Dual band CPW-fed Slot Antenna with Inset fed for WLAN and WiMAX Application

Neha Parmar#, Manish Saxena#, Krishnkant Nayak#
#Bansal Institute of Science and Technology, Bhopal

ABSTRACT- A dual band finite ground coplanar waveguide (CPW) fed patch antenna with inset fed is presented for satisfying wireless local area network (WLAN) and worldwide interoperability for Microwave Access (WiMAX) applications. The proposed antenna, consisting a rectangular planar patch element embedded with two slots on radiating arm of the patch element. The simulated -10 dB bandwidth for return loss is from 2.402-2. 442 GHz as the lower band and 3.427-3.618GHz as upper band, covering some of the WiMAX and WLAN bands. The effect of variation of length and width of inset fed and slot on antenna parameters such as return loss and VSWR are also investigated in detail for proposed antenna.

Keywords: Dual-band antenna, Slot, CPW fed, WiMAX/WLAN application.

I. INTRODUCTION

The study on microstrip patch antennas has made a great progress in the recent years. Compared with the conventional antennas, microstrip patch antennas have more merits and better prospects. In this era of next generation networks we require high data rate and size of devices are getting smaller as technology grows. In this evolution two important standards are Wi-Fi (WLAN) and Wi-MAX. The currently popular designs suitable for WLAN operation in the 2.4 GHz (2.4–2.484 GHz) and 5.2/5.8 GHz (5.15–5.35 GHz/5.725–5.825GHz) bands and WiMAX operation in the 2.5/3.5/5.5 GHz bands have been reported in [2-3].For success of all these wireless applications we need efficient and small antenna as wireless is getting more and more important in our life. This being the case, portable antenna technology has grown along with mobile and cellular technologies. Microstrip antennas (MSA) have characteristics like low cost and low profile which proves Microstrip antennas (MSA) to be well suited for WLAN/Wi MAX application systems [1].

A Microstrip patch antenna consists of a radiating patch on one side of a dielectric substrate which has a ground plane on the other side. The patch is basically made of conducting material such as copper or gold and can take any possible shape. A feed is used to excite to radiate by direct or indirect contact. One type of feed line that is becoming popular apply to printed antenna is coplanar waveguide structure. A coplanar waveguide structure consists of a median metallic strip of deposited on the surface of a dielectric substrate slab with two narrow slits ground electrodes running adjacent and parallel to the strip on the same surface.

Recently, the coplanar waveguide (CPW)-fed monopole antenna has become very popular in WLAN and WiMAX systems, owing to its many attractive features such as, wider bandwidth, low radiation loss, less dispersion, a simple structure of a single metallic layer and easy integration with WLAN integrated circuits [8].

II. ANTENNA DESIGN

The geometry of the proposed single patch finite ground coplanar waveguide (CPW) with inset fed for WLAN/WiMAX dual mode operation is shown in Fig.1. The proposed antenna was design on FR4 substrate with thickness (h) 1.6 mm, dielectric constant (ε_r) is 4.4.

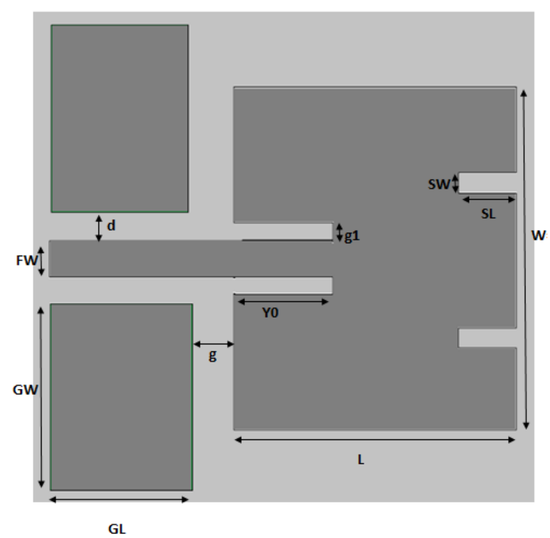

Fig.1 Geometry of proposed antenna

The proposed antenna structure is chosen to be a rectangular patch element with dimension of length L and width W, and vertical spacing of ‘d’ away from the ground plane. A CPW fed line designed with a strip thickness FW and a gap distance of ‘g’ between the signal strip and the coplanar ground plane is used for exciting the patch element. Two coplanar ground planes with same size of length GL and width GW, are situated symmetrically on each side of the CWP feeding line. We cut a inset on patch with length 'Y_0' and width 'g_1'. Patch dimensions are calculated by using transmission line mode.

