A Compact CPW-Fed Modified Disc Antenna for Super-Wideband Applications

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Abstract— A compact novel printed CPW-fed antenna for super-wideband (SWB) application is presented. Modifying the circular disc radiating patch to dome shape and by cutting the lower edges of the radiating patch in the form of rectangular staircase shape the super-wideband is achieved. The proposed antenna has a compact size in its structure compared to conventional antenna designed for the same frequency. The proposed SWB antenna has compact in its size of 26 × 32× 1.6 mm^3 fed by CPW and gives an impedance bandwidth of more than 171% (2.70-32.79 GHz) for $|S_{11}|< -10$ dB and exhibits an omnidirectional radiation characteristics over the entire frequency band and with an moderate gain. The design of the proposed antenna and its various parameters are studied by using the Ansys HFSS software. The present antenna may cover the personal wireless communication services such as Bluetooth (2.8 GHz), WIMAX (3.4 GHz), WLAN (2.4/5 GHz), UMTS and Ultra-wideband (UWB)(3.1- 10.6 GHz) applications.

Key words: CPW-Fed Antenna, Super-Wideband, Ultra-Wideband (UWB), Wi-MAX, WLAN

I. INTRODUCTION

In recent years, the planar CPW-fed antennas are most widely used and extensively useful for short range personal communication systems such as Ultra-wideband (UWB) communication system due to their better features, such as low power consumption, less weight, easy to manufacture, low profile, integration with other MMIC devices and good omni-directional radiation characteristics over the operating band. In 2002, the Federal Communications Commission (FCC) of US was assigned frequency band of 3.1 to 10.6 GHz for the ultra-wideband (UWB) technology [1]. After then, the UWB communication technology has receiving much attention in technically having many advantages such as short range high secured data transmission, low power consumption, easily accessible system structure and avoiding of interference signals with other wireless narrow frequency bands such as WLAN, Wi-MAX, Bluetooth etc. Hence, the UWB communication technology has becoming good candidate for global wireless technology for handheld high-tech multiuser gadgets. In last decade, the various designs of UWB antenna configurations such as circular, square, rectangular, annular, elliptical, disc, head shaped [2-5] with omni-directional radiation patterns for present and future SWB and UWB applications have been studied and installed in many wireless handheld devices. Some antenna designs such as square, rectangular shape, Semi-elliptical, circular, annular ring, egg-shaped and elliptical antennas with impedance ratio bandwidth more than 10:1is achieved and such an antennas are generally known as super-wideband (SWB) antennas [6-10].

In this article, a simple compact printed dome shape SWB antenna fed by a co-planar waveguide (CPW) is presented. By modifying the circular radiating patch to form a dome shape and cutting the rectangular staircase slots at the lower side of the radiating patch, then the proposed antenna is capable to work for the operating band from 2.70 to more than 35 GHz with impedance bandwidth of more than 171% for less than -10 dB (S_{11}) return loss. The details of the antenna performance and optimized design are verified using Ansys High Frequency Structural Simulation (HFSS) software[11] and the obtained results are discussed.

II. DESIGN OF THE PROPOSED ANTENNA

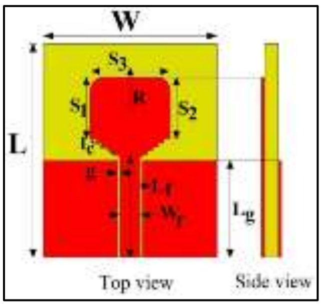


Fig. 1: Geometry of the proposed SWB antenna

The geometry of the proposed SWB CPW-fed antenna is shown in Fig. 1. The proposed antenna is etched on the FR-4 epoxy substrate of permittivity (ε_r) 4.2 and loss tangent (δ) 0.02 with compact size of 26 × 32× 1.6 mm^3. The antenna is formed as dome shape from the conventional circular radiating patch and is fed by co-planar waveguide (CPW). For the better performance of impedance matching between radiating patch and ground plane the minimum gap is maintained between feed line and each

CPW ground planes of g= 1.5 mm, and also to enhance the impedance bandwidth, a simple technique has been adopted i.e. a small narrow rectangular staircase slots are created at the lower position of the radiating patch. The truncated partial ground plane of 32 mm × (2×11) mm is used. To permit the SWB antenna to operate in much higher frequency, the distance between radiating patch and the ground plane is maintained at 0.65 mm. The microstripline feed width (W_f) and length (L_f) is fixed at 3.17 mm and 15.15 mm respectively to achieve 50Ω characteristic impedance.

