International Journal of Emerging Technology and Advanced Engineering
Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 5, Issue 11, November 2015)

Design of CPW Fed Dual Band Cylindrical Dielectric Resonator Antenna.

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***Abstract*— The presented works propose the design of the dual band cylindrical Dielectric Resonator Antenna (DRA) coupled to slot aperture fed by finite ground CPW. In our proposed antenna, a CPW inductive slot performs the function of radiator and also fed the DRA. The two modes HEM_{11} and HEM_{12} are excited with their resonant frequencies respectively. These frequencies can be controlled by changing the aspect ratio of the cylindrical DRA. The effect of the various parameters on the Q-factor and resonant frequency is noticed through parametric study using HFSS simulator and experimental results. The prototype of the proposed cylindrical DRA is successfully constructed and tested for the desired results. The low band resonant frequency is located about 3.09 GHz with -10dB impedance bandwidth from 2.98 GHz to 3.25 GHz. The high resonant frequency is located about 5.07 GHz with -10dB bandwidth from 4.96 GHz to 5.16 GHz. The return loss, radiation resistance, VSWR, input impedances and 3D gain of the proposed antenna are evaluated.**

***Keywords*— Dielectric Resonator antenna, S_{11} Parameter, Resonant Frequency, Impedance Bandwidth.**

I. INTRODUCTION

In the field microwave and antenna Dielectric Resonator antenna got attention of researchers because of its special properties which are useful for many applications like millimetre wave application [1]. Because of the elasticity offer by the DRAs in the design process, they may be designed and fabricated in different shapes and forms for the application in the wireless technologies [2-3]. Several techniques may be used to feed the DRAs, it may be Microstrip line feeding, feeding through slot or probes and feeding through CPW [4-5]. The properties like small size, light weight, simple structures, wide impedance bandwidth, free from metallic loss, easy fabrication, various feeding techniques and flexibility in their shapes make it superior over microstrip patch antennas. Cylindrical DRA has advantage over rectangular and hemispherical shape DRA. Design flexibility of the cylindrical DRA is more with respect to other shapes of DRA.

In cylindrical DRA the ratio of radius to height (aspect Ratio) controls the Quality factor and the resonant frequency. In cylindrical DRA different modes can be excited very easily. Degree of freedom is offered by the cylindrical DRA than any other shape DRA [1].

Different shapes of DRA for multi-mode have been studied in recent past era. Dual band antenna was obtained by combining two DRAs resonating at different frequencies [6]. The resonant mode of the feeding slot was also used for the purpose to widen the bandwidth [7]. In [8] wider bandwidth is achieved by using higher order modes. Higher order modes were used to design a dual band DRA [9]. The major advantages of the higher modes are it does not require any extra DRA and it also provide facilitation for the matching of the dual band.

In this paper, a miniaturized dual band cylindrical DRA is presented. In the proposed DRA both HEM_{11} and HEM_{12} modes are excited. Moreover, resonant frequencies of the HEM_{11} and HEM_{12} are adjusted by changing the aspect ratio of the cylindrical DRA. All the simulations are carried out with HFSS simulator.

II. ANTENNA DESIGN

When a dielectric resonator is not completely bounded by a conductive boundary, it can radiate and become an antenna. Fig. 1 shows structure of the proposed dual band antenna. The DR is chosen having dielectric constant of 9.8, tangent loss of 0.002, radius of 6.35 mm and height of 6mm. The DRA is fabricated using Rogers 4003 having dielectric constant of 3.55 and height of 1.524 mm. The width of the substrate W is 65 mm and length of the substrate L is also 65 mm. The center-fed CPW slot has couple of arms of same length of Ls=8mm and width Ws=4mm. The DRA is placed above a rectangular inductive slot. The cylindrical DRA is excited at desired mode of HEM_{11} and HEM_{12} mode. All the simulations are carried out using HFSS software.

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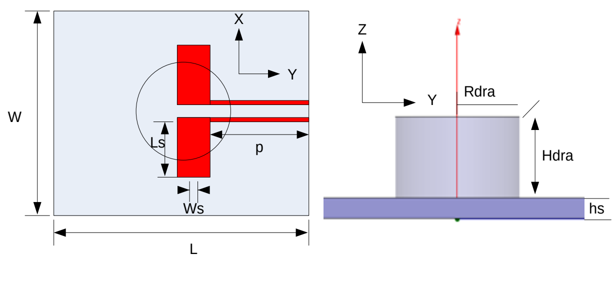

Figure 1. Structure of proposed DRA (a) Top view of proposed structure of DRA. (b) Side view of proposed structure of DRA.

