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Research Article

Investigation on Rectangular Ring DGS for Multi Band Wireless Applications

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A B S T R A C T

The performance of the antenna for multiple resonant frequencies plays a very important role in communication technology. So that only one antenna can be used in the system for all applications. In this paper, an antenna is designed and investigated for multiple resonance frequencies. Hence, DGS has been created, because Defected Ground Structures (DGS) have an inherent resonant property and its equivalent circuit can be considered as a parallel combination of capacitor and inductor. So by altering the shape of DGS internally the capacitance and inductance are altered and hence the resonance occurs. The present antenna is designed on FR4 epoxy substrate with loss tangent ‘δ’ = 0.02 and the thickness h=1.6mm. The substrate dimensions are 20mm X 30mm X 1.8mm. Finally, the designed antenna is simulated on HFSS and studied the results.

Keywords: Defected Ground Structure (DGS), Multiple Resonances, Rectangular Ring, Current Distribution, Percentage Bandwidth

Introduction

In recent years expertise is changing drastically because new methodologies, new techniques and innovations are coming in use. So we need to select and design the candidate which can satisfy all needs for the requirement of integrated microwave devices and wireless communication systems. One of the antennas which are satisfying that type of requirement is the UWB antenna, where FCC has identified the bandwidth allotted is 3.1GHz to 10.6GHz with a bandwidth of 7.5GHz. Along with that super wideband antennas and Defected ground structure concepts included in the design of the UWB antenna leads to the selection of multiple frequency oriented appliances in a super wide band.

DGS is in huge demand when compared with Photonic Band Gap (PBG), Energy Band Gap (EBG), because of simple parameter extraction and compact than PBG and EBG and also easy in fabrication.[1] There are different shapes of DGS in literature like dumbbell-shaped, U-Slot, V-Slot, Cross DGS, Fractal DGS, spiral DGS and so on.[2-5]

Antenna Design

The basic antenna is designed w.r.t the equations as mentioned.[6-10] Then we can get the values for W-Width of the patch, Ɛreff- Effective refractive index, L-Length of the patch, Length (Lg) and width (Wg) of the ground plane, feed point location (X_f, Y_f).

Once the antenna is designed then need to start designing the expected DGS structure with the following flow chart analysis.

Once the antenna is designed at frequency 5.5GHz and inserting the notches without inserting DGS the antenna seems to look like in Figure 2 (a). And inserting of notches will upshift few frequencies and the response is not satisfactory for multiband applications.

