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A Multiband Slot Antenna for GPS/ WIMAX/ WLAN Systems

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Abstract: The design of multiband slot antenna includes different services such as GPS, WiMAX and WLAN systems. The inclusion of a ground slot in an antenna ground plane can be extended to include reconfigurable features. In this multiband slot system is proposed to intend GPS, WLAN(over two frequency bands),and WiMAX. The design of four band slot antenna for the global positioning system, worldwide interoperability for microwave access and wireless local area network is presented. The antenna consists of a rectangular slot with a T-Shaped feed patch, an inverted W-shaped stub and two C-shaped stub to generate four frequency bands. The aim of this project is to model, simulate and fabricate a multiband slot antenna for various frequency bands to achieve enhanced VSWR, S11 parameters and uniform 3D radiation pattern. The dimensions of multiband slot antenna are calculated using general antenna parameter formulae. The layout of the antenna is simulated in an EM tool of Computer Simulation Testing (CST) and the antenna is fabricated using photolithographic process.
Keywords: Global positioning system (GPS), worldwide interoperability for microwave access (WiMax), wireless area network (WLAN).

I. INTRODUCTION

In the domain of wireless communications, the antenna plays a requisite role in transmission and reception of EM (Electromagnetic) signals, and there are many different types of antennas with different properties. With the improvements in the different wireless communication standards, it is necessarily required to integrate various wireless communication sytems such as Global Positioning System (GPS), Worldwide interoperability for Microwave Access (WiMAX) and Wireless local area network (WLAN) standards as possible into a single wireless device. Because of this reason, various multiband antennas have been studied, e.g., the multiband patch antenna having different polarization states in [3], the dual-band monopole antenna for the WiMAX systems in [1], the multiband planar inverted-F antenna (PIFA) for the wireless wide area network (WWAN) system in [2], and the dual-band loop antenna for the 2.45/5.2/5.8 GHz bands in [4]. Slot antenna, with the advantages of compact size, wider bandwidth, and simple integration with other devices is a better equipment for the design of multiband antennas. In the previous years, different designs of multiband antennas have been proposed [5]-[13]. A multi four band slot antenna was proposed in [13] using several stubs on the UWB slot radiator. The dual-band characteristics of the slot antenna in [5], [6], and [7], [8] were generated by etching several narrow slots on the ground planes.

In this paper, we present the design of a four-band slot antenna for GPS/WIMAX/WLAN systems. The antenna consists of a rectangular slot, a T-shaped feed patch, an inverted W-shaped stub, and two C-shaped stubs to generate four frequency bands at 1.57, 2.5, 3.5 and 5.3 GHz for the GPS, IEEE 802.11 b&g, WiMAX and IEEE 802.11a systems, respectively. The proposed multiband antenna is studies and designed using the electromagnetic (EM) simulation tool **CST**. For verification of simulation results, the antenna is fabricated using photolithography process and tested the results using vector network analyzer. The results on reflection coefficient or S11 curve, radiation pattern, VSWR are presented.

II. ANTENNA DESIGN

The proposed four band slot antenna is shown in Figure. 1, which consists of a rectangular slot with a size of L1 × W1 = 48 × 18 mm^2 with triangular cuts on four corners of the slot to achieve better impedance matching on one side of the substrate. The rectangular slot is included with an inverted W-shaped stub at the upper edge of the rectangular slot and two C-shaped stubs on the left hand and right-hand sides of the slot. The inverted W-shpaed stub has the horizontal strip folded on both sides to achieve a compact size. A T-shaped feed patch with microstrip fed is used to feed the rectangular slot . The feed line has a width of Wf = 1.76 mm to achieve an impedance of 50 ohms. The antenna is designed using FR-4 substrate. This material is known to retain its high mechanical and electrical strength. The antenna is studied and designated on a substrate with a relative permittivity of ϵ_r = 4.4, a thickness of about 0.8 mm and a loss tangent of 0.025.