The resonant frequency and Q-factor for the HEM_{11} mode may be calculated from the following equations [1].

$$f_0 = \frac{c\times 6.324}{2\pi a\sqrt{\varepsilon r+2}}(0.27+0.36x+0.02x^2)$$

$$Q = x\varepsilon_r^{1.2}(0.01893+2.925^{-2.08x(1-0.08x)})$$

Where c is speed of light and $x = \frac{a}{H}$, a= radius, H denotes height of DRA.

The Q-factor and resonant frequency of HEM_{11} mode is calculated theoretically for radius of 6.35 mm and height of 6 mm and is found to be and 8.9 and 6.29 GHz respectively. The resonant frequency and Q-factor for the HEM_{12} mode can be calculated from the following equations [1].

$$f_0 = \frac{30}{2\pi a(cm)\sqrt{\varepsilon_r}}(3.72+0.4464x+0.2232x^2+0.521x^3-2.65e^{-1.25x(1+4.7x)})$$

$$Q = \varepsilon_r^{2}(0.068-0.0388x+0.0064x^2+0.007e^{x(37.59-63.8x)})$$

Where $x = \frac{a}{H}$, a= radius and H denotes height of DRA.

The Q-factor and resonant frequency of HEM_{12} is calculated theoretically for radius of 6.35 mm and height of 6 mm and is found to be and 9.03 and 5.23 GHz respectively.

Cylindrical DRA has advantage that the aspect ratio controls the Quality factor and resonant frequency. The effect of aspect ratio on the resonant frequency and Quality factor is shown in the Fig. 2. By increasing the aspect ratio the resonant frequency increases in the both modes. The quality factor of HEM_{12} has maximum value at center and lower value at sides while in case of HEM_{11} it increases with increase in aspect ratio.

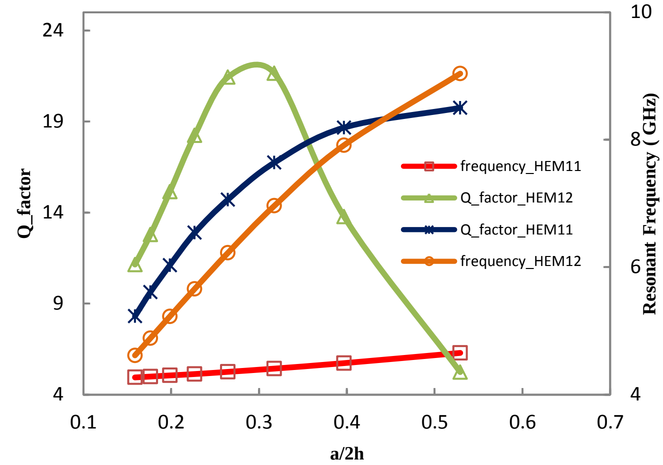

Figure 2. Relation of Resonant frequency and Q-factor with respect to aspect ratio of a/h.

III. Results And Discussions

A. Radiation Resistance

The radiation resistance depends upon the length and width of the slot. Fig. 3 shows the plot of radiation resistance against different values of width and length of the slot.

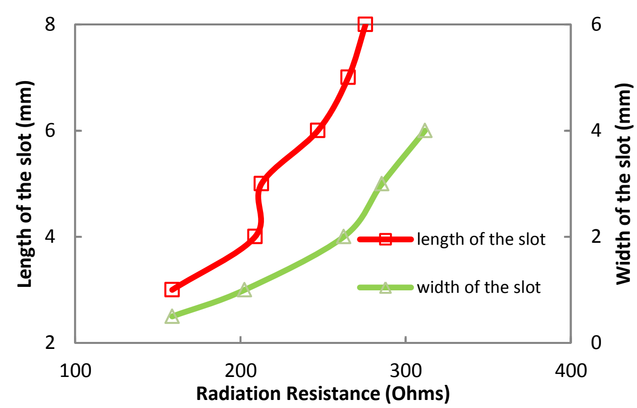

Figure 3. Simulated radiation resistance versus length and width of the slot

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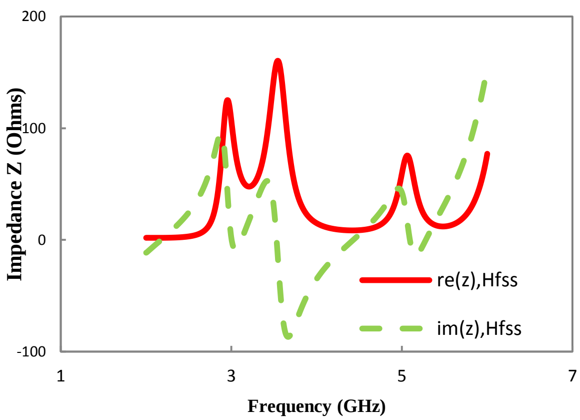

