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### Circular Stub Loaded Defected Ground Monopole Antenna for Ultrawideband Applications

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**Abstract:** Monopole antenna with partial ground is designed to operate in the UWB band. A small rectangular slot is made on the partial ground structure to enhance the return loss performance. The antenna consists of circular patch and three stubs are placed on the patch. The antenna fabricated on the substrate Rogers duroid 5880 with dielectric constant 2.2. The antenna design cover the frequency range of 2.7-12.8GHz with bandwidth of 9.9GHz. The realized gain of the antenna is 5.5dB at 3.5GHz and 3.2dB at 5.5GHz. The proposed antenna provides the better radiation patterns and impedance in the operating band.

**Keywords:** Defected ground structure, Circular stub, Rectangular slot, Ultra wide band

#### 1. INTRODUCTION

In every wireless systems design antenna plays a vital role. Recent wireless technologies like WiMAX, Wi-fi needs wide bandwidth and compact structure antennas. To meet the requirements microstrip antennas are suitable because they provide wide bandwidth and compact in nature. Naturally microstrip antennas suffers with narrow bandwidth to overcome the problem numerous technologies are used for bandwidth improvement. The antenna designed to meet the ultra-wide band (UWB) applications [1-3]. Rogers duroid 5880 material with dielectric constant 2.2 is used as the substrate. If the dielectric permittivity is  $\epsilon_r$  greater than 1 there exists surface waves. The cause's surface waves and mutual coupling effect which degrade the performance of the antenna. To overcome the drawback defected ground structure [7, 8] is used.

Recently microstrip UWB antennas have capture great attention because of its advantages like high data rate, low profile, low cost and easy fabrication [4]. The convectional antennas like wire, reflectors, slot and horn antennas suffers with poor cross polarization, low power handling capability and narrow bandwidth. As the microstrip patch antennas are low profile they can be easily mounted on the missiles and rockets which is main problem with convectional antennas. Ultra wide band (UWB) uses narrow pluses which are in nanoseconds or

less for transmission of data. UWB provides high bandwidth which is in the range of 3.1GHz to 10.6GHz. the UWB antenna having high demand for various applications like medical imaging, radars.

DGS (Defected ground structure) [10-12] is a technique which is etched on the ground plane for improvement of antenna parameters. In this method periodic or non-periodic defect is etched on the ground plane the defect may circular, triangular, square or dumbbell shape it will disturb the current distribution on the ground plane of patch antenna. In the proposed antenna small rectangular shape defect has been created for which the return loss of the antenna is improved. DGS is induced in the ground plane for many applications like cross polarization, size reduction of antennas, harmonic suppression and mutual coupling reduction in antenna arrays.

In previous work the authors reported on design of ultra wide band microstrip antennas which has the circular patch and stepped blocks placed on the patch. This wing like stubs are placed on the either side of the patch. By varying the length of the stub the reactance is realized which increase the capacitance of the stub and decreases the input impedance.

## 2. DESIGN CONSIDERATIONS

The proposed antenna which is shown in Figure 1. The antenna placed on the dielectric substrate. The antenna consists of circular patch with three stubs placed at sides of the circle. The circle patch is feed by microstrip line feeding. The dimensions of the substrate has length  $L_s=44\text{mm}$  and width  $W_s=23\text{mm}$ . It has a stepped feed line  $L_f=10.88\text{mm}$  and feed line width is  $W_f=2.48\text{mm}$ . The radiating patch having a radius of  $R$ .

The three stubs are placed on the circular patch and the length of the first stub is  $L_{p1}=21\text{mm}$  and second stubs length is  $L_{p2}=19\text{mm}$  and the third stub is  $L_{p3}=17\text{mm}$  and all the stubs having the same width which is  $W_b=1.8\text{mm}$  and the spacing between the stubs is  $0.5\text{mm}$ . The additions of stubs in the patch will diverge the radiation pattern at high frequency band. The stubs [9] also allow the return losses below  $-15\text{dB}$ . The length of the conducting ground  $L_g=16\text{mm}$  with partial ground is taken. Table 1 gives the dimensions of the antenna [5, 6].

The basic antenna design is started with the full ground structure for which the antenna doesn't provide considerable return loss. So it is modified with the partial ground structure in this structure it provides dual band nature. The main aim of this antenna is to work in ultra-wide band so antenna is modified with a rectangular slot on the partial ground plane. By the changes the antenna gets the better return loss compared to partial ground structure.

