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Shivkant Thakur[1], Rajesh Kumar Vishwakarma [2], Rohit Gurjar[3]

[1] Department of Electronics & Communication, University College of Engineering & Technology, VBU Hazaribag -825301, Jharkhand, India

[2] Department of Electronics & Communication, Jaypee University of Engineering & Technology, Guna- 473226, Madhya Pradesh, India

[3] Department of Electronics & Communication, Anand Engineering college (SGI), Agra - 282007, India

[1]shivkantjuet2k11@gmail.com; [2] rkv786@gmail.com; [3]rohitgurjar112012mece@gmail.com

Abstract

The area of microstrip antennas has seen some inventive work in recent years and is currently one of the most dynamic fields of antenna theory. In this paper, analysis of double L-slot loaded patch antenna is presented. The antenna is designed for applications in C-band space communication system. The bandwidth of the proposed antenna is found a 421 MHz (5%) and VSWR value is 1.249. Simulated results for main parameters such as return loss, bandwidth and radiation pattern are also discussed herein. The study shows that modelling of such antennas, with simplicity in designing and feeding, can well meet C-band application. This antenna is fed by a coaxial probe feeding.

Keywords

Double L-slot Loaded Rectangular Patch; Rectangular Patch Antenna for C-band ; C-band Application

Introduction

A microstrip patch antenna consists of a dielectric substrate, with a ground plane on the other side. Due to its advantages such as low weight, low profile planar configuration, low fabrication costs and capability integrate with microwave integrated circuits for applications such as wireless communications system, WI-Fi device weather radar system, cellular phones, pagers, and satellite communication system [1, 2].

The development of small-integrate antennas plays a significant role in the progress of rapidly expanding military and commercial communication applications. Wideband wireless connection promises to make interactive voice, data, and video services available any time and anywhere. The technology to support these applications has been made possible according to recent research in high-density packaging of RF and microwave circuit [6]. As system requirements for faster data transmission in lighter compact design drive the technology area, that requires integration of microwave devices, circuitry, and radiating elements that offer light weight, small size, and optimum performance.

Over the past two decades, microstrip patch antenna (MPA) has received considerable attention for use in personal communication system and radar applications due to its compactness among other advantages. Intensive research has been carried out to develop new techniques. To overcome the microstrip patch antenna drawback especially narrow band, the bandwidth enhancement and its return loss improvement without increasing antenna size and production process are important to apply this antenna to the modern mobile communication system .

Many applications in communications and radar require circular or dual polarization, and the flexibility afforded by microstrip antenna technology have led to a wide variety of designs and techniques to fulfill this requirement [3]. In recent years, the demand for the compact mobile handset has grown due to the increased demand of electronics mobility, and the need for small handsets will most likely increase. A small antenna size is required as one of the important factors in the portable mobile communication system. The size of MPA is basically determined by its resonance length and width. The reduction of patch size can be achieved by using patch substrate height [4]. But, in this case, the low radiation efficiency will reduce the antenna gain.

In this study, an L-shaped patch antenna optimized for the simplicity in design and feeding is proposed whose characteristics meet C-band application.

L-shaped Patch Antenna Analysis

The result of the development of a compact wideband radiator for use in wireless communications applications is presented in this section. Bandwidth is specified as the frequency difference in which return loss is less than -10 dB.

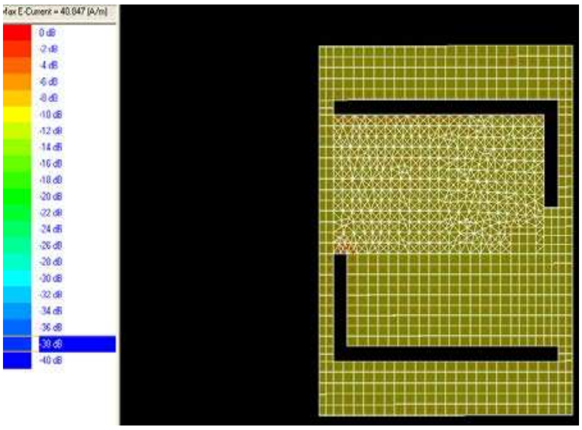

FIG. 1 THE CURRENT DISTRIBUTION ON L-SHAPED

An empirical model generally plays an appreciable role in antenna scaling. Typically, these empirical models include the cavity model and the transmission line analysis of a microstrip patch antenna is a well-established approach among the antenna engineers.

Unslotted microstrip antenna patch antenna can be modeled as a simple LC resonant circuit in [5], and its L and C values are determined by the length of current's path which extend from feeding point towards the edges[8].

Incorporation of two slots into the patch affects the resonance characteristics of the patch in such a way that the current has to flow around the slots at the edge part of the patch.

Moudling and Design Parameters

It is known that increasing the thickness of the patch antenna will increase the impedance bandwidth However, the thicker the substrate of the antenna is, the longer the coaxial probe will be used and, thus more probe inductance will be introduced [6], which limits the impedance bandwidth. Consequently, a patch antenna design that can counteract or reduce the probe inductance will enlarge the impedance bandwidth.

