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Design and Analysis of Wideband Patch Antenna for Dual band 2.4/5.8 GHz WLAN and WiMAX Application

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Abstract: *A new wideband CPW fed microstrip antenna using modified gnd for wideband applications is proposed. The objective of the work is to design a wideband rectangular micro strip antenna for covering WLAN and WiMAX Applications. To enhance the impedance bandwidth, Co-Planar Waveguide (CPW) mechanism has been proposed. The proposed antenna geometry describes a CPW fed microstrip antenna printed over a FR4 substrate of thickness 1.6mm, and permittivity εr=4.4. The proposed design comprises monopole patch with asymmetric coplanar ground plane with conductor backing exhibit dual band of response with simulated bandwidth of return loss ≤−10 dB is 2.30–2.95 GHz and 4.99–6.61 GHz which cover all the WLAN bands (2.4/5.2/5.8 GHz) The proposed antenna possesses the bandwidth 550 MHz at 2.4Ghz and 1620MHz at 5.8Ghz with a good gain of 4.9dB overall the WLAN (2.4GHz) LTE/USB dongle (2.5-2.7GHz), and WiMAX (5.8Ghz) operation. HFSS high frequency simulator is employed to analyse the proposed antenna and simulated results on the return loss, VSWR, bandwidth and Gain of the proposed antenna are presented at various parasitic structure.*

Keywords: *Asymmetric, Coplanar strips, Co-Planar Waveguide (CPW), wideband, Dual band antenna.*

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I. Introduction

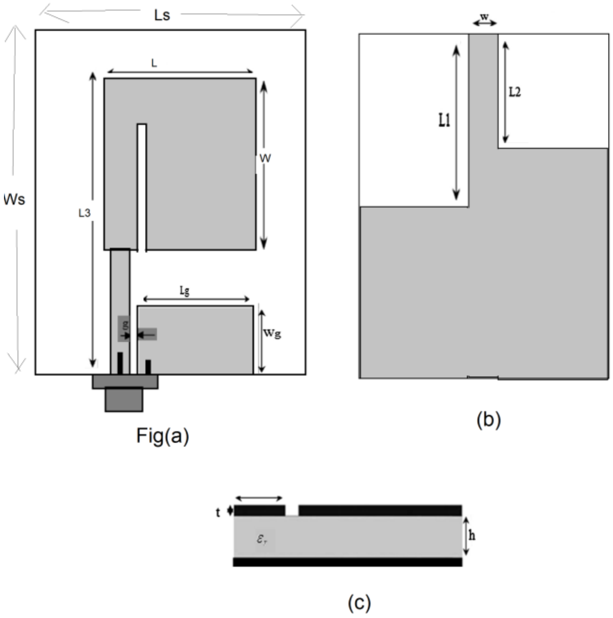
Introduction The rapid growth of high data rate communication devices tremendously increases the demand for wireless antennas equipped with limited space. Therefore researchers are mainly focusing on the design and development of highly miniaturized and low profile antenna for different user requirements. The coplanar waveguide is a promising candidate in this category because of its various advantages of light weight, ease of impedance matching, low profile, ease of integration with monolithic integrated circuits and its broad bandwidth. The design evolution of the proposed antenna has been done through respective field of broadband antenna.

