Compact Broad Band Dual Frequency Slot Loaded Microstrip Patch Antenna with Defecting Ground Plane for Wi-MAX and WLAN

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***Abstract*— A dual frequency, compact microstrip patch antenna with enhanced bandwidth is presented in this paper. Microstrip antenna with bandwidth of 31% is also been designed for Wi-MAX application by defecting the ground plane The single layered antenna has been designed to resonate in dual frequencies for Wi-MAX and WLAN with enhanced bandwidth of more than 12%. Microstrip patch antenna with inset feed is simulated with the method of Moment based standard software.**

***Index Terms*— Microstrip antenna, dual-frequency, compact, broad band, Wi-MAX, WLAN.**

I. INTRODUCTION

Portable devices are widely used in our daily lives such as mobile phones, laptops with wireless connection, wireless universal serial bus (USB) dongles etc., [1-2], and Microstrip patch antenna plays a very significant role for the miniaturization of these devices. Several frequency bands are used in wireless communication viz. 890 MHz to 960 MHz for GSM, 1920 MHz to 2170 MHz for UMTS, 3.4 GHz to 3.6 GHz is for WiMAX, 4.9 GHz to 5.9 GHz is for WLAN, WiMAX etc. [2]. Microstrip patch antenna can be used for multiband operation and it can be obtained by cutting different type of slots [3-7] on the patch. Misran et. al. [3] has proposed a Multi-slotted microstrip patch antenna for wireless communication with band width of 27.89%. In this paper microstrip antenna with bandwidth of 31% has been designed by only defecting the ground plane. Obviously now a days the optimization of the design and efficiency of printed antennas are most important in communication systems [3-8].

Bhunia et. al., [4] has proposed a printed slotted antenna for dual frequency operation cutting unequal slots on the patch. In this paper a simple slotted rectangular, single layered, defecting grounded and inset fed Microstrip patch antenna has also been presented. This compact patch antenna can radiate two frequencies, 3.54GHz and 5.873GHz with return losses about 22.8dB and 10dB bandwidths of these two bands are also 12.03% and 12.06% respectively. This antenna can be used in WiMAX and WLAN application and almost 63% size reduction has been achieved by cutting the unequal slots in patch and ground plane.

Manuscript received December 09, 2011.

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II. ANTENNA DESIGN

The width (W) and the length (L) of Antenna1 are calculated from conventional equations [9-10].

$$f_r = \frac{c}{2W}\sqrt{\frac{2}{(1+\varepsilon_r)}}$$

$$L = L_{eff} - 2\Delta L$$

Where, $$\frac{\Delta L}{h} = 0.412\frac{(\varepsilon_{reff}+0.3)(W/h+0.264)}{(\varepsilon_{reff}-0.258)(W/h+0.8)}$$

$$\varepsilon_{reff} = \frac{(\varepsilon_r+1)}{2} + \frac{(\varepsilon_r-1)}{2\sqrt{(1+12\frac{h}{W})}}$$

$$L_{eff} = \frac{c}{2f_r\sqrt{\varepsilon_{reff}}}$$

Where L_{eff} = Effective length of the patch, $\Delta L/h$ = Normalized extension of the patch length, ε_{reff} = Effective dielectric constant.

The length and width of the microstrip patch antenna, operating in the frequency (f_r) 5.768GHz are 16mm and 20mm respectively with substrate thickness h=1.5875mm and dielectric constant ε_r=2.4(PTFE).

