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Dual Band Notched CPW Fed Printed Monopole Antenna for UWB Applications

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Abstract: A Coplanar waveguide (CPW) fed printed monopole antenna with dual notch band characteristics is proposed for Ultra wideband (UWB) applications. The Ultra wideband antenna operates from 2.48 GHz to 18.35 GHz. Dual notch band is achieved by incorporating double H-slot structure in the radiating element. It achieved notch bands at 3.5GHz (WiMAX) and 8.3GHz (military/radar). The proposed antenna is investigated for the notch bands and operating band as well for various performance parameters like voltage standing wave ratio (VSWR), surface current distribution and far field radiation characteristics. It achieved a peak gain of 5.2dB in the operating band. The proposed antenna is fabricated on fr4 substrate of dimensions 37 x 40 x 1.6 mm3. By analysing the simulated and measured results of the proposed antenna it is observed that the proposed antenna is good for UWB applications by eliminating WiMAX and military/radar application interferences.

Keywords: Coplanar waveguide (CPW) fed, Dual notch band, Double H-slot, Printed monopole antenna, Ultra wideband (UWB) applications.

1. Introduction

Ultra wideband antenna has a vital role in the present wireless communication systems. UWB antennas have large communication capacity with high data rates and are low cost antennas. The advancements in the ultra-wideband technology enable high data transmission rate for indoor and outdoor communications with low power consumption. The simple hardware configurations make this ultra-wideband technology as unique advantageous solution over conventional narrow band technology. Nevertheless, the UWB system still facing different challenges like interference to WLAN operating in the IEEE WiMAX network 3.35-GHz (3.3–3.4 GHz), 3.5-GHz (3.4–3.6 GHz), 3.7-GHz (3.6–3.8 GHz) (5.725–5.85 GHz), WLAN 5.25-GHz (5.15–5.35 GHz) and 5.75-GHz (5.725–5.825 GHz), IEEE INSAT/Super-Extended C-band, and X-band 7.5-8.5 GHz operating bands. Researchers are designing different antennas with multiband characteristics for compact and handheld devices for multi service systems.

Various band notched antennas were proposed and designed by different researchers for ultra wide band applications. Planar UWB antennas with notch band characteristics especially in WLAN, WiMAX and DSRC band are proposed by various authors [1-8]. Rahman M Proposed a CPW fed triple notch band UWB antenna with bandwidth enhancement [9]. Tunable and multi band notched antennas are proposed in [10-14] by researchers using SRR and CSRR. Reconfigurable UWB antennas with dual notches are proposed in [15, 17]. UWB antennas with notch bands are proposed for IoT and wireless medical applications in [16, 18]. Z. Li proposed [19] Vivaldi antenna with dual notch at 5.3-5.8GHz and 7.85-8.55 GHz. Triple band notched UWB antenna with CSRR and inverted U-slot is proposed in [20]. A monopole antenna with gap sleeve is proposed for UWB applications [21].

In this paper, a dual band notched antenna with super ultra-wide band characteristics is proposed. Section 2 gives the proposed antenna design iterations and geometrical specifications. Simulated results, parametric analysis and discussions of various antenna performance parameters are described in section 3. Antenna fabrication, prototype model and the experimental results are represented in section 4 and 5 respectively and comparison of the proposed UWB antenna with dual notch with other research works is also presented in Section 5. Section 6 gives the conclusion of the proposed dual band notched antenna and its simulated and measured performance.

2. Antenna design

Fig. 1 (a), iteration-1 shows the geometry of reference UWB antenna. It is based on a planar monopole structure with truncated rectangular patch and gap Sleeves. Ultra wideband characteristics are achieved by carefully designing the gap between monopole and the ground and coplanar waveguide (CPW) feed method is used to feed the antenna with 50-ohm impedance.

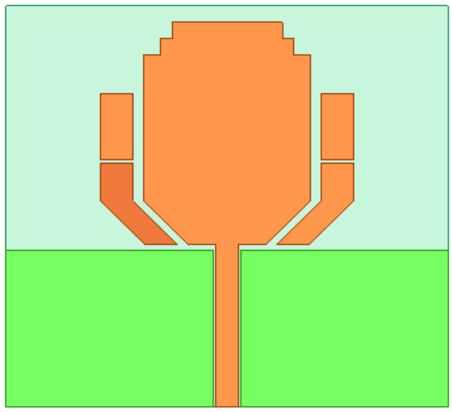
To conquer the surplus potential interference of existing narrow band systems with UWB antenna, notch band antennas are desired to be designed. Double U-slot is introduced in monopole structure to obtain notch band characteristics for the proposed UWB antenna. The geometry is represented in Fig. 1 (b) iteration 2. It achieved single notch band characteristics. By employing H-slot and a pair of U-slots in monopole structure, dual notch bands are obtained through 3.2-3.9GHz (WiMAX) and 7.9-8.6GHz (military/radar applications) bands.

