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Design and Development of a New Wideband CPW Fed Patch Antenna for Wireless Communication

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Abstract

The present work shows a compact size coplanar waveguide (CPW) fed antenna for ultra-wideband (UWB) communication. The designed antenna has a dimension of 20 × 20 × 1.5 mm^3. The proposed antenna design comprises of a slotted rectangular patch etched on an inexpensive FR4 substrate. The proposed antenna offers a good impedance matching over a frequency range of 5.7 – 8 GHz. The characteristic parameters such as return loss, VSWR, radiation pattern and input impedance are analyzed using HFSS 11.0. Designed antenna is fabricated and tested. This antenna is found to be appropriate for various IoT based applications.

Keywords: omnidirectional, return loss, ultra-wideband, wireless communication

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1. Introduction

The Federal Communications Commission (FCC) has defined ultra-wideband as any signal that occupies a frequency band between 3.1 GHz to 10.6 GHz [1]. UWB provides an efficient transmission with low cost in wireless communication systems [2]. While designing UWB antenna the main challenge is to maintain compactness, wide impedance bandwidth and stable radiation pattern [3]. Various UWB antennas have been reported in the literature.

In [4], a CPW fed scaled down size microstrip patch antenna is displayed for ultra-wideband wireless applications. This antenna possessed an inverted L-strip on the radiating patch to reduce monopole antenna's height. A good impedance-matching characteristic and consistent gain were achieved in the whole bandwidth of 2.6 to 13.04 GHz. A flexible dual-band antenna for applications such as WiMAX and X-band is presented in [5]. The basic bow-tie shape design has been replaced by fishtail shape. This antenna gives a bandwidth of around 7 GHz in an upper frequency band. A CPW fed UWB compact antenna is discussed in [6]. A novel type of slot structure, radiating patch and co-ground structure has made this antenna small in size in comparison to various existing antennas. The hexagonally molded fractal geometry based microstrip antenna driven through CPW fed for various ultra-wideband wireless applications are presented in [7]. It has shown constant gain, good impedance matching and stable radiation pattern characteristics over a UWB frequency range. A novel compact-size structure of CPW-fed antenna with a wide bandwidth of 1.2 to 25 GHz has been investigated in [8]. The antenna consists of a circular disc, a spiral split ring resonator and CPW fed along with two tapered transmission lines for improving broadband impedance matching in the required band. In [9], application of inkjet-printing on Molded Interconnect Devices technology for designing of ultra-wideband antennas is presented. This printed antenna shows an impedance

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matching over the whole ultra-bandwidth of 10 GHz. Peng et al. presented a novel design consisting of electromagnetic bandgap geometry on the CPW feedline [10]. It is shown that by using Electromagnetic band-gap (EBG) structure, band notched performance of the antenna can be controlled. To achieve wideband performance capacitive slits and the truncated ground plane is used by Alibakshi et al. [11]. The antenna produces an impedance bandwidth of 5.25 GHz and 5.35 dBi gain. A UWB antenna with triple notched bands covering various wireless applications is reported by Sharma et al. [12]. The bandwidth achieved is 10.74 GHz with an omnidirectional radiation pattern.

As planar and compact antennas are used in mobile devices, there is a need of planar antennas with wideband responses. In this paper a CPW fed planar antenna is designed for use in IoT based wireless devices. The CPW antennas are promising candidates for microwave and millimeter wave application due to their unique features such as reduced dispersion, low radiation losses, wide bandwidth and low cost etc.

The construction of the proposed antenna is defined in Section 2. In Section 3, a parametric study to find out the optimized dimensions of the proposed design is presented. Fabrication and measurement results are included in Section 4. Finally, conclusion and future scope of work are discussed in Section 5.

