

# Patch Loaded DRA for Broadband WLAN Applications

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## ABSTRACT

A wideband patch loaded dielectric resonator antenna (DRA) is discussed here. The rectangular ring shaped slot coupling is used to excite the proposed antenna. In this paper, rectangular ring shaped slot coupled DRA and patch loaded DRA is studied and compared. The combined effect of patch radiator with rectangular ring shaped slot coupled DRA, on the return loss is observed. Simulation is done using Ansoft HFSS which is based on finite element method. Simple DRA resonates at two frequencies centered at 2.25 GHz having return loss of -14.41 db and 4.61GHz with a return loss of -19.29db; The patch loaded DRA shows resonance at frequencies centered around 2.19GHz having return loss of -32.3db and 4.4GHz with a return loss of -29.18db. The patch loaded DRA is based on the multi resonance technique that combines the resonance of slot coupled dielectric resonator and micro strip patch antenna. The bandwidth achieved for simple DRA is 26.8 % while patch loaded DRA offers 44.1 %. As the patch loaded DRA has larger bandwidth, may be used for wideband WLAN applications like WiFi, Bluetooth, Wimax etc.

## General Terms

Broadband, WLAN, antenna

## Keywords

Bandwidth, DRA, Multi-resonance, patch, slot coupling.

## 1. INTRODUCTION

Over the past few years' researchers were focusing on investigations of dielectric-resonator antenna (DRA) technology as an alternative to traditional antennas due to its high radiation efficiency, lightweight, small size, low profile and low dissipation loss [19-22].

DRA is a resonant antenna, fabricated from low-loss dielectric material, the resonant frequency of which is predominantly a function of size, shape, and material permittivity [20]. Bandwidths of up to 10% can be easily achieved with simple rectangular DRA; that cannot fulfill the requirement of broadband/wireless applications. So, various approach has been investigated to enhance the bandwidth of DRA as stacking multiple DRAs, using parasitic dielectric resonator elements, introducing the air gap, slot coupling, thick substrate etc [11-18]. Many bandwidth enhancement techniques investigated earlier increases the overall size and volume of the DRA antenna which can limits its use in portable device. Compact slot and dielectric resonator antenna with dual resonance & broadband characteristic has been investigated [8]. In this paper the novel approach has been introduced to enhance the bandwidth of simple DRA with maintaining its miniaturized size. The simple rectangular DRA-fed by ring slot coupling, is shown in Fig (1). The design is modified to enhance the bandwidth of simple DRA by loading the patch antenna on top of DRA [1]. The impedance bandwidth is a function of the material's

permittivity and aspect ratio. For proposed simple DRA, a return-loss bandwidth of 8.7% and 18.1% for 2.25GHz and 4.61 GHz respectively are obtained. The micro-strip feed line is preferred over probe coupling to avoid spurious radiations. Coupling depends on the slot dimensions & DRA position on it. Microstrip stub also cancels out the reactive component of the slot that is not covered in this paper. The implemented design is based on multi-resonance technique in which the resonance of slot coupled dielectric resonator antenna and patch antenna has been combined to improve the bandwidth of DRA without increasing the volume of the antenna design.

## 2. DESIGN CONCEPT AND ANTENNA CONFIGURATION

As discussed earlier, the slot dimension and permittivity of sub- and supersaturate (DRA) determine the frequencies of slot resonances, while the DRA modes depend on the DR dimensions, permittivity, as well as the feeding mechanism [21-23]. The method used in the proposed design is multi-resonance technique [8]. For feeding the antenna geometry micro strip feed line is used. To couple the energy to the DRA rectangular ring shaped slot coupling is used. DRA is loaded on the ring slot structure. The dimensions of the DRA is so chosen that (if  $L_{dra} \cdot W_{dra} < h_{dra}$ ), height can be given by the relation  $h_{dra}$  equals to  $\lambda_0/4(\epsilon_{dra})^{-1/2}$ . Slot dimensions are taken in terms of free space wavelength i.e.  $\lambda_0$  [1]. Then the antenna geometry is modified by using patch on the top of DRA to improve bandwidth. Ansoft HFSS is used for simulating the antenna design and seeing the result.

### 2.1 Feed line

A 50 ohm microstrip line with the length of 3cm and width 0.157cm is positioned just below the center of the DRA. A 50 ohm coaxial SMA connector is used to feed the microwave power to the feed line.