A lot of investigations have been conducted to exploit the advantage of conventional CPW-fed designs. Lai et al. [1] presented miniaturization of CPW-fed slot antenna with reactive terminations and truncated bi-lateral ground plane which employed truncated meandered ground plane for achieving miniaturization and broad bandwidth. Zhang et al.[2] proposed a compact dual band CPW-fed planar monopole antenna for WLAN application and achieved dual band response by using asymmetrical ground plane. Chow et al. [3] demonstrated a dual band CPW-fed monopole antenna with the asymmetrical ground plane for bandwidth enhancement to improve operating bandwidth by varying the width of the ground plane. Zhaoet al. [4] presented an architecture of compact monopole antenna with double meander line that is proposed for WLAN application and has got maximum bandwidth of 45.3% by meandering the radiating signal strip. Shanmuganantham et al. [5] proposed CPW-fed slot antenna with a measured impedance bandwidth of 52% (4.27–7.58 GHz) by improving the impedance character-is tics. Lee et al. [6] presented a compact printed slot antenna for dual and multiband wireless applications and deployed larger slotted ground plane to achieve multiband WLAN operation. Liuet al. [7] demonstrated a compact CPW-fed monopole antenna with a U-shaped strip and a pair of L-slits ground for WLAN and WiMAX applications utilizes a pair of L-shaped defected ground structure and U-shaped parasitic element for achieving dual band operation. Zhang et al. [7] presented a miniature triple-band CPW-fed monopole antenna for WLAN/WiMAX applications that employs tapered ground plane with slotted radiating element for achieving triple band operation. Sujith et al. These designs [1–7], however, have complex or slotted structures and occupy more area, therefore it is difficult to integrate with WLAN systems.

II. Antenna Design

The three essential parameters for the design of a rectangular Microstrip Patch Antenna are:

- Frequency of operation (*f o)*: The resonant frequency of the antenna must be selected appropriately. The resonant frequency selected for design is 2.45 GHz.
- Dielectric constant of the substrate (ε *r*): The dielectric material selected for design is glass epoxy which has a dielectric constant of 4.4.
- Height of dielectric substrate (h*)*: For the microstrip patch antenna to be used in cellular phones, it is essential that the antenna is not bulky. Hence, the height of the dielectric substrate is selected as 1.6 mm.



Fig(a)

(b)

(c)

Figure 1: Geometry of the proposed antenna: (a) front view, (b) backside ground plane, (c) side view.

The initial calculation starts from finding the width of the patch which is given as:

Step 1: Calculation of the width of Patch (W):

The width of the Microstrip patch antenna is given as

$$W = \frac{c}{2f0\sqrt{\frac{\varepsilon r+1}{2}}} \qquad (1)$$

For c=3*10^8 m/s2, fo=2.4GHz, ε r=4.4

We get W=38.22 mm

Step 2: Calculation of effective dielectric constant:

Fringing makes the microstrip line look wider electrically compared to its physical dimensions. Since some of the waves travel in the substrate and some in air, an effective dielectric constant is introduced, given as:

$$\varepsilon reff = \frac{\varepsilon r+1}{2} + \frac{\varepsilon r-1}{2}\sqrt{[1+12\frac{h}{W}]} \qquad (2)$$

Where, εreff = Effective dielectric constant

εr = Dielectric constant of substrate

h = Height of dielectric substrate

Step 3: Calculation of Length of Patch (L):

The effective length due to fringing is given as:

$$Leff = \frac{c}{2f0\sqrt{\varepsilon reff}} \; . \qquad (3)$$

Due to fringing the dimension of the patch as increased by Δ*L* on both the sides, given by:

$$\Delta L = 0.412h\frac{(\varepsilon reff + 0.3)(\frac{W}{h} + 0.264)}{(\varepsilon reff - 0.258)(\frac{W}{h} + 0.8)} \qquad (4)$$

Hence the length of the patch is:
L= Leff-2Δ*L* (5)
L= Leff-2ΔL=28.4 mm

Step 4: Calculation of Substrate dimension:
For this design this substrate dimension would be Ls=L+2*6h=48mm (6)
Ws=W+2*6h=58mm (7)

Step 5: Calculation of feed point:
For this feed would be given L/4 distance.

