International Journal of Computer Sciences and Engineering Open Access
Research Paper Volume-6, Issue-3 E-ISSN: 2347-2693

Broadband CPW-Fed L-Shaped Slot Antenna with T-Tuning Stub for IMT Applications

Sandeep Kumar Singh[1], Vepakomma Kavya[2*], Rajendra Singh[3], Himanshu Parashar[4]

[1]Department of ECE, SET, Sharda University, Greater Noida, India
[2,3,4]Department of ECE, SET, Sharda University, Greater Noida, India

Available online at: www.ijcseonline.org

Received: 18/Feb//2018, Revised: 24/Feb2018, Accepted: 16/Mar/2018, Published: 30/Mar/2018

Abstract – In this paper, design and analysis of a coplanar waveguide (CPW) fed broadband square patch antenna is introduced. The proposed antenna consists of a square slot, L-shaped feed line, and with 'T' and inverted 'T' like structure which acts as tuning stubs. The Proposed antenna achieved IMT band (f_c=2.8 GHz) and bandwidth of antenna is 2.51GHz from 1.25 GHz to 3.76 GHz. The structure of antenna occupies a small volume 60(L) × 60(W) × 0.76(H) mm^3 and printed on FR-4 lossy (ε_r= 4.3) substrate.
The proposed antenna is simulated using CST V.12 microwave studio, and the performance of the antenna parameters is measured and characterized in the terms of return loss, VSWR, radiation pattern and surface current density at the resonant frequencies respectively**.** The simulated results confirmed by the successful design, using 50Ω CPW-feed line of antenna with return loss <-10 dB and VSWR <2 dB.

Keywords— Coplanar Waveguides (CPW), Microwave Integrated Circuits (MICs), Monolithic Microwave Integrated Circuits (MMICs), Voltage Standing Wave Ratio (VSWR), International Mobile Telecommunication (IMT), Industrial, Scientific, and Medical (ISM)

I. INTRODUCTION

Antennas play an important role of any wireless system. It can be stated as a transducer or transition device between a guided wave and in free space propagation. Antennas radiate/direct electromagnetic energy in the desired or assigned direction. The rapid growth of wireless systems and extensive usage of various forms of wireless applications raises the demand to design broadband antennas to cover a wide frequency range. Even though several antennas were designed from past several years, still the design of an antenna faces challenges like compactness, less complexity, light weight etc.

In today's era micro strip Patch antennas are widely used in Satellite Communication, military purposes, GPS, mobile, missile systems etc due to its compact shape and light weight, less complexity and easy to implement.

Micro strip antennas were introduced in the 1950's.However this concept had to wait for about 20 years to be realized after the development of the printed circuit board technology in the 1970's.Since then micro strip antennas became as most common type of antennas.

At present, many attractive characteristics of micro strip patch antennas like very small size, low profile, low cost, planar and lesser power consumption capabilities have made it a potential candidate in various wireless communications. They have been widely engaged for the Civilian and military applications, vehicle collision avoidance systems, satellite systems, health care systems etc.

The issue which comes with these micro strip patch antennas is their bandwidth and level of complexity for making the antenna. In this regard CPW antennas are becoming more and more popular due to their less complex design and high band width capabilities. CPW provides an easy solution for making wideband applications.

Since 1969, tremendous progress has been made in CPW based MICs as well as MMICs. The coplanar wave guide antennas are more distinguishable now days because of the simple two layer structure with relatively less thickness. Perturbation technique is commonly used on CPW-fed Micro strip patch antennas, such as loading with extra stub [1, 2], truncating corners [3], etching slots on the patch [4], and series feed coupling [5].

Impedance matching plays an important role in antenna design. By properly choosing the location and size of the tuning stub, a wide impedance bandwidth can be achieved [6]. The bandwidth of the planar antennas can be extended using embedded slits for reliable multiband RF communications [7]. The design of antenna can be done with different shapes of slots like wide rectangular slot, bow-tie slot etc.

