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SLOT LINE FED DIPOLE ANTENNA FOR WIDE BAND APPLICATIONS

V. Deepu, S. Mridula, R. Sujith, and P. Mohanan
Centre for Research in Electromagnetics and Antennas (CREMA), Department of Electronics, Cochin University of Science and Technology, Cochin, Kerala, India; Corresponding author: drmohan@cusat.ac.in

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ABSTRACT: *A slot line fed planar dipole antenna with a parasitic strip for wide band applications is presented. The presented antenna offers a 2:1 VSWR bandwidth from 1.66 to 2.71 GHz covering the DCS/PCS/UMTS and IEEE 802.11b/g bands with a gain better than 6.5 dBi. The uniplanar design, simple feeding, and high gain make it a versatile antenna for wireless applications.* © 2009 Wiley Periodicals, Inc. Microwave Opt Technol Lett 51: 826–830, 2009; Published online in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/mop.24184

Key words: *slot line; uniplanar antenna; printed dipole; DCS/PCS/UMTS and IEEE 802.11b/g bands*

1. INTRODUCTION

Printed dipole antennas are usually fed by a microstrip line [1–3]. Recently, uniplanar dipoles have received wide attention because of advantages of easy fabrication and integration of active circuit elements [4, 5]. Most of the reported designs have either a double layer structure or a balun configuration [6]. Because antennas are nowadays embedded in the circuit boards, simple cost-effective and easily printable designs are preferred. Recently, printed self-balancing folded dipole antennas devoid of baluns have gained attraction [7–9] because of their compactness and simplicity. In this article, a simple planar dipole fed using a slot line has been presented [10, 11]. The antenna exhibits good matching and radiation characteristics similar to antennas using baluns even though it does not have any complicated baluns or other matching networks.

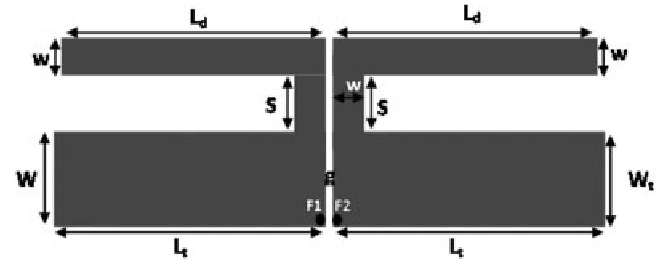

Figure 1 Slot line fed dipole: L_d = 32 mm, w = 5 mm, L_t = 35 mm, W_t = 10 mm, S = 5 mm, g = 0.5 mm ε_r = 4.4, and h = 1.6 mm

An exhaustive experimental and simulation study has been performed to find out the effect of the various parameters on the antenna performance. The proposed slot fed dipole antenna with a parasitic strip has wide band, covering the DCS/PCS/UMTS and IEEE 802.11b/g bands with gain better than 6.5 dBi in the entire operating band.

2. SLOT LINE FED DIPOLE ANTENNA

A simple dipole fed by the slot line feed is shown in Figure 1. The dimensions of the slot line are taken from standard design equations [12] The dipole arms have a total length of $\lambda_d/2$ ($2L_d$) and width of $0.05\lambda_d$ (w) where λ_d is the dielectric wavelength corresponding to the resonant frequency. The dipole is fed by a slot line of length slightly greater than $\lambda_d/2$ and width $0.1\lambda_d$ with a separation gap "g" = 0.5 mm. The signal strip of the coaxial cable is connected to F1 and the ground to F2.The dimensions are chosen after a series of experimental and simulation studies. The antenna resonates at 1.7 GHz with 22% band width from 1.65 to 2.05 GHz (see Fig. 2). The radiation pattern is shown in Figure 3 and is identical to that of a dipole. A gain better than 4 dBi in the entire operating band is noted. The enhancement in gain may be due to the reflecting effect of the slot line feed. Field distribution in Ref. [5] show a half-wave variation along the length of the strip at 1.7 GHz (Figure 4). From the above observations, it can be seen that the slot line fed dipole exhibits almost similar characteristics as that of an ordinary dipole. The effect of various parameters on the antenna performance is discussed.

