Square Slot Loaded Microstrip Fed Multi Octave Band Radiator

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***Abstract*—Ultra-wideband antennas covering the frequency range of 3.1-10.6 GHz. have been reported extensively in the literature. Considering tactical band of 6-18GHz is important to cover the band of Communications, Radar and EW applications, Vivaldi radiators have been widely used for this purpose. The Vivaldi antenna is essentially a 3-dimensional antenna and there is a need for a planar printed unidirectional antenna covering 6-18GHz. In this paper, the ultra-wide band antenna design methodology has been adopted and an attempt has been made to cover the frequency range of 6-18GHz. Two types of antennas have been designed, analyzed and implemented, namely the bidirectional and the unidirectional ones. In simulations, the bi-directional antenna has yielded a VSWR of less than 2.1 over 2-18GHz. Both the antennas showed satisfactory radiation patterns. The antennas have been evaluated in measurements over 6-18GHz. The unidirectional antenna however has yielded satisfactory radiation patterns over 6-15GHz only. These antennas have been designed using HFSS simulations and implemented in hardware. The practical patterns in both cases are reported.**

***Index Terms*—UWB; Printed Antennas; Communications; EW Antennas; HFSS.**

I. INTRODUCTION

Ultra-wideband antennas have been widely reported in literature [1-4]. Wide slot antennas have been used to extend the frequency coverage [5-8]. Diamond slot antenna covering the frequency range of 3.28- 19.64 GHz is one such antenna that has been reported earlier [9] and has been taken as a reference antenna. Simulated radiation patterns reported in this paper are over 3-9 GHz only. A VSWR of less than 2.0 has been reported over 4.7 GHz to 18.68 GHz. The stepped line matching technique reported in the above reference papers has been adopted in our design to demonstrate the affect of matching the antenna to the micro strip line feed.

In this paper, the micro strip fed square slot loaded antenna has been designed and analyzed through HFSS simulations. The stepped matching is found to be inadequate for obtaining the aimed coverage of 2-18 GHz. Hence, an additional parasitic electromagnetically coupled strip has been introduced at the top of the square patch at the back of the substrate to improve the impedance matching over 2-18 GHz. Using the same methodology, a unidirectional antenna has also been designed, analyzed and implemented in hardware keeping in view the communications, radar and EW applications.

II. BIDIRECTIONAL ANTENNA

The bidirectional antenna is as shown in Figure 1. The Square patch is fed by a micro strip line, and the patch is simulated with a substrate RT Duroid 5880 with $\varepsilon r = 2.2$ and thickness of 1.6 mm. It is loaded with a wide square slot to enhance the bandwidth. Extensive simulations have been made to optimize the slot dimensions. To match to the micro strip line, the step height and width are adjusted to yield a maximum bandwidth that can be obtained with this variation. Parasitic elements are known to enhance the bandwidth [10] and the rectangular parasitic strip is introduced on the back top-side of the substrate centrally in the simulations. This is an electromagnetically coupled parasitic element. The strip length and width are varied and optimized to give a VSWR of less than 2.1 over 2-18 GHz in simulations. The dimensions that have been varied are as shown in Figure 1 and Table 1.

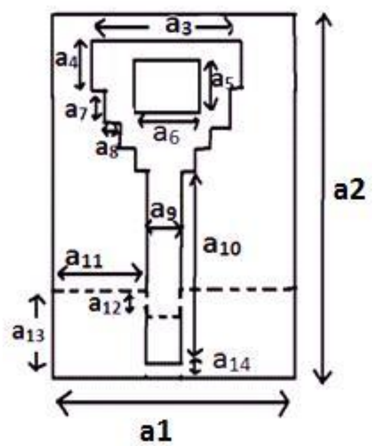

Figure 1: Sketch of the bidirectional antenna

Table 1
Dimensions of the antenna

Symbol	Dimensions (mm)	Symbol	Dimensions (mm)
A_1	21	a_8	1.0
a_2	37.5	a_9	2.7
a_3	14.5	a_{10}	10.8
a_4	7.0	a_{11}	9.1
a_5	6.0	a_{12}	2.7
a_6	6.0	a_{13}	8.5
a_7	1.5	a_{14}	0.2

