Three Cylindrical Stacked DRA Excited by Coaxial Feeding for Wideband Radiation Pattern

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ABSTRACT
A cylindrical dielectric resonator antenna (DRA) is examined, in this structure three cylindrical stacked DRA is excited by coaxial feeding for wideband radiation pattern. In this we have use three cylindrical dielectric material of equal thickness. These three dielectric materials have different dielectric constants and excitation is provided by varying length of co-axial probe to provide improve impedance bandwidth with a broadside radiation pattern. The structure will provide wideband low profile monopole like structure. Results are verified using CST Microwave Studio Suite 10.

Keywords- Dielectric resonator (DR), Cylindrical dielectric resonator antenna (CRA), $S_{11}$ Parameter, Perfect conductor (PEC), VSWR.

INTRODUCTION
After studying about the different materials, it is found that dielectric resonators are efficient radiator and energy storing element [4]. It is easy to design DRA, because of its features such as small size, high radiation efficiency and simple structure [4]. And it provides wideband width and low conductor loss. After examination of different dielectric resonator shape and when comparing their result, it was found that some shape gives better impedance bandwidth. For excitation of antennas we can use different feeding method. Such as microstrip feeding, disk feeding, slot line feeding, coaxial feeding, as this provides better matching [4]. In this paper, the simulation of a three cylindrical stacked DRA excited by coaxial probe for wideband radiation pattern is shown.

THEORY
For good antenna performance, a thick dielectric substrate having a low dielectric constant is desirable since this provides better efficiency, larger bandwidth, better radiation power, reduces conductor loss and also reduces Q factor. For antenna designer bandwidth enhancement is main concern now a days. Enhancement of bandwidth can be achieve by working on different parameter such as by varying probe height, or thickness of dielectric substrate, or by changing of dielectric constant of substrate, etc. And if we compare Dielectric resonator antenna with other antenna such as microstrip antenna, we will get better antenna efficiency and wider bandwidth.

ANTENNA-STRUCTURE
Given antenna is three layer structure designs, in which we are using three coaxial cylindrical DRA of equal thickness, which is based on ground plane as shown in figure. These three DRA is of different dielectric constant and they are Arlon AR 1000(loss free) having dielectric constant 10,
Dupont 943 (loss free) having dielectric constant 7.4 and Aluminium nitride (loss free) having dielectric constant 8.6 with all having equal diameter and thickness of 6mm and 3mm respectively. Ground plane have equal length and width of 10 mm and thickness of 3mm. In which a insulator of Teflon material of inner radius 1.67mm and outer radius of 0.5 mm is inserted in (+)Z-direction from -3mm to origin having dielectric constant 2.1. And a probe of PEC material of 0.5 mm radius is used of varying length starting from-3mm to 5.25mm in (+) Z-direction.

Below we have shown different views of the antenna.

Figure 1: Geometry of three cylindrical stacked DRA antenna structure is shown in figure (a) Top view, (b) Side view, (c) Bottom view. \([h_g=3, l_g=10, w_g=10, h_d=3, h_p=3.25]\) all dimensions are in mm.
Where $h_g$ is the height of the ground, $l_g$ is the length of the ground, $w_g$ is the width of the ground, $h_d$ is the height of the DRA, which is equal for all elements of structure, $h_p$ is the height of the probe.

RESULT

After simulation of this structure, results are shown below. In figure 2, the S-parameter is shown in db. We have achieved antenna ranging from 9.5GHz-12GHz i.e. a bandwidth of 2.5GHz (where $S_{11}<-10$db), which is much sufficient for an antenna to radiate in wide range. The resonance frequency is 10.9GHz. The return loss i.e. $S_{11}$ is -22.50 db, which is very good because for an antenna to radiate efficiently, it must have as low loss as possible, lesser the loss better will be the antenna.

**Figure 2**: this is $S_{11}$ parameter showing bandwidth of nearly 2.5GHz and return loss of near about -22.5db [$h_g=3$, $l_g=10$, $w_g=10$, $h_d=3$, $h_p=3.25$] all dimensions are in mm.