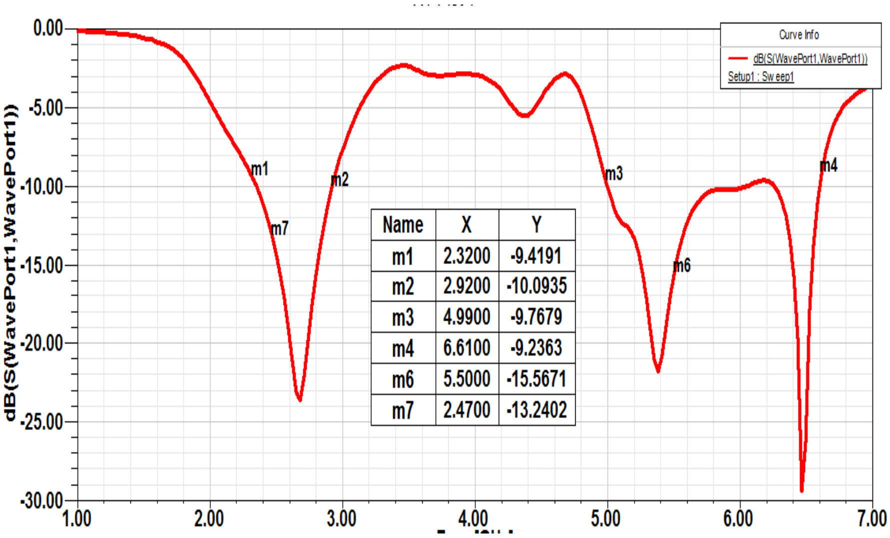
Step 7: CPW calculation:
Lambda (λ)=c0/f=3x10^8/2.4*10^9=125mm
1. Length of CPW (Lg) =λ/4*sqrt (4.4) =15.2mm
2. Width of CPW (Wg) =λ/8*sqrt (4.4) =7.2mm
3. Gap (g)=0.004*λ=0.5mm

Table 1. Optimized Design parameters of the proposed antenna.

Para-meters	**L**	**W**	**Lg**	**Wg**	**L1**	**L2**	**L3**	**Ls**	**Ws**	**g**
Values(mm)	22	29	16	6.5	25	30	40	44	58	0.5

III. Results & Discussion

A simulated proposed dual band antenna is designed on an FR4 substrate with dielectric constant (εr) 4.4, thickness (h) 1.6 mm, and it is shown in Fig. 2. The simulated return loss characteristics of the proposed antenna are shown in Fig. 3. It can be seen that results its exhibits good bandwidth and obtained bands are wide enough to cover ISM 2.4/5.2/5.8 WLAN & WiMAX bands. The lower band is at 2.45 GHz (2.30–2.95 GHz) and upper band is at 5.8 GHz (4.99–6.61 GHz).Fig. 4 shows another important parameter which represents VSWR matching of the designed antenna with respect Fig.5. To its feed point. If the antenna is not properly matched with feed then the major portion of the incident signal which is reflected in turn causes voltage standing waves in the feed wire. Due to this only a few portion of the incident signal is emitted by the antenna. Ideally the theoretical value of VSWR is 1, which means 100% of the incident power is accepted with no reflection. But practically VSWR is tolerable to 2. Whereas proposed design exhibits the VSWR value of 2:1 for the desired dual band of response.



Name	X	Y
m1	2.3200	-9.4191
m2	2.9200	-10.0935
m3	4.9900	-9.7679
m4	6.6100	-9.2363
m6	5.5000	-15.5671
m7	2.4700	-13.2402

