International Journal of Engineering and Technology, 1 (3) (2012) 223-230

www.sciencepubco.com/index.php/IJET

Tunable Liquid Dielectric Antenna

Kamal Raj Singh Rajoriya, P.K. Singhal

Department of Electronics, Madhav Institute of Technology & Science, Gwalior, (M.P.) - 474005, India
Email: kamal.sr786@gmail.com, pks_65@yahoo.com

Abstract

This paper presents on modified the dielectric properties of liquid with varying salinity that was based on monopole structure. Dielectric resonator antennas (DRAs) can be made with a wide range of materials and allow many excitation methods [1]. Pure water does not work at high frequency (> 1 GHz) but increase in the salinity of water modifies the dielectric properties of water. Here proposed antenna shows that when the salinity increased in form of molar solution, the antenna was tuned at different frequency with increased return loss.

Keywords: *Liquid dielectric, molar (M), monopole antenna, resonant frequency.*

1 Introduction

The dielectric resonator antenna (DRAs) was first study in1983 [2]. It has been shown that electrically conducting liquids and some biological fluids can operate as antennas at microwave frequencies [3]. The advantage of liquid dielectric is that permitted improvement in electromagnetic coupling between dielectric and antenna because there is no air gap. H. Fayad and P. Record used a Salt (S< 6ppt**)** was added to decrease the dielectric response (real and imaginary) of pure water at (2< GHz) [4]. K. R. Singh and Deepak Patidar used salinity up to 2 M, resulted are return loss increased with sufficient return loss when increasing salinity [5]. Here presented a liquid tunable antenna from 1.509-1.974 GHz band in L band (1-2 GHz).

2 Antenna Design

The monopole antenna constructed from the PVC (polyvinyl chloride) container mounted on a 5×5 cm PCB (FR-4) attached to ground plane via BNC connector. The monopole antenna (brass wire) of diameter 1.8 mm and length 50 mm, the length of monopole is calculated by "λ/4" [6], which was protruded into the center of the container of height 5.1 cm and 3.3 cm diameter with 1 mm thickness as shown in Fig. 1. The resonant frequency for this proposed antenna was 1.509 GHz in L-band (1-2 GHz).

Fig. 1 Photograph of monopole antenna

3 Analysis

The return loss of the monopole antenna was measured with FS315 spectrum analyzer connected by SWR (50 Ω) bridge as shown in Fig. 2. Spectrum analyzer operated at minimum hold position for all measured value. Fig. 3 shows measured resonant frequency 1.509 GHz with 17.7 dB return loss of monopole antenna without liquid.

Fig. 2 Experimental set up

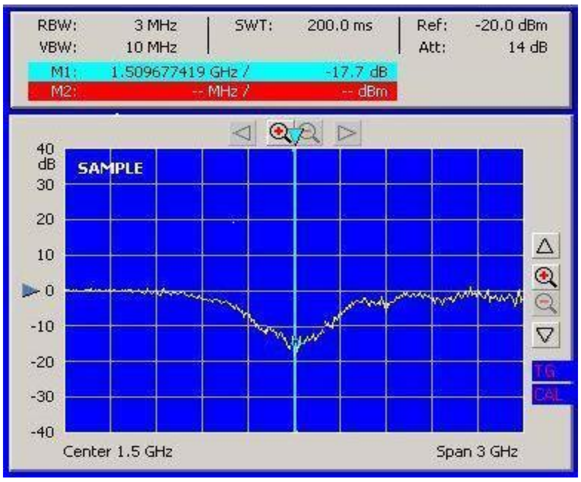

Fig. 3 Measured resonant frequency of monopole antenna without liquid

The test saline antennas were constructed from 3.2 cm diameter PVC container filled with 4 cm different salinity water shown in Fig. 4. The height of liquid was calculated from the volume of liquid in container. A fixed antenna length 50 mm height was concerned.

