Multiresonantslotted microstrip patch antenna (MPA) design forIMT, WLAN &WiMAX applications

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ABSTRACT: *In this paper, a multi resonant MPA capable of operating in a frequency range of 3 GHz to 7 GHz have been proposed. The antenna has been designed using substrate of FR4 material having dielectric constant of 4.4 with radiating patch and a ground plane. The ground plane has been partially reduced to improve the antenna performance. The antenna has a feed line which is connected to patch. The feed line has to be of suitable width so as to match the antenna impedance with the port impedance (50 ohm).The feed line thickness is same as that of the patch thickness. The antenna performance has been analyzed in terms of various antenna parameters such as return loss (dB), impedance bandwidth (GHz), gain (dB), directivity (dBi) and VSWR. The antenna has been designed and simulated using CST Microwave Studio (2010).The designed MPA is suitable to be used for IMT, WLAN standard and WiMAX applications. The antenna has a bandwidth of 4.01GHz and VSWR is less than 2. Theantennahasbeenfabricatedandtested.Ithasbeenobservedthatthepracticalresultsobtainedbytesting the fabricated antenna using Network analyzerE5071C closely matches with the theoretical results obtained by simulating the antenna design in CST MWS 2010.*

Keywords: *Directivity, Gain, Reduced ground plane, Return loss(S_{11}), VSWR.*

I. INTRODUCTION

Micro strip patch antenna also termed as patch antenna, is usually fabricate dona dielectricsub strate which act sasaninter mediate between a ground plane at the bottom side of substrate and aradiating patch on the top of substrate [1].The patch is made up of perfect electric conductor (PEC) material. The patch can be designed in many shapes like rectangular, circular, triangular, elliptical, ring, square and any more but most commonly, rectangular shape is widely used [1] because of the simplicity associated with the design. The selection of substrate is the most important parameter while designing an antenna. The substrate consists of a dielectric material which perturbs the transmission line and electrical performance of antenna. The size of an antennais dependent on the dielectric constant of a substrate. The size of antenna is inversely proportional to dielectric constant i.e.higheris the dielectric constant, lower is the size of antenna[2]. The rearevariety of substrates available with different dielectric constants but in this antenna design, FireResistance4 (FR4) material with dielectric constant of4.4hasbeenused.

The antenna can be fed by various methods like coaxial feed, proximity coupled micro strip feed and aperture coupled micro strip feed[3].The feeding can be defined as the means to transfer the power from the feed line to the patch, which itself actsasaradiator. The micro strip feed line has been used in MPA designs becauseitisrelativelysimpleto fabricate[3].

The micro strip antenna has been commonly used for wireless applications because of small antenna size, low cost, light weight, better efficiency, ease of installation, ease of mobility, and is relatively inexpensive etomanufacture on printed circuit board (PCB) of specific characteristics anddimensions. However,apartfromitsadvantages,therearesome drawbacksof MPA.It handleslesspowerand has limitedbandwidth[4]. ThebandwidthofMPAcanbeimprovedby eitherusingaslottedpatch[5][6]orbyusingreducegroun d plane[7][8].Theslotonthepatchcanbeof any shapelikeH-slot [9],E-slot [10],circular,rectangular, etc.Thesetechniquescanalsobeusedtoimprove thereturnlossalongwithbandwidthenhancement. Differentshapesofslotshave different effecton antenna parameters. Morethanoneslotshaving differentdimensions canbeetchedonpatch simultaneously inordertoimprovevariousantenna parameterslikereturnloss,bandwidth,VSWR.

Section II (Antenna Geometry) explains the geometry of antenna. The top view, bottom view and dimensions of substrate, patch, slots on the patch and ground plane are listed in section II.

Section III (Results and Discussions) describes the simulated results obtained by using CST MWS (2010) which includes Return loss(S_{11}), Directivity, Gain at corresponding resonant frequencies, VSWR and Smith chart plots.

Section IV (Experimental verification) indicates the top and bottom view of practically designed antenna and describes practical results obtained by testingthe practically designed antennausingE5071C ENAseries NetworkAnalyzer.
Section V (conclusion) explains both simulated theoretical results and practical results in terms of return loss at corresponding resonant frequencies and bandwidth, along with list of applications in which designed antenna can be used.

