Design of Defected Ground Microstrip Patch Antenna with Tapered Feed for X-Band Application

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Abstract: **In this paper a structure of microstrip antenna which is operated on 8.28 GHz is proposed. The given antenna has a ground which defected by the slots structure (DGS) with some modification in the patch and tapering in the feed line. The impedance bandwidth can be increased by using DGS technology. The proposed antenna is used for x-band application such as radio location. The return loss at the frequency 8.28 GHz is -47.82 dB. The gain at the correspondence frequency is 3.76dBi. The antenna shows the improvement in impedance bandwidth and gain is sufficient high for the complete x-band.**

Keywords: Defected ground structure, CST, X-Band

1. INTRODUCTION

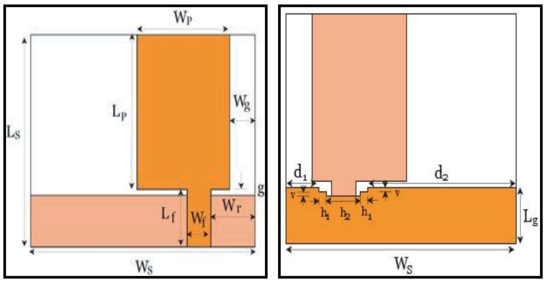
The ultra-wideband antennas with the single pole attracting the researchers 'for working in this field The UWB range which is given by the Federal Communications Commission (FCC) is 3.1 to 10.6 GHz, in February 2002 [1]. The UWB technology has been used where excellent immunity is required to multipath interference and high data rate is necessary [2]. The narrowband systems already exists WLAN (5.15-5.35 GHz and 5.7-5.8 GHz), Wi-MAX (3.3-3.6 GHz) which interferes in this band. The antenna with DGS technology is discussed in details [3]. So, further improvement of impedance bandwidth and gain there is some modification in patch and the feed line [4]. The modification is capable to decrease the return loss too. The antenna input impedance and the radiation pattern verified by CST MWS.

2. ANTENNA DESIGN AND ANALYSIS

The design of the antenna structure is as follows, the length and the width of the overall antenna is 21.5×29.5mm^2 respectively, shown in Fig. 1(a). The antenna structure is designed on the x-y plane. The perpendicular direction is parallel to z-axis. The substrate used for design is FR-4 epoxy with dielectric constant 4.4, loss tangent 0.025 and the height of the substrate is 1.6 mm. A 50-Ω microstrip line is used as a feed line. To achieve 50Ω impedance, for perfect matching is calculated as earlier reported [5].

The dimensions of the patch, length is 16.2mm, width is 11.3mm. The value of lower cutoff frequency is 3.78 GHz. The size of the rectangular patch is 16.2 × 11.3 mm^2. The length of the ground plane is 5.4mm and there is equal width of the ground and the substrate that is 5.4mm. The impedance bandwidth is 8.02 GHz (3.11 to 11.13 GHz).

The dimensions of the optimized monopole UWB antenna are as follows: Ls= 21.5 mm, Ws= 29.5 mm, Lp= 16 mm, Wp= 11mm, Wf= 2.7 mm, Lf = 6.5 mm, Lg= 5.5 mm, g = 0.5 mm, Wr= 6.2 mm, Wg= 4 mm, d = 1.6 mm, d1 = 4.5mm, d2 = 18.5 mm, h1 = .75 mm, h2 = 4mm, v = 0.25 mm. Then for improving the impedance bandwidth and reducing return loss by introducing a ground plane with the DGS technique.. In order to enhance the impedance bandwidth, there are two rectangular slots cut out from the upper edge of the ground plane. The length of both rectangular slots is 0.20mm. The widths of the rectangular slots are 6.2mm and 4mm as shown in fig. 1(b). The width of the upper rectangular slot is $h_1 + h_2 + h_1$ = 5.5mm where h_1 = 0.75mm, and length is v = 0.25 mm. Similarly, the width of the lower rectangular slot is h_2 = 4mm, and length is same as upper rectangular slot. The two rectangular slots give additional resonance at lower and higher cutoff frequencies. An UWB antenna with ground plane has a big impedance bandwidth as claimed in fig. 3. The simulated results indicate a wider impedance bandwidth of 10.25 GHz.



