



ANALYSIS OF DEFECTED GROUND STRUCTURE NOTCHED MONOPOLE ANTENNA

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ABSTRACT

A compact defected ground structure curved wideband monopole antenna and notched monopole antenna are designed and presented in this paper. In the basic cured monopole antenna wide band characteristics are obtained and in the case of notched monopole antenna, some frequency bands are cut-off in the wide band operation. The band notched characteristic involved the WLAN operating band. The curved monopole antenna with defected ground structure is operating in a wide bandwidth of 16 GHz. The designed antennas are showing impedance band width more than 140% with VSWR less than 2 in the desired band.

Keywords: notch, wideband, monopole, defected ground structure (DGS), wireless local area network (WLAN).

1. INTRODUCTION

Design and development of microstrip antennas [1] for different applications became the subject to the antenna engineers all over the world. Demand of wideband antennas with omnidirectional radiation patterns are increasing day by day in the communication applications. Over the Wide operating bands, some of the bands can be rejected by using notched antennas. In order to notch certain frequency bands, so many techniques and antennas are available in the literature [2-6]. The conventional methods including cutting a slot on the patch, inserting a slit on the patch, using conductor backed plane, and embedding a tuning stub within a slot on the patch or used by the researchers in so many cases. Moreover band rejection characteristics are generated by using a resonator at the centre of antenna and with a pair of inverted L-shaped slots on the ground plane.

Moreover, many UWB applications require more than one notch-band, necessitating the use of mutually non-interacting band-notch elements. Different multiple (dual, triple, quadruple) band-notched UWB antenna topologies have also been reported in recent literature [7-10]. Use of split-ring resonators (SRRs) and complementary split-ring resonators (CSRRs) to design reconfigurable multiple band-notched UWB antennas have been presented in [11-12].

In this paper a new design is proposed to get wide band characteristics from one antenna and band notched characteristics from another antenna. Comparing with the conventional designs, the proposed models are occupying a small size of 16 x 18 x 1.6 mm. Stable radiation patterns at high frequencies and wide impedance band width are achieved by designing the lower edges of the radiating patch in the form of curved shape. In order to compensate the effect of minimizing the size of antenna on the lowest frequency, the radiating patch is notched by removing square shaped slots at the bottom. The band stop frequency can be controlled by adjusting the dimensions of the filter structure at the lower side of the patch. A finite

element method based EM tool, HFSS is used to simulate and optimize the models.

2. ANTENNA DIMENSIONAL CHARACTERISTICS

The geometry of the proposed models is shown in Figure-1. Figure-1(a) shows the curved monopole antenna operating in the wide band and Figure-1(b) shows notched monopole antenna to reject the WLAN band. The width of the microstrip feed line is kept constant to achieve 50 ohm impedance in both the cases. A dielectric material of FR4 with dielectric constant 4.4 and loss tangent 0.02 is used in the design of the models. The lower edge of the patch is taken in the form of ark shaped step to generate additional resonances with improved impedance bandwidth. The notched band is generated with the vertical strip connected to the rectangular ring embedded in the slot that is rotated under the feeding line at the centre of the ground plane.

The notch frequency can be controlled by varying the dimensions of the L1 and W1. The design equations are constructed based on the resonant frequency and dielectric material permittivity. f_n is the centre rejected frequency and it can be calculated from the following equations.

$$f_n \approx \frac{c}{4L_n \sqrt{\epsilon_{eff}}} \quad (1)$$

$$L_n = L_1 + W_1 \approx \frac{\lambda_g}{4} \quad (2)$$

$$\epsilon_{eff} \approx \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2 \sqrt{1 + \frac{12h}{W_f}}} \quad (3)$$

The design values of the notched band antenna parameters are $W_s=16$ mm, $L_s=18$ mm, width of the feed line =1.9 mm, length of the feed line = 6 mm, defected ground structure width $W_1=3.4$ mm, $L_1=3.8$ mm, $W_2=0.4$ mm and $L_2=2$ mm. Figure-1 shows the geometry of the



notch band antenna with slotted defected ground structure. Figure-2 shows the notch band antenna with the defected ground structure i.e. planar quarter ground plane on the bottom side. Figure-3 shows the wide band antenna without notch and DGS on the bottom side.