To design a rectangular microstrip patch antenna following parameters such as dielectric constant (ε_r), resonant frequency (f_o), and height (h) are considered for calculating the length and the width of the patch.

Width of patch (w):

$$W = \frac{c}{2fo\sqrt{\frac{\varepsilon r+1}{2}}}$$

Substituting c = $3x10^8$ m/s, ε_r = 4.4, and f_o =2.4 GHz, then W =38mm.

The effective of the dielectric constant (εreff) depending on the same geometry (W, h) but is surrounded by a homogeneous dielectric of effective permittivity ε_{reff}, whose value is determined by evaluating the capacitance of the fringing field.

Effective dielectric constant of antenna ($€_{reff}$):

$$\varepsilon reff = \frac{\varepsilon r+1}{2} + \frac{\varepsilon r-1}{2}\left[1+12\frac{h}{w}\right]^{-1/2}$$

Substituting ε_r = 4.4, W= 38mm, and h=1.6mm, then ε_{reff} =4.085.

Effective electrical length of antenna:

$$Leff = \frac{c}{2fo\sqrt{\varepsilon reff}}$$

Substituting c = $3x10^8$ m/s, εr_{eff} =, and f_o =2.4GHz, then L_{eff} =31mm.

The extended length of antenna (ΔL):

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

Substituting εr_{eff} =4.085, W= 38mm, and h =1.6mm, then ΔL=0.739mm.

The length of the patch is:

$$L = Leff - 2\Delta L$$

Substituting ΔL= 31mm, and Leff =0.739mm, then L=29.5mm.

The final optimized dimensions of proposed antenna are shown in table .1.

TABLE: 1 DESIGN SPECIFICATION

Sr. No.	Parameter Name	Design values
1.	Patch length (L)	29.5mm
2.	Patch width (W)	38mm
3.	Ground plane length (GL)	12.6mm
4.	Ground plane width (GW)	20mm
5.	Feed width (FW)	3.68mm
6.	Feed length (FL)	15.6mm
7.	Slot length (SL)	5mm
8.	Slot width (SW)	2.5mm
9.	Inset length (Y_0)	11.5mm
10.	Inset gap (g_1)	0.1mm
11.	Spacing b/w patch & ground (g)	3mm
12.	Spacing b/w feed-line & ground (d)	1mm

III. SIMULATION RESULTS

In this section, simulated results for return loss and VSWR of the proposed antenna for the frequency range from 2 to 4 GHz are shown in Fig. The simulated results are obtained using IE3D Simulator. It can cover the 2.4-2.483GHz WLAN/Wi-Fi/Bluetooth band and 3.4-3.6GHz WiMAX band of wireless communication system. The simulated impedance bandwidth of the proposed antenna covers two impedance bandwidths, 2.402-2.442 GHz as the lower band and 3.427-3.618GHz as upper band respectively.

A. *S11 PARAMETER or RETURN LOSS*

The simulated result for the return loss less than -10dB is shown in figure 2. From simulated result we get dual band. At center frequency of lower band 2.422 GHz a return loss of -19.98dB was good which proves that this antenna is fruitful for WLAN/Wi-Fi/Bluetooth and center frequency of upper band 3.568GHz with return loss of -37.32dB suitable for WiMAX applications.

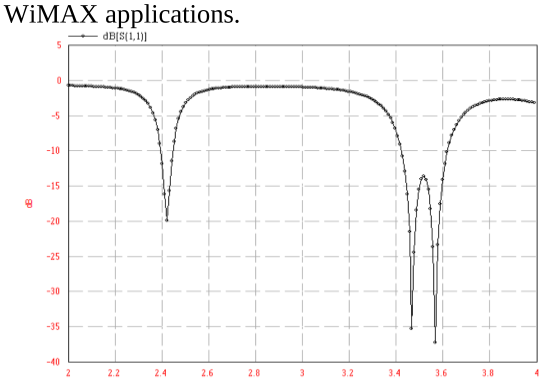

Fig.2 Return loss for proposed antenna

B. *VSWR*

VSWR plot shows that the VSWR occur at first resonant frequency is 1.66 and second resonant frequency is 1.07 shown in fig.3. This depict that there is good impedance matching between probe-fed microstrip transmission line and the radiating element.

