

# High Efficiency Liquid Antenna for Wireless Communication

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**ABSTRACT:** Wireless Communication is continuously evolving in order to provide multimedia either to fixed nomadic or mobile uses through reliable channels. However metallic antennas are not ideal for some applications. Once the antennas are made, it is hard to make them reconfigurable and flexible in terms of the electromagnetic performance and mechanical configurations. Hence, the liquid antenna for maritime wireless communications is considered. Liquid antenna consists of a feeding probe and a glass tube to hold the liquid. It is a reliable concept to send confidential data through salt water in a secure way through the antenna in submarine. The main features of the liquid antenna include its high radiation efficiency, high transparency, reconfigurability, low cost, and simple structure. Further, the proposed monopole antenna with three types of liquids like pure water, glycerin, and sea water.

**KEYWORDS:** VNA (vector network analyzer), RCS (radar cross section)

## I. INTRODUCTION

Antenna being an essential device for communication system, is in high demand over a wide range of wireless products. So, for this communications purpose the antennas are used to transmit and to receive the data from near field region to far field region. To transmit (or) receive properly we have to use the antenna having more gain and less attenuation. Where in the case of the normal antennas like (dipole, monopole, horn antennas) the frequencies are fixed and it can't be changed. Liquid antennas are a special type of antennas utilizing fluid to transmit and receive radio signals. Liquid that contains charged particles in the form of ions is used as the radiating medium. Because of the liquidity, liquid may be pumped right into a tube and thereby "deployed" while the antenna is activated. If antenna is deactivated, the liquid can be pumped out or drained and the tube can also be removed, resulting in occupying small area and radar cross section (RCS). Liquid antenna is the one capable of modifying its frequency according to the liquid level. Numerous varieties of liquid materials consisting of mercury, gallium based liquid metallic alloy and water, were used to construct antennas. The structure of liquid antennas can be easily tuned to realize the desired radiation performance. Liquid antennas could overcome many problems facing in traditional metal antennas.

Compared with the metal antenna, the sea water antennas have the advantages of better stealth and good compatibility. Salt water may be taken into consideration as a conductor because the conductive ions in it may carry electric current flow. The conductivity of the salt water is a feature of its salinity. In this project, a new transparent and reconfigurable sea-water liquid antenna operating at Very High Frequency Band.

II. DESIGN OF MONOPOLE LIQUID ANTENNA

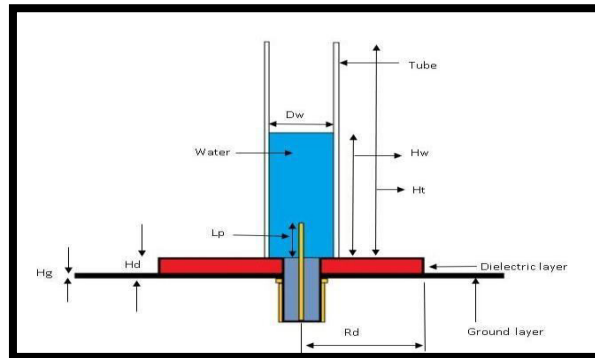


Figure 1: Design of Liquid Antenna.

where,

**Hd** = Height of dielectric layer.

**Hw** = Height of water filled depend upon frequency.

**Dw** = Inner diameter of tube.

**Ht** = Height of the tube.

**Hg** = Height of the ground.

**Lp** = Height of the feeding

Figure 1 shows the design of Liquid Antenna, A monopole liquid antenna design is carried out by considering the ground length greater than the lambda value with respect to designed frequency. A circular dielectric layer is placed at the center of the ground plane considering its radius, height and dielectric constant. A monopole structure of tube is placed perpendicularly on the dielectric material and feeding probe is placed through ground and dielectric layer. In the hollow tube liquid is filled to one fourth of lambda value by calculating lambda value depend upon frequency. SMA connector is placed to the feeding pin to provide signal conductivity for trans receive of signals.

$$\lambda = \frac{c}{f}$$

..... (1)

where,

$$Hw = \frac{\lambda}{4} \text{..... (2)}$$

$c = 3 \times 10^8$  m/s (Speed of light) &  $f$  = Resonate frequency.