Figure 2. Return Loss of the proposed antenna

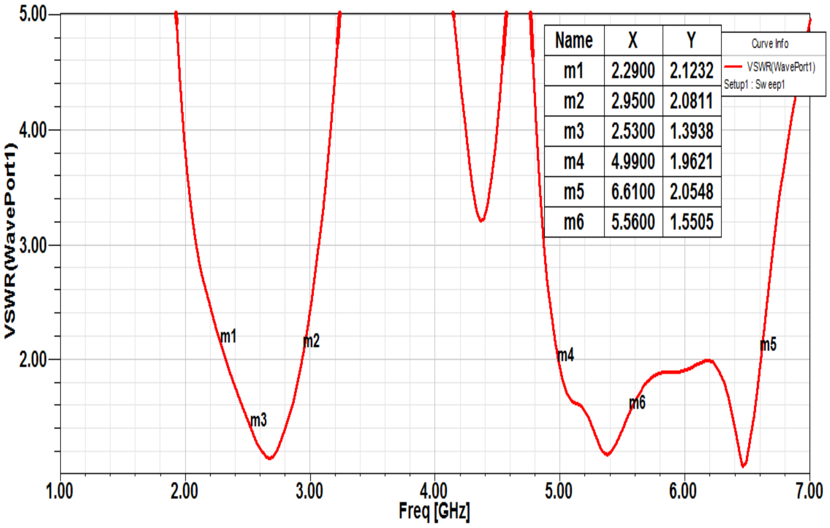


Figure 3. VSWR of the proposed antenna

The simulated current distribution through the radiating element and backside conductor of the proposed antenna for their resonant frequencies is shown in Fig. 5, which shows that in the lower band of resonance current is perturbed more through upper and lower ground plane with less reflection. In the upper band of resonance the current is distributed across the backside ground Fig. plane and radiating strip. Here it is clear that in the upper band of resonance the truncated ground plane plays the major role to enhance the operating bandwidth

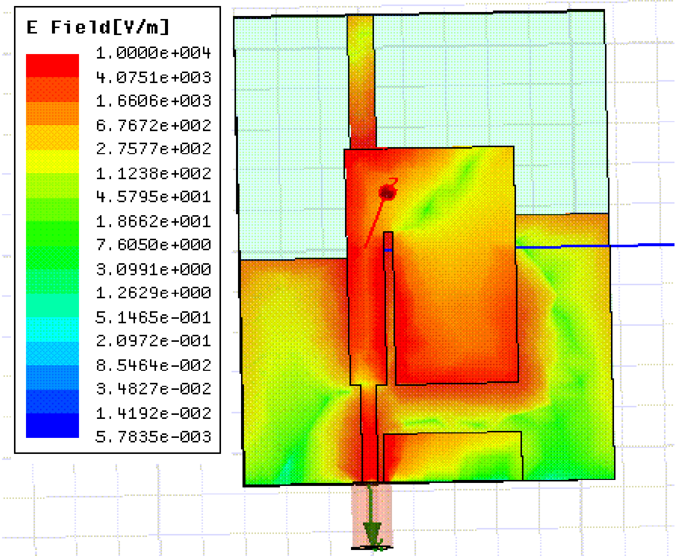


Figure 4. Current Distribution of the proposed antenna

The parametric study of the proposed antenna by with and with-out conductor backing (CB) is carried out and given in Fig. 6, and here it is found that with the application of additional ground plane the upper band of resonance widens and it is tuned to the desired frequency by a wide band asymmetric tuning stub in the truncated ground plane. The asymmetry of the wide band tuning stub greatly influences the bandwidth of the upper band of resonance by varying the dimension L2 by keeping L1and w (L1= 30 mm and w = 3.0 mm) constant as shown in Fig. 7, and from this analysis we can observe that L2= 25 mm and a better response has been achieved.

