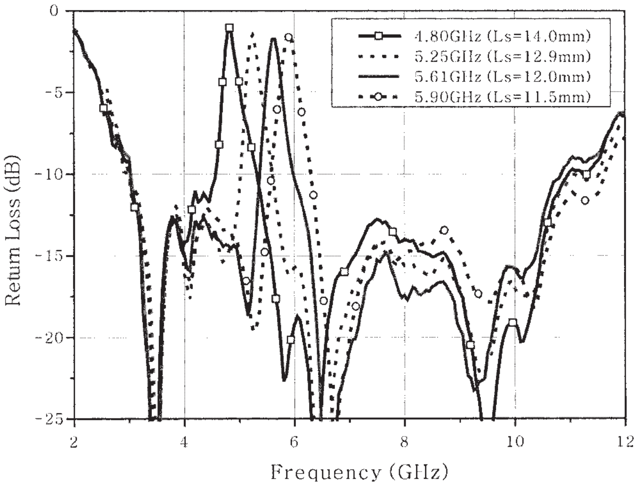

Figure 5 Measured results of notch frequency variations per U-slot length L_s

3. EXPERIMENTAL RESULTS

The proposed antenna has been simulated with the CST Microwave Studio software and constructed. The antenna was built on a 50-μm-thick PET (polyethylene, $\varepsilon_r = 3.9$, tan $\delta = 0.003$) substrate.

Figure 3 shows the simulated and measured VSWR of the proposed antenna with and without a notch. The frequency bandwidth defined by VSWR ≤ 2 is approximately 3.0–11.0 GHz without a notch. It is also shown that a sharp frequency-band notch was created very close to the desired centre frequency ($f = 5.25$ GHz) by inserting the half-wavelength U-slot. The etched U-slot becomes resonant at the frequency where L_s is a quarter-wavelength of slotline. The antenna with a U-slot has dual- and wideband characteristics. The return-loss level at the eliminated frequency between both bands is almost 0 dB.