III. UNIDIRECTIONAL ANTENNA

A unidirectional antenna has been designed as a derivative of the above bidirectional antenna. The bidirectional antenna has been modified with an absorber (Abs), which is backed by a ground plane (gp) as shown in Figure 2. The absorber thickness is 20 mm. This antenna has yielded a VSWR of less than 1.75 over 2-18 GHz in the simulations. The simulated and measured radiation patterns are satisfactory.

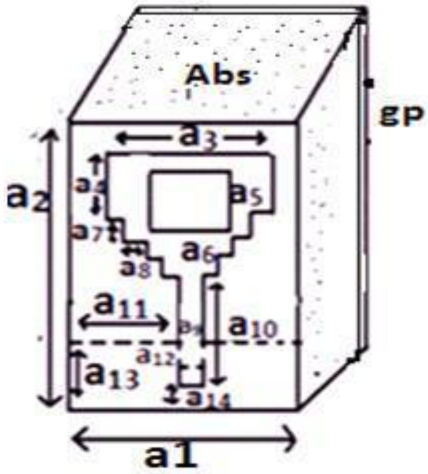

Figure 2: Sketch of the unidirectional antenna

Using the optimized dimensions as shown in Table 1, the antenna is fabricated with a substrate of 5880 which is laminated with εr =2.2 and thickness 1.6 mm. The photo of the antenna is as shown in Figure 3.

IV. SIMULATED RESULTS

Both the antennas have been simulated using ANSYS HFSS software. The VSWR plot of both the antennas is as shown in Figure 4 and 5. It can be seen that the VSWR is less than 2.1 obtained over 2-18 GHz. for the bidirectional antenna.

Figure 3: Photograph of the unidirectional antenna

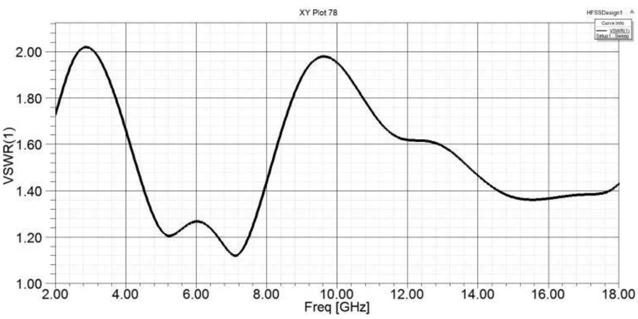

Figure 4: VSWR of bidirectional antenna

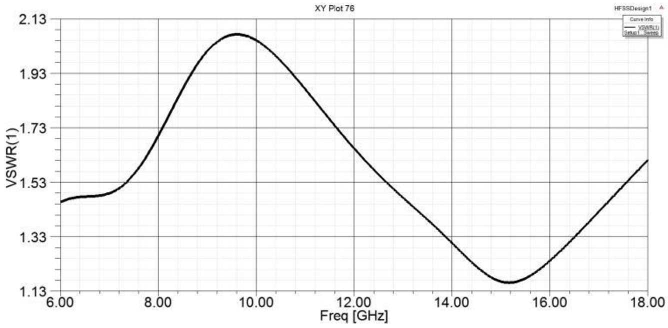

Figure 5: VSWR of unidirectional antenna

V. MEASURED RESULTS

The measured VSWR plot of the bi-directional and unidirectional antennas are as shown in Figure 6 and 7. In the bi-directional case, the VSWR is less than 2.0 over 6-18 GHz, with the exception when the band is between 10.6 GHz to 13.4 GHz, the VSWR goes up to 3.0. However, the unidirectional antenna has a VSWR of less than 2.0 over the entire band.

The patterns of the bidirectional and unidirectional antennas are measured over 6-18 GHz only and are as shown in Figure 6 and 7 respectively. The radiation patterns are satisfactory.