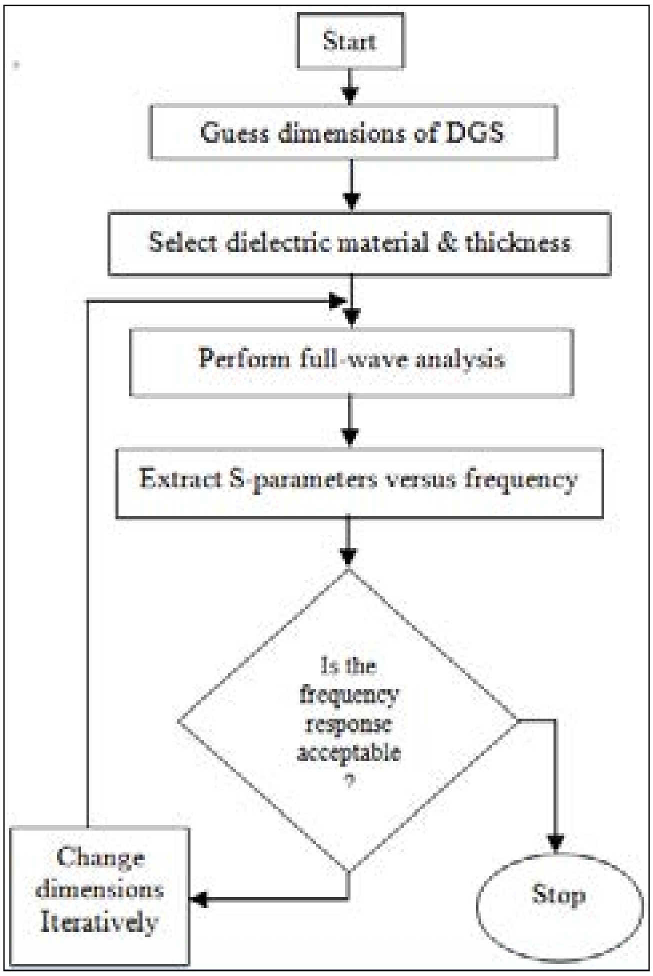


Figure 1

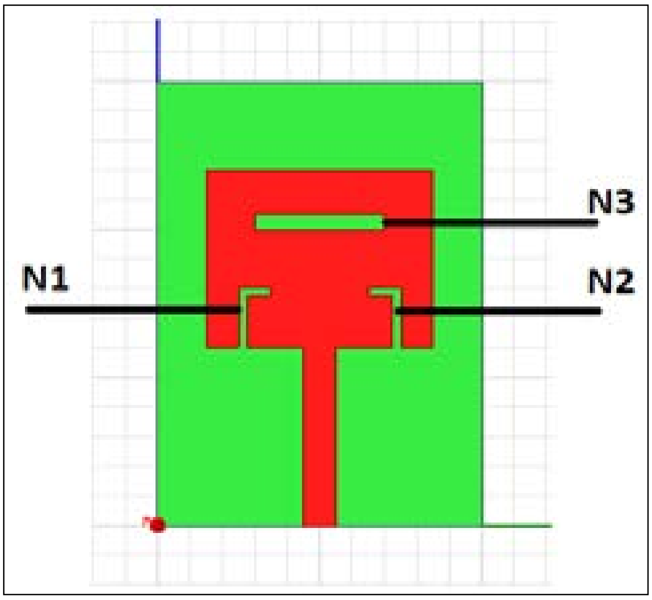


Figure 2(a).Antenna with Notches

Table 1.Antenna Parameters

S.No.	Parameter	Values in mm
1.	Patch width	14
2.	Patch length	12
3.	Feed line (width and Length	(2,12)
4.	Ground layer width	20
5.	Ground layer length	30
Notch measurements (N1 and N2)		
6.	Slot-1	(0.5,4)
7.	Slot-2	(2,0.5)
Notch measurements (N3)		
8.	Slot-1	(8,1)

The S11 parameters for the listed values show that the antenna is not perfectly tuned for any application as shown in Figure 2 (b).

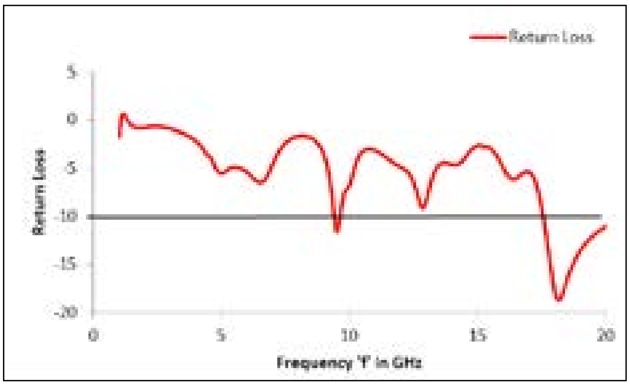


Figure 2(b).Return Loss

Inserting DGS

The rectangular ring-shaped DGS are inserted on the ground planed as shown in Figure 3 (a).