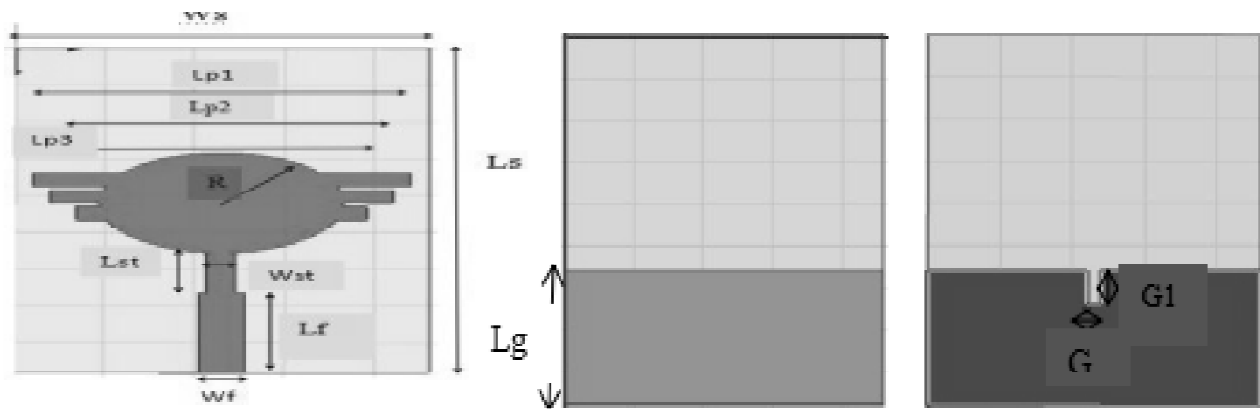


Figure 1: Designed antenna with partial ground structures

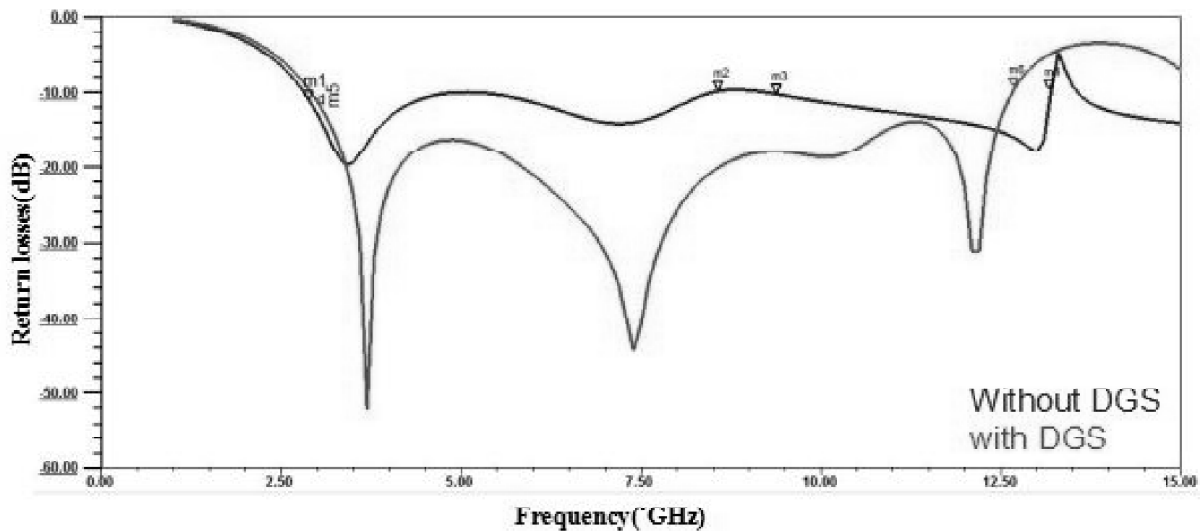
**Table 1**  
**Dimensions of antennas**

<i>parameter</i>	<i>Dimensions (mm)</i>	<i>parameter</i>	<i>Dimensions (mm)</i>
Ls	44	Lf	10.88
Ws	23	Wf	2.48
Lp1	21	Lg	16
Lp2	19	G1	4
Lp3	17	G2	1
Lst	5.4	h	0.78
Wst	1.6		