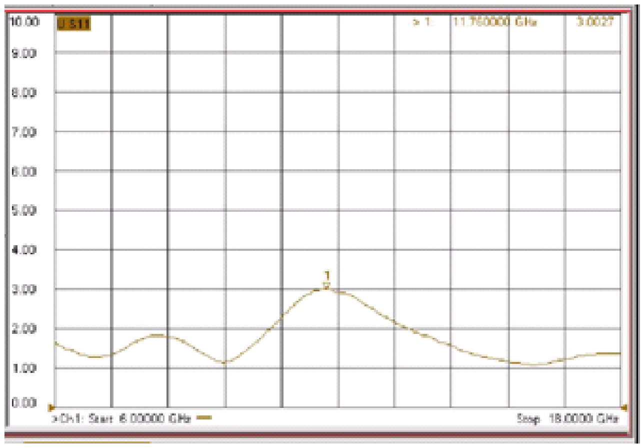

Figure 6: Bi-directional VSWR plot

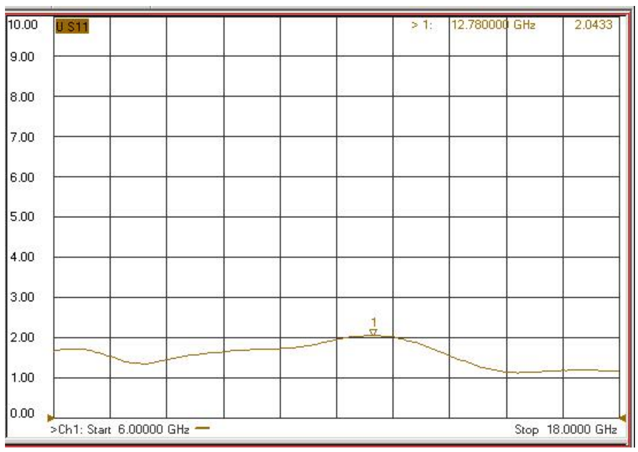

Figure 7: Unidirectional VSWR plot

The measured radiation patterns of the bi-directional antenna are as shown in Figure 8 and the unidirectional patterns are as shown in Figure 9. The radiation patterns are quite satisfactory. The unidirectional antenna has yielded a minimum front to back ratio of 12 dB over the band. The H plane patterns are given in solid line and the E plane patterns are given in the chained line.

The gain plot of the unidirectional antenna is as shown in Figure 10. The top curve represents the simulations and the bottom curve shows the measurement.