The influence of the dipole length L_d on the resonant frequency was studied, and it was observed that the resonant frequency decreases as the dipole length increases similar to an ordinary

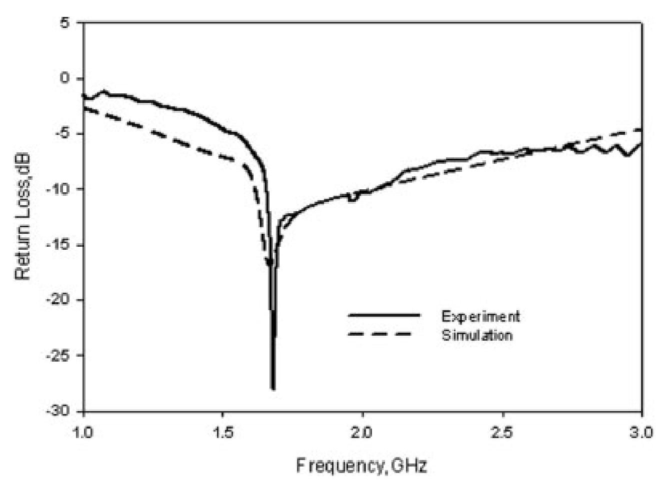

Figure 2 Return loss characteristics of the dipole antenna shown in Figure 1

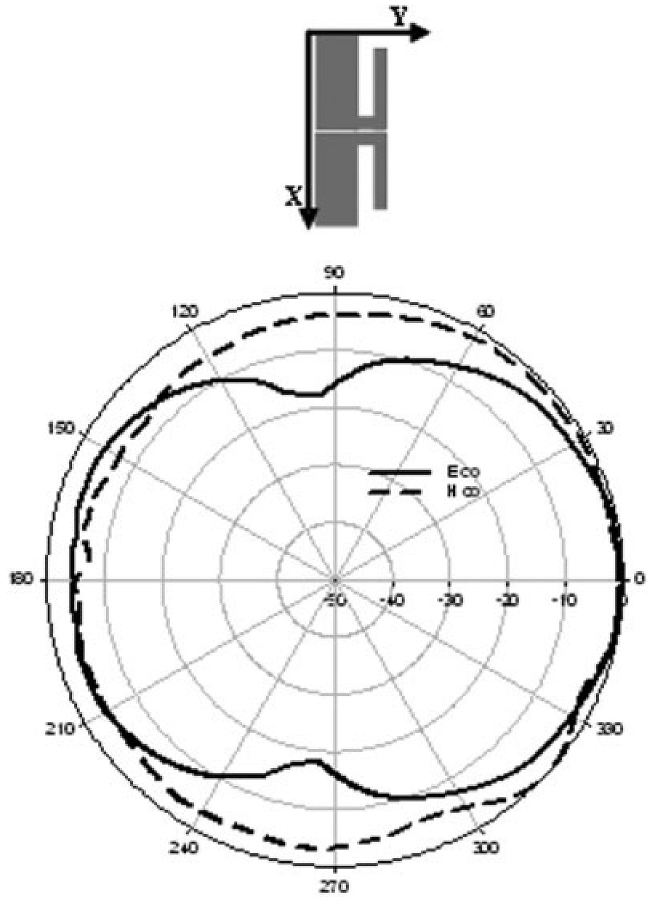

Figure 3 Principal *E* and *H* plane patterns of the dipole shown in Figure 1

dipole. The dependence of the resonant frequency with the slot line length L_t is shown in Figure 5. There is only slight variation in the resonant frequency with $L_{t.}$ But when the slot line length L_t is halved, the 3-dB beam width is increased by 30° due to increased radiation toward the slot line with a slight reduction in the gain by 0.8 dBi.

The variation of the resonant frequency of the dipole with lateral slot width W_t and separation distance "*S*" is shown in Figures 6 and 7. In both cases, there is no shift in the resonant frequencies but the matching conditions are severely affected. Hence from parametric studies the optimum width is taken as $W_t = 0.1\lambda_d$ and "*S*" as $0.05\lambda_d$ mm considering the compactness of the antenna.

