Novel RFID Conformal Tag Antennas for Liquid Level Detection Applications

Bassant H. El Swiefy [1], M. I. Ahmed [1], Hala El Sadek [1], and Wagdy R. Anis [2]

[1] Department of Microstrip Circuits
Electronics Research Institute, Cairo, 11483, Egypt
d.bassant.h@eri.sci.eg

[2] Department of Electronics and Communication
Ain Shams University, Cairo, 11566, Egypt
wagdyanis51@yahoo.com

***Abstract* ─** Detection of liquid level in large tanks is presented in this paper. The liquid level is detected using a transmitter and RFID tag antennas as a receiver. The transmitter antenna is a Vivaldi with wide bandwidth from 0.5 GHz to 3 GHz. The Vivaldi antenna is fabricated on FR4 with $\varepsilon_r = 4.3$ and thickness of 0.8 mm. Two conformal RFID tag antennas are used as receiver antennas. The conformal antenna is placed on Rogers Ultram 3850 flexible substrates with $\varepsilon_r = 2.9$ and a thickness of 0.1016 mm. The conformal antenna is designed to set on a cylindrical tank made from PVC material. The first tag works at 0.9 GHz and the second tag works at 2.45 GHz. Water and Oil are used as liquids for testing. The antennas are simulated using CST microwave studio simulator Ver.14. The system is also fabricated and measured. Good agreement is achieved between simulated and measured results.

***Index Terms* ─** Conformal, microstrip, RFID tag, tank, Vivaldi.

I. INTRODUCTION

Tank flooding becomes a major cause of pollution in both residential and industrial areas. Majorly caused by overflows of water and volatile poisonous industrial liquids from the storage tanks [1]. First, a mechanical technique with wireless sensor networks using frequency reconfiguration with microstrip patch antennas is used. Frequency reconfiguration is achieved by mechanically changing the dielectric properties of the antenna and thereby obtaining a tunable frequency range from 2442 MHz to 2716 MHz [2]. The antenna can sense and transmit the information simultaneously with reduced complexity and less power consumption. The proposed antenna could be used as a fast wireless sensor for remote fluid level monitoring in wireless sensor networks [2]. The need for remote monitor and control of the tank flooding by real-time communication has motivated researches in Radio Frequency Identification. RFID tag antennas have their application in many major fields. The operating frequency of the tag antenna for an intended application needs to be specified from the onset of the design as the geometry specifications that may be altered depending on the selected application frequency [3]. Volumetric sensors are kept in the water tank for the detection of the leakage and further, a reserved tank is present underneath the main tank to store the leaked liquid with the assistance of an electric valve [4].

Using radio frequency signals to identify different liquids by a compact, cylindrical dielectric resonator antenna (CDRA). The proposed CDRA sensor is excited by a rectangular slot through a 3-mm-wide microstrip line. The proposed CDRA acts as a sensor because different liquids have different dielectric permittivities and, hence, will have different resonance frequencies. Two different types of CDRA sensors are designed and experimentally validated with four different liquids (Isopropyl, ethanol, methanol, and water) [5]. Design through a series of structure evolutions a UHF RFID tag antenna that can work well on the surface of a liquid-filled bottle [6]. The main body of the tag antenna consists of a folded dipole and a loop impedance matching structure. The folded dipole is used to reduce the size of the tag antenna and improve the gain. Finally, the single-loop structure is replaced by a three-loop structure to introduce more resonances, which can optimize the impedance matching and broaden the impedance bandwidth [6].

An application of RFID tag antenna based sensing in the restaurant industry as a low-cost method to detect empty drink glasses in need of a refill. This application examines our ability to detect whether the glass is empty or full, and also whether it is possible to approximately localize an empty glass' position based solely on RSSI power measurements [7]. In this specific application scenario, this would entail detecting which table the

Submitted On: June 24, 2020
Accepted On: October 20, 2020
https://doi.org/10.47037/2020.ACES.J.351020

empty glass is placed on. Another way of detecting the level of fluids, remotely, using a chipless RFID sensor. For the sake of comparison, a classical RFID tag applied on a box is used to measure the water level, Thanks to the variation of the threshold transmitting power. A chipless RFID sensor design based on multiple resonators etched on a flexible laminate works between 2.5 and 4 GHz is proposed in [8]. A Vivaldi antenna which is kind of end-fire traveling-wave antennas has theoretically infinite bandwidth, especially at high frequencies. However, the low-end operating band is practically limited by the width of the antenna. Therefore, to have a better low-end performance, larger antenna size is usually required. According to, the slot width of a Vivaldi antenna that reaches at least half-wavelength of the corresponding frequency, effective radiation can be obtained [9].

A compact wearable dual-band quasi-Yagi RFID-reader antenna is designed for being incorporated into a smart glove. The antenna dual-band capability allows the integration of both the RFID reader at UHF band and a wireless data link at 2.4GHz, into a single compact and wearable device [11-13].