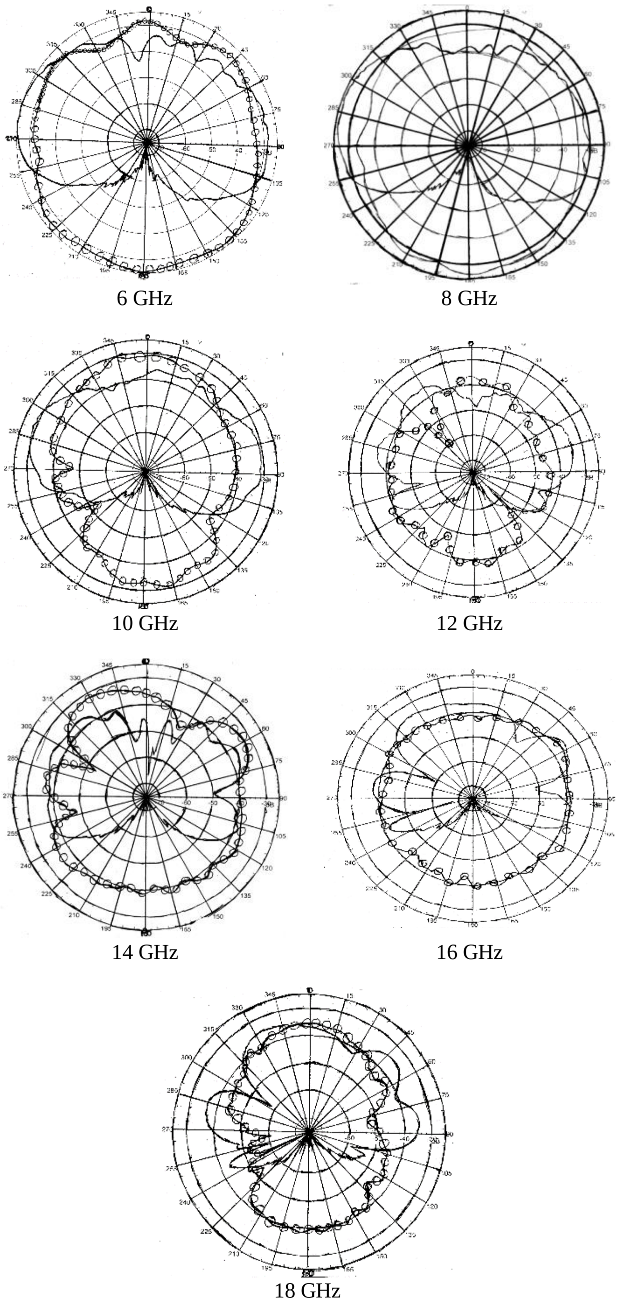

Figure 8: Radiation patterns (Bi-directional)

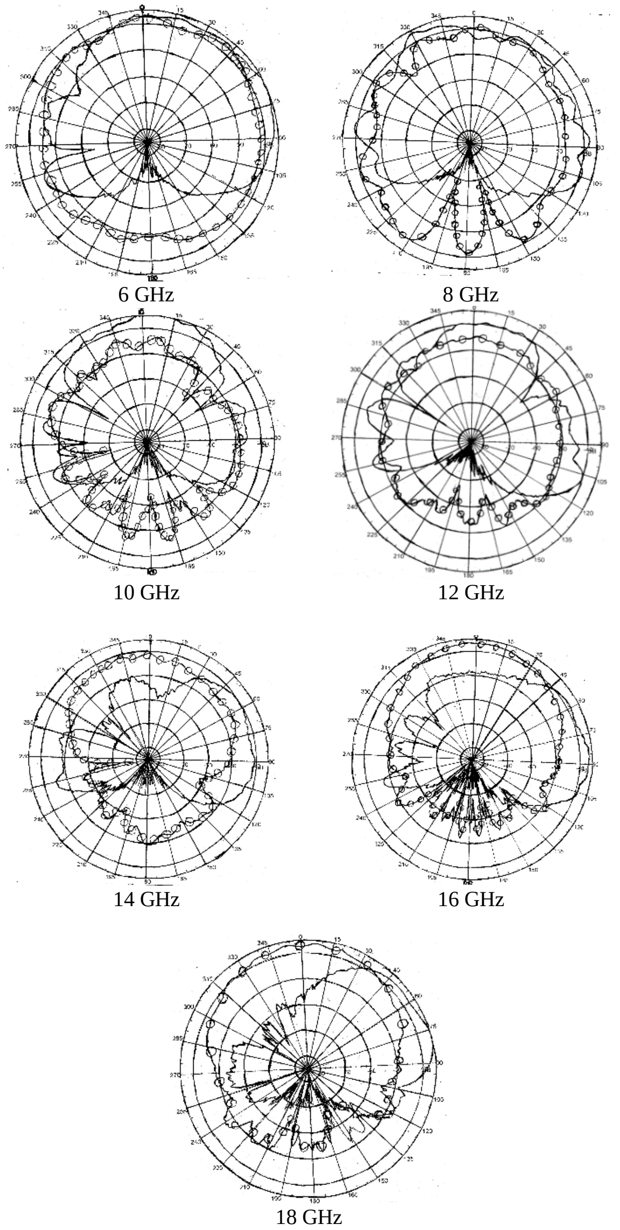

Figure 9: Radiation patterns (Unidirectional)