Hw = Height of liquid filled to tube

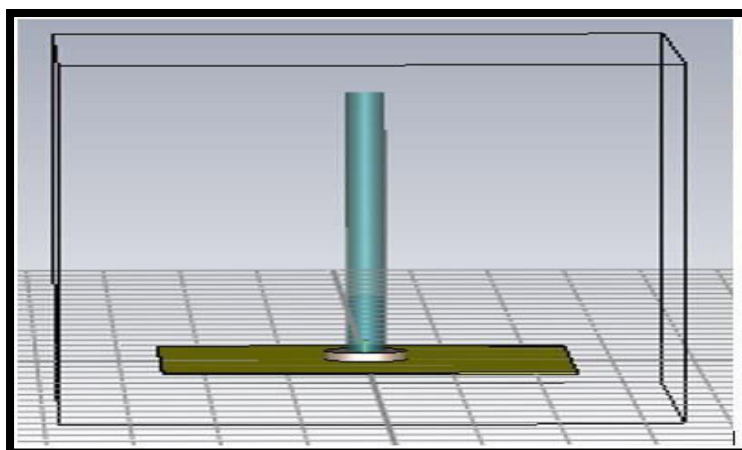
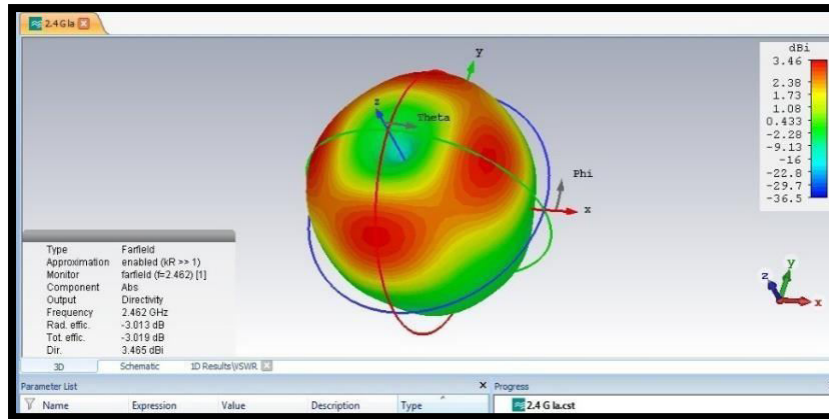


Figure 2: Monopole antenna in CST tool.

This figure represents a design of monopole liquid antenna by using software simulation tool. By using resonant frequency, we test the result parameters of the designed antenna in CST tool this result's will be discussed below.

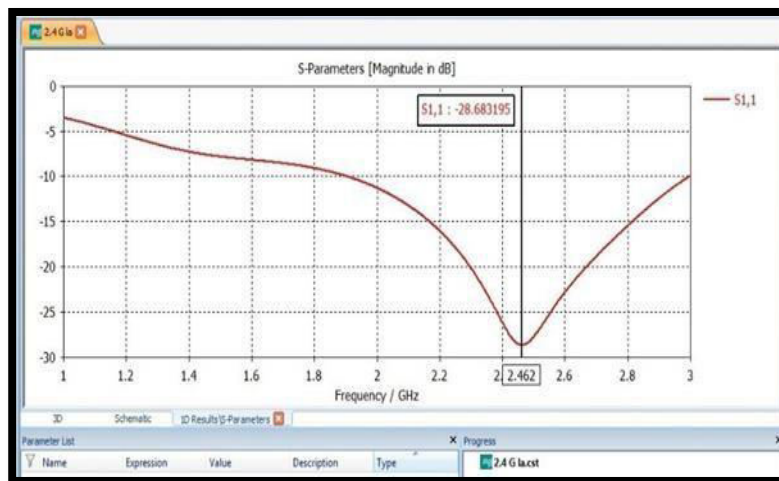
### III. SOFTWARE SIMULATED RESULTS



**Figure 3: Radiation pattern, directivity and gain of antenna at 2.4GHz.**

In Fig 3 the radiation pattern, directivity and gain of antenna is described. In radiation pattern an omnidirectional donut structure is obtained in which red color defines the higher radiation rate and dark blue color describes the lower radiation rate of the antenna. The designed antenna gives the highest radiation pattern gain of about 3.46dBi through simulation.

The reflection co-efficient, S11 parameter is shown in Fig 4. S11 represents how much power is reflected from the antenna, and hence is known as the reflection coefficient. If S11=0 dB, then all the power is reflected from the antenna and nothing is radiated. The highest reflection co-efficient -28.68 dB is obtained for 2.4GHz frequency.



**Figure 4: S11 parameter of antenna.**

Fig 5 shows VSWR of antenna at 2.4GHz frequency. VSWR value of 1.07 is recorded at frequency of 2.4GHz. VSWR is a measure of how efficiently radio-frequency power is transmitted from a power source. For a well-designed antenna VSWR should lie between 1 to 2. It numerically describes how well the antenna is impedance matched to the radio or transmission line.