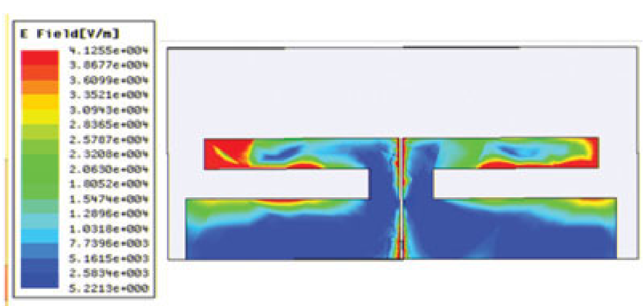

Figure 4 Computed field distribution in the dipole antenna shown in Figure 1. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]

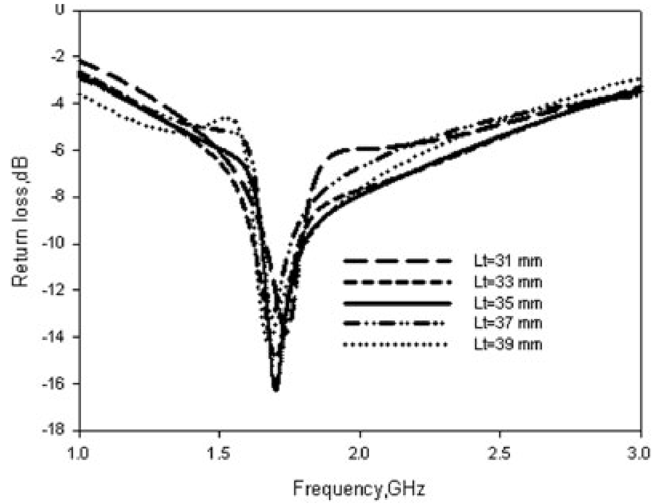

Figure 5 Variation of resonant frequency with lateral strip length L_t of the dipole antenna shown in Figure 1

The above studies confirm that the slot line as an efficient uniplanar excitation for strip dipole and the resulting antenna retains all the characteristics of a dipole without the need of any additional circuitry. The lateral width L_t of the slot line can be chosen based on the user requirements of either enhanced gain or pattern front to back ratio without affecting the resonant frequency.

3. FINAL ANTENNA—SLOT LINE FED DIPOLE ANTENNA WITH A PARASITIC STRIP

The dipole antenna mentioned above has relatively narrow bandwidth. To increase the bandwidth of the antenna, a parasite is introduced in the structure [13]. The optimized design with the parasite exhibits nearly 50% bandwidth with enhanced gain.

The geometry of the antenna with the parasite is shown in Figure 8. The dipole has a total length of $\lambda_d/2$ and width of $0.05\lambda_{d.}$ The dipole is fed using a slot line having lateral slot length $L_t = 0.27\lambda_d$ and $W_t = 0.1\lambda_d$ with a gap "*g*" = 0.5 mm. A parasite having length $L_p = 0.27\lambda_d$ is placed at a separation "*S*" = $0.05\lambda_d$ from the dipole.

The measured return loss using HP 8510C network analyzer is compared with the simulation results in Figure 9. The 2:1 VSWR band of the antenna is from 1.66 to 2.71 GHz, which offers a

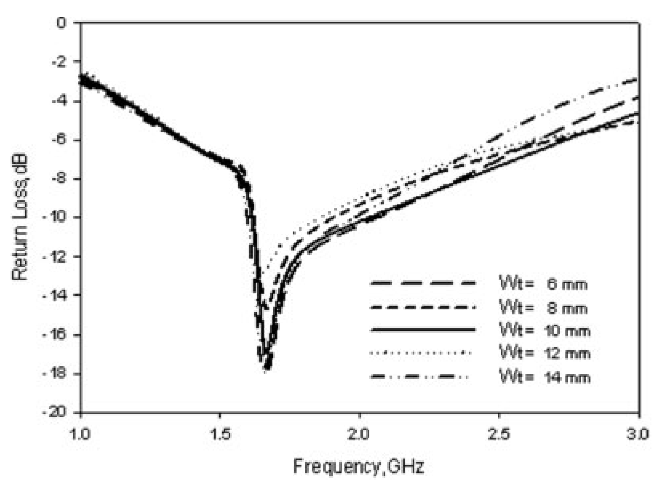

Figure 6 Variation of resonant frequency with lateral strip width W_t of the dipole shown in Figure 1