### 3. RESULTS AND DISCUSSIONS

#### (A) Return Losses

The prototype of proposed antenna with correct dimensions which are listed on the Table 1. Figure 2 which is constructed from the designed antenna results. The designed antenna provides the dual band nature covering the frequencies range of 2.7-8.4GHz and 9.2-13.1GHz. The antenna has a small notch band at 8.5-9.2GHz. The band width at first band is 5.7GHz and at second band is 3.9GHz. The antenna is resonating at three frequencies and has the return losses at 3.75GHz is -52.7dB, at 7.4GHz the return losses of -44.4 and at 12.2GHz it shows -31dB return losses and the band width coverage of antenna compared with antenna shows good return losses with bandwidth range of 2.8-12.7GHz.



**Figure 2: Return losses of antenna**

#### (B) Vswr

VSWR is derived from the reflected and incident waves. It also indicates how efficiently the input impedance is matched with the characteristic impedance of transmission line. The proposed antenna provides VSWR from 2.8-12.6GHz which is less than 2. At some frequencies like 3.7, 7.5, and 12.5GHz the VSWR curve touches the VSWR = 1 line. This resembles antenna provides the perfect impedance matching and reflected power will be minimum.

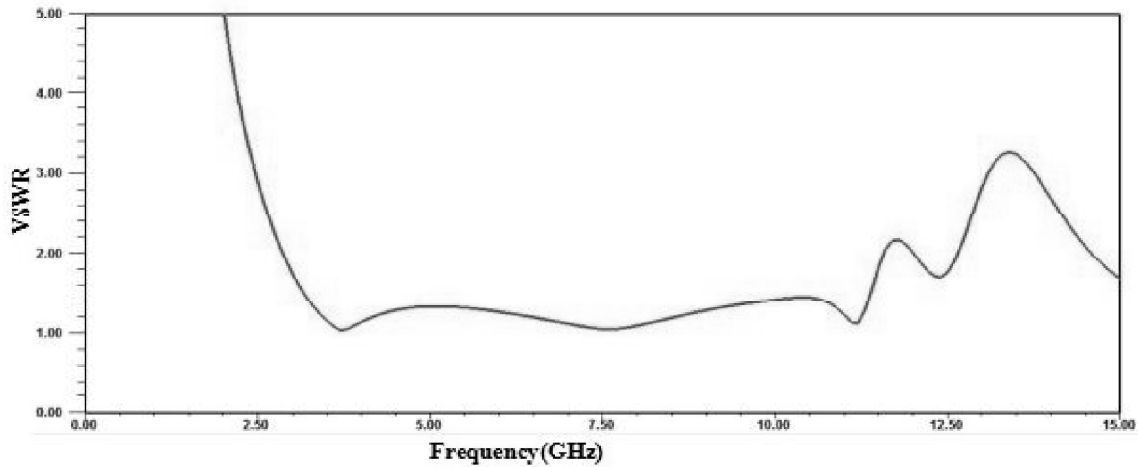


Figure 3: VSWR of proposed antenna

### (C) Radiation Patterns

Radiation pattern describes how the antenna radiates the energy in particular direction. The radiation pattern of the proposed antenna at two different frequencies are shown. The simulated Figure 4 illustrates the E-plane and H-plane radiation patterns. The radiation pattern describes the directional behavior of antenna with main lobe direction. At 3.5GHz most of the E-plane is distributed and provide dipole like radiation pattern