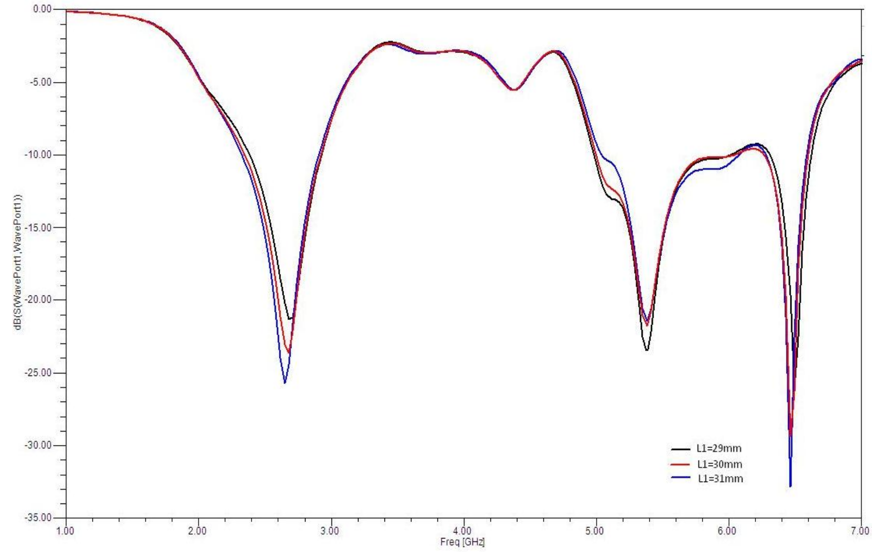


Figure 5. Comparison of Return variation with L1

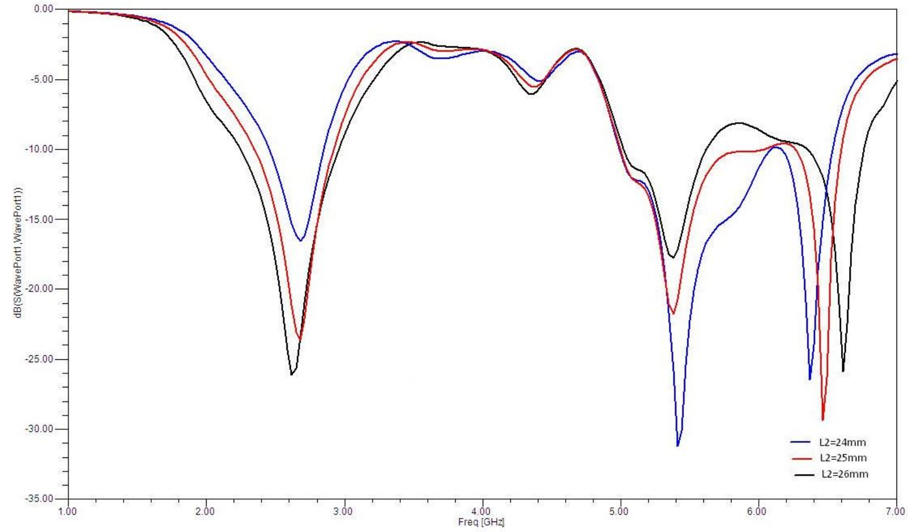


Figure 6. Comparison of Return variation with L2

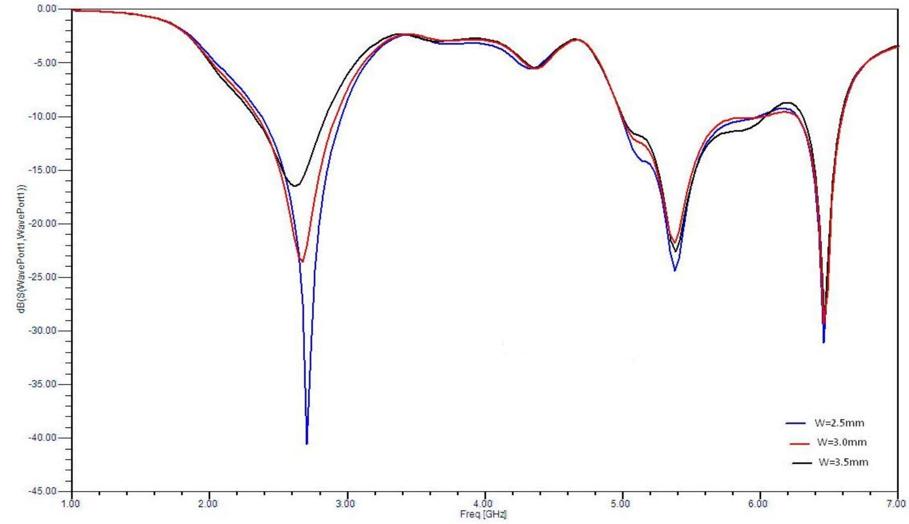
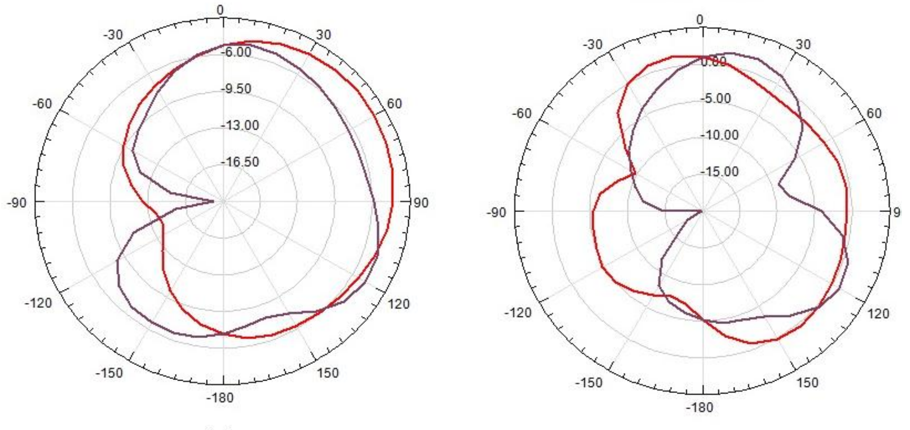