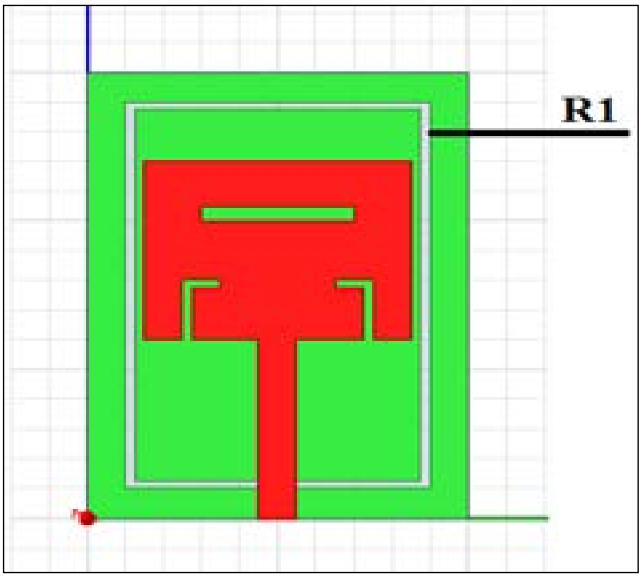


Figure 3(a).Rectangular Ring DGS

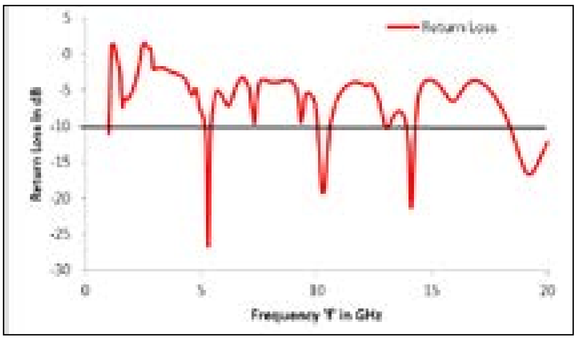


Figure 3(b).Return Loss for Single Rectangular Ringdgs

By observing the result w.r.t the above Figure the antenna is responding at three distinct frequency off of which the first frequency is the designed patch width and length frequency. Now by inserting more rectangular DGS rings as shown in the below diagram we get more responses for different frequencies.

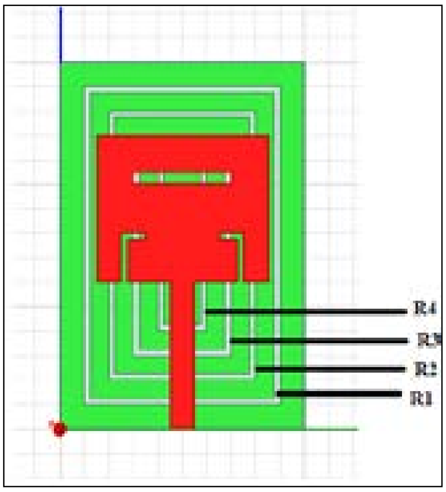


Figure 4(a).Patch with Ground Plane DGS (R1, R2, R3, R4)

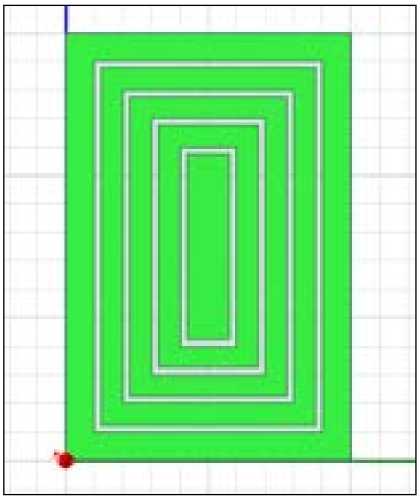


Figure 4(b).Patch with Ground Plane DGS (R1, R2, R3, R4)

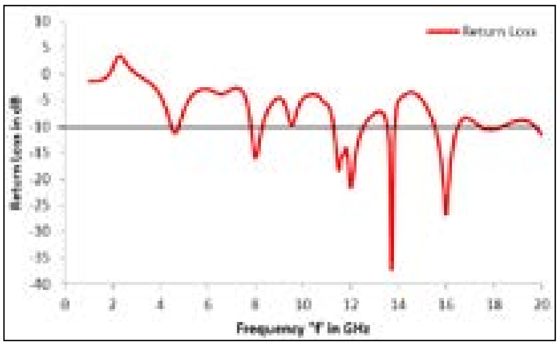


Figure 4(c).Return Loss with DGS (R1, R2, R3, R4)

From the above response, the antenna is resonating at six multiple frequencies at f1=4.62GHz, f2=7.96GHz, f3=11.50GHz, f4=11.97GHz, f5=13.69GHz, f6=15.98GHz. The VSWR for the above frequencies is shown in the below diagram.

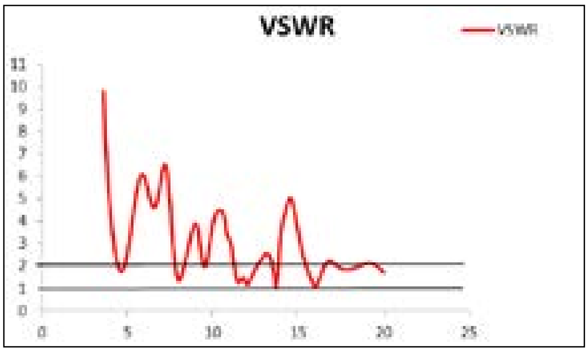


Figure 4(d).VSWR with DGS (R1, R2, R3, R4)

From the above figure, we can observe that at f1,f2,f3,f4,f5,f6 the VSWR are 1.75, 1.38, 1.27,1.18, 1.02, 1.09 respectively.