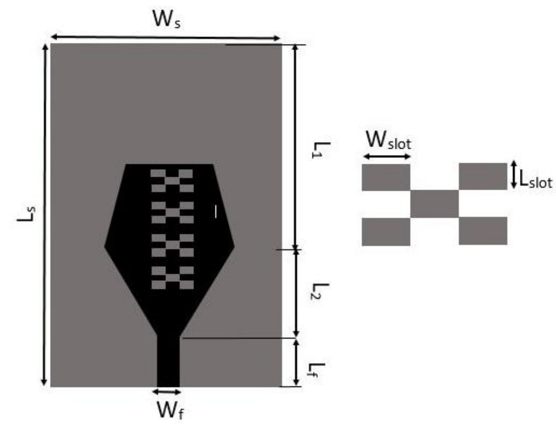
A moisture system is done using resonating structure comprises of elliptically shaped slots in a nested loop made from three different materials and deploying heat-resistant sheet on a sensing slot works from 3.5 GHz-15.5 GHz. The tag is suitable for deployed on the conformal surfaces for identification and sensing purposes [14]. The effect of curvature on passive tags and the theoretical limitations of curved tag are studied by Maxwell's equations. Also the effect of curvature on impedance load matching and gain. The curvature of passive tags have significant impact on the performance of readability [15]. Conformal chipped RFID tag antenna operates at 902-928 MHz. It consists of two microstrip patches with narrow gap filled with microchip. The tag antenna is measured in free space, metal and on human arm. The radiation efficiency of the tag is approximately 95% in free space, 60% on metaland about 50% on human arm model. While the read range of tag antenna is about 3.5m [18].

In our paper, a pentagon monopole antenna is investigated to act as an RFID passive tag. Rectangular slots are etched on antenna surface to adjust operation at multiple resonances as well as improving the impedance matching. The partial ground is used with the inserted dumbbell-shaped structure to enhance the bandwidth.

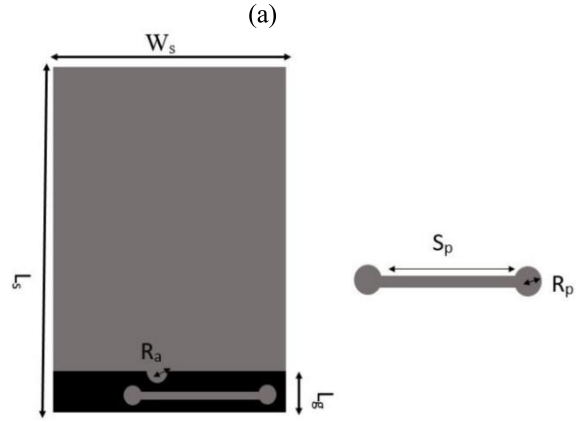
II. PLANAR ANTENNA DESIGN

A. First tag

The configuration of a pentagonal monopole antenna is shown in Figs. 1 (a), (b). The top and bottom sides of the antenna are printed on two separate substrates with an air gap between them. The air gap is filled with foam. The pentagon patch was chosen as it provides high gain and wide bandwidth. Rectangular slots are inserted in the patch surface to adjust resonance to the desired frequency. The material of the substrate is flexible Roger 3850 with a thickness $h = 0.1016$ mm and dielectric constant $\varepsilon_r = 2.9$. The structure is filled by foam with $h = 0.3$ mm and $\varepsilon_r = 1.07$. A partial ground plane with a cut in the middle with radius $R_a = 2.825$ mm is used to enhance the bandwidth. The partial ground has a dumbbell shape. The radius of its circles is R_p=4.95 mm and the space between them is S_p=40.2 mm. The overall dimensions are 89x95 mm^2. Four arrays of five rectangular-shaped slots are cut into the patch surface. The dimensions of each slot are 4 mm in length and 2mm in width. The patch is excited through a 50 Ω microstrip feed line. This planar patch is simulated using same CST microwave studio ver.14. The obtained impedance bandwidth is 76%. All geometrical dimensions of the proposed antenna are presented in Table 1.



(a)



(b)

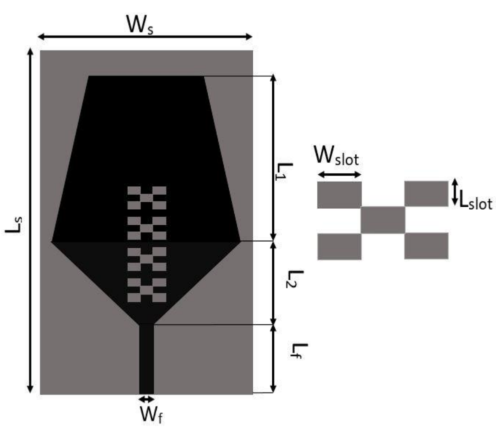
Fig. 1. (a) The top view of the first tag, and (b) the bottom view of the first tag.