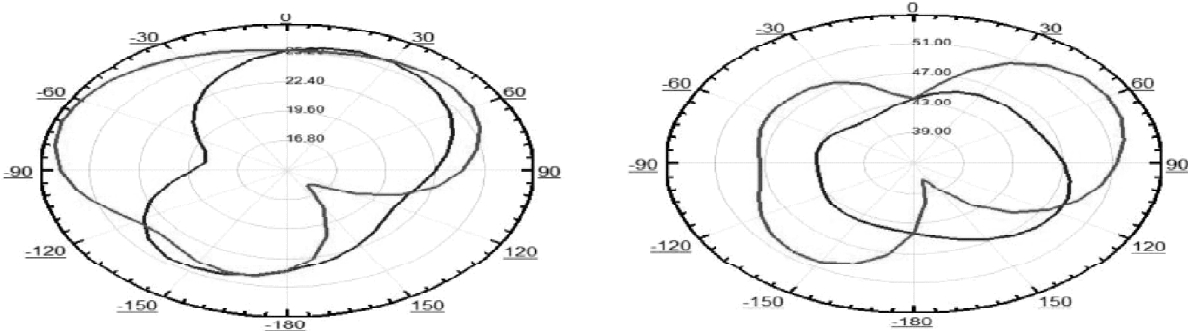


Figure 4: Radiation pattern at (i)3.5GHz (ii)5.5GHz

### (D) E-Field Distribution

The E-field distribution is shown in the Figure 5 at different frequencies like 3.5GHz and 5.5GHz. At 3.5GHz the maximum E-field distribution is present in the feed line and the side corners of the circular patch and stub

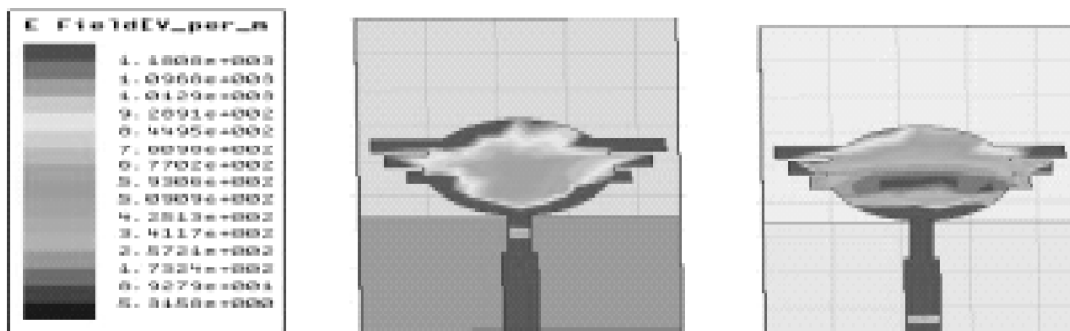


Figure 5: E-field distribution at (i) 3.5GHz (ii)5.5GHz

edges. At 5.5GHz field distribution is along the feed line and lower edge of radiating patch and the feeding. The red color on the patch shows the maximum field is distributed in particular position.

**(E) Gain**

The 3D polar plot for gain ids shown in the Figure.6 at different frequencies.It is observed that the antenna gain at 3.5GHz is 5.5dB and at 5.5GHz it is 3.2dB. At the 5.5GHz the gain is distributed in Omni directional pattern. If the antenna gain is above the 5dB is good antenna.

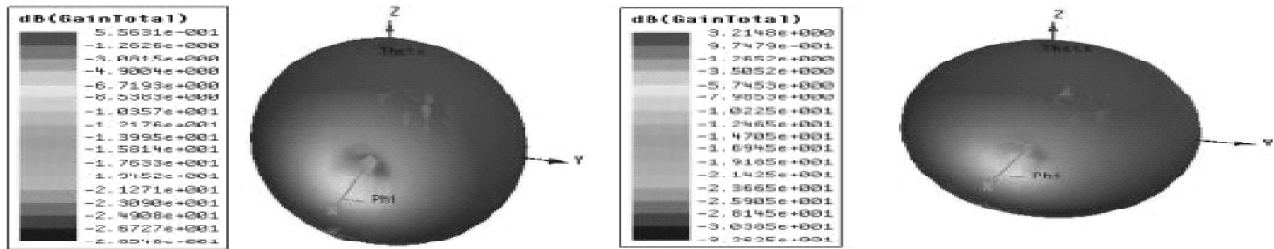


Figure 6: Gain of antenna at (i)3.5GHz (ii) 5.5GHz

**(F) J-Surface Current**

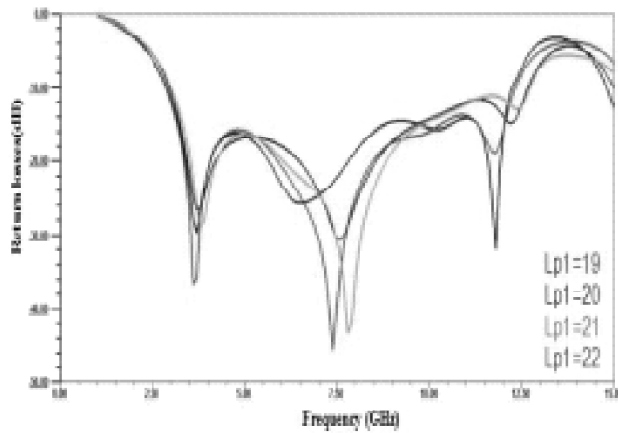
Figure 7 shows the surface current distribution at resonant frequencies. It gives the information about the polarization of the antenna. From the below figure the current is distributed along the radiating patch. Most of the surface current is distributed along the edge of the feeding point the red color arrow on the patch shows the maximum surface current is distributed along the patch of microstrip antenna.