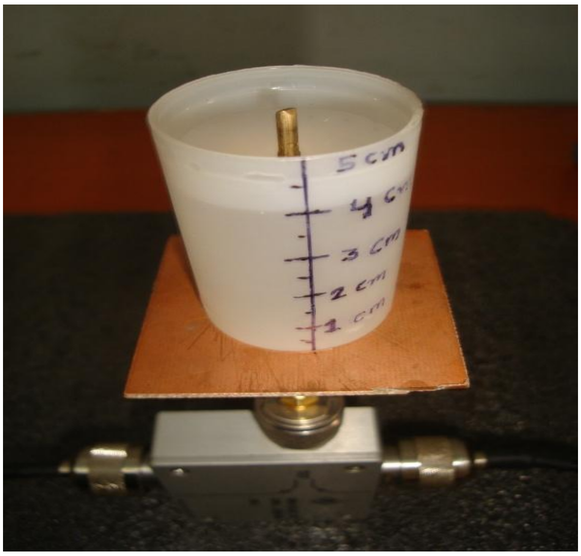
Fig. 4 Photograph of monopole antenna with 4 cm liquid

The frequency of monopole antenna was tuned 1.606 GHz at 0.5 M salinity with 21.0 dB return loss as shown in Fig. 5 because it reduces a dielectric response of water. The salinity of distilled water continues to increase up to 3.5 M with 0.5 M differences, further resonant frequency of antenna was changed 1.635 GHz, 1.664 GHz, 1.674 GHz, 1.974 GHz, 1.935 GHz and 1.808 GHz with proficient return loss 23.3 dB, 26.2 dB, 29.8 dB, 28.0 dB, 19.8 dB and 16.7 dB,(as shown in Fig. 6–11) respectively.

Fig. 5 Measured resonant frequency of liquid monopole antenna at specific salinity (0.5M)

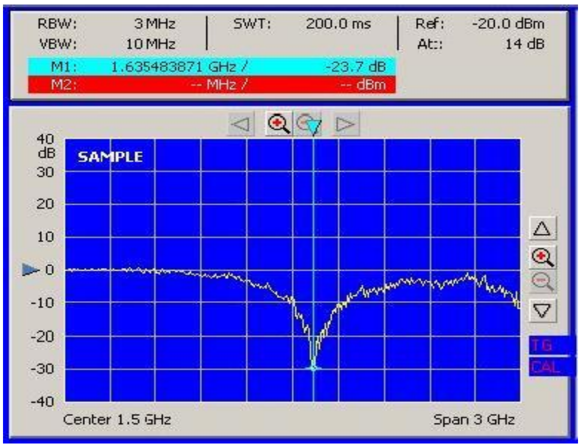

Fig. 6 Measured resonant frequency of liquid monopole antenna at specific salinity (1M)

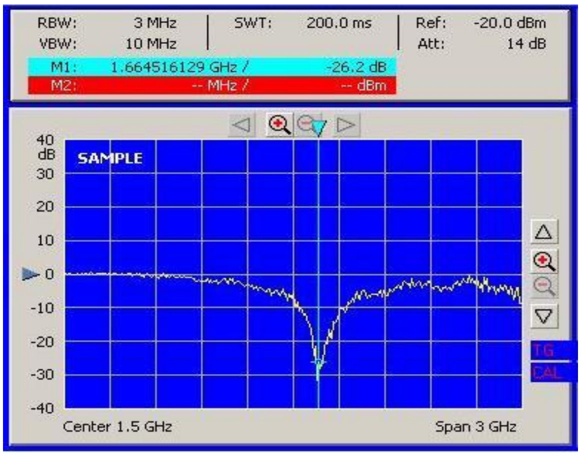

Fig. 7 Measured resonant frequency of liquid monopole antenna at specific salinity (1.5 M)

Fig. 8 Measured resonant frequency of liquid monopole antenna at specific salinity (2 M)

Fig. 9 Measured resonant frequency of liquid monopole antenna at specific salinity (2.5M)

Fig. 10 Measured resonant frequency of liquid monopole antenna at specific salinity (3 M)

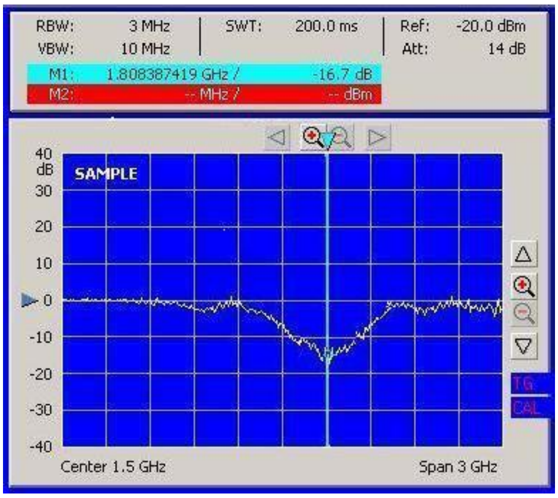

Fig. 11 Measured resonant frequency of liquid monopole antenna at specific salinity (3.5 M)

