IOSR Journal of Electronics and Communication Engineering (IOSR-JECE)
e-ISSN: 2278-2834,p- ISSN: 2278-8735.Volume 11, Issue 6, Ver. II (Nov.-Dec .2016), PP 38-41
www.iosrjournals.org

Design and Analysis of a Compact Water Based Cylindrical Dielectric Resonator Antenna

Sukla Basu
Department of Electronics & Communication Engineering, Kalyani Government Engineering College, Kalyani, Nadia, West Bengal, India, Pin 741235

Abstract: *A simple DRA (Dielectric Resonator Antenna) made of water filled hollow porcelain cylinder operating in L band (1GHz-2GHz) and S band (2GHz-4GHz) is designed and its performance characteristics is analyzed. The attractive feature of this simple configuration is its small size compared to operating wavelength (30cm-7.5cm). Effects of water level and exciting probe length on resonant frequency of this antenna are investigated. With the increase in water level increase of number of resonant frequency within the said frequency ranges is observed. It is found that directivity of this DRA can be significantly increased by proper placing of a metal rod within water. Proposed simple and compact water based antenna design can be used for various wireless communication systems including GPS (Global Positioning System) operating in L band, WLAN (Wireless Local Area Network) and WiMax.(Worldwide Interoperability for Microwave Access) systems operating in S band. Multiple frequency operation characteristics, high directivity, simple and compact structure are the advantages of the proposed DRA.*

Keywords: *Dielectric Resonator Antenna, Liquid based Dielectric Resonator Antenna, Frequency Tuning of DRA, L and S Band DRA*

I. Introduction

DRAs have attracted much attention in the last few decades due to their simple structures, flexible feeding techniques, low losses and high radiation efficiencies. Most of the studies found in literature are on DRAs made of solid material of dielectric constant values 2 to 10. Compactness of a DRA depends on the dielectric constant of the material used for its construction. DRAs made of material of high dielectric constant are small in size compared to its operating wavelength, however, operating bandwidth of these DRAs are narrow. Recently, liquid DRAs [1,2,3,4,5] have attracted much attention of the antenna designers since size of the antenna can be made compact by using liquid of high dielectric constant like water and the antenna can be tuned easily over a wide frequency range by changing the liquid level. Dual band liquid DRA in L band with omnidirectional / directional radiation pattern has recently been reported in literature [6] using array of two identical DRA structures. In the present paper a single liquid DRA structure using water is proposed which is capable of giving single frequency , dual frequency and multi frequency band operation at 1 GHz to 4 GHz range for different water levels . Radiation pattern of this antenna is similar to a dipole antenna with directive gain around 2dBi. Directivity of the antenna can be increased up to 5.5 dBi by properly placing a metal rod inside the liquid.

II. Antenna Design

A cylindrical DRA of outer radius (r_o) 10mm, inner radius (r_i) 8mm and height(h) 20mm is designed. Thus diameter of the DRA is less than 7% of the longest operating wavelength in this 1GHz-4GHz band. It is placed on a cylindrical base of radius 20mm and thickness 2mm. Both base and DRA are made of porcelain ($\varepsilon_r = 6$) . Normal water ($\varepsilon_r \sim 78$) is used to fill up the inner cylinder. The proposed structure completely filled up with water is shown in Fig.1. A probe at the centre along the axis of the DRA is used for exciting it.

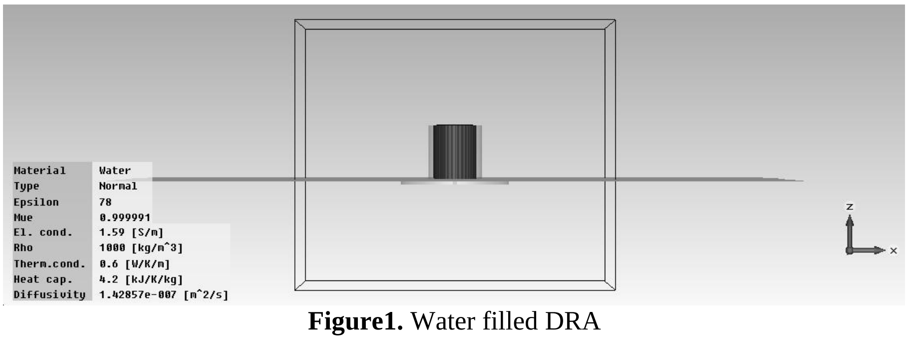

Figure1. Water filled DRA

III. Results and Discussions

Analysis of the performance characteristics of the proposed DRA under different parametric conditions is done using CST (Computer Simulation Technology) Microwave Studio software, based on finite integration technique. Frequency tuning characteristics and directivity are two important performance characteristics of the DRA. These two characteristics are studied from return loss versus frequency graph and directivity plots under different conditions as illustrated below.