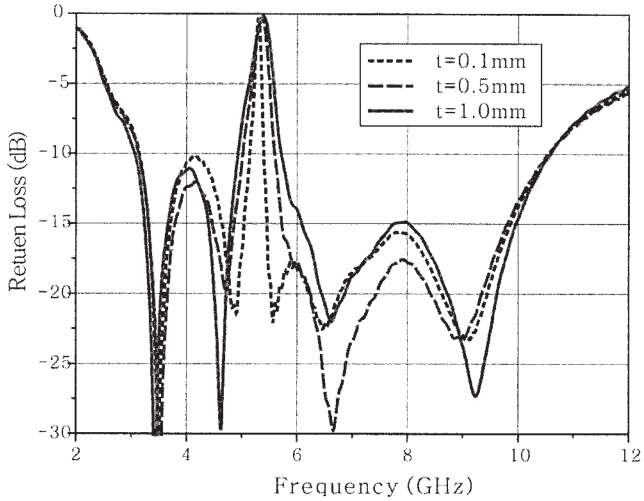

Figure 6 Measured return losses per U-slot thickness t

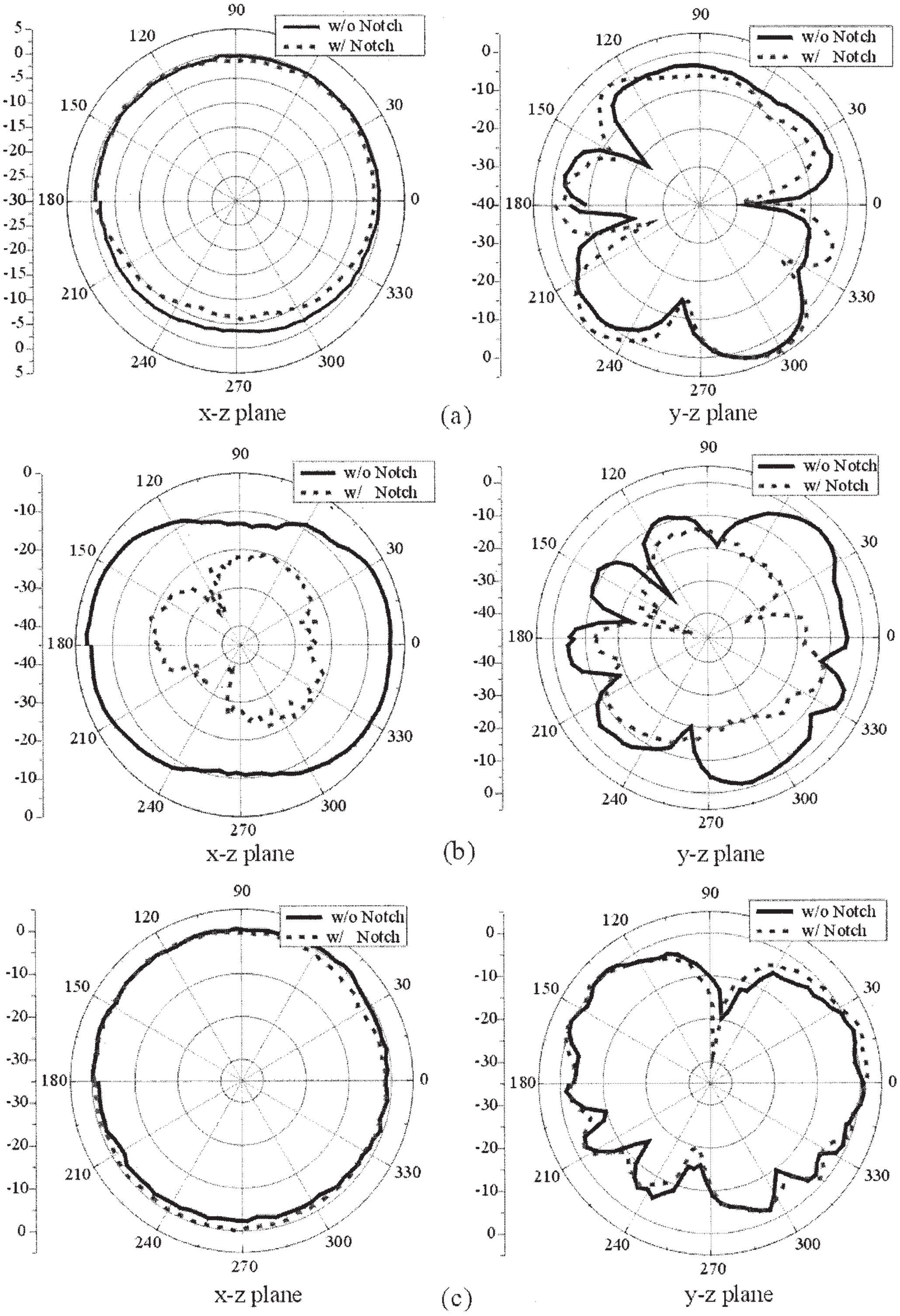

Figure 7 Measured radiation patterns for the proposed antenna with/without notch: (a) 3.96 GHz at the passband frequency; (b) 5.25 GHz at the notch frequency; (c) 8.18 GHz at the passband frequency

In Figure 4, at the notch frequency, the current is concentrated around the top of the slot and is oppositely directed between the interior and exterior of the slot. This causes the antenna to operate in a transmission-linelike mode, which transforms the nearly zero impedance at the top of slot to high impedance at the antenna feeding point. This high impedance at the feeding point leads to the desired high attenuation and impedance mismatching near the notch frequency.

Figure 5 shows that the notch frequency can be adjusted by changing the length of the U-slot.

Figure 6 shows the effects of the thickness *t* of the U-slot. As can be seen, increasing *t* has the effect of increasing the notch bandwidth.