If the inner ring dimensions increase by 0.5mm then the return loss alters also the curve slightly tunes to higher frequency .

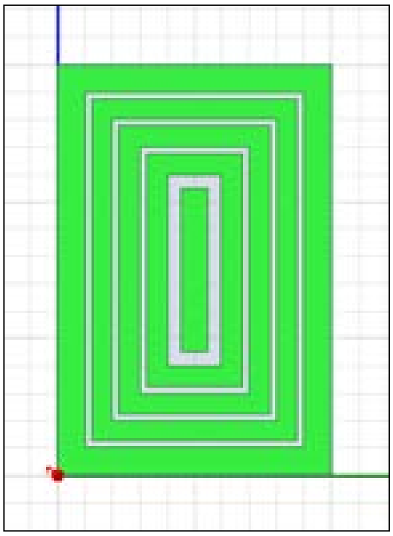


Figure 5(a).Ground Plane DGS (R4 increased to 1 mm)

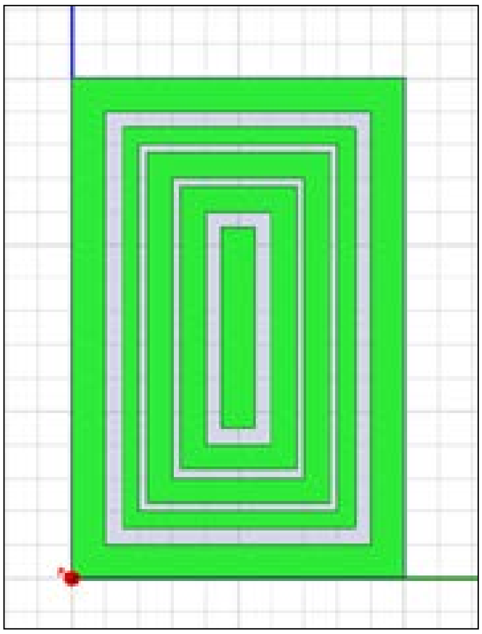


Figure 5(b).Ground plane DGS (R1 and R4 increased to 1 mm)

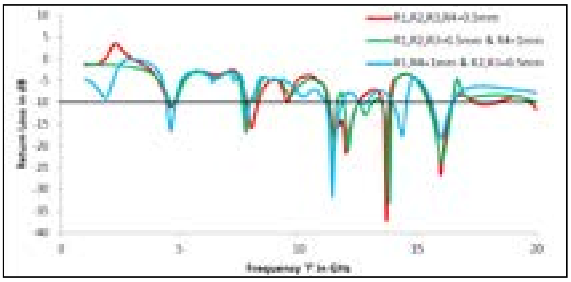
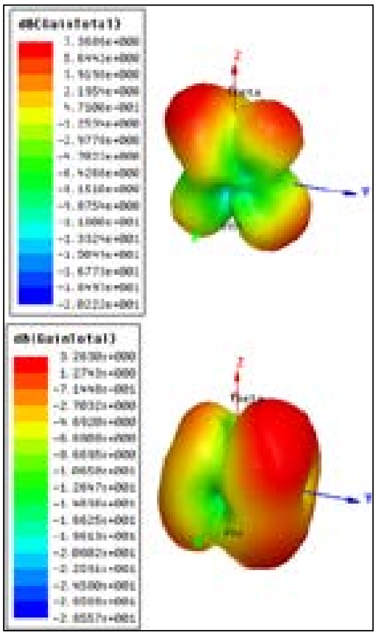
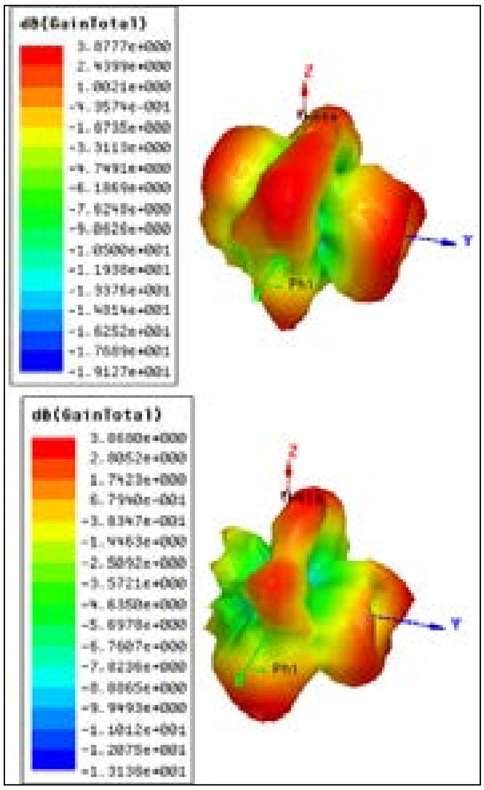