### 2.2 Substrate

A thin substrate layer of FR 4 having low dielectric constant of 4.4 is used with thickness 0.165cm. Length and width of it is chosen as 5cmx5cm.

### 2.3 Slot

Rectangular ring slot is used with dimension  $L_{s1}$  2cm,  $L_{s2}$  1cm and  $W_s$  0.2cm. Rectangular slot is used for maintaining the symmetry with rectangular DRA.

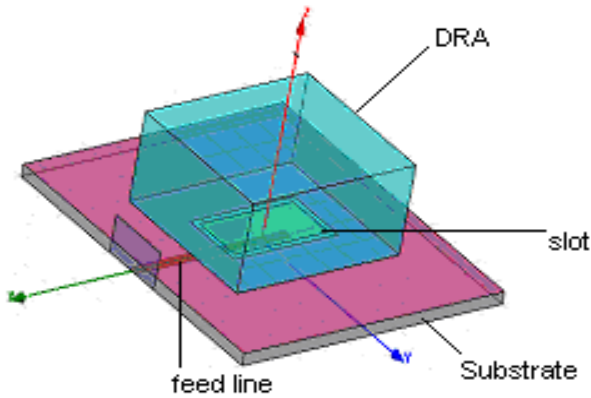
### 2.4 Patch

Micro strip Patch of dimension 3.12cm x 2.44 cm is etched on DRA top. It is designed as to cover the complete top surface of DRA.

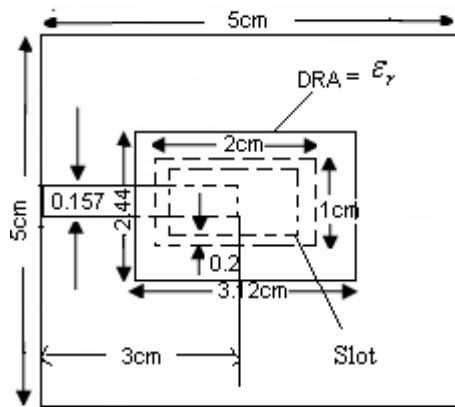
### 2.5 DRA Dimensions

Rectangular DRA of dielectric constant 11.9 with the size length ( $L_{dra}$ ) =3.12 cm, width ( $W_{dra}$ ) 2.44, height ( $h_{dra}$ ) 1.2 cm is considered.

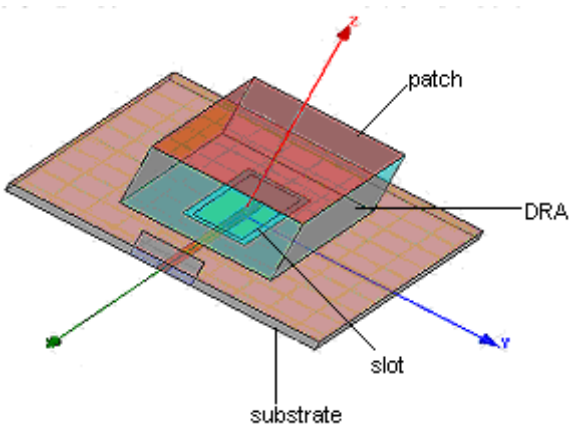
The two designs has been simulated with and without the patch radiator. The figure 1 and 2 shows the DRA without the patch. Figure 3 and 4 shows DRA design with patch on top of it.



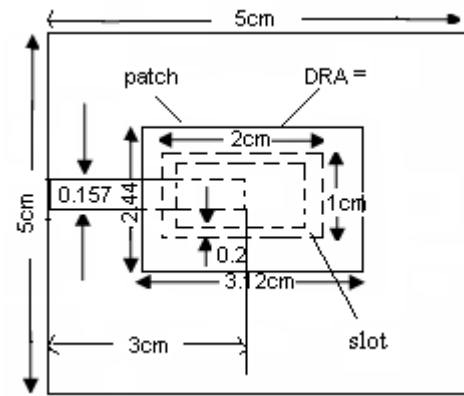
**Figure 1: Simple rectangular ring shaped slot coupled DRA (HFSS view)**



**Figure 2: Simple rectangular ring shaped slot coupled DRA (HFSS view)**



**Figure 3 Rectangular slot coupled Patch Loaded DRA (HFSS view)**



**Figure 4: Rectangular slot coupled Patch Loaded DRA (top view)**

### 3. RESULTS & DISCUSSION

The antenna designs (SDRA and PLDRA) based on the multi-resonance technique and gives dual band operation. The resonant frequencies of simple DRA are obtained around 2.25 GHz and 4.61 GHz while that of the patch loaded DRA (PLDRA) is obtained around 2.19 GHz and 4.4 GHz. The return loss graph with respect to frequency for both the designs is shown in fig (5) and fig (6).