The radiation patterns of the proposed antenna with and without a U-slot were studied. Figure 7 shows the measured radiation patterns at 3.96, 5.25, and 8.18 GHz. The radiation patterns at 5.25

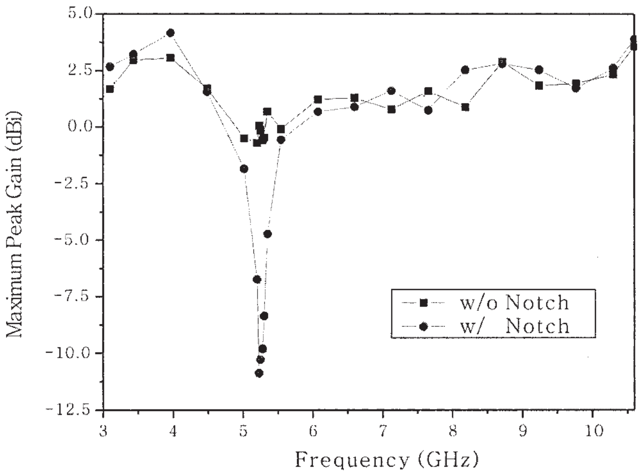

Figure 8 Measured maximum peak gain for the proposed antenna with/without notch

GHz are for the notch frequency and the radiation patterns at 3.96 and 8.18 GHz are for the passband frequency. The measured radiation patterns at the passband frequency are about the same for the antenna both with and without the U-slot. The measured results show that the radiation patterns in the *y–z* plane are conical and the patterns in the *x–z* plane are nearly omnidirectional for all the measured frequencies.

Figure 8 shows the measured peak gain of the proposed antenna with and without the U-slot. The notches of 10–12-dB magnitudes at 5.25 GHz have been created by inserting the U-slot. For the other frequencies outside the notch frequency band, the antenna gain is about the same for the antenna both with and without the U-slot.

4. CONCLUSION

A frequency-notched UWB planar monopole antenna with L-shape ground plane has been presented. The measured results show that a sharp frequency-band notch has been created very close to the centre frequency of the 5-GHz WLAN frequency band by inserting the half-wavelength U-slot.

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MICROSTRIP BANDPASS FILTERS WITH WIDE BANDWIDTH AND COMPACT DIMENSIONS

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ABSTRACT: *In this paper, novel microstrip band-pass filters with small dimensions and wide bandwidth are proposed. The devices are based on a new type of lumped resonators recently reported by the authors: double-slit complementary split-ring resonators (DS-CSRRs). Properly combined with grounded stubs, and coupled by means of variable-width transmission-line sections, these resonators provide the necessary bandwidths for the design of wideband band-pass filters in microstrip technology. To illustrate the potentiality of the proposed approach, a 5th-order prototype device with central frequency $f_o = 3.8$ GHz and 30% fractional bandwidth has been designed and fabricated. The measured frequency response reveals that in-band losses are below 1 dB, while the return losses are larger than 15 dB. High-frequency selectivity has been also obtained, with very sharp cutoff in the upper band edge and 40-dB rejection at 2.3 GHz. These wide bands are not easily obtainable with conventional filter implementations. This fact and the small dimensions, derived from the use of DS-CSRRs, make the proposed approach very attractive for those applications requiring wide bandwidths for data transmission.* Microwave Opt Technol Lett 46: 343–346, 2005; Published online in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/mop.20982

Key words: *complementary split-ring resonators (CSRRs); microstrip technology; microwave filters*

1. INTRODUCTION

Recently, a new class of lumped resonators has been used for the design of frequency-selective structures in planar circuit technology [1]. The main relevant characteristic of all these resonators, which are inspired on the canonical topology proposed by Pendry [2] (see Fig. 1), is their electrical length. This can be made very small due to the edge capacitance between concentric rings. Therefore, these resonators can be considered as planar lumped (rather than distributed) elements, which may open the door to new design strategies where device miniaturization is of major concern. This paper deals with one of such resonators, that is, the double-slit complementary split-ring resonator (DS-CSRR) and its application

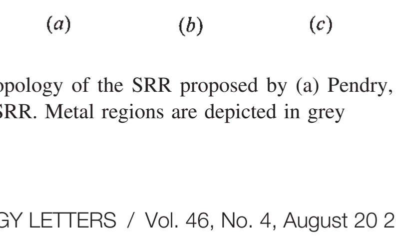

Figure 1 Topology of the SRR proposed by (a) Pendry, (b) DS-SRR, and (c) DS-CSRR. Metal regions are depicted in grey