Table 1: Pentagon patch antenna dimensions in mm

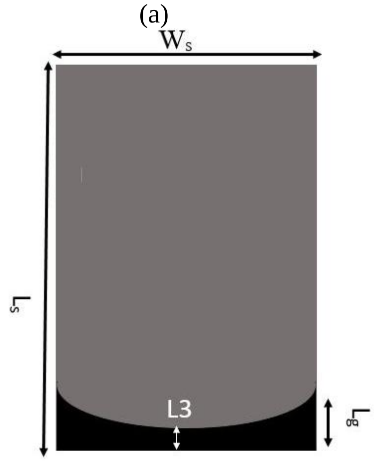
Antenna Paramter	Dimension (mm)	Antenna Paramter	Dimension (mm)
Ws	89	Lslot	4
Ls	95	Wslot	2
Lg	13.5	L1	62.6
Lf	13.5	L2	18.85
Wf	2.25	hfoam	0.3
hsub	0.1016	Ra	2.825
Sp	40.2	Rp	4.95

B. Second tag

The configuration of the same pentagonal monopole antenna with the same material and height but has a difference in the ground is shown in Figs. 2 (a), (b). A partial ground plane is used with the circular shape at a length Lg = 20.8 mm from the end of the substrate. This difference in the ground leads to a difference in the frequency response. The overall dimensions are 87 x 125.5 mm^2. The dimensions of the proposed antenna are presented in Table 2.



(a)



(b)

Fig. 2. (a) The top view of second tag, and (b) the bottom view of the second tag.

Table 2: Second pentagonal antenna dimensions in mm

Antenna Paramter	Dimension (mm)	Antenna Paramter	Dimension (mm)
Ws	87	Lslot	4
Ls	125.5	Wslot	2
Lg	20.8	L1	75.66
Lf	15	L2	46.65
Wf	2.18	L3	14.85
hsub	0.1016	hfoam	0.3

C. Vivaldi reader

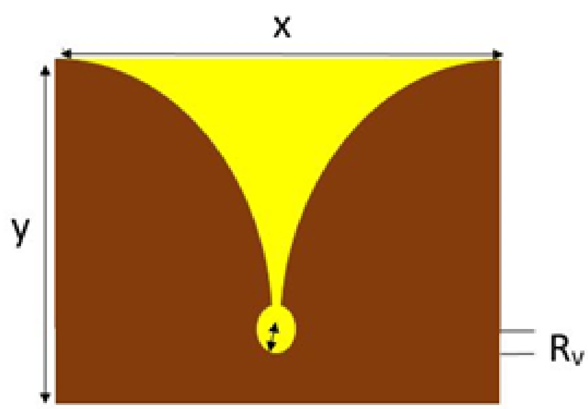
Figure 3 shows the design of the transmitter Vivaldi antenna with antipodal shape ending with a circle with no ground and has an incremental line ending with a circle. The radius of circle R_f is 9 mm. The radius of circle R_v is 3.9 mm. The dielectric substrate used is chosen FR4 with a thickness of 0.8 mm, a dielectric constant of 4.3, and a tangent loss of 0.025. The exponential profile curves are employed in this design which can be described by the following:

$$y = 88.7(e0.0007x - 0.85e - 0.0617x + 1.87),$$
$$2g1 \leq x \leq W/2 \text{ [10]}.$$

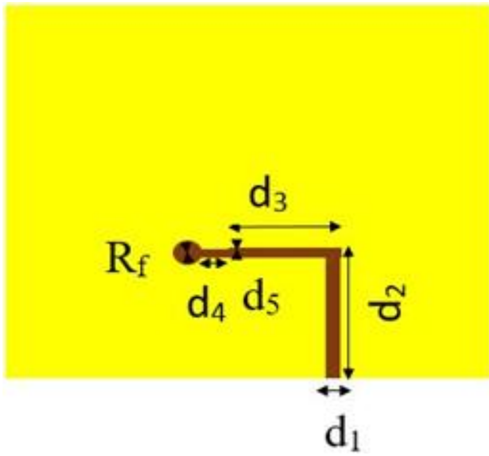
The overall dimensions of the antenna are 258×250 mm^2. A 50-Ω SMA connector is used to feed the antenna. The Vivaldi antenna is used in the experimental setup as a transmitting reader antenna. All dimensions of the proposed antenna are presented in Table 3.

Table 3: Vivaldi antenna dimensions in mm

Antenna Paramter	Dimension (mm)	Antenna Paramter	Dimension (mm)
x	280	d_2	65
y	285	d_3	42
R_v	22	d_4	10
R_f	19.5	d_5	0.6
d_1	1.63	hsub	0.8



(a)



(b)

Fig. 3. (a) The top view of Vivaldi reader, and (b) the bottom view of Vivaldi reader.

III. CONFORMAL ANTENNA DESIGN

In Fig. 4 the configuration of the first conformal tag printed antenna and second tag printed antenna are placed on the tank as shown. The first antenna is bent with angle = 10 degrees and placed at a height of 65 mm from the top of the cylindrical tank. The second tag is also bent on the same tank but with a distance of about 160 mm from the first tag. The Vivaldi reader is far from the tank at a distance = 105 mm ta act in the far-field radiation zone. The overall tank has a radius = 150mm and with a height of 590 mm.