The optimized design parameters of the prosed CPW-fed SWB antenna are as follow:

W = 26 mm, L= 32 mm, S_1 & S_2= 7.23 mm, S_3= 8 mm W_f= 3.068 mm, L_f = 15.15 mm, L_g = 14.5 mm, R= 7.9 mm and g = 0.65 mm.

III. RESULTS AND DISCUSSION

The proposed CPW-fed super wideband antenna is designed and simulated with 3D full-wave electromagnetics ANSYS HFSS software. The return loss versus frequency and VSWR curves for the optimized design parameters are as shown in Fig. 2 and 3 respectively. From these figures it is observed that, the designed SWB antenna meets the expectations of the magnitude of the return loss (S-parameter) is less than -10dB ($|S_{11}| < -10$ dB) and the VSWR ≤ 2which gives a impedance bandwidth of more than 171% covers the wide operating frequency range from 2.70 to more than 35 GHZ. Hence, the proposed CPW-fed SWB antenna can covers the all applications such as personal wireless communication (PCS) systems such as Bluetooth, Worldwide Interoperability for Microwave Access (WiMAX), Universal Mobile Telecommunication System (UMTS), X-band Satellite communication, Wireless Local area Network (WLAN) and ultra-wideband UWB system etc.

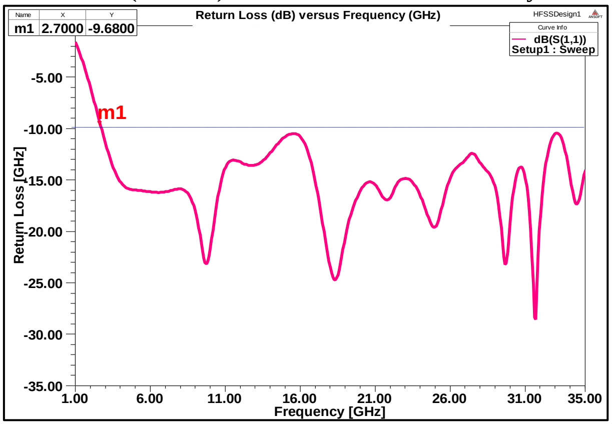


Fig. 2: Return loss versus frequency plot of the proposed CPW-fed SWB antenna

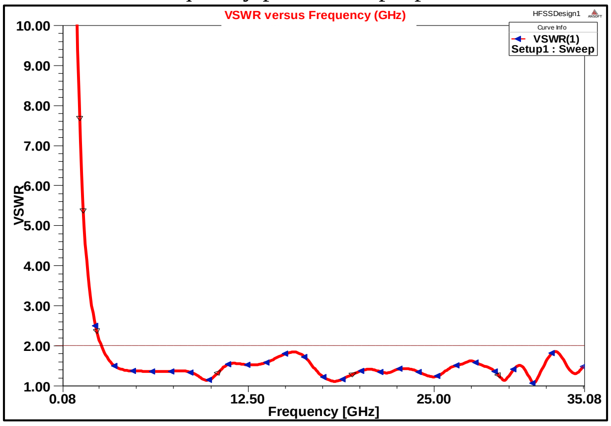


Fig. 3: The VSWR plot of the proposed CPW-fed SWB antenna

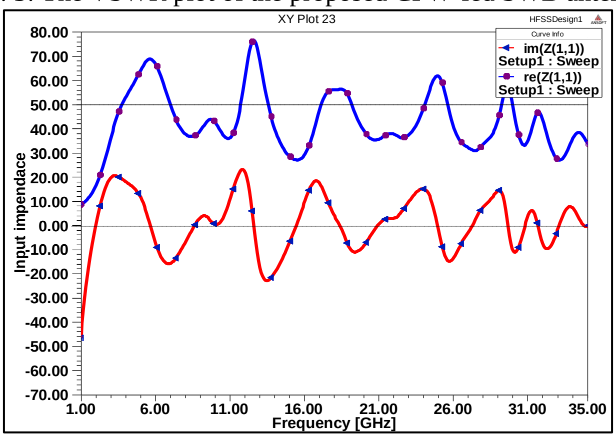


Fig. 4: The input impedance (Z_{in}) versus frequency plot for the proposed CPW-fed SWB antenna

Figure 4 shows the simulated input impedance (Z_{in})of the proposed CPW-fed SWB antenna. From this figure it is clear that, the real and imaginary parts of the input impedance are maintained constantnearly vicinity of 0 Ω and 50 Ω respectively throughout the entire operating frequency band. It is also known from the imaginary component of the input impedance Z_{in} that major part of the operating frequency band showing better impedance matching between radiating patch and partial ground plane.

The surface current and distributions for the minimum return loss ($|S_{11}|$) of the proposed antenna at frequencies 3, 5.5, 15.2, 21.3, 27.4 and 30 GHz respectively. From these figures, it can observe that, the current densitiesare mainly distributing near along the edges of the co-planr waveguide (CPW) ground planes, while on the top surface the currents are primarily concentrated on microstripline feed and lower outer edges of the radiating patch.