II. ANTENNA GEOMETRY

Fig.1represents thetopview of aslottedMPA.As shownin theFig.1,theshape ofpatchissquarewith a 4slotscutonpatch.Thepatch hasbeenfedby afeed lineofcertainspecifiedwidth. InFig.2, thebottom view ofslottedMPA isshown.Thegroundplanehas been designedatthebottom of substrateasshown in Fig.2.The antenna isfabricatedusingFR4substrate having dielectric constant of 4.4 and substrate thickness of1.57mm.Thefeedlinewidthhasbeen adjustedtomakesurethattheimpedanceofantenna is nearly50ohmssoastoperfectly matchwiththe connectorimpedanceformaximum powertransferto antennawithminimalbackreflections.Thebottomofthe substrateconsists of groundplane whichis partiallyreducedtoimproveantennabandwidth.The dimensionsofsubstrate,patch,feed, slotscutonpatch andgroundarelistedinTable1

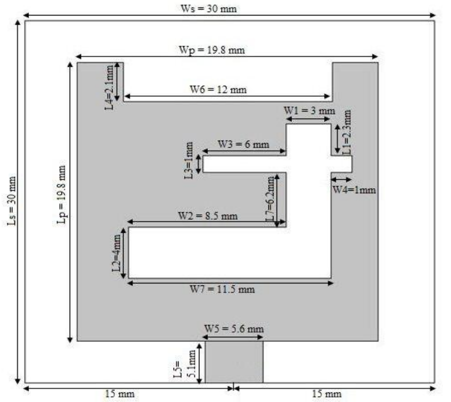

Figure.1Top viewofslottedMPA

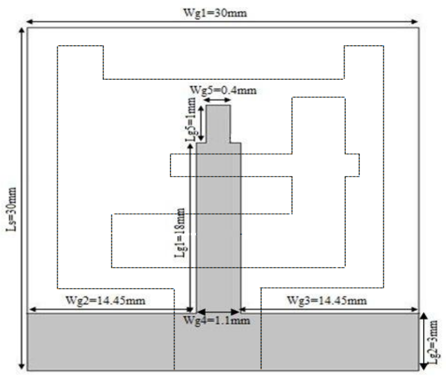

Figure.2Bottomviewof notchedslottedMPA

Note: The dotted portion shown in Fig.2 indicates the projection of patch and feed line on ground.

TABLE 1 Antenna parameters

Antenna Parameter	**Specification**
Length of substrate (L_s)	30mm
Width of substrate (W_s)	30mm
Length of Patch (L_P)	19.8mm
Width of Patch (W_p)	19.8mm
Length of feed (L_5)	5.1mm
Width of feed (W_5)	5.6mm
Length of slot 1 (L1+L3+L7)	9.5mm
Width of slot 1 (W1)	3mm
Length of slot 2 (L2)	4mm
Width of slot 2 (W2+W1=W7)	11.5mm
Length of slot 3 (L4)	2.1mm
Width of slot 3 (W6)	12mm
Length of slot 4 (L3)	1mm
Width of slot 4 (W3+W4)	10mm
Length of ground 1 (Lg2)	3mm
Width of ground 1 (Wg1)	30mm
Length of ground 2 (Lg1)	18mm
Width of ground 2 (Wg4)	1.1mm
Length of ground 3 (Lg5)	1mm
Width of ground 3 (Wg5)	0.4mm

III. RESULTS AND DISCUSSIONS

Thedesigned slotted antenna have been simulated using CSTMicrowave Studio 2010 and the performance of the antenna has been analyzed in terms of return loss,VSWR,radiation pattern, directivity, impedanceandgain. The experimental resultshave been alsoobtainedusing E5071C ENA series Network Analyzer and concluded that the practicalresultsclosely matches withthesimulated theoretical results. Fig. 3representsthesimulatedresultsofreturnloss (S_{11})fordesignedslottedantenna.Ithasbeen observed that thereturnlossis -33.90dBat3.3GHz, -22.76dBat3.7 GHz, -27.71 dBat5.5GHzand-18.30dBat6.6GHz. Thesimulatedbandwidth oftheproposedantennais 4.01GHz.

