Slotted Elliptical Dual band Antenna for WiMAX/UMTS Applications

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***Abstract*— A compact slotted elliptical shaped dual band micro-strip patch antenna for Universal Mobile Telecommunications System (UMTS) and Worldwide interoperability for Microwave access (WiMAX) applications is proposed. By adjusting a few parameters of the slots, the resonant frequencies can be easily tuned. The proposed antenna was analysed and optimized to cover two bandwidths from 1.878 to 1.92 and 2.50 to 2.55 GHz that for UMTS and WiMAX applications respectively, with the return loss of better than 10 dB.Various antenna performances such as radiation patterns as well as antenna gains over different operating bands of UMTS and WiMAX have been observed. Parametric study by variation of shape and its slots is also done.**

***Keywords*— Dualband, HFSS, Micro-strip patch antenna, slotted elliptical shape**

I. Introduction

Today's, with the increasing development of wireless communications, the need to design low volume, low profile planar configuration compact, and wideband multi-frequency planar antennas become highly desirable. These types of antennas would simplify the installation of multi-band systems. The approach of the micro strip antenna can fulfil all these requirements because it require printed circuit technology. On the other hand, the drawbacks of basic micro strip structures may include narrow bandwidth, half plane radiation, loss and limitation on the maximum gain.
To improve the bandwidth of micro-strip patch antenna, some techniques such as increasing the thickness of substrate, by adding parasitic element in coplanar or multilayer configuration, and performing slots in patch.[1] The last approach is simple to implement because it provide good bandwidth improvement by maintaining a single-layer radiating structure.
We have used a slot antenna because it has special advantages like simple structure, bandwidth is wide, conductor loss is less, and it is having a very good isolation between the feeding network and radiating element. [2] By slotting others benefits likelow profile, low cost, smaller size and easier integration with other circuits can also be achieved.

Various dual band slot antenna for UMTS and WiMAX has been designed in the past few years.The proposed antennas in [3-7] can wholly cover the UMTS and WiMAX bands, but are not very compact and will be difficult when integrated with some other circuits.Based on investigating some dual band antennas [2][5], multi band antennas [3][6][7] and slot antenna [1][2][9] we proposed compact slotted elliptical dual band antenna.
We have organised thepaper as follows. In which, Section 2 contains the proposed antenna's designto be presented. Section 3, the results and discussions of the various parameters is presented. It also include shape selection of proposed antenna and parametric study by variation of slot dimensions.Section 4 contain the concluding remarks. We have used finite "High Frequency StructureSimulator" HFSS Ver.15.0. for simulation which uses the highly accurate finite element method.

II. Antenna Design

In Fig. 1. we have shown the geometry of the proposed antenna. We have taken the ground of size 39.5mm × 22 mm at the bottom of the antenna. The radiating element of the proposed antenna consists of slotted elliptical patch. As we know that the dimensions of the patch antenna effects in the results as the main part, especially length (L) and the width (W). The dimensions of the proposed antenna is calculated using formulas 1 to 4.

$W = c/fr \times (2/(\varepsilon_r + 1))$,c = speed of light, fr= the resonant frequency (1)

$$\Delta L = 0.412 \times h \times \frac{\left\{(\varepsilon_{reff}+0.3)\times\left(\frac{W}{h}+0.264\right)\right\}}{\left\{(\varepsilon_{reff}+0.3)\left(\frac{W}{h}+0.264\right)\right\}},$$
(2)

$L_{eff} = \mathrm{L} - 2\Delta\mathrm{L}, \mathrm{L}=\lambda/2$ (3) h = height of patch, w= width of patch,

$$\varepsilon_{reff} = \frac{(\varepsilon_r + 1)}{2} + \left\{\frac{(\varepsilon_r - 1)}{2}\right\} \times {}^{-1/2}\sqrt{\left(1 + \frac{12h}{w}\right)}$$
Ɛr= dielectric constant. (4)

For calculations of impedance, length and width of quarter wave line feeding we have used the formulas 5 to 8.

$$Z_{patch} = 90\left\{\frac{\varepsilon_r{}^2}{(\epsilon_r - 1)}\right\}\left(\frac{L}{W}\right)^2 \quad (5)$$

$$Z_{transmission\_line} = \sqrt{(50 \times Z_{patch})} (6)$$

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$L_{feed} = Z_{50\Omega feed}/Z_{transmission\_line}$ (7)

$L_{transmission\_line} = \lambda/4$ (8)

Width of transition line is calculated from formula9

$Z_{transmission\_line} = 60/\sqrt{\varepsilon_r} \times \left\{ln\left(\frac{8d}{w_{transmission\_line}} + \frac{w_{transmission\_line}}{4d}\right)\right\}$ (9)

Similarly the width of 50Ω micro strip feed can be found from formula 10

$Z_{50\Omega feed} = 120\pi/\left[\sqrt{\varepsilon_{reff}}\left\{1.393 + \frac{w}{h} + 0.66ln \times \left(\frac{w}{h} + 1.44\right)\right\}\right]$, w=width of 50Ωfeed. (10)

Based on the above calculation and certain optimisations of the parameters, the dimensions of the proposed antenna is shown in the following figure1.