The geometry of the proposed dual notched band antenna along with its specifications are given in Fig. 1 (c) iteration 3. ANSYS HFSS simulation tool is used to design and optimize the proposed antenna. The proposed antenna is fabricated on a FR-4 substrate of dielectric constant 4.4 and thickness 1.6mm.

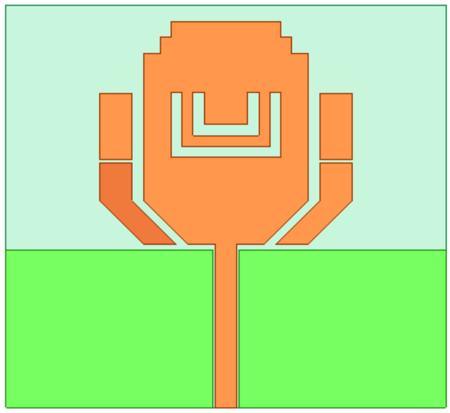
3. Antenna design

3.1 VSWR characteristics

Simulated VSWR characteristics of the proposed antenna iterations are plotted in Fig. 2. It is observed form these characteristics that iteration-1 has achieved super ultra wide band characteristics ranging from 2.4GHz to 18.35GHz. By introducing double U-slots in truncated rectangular patch structure of the proposed UWB antenna in iteration-2, single notch is observed in VSWR characteristics from 4.0 – 4.78GHz. Dual notches are observed in iteration-3 by employing a pair of H-slot and U-slots in the monopole structure. Dual band notched characteristics are observed at 3.2-3.9GHz (WiMAX) and 7.9-8.6GHz.



(a)



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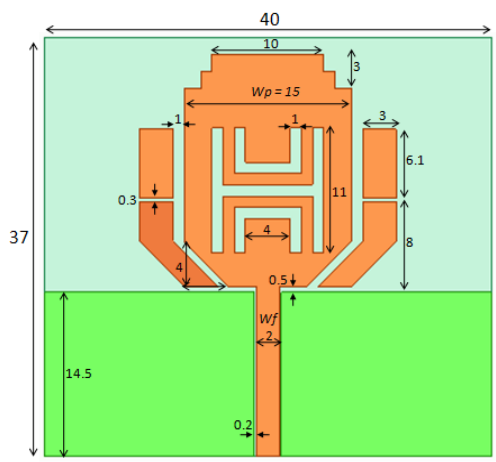


(c)

Figure. 1 Iterations of the proposed antenna: (a) iteration 1, (b) iteration 2, and (c) iteration 3

