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A Compact L-slot Microstrip Antenna for Quad band Applications in Wireless Communication

By U.Chakraborty, B.Mazumdar, S.K.Chowdhury, A.K.Bhattacharjee
National Institute of Technology, Durgapur, West Bengal, India

Abstract - A single feed compact rectangular microstrip antenna for quad band applications has been designed and developed. This antenna is incorporated by four L-shaped slot structure along the length on the patch. Four resonating frequencies are obtained at 1.845 GHz with return loss -21.19 dB, 2.59 GHz with return loss -17.69 dB, 3.29 GHz with return loss -21.56 dB and 4.825 GHz with return loss -22.31 dB. The size of the antenna has been reduced by 77.3% when compared to a conventional microstrip patch without slot. An extensive analysis of the return loss, radiation pattern and gain of the proposed antenna has been given in this paper. The characteristics of the designed structure are investigated by using MoM based electromagnetic solver, IE3D.The simple configuration and low profile nature of the proposed antenna leads to easy fabrication and multi frequency operation makes it suitable for the applications in Wireless Communication system.

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A COMPACT L-SLOT MICROSTRIP ANTENNA FOR QUAD BAND APPLICATIONS IN WIRELESS COMMUNICATION

Strictly as per the compliance and regulations of:

A Compact L-slot Microstrip Antenna for Quad band Applications in Wireless Communication

U.Chakraborty [α], B.Mazumdar [σ], S.K.Chowdhury [ρ], A.K.Bhattacharjee [ω]

Abstract - A single feed compact rectangular microstrip antenna for quad band applications has been designed and developed. This antenna is incorporated by four L-shaped slot structure along the length on the patch. Four resonating frequencies are obtained at 1.845 GHz with return loss -21.19 dB, 2.59 GHz with return loss -17.69 dB, 3.29 GHz with return loss -21.56 dB and 4.825 GHz with return loss -22.31 dB. The size of the antenna has been reduced by 77.3% when compared to a conventional microstrip patch without slot. An extensive analysis of the return loss, radiation pattern and gain of the proposed antenna has been given in this paper. The characteristics of the designed structure are investigated by using MoM based electromagnetic solver, IE3D.The simple configuration and low profile nature of the proposed antenna leads to easy fabrication and multi frequency operation makes it suitable for the applications in Wireless Communication system.

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I. Introduction

Design of compact microstrip antenna has become an interesting topic of research in recent years due to the demand for small antennas in wireless communication systems [1-5]. The development of antenna for wireless communication also requires an antenna with more than one operating frequency. Therefore one antena that has multiband characteristic is more desirable than having one antenna for each frequency band. Unlike normal antenna a defected structure introduces discontinuities on the signal plane and disturbs the shielded current distribution in signal plane [6].As a result apparent permittivity of the substrate varies as a function of frequency. The work to be presented in this paper is a compact microstrip antenna design obtained by the insertion of four L-shaped slot on the two sides of the patch.Two inverted slots are inserted on the left side and two slots are inserted on the right side (one inverted and one simple L slot) on the patch (Fig: 2).The work to be presented in this paper is directed towards the reduction of the size of the antenna as well as to operate the antenna in multi-frequencies. The proposed antenna (substrate with εr=4.4) has four resonant frequencies and presents a size reduction of about 77.3% when compared to a conventional rectangular microstrip patch The simulation has been carried out by IE3D software which uses the MoM method [10]. Due to the Small size, low cost, low weight and multiband characteristics this antenna is a good candidate for application in Wireless communication system.

Author [α] : ECE Dept, National Institute of Technology, Durgapur, West Bengal, India. Telephone: 9563606800
E-mail : ujjal_dgp@ yahoo.co.in
Author [σ] : ECE Dept, Aryabhatta Institute for Engineering and Management, Durgapur, West Bengal, India.
(Telephone: 9734209740 E-mail : barun_bm@ rediffmail.com
Author [ρ] : ECE Dept, JIS College of Engineering, Phase-III, Block-A5, Kalyani, Nadia, West Bengal, India.
E-mail : santoshkumarchowdhury@gmail.com
Author [ω] : ECE Dept, Natinal Institute of Technology, Durgapur, West Bengal, India. E-mail : akbece12@yahoo.co.in