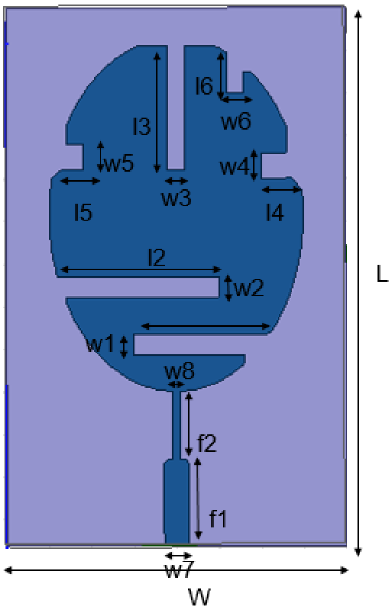

Figure1: Design of proposed antenna

Table 1: Optimized Parameters

Antenna Parameters	Values/mm
L	39.5
W	22
l1	16
w1	2.45
l2	19
w2	2.45
l3	15.2
w3	2
l4	5
w4	3
l5	3.5
w5	3
l6	4
w6	2
f1	10
w7	3
f2	8.5
w8	0.925

III. RESULT AND DISCUSSION

A prototype of the proposed antenna was implemented and fabricated using FR4 (ϵ_r= 4.4) then various simulation result was validated using HFSS 15.0.1 the simulated reflection coefficient in shown in figure2.

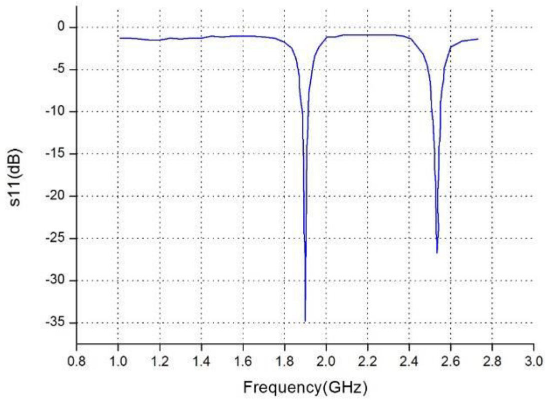

Figure 2: Reflection Coefficient of the proposed antenna

From the above figure it can be seen that that the antenna resonate at two different frequencies 1.89GHz and 2.52GHz. The proposed antenna was analysed and optimized to cover two bandwidths from 1.87 to 1.91 and 2.50 to 2.55 GHz that for UMTS and WiMAX applications respectively, with the return loss of better than 10 dB.

Frequency(GHz)	Return Loss
1.89	34dB
2.52	26dB

Table2: Return loss of the Proposed Antenna

From table 2, it can be seen that at 1.89GHz and at 2.52GHz, the return loss are 34 dB and 26 dB respectively.

The gain of the antenna is shown in figure 3. At frequency 1.89 GHz and 2.52 GHz, the peak realised gain is 11.0 dB and 3.0 dB respectively.

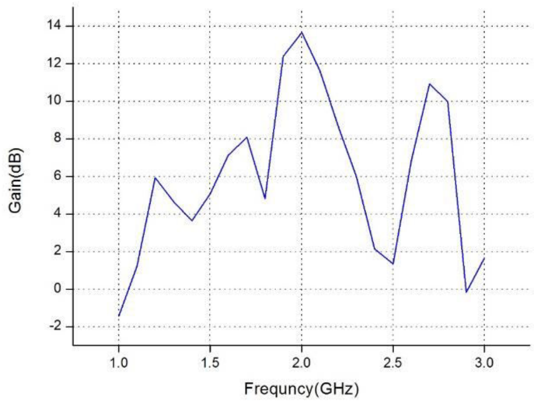

Figure 3: Gain of the proposed antenna

There is more current flow at lower frequency i.e at 1.89 GHz than at higher frequency i.e at 2.52 GHz and the current distribution at the both frequencies 1.89 GHz and 2.52 GHz is shown in figure 4 and figure 5 respctively.

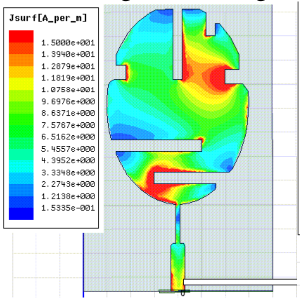

Figure4: Current distribution at 1.89 GHz.