3.1 Dependence of resonant frequencies on water level (h_w) and probe length (l):

Fig.2 shows variation of return loss of the DRA with frequency for three different water levels with probe length l=20mm. It is seen that as water level is increased number of resonant frequency bands is increased. For quarter filled DRA only one resonant frequency at 1.92 GHz is obtained. Half filled DRA gives two resonant frequencies (1.48 GHz and 3.08 GHz) and when the DRA is completely filled with water four resonant frequencies are obtained with minimum resonant frequency at 1.2GHz. Thus, varying the water level multiple frequency bands operation of the antenna is possible. Minimum resonant frequency band is shifted to lower frequency side as water level is increased.

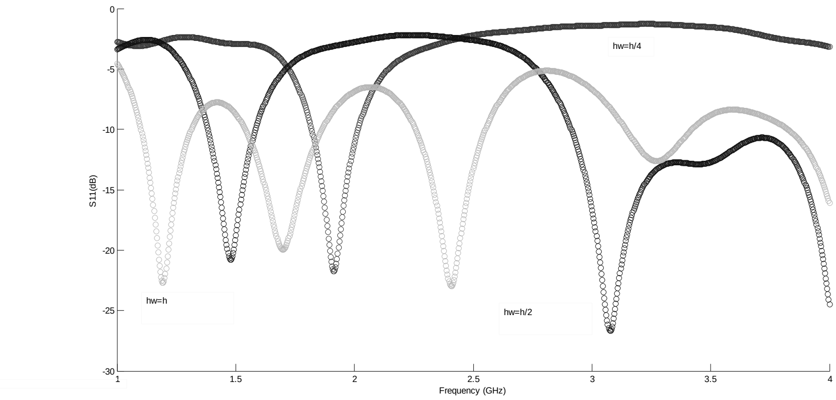

Figure 2. Return loss versus frequency graphs for three different water levels(h_w).Probe length(l) equals to DRA height (h)

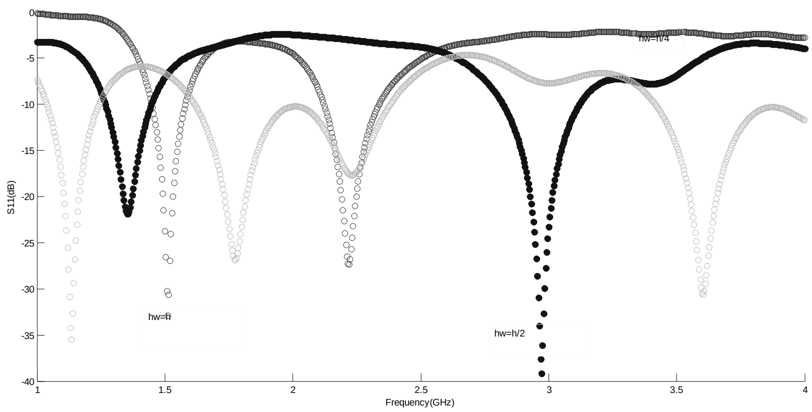

Figure 3. Return loss versus frequency graphs for three different water levels (h_w).Probe length(l) equals to twice DRA height (h)

Fig 3 .shows return loss versus frequency graph for probe length equals to twice DRA height (l=20mm) for three different water levels as taken in the earlier case. Again four resonant frequencies are obtained for completely water filled DRA and two resonant frequencies for half filled DRA. Quarter filled DRA also gives two resonant frequencies with this double probe length. From Fig.2 and Fig 3 it is seen that when probe length is doubled, minimum resonant frequencies are lowered for the same water level.

3.1 Dependence of directivity (D) on water level (h_w) and probe length (l):

The proposed DRA behaves like a dipole antenna as seen from Fig 4. Table I shows effect of water level and probe length on resonant frequency values and directivity at these resonant frequencies. Directivity does not depend much on probe length or water level which is seen from Table I .

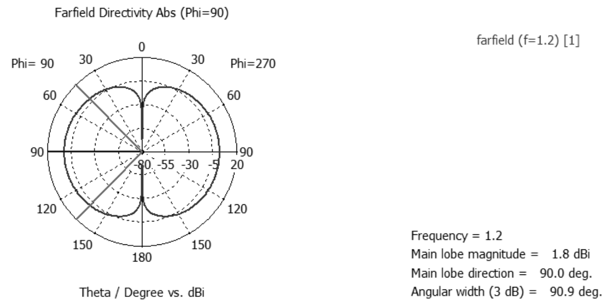

Figure4. Directivity plot of completely filled DRA with l=h=20mm

3.2 Effect of insertion of a metal rod:

A metal rod of length 20mm and radius 2mm is inserted at an optimized distance of 4mm from the axis and its effect is investigated. It is seen from Table I that resonant frequency is doubled with the insertion of metal rod for quarter filled DRA. However, for half filled or completely filled DRA resonant frequencies remain almost unchanged. Significant increase in directivity is obtained with the insertion of metal rod. Fig 5 shows maximum directivity of 5.5 dBi is obtained for completely water filled DRA at fifth resonant frequency of 3.888 GHz.

