

A CPW-Fed Compact Ku-band Microstrip Antenna

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ABSTRACT: A Coplanar Waveguide (CPW)-Fed Monopole Compact Ku-band Microstrip Patch Antenna is proposed for Satellite Applications (12 to 18 GHz). The basic antenna structure consists of a corner etched U-shaped rectangular patch with a central slot. The ground structure surrounds the entire single radiator by maintaining a gap of 1 mm on all sides. The proposed structure is on FR-4 Substrate with dielectric constant 4.4. This antenna has operating frequency from 11.2 GHz to 14.2 GHz and resonates at 11.8 GHz for Satellite services. The overall antenna structure is of 25 X 25 mm with height 1.6 mm³ achieves a good impedance matching with an operating bandwidth of 25%. As an improvisation to the proposed structure, a compact structure is designed by reducing the size of the antenna to 12.5 X 25 mm which gives even better results than the proposed structure.

KEYWORDS: Coplanar Waveguide, Monopole antenna, Ku-band.

I. INTRODUCTION

In recent years, Microstrip Patch Antenna has made great progress because of its huge applications. Better prospects have made it more advantageous compared to conventional antennas. These microstrip antennas are smaller in dimensions, low cost, low volume, low profile, lighter in weight and easy to fabricate. Moreover, these antennas can provide broad band-width, circular and dual polarizations, frequency agility, dual-frequency operation, dual and circular polarizations, beam scanning Omni-directional patterning.

Coplanar Waveguide is chosen over all other feeding methods, for the proposed design because of more advantageous. Coplanar Waveguide is one of the alternatives to microstrip patch antenna that place both, patch and the ground plane on the same layer. In this paper, A CPW-Fed Microstrip antenna is designed to operate in Ku-band for Satellite applications. Ku-band is one among the microwave frequency bands in the range of 12 to 18 GHz used for satellite communications and broadcasting. In the frequency range of ku-band, 12 GHz is used for terrestrial reception and 14 GHz for transmission.

II. RELATED WORK

The Microstrip UWB antennas have attracted much attention owing to their advantages such as simplex design, low profile, more bandwidth and high data rate. An antenna with inverted L-strip is designed over the conventional antenna to decrease the height and to minimize the monopole antenna [1]. To achieve more bandwidth along with good radiation patterns across full band, a triangular wide slot antenna with similar shaped patch fed by CPW has been developed [2]. An antenna is designed, which consists of an octagonal slot fed by a bevelled and square patch that covers the GPS, Bluetooth bands and also covers part of GSM UWB bands [4]. Various shapes of monopole antennas, such as a bevelled rectangular patch and a circular printed monopole with steps, and various shapes of slot antennas have been reported for a CPW-Fed antenna [6]. An antenna is designed for Ku-band (12 GHz to 18 GHz) on a Teflon substrate which has a dielectric constant of 2.1 [8]. However size reduction is a challenging job in the Microstrip Patch antennas for Satellite communications. So in this paper, A CPW-Fed Ku-band Microstrip Patch Antenna is designed.

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The proposed antenna consists of a single radiator which gives a good operating range from 11.2 GHz to 14.2 GHz for Satellite Applications. As an improvisation, a compact structure is designed by reducing the size of the antenna which gives even better results than proposed structure.

III. ANTENNA DESIGN OF PROPOSED STRUCTURE

A CPW-Fed Microstrip Patch Antenna is designed to operate in Ku-band. The primary use of antennas operating in ku-band is satellite communication, specifically for editing and broadcasting satellite television. A Microwave frequency band used for satellite communication and broadcasting, using frequency of about 12 gigahertz for terrestrial reception and 14 gigahertz for transmission. Ku Band Usage links are like Fixed Satellite Service (11.7 – 12.2GHz) and Broadcast Satellite Service (12.2 – 12.7GHz). Figure 1 show the geometry composed of a single radiated patch and a ground which surrounds the radiator. The major factor of the design is a small gap between the radiator and the ground plane which cause strong capacitive coupling.