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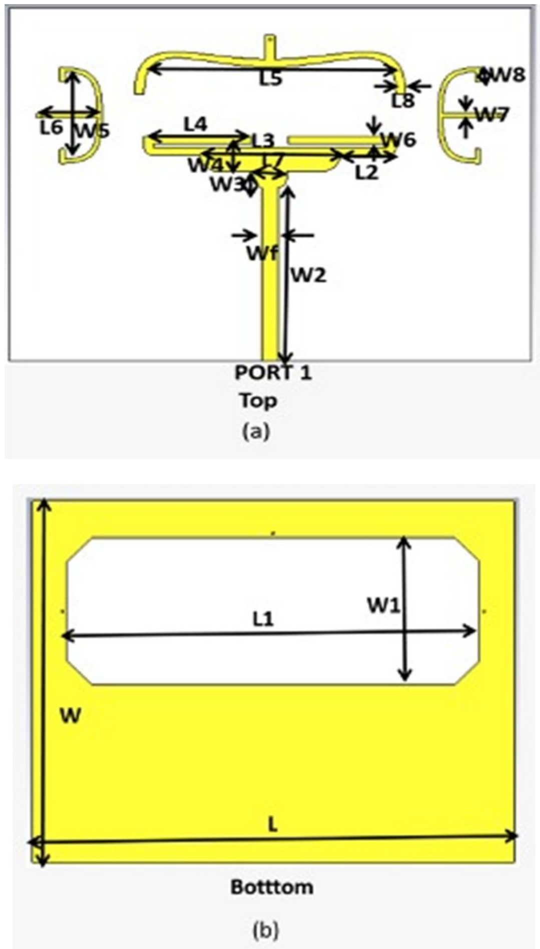

Fig. 1. Proposed Antenna (a) top view; (b) bottom view

The rectangular slot with chamfered edges with W-shaped stub with bending generate band 1 at about 1.57 GHz. The two C-shaped stubs with bending operating as monopole radiators generate band 2 at about 2.5 GHz for IEEE 802.11 b&g standard. Due to the coupling of the T-shaped feed patch and W-shaped stub generate band 3 at about 3.5 Ghz for WiMAX applications. The T-shaped feed patch in the higher mode generates band 4 at 5.3 Ghz for IEEE standard 802.11a WLAN.

The concluding dimensions of the proposed multiband antenna is depicted in Table 1.

L	L1	L2	L3	L4	L5
56	48	6	15	12.5	29
L6	L7	L8	W	W1	W2
5.5	3.6	1	44	18	21.6
W3	W4	W5	W6	W7	W8
2	2	12	1	0.5	1.3
h	Wf				
0.8	1.76				

Table 1 Dimensions of the proposed multiband antenna (in mm)

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III. RESULTS

The antenna is designed with a rectangular slot of dimensions 48 × 18 mm^2 as shown in the Fig1. The antenna is designed and simulated in CST studio suite and the antenna should maintain the input-output relantionship between ports which is described by return loss curve or S11 curve. S11 represents how much power is reflected from the antenna. For a better antenna performance, S11 should always be less than -10 db. Fig2 depicts the S11 curve for the four bands.

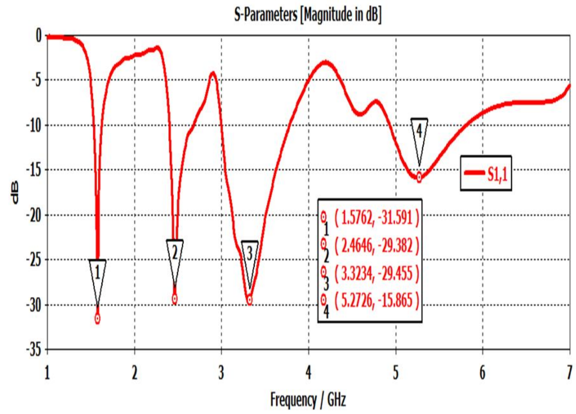

Fig2. Return loss curve for four bands

VSWR is a measure that describes how well the antenna is impedance matched. The smaller the VSWR is, the better the antenna is matched to the transmission line and more power is delievered to the antenna. The minimum VSWR is 1.0. For better performance, VSWR reading should be near to 1. Fig3 depicts the VSWR curve for the four bands of the antenna.