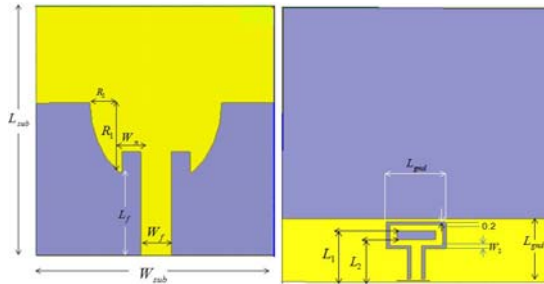


Figure-1. Notch Band Antenna with slotted defected ground structure, (a) Top view, (b) Bottom view.

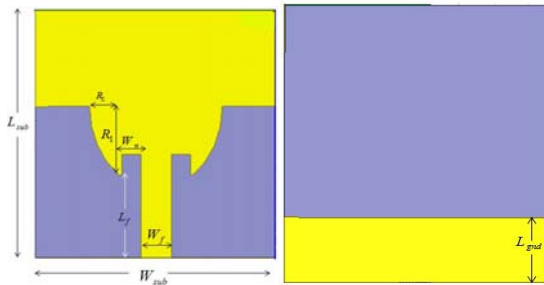


Figure-2. Wide Band Antenna with defected ground structure, (a) Top view, (b) Bottom view.

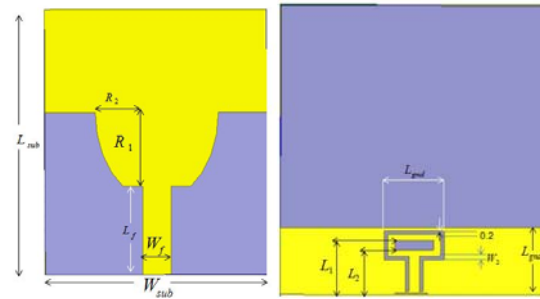


Figure-3. Wideband Antenna with slotted defected ground structure, (a) Top view, (b) Bottom view.

3. RESULTS AND ANALYSIS

Figure-4 shows the return loss curve for the proposed three models. Notch band with slotted DGS is resonating between 3.4 to 12 GHz with notch band characteristics at 6.5 - 7.5 GHz. Wide band with DGS is resonating between 4 GHz to 11 GHz with bandwidth of 7 GHz. Wide band antenna with slotted DGS is operating between 4 to 20 GHz with bandwidth of 16 GHz.

Figure-5 shows the radiation pattern for notch band antenna with slotted DGS in E and H plane. An omnidirectional radiation pattern with cross polarization less than -35 dB can be observed from the H plane.

Figure-6 shows the radiation pattern of wide band antenna with DGS in E and H plane. Same kinds of results are achieved in this case with low cross polarization compared to notch band antenna with DGS. Figure-7

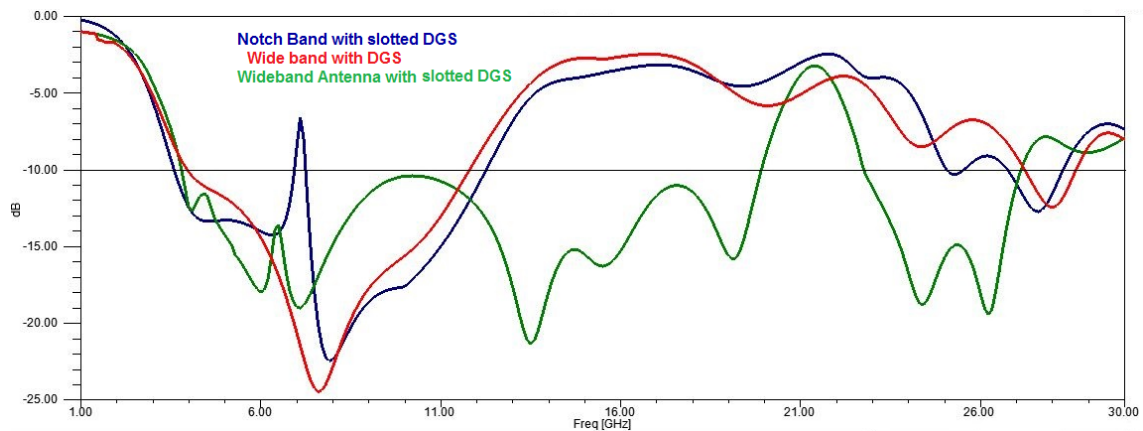


Figure-4. Return loss Vs Frequency.

Figure-6 shows the radiation pattern of wide band antenna with DGS in E and H plane. Same kinds of results

are achieved in this case with low cross polarization compared to notch band antenna with DGS. Figure-7



shows the quasi omni directional pattern in H plane for wide band antenna with slotted DGS. In the E plane

nulling is observed at 70 degrees and 300 degrees.