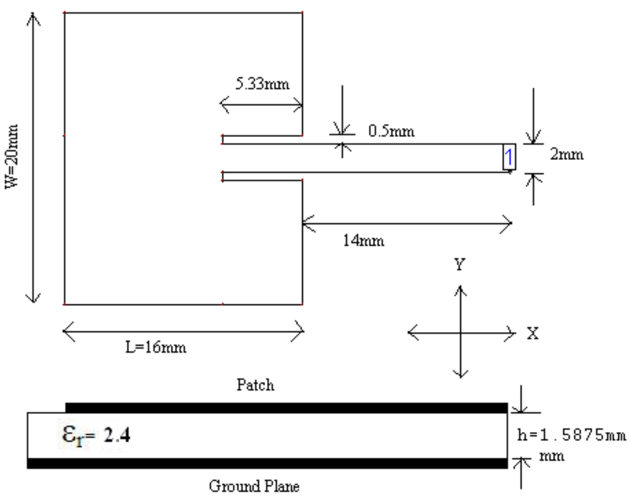

Figure-1: Antenna1 configuration

Published By:
Blue Eyes Intelligence Engineering
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Antenna1 is fed at optimum feeding location with a microstrip line.

Antenna2 structure has been designed by taking finite ground plane and defecting it. All other parameters of Antenna2 structure are same as Antenna1.The optimum results found for the ground plane of width W_g= 40mm and length L_g= 25mm. Antenna3 structure has been designed to get dual frequency in dual band for the WiMAX and WLAN applications by cutting unequal slots on the patch and ground plane in the Antenna2 structure.

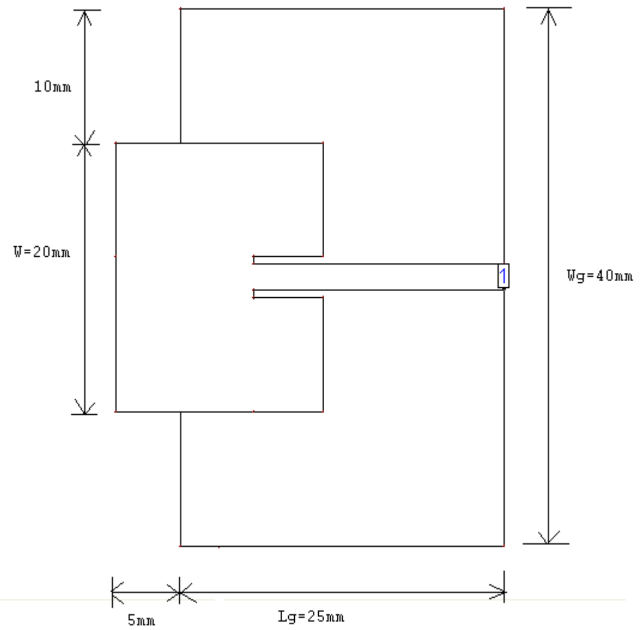

Figure-2: Antenna2 configuration

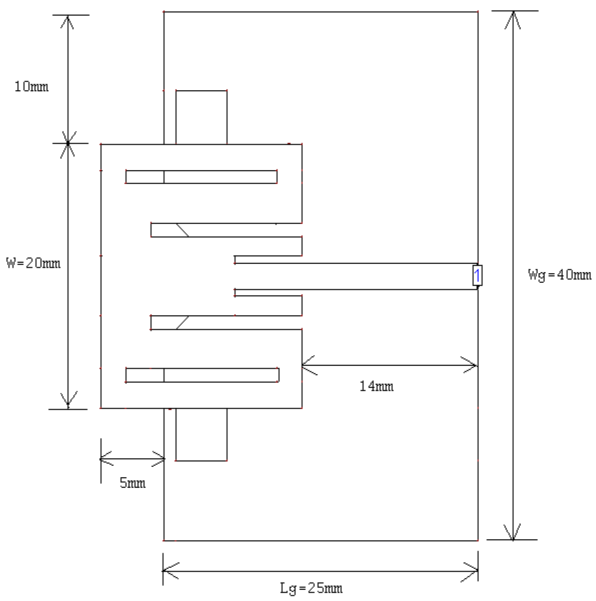

Figure-3: Antenna3 configuration

Antenna3 structure represents the slot loaded patch antenna with defecting ground. In this monopole structure triangular slot and two small square slots in ground plan are used for proper dual resonant frequency selection and bandwidth enhancement.