Figure 5(c).Return Loss R1 and R4 at 1mm and R2 and R3 at 0.5mm)

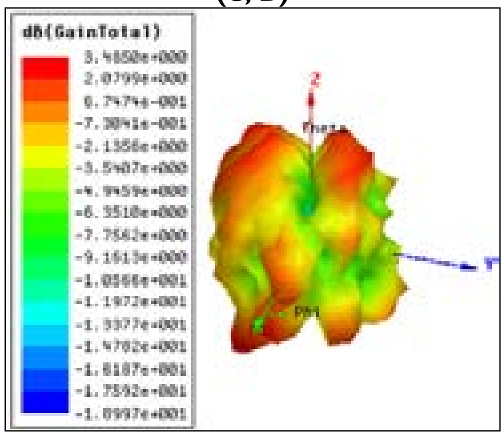
Experimental Result



(A, B)



(C, D)



(E)

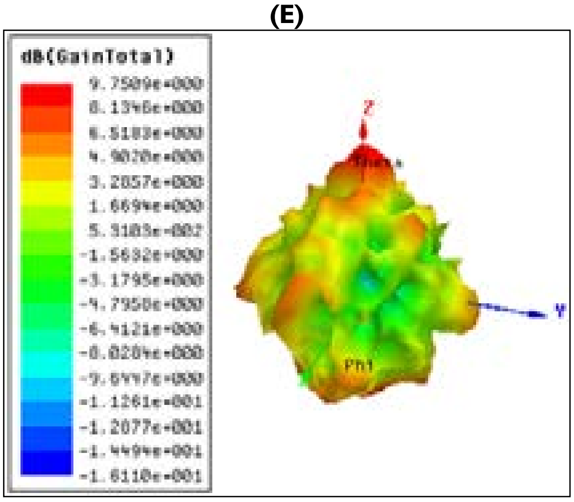


Figure 6.3D Gain at A, B, C, D, E

Table 2.Result Analysis

S.No.	Freq 'f' GHz	Return Loss (dB)	VSWR	Gain (dB)
1.	4.62	-11.23	1.75	7.36
2.	7.96	-15.83	1.38	3.26
3.	11.50	-18.34	1.27	3.87
4.	11.97	-21.50	1.18	3.86
5.	13.69	-37.21	1.02	3.48
6.	15.98	-26.72	1.09	9.75

Table 3.Percentage Bandwidth

S.No.	Freq 'f' GHz	BW	Fractional BW
1	4.62	290 MHz	6.27%
2	7.96	480 MHz	6.03%
3	11.50	420 MHz	3.65%
4	11.97	460MHz	3.84%
5	13.69	320MHz	2.33%
6	15.98	980MHz	6.13%

Conclusion

The antenna is simulated in HFSS on the FR4 substrate and achieved six multiple resonances for multiple wireless applications. Also observed that altering the shape of DGS will alter the capacitance and inductance of DGS there by changes the current distribution and resonates at peak current. The larger the DGS dimension then the inductance will increase so the resonant frequency moves towards the lower values. And smaller the DGS dimension then capacitance will lead to move the resonance towards higher frequencies. As per the resonated frequencies, this antenna can be used in C-band satellite microwave relay, X-band RADAR applications, Ku-band satellite TV and Police RADAR applications. A single antenna used for multiple applications and in future can increase the gain of the antenna furthermore by applying new techniques further.

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