Single layer configuration along with its current distribution, in which double L-shape slot is incorporated in the fed rectangular patch. It consists of a rectangular patch with dimensions ($L \times W$). The rectangular patch is separated from ground plane with an FR4 substrate ($\varepsilon_r = 4.4$) of thickness, h is 1.6 mm.

In which L is the length of the patch W is the width of the patch Y_0 is feed point location, h is thickness of the substrate material.

$$\varepsilon_e = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left(1 + \frac{10h}{W}\right)^{-1/2} \quad (1)$$

ε_e is effective permittivity of the medium which is given by [7]

The dimension of patch along its length has been extended on each end by distance given as:

$$\Delta L = 0.412h \frac{\varepsilon_e + 0.3}{\varepsilon_e - 0.258}\left(\frac{\frac{w}{h} + 0.264}{\frac{w}{h} + 0.8}\right) \quad (2)$$

The actual length of patch is given as:

$$L = \frac{\lambda_0}{2} - 2\Delta L \quad (3)$$

For efficient radiation W is given as:

$$W = \frac{c}{2 f_0 \sqrt{\frac{\varepsilon_r + 1}{2}}} \quad (4)$$

Where, ε_r is the relative permittivity of substrate material

The position of coaxial cable can be obtained given as:

$$R(x) = R(0)\cos^2\left(\frac{\pi}{L} y_0\right) \quad (5)$$

Where $R(x)$ is the desired input impedance to match the coaxial cable and $R(0)$ is the edge impedance of patch antenna.

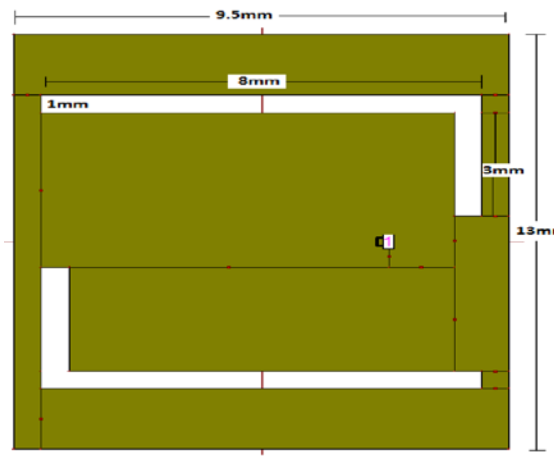

FIG. 2 GEOMETRY OF PARALLEL L-SLOT PATCH ANTENNA FEED AT 2.2mm

TABLE 1 SPECIFIATION OF MICROSTRIP ANTENNA

Substrate material used	FR4 ($\varepsilon_r = 4.4$)
Thickness between ground and fed patch (h)	1.6 mm
Length of the rectangular patch (L)	9.5 mm
Width of rectangular patch (W)	13 mm
Width of slot thickness (d)	1 mm
VSWR	1.249
Feed location (x_0, y_0)	(2.2 mm,0)

Slot in microstrip patch can be analyzed by using a dual relationship between the dipole and the slot. In this paper, the patch is fed by a coaxial feed (50Ω). The L-shape slot is considered as two slots, one of which is along the length of patch and another is along the width.

The reflection coefficient of the patch can be calculated as

$$\Gamma = \frac{Z_0 - Z_T}{Z_0 + Z_T} \tag{6}$$

Where, Z_0 is characteristic impedance of the coaxial feed (50 ohm)

$$VSWR = \frac{1+|\Gamma|}{1-|\Gamma|} \tag{7}$$

$$\text{Return loss } = 20\log|\Gamma| \tag{8}$$

Simulation Results and Discussion

For simulation we used a Zeland IE3D simulator, which is very good simulator for RF antennas.

Figure 3 shows the variation of return loss with frequency and it is observed that the antenna radiates frequency 6.981 GHz the bandwidth is 5%.

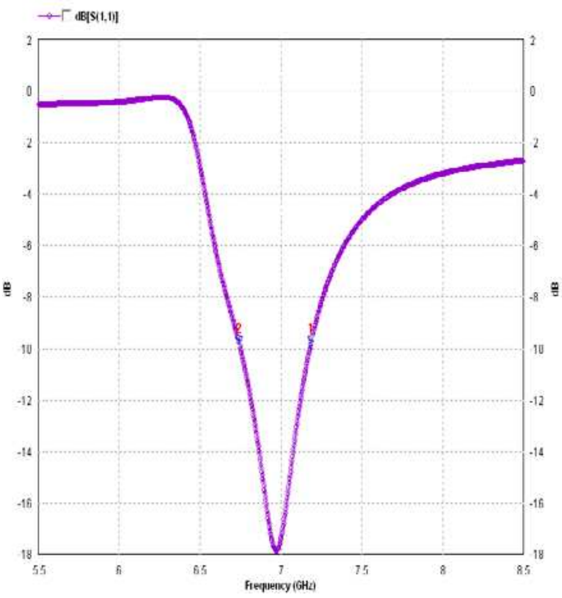

FIG. 3 RETURN LOSS OF MICROSTRIP PATCH ANTENNA

TABLE 2 RETURN LOSS (s11) VALUES

Frequency (MHz)	Minimum return loss(S11)dB
6941	-17.67
6951	-18.22
6961	-18.67
6971	-18.98
6981	-19.11
6991	-19.04
7001	-18.78
7011	-18.33
7021	-17.85

Figure 4 shows the variation of VSWR with frequency and it is observed that it is minimum at the resonant frequency and value is 1.249.