Figure 4. Plot of input impedance versus frequency

Input impedance of the proposed antenna is shown in the Fig. 4. It is clearly seen from the input impedance plot that best matching of impedances occurs at 3.09 GHz and 5.07 GHz although the modes are at some variation.

B. Simulated S11 Parameter and Discussion

The simulated S_{11} parameter of proposed cylindrical DRA plotted against frequency is shown in Fig. 5. By changing the length p, change in the resonant frequencies can be seen.

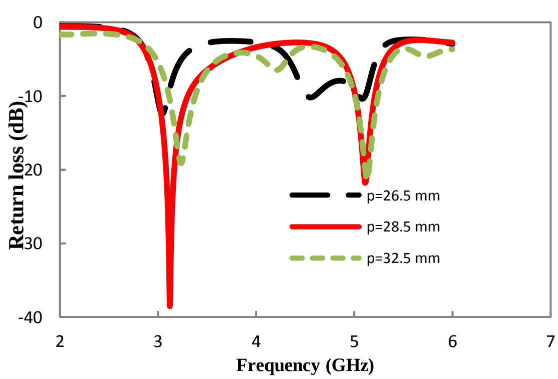

Figure 5. Simulated S-parameter against Frequency

C. VSWR

Fig. 6 shows the simulated VSWR which is less than 2 dB for both resonant frequencies. VSWR is 0.2054 dB and 1.41 dB at 3.09 GHz and 5.07 GHz respectively. An antenna is said to be fair if it has VSWR less than 2dB.

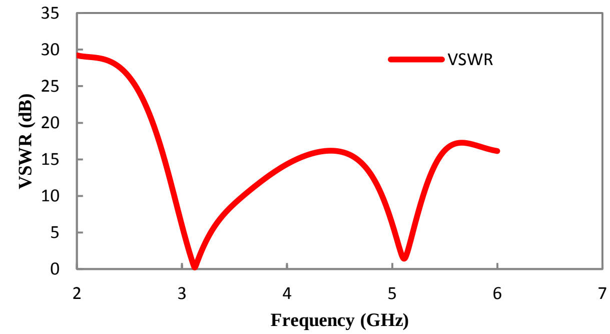

Figure 6. VSWR against different frequencies

Figure 7. shows the simulated and measured results of the proposed dual band DRA.

D. Radiation Characteristics

The radiation characteristics for the two bands of the dual band DRA are shown in Fig. 8 and Fig. 9. The gain for the frequencies of 3.09 GHz and 5.07GHz is noted to be 2.73 and 6.8 dBi.

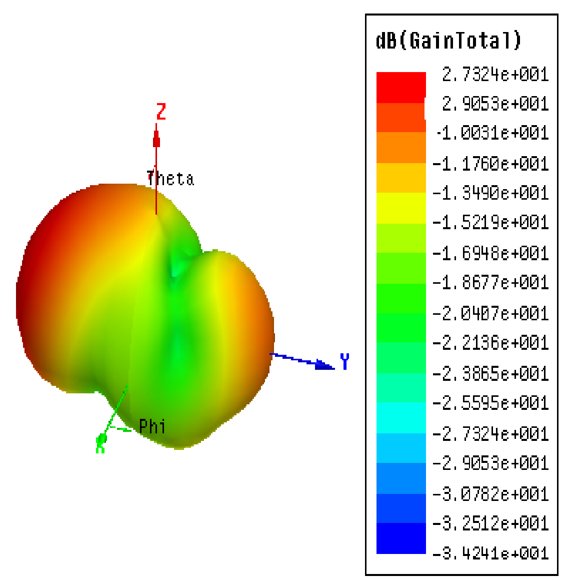

Figure 8. The gain of dual band DRA at 3.09 GHz is 2.73 dBi

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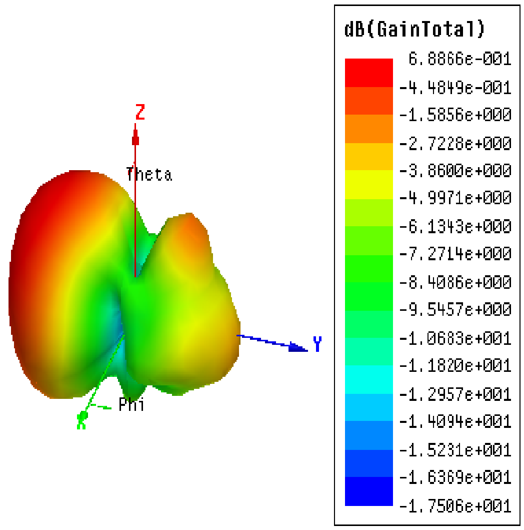