II. Antenna Structure

The configuration of the conventional antenna is shown in Figure 1. The antenna is a 24 mm x 18 mm rectangular patch. The substrate selected for this design is an FR4 epoxy with dielectric constant (εr) =4.4 and height of the substrate (h) =1.5875 mm. Co-axial probe feed of radius 0.5 mm with a simple ground plane arrangement is used at the point (0,-3) where the centre of the patch is considered at point (0, 0).Figure 2 shows the configuration of proposed antenna which is designed with the similar substrate. The antenna is also a 24 mm x 18 mm rectangular patch. Four L-shape slots which are created on the rectangular patch (as shown in the figure 2). The location of the coaxial probe-feed (radius =0.5 mm) is also same as shown in antenna1.Optimal values of the parameter of the L-slots and their positions are given in fig 2.

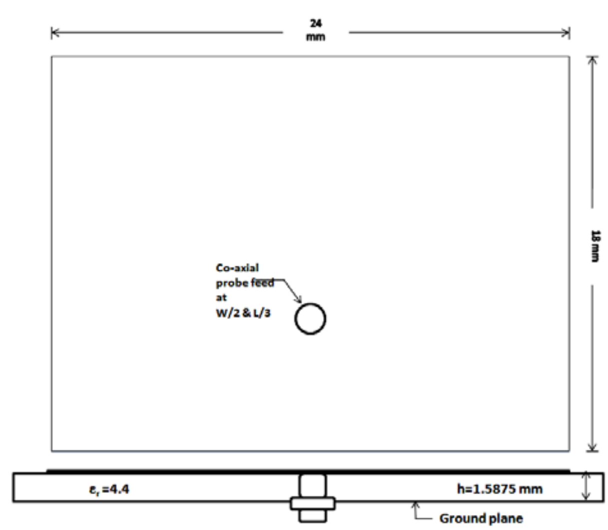


Fig.1 : Antenna 1 Configuration

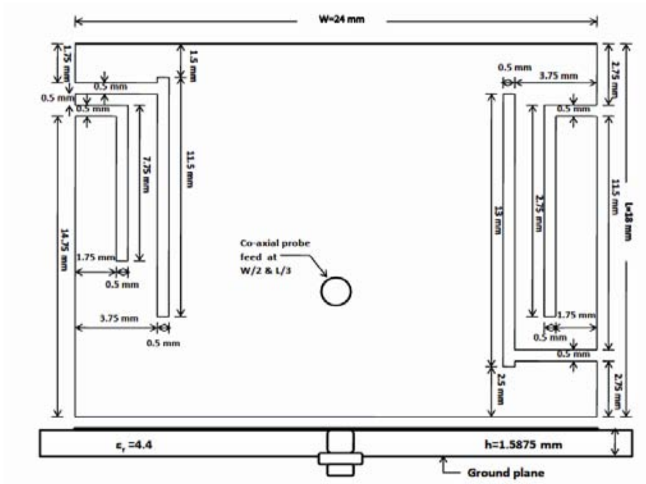


Fig.2 : Antenna 2 Configuration

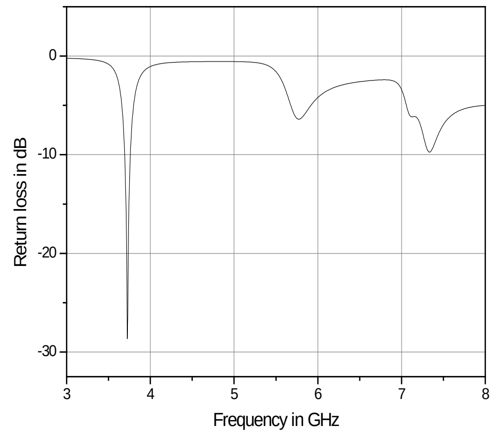


Fig .3 : Simulated return loss of the antenna1

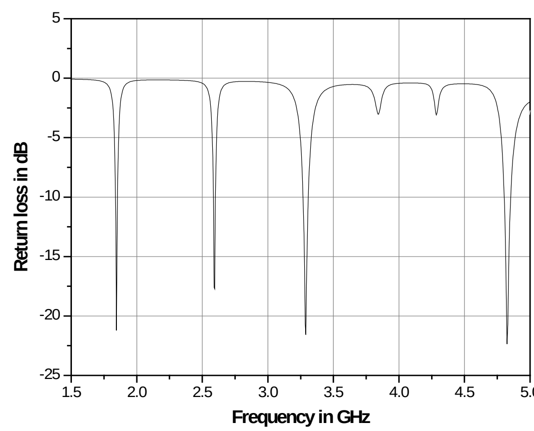


Fig .4 : Simulated return loss of the antenna2

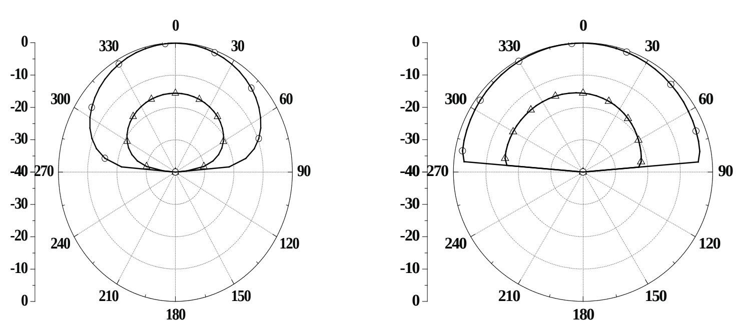
III. Simulated Results