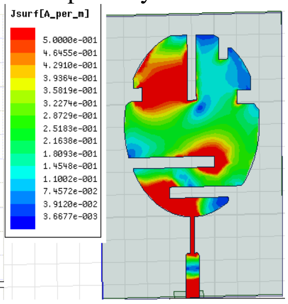

Figure5: Current distribution at 2.52 GHz

A. Selection of shapes

The shape of antenna is chosen by transformation of rectangular antenna to elliptical and then to multiple slotted elliptical. This transformation is shown in below figure6.

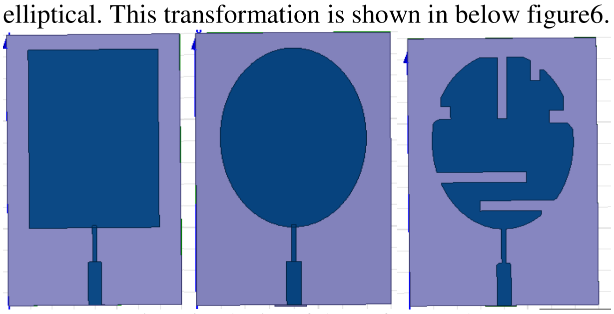

Figure6: Selection of shape of proposed antenna

In the below figure7 the reflection coefficient of all the design in figure6 is merged.

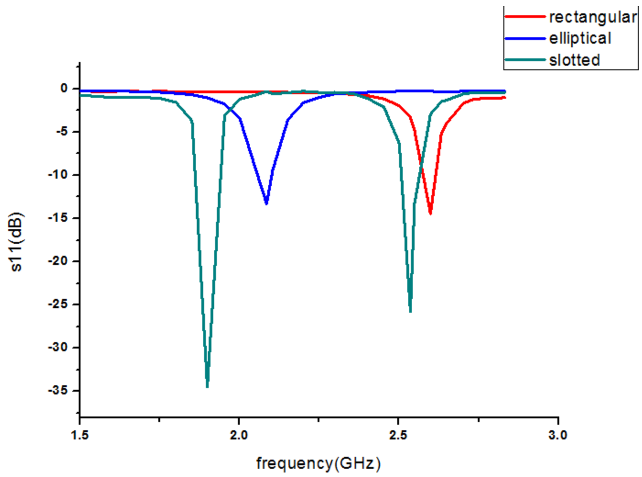

Figure7: Reflection coefficient

The graph (figure6) show return loss of rectangular patch antenna is approximately 13 dB at frequency 2.6 GHz and 12 dB at frequency 2.GHz for elliptical design. The proposed slotted elliptical design is having return loss of 34 dB at 1.89 GHz and 27 dB at 2.52 GHz.

B. Comparison between simulated and fabricated results

In the Figure8 and Figure9 we have shown the fabricated top view and the bottom view of the antenna.

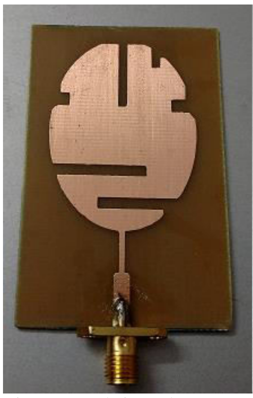

Figure8: Fabricated antenna top view.

Figure9:Fabricated antenna bottom view.

Then testing of the antenna is done using VNA (Vector Network Analyser) E5071C (ENA Series) which analyses one or two port networks. The frequency range of VNA is from 9KHz to 8.5 GHz. In the Figure10 we can see that antenna is resonating below -20dB at the UMTS and WiMax frequency.

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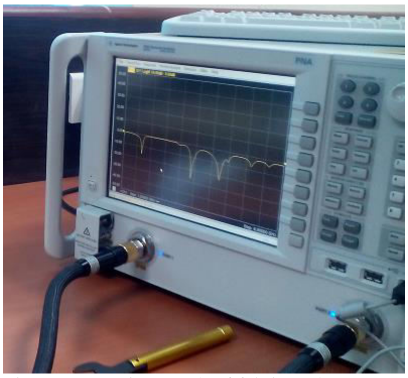
Figure10: Testing result of fabricated antenna

C. Parametric Variation by changing Dimensions of slots

Actually this design is made of multiple slots so there is trade-off between the selections of dimensions of different slots. The variation of dimensions will have a varied pattern. These patterns are shown in the below figure11 to figure16.