This research is focused on designing of planar CPW fed square patch antenna with L shaped slot and 'T' & inverted 'T'-stubs .Various methodologies such as changing the thickness of substrate, position of tuning stubs in to the patch etc.. has been carried out in order to get better results. The structure of antenna is discussed in section II. Simulated result analyses of IMT band (f_c=2.8 GHz) are discussed in section III and finally, conclusion is given in section IV.

II. ANTENNA STRUCTURE

The schematic geometry of the conventional antenna is shown in Fig. 1. FR-4 has been used as a substrate ground (60x60 mm^2) with relative dielectric constant of 4.3 and thickness of 0.76 mm respectively .By etching a square slot (40x40 mm^2) in the ground plane and adding a L-shaped radiating patch in a modified square ring. The width of feeding line is connected to a 50 Ω CPW transmission line.

Table 1: Geometrical Parameters of Conventional Antenna

Parameters	L	W	L_1	W_1	L_2	W_2	G
Unit (mm)	60	60	40	40	30	30	4.3

A. Antenna Structure I

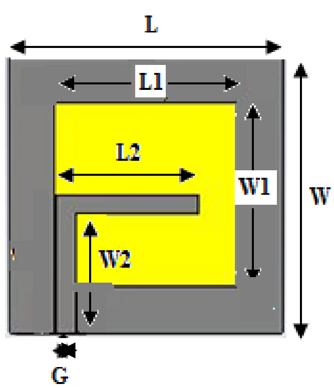


Figure 1: Geometry of the conventional antenna [8]

B. Antenna Structure II

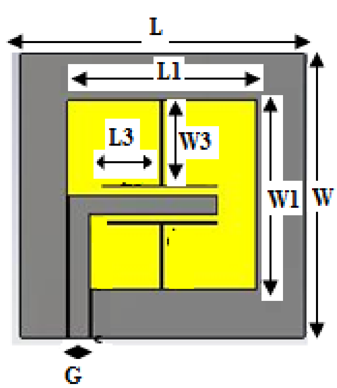


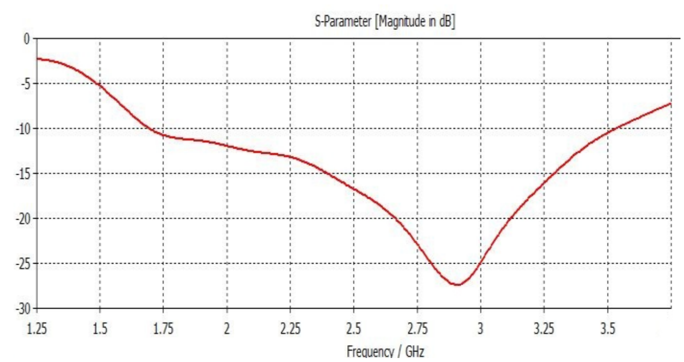
Figure 2: Geometry of the proposed antenna with 'T' and inverted 'T' shaped tuning stubs

Table 2: Geometrical Parameters of Proposed Antenna

Parameters	L	W	L_1	W_1	L_2	W_2	L_3	W_3	G
Unit (mm)	60	60	40	40	30	30	12	18	4.3

Fig. 2 shows the schematic representation of the proposed antenna. It is similar as Fig. 1.But the design of proposed antenna loaded on the 'T' and inverted 'T' shaped tuning stubs in inner square ring. The tuning stubs of the proposed antenna are empirically tuned to derive the good antenna performance and produces wide bandwidth with omni-directional radiation pattern.

III. SIMULATED RESULTS AND ANALYSIS



This section discusses and analyzes simulated results of reference and proposed antennas. The reflection coefficient curves of both the antennas are plotted as Fig 3 and Fig 4.The comparative graph has been plotted as Fig5 which shows that by introducing the T stubs the bandwidth has been increased to 2.5GHz from 1.84 GHz.