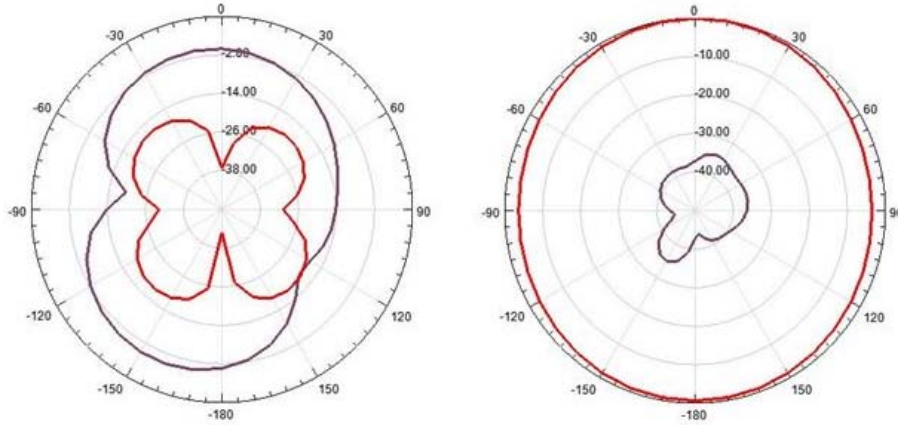


Figure-5. Radiation pattern in H and E-plane for Notch Band Antenna with slotted DGS.

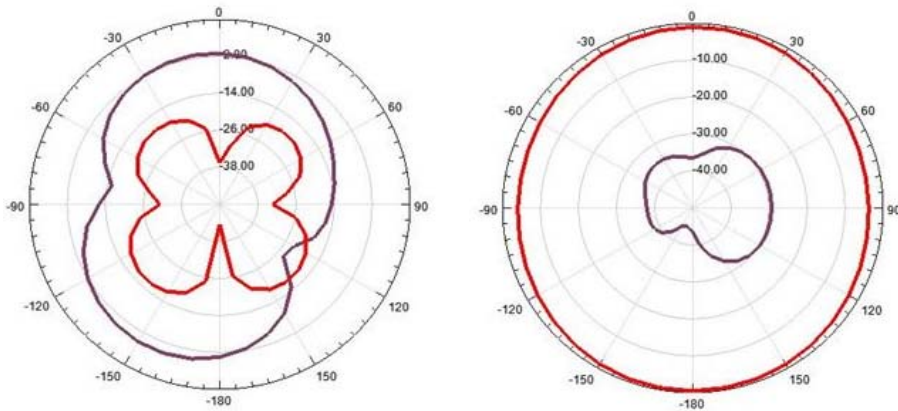


Figure-6. Radiation pattern in H and E-plane for Wide Band Antenna with DGS.

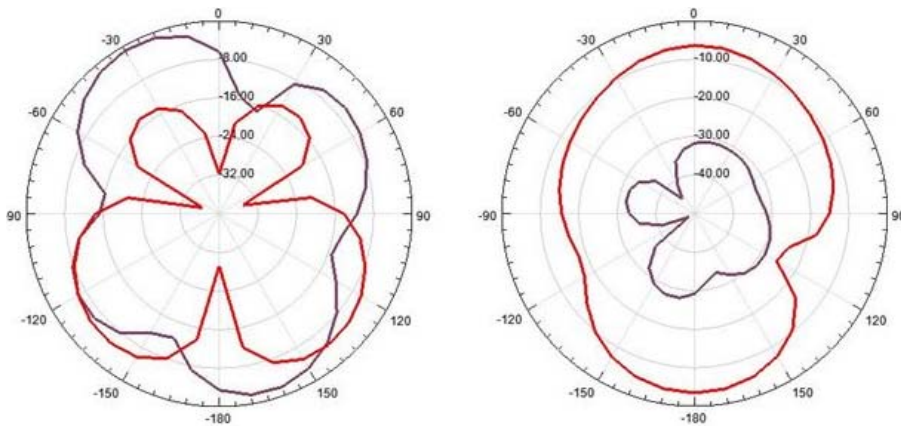


Figure-7. Radiation pattern in H and E-plane for Wide Band Antenna with slotted DGS.