In this section, simulated return loss (of antenna 1 and 2) and normalized E-field and H-field radiation patterns (of antenna2) are shown. The simulated return loss of the conventional antenna (antenna 1) and the proposed antenna (antenna 2) are shown in fig. 3 and fig 4 respectively.

In conventional antenna only one resonant frequency is obtained below -10 dB which is 3.725 GHz and the return loss was found to be about -28.59 dB with 68(3.693-3.761) MHz bandwidth. For the proposed antenna resonant frequencies are 1.845 GHz, 2.59 GHz, 3.29 GHz, 4.825 GHz and their corresponding return losses are -21.19 dB,-17.69 dB,-21.56 dB and -22.31 dB respectively. Simulated 10 dB bandwidths are 16 (1.837-1.853) MHz, 16 (2.584-2.600) MHz, 40 (3.268-3.308) MHz and 49 (4.803-4.852) MHz respectively. Hence a significant improvement of frequency reduction is achieved in antenna 2 with respect to the conventional antenna1 structure for resonant frequencies of 1.845 GHz, 2.59 GHz and 3.29GHZ.

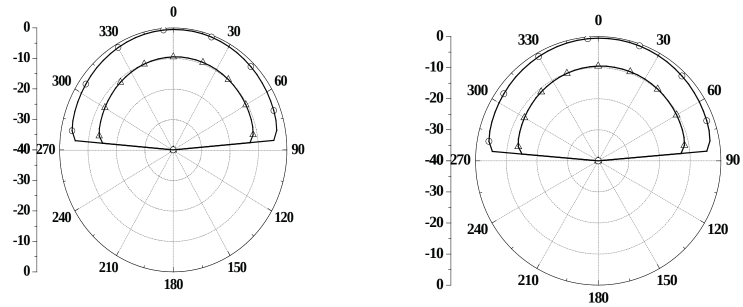
The simulated E plane and H plane radiation patterns for antenna 2 are shown in Figure 5-8.

Isolation between co-polarization and cross pola-rization is more than -15 dB for 1.845 GHz and it decreased with the increase of the frequency for 2.59 GHz and 3.29 GHz. 3 dB E-plane beamwidths are found to be reasonably good for all the cases.