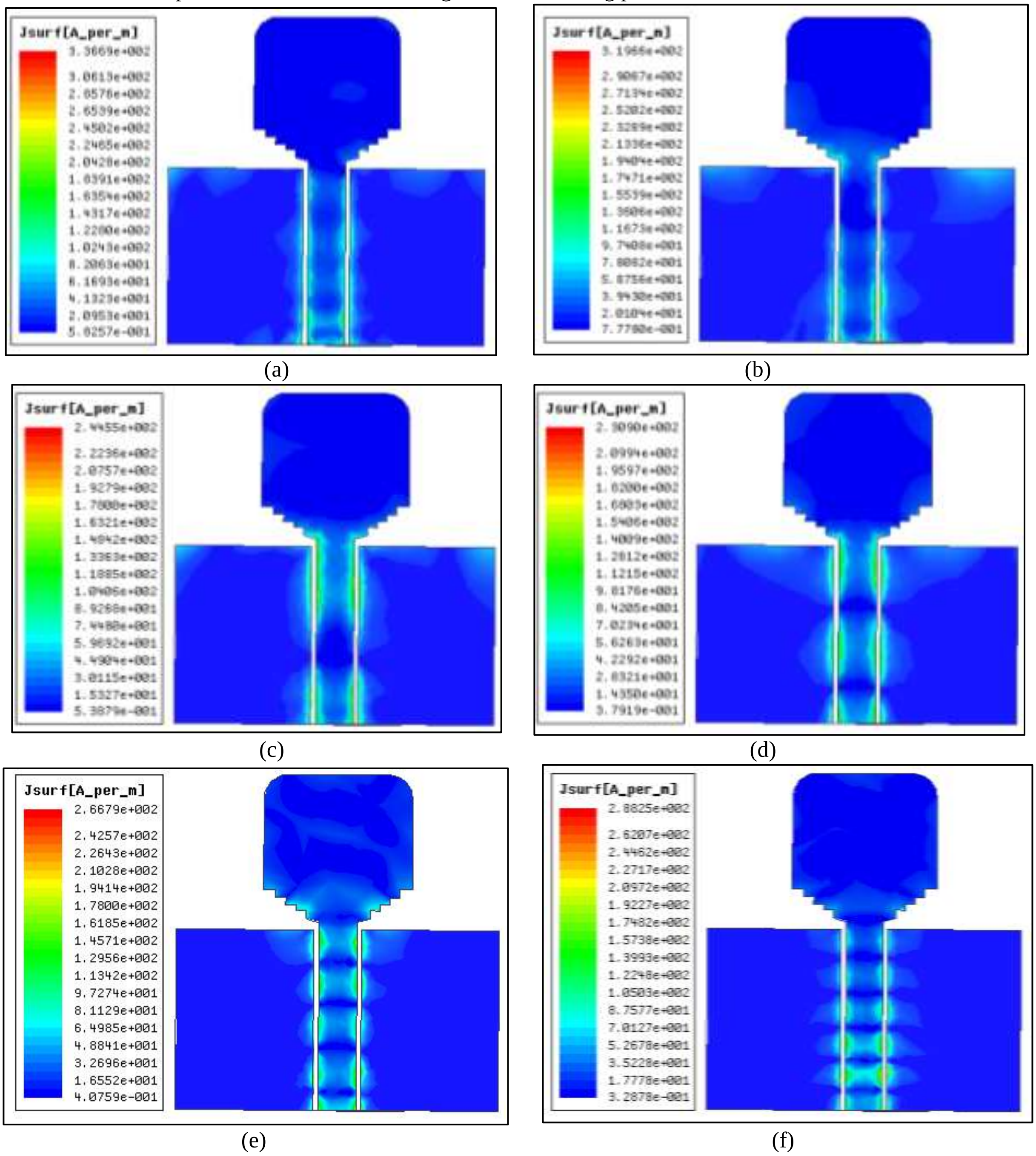