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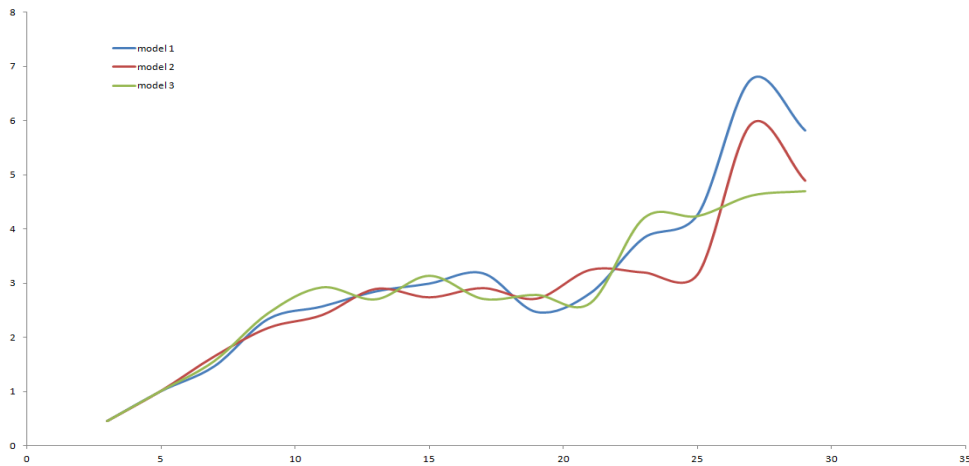


Figure-8. Frequency Vs Directivity of three models.

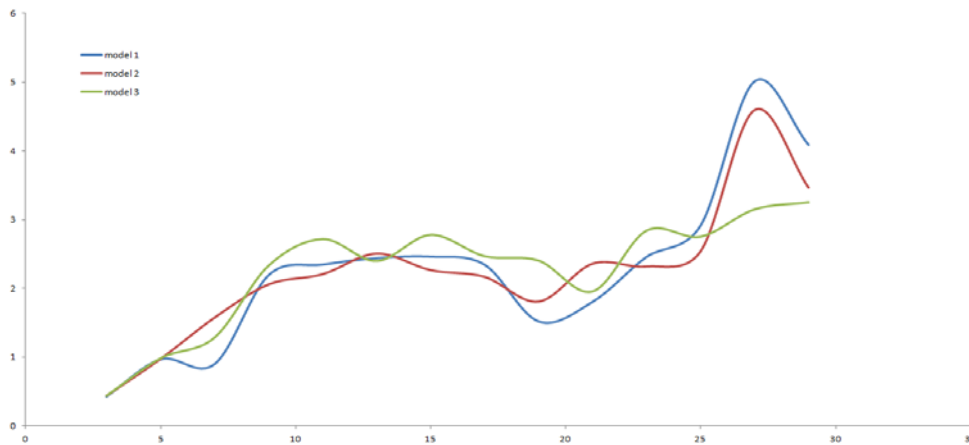


Figure-9. Frequency Vs Gain of three models.

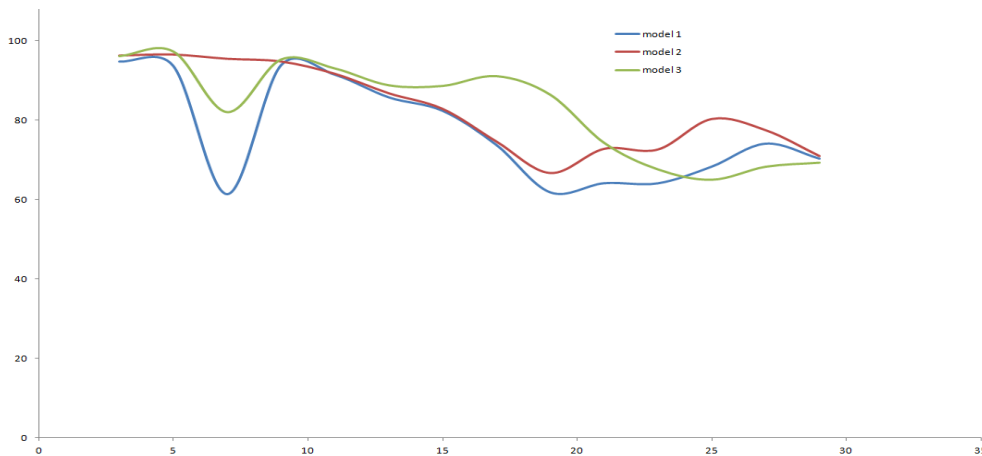


Figure-10. Frequency Vs Efficiency of three models.