2. Design of Proposed Antenna

The antenna comprises of a symmetrical slotted CPW fed rectangular patch over an FR4 substrate as shown in Fig. 1. The antenna dimensions are chosen to meet the requirement of compactness. As the bandwidth of patch antenna is generally narrow, slots have been created to enhance the bandwidth. Three slots have been created in the rectangular patch of size 11 × 8 mm^2. FR4 substrate is used as it is easily available and easy for prototyping in laboratories. CPW fed line width is 3 mm to achieve proper impedance matching. The designed antenna is compact in size as compared to antennas presented in [4, 5].

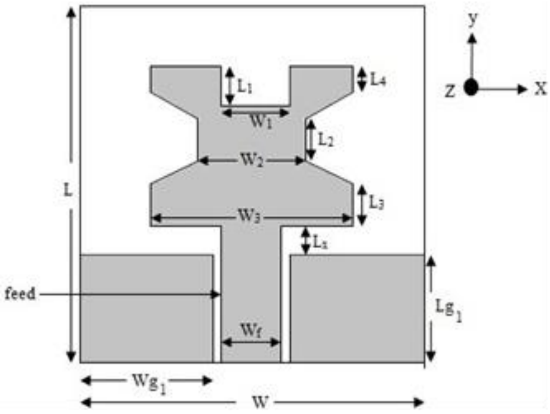


Figure 1. Structure of proposed CPW antenna

The geometrical dimensions are listed in Table 1.

Table 1. Geometrical dimensions of CPW antenna

Dimension	Value
Substrate (L, W, h)	20 × 20 × 1.5 mm^3
Patch	11 × 8 mm^2
Feedline Width (W_f)	3 mm
Feedline length	9 mm

The various dimensions of the patch are indicated in Table 2.

Table 2. Dimensions of radiating structure

Parameter	Value (mm)
Wg_1	8.1
L_1	2
W_2	11
L_2	2
L_3	2
L_{g1}	7.8
L_4	2
W_3	7

3. Simulation and Results

The designed CPW antenna was simulated using HFSS 11.0. The performance metrics such as return loss, VSWR, radiation pattern and input impedance were obtained from simulations. The critical parameters are chosen for parametric study. These parameters are a gap between ground planes and patch Lx and slot width W_1. The other dimensions are kept unchanged as indicated in Table 2 while performing parametric studies. Figs. 2 - 3 demonstrate the simulation results of the return loss at different values of these parameters.

Fig. 2 shows the impact of slot length W_1 on return loss. There is a change in resonating frequency and bandwidth with a change in the slot length. This parameter affects the return loss characteristics near the low and middle frequency. The lowest value of return loss is obtained while keeping W_1 =3 mm.

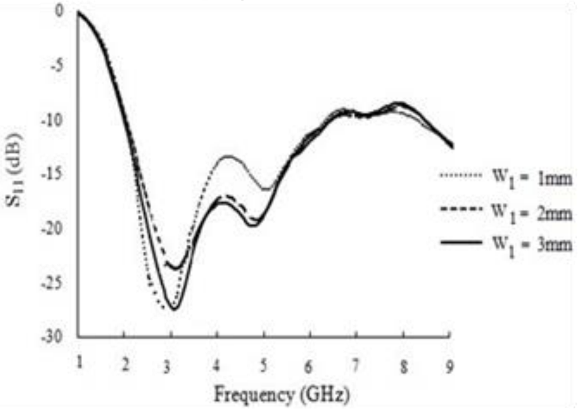


Figure 2. Impact of slot length W_1 on return loss S_{11}

From Fig. 3, it can be analyzed that as Lx increases from 1 mm to 1.4 mm, the corresponding return loss changes for a whole band. So, to have proper coupling from feed to patch, this parameter has to be optimized. Three significant bands can be observed by keeping Lx = 1.4 mm.