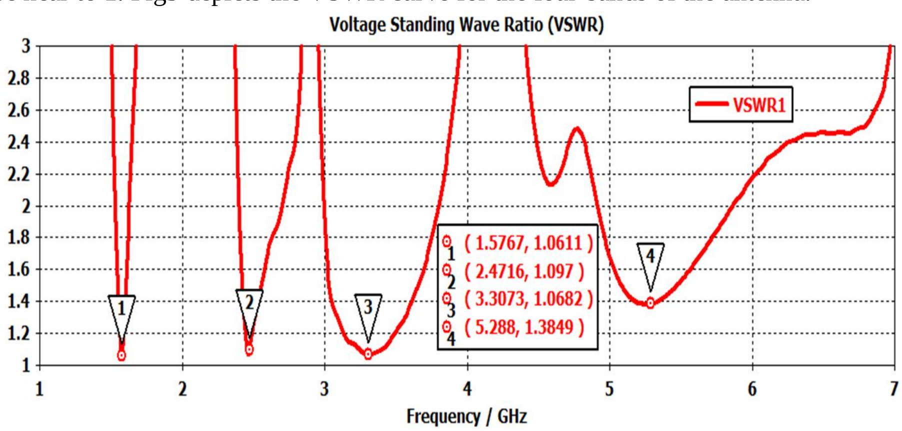

Fig3. VSWR curve for four bands

The antenna shows an uniform radiation pattern which is one of the advantageous property for the antenna.

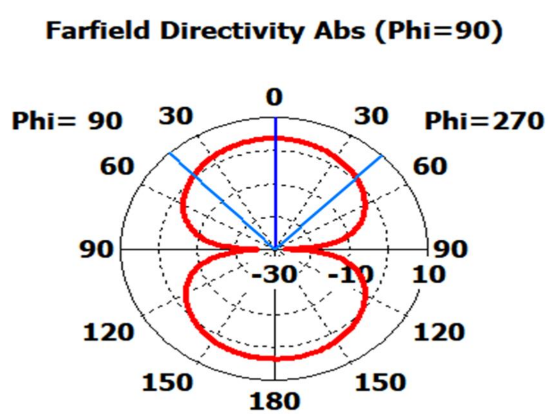

Fig4. 2D radiation pattern for GPS band at 1.57 GHz.