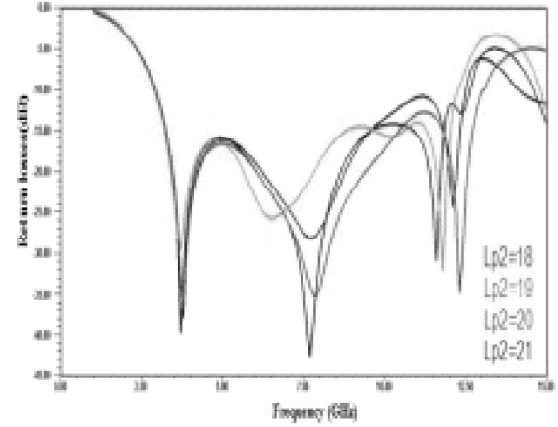
Figure 7: Surface current at (i)3.5GHz (ii) 5.5GHz

**(G) Parametric Analysis**

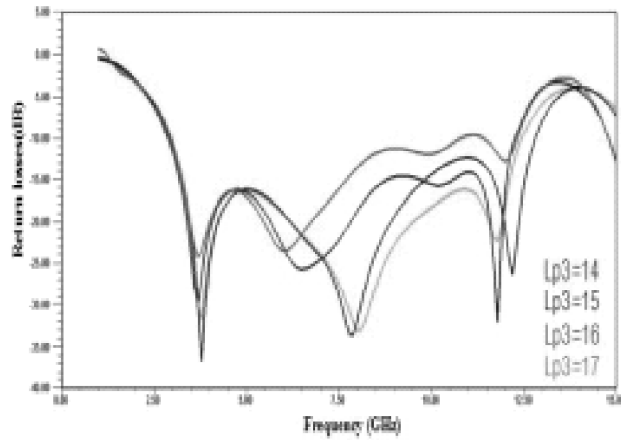
For doing the parametric analysis the length of the stub is varied at the stub1 is varied from  $Lp1=19-22\text{mm}$ , second the stub2  $Lp2=18-21\text{mm}$  is varied and stub3 is varied  $Lp3=14-17\text{mm}$  depending on the best return losses the best value is selected for doing the analysis similarly the radius of the circle is varied for  $R=6.18-7.08\text{mm}$ . when the parameter of first stub  $Lp1$  is varied the return loss curve of  $Lp1=19$  touches the  $-45\text{dB}$  and provides the better return loss compared to  $Lp1$  value is varied from 20,21 and 22. Similarly the second stub length is varied we see the for the  $Lp2=20$  the better return losses is observed. If the third stub is varied we observe the better return losses for the  $Lp3=17$  when compared to other curves. At last the radius of the circle is varied for the values  $R=6.18, 7.08$  we see the return loss curves doesn't provide the return losses which are above  $-10\text{dB}$  line but for the values of 6.48,6.78 it shoes the good return losses which are below the  $-10\text{dB}$ .



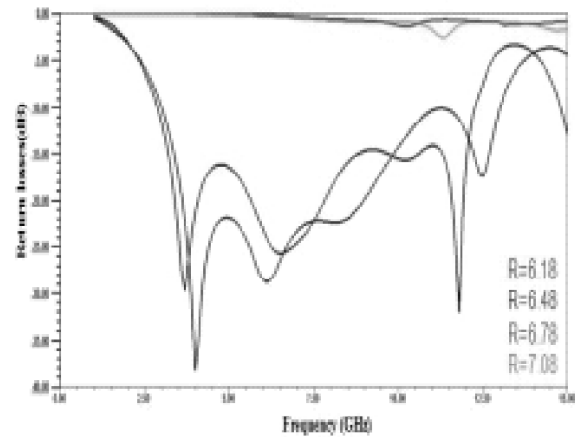
(a) Stub Lp1 varied from 19-22



(b) Stub Lp2 varied from 18-21.