Typical radiation pattern of proposed antenna as shown in Figure 5 having one operating frequency. The half power beamwidth in E planes is -30^0 and 30^0 For the radiation pattern.

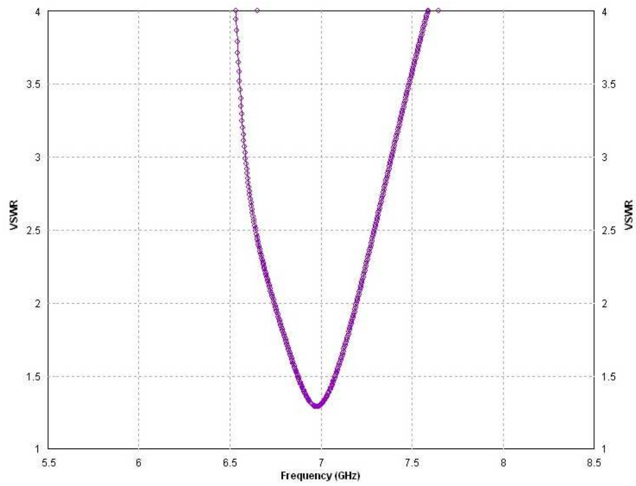

FIG. 4 VARIATION OF VSWR WITH FREQUENCY

TABLE 3 VSWR VALUES

Frequency (MHz)	VSWR
6940	1.303
6950	1.280
6960	1.263
6970	1.254
6980	1.249
7010	1.273
7020	1.290
7030	1.311
7040	1.344

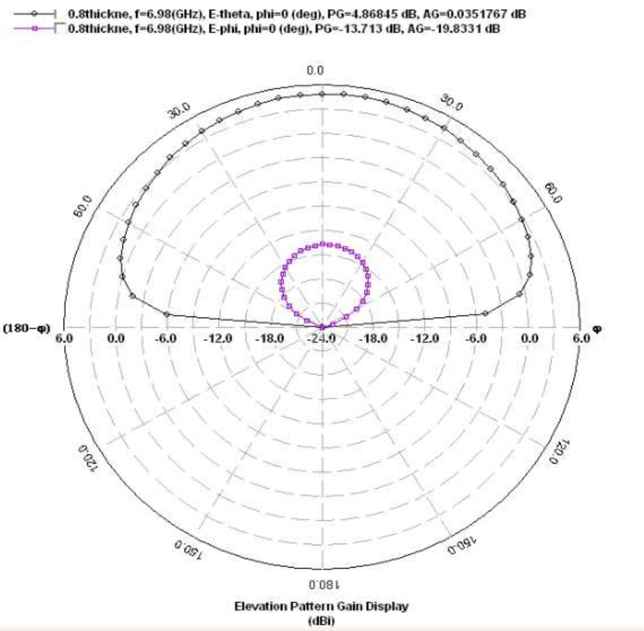

FIG. 5 RADIATION PATTERN

Conclusion

Microstrip antennas have become a rapidly growing area of research. Their potential applications are limitless, because of their light weight, compact size, and ease of manufacturing. The low profile L-shaped patch antenna is presented in this paper. The simulation results of the L-shape microstrip patch antenna have provided a useful design for an antenna operating at a frequency of 6981 MHz. At the time, the antenna is thin and compact with the use of low dielectric constant substrate material.

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Authors

Shivkant Thakur (Bihar, 06/01/1982)

Working as Assistant Professor in University College of Engineering and Technology, Vinoba Bhave University Hazaribagh, Jharkhand, India

Area of Interest: Rectangular Micro-strip Antenna for Wideband and Multipolarization.

Mr. Rajesh Kumar Vishwakarma (Sr. Lecturer)

working in Jaypee University of Engineering & Technology, Guna, Madhya Pradesh, India.

Areas of Interest: Microstrip for broadband antenna, Multiband & Wideband Antenna.

He received B.Sc and M.Sc degree in Electronics from DR. R. M. L. Avadh University Faizabad India in 1997 & 1999, respectively. He has four years research experience on topic "Design and development of dual-band microstrip antenna" from department of Electronics Engineering Institute of Technology, Banaras Hindu University, Varanasi in September 2000 to August 2004. Presently he is pursuing his PhD work on the topic of "Simulation, design and testing of dual band microstrip antenna" from School of Studies in Electronics, Pandit Ravishankar Shukla University Raipur. He was also involved as a gust faculty at department of computer science Banaras Hindu University Varanasi.

Rohit Gurjar (Agra,U.P: 26/09/1987) Working as Assistant Professor in Anand Engineering College (Sharda Group of Institutions), Agra, Uttar Pradesh, India.

Area of Interest: Multiband Fractal Antenna, Microstrip antennas