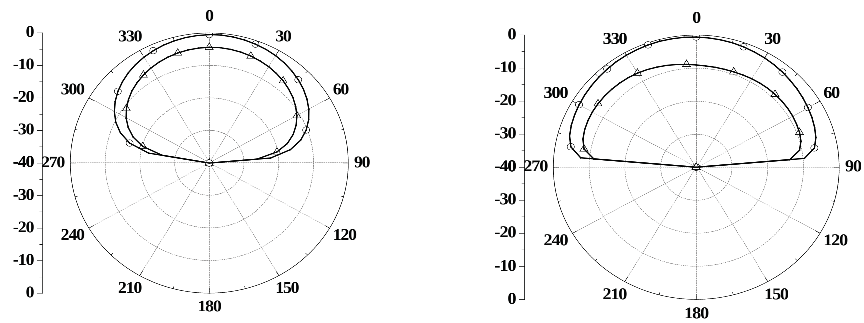
(a) E-field pattern (b) H-field pattern

Fig .5. : Simulated normalize radiation pattern at 1.845 GHz



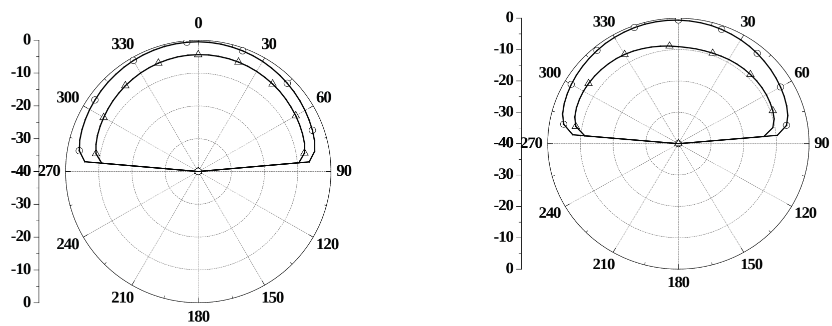
(a) E -field pattern (b) H -field pattern

Fig .6 : Simulated radiation pattern at 2.59 GHz.



(a) E-field pattern (b) H-field pattern

Fig .7 : Simulated normalize radiation pattern at 3.29 GHz



(a) E-field pattern (b) H-field pattern

Fig. 8 : Simulated normalize radiation pattern at 4.825 GHz

IV. Experimental Results

The prototype of the antenna 1 (conventional) and antenna 2 (proposed antenna) was fabricated and tested, which are shown in Fig. 9 and 10. All the measurements are carried out using Vector Network Analyzer (VNA) Agilent N5 230A.

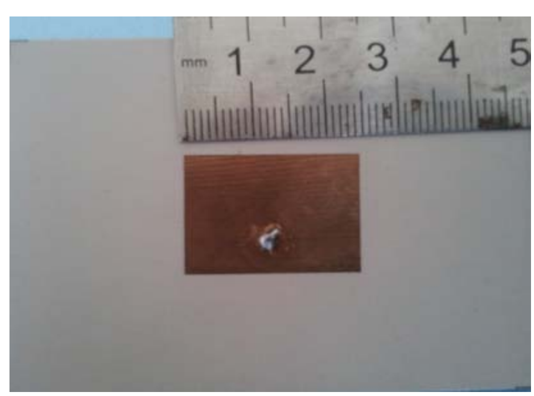


Fig .9 : Antenna 1

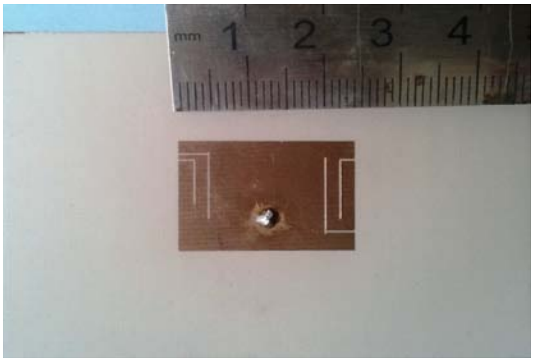


Fig. 10 : Antenna 2

The measured return losses of the antennas are illustrated in Fig. 11-12.