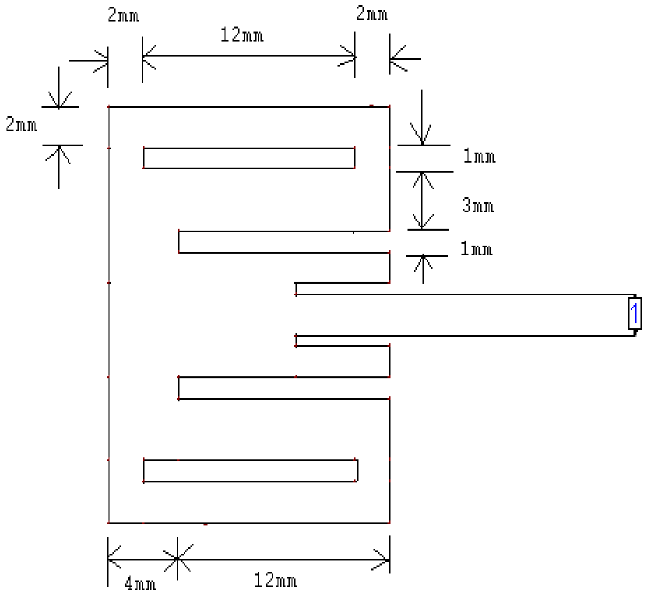

Figure-4: Slotted patch of Antenna3

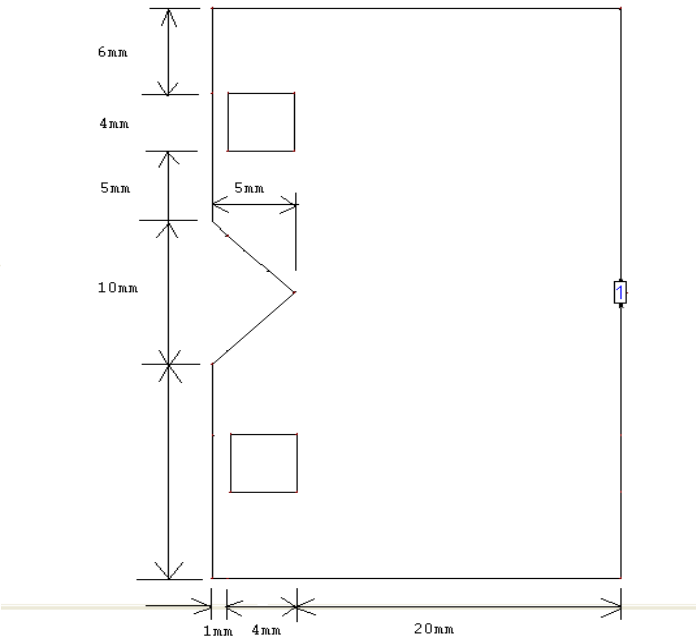

Figure-5: Defecting ground plane of Antenna3 structure

III. RESULTS AND DISCUSSION

For the Antenna1 structure, the resonant frequency is at 5.786GHz with return loss of about 32dB and 10dB bandwidth is 180MHz i.e. 3.12% of the center frequency. The resonant frequency for the Antenna2 structure is at 4.815GHz with return loss of 16dB and 10dB bandwidth is 1.51GHz i.e. 31.36% of the center frequency. In the Antenna3 structure dual frequencies are found at f_1=3.54GHz with return loss about 23dB and 10dB bandwidth is 426MHz i.e. 12.03% of the center frequency and f_2=5.873GHz with return loss about 23dB and 10dB bandwidth is 708MHz i.e. 12.06% of the center frequency.

The Antenna2 structure can be used in WiMAX application with wide bandwidth. Antenna3 can be used for both WiMAX and WLAN applications with wide bandwidths and reduced size also.