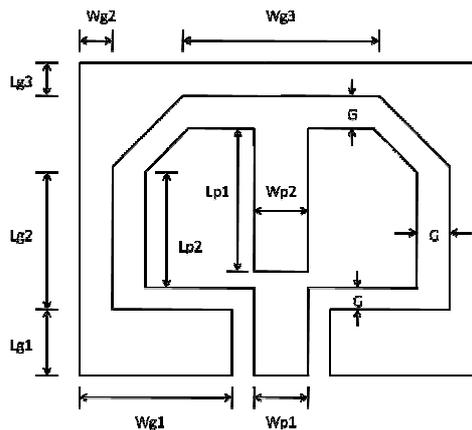


Figure 1: Proposed CPW-Fed Microstrip Patch Antenna Structure.

In the rectangular patch, length of the single radiator is $Lp2$. A central slot is made in the radiator patch, which makes the radiator looks like U-shape. The dimensions of the slot are of length $Lp1$ and width is of $Wp2$. The ground plane surrounds the radiator on all sides by maintaining a gap of 1mm. The Coplanar Waveguide feed is provided when both ground plane and radiator are on the same plane. The entire size of the antenna is $25 \times 25 \times 1.6 \text{ mm}^3$, and ground plane on either side has a vertical section of 25 mm as well as the horizontal section of 25 mm on upper side and 10 mm each on lower side. The Radiator is separated from the ground by a gap of 1 mm on entire surrounding.

To achieve 50 ohm characteristic impedance the CPW feed line is fixed at 3.0 mm. The designed Microstrip Patch antenna is then fabricated and placed on a 1.6 mm thick FR4 Substrate with dielectric constant 4.4 and a loss tangent of 0.024. The detailed dimensions of the structures are shown in the below Table 1.

Table 1: Design Parameters of proposed antenna structures

Parameters	$Lp1$	$Lp2$	$Lg1$	$Lg2$	$Lg3$
Unit (mm)	13.5	9	8	10	1
Parameters	$Wp1$	$Wp2$	$Wg1$	$Wg2$	$Wg3$
Unit (mm)	3	3	10	1	11

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IV. ANTENNA DESIGN OF COMPACT STRUCTURE

An attempt has been made to reduce the size of the patch antenna but not compensating with the results that are got earlier. So the proposed structure is made compact by reducing the size of the patch to 12.5 X 25 mm. Size reduced compact microstrip antenna is shown in figure 2. The dimensions of the compact structure are same as of the proposed structure except the width is reduced to half.

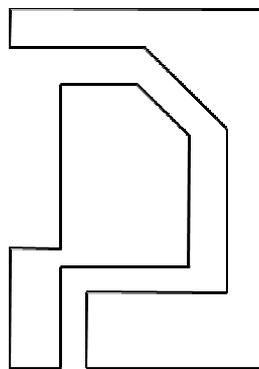


Figure 2: Compact Microstrip Patch Antenna

An integrated electromagnetic simulator, IE3D is used to design and optimize the proposed configurations. After the simulations, the design undergoes fabrication which involves mask design, lithography and wet etching. The fabricated structures are as shown in figure 3. Once the fabrication is done, both proposed and compact structures are tested in ZVL-Network Analyzer. The Network analyzer transmits a stimulus signal to the input port of the Device Under Test (DUT) and measures the reflected wave. The results measured in the analyzer are noted.



Figure 3: Fabricated structures

V. RESULTS AND DISCUSSIONS

Figure 4 shows the Comparison Graph of Simulated Return loss against frequency for the proposed structure and Compact Structure. So from the graph, it is observed that there are slight changes in bandwidth and return loss. Bandwidth of Proposed structure is 11.2 GHz to 14.2 GHz whereas in case of compact structure it is from 11 GHz to 14 GHz. And return loss of proposed structure and compact structure are -42 db and -22.5 db respectively.