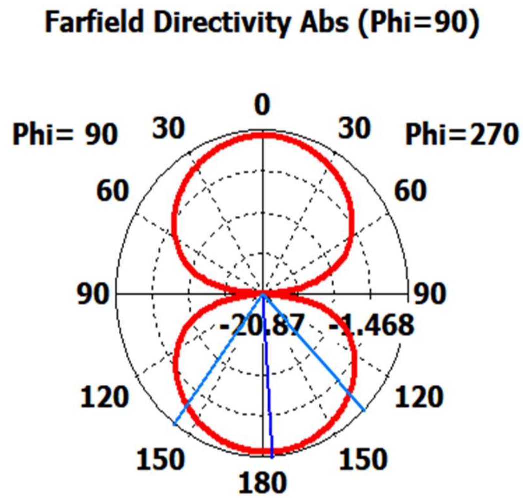

Fig5. 2D radiation pattern for IEEE 802.11 b&g at 2.5GHz

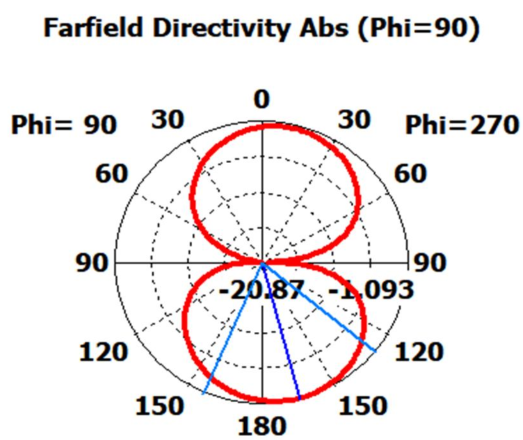

Fig6. 2D radiation pattern for WiMAX at 3.5GHz

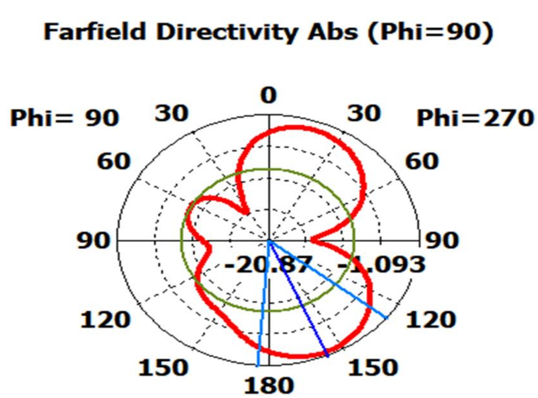

Fig7. 2D radiation pattern for IEEE 802.11a at 5.3GHz

Figure 4, 5, 6, 7 represents the 2D radiation patterns of GPS, IEEE 802.11 b&g, WiMAX and IEEE 802.11a WLAN respectively. As it can be observed, the radiation patterns are in the form of 8, which represents better radiation pattern. The antenna is fabricated using photolithographic process. Fig8 represents the fabricated antenna

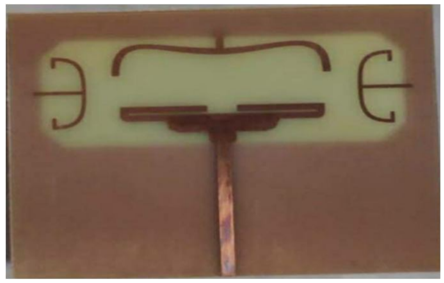

Fig8. Fabricated antenna

After the antenna is fabricated, it is tested in vector analyzer. Fig9 represents the testing of the antenna in vector network analyzer.

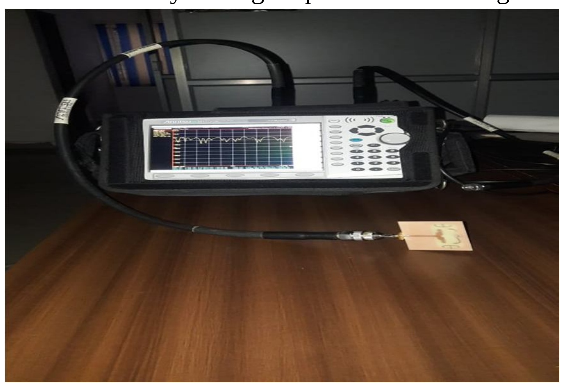

Fig9. Testing in Vector network analyzer

Fig10 and Fig11 represents the S11 and VSWR curve respectively of the fabricated antenna in vector network analyzer.

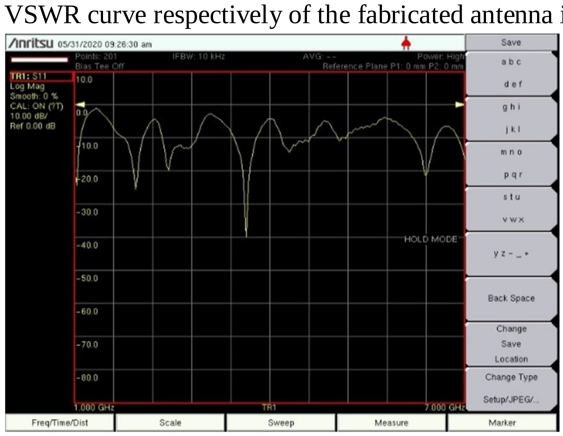

Fig10. S11 curve in vecor network analyzer

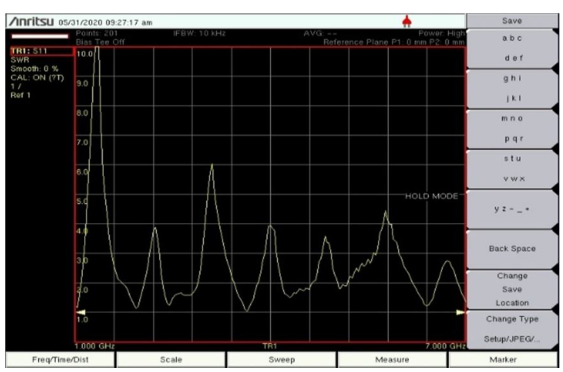

Fig11. VSWR curve in vector network analyzer

Simulated vs measured results of S11 and VSWR are shown in fig11 and fig12.