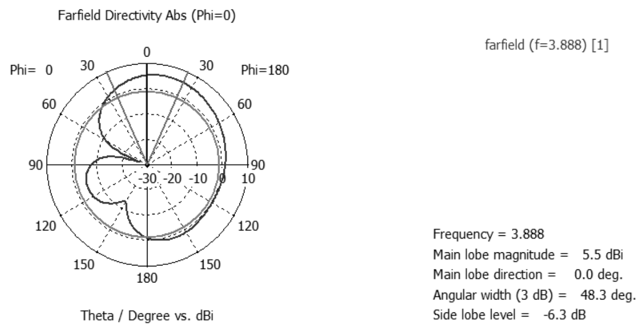

Figure5. Directivity plot for completely water filled DRA with metal rod

Table I. Effect of different parameters on resonant frequency and directivity of DRA

	f_1,D_1	**f_2, D_2**	**f_3, D_3**	**f_4, D_4**	**f_5, D_5**
Without metal rod, l=h					
h_w=h	1.2, 1.82	1.696, 1.77	2.408, 1.68	3.272, 1.54	-
h_w=h/2	1.48, 1.79	3.076, 1.6	-	-	-
h_w=h/4	1.915, 1.69	-	-	-	-
Without metal rod, l=2h					
h_w=h	1.136, 1.84	1.776, 1.89	2.235, 1.86	3.604, 1.71	-
h_w=h/2	1.356, 1.88	2.972, 1.94	-	-	-
h_w=h/4	1.512, 1.95	2.22, 1.81	-	-	-
With metal rod, l=h					
h_w=h	1.24, 2.03	1.688, 3.78	2.448, 2.66	3.22, 3.41	3.888, 5.5
h_w=h/2	1.414, 2.31	3.031, 4.8	-	-	-
h_w=h/4	3.841, 1.42	-	-	-	-

f_i ith resonant frequency in GHz ,D_i Directivity in dBi at ith resonant frequency. i=1,2,3,4,5

IV. Conclusion

The proposed compact DRA structure is capable of operating at different frequencies in 1GHz to 4GHz range. Single frequency, double frequency and multiple frequency band operation can be done by changing water level of the DRA . Operating frequency can be lowered by a small amount by doubling the probe length for a fixed water level. Omni directional radiation pattern like dipole antenna is obtained without metal rod. Directional pattern can be obtained with this DRA by properly placing a metal rod inside water. When the DRA is half or completely filled there is not much effect of insertion of metal rod on resonant frequencies. However, number of resonant frequency bands is increased from four to five due to insertion of metal rod in completely water filled DRA . Significant improvement in directivity is also observed for both half filled and completely filled DRA due to insertion of metal rod. The proposed antenna design is useful for applications in 1GHz to 4GHz frequency range including GPS (1.24GHz), WLAN (2.4 GHZ) and WiMax (3.89GHz).

References

[1]. Sukla Basu, 'A compact liquid based cylindrical dielectric resonator antenna for s band', International Journal of Electronics , Electrical and Computational System,Vol.4 Special Issue, September,2015.
[2]. Rongguo Zhou, Hailiang Zhang, and Hao Xin, 'A Compact Water Based Dielectric Resonator Antenna', Proceedings of Antennas and Propagation Society International Symposium (APSURSI, 2009), IEEE, p-1-4.
[3]. Steven G. O'Keefe and P. K Simon,'Tunability of Liquid Dielectric Resonator Antennas', Antennas and Wireless Propagation Letters, vol. 6, 2007.
[4]. Singh , K. R. , P.K. Singhal , 'Tunable Liquid Dielectric Antenna', International Journal of Engineering and Technology, 2012, 223-230, Science Publishing Corporation.
[5]. Fayad,H. and P. Record, 'Broadband liquid antenna', Electronics Letters vol. 42, No.3,2006.
[6]. Yikai Chen and Chao-Fu Wang , 'Dual-Band Directional/Omni-Directional Liquid DielectricResonator Antenna Designs Using Characteristic Modes', Proceedings of Antennas and Propagation Society International Symposium (APSURSI, 2014),IEEE, p-848-849.