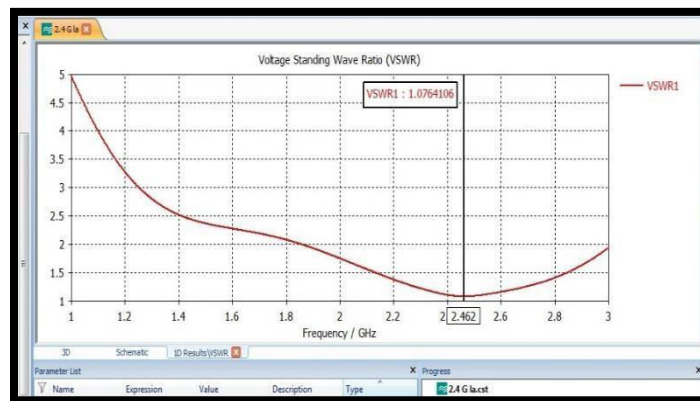


Figure 5: VSWR of antenna.

#### IV. HARDWARE IMPLEMENTATION RESULTS

Hardware implementation of monopole antenna is carried out by following methodology and software designing. Implemented antenna is tested through VNA (Vector Network Analyzer) and its S11 parameters is shown in Fig 6. Distilled water is filled to tube up to 15mm of height and antenna resonates at 6GHz. In Fig 7 distilled water is filled to tube up to 40mm of height and antenna resonates at 3.5GHz. In Fig 8 distilled water is filled to tube up to 60mm of height and antenna resonates at 2.75GHz and 3GHz.

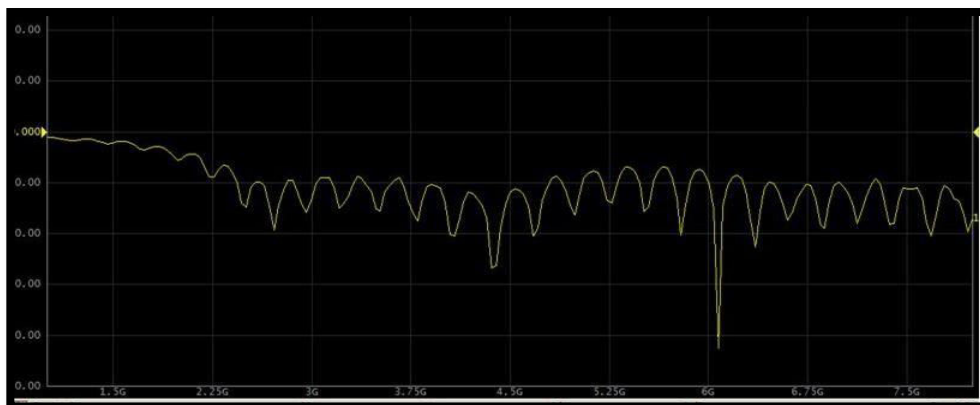


Figure 6: Distilled water at height 15mm, monopole antenna resonates at 6GHz frequency.

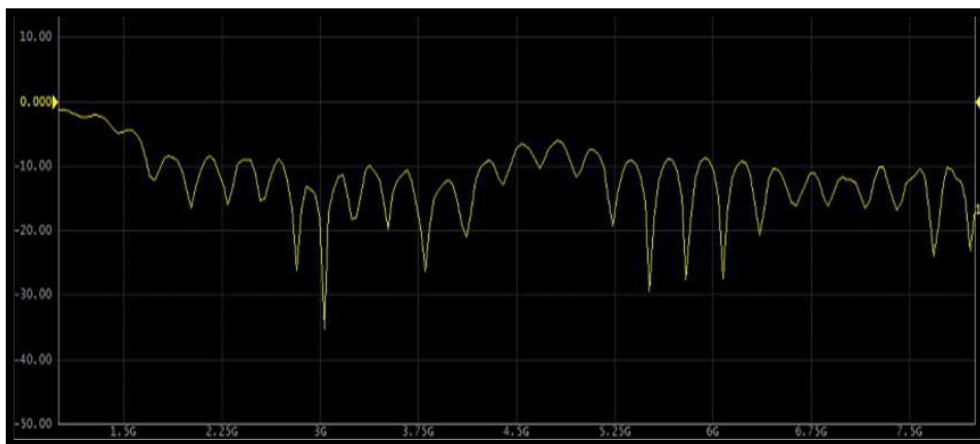


Figure 7: Distilled water at height 40mm, monopole antenna resonates at 3.5GHz frequency.