4 Results and Discussions

The whole procedure of dielectric resonator liquid antenna was moving around the modification of resonant frequency of monopole antenna. It was normally operated at 1.509 GHz without liquid. Pure water becomes lossy dielectric at high frequency (> 1 GHz). When adding the salt in distilled water (specific molarities) to reduce the dielectric response (real and imaginary), it was analysis that salt does not impact antenna conductivity but only alters the dielectric properties of water. In Fig. 12 that was observed that the return loss and resonant frequency

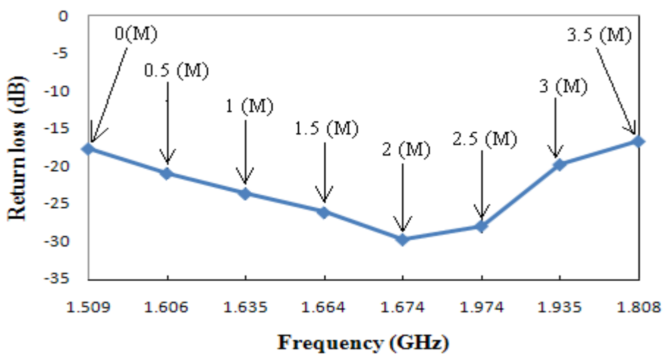

Fig. 12 Return loss (dB) Vs Frequency (GHz) for different concentrations ranging from 0.5-3.5 M

increased by increasing the four salt solution of different salinities. It is observed that when salinity increases, the antenna is tuned at different frequency. After 2.5 M salinity the return loss and frequency valued is begin decreased. When increasing the salinity up to 3.5 M the frequency and return loss is decreased. The proposed antenna offered a resonant frequency band from 1.509-1.974 GHz in L-band (1-2 GHz) as shown in Table 1.

Table 1: Comparison among different salinities

Sr. No.	Salinity (Molar)	Resonant Frequency (GHz)	Return loss (dB)
1	0	1.509	-17.7
2	0.5	1.606	-21.0
3	1	1.635	-23.7
4	1.5	1.664	-26.2
5	2	1.674	-29.8
6	2.5	1.974	-28.0
7	3	1.935	-19.8
8	3.5	1.808	-16.7

5 Conclusion

This paper presents the experimental analysis of liquid dielectric antenna that was effective microwave radiator. The simple monopole antenna was tuned at different resonant frequency with sufficient return loss more than -10 dB level through with different salinity of distilled water. The liquid antenna has reconfigurable properties that employ in many applications, medical and dielectric resonator liquid antenna. However, the primary restriction in water based antenna was not work at high frequency up to 1GHz because water becomes lossy. The obtain result are compared with available published data and good agreements are found.

References

[1] H. Fayad, P. Record,"Wideband liquid antenna" IEE. Conf. on Wide Band and Multi-band Antennas and Arrays, UK, (September 2005), 197-201.

[2] Long S. A., Mc-Allister M. W. and Shen C. L.,"The resonant cylindrical dielectric cavity antenna" IEEE Trans. Antenna Proragat., Vol. AP-31, (May1983), 406-412.

[3] Kosta, Y., "Liquid antenna". IEEE Antennas and Propagation Society Symp, Vol. 3, (June 2004), 2392–2395.

[4] H. Fayad, P. Record, "Broadband liquid antenna" IEE., J. , Vol. 42, No. 3, (Febuary 2006), 133-134.

[5] Kamal Raj Singh Rajoriya and Deepak Patidar "Innovative Reconfigurable Dielectric Resonator Liquid Antenna", on International Conference at SRGI Jhansi Proceedings name "E-Manthan," (2012), pp. 203-205.

[6] Balanis, C.A., Antenna Theory, Analysis and Design, 2nd edition, John Wiley & Sons, Inc., 1997.