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SHORT COMMUNICATION

Ultra Wide-band Microstrip Line-fed Rectangular Slot Antenna

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ABSTRACT

An ultra wide-band antenna fed by a microstrip line with a U-shaped tuning stub has been developed which provides an impedance bandwidth of 7.2 GHz corresponding to 118 per cent ($S11 < -10$ dB). The radiation pattern of the antenna is bidirectional. Details of the proposed antenna design have been described and the typical experimental results are presented and discussed.

Keywords: Ultra wide-band antennas, printed antennas, rectangular slot antennas

I. INTRODUCTION

The printed antennas are widely used due to their various attractive features like light-weight, low-cost, easy-fabrication and conformability on the curved surface. The microstrip element suffers from an inherent disadvantage of narrow impedance bandwidth[1]. Techniques are reported to increase the bandwidth of the printed antenna[2-6] by varying the geometry of the slots and using different feed structures. One of the major reasons for the wide areas of research in the field of printed antennas is a need for the antennas to perform in various environment with required characteristics along with wide bandwidth. This also spurred research in the materials being used so as to enable the antenna researchers to achieve the required characteristics. Various configurations of wide-band antennas were developed like using photonic bandgap elements and frequency selective surfaces. But, these techniques make the fabrication costly by increasing the total cost of the antenna.

One of the simple techniques is to change the geometry of the structure to bring the resonant frequencies close by, thereby increasing the bandwidth. Many researchers have explored this technology and it is in the forefront of the technologies being investigated for wide bandwidth in the present day scenario.

This paper presents an ultra wide-band printed rectangular slot antenna fed by a microstrip line with a U-shaped tuning stub. This antenna produces an impedance bandwidth of 118 per cent ($S11 < -10$ dB). The antenna is simulated using Ansoft HFSS 9.2.1 software.

2. ANTENNA STRUCTURE

The antenna structure is shown in Fig. 1. The RT duroid substrate has a dielectric constant of $\varepsilon_r = 3.5$ and loss tangent 0.0019. The thickness of the substrate is 60 mil and the dimension is 100 mm x 100 mm. A rectangular slot of dimension

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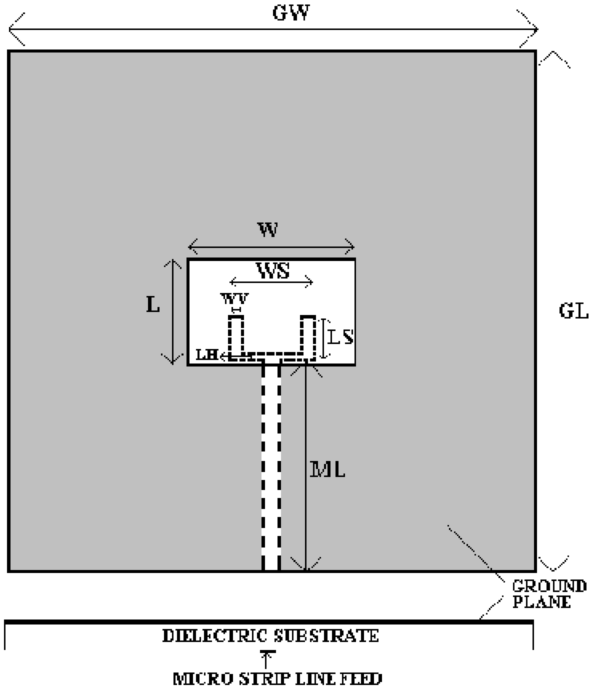

Antenna parameters ε_r=3.5	Thickness 1.524 mm
GL = GW=100 mm	L=20.9 mm
W = 31.9 mm	ML=40.8 mm
WS=15.5 mm	LS=8 mm
WV=2 mm	LH=1 mm

Figure 1. Geometry of microstrip fed slot antenna.

31.9 mm x 20.9 mm is etched at the centre of one side of the ground plane (1/2 ounce thick copper) of dielectric substrate. A microstrip line terminated by a U-shaped stub of width 15.5 mm x length 8 mm is etched on the other side of the dielectric substrate. L, W and ML denotes the length, width of the slot and length of the microstrip line, respectively. The rectangular slot is the radiating aperture.