(a) (b)

Figure 1 : An UWB antenna structure with single pole: (a) Front view (b) Back view

Now for further improvement in the impedance bandwidth and decrease the return loss, the patch and the feed both are taper mode, as shown in fig. 2. There is a square (side= 1mm) part which is cut away from the patch. And two rectangular slots are cut away from both side of the feed line. The dimensions of the rectangular slots are 2mm× 0.25mm and 4mm × 0.25 mm.

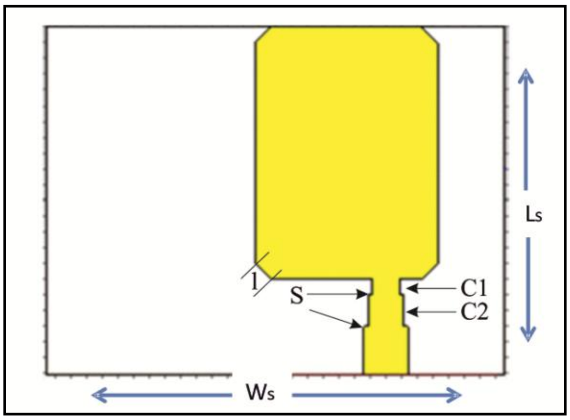


Figure 2: Front view after optimization in the patch and feed line

The dimensions are as follows: Ls= 21 mm, Ws= 29.5 mm, l = 1.41 mm, c1 = 1 mm, c2 = 2 mm, S = 0.25 mm.

3. RESULT AND DISCUSSION

The changes in the reflection coefficient S_{11} to the frequency is shown in Fig. 3 of without DGS structure. For the proposed antenna return loss is -47.82 dB at resonance frequency 8.28 GHz. Impedance bandwidth is also calculated from reflection coefficient v/s frequency plot. The impedance bandwidth of the antenna is nearly 18.93 GHz (3.36 GHz to 22.29 GHz) which is higher than the antenna without any optimization in patch and feed line. The S11vs frequency graph of the proposed structure shows in the fig. 4.

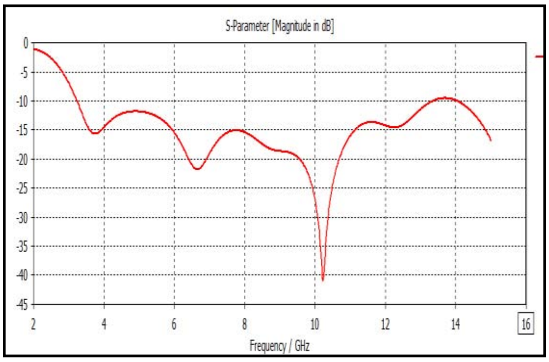


Figure 3: S11 plot of the structure without DGS

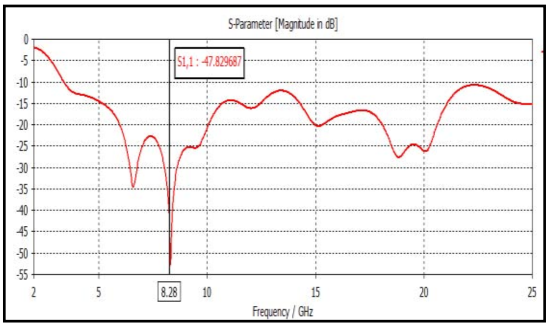


Figure 4: Reflection coefficient Vs frequency of proposed structure

Fig. 5 shows VSWR variations with frequency, VSWR is 1.01 which indicates very good matching between feed arrangement and antenna.