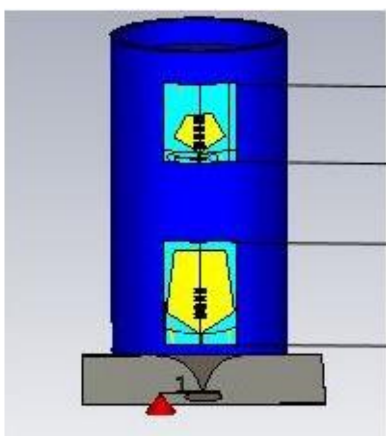


Fig. 4. The configuration of the first and second tags on the PVC tank.

IV. SIMULATION AND EXPERIMENTAL RESULTS

A. Planar antennas results

1-First Tag

The planar tag is fabricated by using a wet photolithography technique. Figure 5 shows the fabricated antenna. Figure 6 shows a comparison between the simulated and measured results of the return loss of the planar tag printed antenna. The measured results show a return loss of -35 dB at a frequency of 3.42 GHz while simulation gives a return loss of -48.588 dB at 3.398 GHz.

(a) Front (b) Back

Fig. 5. The fabricated first tag antenna.

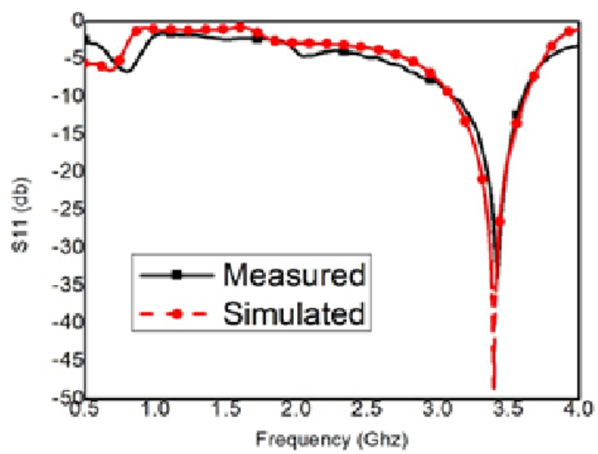
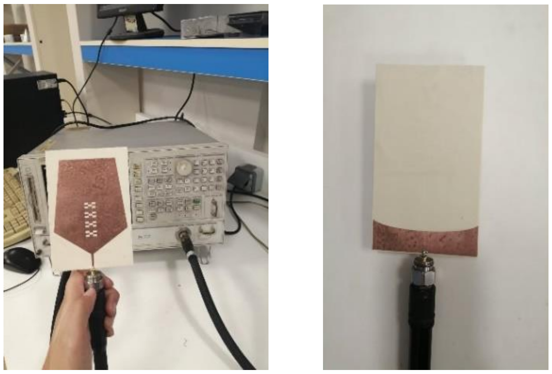


Fig. 6. Comparison between simulated and measured results of the pentagonal planar first tag antenna.

2-Second Tag

The planar tag is fabricated by using the same wet photolithography technique. Figure 7 shows the fabricated antenna. Figure 8 shows a comparison between the simulated and measured results of the return loss of this planar tag printed antenna. The measured results show a return loss of -28 dB at a frequency of 1.28 GHz while simulation gives a return loss of -29.795 dB at 1.2525 GHz. This minor difference is considered due to the fabrication tolerance as in the manual SMA connector soldering.



(a) Front (b) Back

Fig. 7. The fabricated second tag antenna.

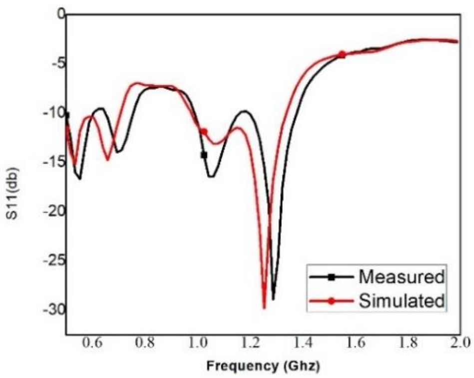
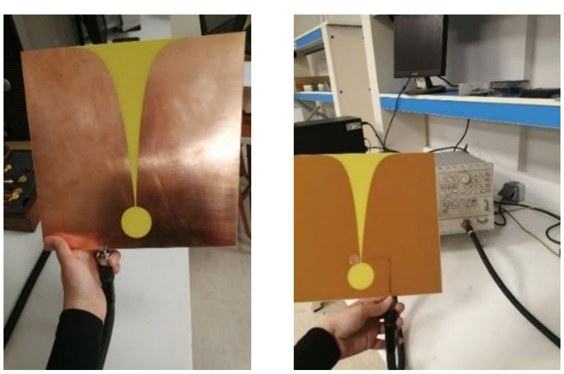


Fig. 8. The simulated and measured results of the planar second pentagonal tag printed antenna.