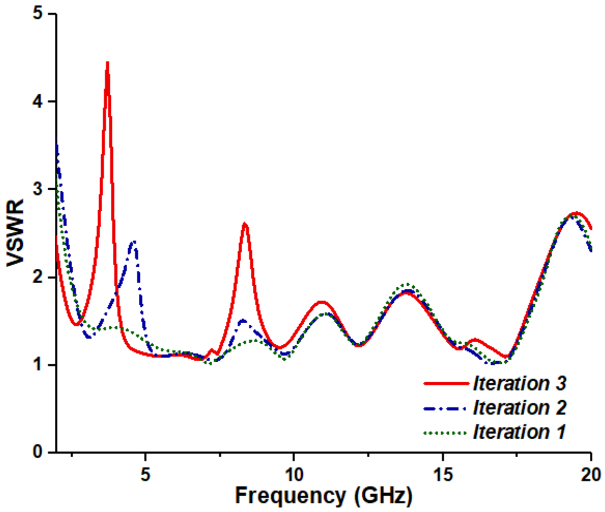
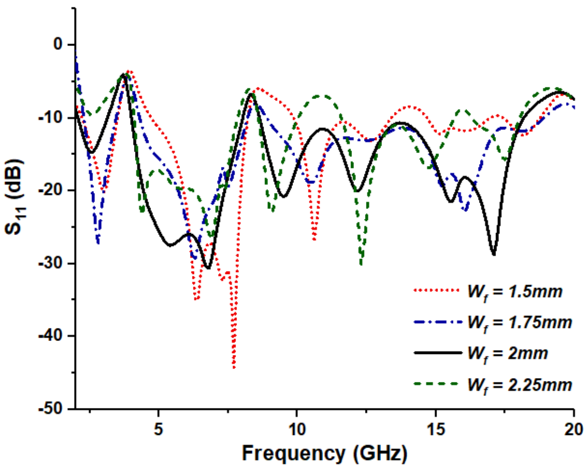
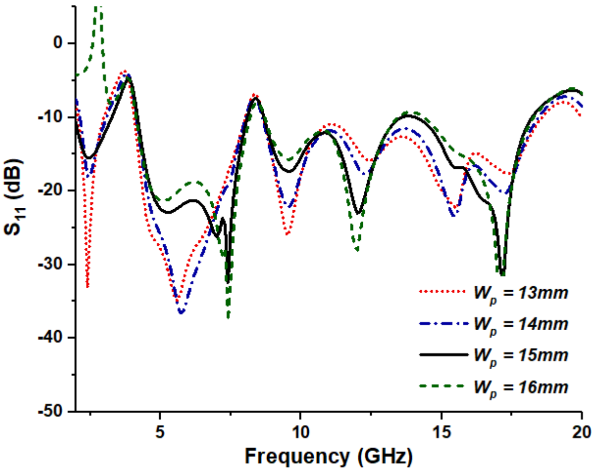


Figure. 2 Simulated VSWR characteristics of the proposed antenna iterations



(a)



(b)

Figure. 3 Simulated S_{11} characteristics of the proposed antenna for: (a) variations in W_f and (b) variations in W_p

3.2 Parametric analysis

To optimize the proposed antenna parameters and performance, parametric analysis is carried out for the proposed dual band notch antenna. The parameters, feed width (Wf) and width of the truncated rectangular patch (Wp) are analyzed for different values. Fig. 3 (a) represents the parametric analysis with respect to Wf in-terms of S11 characteristics. Wf is varied from 1.5mm to 2.5mm with a step size of 0.25mm. It is observed that for Wf = 2mm, the proposed antenna exhibits good notch band characteristics for WiMAX and Military/radar applications. S11 characteristics for the variation of Wp from 13mm to 16mm with a step size of 1mm are plotted in Fig. 3 (b). Form these characteristics, it can be viewed that for Wp = 15mm, the proposed antenna has good UWB characteristics with dual notches for WiMAX and military/radar applications.

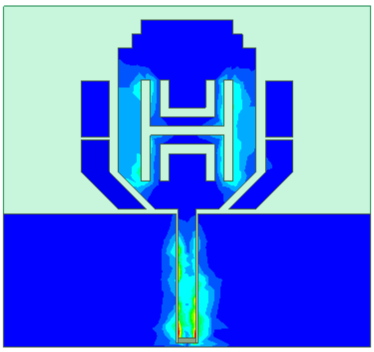
3.3 Surface current distribution

Surface current distribution of the proposed dual band notch antenna at notch frequencies 3.6GHz , 8.3GHz and at two operating frequencies 5.8GHz, 10GHz are represented in Figs. 4 (a), (b), (c), and (d) respectively. The current distribution at notch frequencies is very less and the current distribution for operating frequencies is high and it is more concentrated in radiating element feed line and the corners of truncated rectangular patch.

4. Fabricated antenna

The proposed CPW fed UWB antenna with dual bands notched is fabricated on FR-4 substrate of dimensions 37 x 40 mm^2, thickness 1.6mm and dielectric constant of 4.4.

The fabricated proposed antenna is presented in Fig. 5 (a) and its experimental set-up with VNA for measuring antenna performance parameters is represented in Fig. 5 (b).