Figure 7. Comparison of Return variation with W

Figs. 8 and 9 illustrate the return loss of antenna as function of frequency for the different values of L1and w by keeping all the Fig.8, 9. And Fig. 10. The figure illustrates both co-polarization and cross polarization at different frequencies. It is evident that the simulated patterns exhibit omnidirectional radiation pattern at H-plane and dipole like bidirectional patterns at E-plane. The small asymmetry in the patterns is because of asymmetry in the proposed antenna feeding configuration.



(a) (b)

Figure 10.radiation patterns at E- and H-plane of the proposed antenna: (a) 2.4 GHz, (b) 5.8 GHz

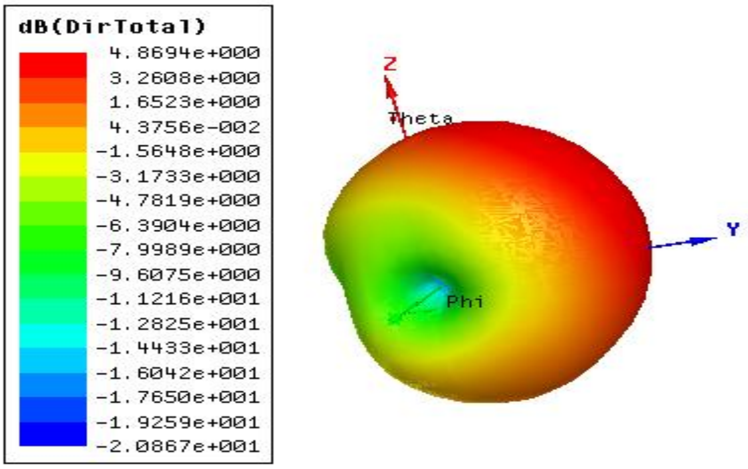


Figure 11. 3D radiation patterns

To improve the bandwidth of this antenna, modified gnd technique & CPW feed are introduced where depending on the gnd slot, optimum results can be achieved. As seen from the table 2, with CPW feed antenna, getting more than 1.5GHZ bandwidth.

Table 2. Comparison table of with and without CPW feed

Sr. No	Type of MSA	Freq range (GHz)	Return loss (dB)	VSWR	BW (MHz)	BW (%)	Gain (dB)
1.	Without CPW feed	2.35-2.57	-16.61	1.36	200	8.0	4.5
		5.92-6.90	-14.86	1.45	980	39.6	
2.	With CPW feed	2.30-2.95	-27.97	1.12	550	22.2	4.9
		4.99-6.91	-28.45	1.09	1620	65.5	

IV. Conclusion

A CPW fed microstrip antenna using modified gnd suitable for broadband applications has been presented. First start with the basic configuration, modified gnd at different position is discussed. Several parameters were taken into account in analyzing advantages and disadvantages in potential antenna designs including impedance bandwidth, return loss, and gain. The proposed antenna has a bandwidth 550 MHz at 2.4 GHz and 1620 MHz at 5.8 GHz with 5.0dB gain. The proposed antenna to possess much more increasing bandwidth as compared that of the conventional microstrip patch with CPW feed techniques. The proposed antenna is suitable for WLAN, WiMAX, USB dongle frequency and ISM applications.

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