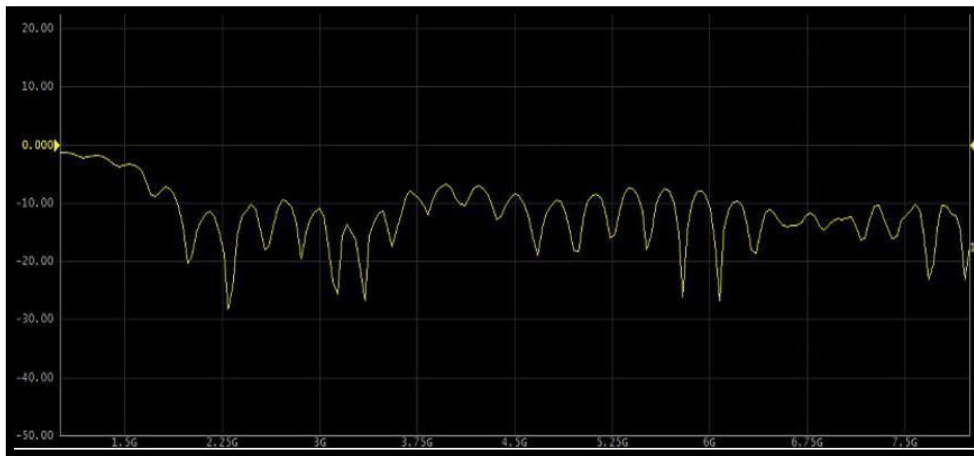


Figure 8: Distilled water at height 60mm, monopole antenna resonates 2.75 and 3GHz frequency.

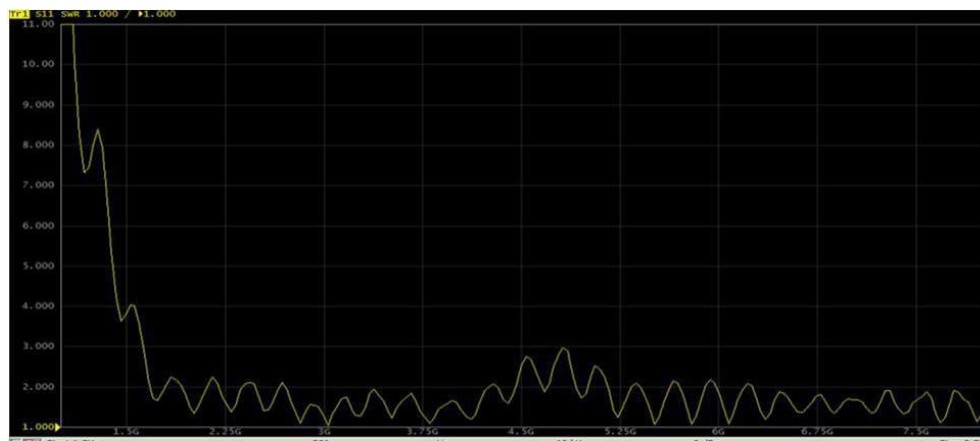


Figure 9: VSWR Parameter of monopole antenna.

VSWR of monopole antenna is measured and it lies between 1 to 2 for frequency from 1.75GHz to 6.75GHz as shown in Fig 9.

Type of water	Water level in mm	VSWR	S11 in dB	Frequenc
Sea water	25	1.5	-20	700MHz
Sea water	50	1.08	-13.7	450MHz
Sea water	70	1.6	-8	250MHz
Distilled water	15	1.3	-42	6GHz
Distilled water	40	1.12	-28	3.5GHz
Distilled water	60	1.1	-35	2.75GHz

Table 1: VSWR and S11 for different water level

Table 1. tabulates the result of sea water and distilled water in antenna with its VSWR, S11 and their frequencies.

## V. CONCLUSION

Liquid antenna has been developed for wireless communication in realtime. Liquid antenna is designed to work in ISM (Industrial, scientific and medical) band frequency 2.4GHz and 435MHz, antenna parameters such as VSWR, S11 and radiation pattern are obtained and verified. VNA is used to test the designed antenna in real time and results agree well with the simulations. Liquid antenna is designed for monopole structure which results in increasing bandwidth depending on the level of liquid. It has been demonstrated that the monopole liquid antenna with a dielectric layer is superior to the traditional antenna in the following aspects: a) a large bandwidth with reasonable efficiency, b) cost-effective, c) transparent, d) conductivity and frequency reconfigurable characteristic.

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