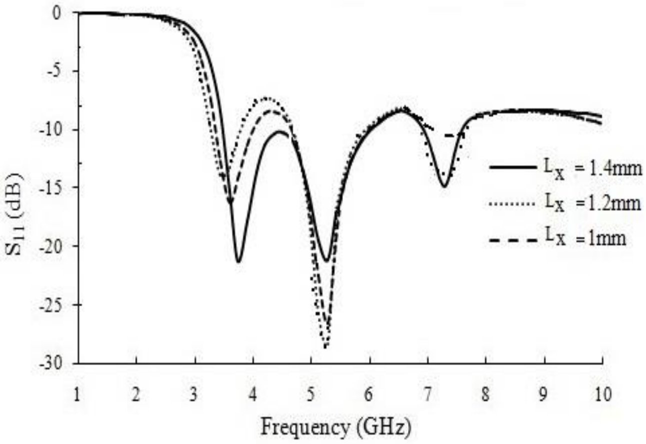


Figure 3. Impact of ground plane length Lx on return loss

From the parametric study, optimized values of parameters were obtained. The obtained optimized values are mentioned in Table 3.

Table 3. Dimensions of optimized parameters

Dimension	Value (mm)
W_1	3
Lx	1.4

Fig. 4 illustrates the simulated return loss curve over the entire frequency range. This antenna produces a dual-band response. The lower band is centered at 3.6 GHz with a bandwidth of 400 MHz and the upper band is from 5.7 GHz to 8 GHz. The values of S_{11} are -20.7 dB at 3.6 GHz and -28 dB at 5.8 GHz.

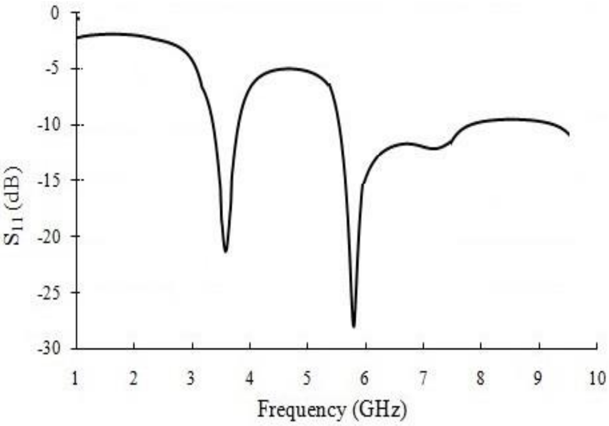
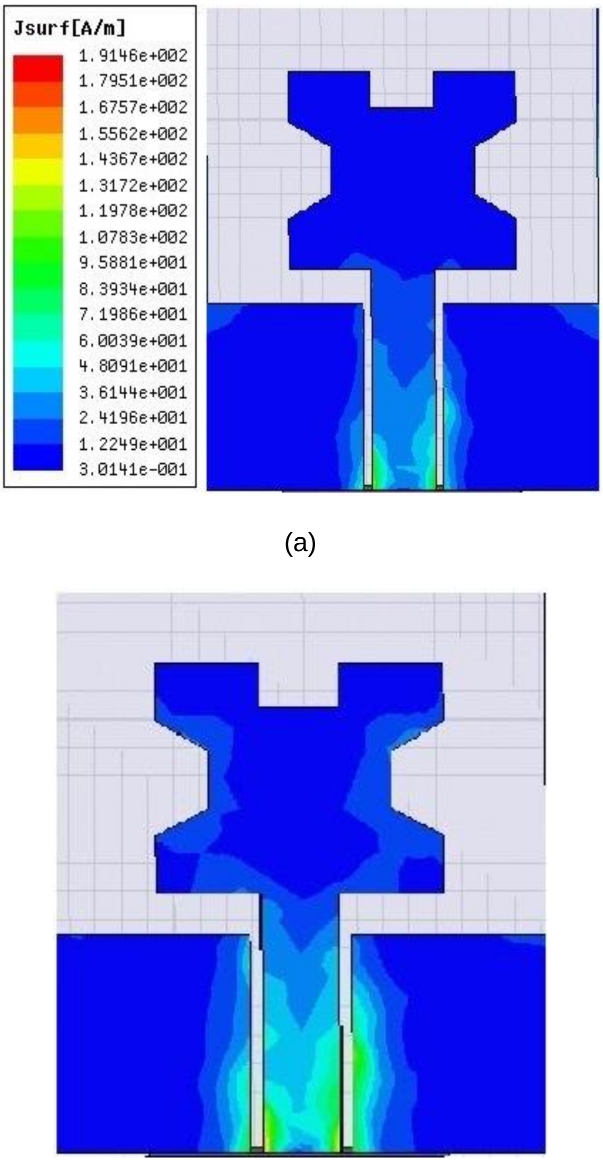