Figure 3: Return loss of conventional antenna

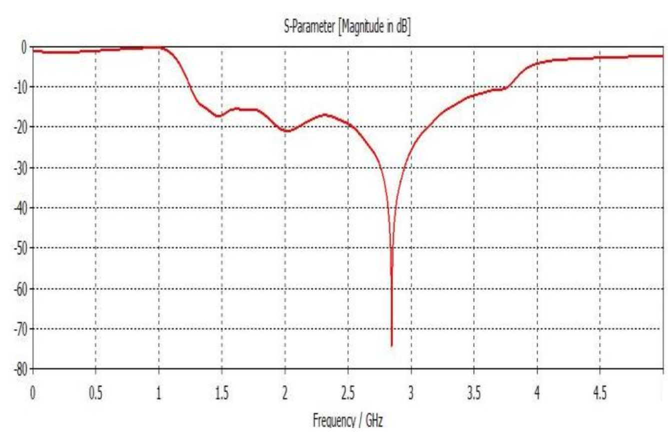


Figure 4: Return loss of proposed antenna

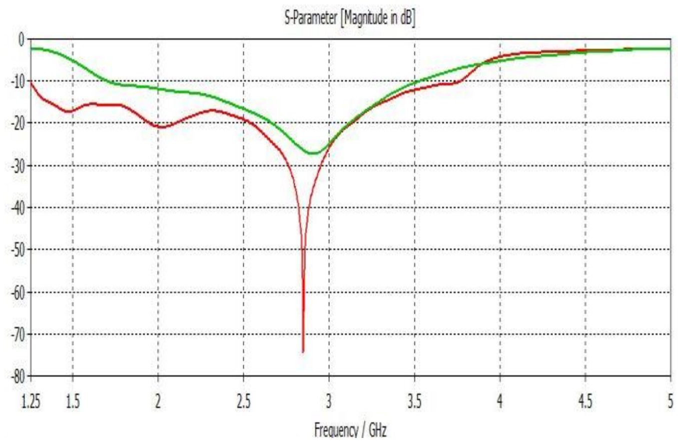


Figure 5: Comparison of Return loss

The VSWR Voltage standing wave ratio has been analyzed for the two antennas. The antenna with T and Inverted T stubs achieved VSWR which is equal to 1dB at 2.8GHz and less than 2dB is achieved for the bandwidth of 2.5GHz.As the results from comparative graph shows that the power delivered to antenna is more in proposed antenna design than to that of reference antenna.