(a)

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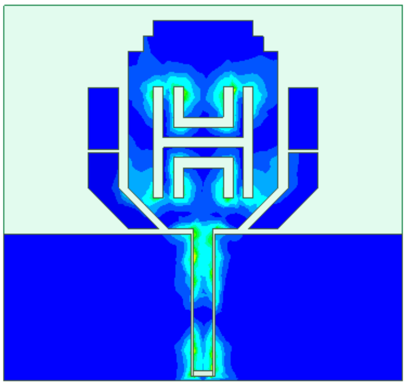

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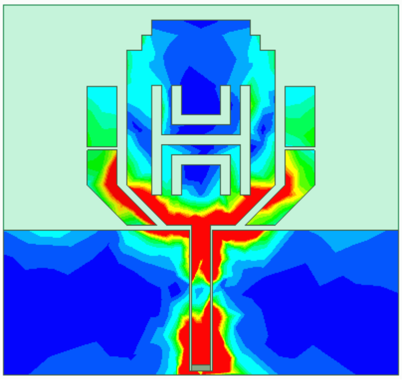

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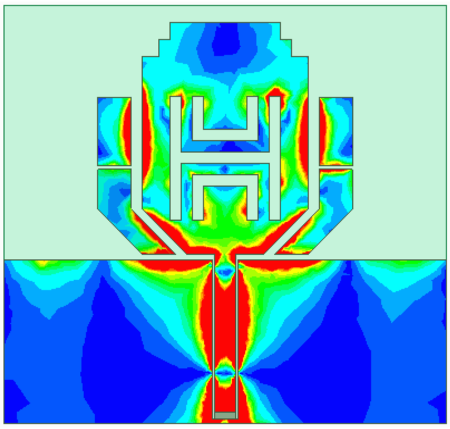
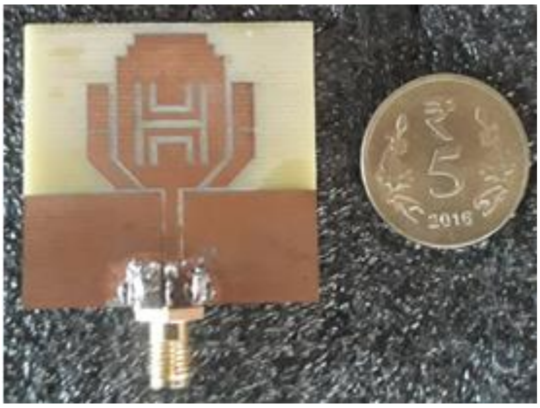
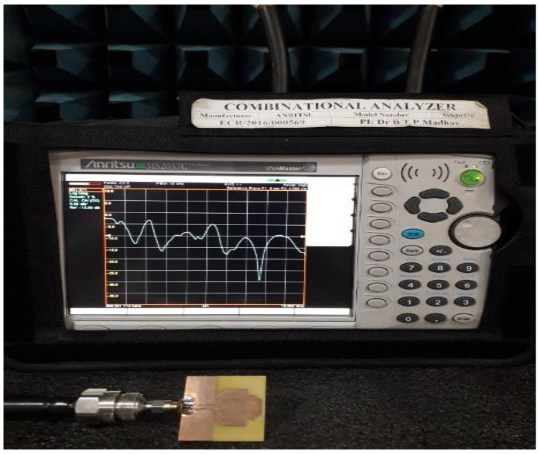


(d)

Figure. 4 Surface current distribution of the proposed antenna: (a) 3.6GHz, (b) 8.3GHz, (c) 5.8GHz, and (d) 10GHz



(a)



(b)

Figure. 5 Fabricated proposed antenna and its experimental set-up: (a) fabricated antenna and (b) Experimental set-up with VNA

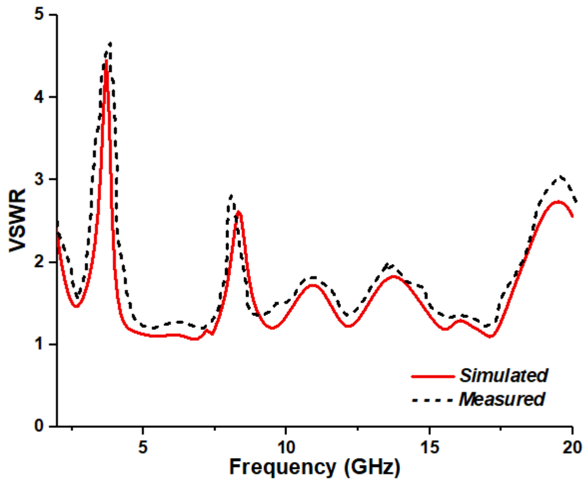
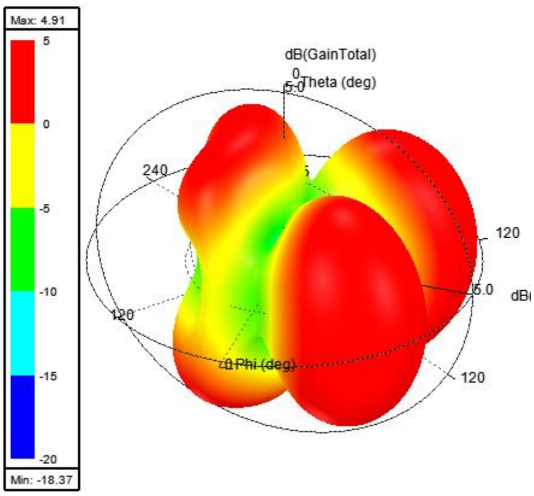