The simulated return loss plot is as shown in the Fig. 2. The return loss plot shows an impedance bandwidth of 7.2 GHz (2.5 - 9.7 GHz) that corresponds to 118 per cent of the centre frequency. The wide bandwidth is due to the multiple resonances introduced due to the combination of slot and U-shaped tuning stub. The close resonant loops in the Smith chart shows that multiple resonances are present. The Smith chart is shown in Fig. 3.

The bandwidth obtained for this antenna is greater than 10 times the bandwidth obtained when there is only a microstrip line of appropriate length used for

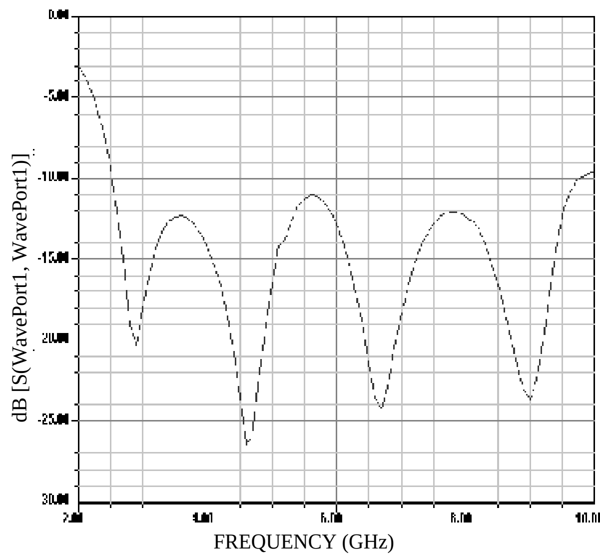

Figure 2. Simulated return loss.

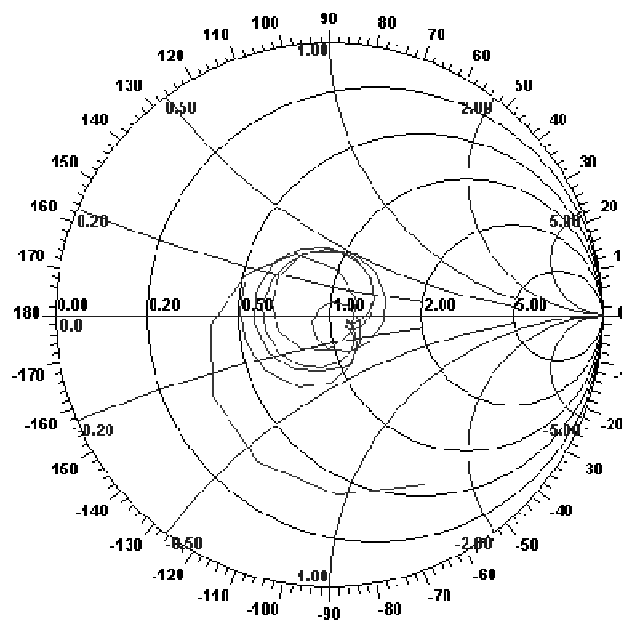

Figure 3. Simulated Smith chart.

feeding. For a feed with a microstrip line, only the loop, is along the edge of the Smith chart indicating the absence of multiple resonances. The resonant loop is again wide when the vertical arms are not present indicating the absence of multiple resonances.

The length and width of the horizontal and vertical arms play a major role in the impedance matching for the whole frequency range. The widths of the vertical arms of the stub help to maintain the resonant loop close to the centre. When the width is increased or decreased, the resonant loop becomes larger. The length of the vertical arm also plays a similar role in the impedance matching of the antenna. The length of the vertical arms and the width of the horizontal arms are also found out in same manner. The length of the microstrip line is chosen such that there is a gap of 1mm between the slot edge and the end of microstrip line or start of the stub so that maximum coupling occurs between the feed and the slot. This gap length is found to be same even when the size of the ground plane increases. The various parameters discussed above are optimised using the simulation software Ansoft HFSS 9.2.1.

The radiation pattern obtained for this antenna is shown in Fig. 4. The azimuth pattern in omni-directional and elevation pattern is figure of eight (bidirectional). The average gain obtained from simulation is 2 dBi.

3. RESULTS

The antenna is fabricated on a 100 mm x 100 mm x 60 mil RT duroid substrate of dielectric constant 3.5 and loss tangent 0.0019. The measured return loss plot is shown in Fig. 5. The 10 dB points are 2.3 GHz and 9.4 GHz, which give an impedance bandwidth of 121 per cent. The Smith chart is shown in Fig. 6.