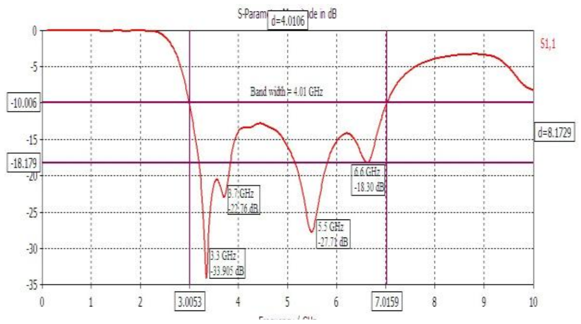

Figure.3 ReturnlossplotofslottedMPA

Thedirectivity atresonantfrequencieshasbeen obtained andanalyzed. Fig.4 (a), Fig.4 (b) and Fig.4(c)showsthe3Dplotofdirectivity ofslotted MPAatresonantfrequencies of3.3GHz,3.7GHzand 5.5GHz,respectively. Thedirectivity is2.308dBiat 3.3GHz,2.350dBiat3.7GHzand4.153dBiat5.5 GHz.Ithasbeen observed thatdirectivity isbetterfor higherresonantfrequenciesthanlower frequencies.

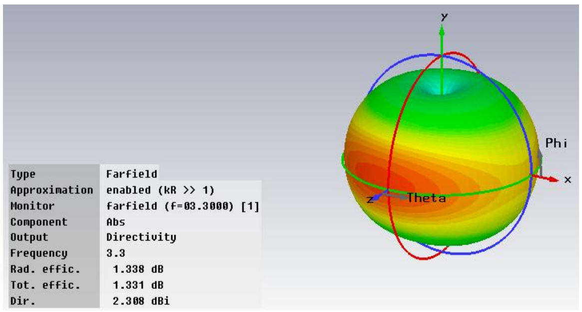

Figure.4(a) 3D plot of DirectivityofslottedMPAat 3.3 GHz

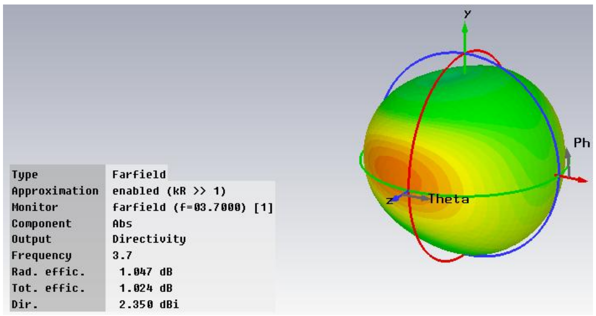

Figure.4 (b)3DplotofDirectivityofslottedMPAat3.7 GHz

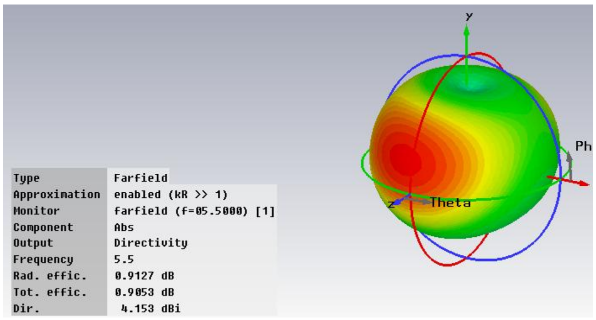

Figure.4(c)3DplotofDirectivityof slottedMPAat5.5 GHz

Fig.5(a),Fig.5(b)andFig.5(c)illustratesthe3Dplot ofgainforslottedMPAatresonantfrequencies3.3 GHz, 3.7GHzand5.5GHz,respectively. The3D plotshowsthatthegain is3.646dBat 3.3GHz, 3.396 dBat 3.7GHzand5.065 dBat 5.5GHz.