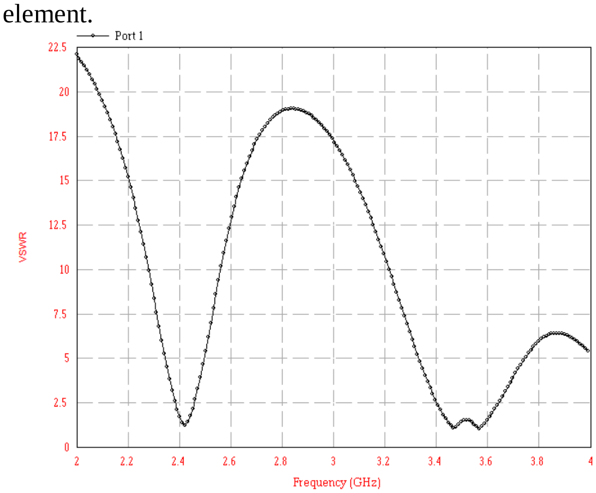

Fig.3: VSWR plot of proposed antenna

IV. PARAMETRIC STYDY

This section presents the important parameters, such as SL and SW are length, width of slot respectively. Which influence the operating frequency bands of 2.4 and 3.5 GHz, and then the effects of these parameter of the proposed antenna on return loss and bandwidth are illustrated.

4.1 *Effect of parameter SL*

The antenna configuration parameters, as illustrated in fig.4, have been chosen the length of the slot denoted by parameter SL has been varied (SL=1.5 mm to10 mm). The first resonant frequency is varying slightly with variation in parameter SL. The major effect of variation in SL has shown on second resonant frequency around 3.5 GHz. The return losses of the designed antenna are shown in fig.6. As SL increases above 5mm, the return loss of the second resonant frequency becomes worse and the bandwidth performance is poor and become saturated above 5mm. The second resonant frequency largely affected by parameter SL between 1.5 to 2.5 mm. The best result obtained at SL=5mm with minimum return loss at second frequency is 37.32dB.

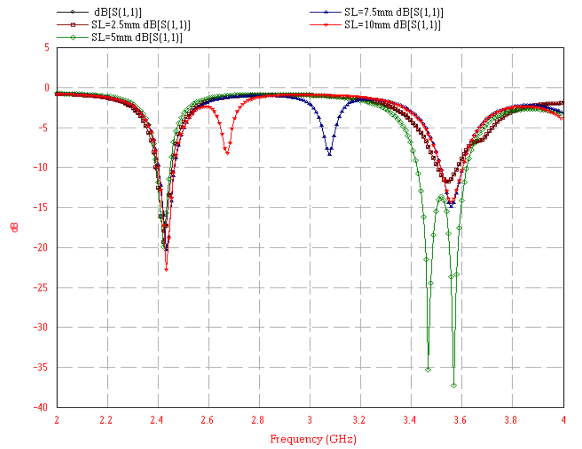

Fig.4: Comparative graph of Return Loss for SL

4.2 *Effect of parameter SW:*

The antenna configuration parameters, as illustrated in figure.5, have been chosen the width of the slot denoted by parameter SW has been varied (SW=0.5 mm to 2.5 mm). The return losses of the designed antenna are shown in fig.7. As SW increases, the return loss of the second resonant frequency becomes minimum (-37.32dB). The second resonant frequency largely affected by parameter SW between 0.5 to 2.5 mm. The best result obtained at SW=2.5mm with minimum return loss at second resonant frequency 3.568GHz is -37.32dB.

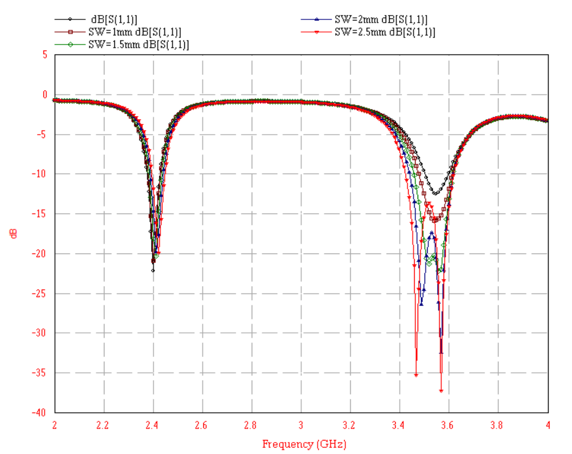

Fig.5: Comparison of Return Losses for different values of SW

V. CONCLUSION

The dual frequency and wide-band operation of a rectangular patch with double slot have been studies and simulated. The proposed antenna is compact, occupies small volume and has simple structure compared to other antenna design. The antenna offer a 2:1 VSWR bandwidth of first resonant frequency cover the WLAN(2.402-2.442)GHz band application with impedance bandwidth of 40MHz and 191MHz from frequency range (3.427-3.618)GHz at second resonant frequency which cover 3.568 GHz band WiMAX applications. The simulated return loss and VSWR showed well performance.

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