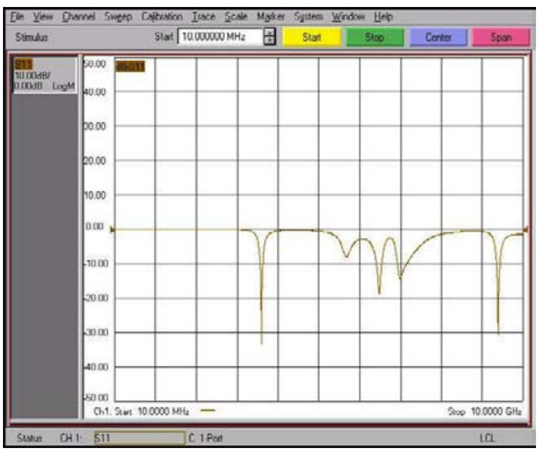


Fig .11 : Measured return loss of antenna 1

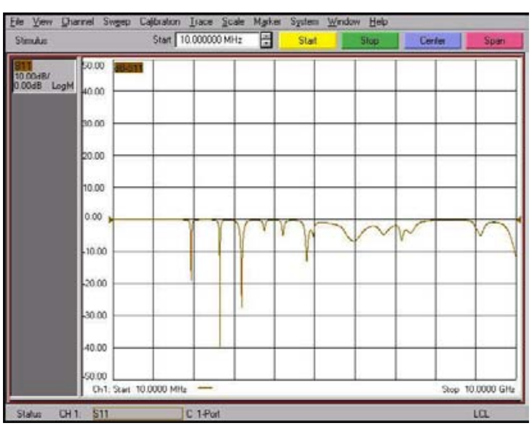


Fig .12 : Measured return loss of antenna 2

Comparisons between the measured return loss with the simulated ones are shown in Fig.13 and 14. The agreement between the simulated and measured data is reasonably good. The discrepancy between the measured and simulated results is due to the effect of improper soldering of SMA connector or fabrication tolerance.

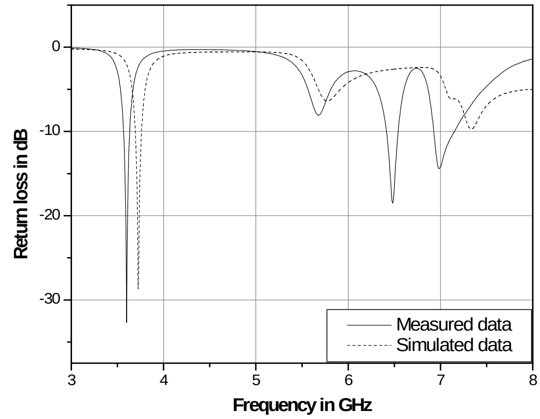


Fig. 13 : Comparison between measured and simulated return losses for antenna1

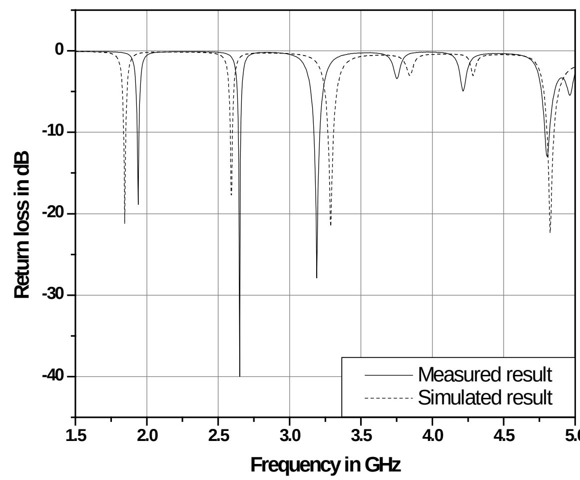


Fig. 14 : Comparison between measured and simulated return losses for antenna 2

V. Conclusion

A single feed single layer rectangular microstrip antenna with L-shaped slot insertion has been proposed in this paper. It is shown that the proposed antenna can operate in four frequency bands in the frequency ranges of GSM (1800 MHz), WiMAX (2.5-2.69 GHz and 3.2-3.8 GHz) and Hyperlan (4.8-5.8 GHz). The polarization type of the antenna is linear and due to the perturbation of the time varying current, effective patch area of the proposed antenna is reduced by 77.3 % when compared to a conventional patch (without slot). Maximum gain of the proposed antenna is found to be about 5 dBi at 3.29 GHz. The location and length of the L-slots are optimized in such a way that the antenna can operate in four suitable band. The experimental result shows that this design is ideally practical for quad band applications.

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