The % bandwidth is calculated from return loss verses frequency plot and is given by:

$$BW (\%) = (f_H - f_L) / f_C$$

where  $f_C = (f_H + f_L) / 2$  and  $f_H$ ,  $f_L$  are high cut off frequency and low cut off frequency respectively.

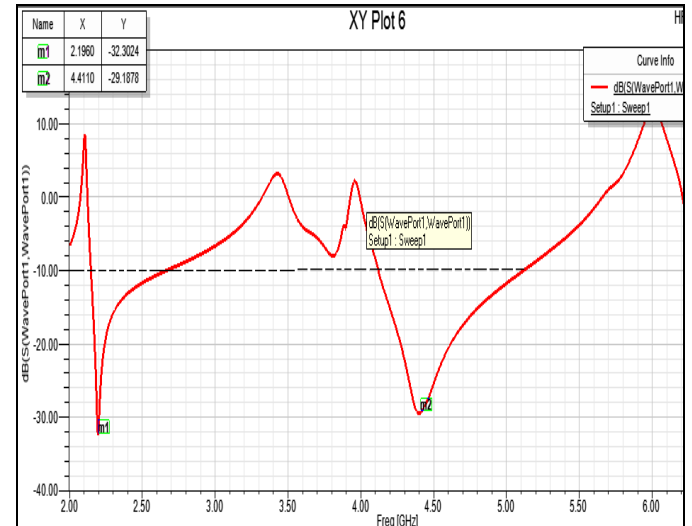
The return loss bandwidth for simple design is 8.7% and 18.1% at 2.25GHz and 4.61 GHz respectively. The patch loaded DRA gives the bandwidth of around 500 MHz at resonant frequency 2.19 GHz & 970MHz at frequency 4.4 GHz. Hence the PLDRA gives dual band operation with improved bandwidth of 20.8% and 23.3%.

The resonant frequencies in PLDRA are shifted to 2.19 GHz and 4.4GHz respectively due to the effect of patch antenna. So, it would be useful for lower microwave frequency applications mainly for mobile communication. The bandwidth of PLDRA is improved due to combined effect of patch with DRA. The return loss is above -10 db between the frequency range 2.65 GHz to 4.1 GHz that lowers the performance over this frequency range. This problem can be overcome by changing dielectric constant and size of DRA.

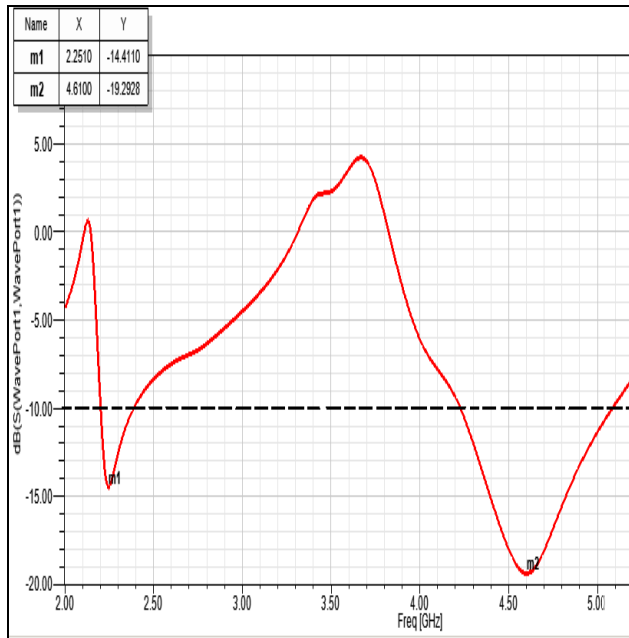
The return loss can be further lowered by optimizing the design parameters of DRA, patch and using the stub matching method. The radiation pattern for SDRA and PLDRA at 2.2 GHz is shown in fig 7 and 8 respectively. The radiation characteristic of PLDRA is maintained as that of SDRA. FBR (front to back ratio) of SDRA is 12.7db with gain 16.82dbi at 2.2GHz. PLDRA gives the FBR of 7.04 db with gain of 9.26 dbi at desired frequency 2.2GHz. PLDRA offers improved bandwidth with reasonably good gain.