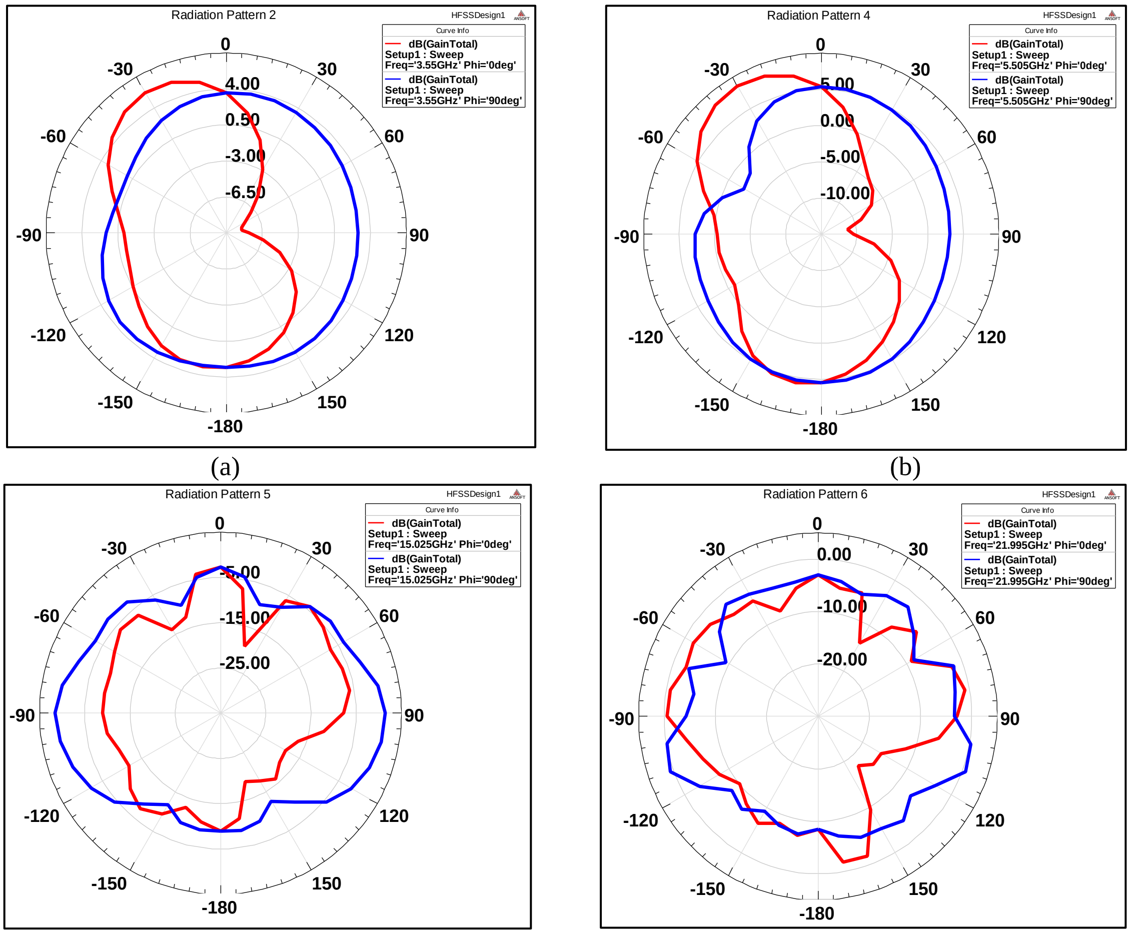