3-Vivaldi Reader

The antenna has been simulated and fabricated using photolithography. Figure 9 shows the configuration of the simulated and fabricated antenna. Figure 10 shows a comparison between the simulated and measured results. The measured results show a return loss of -43 dB at a frequency of 0.8 GHz and a return loss of -30 dB at a frequency of 2.35 dB while simulation gives a return loss of -22.8 dB at 0.865 GHz and gives a return loss of -26 dB at 2.4 GHz, respectively.



(a) Front (b) Back

Fig. 9. The fabricated Vivaldi reader after fabrication.

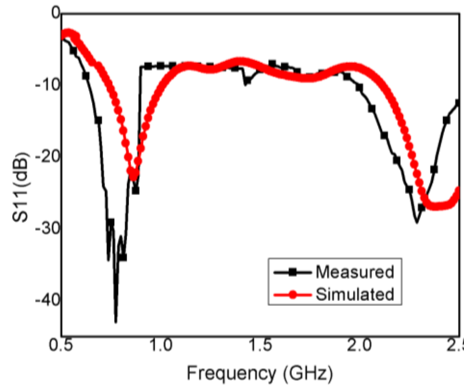


Fig. 10. Comparison between simulated and measured results.

B. Conformal antennas results

1-In Empty Tank Case

The liquid level is detected using a transmitter and receiver RFID tag antenna. The transmitter antenna is Vivaldi and the receiver are two tags on the tank. Figure 11 shows the configuration of the experimental setup of two antennas and Vivaldi one while the tank is empty. The measured result shows a return loss of -45 dB at a frequency of 0.9 GHz and a return loss of -20 dB at a frequency of 2.45 GHz while the simulated one shows a return loss of -35 dB at a frequency of 0.9 GHz while gives a return loss of -25 dB at 2.5 GHz. Figure 12 shows the comparison between this simulated and measured results. The coupling between two tag antennas which are the first and second tags is illustrated in Fig. 13. The figure shows that S_{12} which resembles the coupling magnitude is always under-15dB. This illustrates that there is approximately no coupling affects the results of antenna scattering parameters S_{11} [16].

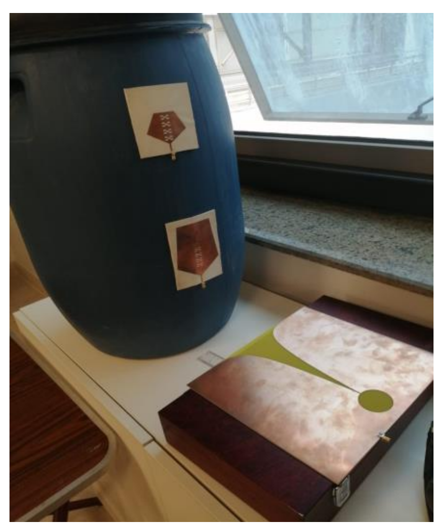


Fig. 11. Experimental setup tank with first and second tags and Vivaldi reader in front of them.

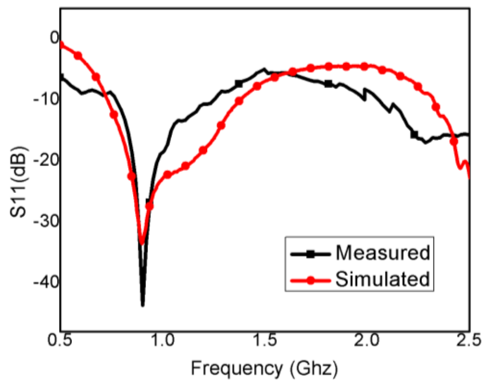
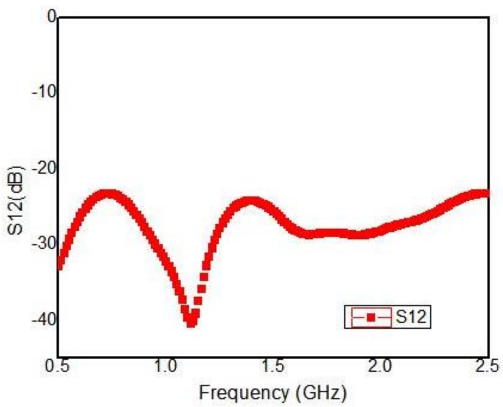
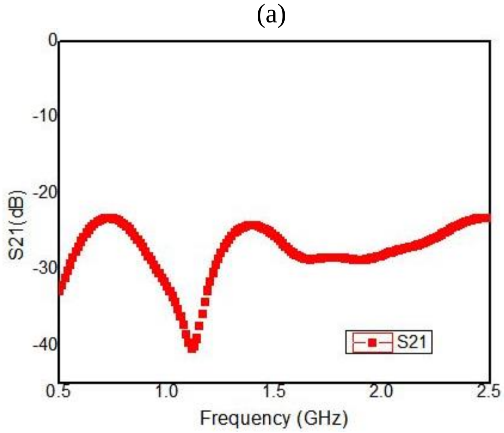


Fig. 12. Comparison between simulated and measured results in an empty case.



(a)



(b)

Fig. 13. Coupling parameter results between the two conformal tag antennas on the PVC tank: (a) S12 result and (b) S21 result.