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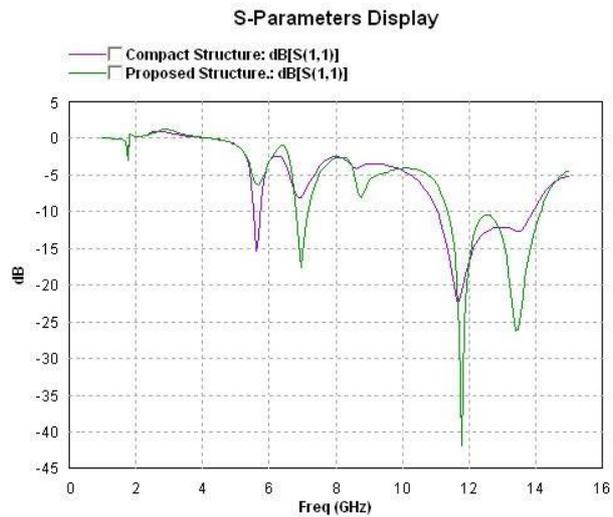


Figure 4: Comparison of Simulated Return loss against frequency of proposed structure and compact structure.

The VSWR (Voltage Standing Wave Ratio) or SWR (Standing Wave Ratio) is a function of Reflection Coefficient, which depicts the power reflected from the antenna. The Smaller the VSWR is, the better the antenna is matched to the transmission line and the more power is delivered to the antenna. The Simulated results of the Proposed and compact structure are shown in the figures 5 and 6 respectively. It is observed that the VSWR of both proposed and compact are 1.2 db.

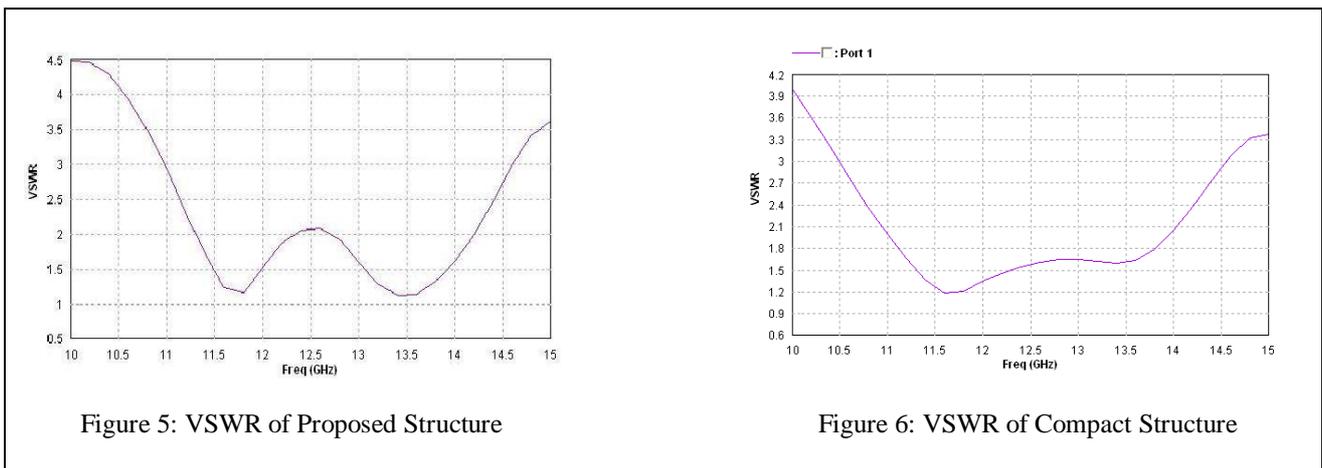
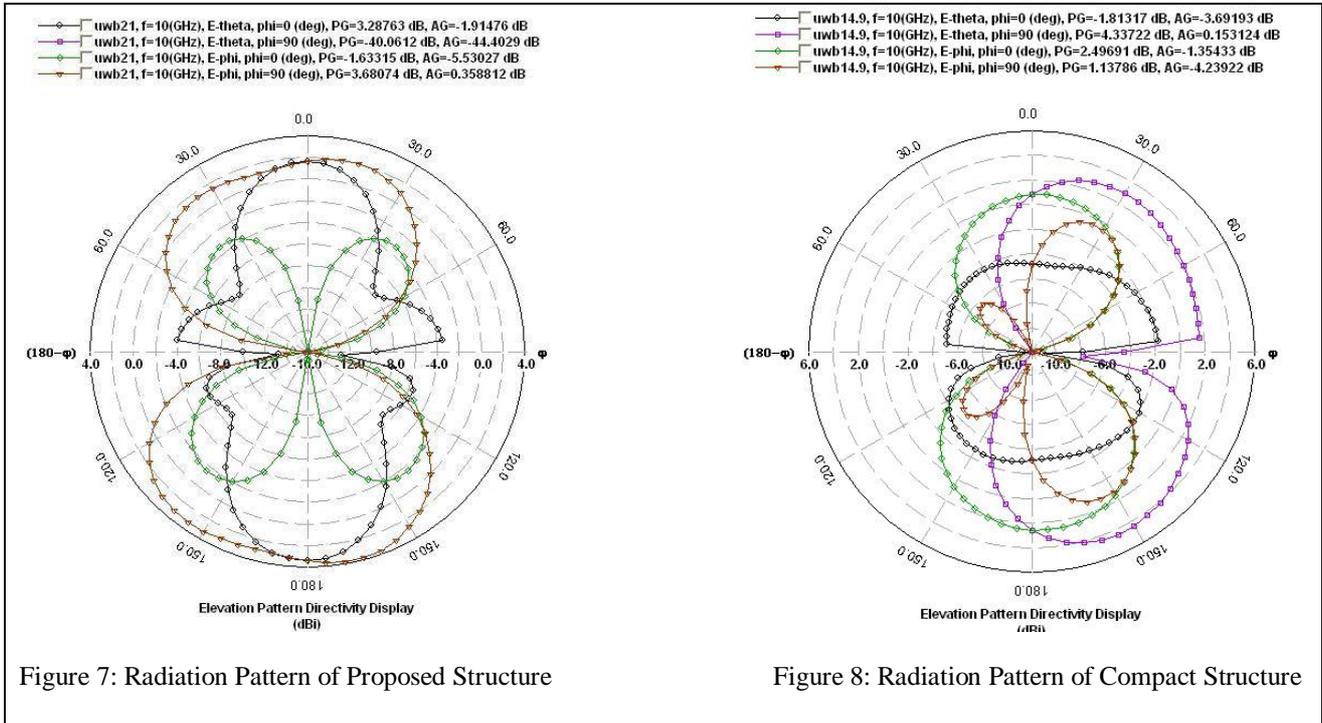