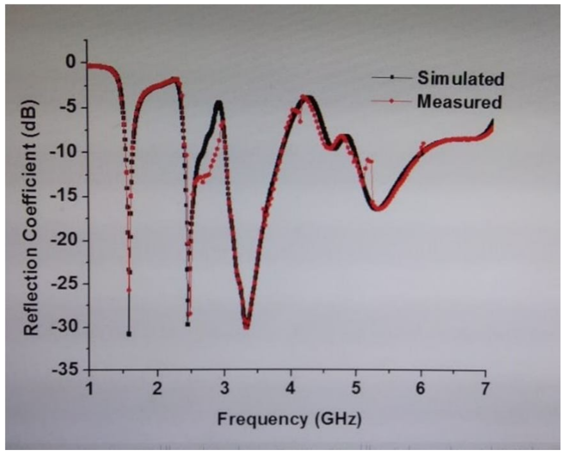

Fig11. Simulated vs Measured S-parameter graph

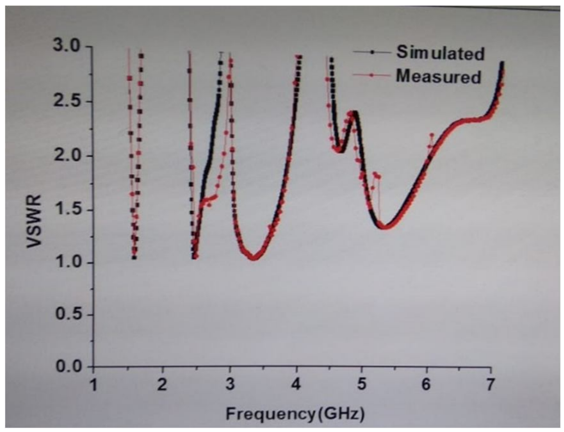

Fig12. Simulated vs Measured VSWR graph

Table 2 Simulated vs Measured results for GPS at 1.57GHz

Parameter	Simulated	Measured
VSWR	1.0611	1.069
S-parameter	-31.591	-29.65

Table 3 Simulated vs Measured results for IEEE 802.11 b&g WLAN at 2.5GHz

Parameter	Simulated	Measured
VSWR	1.097	1.093
S-parameter	-29.382	-20.00

Table 4 Simulated vs Measured results for WiMax at 3.5GHz

Parameter	Simulated	Measured
VSWR	1.0682	1.0633
S-parameter	-29.455	-39.95

Table 5 Simulated vs Measured results for IEEE 802.11a WLAN at 5.3GHz

Parameter	Simulated	Measured
VSWR	1.3849	1.3722
S-parameter	-15.865	-21.22

IV. CONCLUSION

In this project, a multiband slot antenna for GPS/ WiMax and WLAN systems at 1.57GHz for GPS, 2.5GHz for IEEE 802.11 b & g WLAN, 3.5GHz for WiMax and 5.3GHz for IEEE 802.11a WLAN is designed and simulated using CST microwave studio software and achieved very low return loss and excellent voltage standing wave ratio.

Antenna designed in CST is fabricated using photolithographic process and tested using vector network analyzer. The antenna has observed in providing better impedance matching, exceptional VSWR readings, S11 parameters and uniform radiation pattern. The antenna is designed using the FR-4 substrate which is of very low cost.

Hence, we can conclude that due to the above antenna characteristics, it can be used for many applications such as GPS/ WiMax and WLAN systems as it resonates at multiple bands of frequencies.

V. FUTURE SCOPE

Using the same technique, the antenna can also be extended to resonant at few more frequencies for various applications. With the increase in the number of frequencies, impedance gets mismatched, to reduce the impedance mismatch, various feeding techniques can be adopted.

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