2-In Case of Water of Level of 150 mm

In this case, the tank is filled with water at a level that covers the first antenna. The water has a dielectric constant $\varepsilon_r = 79$ .The measured result shows a return loss of -10 dB at a frequency of 0.9 GHz and a return loss is kept the same -20 dB at a frequency of 2.45 GHz. The results of S_{11} at first frequency 0.9 GHz, in this case, have been largely decayed as a result of water presence. Figure 14 shows the comparison between these measured results in case of an empty and filled the tank with water that covers only the first tag.

Applying Debye model, as water is dispersive material so its permittivity changes with frequency. The Debye model is the dielectric relaxation response of an ideal, non interacting population of dipoles to an alternating external electric field. It is usually expressed in the complex permittivity ε of a medium as a function of field's frequency ω:

$$\varepsilon(\omega) = \varepsilon_{\infty} + \frac{\Delta\varepsilon}{1 - i\omega\tau},$$

$$\Delta\varepsilon = \varepsilon_S - \varepsilon_{\infty}.$$

Where ε_∞ is the permittivity at the high frequency limit, ε_s is the static, and τ is the characteristics relaxation time of the medium [17].

For water first order Debye model has $\varepsilon_\infty = 3.1$, $\varepsilon_s = 78.4$, $\tau = 8.27e\text{-}12$ and thermal conductivity = 0.6 w/k/m. Figure 15 indicates the results of S_{11} with water Debye order covers first antenna

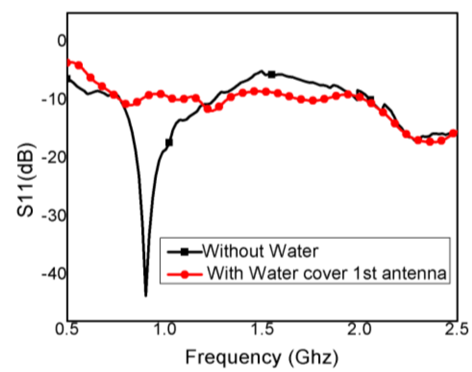


Fig. 14. A comparison between the measured results in case of empty and filled PVC tank with water that covers only the first tag.

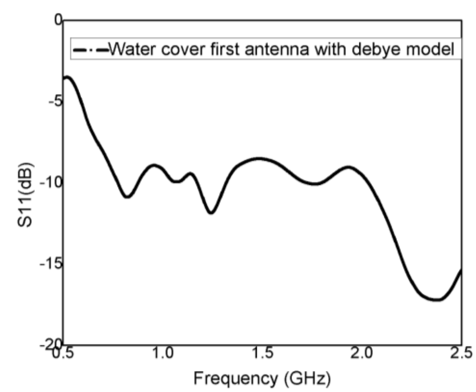


Fig. 15. The results of S_{11} taking into account Debye first order model for water that covers first antenna.

3-In Case of Water at Level=300mm

In this case, the tank is filled with water at the level that covers the first antenna and second antennas. The measured result shows a return loss of -10 dB at a frequency of 0.9 GHz and a return loss of -7 dB at a frequency of 2.45 GHz. The results of S_{11} at first frequency 0.9 GHz and second frequency 2.45GHz, in this case, have been decayed as a result of water presence. Figure 16 shows the comparison between these measured results in the case of an empty and filled tank with water that covers the first and second antennas. Applying water first order Debye model. Figure 17 indicates the results of S_{11} with water Debye order covers two antennas.

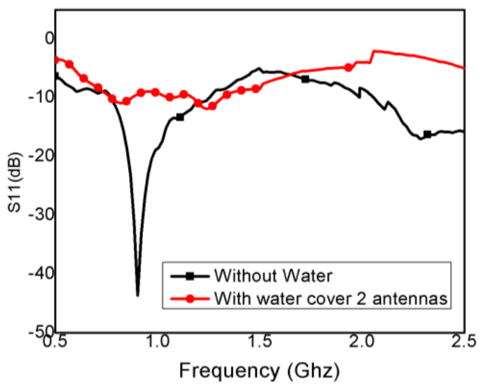


Fig. 16. Shows a comparison between the measured results in case of empty and filled PVC tank with water that covers first and second tag antennas.

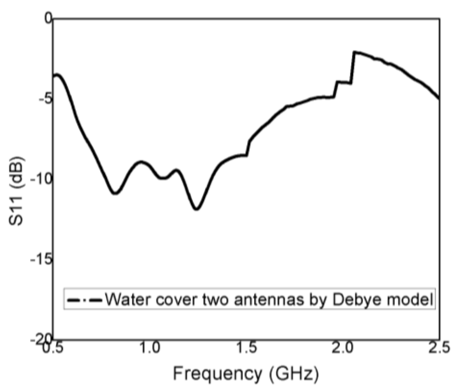


Fig. 17. The results of S_{11} taking into account Debye first order model for water that covers two antennas.