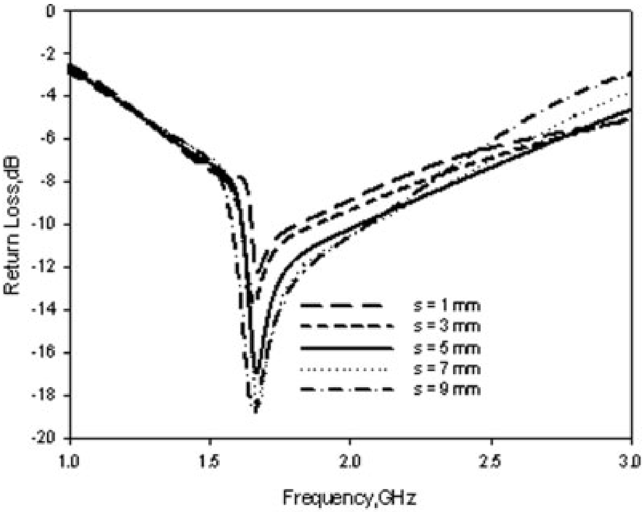

Figure 7 Variation of resonant frequency with separation "*s*" of the dipole antenna shown in Figure 3

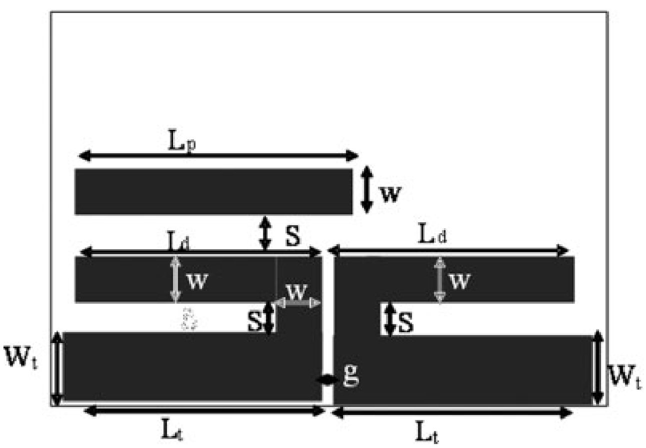

Figure 8 Slot line fed dipole with the parasite: L_d = 32 mm, w = 5 mm, L_t = 35 mm, W_t =10 mm, S = 5 mm, g = 0.5 mm, L_p = 35 mm, ε_r = 4.4, h = 1.6 mm

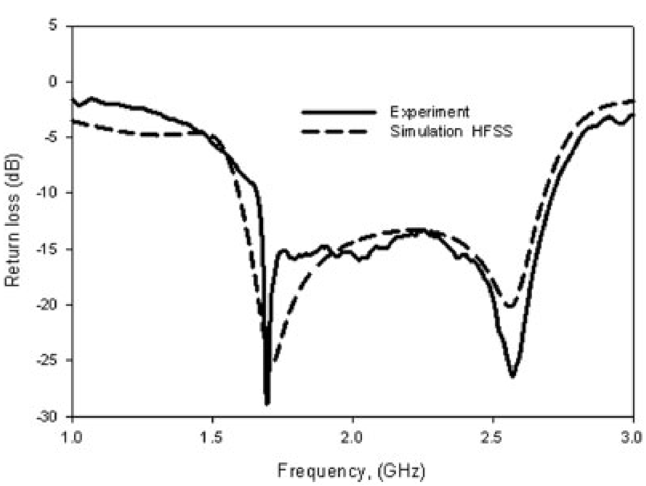

Figure 9 Return loss characteristics of the final antenna shown in Figure 8

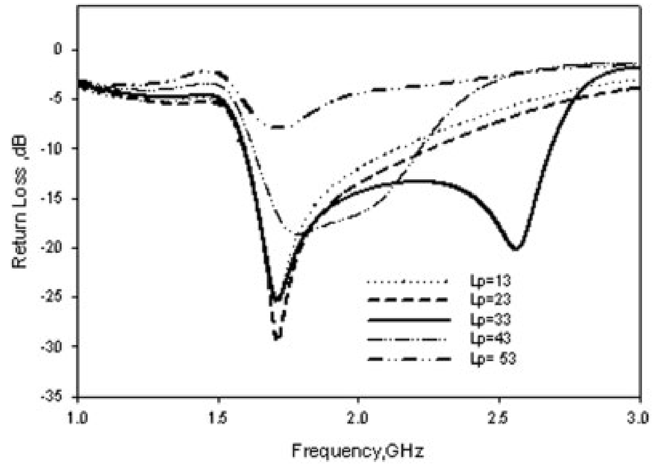

Figure 10 Variation of resonance with parasite length L_p of the final antenna shown in Figure 8