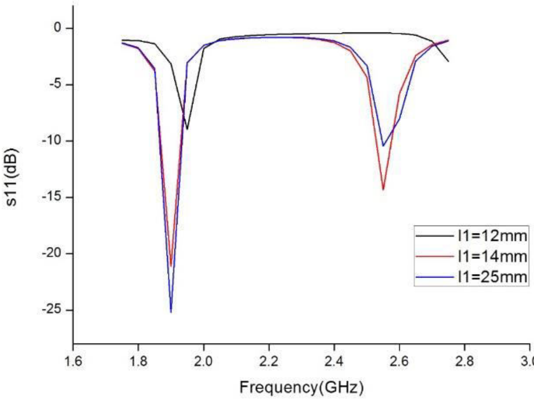

Figure11: By varying slot1(l1)

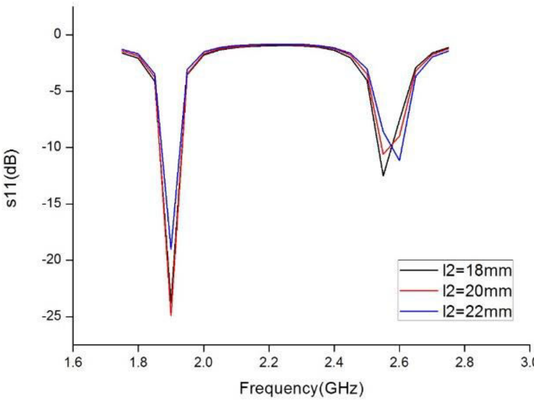

Figure12: By varying slot2(l2)

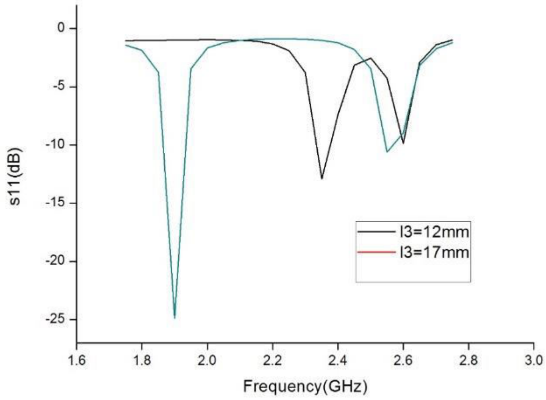

Figure13: By varying slot3(l3)

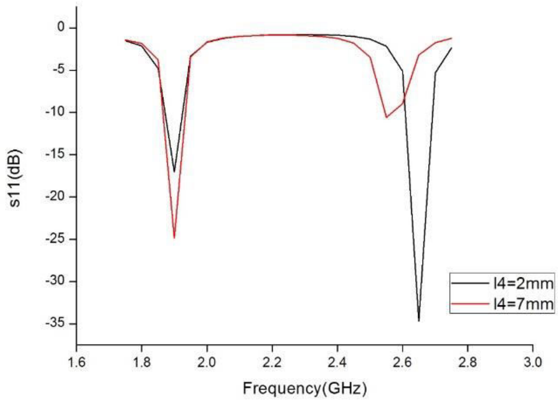

Figure14: By varying slot4(l4)

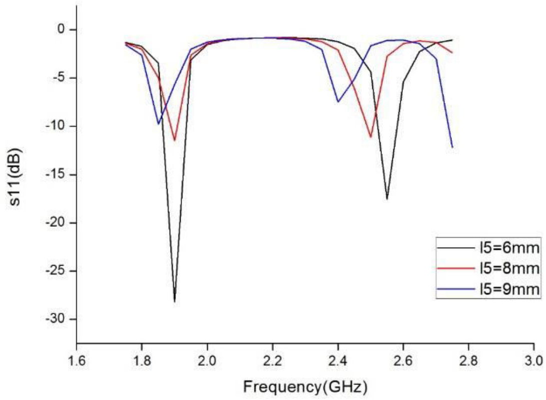

Figure15: By varying slot5(l5)

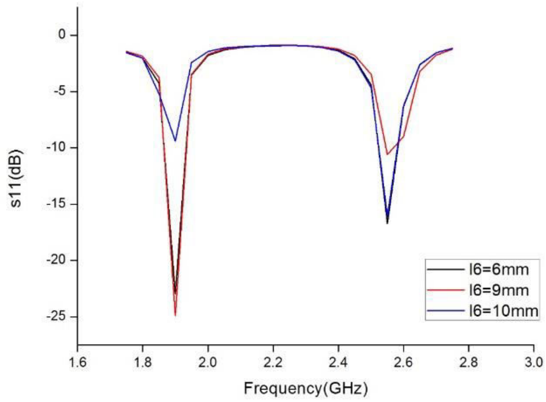

Figure16: By varying slot6(l6)

IV. Conclusions

This paper presents the design of a printed micro-strip patch antenna for dual-band operation. A compact elliptical slot antenna for UMTS and WiMAX at 1.89GHz and 2.52GHz is presented. Results of simulated, tested and measured refection coefficient, gain, the current distribution at the operating frequencies are obtained.The parameters of proposed design micro-strip antenna elements are fully adjusted to get the best possible response for dual-band operations. The low-cost antenna is only 39.5×22×1.6mm^3 in size, and easy to fabricate.

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BioGraphy:

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