4-In Case of Oil at Level=150 mm

In this case, the tank is filled with oil at a level that covers only the first antenna. The oil has a density of 0.9 kg/m^3 and dielectric constant $\varepsilon_r = 3$. The measured results show a return loss of -13 dB at a frequency of 0.9 GHz and a return loss of -23 dB at a frequency of 2.45 GHz. Figure 18 shows the comparison between these measured results in the case of a PVC tank filled with oil and filled with water that covers only the first tag.

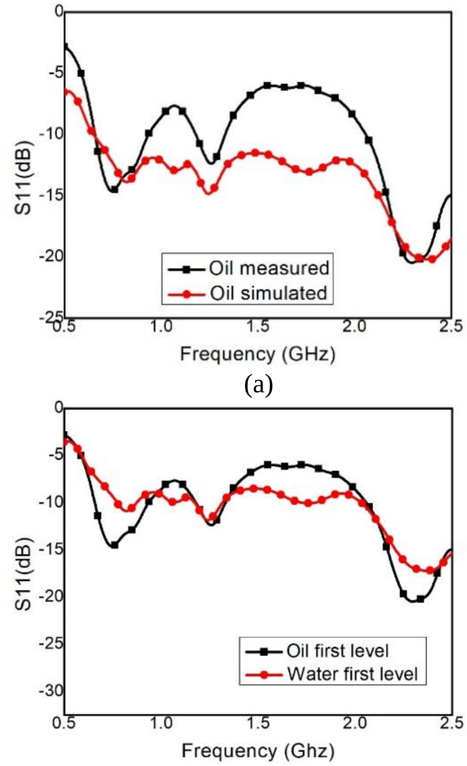


Fig. 18. (a) Shows a comparison between the measured and simulated results of PVC tank filled with oil covered the first tag only, and (b) shows a comparison between the measured results in case of the filled tank filled with oil that covers the first tag.

In the following Table 4, there is a comparison between the paperwork and the most similar work in literature from different design parameters and functional aspects. From the table, it shows that our design has merits of multiple frequency operations with flexible configuration although of its larger size.

Table 4: Comparison between other work and our work

	Frequency (GHz)	**Size**	**Thickness (mm)**	**Chip**	**Flexible**
This work	2.45 0.9	87x125.5 89x95	**0.4016**	**No**	**Yes**
[3]	0.85	48x27.7	0.8	Yes	No
[5]	5.25	30x30	1.6	No	No

V. CONCLUSION

A liquid level is detected using two RFID conformal pentagonal tags working at two different frequencies and a Vivaldi reader antenna. The two designed tag antennas made from flexible substrate Roger 3850 are designed, analyzed, and fabricated in this paper. The Vivaldi reader antenna is made from FR4 material with high gain design. The two tags antennas are bent on the PVC tank. Comparisons between results of an empty and full tank with different liquids are illustrated which shows a change of responses. For the cases of the filled tank that covers the tag antennas than the empty tanks which verify the functionality of level detection due to either water or oil liquids.

REFERENCES

[1] A. Atojoko, M. Bin-Melha, E. Elkazmi, M. Usman, R. Abd-Alhameed, and C. See, "Liquid level monitoring using passive RFID tags," *2013 8th IEEE Design and Test Symposium*, Marrakesh, pp. 1-5, Dec. 2013.

[2] A. Raveendran, P. Mathur, and S. Raman, "Mechanically frequency reconfigurable antenna and its application as a fluid level detector for wireless sensor networks," *URSI Asia-Pacific Radio Science Conference (AP-RASC)*, New Delhi, India, pp. 1-4, Mar. 2019.

[3] A. Atojoko, R. A. Abd-Alhameed, H. S. Rajamani, N. J. McEwan, C. H. See, and P. S. Excell, "Design and analysis of a simple UHF passive RFID tag for liquid level monitoring applications," *Internet Technologies and Applications (ITA)*, Wrexham, pp. 484-488, Sep. 2015.

[4] S. Ravichandran, "Liquid level monitoring system using IoT," *International Science Press I J C T A*, pp. 215-218, Nov. 2016.

[5] A. Iqbal, A. Smida, O. Saraereh, Q. Alsafasfeh, N. Khaddaj Mallat, B. Lee, "Cylindrical dielectric resonator antenna-based sensors for liquid chemical detection," *Sensors*, vol. 19, no. 5, pp. 1-9, Mar. 2019.

[6] S. He, Y. Zhang, L. Li, Y. Lu, Y. Zhang, and H. Liu, "High performance uhf rfid tag antennas on liquid-filled bottles," *Progress In Electromagnetics Research*, vol. 165, pp. 83-92, Jan. 2019.

[7] R. Bhattacharyya, C. Floerkemeier, and S. Sarma, "RFID tag antenna based sensing: Does your beverage glass need a refill?," *IEEE International Conference on RFID*, Orlando, FL, pp. 126-133, Apr. 2010.

[8] A. Guillet, A. Vena, E. Perret, and S. Tedjini, "Design of a chipless rfid sensor for water level detection," *15 International Symposium on Antenna Technology and Applied Electromagnetics*, pp. 25-28, June 2012.