Figure. 6 Simulated and measured VSWR characteristics of the proposed antenna

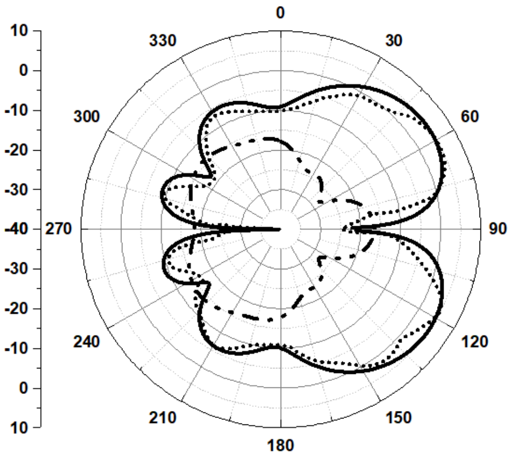
5. Experimental results

Fig. 6 plots the simulated and measured VSWR characteristics of the proposed UWB antenna with dual band notched. As observed in the figure, measured values are close to simulated values and notches are observed at 3.65GHz and 8.2GHz.

Fig. 7 (a) illustrates 3D gain plot of the proposed UWB antenna at 10GHz resonant frequency. It achieved directional radiation and the plane of radiation is along the plane of antenna. Figs. 7 (b), (c), (d), and (e) represent the simulated and measured radiation patterns (co-polarization and cross polarization) of proposed dual notch antenna for two operating frequencies (10 GHz and 5.8GHz) and for the two notched band (3.6GHz and 8.3GHz). At 10 GHz, the proposed antenna exhibits directional patterns with a maximum of 4.8dB gain. At 5.8GHz, the patterns are dipole like directional and achieved valid gain. At operating frequencies, the proposed antenna maintains good acceptable difference between co-polarization and cross polarization patterns. At notch frequencies, 3.6GHz and 8.3GHz it can be observed that there is not much difference between co-polarization and cross polarization patterns. Hence, it suppresses the dual notch frequencies.



(a)



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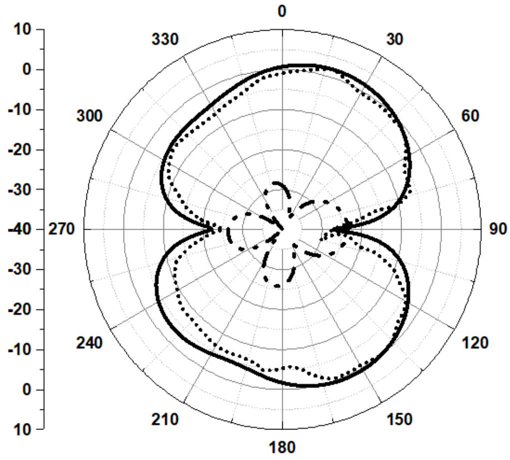

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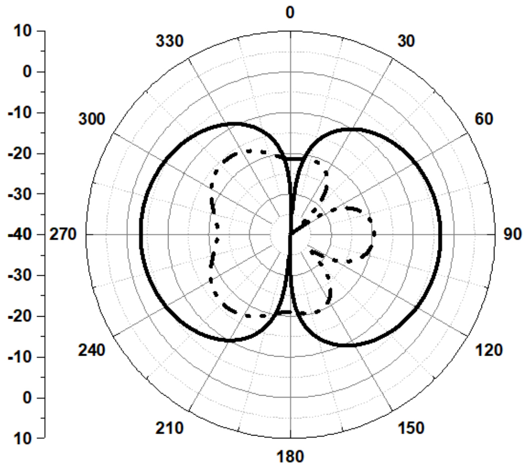