The simulated results for Antenna1, Antenna2 and Antenna3 are given in Table-1

Table 1: Simulated results

Antenna	Frequency (GHz)	Return Loss (dB)	10dB BW (MHz)	BW (%)
Antenna 1	5.768	31.9726	180	3.12
Antenna 2	4.815	16.0274	1510	31.36
Antenna 3	f_1=3.54	22.7815	426	12.03
	f_2=5.873	22.7748	708	12.06

The return losses and radiation patterns for E-total at phi=0^0 and phi=90^0 of the reference and designed antennas are shown in Figure-6-11.

The absolute gain for Antenna1 is 6.99dBi for E-plane and 6.82dBi for H-plane. The 3dB beamwidth is 171.36^0 for E-plane and 129.6^0 for H-plane

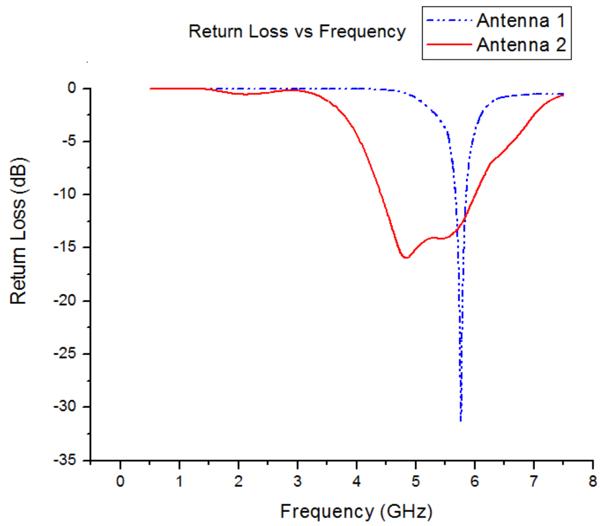

Figure-6: Return Loss for Antenna1 and Antenna2

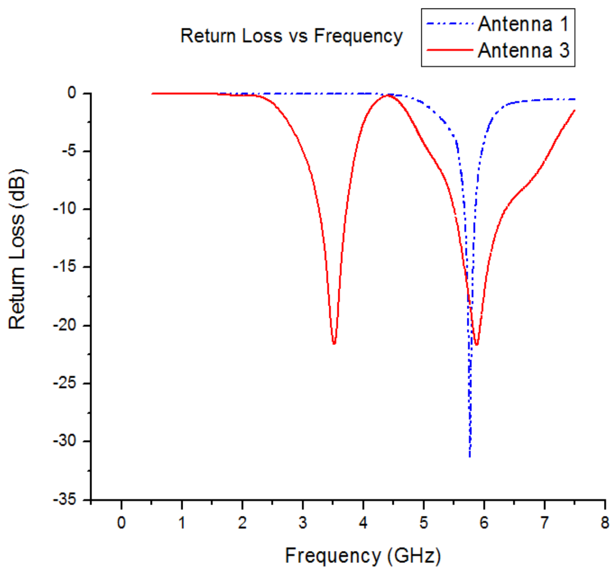

Figure-7: Return loss for Antenna1 and Antenna3

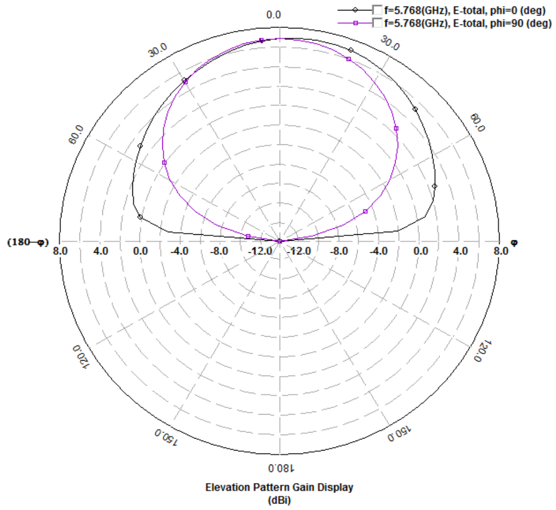

Figure-8: Radiation Pattern for Antenna1 at f_r = 5.768GHz

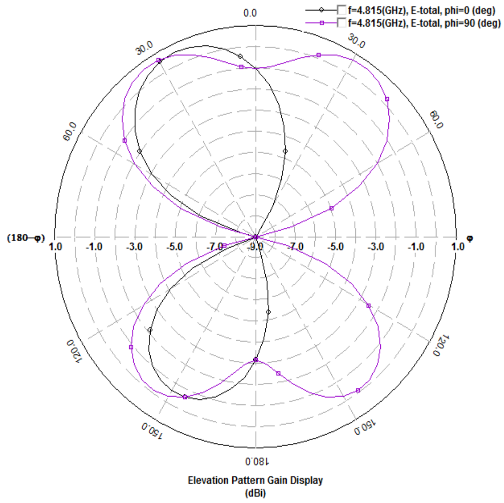

Figure-9: Radiation Pattern for Antenna2 at f_r = 4.815GHz

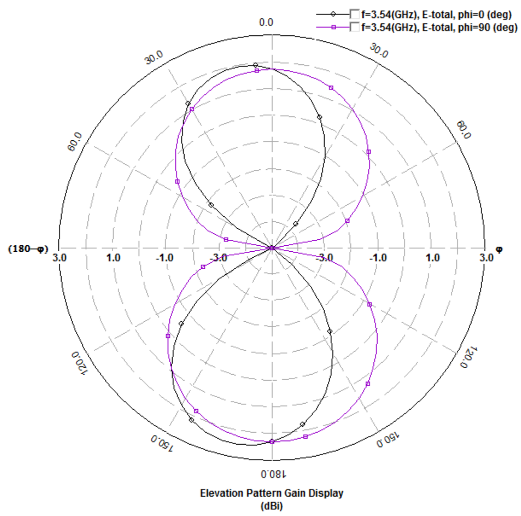