[9] D. Geng, D. Yang, H. Xiao, Y. Chen, and J. Pan, "A novel miniaturized vivaldi antenna for ultra-wideband applications," *Progress In Electromagnetics Research C*, vol. 77, pp. 123-131, Jan. 2017.

[10] Y. Liu, W. Zhou, S. Yang, W. Li, P. Li, and S. Yang, "A novel miniaturized vivaldi antenna using tapered slot edge with resonant cavity structure for ultra wide band applications," *IEEE Antennas and Wireless Propagation Letters*, vol. 15, pp. 1881-1884, Mar. 2016.

[11] R. K. Singh, A. Michel, P. Nepa, and A. Salvatore, "Wearable dual band Quasi Yagi antenna for UHF RFID and 2.4 Ghz applications," *IEEE Journal of Radio Frequency Identification*, pp. 1-1, June 8, 2020.

[12] V. Le, U. Lemmer, and E. Mackensen, "Analysis of miniaturized printed flexible RFID/NFC antennas using different carrier substrates," in *IEEE Journal of Radio Frequency Identification*, pp. 1-1,10 June 2020.

[13] M. Liu, W. Yu, and M. Xu, "Security job management system based on RFID and IoT technology," *6th International Conference on Control, Automation and Robotics (ICCAR)*, Singapore, Singapore, pp. 44-48, June 4, 2020.

[14] I. Jabeen, A. Ejaz, M. Riaz, M. Khan, A. Akram, Y. Amin, and H. Tenhunen, "Miniaturized elliptical slot based chipless RFID tag for moisture sensing," *Applied Computational Electromagnetics Society Journal*, vol. 34, no. 6, pp. 1366-1372, Oct. 2019.

[15] D. Arumugam, D. Engels, and M. Mickle, "The effect of curvature on the performance and readability of passive uhf RFID tags," *Applied Computational Electromagnetics Society Journal*, vol. 25, no. 3, pp. 206-217, Mar. 2010.

[16] G. L. Matthaei, L. Young, and E. M. T. Jones, *Microwave Filters, Impedance-Matching Networks, and Coupling Structures*. Norwood, MA: Artech House, 1980.

[17] Z. He, K. Huang, C. Guo, Z. Jin, and C. Hou, "A Debye dispersion model of a two-layered material," *AIP Advances*, vol. 9 no. 4, pp. Apr. 2019.

[18] H. Rajagopalan and Y. Rahmat-Samii, "Platform tolerant and conformal RFID tag antenna: Design, construction and measurements," *Applied Computational Electromagnetics Society Journal*, vol. 25, no. 6, pp. 486-497, June 2010.

Bassant Hesham Elswiefy received a B.Sc. degree, with grade excellent with honors, in Electronics and Communication Engineering from the Higher Technological Institute, Egypt in 2014. She has joined the Electronics Research Instute (ERI) since 2016 as an Research Assistant.

Mohamed Ismail Ahmed received a B.Sc. degree, with grade very good with honors, in Electronics and Communication Engineering from the Zagazig University, Zagazig, Egypt in 1998. He was awarded the M.Sc. degree in Electrical Engineering from Al Azhar University, Cairo, Egypt in 2007. His M.Sc. area was in design, simulation, fabrication, and measurement of fractal microstrip patch antennas. He received a Ph.D. degree in the area of design and implementation of wideband antenna array based on electromagnetics band gap structures (EBG) at Ain Shams University, Cairo, Egypt. Currently, he is a Researcher Assistant at the Microstrip Department, Cairo, Egypt in 2015. He has joined the Electronics Research Instute (ERI) since 1999 as an Assistant Researcher. From 2010 to 2012, he was a Researcher in the Prince Sultan for Advanced Technology Research Institute (PSATRI), King Saud University, Saudi Arabia. His research interests include the design, simulation, and fabrication of microstrip antenna array for wideband applications in the microwave band. Aslo, he interests in antenna mutual coupling reduction using EBG and DGS.

Hala Elsadek Professor and Dept. Head at Electronics Research Institute. She had her master degree, Japan, 1996 while Ph.D. with University of California, Irvine, USA, 2002. Her research interests are in RF wireless communications, electromagnetic engineering and microstrip antenna systems. She has six books and six patents. She is a single and co-author in more than 150 Research papers. Elsadek participates in more than 35 research and development projects at the national and international levels. She is awarded several prizes as Women in Innovation Certificate, Egypt, 2018, Silver Medal from 10th international invention Fair in the Middle East, 2018, Cambridge International College, Certificate of Recognition, 2017, Award of Recognition in the Fourth Cairo Innovates Exhibition 2017 and Award for the First Best Researcher in Electronics Research Institute in 2019. She is included in several biographical indexes and acts as reviewer in many international societies in her field as IEEE AP-S and MTT.

Wagdy Refaat Anis Emeritus Professor at Electronics Engineering and Electrical Communications. Faculty of Engineering, Ain Shams University, Cairo, Egypt. He had master degree, Japan, 1973 while Ph.D. at 1977.