Figure 5: VSWR of Proposed Structure

Figure 6: VSWR of Compact Structure

The radiation pattern in the E-plane ($E\theta$ in the $\Phi=0^\circ$ and 90° planes) and H-plane ($E\Phi$ in the $\Phi=90^\circ$ plane) of the proposed and compact structures are shown in figures 7 and 8 respectively. By convention the co-pol direction is the direction of the Electric field (E) while the cross pol direction is the direction of the Magnetic field (H). The directivity and efficiency of proposed structure are 6.19 db and 42.53 % respectively, which gives a gain $G(\eta D)=2.476$ db. Whereas for compact structure directivity and efficiency are 6.99db and 51.26 % respectively, which gives a gain $G(\eta D)=4.09$ db.



The comparison of Simulated results of all parameters of proposed and compact structures are shown in the below table 2. It is observed that the Compact structure with overall size of 12.5 X 25 mm gives better results than the proposed structure with overall size of 25 X 25 mm. So with compact structure, the size has been reduced and yields good results than proposed structure.

Table 2: Comparison of Proposed and Compact Structure

Parameters	Proposed Structure	Compact Structure
Operating frequency	11.2 - 14.2 GHz	11 – 14 GHz
VSWR	1.2	1.2
Bandwidth	25.42%	25.42%
Radiation Efficiency	42.7836%	51.7528%
Antenna Efficiency	42.5323%	51.2638%
Gain	2.47637 dBi	4.0949 dBi
Directivity	6.18917 dBi	6.99679 dBi
Area Including Ground Plane	25 mm X 25 mm X 1.6 mm	12.5 mm X 25 mm X 1.6 mm

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After the fabrication, the structures are tested in ZVL-Network Analyzer and the results are measured and noted. The Return loss of the proposed structure and compact structure are shown in figures 9 and 10 respectively. The measured results show that, the bandwidth of proposed structure is 11.8 GHz to 12.77 GHz whereas in case of compact structure it is from 11 GHz to 13.31 GHz. And return loss of proposed structure and compact structure are 18 db and 15.5 db respectively.