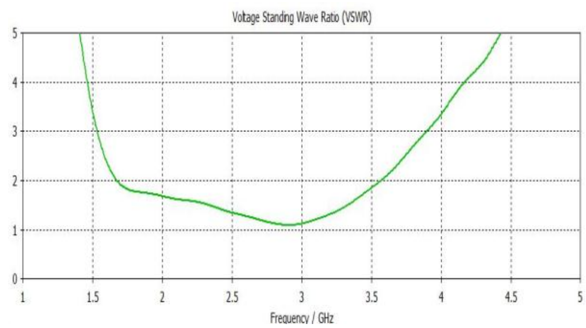


Figure 6: VSWR of conventional antenna

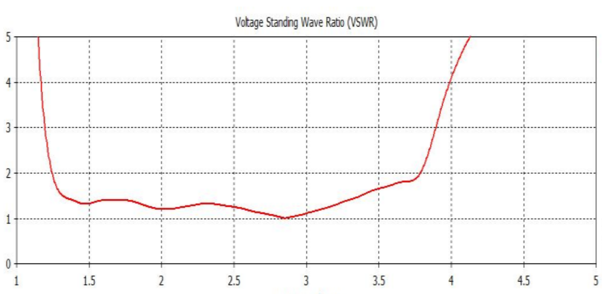


Figure 7: VSWR of proposed antenna

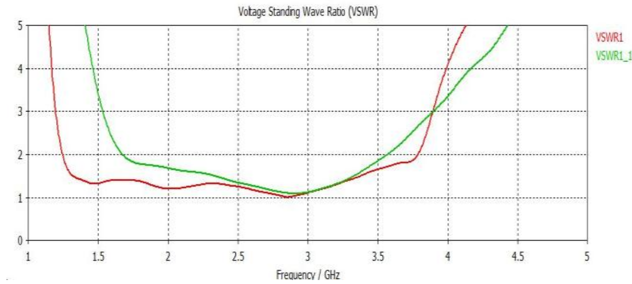


Figure 8: Comparison of VSWR

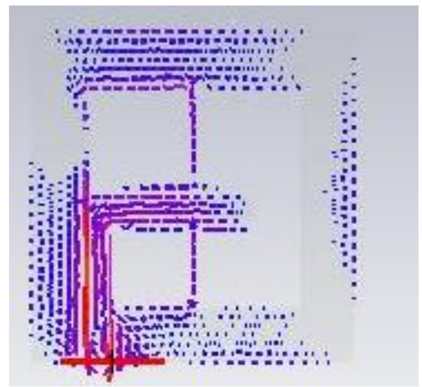


Figure 9: Surface current distributionof proposed antenna at 2.8 GHz

Table 3: Comparison between conventional antenna and proposed antenna

Parameters	Antenna-I	Antenna-II
Return Loss	The notch has been obtained at -27dB	The notch has been obtained at -75dB
VSWR	<2dB	≤1.5dB
Bandwidth	Broad band achieved with center frequency (f_c) approximately approaching 2.8GHz (B.W. = 1.84 GHz)	Broad band achieved with center frequency (f_c) exactly at 2.8 GHz suitable for IMT band (B.W. = 2.5 GHz)

IV. CONCLUSION

The novel broadband CPW-Fed antenna is designed and simulated. The proposed antenna achieved better bandwidth of 2.5GHz and VSWR ≤1.5dB .This can be used for IMT/ISM bands and in future long term evolution indoor Pico base station systems applications. The simulated results of proposed prototypes are yet to be validated through fabrication.

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Authors Profile

Mr. Sandeep Kumar Singh pursued his Bachelor of Engineering (ECE) from B R Ambedkar University, Agra and Master of Technology (ECE) from H B T I Kanpur and currently pursuing Ph.D from ISM Dhanbad. He is having good expertise in RF and Microwave Engineering. He developed and designed co-planar antennas and its characterization. Presently, Mr. Sandeep Kumar Singh is working as Assistant Professor (S.G.) in Electronics and Communication Engineering Department, SET, Sharda University ,Greater Noida. His area of interest is to design the microstrip patch antennas for broadband wireless communication.

Mrs. Vepakomma Kavya pursued Bachelor of Technology in electronics & Instrumentation Engineering from Jawaharlal Nehru Technological University, India in 2009 and currently pursuing Master of Technology in Digital communication from Sharda University Greater Noida. She has two years experience as a Guest lecturer in Govt. polytechnic college. Her main research work focuses on Antenna Design, Transducers, Sensors, IOT and Wireless Communication.

Mr. Rajendra Singh pursued Bachelor of Engineering in electronics and communication from Pokhara University, Nepal in the year 2011. He is currently pursuing M.Tech. in Digital Communication, Sharda University , Greater Noida, India. He has three years Teaching experience in Microcontroller system and interfacing. His research interests includes Antenna and Wave Propagation, Radio Networks, IOT and Wireless Communication.

Mr. Himanshu parashar pursued Bachelor of Technology from Bharati Vidyapeeth Deemed University,Pune,India in Electronics and Telecommunication in 2014 and currently pursuing Master of Technology from Sharda University in Digital Communication. He has one and half years experience in Telecom Domain as a Transmission engineer.His research interest includes RF and Microwave Integrated Circuit, Wireless and Radar Communication.