Figure 4. Simulated return loss versus frequency curve of design CPW antenna for optimized parameters

The simulated current density distribution in Fig. 5 shows that at 3.6 GHz current is mainly concentrated near the feed and side portion of ground plane, whereas at 5.8 GHz it spreads uniformly over the patch.

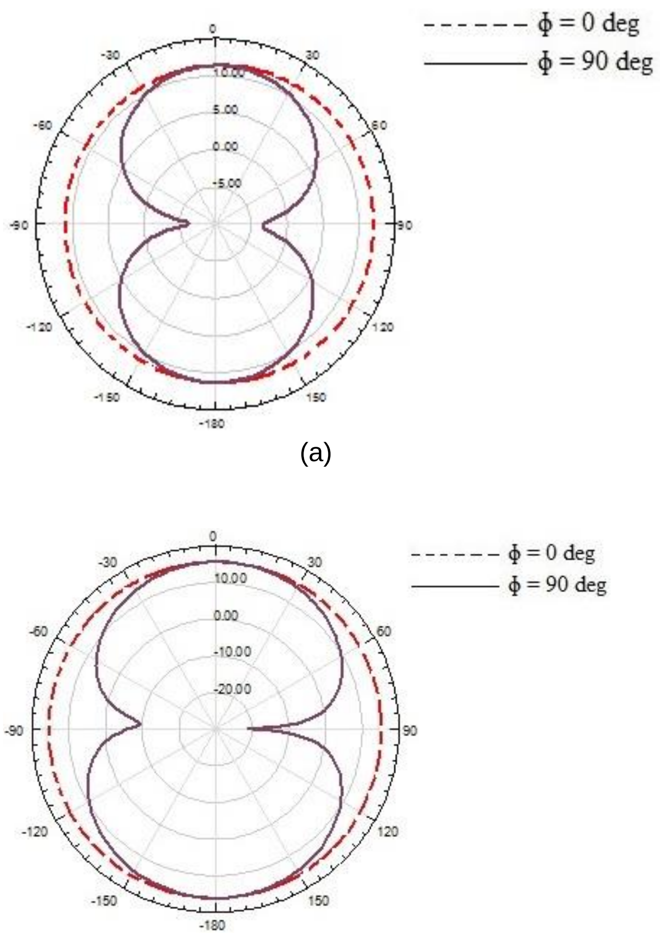


(a)

(b)

Figure 5. Simulated current density distribution at (a) 3.6 GHz and (b) 5.8 GHz

Radiation patterns at 3.1 GHz and 5.8 GHz are plotted for two different values of ϕ as shown in Figure 6 (a) & (b). The obtained, radiation patterns are omnidirectional, which are suitable for mobile communication.



(a)

(b)

Figure 6. Radiation pattern plots of designed CPW antenna at (a) 3.1 GHz and (b) 5.8 GHz

4. Fabrication & Testing

The designed antenna is developed on an FR4 material as shown in Fig. 7 using photolithographic technique.

Figure 7. A photograph of fabricated CPW antenna

The testing of the fabricated antenna is performed using Anritsu MS46322A Vector Network Analyzer.

According to Fig. 8, the fabricated antenna was found to resonate at three different frequencies. The 1st band resonates at 2.1 GHz with a bandwidth of around 200 MHz. The 2nd band is at 3.7 GHz with a minimum return loss of -32 dB and 350 MHz bandwidth. The 3rd band is at 6.9 GHz with a bandwidth of 1.1 GHz. The antenna response makes it suitable for various present generation wireless applications such as WLAN, RFID etc.