Figure-10: Radiation Pattern for Antenna3 at f_r = 3.54GHz

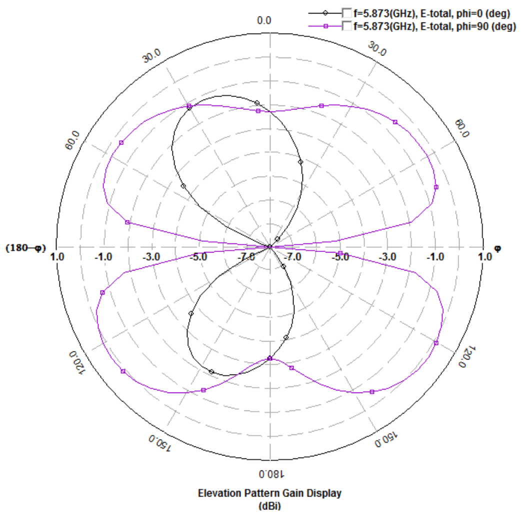

Figure-11: Radiation Pattern for Antenna3 at f_r = 5.873GHz

IV. CONCLUSION

Single layered defecting grounded and single layered defecting grounded with slotted patch Microstrip antennas are proposed and designed. Microstrip antenna with only defecting ground plane(Antenna-2) offers a huge bandwidth of about 31% of the center frequency suitable for WiMAX application which is very much encouraging. Microstrip antenna with defecting ground plane and slotted patch (Antenna-3) offers dual frequency in dual band (S and C) with bandwidths about 12% which is suitable for WiMAX and WLAN applications. The size reduction of about 63% has been achieved along with the dual band operation. The antenna gains of the proposed structures are not good but it can be enhanced by using the stacked structures or any other gain enhancement scheme.

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