Figure 9: Measured Return loss of Proposed Structure

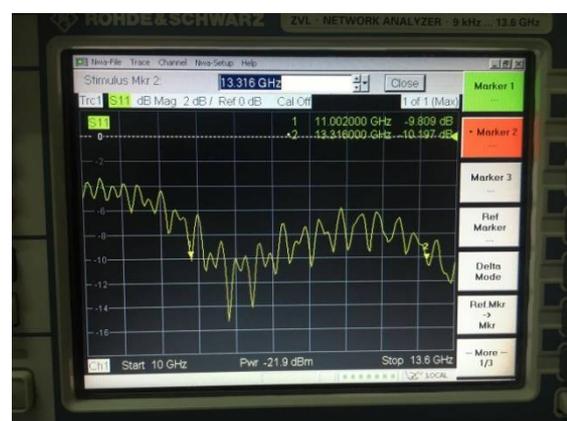


Figure 10: Measured Return loss of Compact Structure

The Measured VSWR of Proposed and compact structure are shown in the figures 11 and 12 respectively. VSWR is the voltage calculated along a transmission line i.e., ratio of the peak amplitude to the minimum amplitude of a standing wave. When an antenna is not exactly matched to the receiver, power is reflected (Reflection coefficient is not zero). It is observed that the VSWR of both proposed and compact are 1.2 db.

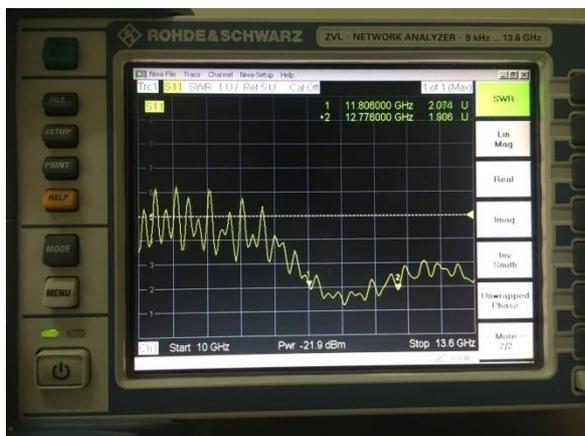


Figure 11: Measured VSWR of Proposed Structure

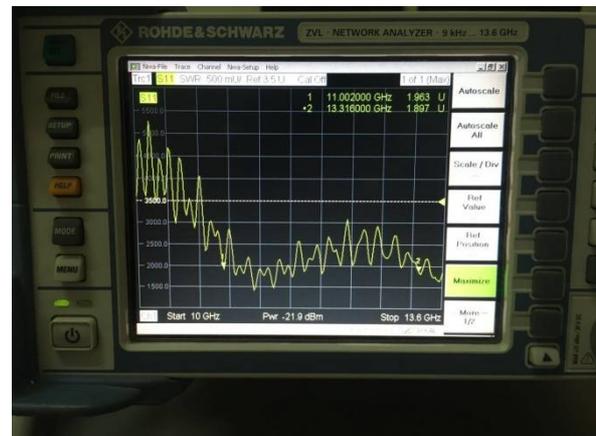


Figure 12: Measured VSWR of Compact Structure

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The Comparison of Simulated results and Measured Results of proposed and compact structure are shown in below table 3. Operating frequency range and VSWR are the two parameters measured in Network analyser and it is observed that the results the comparable with the simulated results.

Table 3: Comparison of Simulated and Measured Results

Parameters	Simulated Results		Measured Results	
	Proposed Structure	Compact Structure	Proposed Structure	Compact Structure
Operating Frequency	11.2 – 14.2 GHz	11 – 14 GHz	11 – 12.77 GHz	11 – 13.31 GHz
VSWR	1.2	1.2	1.2	1.2

VI. CONCLUSION

A CPW-Fed Ku-band Microstrip patch antenna is proposed. And as an improvisation by reducing size of the antenna, a compact structure is designed which gives even better results than proposed. The structures are fabricated and measured in ZVL-Network Analyzer. The measured results are almost comparable with the simulated results. The designed antennas are operating in the Ku-band (12 to 18 GHz) frequency range. These types of antennas are used for satellite applications. For further improve we can enhance the gain by forming an array.

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