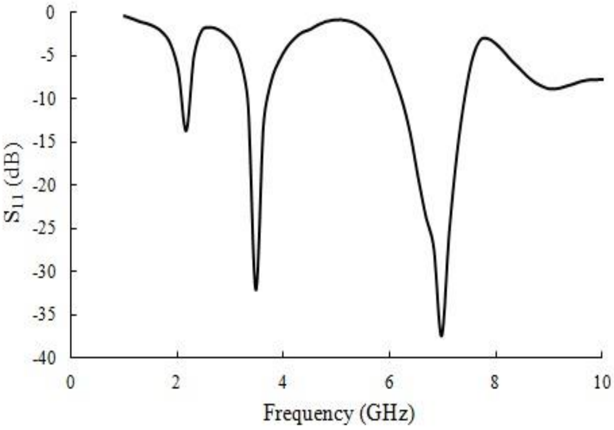


Figure 8. Measured return loss versus frequency curve of fabricated CPW antenna

All the obtained bands are suitable for different present generation mobile applications. The discrepancy between the simulated and measured results could be attributed to the fabrication inaccuracies and effect of improper soldering of SMA connector.

Fig. 9 gives the VSWR variation for the entire operating range. It can be seen that for three different bands VSWR values are less than 2, which are desirable.

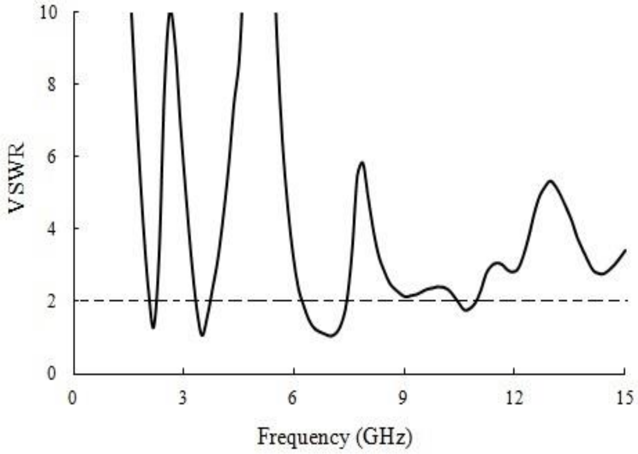


Figure 9. VSWR versus frequency plot of CPW antenna

According to the measured impedance curve shown in Fig. 10, the fabricated antenna shows impedance matching close to 50 ohms at point M1 (5.06 GHz).

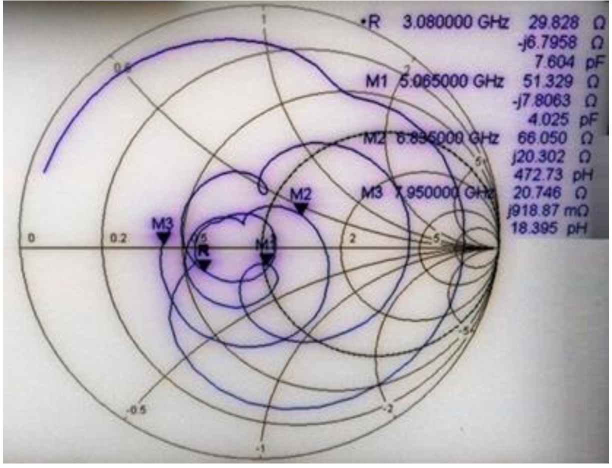


Figure 10. Measured Impedance curve of fabricated CPW antenna

5. Conclusion and Future Scope

In the present work, an ultra-wideband patch antenna with CPW feed is designed and analyzed. The simulated results display that the proposed antenna gives a dual-band response with a bandwidth of 2.3 GHz for one of the band. The proposed antenna shows good properties such as dual band response at 3.1 GHz and 5.8 GHz, omnidirectional radiation pattern, wide bandwidth and compact size etc. These properties make the designed antenna suitable for various wireless communication systems.

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