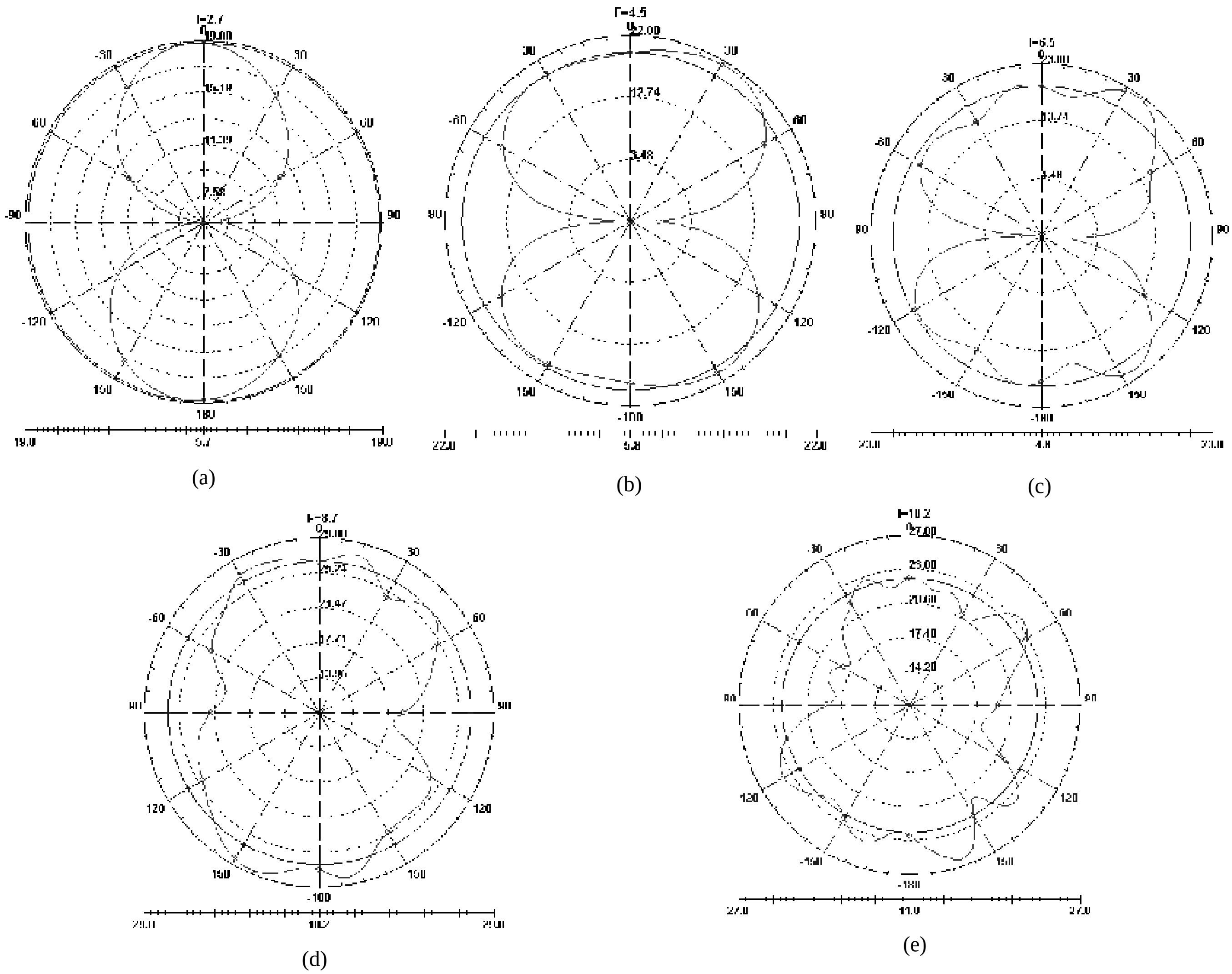

Figure 4. Simulated azimuth (─┤) and elevation (─◆) plane radiation patterns with frequency: (a) 2.7 GHz, (b) 4.5 GHz, (c) 6.5 GHz, (d) 8.7 GHz, and (e) 10.2 GHz.