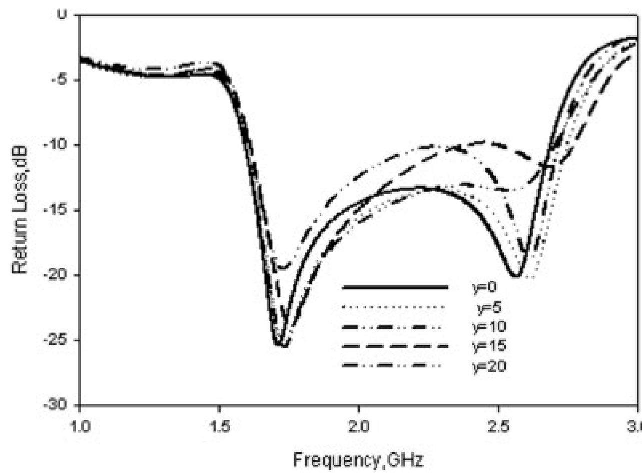

Figure 11 Variation of resonances with the position of the parasite in the final antenna shown in Figure 8

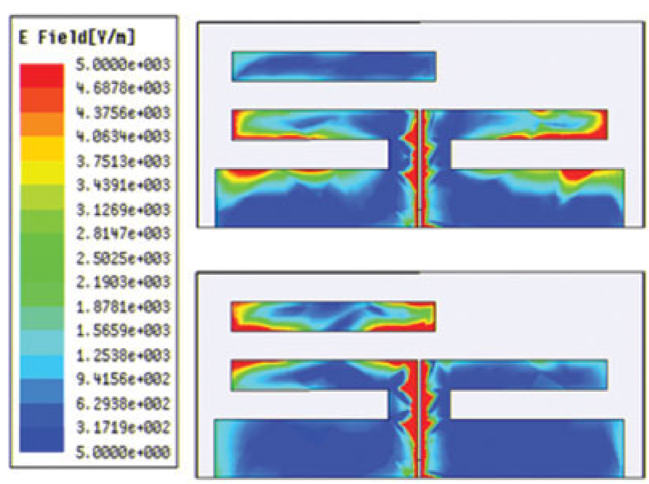

Figure 12 Field distribution in the final antenna. (a) At 1.69 GHz and (b) at 2.56 GHz. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]

bandwidth of 50%. A detailed study has been performed to determine the effect of the parasite in this case.

It is well known that the position, length, and loading height of the parasite determine the matching conditions of the antenna. The input impedance at the second resonance is greatly affected by the parasite length (Fig. 10). Similar effects are noted with variation in parasite position along *Y* axis (Fig. 11.).The loading height is also optimized to be equal to "*S*."