The directivity of the wide band antenna with DGS at lower frequency band is somewhat better compared to the other models. The notch band with slotted DGS is giving better directivity at higher frequency band

compared to other models. The average gain obtained from model 1 is 3 dB, model 2 is 2.8 dB and model 3 is 2.5 dB. The efficiency of model 1 is less than 70% at



notch band and for wide band models it is above 80% in the operating frequency range.

Figure-11 shows the impedance matching and current distribution of the model 1. It is found that by creating a step on the lower edges of the patch, the impedance bandwidth is improved especially at the higher frequencies. This occurred because the step affects the electromagnetic coupling the patch and the ground plane. Because of the existence of the discontinuity on the patch and more flexibility of the surface current path compared to the simple antenna, the higher resonant mode of the antenna can be excited. As a result, a additional resonant frequency appears that is tuneable by adjusting the parameters of the step.

Figure-12 shows the current distribution of wide band antenna with DGS. Figure-13 and Figure-14 are showing the current distribution of wide band antenna with slotted DGS at 7.1 and 13.5 GHz respectively. At lower frequency the current distribution is maximum at feed line and on the lower side of the radiating element. At higher frequency the current distribution is all over the surface of the radiating element including feed line.

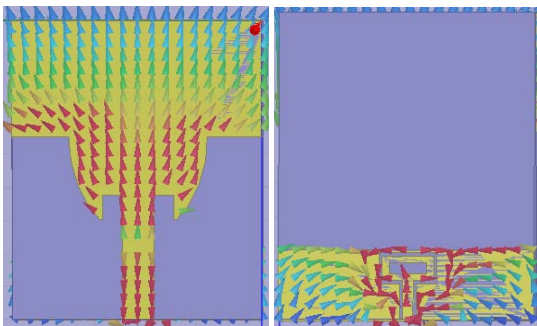


Figure-11. Current distribution of Notch Band Antenna with slotted DGS.

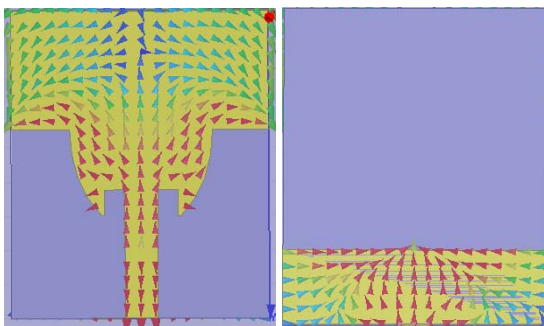


Figure-12. Current distribution of Wide Band Antenna with DGS.

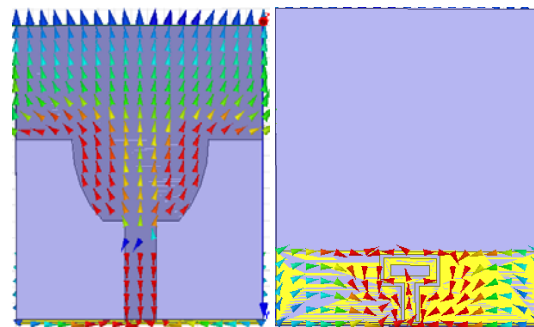


Figure-13. Wide Band antenna with slotted DGS at 7.1 GHz.

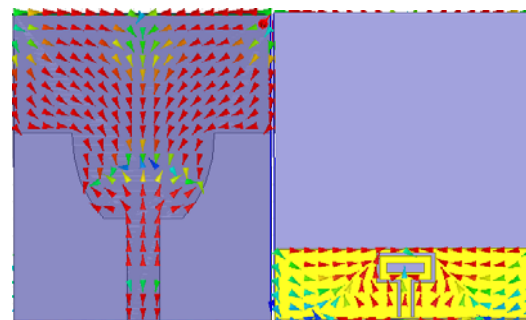


Figure-14. Wide Band antenna with slotted DGS at 13.5 GHz.

CONCLUSIONS

In this paper, we designed three antennas with notch band character on one model and wide band characteristics in other two models. Model 1 is giving a band width of 8 GHz with notch band of 1 GHz at 6.5 - 7.5 GHz. Model 2 is providing the bandwidth of 7 GHz and model 3 is providing the huge bandwidth 16 GHz. Peak Directivity of 7 dB from model 1, 6 dB from model 2 and 5 dB from model 3 is attained. Peak gain of 5 dB, 4.5 dB and 3 dB is attained for model 1 to model 3. Efficiency more than 80% achieved for wide band antennas whereas efficiency less than 70% from model 1 at lower frequency band. The proposed models can be used for ultra wideband and Ku band communication systems.

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