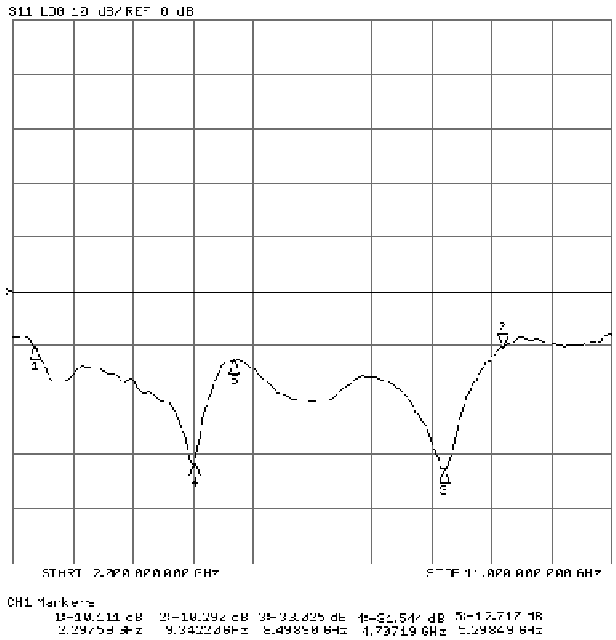

Figure 5. Measured return loss.

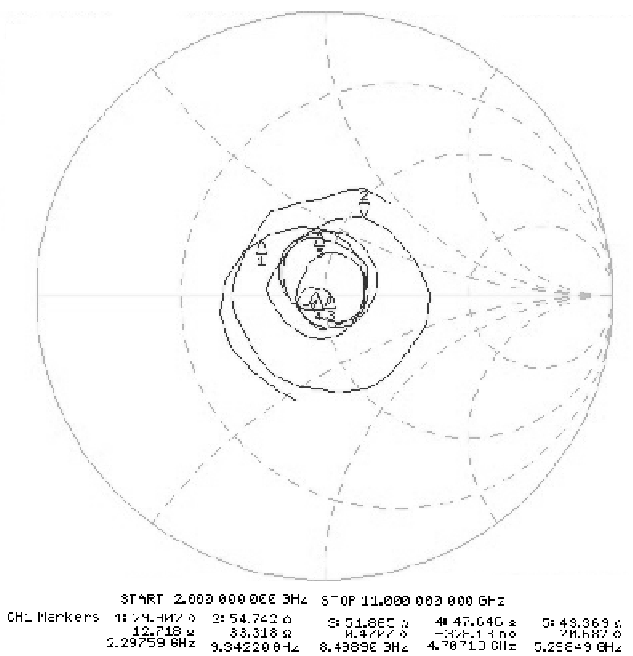

Figure 6. Measured Smith chart.

The measured values are compared with the simulated results and a good agreement is obtained.

4. CONCLUSIONS

An ultra wide-band rectangular slot antenna fed by a microstrip line with a U-shaped tuning stub is presented. The bandwidth achieved with this antenna is around 7.2 GHz. The antenna has good radiation pattern across the matching band.

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REFERENCES

1. Yoshimura, Y. A microstrip line slot antenna. *IEEE Trans. Microwave Theory Tech.*, 1972, **MTT-20**, 760-62.

2. Jan, Jen-Yea & Su, Jia-Wei. Bandwidth enhancement of a printed wide-slot antenna with a rotated slot. *IEEE Trans. Antennas Propag.*, 2005, **53**(6), 2111-114.

3. Chiou, Jyh-Ying; Sze, Jia-Yi & Wong, Kin-Lu. A broad-band CPW-fed strip-loaded square slot antenna. *IEEE Trans. Antennas Propag.*, 2003, **51**(4), 719-21.

4. Sze, J.Y. & Wong, K.L. Bandwidth enhancement of a microstrip line-fed printed wide-slot antenna. *IEEE Trans. Antennas Propag.*, 2001, **49**, 1020-024.

5. Abdallah, A.S.; Liu, Yuan-an & Molairuned, Y.E. Wide-band wide-slot microstrip antenna. *In* Antenna Radio Science Conference, 2004, 27-30.

6. Chair, R.; Kishk, A. & Lee, K.F. Ultra wide-band coplanar waveguide-fed rectangular slot antenna. *IEEE Antennas Wireless Propag. Lett.*, 2004, **3**, 227-29.