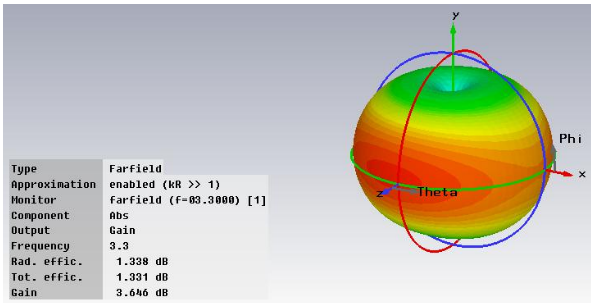

Figure.5(a)3DplotofGainofslottedMPAat3.3GHz

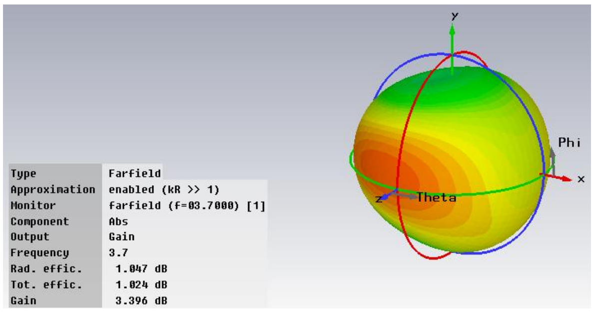

Figure.5(b)3DplotofGainofslottedMPAat3.7GHz

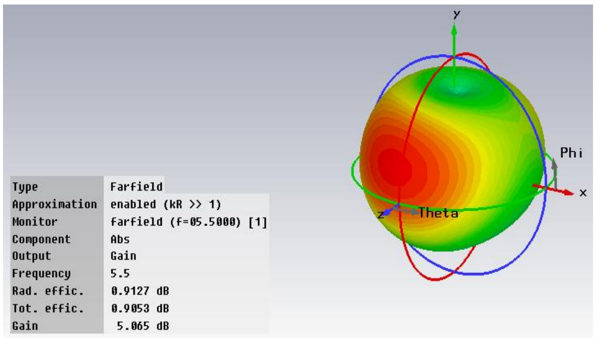

Figure.5(c)3DplotofGainofslottedMPAat5.5GHz

Fig.6 depicts the simulated VSWR plot forslotted MPA.TherequiredvalueofVSWRshouldbeless than2.Fig 6showsthatvalueofVSWRforslotted MPAis less than 2 in an operating frequency range of 3 GHz to 7 GHz.

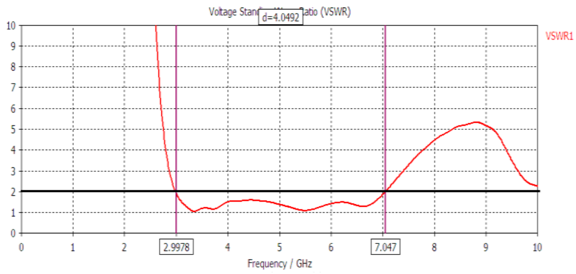

Figure.6VSWRplotofslottedMPA.

Fig.7indicates SmithchartplotforslottedMPA. The

SmithChartplotindicates the variation in impedance of antenna with frequency.Thevalue of impedance should lienear50 ohmsin orderto perfectly match the portwith the antenna. The antennaimpedancefordesignedslottedMPAantenna is 49.8Ω.

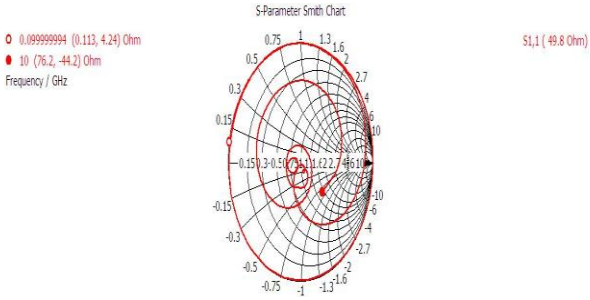

Figure.7SmithChartplotforslottedMPA

IV.EXPERIMENTAL VERIFICATION

Theproposedantennahasbeenphysicallydesigned, the top and bottom view of practically designed antenna are shown in Fig.8(a) and Fig.8(b), respectively andtestedusingE5071C ENAseries NetworkAnalyzer.Thepractically analyzedresultsof slottedMPA are shown in Fig.9. It has been observed that the practical results of designed MPA have return loss of -29.527 dB and -24.329 dB at 3.47 GHz and 5.62 GHz, respectively. The bandwidth obtained from practical results of designed MPA has been 3.868 GHz having frequency range from 3.159 GHz to 7.027 GHz.