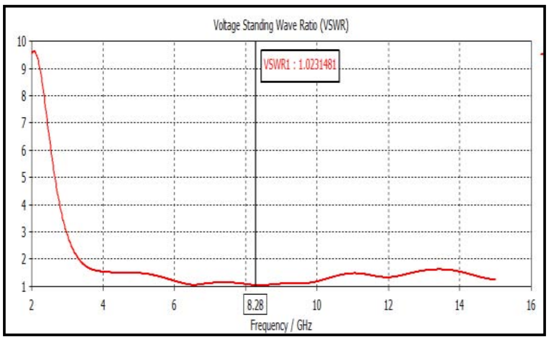


Figure 5: Plot of VSWR of designed antenna

Fig. 6 shows the gain variation with frequency for proposed antenna. The achived gain at the frequency, on which the designed antenna work, is 3.76dBi as shown in the figure. The complete x-band has good gain.

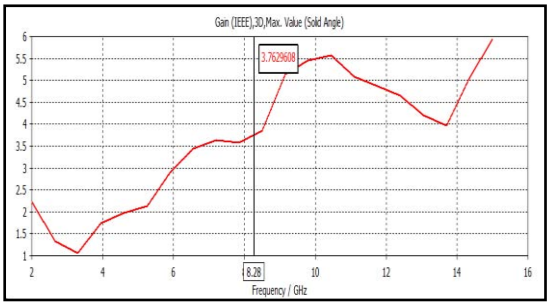


Figure 6: Simulated graph of Gain Vs Frequency

Fig. 7 shows the radiation pattern at the resonant frequency 8.28 GHz. As shown in figure pattern is directive. This radiates in the range of 30° to 150°.

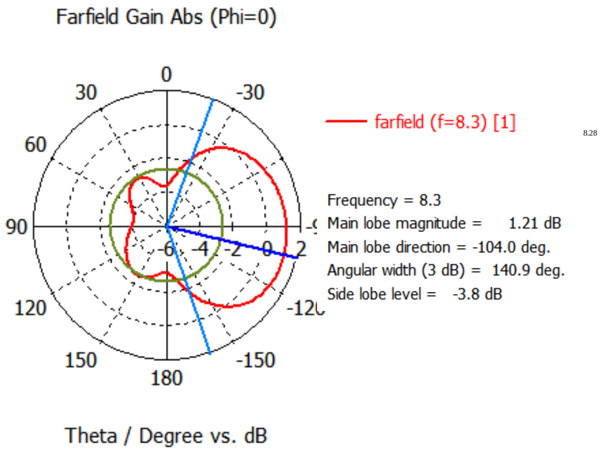


Figure 7: Radiation Pattern

4. CONCLUSION

An UWB antenna compact sized is designed. Due to some modification in the patch and the line of feed, the return loss decreased from -41dB to -47.82dB. The bandwidth is increased by 10.91 GHz. The simulated VSWR, and radiation pattern has been also presented. Due to the high bandwidth and the cut off frequency designed antenna is used for military applications in x-band.

REFERENCES

[1] Federal Communications Commission, Washington, DC, USA, Federal Communications Commission revision of Part 15 of the Commission's rules regarding ultra-wideband transmission system from 3.1 to 10.6 GHz, ET-Docket, (2002), 98-153.

[2] F. Fereidoony, S. Chamaani, and S. A. Mirtaheri, "Systematic design of UWB monopole antenna with stable omnidirectional radiation pattern," IEEE Antennas Wireless Propag. Lett, (2012), 11,752–755.

[3] Dinesh Yadav, Mahesh P. Abegaonkar, Shiban K. Koul, Vivekanand Tiwari, and Deepak Bhatnagar, "A Novel Frequency Reconfigurable Monopole Antenna with Switchable Characteristics between Band-Notched UWB and WLAN Applications", Progress In Electromagnetics Research C, (2017), 77, 145–153.

[4] A. A. Gheethan, and D. E. Anagnostou, "Dual band-reject UWB antenna with sharp rejectionof narrow and closely-spaced bands," IEEE Trans. Antennas Propag., (2012), 60, 2071–2076.

[5] K. C. Gupta, R. Garg, I. J. Bhal, and P. Bhartia, "Microstrip Lines and Slotlines", Artech House, 2nd Edition, (1996), 10–15.