Fig. 5: Current distributions (in A/m) at (a) 3, (b) 5.5, (c) 15.2,(d) 21.3, (e) 27.4 and (f) 30 GHz

Figure 6 shows the normalized E- and H-plane radiation patterns of the proposed CPW-fed SWB antenna measured at 3.66, 6.6, 16.02 and 21.99 GHz respectively. From these figures, it is observed that, the radiation patterns nearly omnidirectional in the H-plane (Y-Z plane) and bidirectional radiation patterns in E-plane (X-Y plane) and also at the higher frequencies. The simulated peak gain variation of the proposed SWB antenna is shown in Figure 7. As seen from Fig. 7 that, the constant average stable gains from 5-6 dB from 1- 11 GHz over the entire SWB band is found.



(a) (b) (c) (d)

Fig. 6: 2D and 3D E-plane (X-Y plane) and H-plane (X-Z) radiation patterns measured at (a) 3 GHz, (b) 5.2 GHz and (c) 9.9 GHz and 15.44 GHz

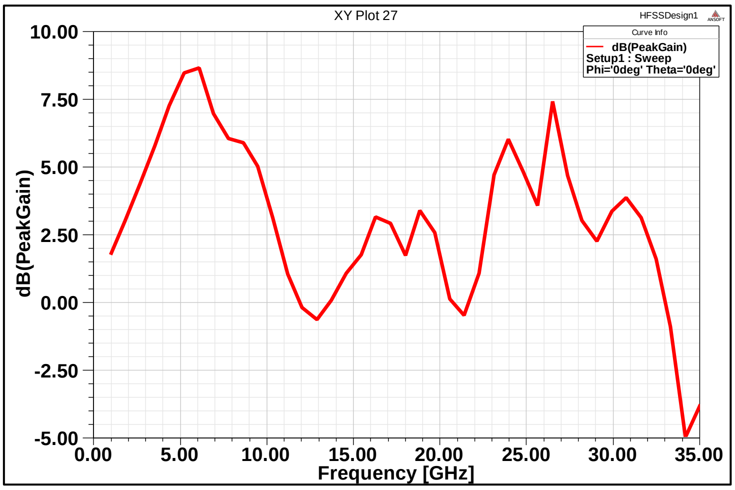


Fig. 7: Simulated peak gain of the proposed SWB antenna

IV. Conclusion

A novel design of compact dome-shaped SWBCPW-fed antenna is proposed in this paper. By cutting the optimized dimensions of rectangular staircase slots near at lower radiating patch, the super-wideband (SWB) is achieved and covers the frequency band of 2.70 to more than 35GHz. This antenna gives a -10dB impedance bandwidth of more than 171%. From the obtained results it is seen that, the proposed SWB antenna has a good omnidirectional radiation patterns even at higher frequencies and moderate gains of 5-6 dB over the entire SWB operating band. Hence, the proposed antenna has a compact in its size, simple configuration structure and low cost to manufacture and which is most useful for many wireless communication systems.

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