Figure 9. The gain of the dual band DRA at 5.07 GHZ is 6.8 dBi

E. Simulated and Measured Results

Fig. 10 shows the simulated and measured results of the proposed DRA. The result shows reasonable agreement between the simulated and measured value.

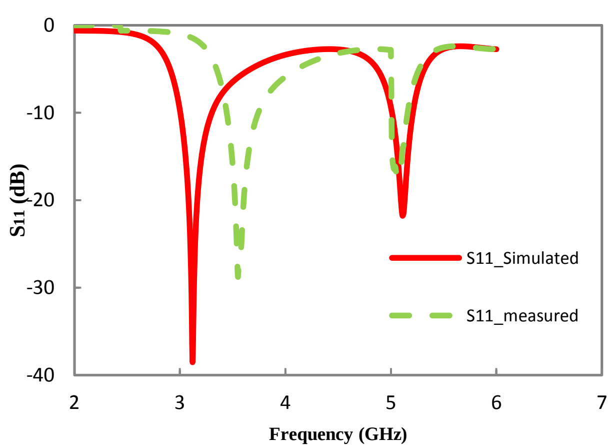

Figure 10. S_{11} plot of simulated and measured results of proposed DRA

IV. CONCLUSION

A dual band cylindrical DRA fed by CPW inductive slot has been designed and tested. Different values of parameters were changed to study the characteristics of the proposed dual band antenna. The resonance of the inductive slot is fused with that of the cylindrical DRA to achieve our desired goal. The result shows that the design antenna offered desired resonant frequencies. The gain of the DRA at two bands is 2.73 dBi and 6.8 dBi. The value of VSWR is also less than 2 dB for both resonant frequencies.

REFERENCES

[1] Petosa, A.: 'Dielectric Resonator Antenna Handbook', (Artech House Publishers, Norwood, 2007)

[2] Kumari, R., Parmar, K., and Behera, S.K.: 'Conformal Patch Fed Stacked Triangular Dielectric Resonator Antenna for WLAN Applications', IEEE International Conference on Emerging Trends in Robotics and Communication Technology, Chennai,2010, pp. 104-107

[3] Gao, Y., Ooi, B.L., Ewe, W.B., and Popov, A.P.: 'A Compact Wideband Hybrid Dielectric Resonator Antenna', IEEE microwave and wireless components letters, 2006, **16**, (4), pp. 227-229

[4] Buerkle, A., Sarabandi, K. and Mosallaei, H.: 'Compact slot and dielectric resonator antenna with dual-resonance, broadband characteristics', IEEE Trans. Antennas Propag., 2005, **53**, (3), pp.1020-1027,

[5] Al Salameh, M.S., Antar, Y.M.M., and Seguin, G.: 'Coplanarwaveguide- fed slot-coupled rectangular dielectric resonator antenna', IEEE Trans.Antennas Propag., 2002, **50**, (10), pp.1415-1419

[6] Behdad, N., and Sarabandi, K.: 'Dual-band reconfigurable antenna with a very wide tunability range', IEEE Trans. Antennas Propag., 2006, **54,** (2), pp. 409–416

[7] Su, Y C.M., Chen, H.T., Chang, F.S., and Wong, K.L.: 'Dual-band slot antenna for 2.4/5.2 GHz WLAN operation', Microw. Opt. Tech. Lett.,2002, **35**, (4), pp. 306–308

[8] Fan, Z. and Antar, Y.M.M.: 'Slot-coupled DR antenna for dual frequency operation', IEEE Trans. Antennas Propag., 1997**, 45**, (2), pp. 306–308

[9] Gao, Y., Ooi, B.L., and Popov, A.P.: 'Dual-band hybrid dielectric resonator antenna with CPW-fed slot, Microw',. Opt. Tech. Lett.,2003, **48**, (1), pp. 170–172