VSWR is shown in below figure, it is clear from figure that the value of VSWR exist between 1 and 4 for the frequency range from 8GHz-12GHz i.e. for $S_{11}$ ($<10$ db).

**Figure 3**: VSWR [$h_g=3$, $l_g=10$, $w_g=10$, $h_d=3$, $h_p=3.25$] all dimensions are in mm.

VSWR can be calculated using the following formula as:

$$\Gamma = \frac{(Z_1-Z_0)}{(Z_1+Z_0)}$$

$$\text{VSWR} = \frac{1+\Gamma}{1-\Gamma}$$

Where $Z_1$ is the antenna impedance, $Z_0$ is the impedance of feed line and $\Gamma$ is the reflection coefficient.
The farfield radiation pattern at the resonance frequency of 10.9GHz is shown in the figure below, the gain is 4.851dbi, radiation efficiency of 99.20% and total efficiency of 98.64% which is more than sufficient for an antenna to perform efficiently.

![Farfield radiation pattern of antenna showing gain at resonance frequency of 10.9GHz](image)

**Figure 4**: Farfield radiation pattern of antenna showing gain at resonance frequency of 10.9GHz $[h_g=3, l_g=10, w_g=10, h_d=3, h_p=3.25]$ all dimensions are in mm.

![E-field distributions](image)

**Figure 5**: E-field distributions $[h_g=3, l_g=10, w_g=10, h_d=3, h_p=3.25]$ all dimensions are in mm.

![H-field distributions](image)

**Figure 6**: H-Field distributions $[h_g=3, l_g=10, w_g=10, h_d=3, h_p=3.25]$ all dimensions are in mm.
Figure below shows the $S_{11}$ parameter variation for different height of probe, some selected curves are shown out of various results. All curves shows the different values of $h_p$ i.e. height of probe. The best results are shown at $H=h_1=h_2=h_3=4.45$ mm.

**Figure 7:** Variation in bandwidth for different values of heights of probe. $[h_g=3, l_g=10, w_g=10, h_d=3, h_p=3.25]$ all dimensions are in mm.

**Impedance Bandwidth (I.BW):** This can be calculated by following formula.

$$I.BW = \frac{((F_H-F_L)/F_C)}{F_C}$$

Where,

$F_H = $ higher cut off frequency, $F_L = $ lower cut off frequency, $F_C = $ resonance frequency

**TABLE I:** Impedance bandwidth for different height of probe ($h_p$) is shown below in table.

<table>
<thead>
<tr>
<th>Height of probe($h_p$), mm</th>
<th>Frequency range ($F_H-F_L$),GHz</th>
<th>Bandwidth (BW),GHz</th>
<th>Resonance frequency($F_C$) GHz</th>
<th>Impedance BW% $[(F_H-F_L)/F_C]$</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.05</td>
<td>12.736-10.4</td>
<td>2.336</td>
<td>11.7</td>
<td>19.96%</td>
</tr>
<tr>
<td><strong>4.45</strong></td>
<td><strong>12.95</strong></td>
<td><strong>2.5</strong></td>
<td><strong>10.9</strong></td>
<td><strong>22.94%</strong></td>
</tr>
<tr>
<td>4.85</td>
<td>11.4-10</td>
<td>1.4</td>
<td>10.4</td>
<td>13.46%</td>
</tr>
</tbody>
</table>

**CONCLUSION**

In this paper, three cylindrical stacked DRA is excited by coaxial feeding for wideband radiation pattern and examined numerically using CST Microwave studio suit 10, by varying height of probe and a wideband antenna is simulated with the following specifications. Bandwidth of 2.5GHz ranging from 9.5GHz-12GHz (<-10 db $S_{11}$), Impedance bandwidth of 22.94%, Radiation efficiency of 99.20%, Total efficiency of 98.64% and Gain of 4.851 dbi is achieved.

**REFERENCES**