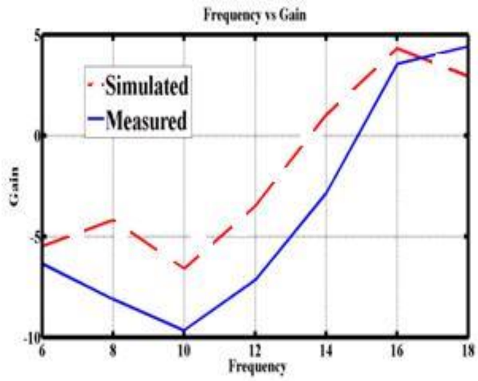

Figure 10: Frequency versus Gain of unidirectional antenna

VI. CONCLUSION

A wide band antenna has been designed and analyzed using HFSS simulations and implemented in the hardware. Two variants of the antenna have been designed, namely the bi-directional and the unidirectional antennas. In simulations, .the bidirectional antenna has yielded a VSWR of less than 2.1 over 2-18 GHz. A measured VSWR of less than 2.0 over the band of 6-18 GHz excepting over 10.6 to 1.4 GHz in which the VSWR goes up to 3.0 has been obtained. The unidirectional antenna however has yielded a VSWR of less than 1.75 over the band. A measured VSWR of less than 2.0 has been obtained. In the unidirectional case, a minimum front to back ratio of 12 dB is achieved over the band. The antennas can be applied in communications, radar and EW.

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REFERENCES

[1] Cengizhan M.Dikmen, Sibel Cimen and Gonca Cakir," Planar Octagonal- shaped UWB Antenna with Reduced Radar Cross Section", *IEEE Transactions on antennas and propagation*, Vol. 62, NO. 6, JUNE 2014.

[2] Tharaka Dissanayake, Karu P. Esselle, "UWB Performance of Compact L-shaped Wide Slot Antennas", *IEEE Transactions On Antennas And Propagation*, Vol. 56, No. 4, April 2008.

[3] Ming-Chun Tang, Richard W.Ziolkowski, Shaoqiu Xiao, “Compact hyper band printed slot antenna with stable radiation properties,” *IEEE Trans. Antennas and Propag*., vol.62, no6, Jun. 2014.

[4] Yangyi Zhao, Weidong Hu, "Design of A UWB Unidirectional Radiation Compound Spiral Antenna", *Beijing Key Laboratory of millimeter wave and Terahertz Technology, IEEE 2016*, Beijing, China.

[5] Lei Wang, Yu Jian Cheng, Da Ma, Cheng Xiang Weng, " Wideband High-Gain Substrate Integrated Antenna Array for E-Band Multi-Gigahertz Capacity Wireless Communication Systems", *IEEE Transactions on Antennas and Propagation*, Volume: 62, Issue: 9, Sept. 2014.

[6] Jie Wu, Yu Jian Cheng, Yong Fan, "A wideband planar array antenna for Ka-band wireless communication applications", *Radar Conference (EuRAD) 2015 European*, pp. 485-488, 2015

[7] Guo-Ping Gao; Bin Hu; Jin-Sheng Zhang, “Design of a Miniaturization Printed Circular-Slot UWB Antenna by the Half-Cutting Method", *IEEE Antennas and Wireless Propagation Letters*, Volume: 12, 24 April 2013.

[8] Wen-Jun Lu, Lei Zhu, "A Novel Wideband Slotline Antenna with Dual Resonances: Principle and Design Approach", *Antennas and Wireless Propagation Letters IEEE*, vol. 14, pp. 795-798, 2015, ISSN 1536-1225.

[9] Chia Ping Lee, Chandan Kumar Chakrabarthy, "Ultra-wideband Microstrip Diamond Slotted Patch Antenna With Enhanced Bandwidth", *International Journal of Communications, Networks and System Sciences*, 2011,4,468-474.

[10] Rina Abdullah; M. T Ali; N. Ismail; S. Omar; N. N. S. N. Dzulkefli, "Multilayer parasitic microstrip antenna array for WiMAX application" *2012 IEEE Asia-Pacific Conference on Applied Electromagnetics (APACE)*, 2012.