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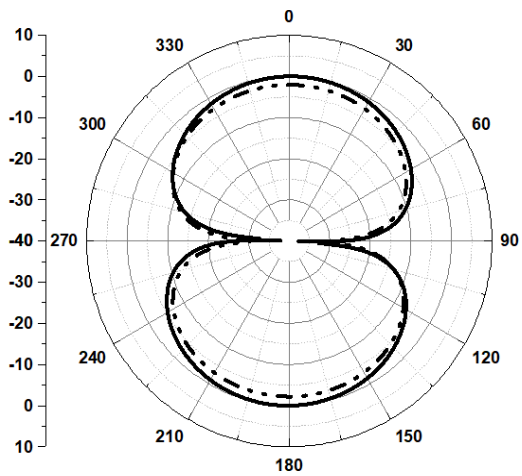

(e)

Simulated Co-polarization
Simulated Cross polarization
. . . . Measured Co-polarization

Figure. 7 Radiation patterns of proposed antenna: (a) 3D gain plot of proposed antenna at 10GHz, (b) theta=90deg at 10GHz, (c) theta=90deg at 5.8GHz, (d) theta=90deg at 8.3GHz, and (e) theta=90deg at 3.6GHz

Table 1. Comparison of parameters of the proposed antenna

Author, [Ref. No.]	Operating Band (GHz)	Bandwidth (GHz)	Notch Bands (GHz)	Gain (dB)	Radiation Efficiency (%)
M. Abedian [7]	3 - 13	10	3.22-4.06 4.84-5.96	4.8	96
Le Kang [8]	3.08-11.8	7.72	5.03-5.97	3.6	82
Z. Li, C. Yin [19]	2.9 - 11.6	8.7	5.3-5.8, 7.8-8.5	6	NA
Proposed	2.48 - 18.35	15.87	3.2-3.9, 7.9-8.6	5.2	96.2

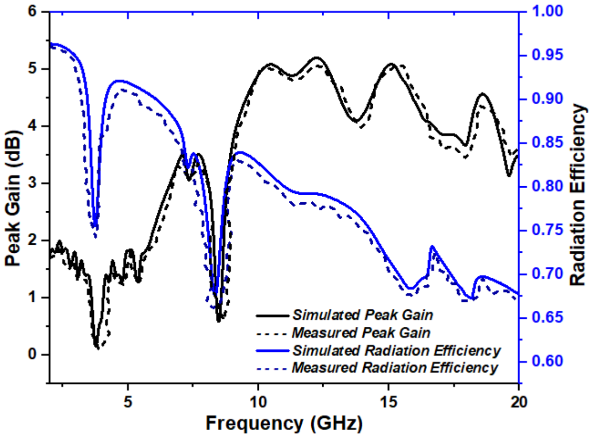

Figure. 8 Gain and radiation efficiency characteristics of the proposed antenna

Simulate and measured gain (dB) vs frequency (GHz) and radiation efficiency vs frequency (GHz) characteristics are plotted in Fig. 8. Simulated peak gain is 5.2dB at 12.2GHz and measured peak gain is 5.1dB at 12.2GHz. The simulated maximum radiation efficiency is 96.2% obtained at 2.4GHz. It can be observed that simulated and measured values are in good agreement and the gain, radiation efficiency values are less at notch frequencies compared to operating band values.

To validate the proposed dual notched UWB antenna, the parameters gain, notch bands, operating band, bandwidth and radiation efficiency of the proposed model are compared with existing UWB notch antenna models in Table 1.

As mentioned in Table 1, the proposed dual notched band UWB antenna has better performance parameters. It achieved super ultra wide band with reasonably good gain and radiation efficiency.

6. Conclusions

In this paper, CPW fed super UWB antenna operating from 2.4-18.35GHz is presented with dual notch at 3.5GHz (WiMAX) and 8.3GHz (military/radar applications bands). Dual notch bands are achieved with the employment of a pair of H-slot and U-slots in monopole structure of the proposed antenna. Simulated and measured values of various antenna performance parameters like VSWR characteristics, surface current distribution, far-field radiation characteristics are investigated. VSWR values are between 2 and 1 in the entire operating range except at notch frequencies. At 3.6GHz VSWR value is 4.5 and at 8.3GHz it is 2.8. The proposed antenna achieved a peak gain of 5.2dB and maximum radiation efficiency of 96.2%. The radiation patterns are directional, and the proposed antenna radiates maximum for 60^0 and 120^0 at 10GHz. The analysis of the proposed antenna suggests it as a good candidate for UWB applications with the provision of WiMAX and military/radar applications band rejection. Further work can be carried out with reconfigurable MIMO antenna for UWB applications.

Acknowledgments

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