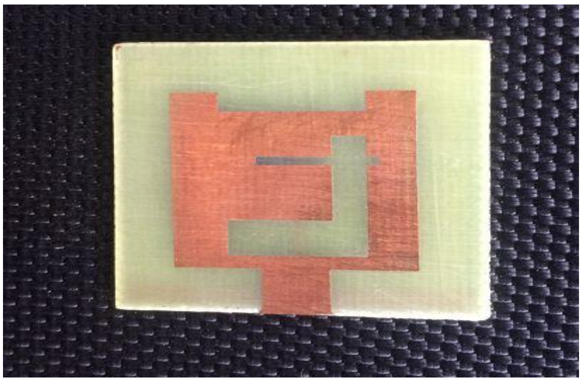

Figure.8 (a) Top view of RectangulardesignedMPA

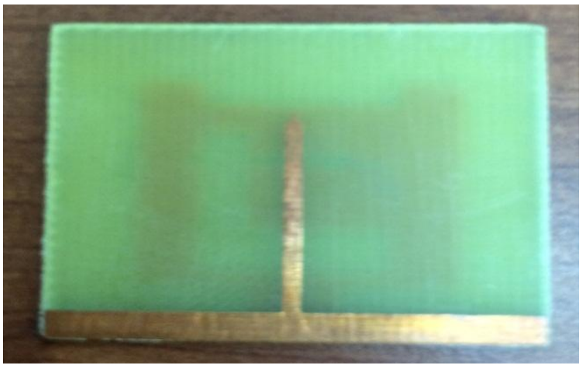

Figure8(b) Bottom view of RectangulardesignedMPA

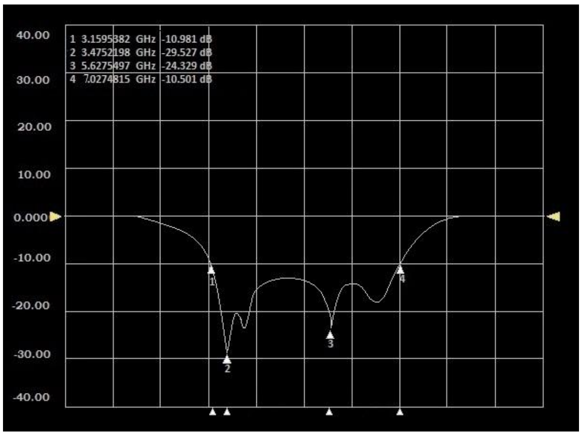

Figure.9ExperimentalResultsforslotted MPA.

V. CONCLUSION

From theabovediscussion, ithasbeenconcludedthat theslottedmicrostrippatch antennahasbandwidthof 4GHzwithoperatingfrequencyrangefrom3GHzto 7GHzandcorrespondingresonantfrequenciesof3.3 GHz,3.7GHz,5.5GHzand6.6GHz.Thedirectivity correspondingtoresonantfrequenciesof3.3GHz, 3.7 GHzand5.5GHzare2.30dBi,2.35dBi,4.15dBi, respectively.Thegainat3.3GHz,3.7GHzand5.5 GHzis3.64dB,3.39dBand5.06dB,respectively. Thereturnlossis-33.90dBat3.3GHz, -22.76dBat 3.7GHz,-27.71dBat5.5GHzand-18.30dBat6.6 GHz,respectively. TheVSWRforslottedmicrostrip patchantennaislessthan2 in an operating frequency range of 3GHz to 7 GHz.Thesimulated results of thedesignedslottedantenna closely matchwith practicalresults.It has been observed that the practical results of designed MPA have return loss of -29.527 dB and -24.329 dB at 3.47 GHz and 5.62 GHz, respectively. The bandwidth obtained from practical results of designed MPA has been 3.868 GHz having frequency range from 3.159 GHz to 7.027 GHz. Thedesignedantennaissuitableto beusedforIMT (3.4 GHz to 4.2 GHz, 4.4 GHz to 4.9 GHz),WLAN standard (5.15 GHz to 5.35 GHz, 5.725 GHz to 5.825)andWiMAX (3.4 GHz to 3.69 GHz, 5.25 GHz to 5.85 GHz)applications [11].

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