**Table 1 Return loss, resonant frequencies and bandwidth of SDRA and PLDRA**

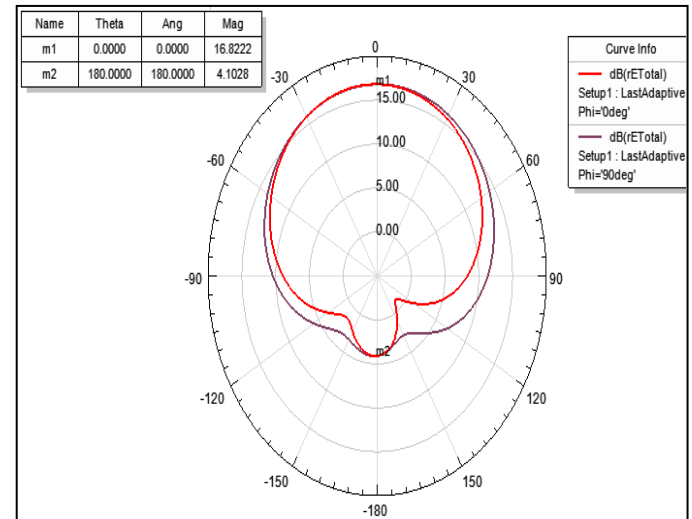
Results	Resonant freq(GHz)	Min Return loss(db)	Operating frequency range(GHz)	BW (MHz)	BW %	FBR (db)
Simple DRA	2.25	-14.41	2.2-2.4	200	8.7	12.7
	4.61	-19.29	4.25-5.1	850	18.1	
Patch loaded DRA	2.19	-32.3	2.15-2.65	500	20.8	7.04
	4.4	-29.18	4.13-5.1	970	23.3	



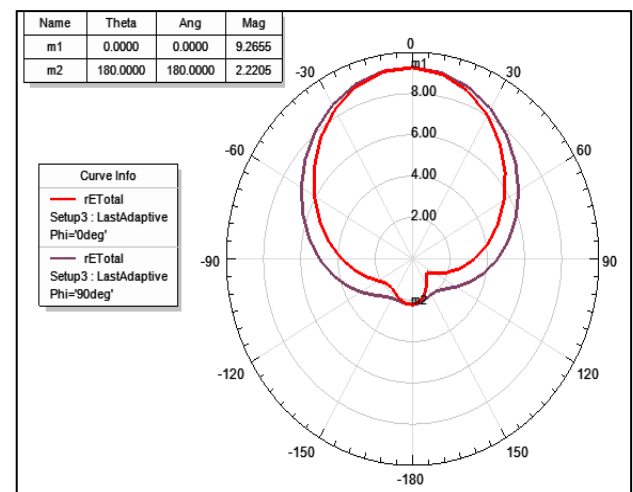
**Figure 6: Return loss of patch loaded DRA<sub>1</sub> (dielectric constant 11.9)**



**Figure 5: Return loss of rectangular ring slot coupled DRA (Simple DRA)**



**Figure 7: Radiation pattern of SDRA at 2.2 GHz**



**Figure 8 Radiation pattern of PLDRA at 2.2 GHZ.**

#### 4. CONCLUSIONS

In this communication, broadband patch loaded DRA has been proposed. The resonance of the slot and DRA is merged with the patch antenna to get broadband characteristics. This broadband antenna design can be useful for mobile communication, WLAN, IEEE 802.16 WiMAX applications with the operating frequency band 2.15-2.65GHz and 4.13-5.1GHz. From the analytical and comparative study it has been observed that the combination of patch antenna and DRA gives broadband characteristics. Thus; the PLDRA is better choice than simple DRA because it gives much wider bandwidth (44.1 %) whereas simple DRA offers bandwidth of 26.8 %. As PLDRA is having minimum return loss of -32db at frequency 2.19GHz and return loss of -29.18 at 4.4 GHz, improved matching is achieved. The patch loaded DRA has been introduced as an antenna for broad band applications without compromising with miniaturization of the antenna design. The drawback of increased volume of previous bandwidth enhancement techniques (such as stacking multiple DRAs, multi segment DRA or introducing air gap) is reduced in the proposed method.

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