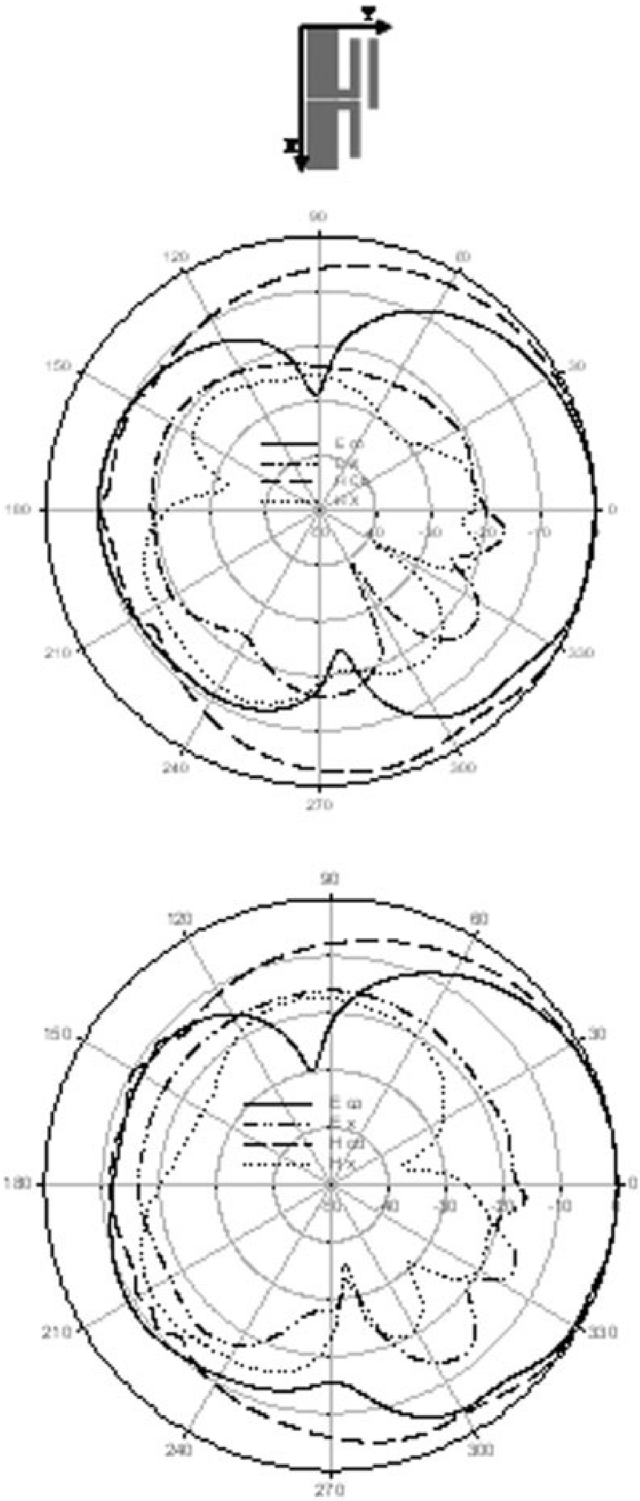

Figure 13 (a) Principal *E* and *H* plane patterns of the antenna at 1.69 GHz. (b) Principal *E* and *H* plane patterns of the antenna at 2.56 GHz

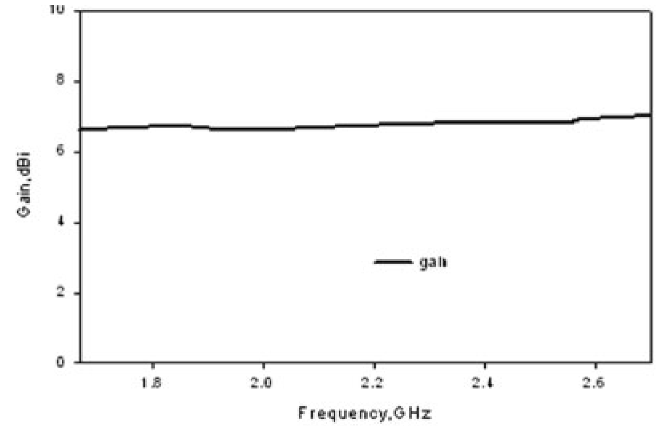

Figure 14 Gain of the final antenna

In addition to impedance matching it can be seen that when the parasite is kept off centered, the 3-dB beam width gets reduced the measured gain shows an increase of around 0.6 dBi. Hence, the offcentered parasite is chosen in the final design.

The simulated field distribution in the antenna is shown in Figure 12. Figure 12(a) shows the field variation at 1.69 GHz. The field is concentrated only on the dipole arms and a half-wave variation corresponding to 1.69 GHz is observed along the length of the dipole. But at 2.56 GHz [Fig. 12(b)] a half-wave variation of the induced field is observed in the parasitic strip. These results confirm that the lower resonance is due to the dipole arm length and the higher resonance is due to the parasitic strip. The principal *E* and *H* plane patterns of the antenna are shown in Figure 13. It can be seen that the pattern remains almost stable in the entire operating band and polarized along the *X* axis for both the bands. The measured gain of the antenna in the entire operating band is greater than 6.5 dBi (see Fig. 14).This higher gain is due to the directive effect of the parasite. Also, the addition of the parasite reduces the broadness of the pattern thereby increasing the gain of the antenna.

4. CONCLUSIONS

An uniplanar parasitic loaded wideband dipole antenna for DCS/PCS/UMTS IEEE802.11b/g applications is presented and discussed. The antenna is fed by a simple slot line without the use of baluns or other transitional structures. The dipole retains all the properties of an ordinary dipole but with an enhanced gain due to effect of the slot line and the parasitic strip. A detailed study of the various parameters affecting the antenna characteristics is also presented. The design can be scaled and effectively used for the constructing high gain wideband printed antennas for wireless gadgets for Wi-Fi and WiMAX applications which are in a high demand.