(c) Stub Lp3 varied from 14-17



(d) Circle radius varied from R=6.18-7.08

Figure 8: Parametric analysis of antenna

### (H) Prototype Model and Measured Results

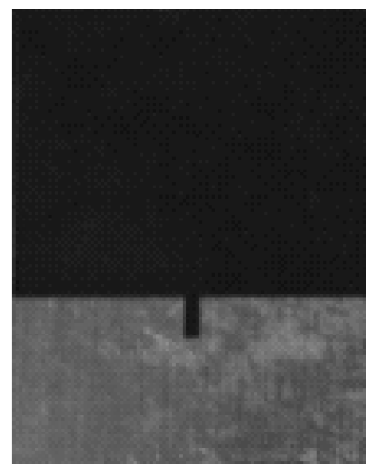
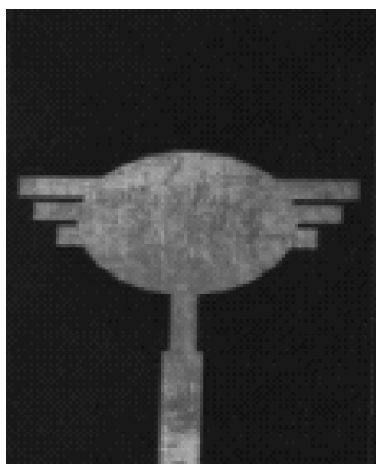


Figure 9: Fabricated model

The prototype of the antenna has been fabricated and shown in the figure 9. From the reflection curve bandwidth is measured from vector network analyzer. The similar results are observed between the measured and simulated results. With the defected ground structure the measured values are 1.7 GHz -14.5GHz and the simulated results are 3GHz-12.5GHz.for the observed results the measured antenna shoes the better performance than the simulated results.

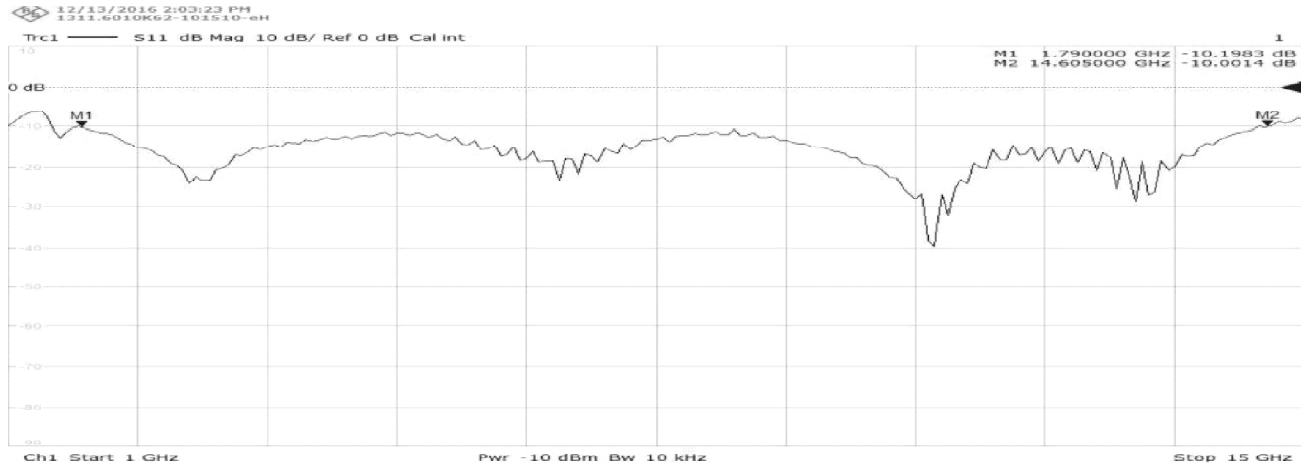


Figure 10: Measured return losses

#### 4. CONCLUSION

Ultra wide band (UWB) antenna with partial ground structure is presented. The open end stubs placed on the patch gives the good radiation patterns entire UWB range. By varying the key parameters of antenna performance is studied. The proposed antenna provides the bandwidth ranging from 2.7-12.8GHz which cover the frequency of ultra wide band. The antenna has various advantages such as small in size and high gain. The characteristics of the antenna are very attractive for wireless communication.

#### ACKNOWLEDGMENTS

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