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NEW MICROSTRIP LOW PASS FILTER WITH TRANSMISSION ZERO AND WIDE STOPBAND

Jian-Kang Xiao, Q.-X. Chu, and H.-F. Huang
School of Electronic and Information Engineering, South China University of Technology, Guangzhou 510640, China; Corresponding author: xiaojk@lzu.edu.cn

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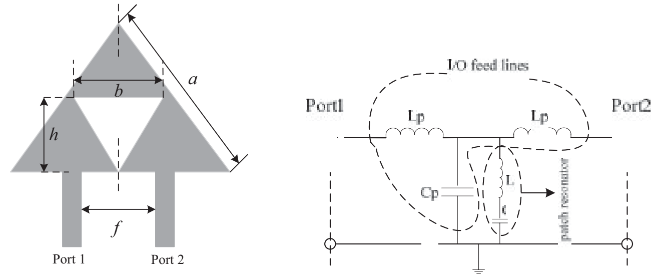
ABSTRACT: *New microstrip low pass filters with low insertion loss, ultra-wide stopband and transmission zero are presented by using triangular patch resonator with fractal defection. With such defection and a certain parallel feed method, undesired responses and harmonics are effectively suppressed and wideband, sharp attenuation obtained. The new filter has simpler and more compact configurations even better filter properties than the traditional line based ones.* © 2009 Wiley Periodicals, Inc. Microwave Opt Technol Lett 51: 830–831, 2009; Published online in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/mop.24138

Key words: *triangular resonator; lowpass filter; fractal defection; wide stopband; transmission zero*

1. INTRODUCTION

Fractal means broken or fractured which is derived from Latin word “fractus” dates back to the 19th century as a branch of classical mathematics. Fractal can generate almost any complex configurations in nature by iterating certain simple geometries, and have advantages including miniaturization and wideband or multiband operation [1], which attribute to its basic properties of self-similarity and space filling. Self-similarity means a portion of the fractal geometry always looks like that of the entire structure, and space filling means a fractal shape can be filled in a limited region as the order increases without increasing the whole area. In microwave filters design, harmonic suppression is very important, and some method such as defected ground structure (DGS) [2] is proved efficiency, however, it make filters complicated and have a leaky wave problem because of the discontinuity in ground plane. Now, fractal principle brings a new way to overcome the above deficiencies. For a patch resonator filter, fractal defection can act as filter perturbation which suppresses the undesired harmonics for implementing a wideband. Conventional implementation of a low pass filter (LPF) involves the use of open stubs or stepped-impedance microstrip lines. However, these structures have gradual cut-off response that only by increasing the number of section, the filter rejection characteristic can be improved, and this improving method increases the passband insertion loss and filter physical size. Recently, some new methods such as DGS [3, 4], complementary split ring resonators (CSRR) [5], and others are applied to design LPFs, however, the filter performances such as bandwidth of stopband and sharp attenuation responses are enhanced by increasing cells, which lead to larger size and more transmission losses. In our report, new microstrip LPF using single patch resonator with fractal-shaped defection is proposed for the first time to implement nicer performances of transmission zero to get sharp attenuation, ultra-wide stopband and low insertion loss, which has advantages of simple and compact circuit topology, miniaturization, etc.



(a) Topology (b) Rough circuit model

Figure 1 Equilateral triangular low pass filter ($a = 15$ mm, $b = 8$ mm, $h = 6$ mm): (a) Topology; (b) Rough circuit model

2. FILTER DESIGN

Patch resonator is popular for miniature microstrip bandpass filter design, however, seldom used to other filters implementation. Fractal-shaped defection has very important applications to patch resonator filter, which acts as perturbation and introduce degenerate modes or higher order modes operation, and suppress the undesired harmonics to implement a multiband or wideband. For a regular triangular fractal defection, it consists of a loop resonator filter with bandpass operation [6], however, if the triangular fractal defection is reversed to intersect the patch hemline, the perturbation will be strong enough to suppress the reject-band of a bandpass filter. If the upper reject-band of a bandpass filter with dominant mode $TM_{1,0,-1}$ operation is suppressed and a passband instead, a lowpass filter can be obtained.

The proposed low-pass filter topology and circuit model are shown in Figure 1, where, an inverted isosceles triangular defection with hemline length of b and height of h is etched in the equilateral triangular patch with triangle side length of a, and divided it into three similar parts. I/O feed-lines that set at the triangular hemline are microstrip lines with characteristic impedance of 50 Ω, and act as coupled lines that the shunt capacitor between them can be tuned to obtain sharp attenuation, and the corresponding equivalent circuit consists of C_p and L_p. The filter is