A Miniature Raspberry Shaped UWB Monopole Antenna based on Microwave Imaging Scanning Technique for Kidney Stone Early Detection

Ahmed Jamall Abdullah Al-Gburi, IM Ibrahim and Z. Zakaria

Abstract--- *A small size of monople antenna is presented and experimentally discussed for kidney stone early detection at an ultra wide band frequency range (3-11) GHz. The malformation of the kidney can be specified through ultra-sound machine. the kidneys may have an atomic alanomalya like kidney malformation, in turn develops in its location and semblance kidny malformation may as well grow because of the creation of stones, inherent defect, Clogging of urine &c. For surgical operations it is extremely necessary to locate the precise posistion of stone in the kidney. The ultra-sound machine is high inoizing radiation that effect the human body, micro-wave imaging can be a perfect substitute, A UWB monopole antenna scanning technique authorized to recognize the right and accurate position of stone in the kidney. this antenna has very low profile, simple structure, easy to manufacture and light weight, hence produced good results in radiation characteristics, High gain of 5 dB at frequency 11GHz. The substrate is based on the RT Rogers 5880 with dielectric constant of 2.2. With overall dimensions of 17.5 mm x17.5 mm x 0.8 mm. Anauthentic verification system will be developed for the purpose of create antenna response level overt issues that could represent the human body. The water is selected to be use in the practical measurement because it has nearly identical density characteristics as human body.* In The Interest Of *demonstrate stone existence in a symmetrical medium, small calcium stone is adjusted to measure the anomaly.*

Keywords--- *UWB Raspberry Monopole Antenna, Kidney Stone, Microwave Imaging, Reflection Coefficient.*

I. INTRODUCTION

Micrwave testing and Ultra-Wide Band recognition, commonly in the (3.1-10.6) GHz, more and more being reviewed and applied for biomedical applications such as microwave imaging. certainly, UWB technology for kidny stone detection have many benefits: i) in the frequency band equivalent to these ultrashort radar oscillations, a relevant disparity seems among the dielectric constant and conductivity of well tissues and those of malicious tissues. (ii) These oscillations produce, a sufficient permeation in-depthinside the kediny and a decision of, at a minimum, one point five centi-meter. This variety of UWB frequencies gives us to have at the same time a best high-sensitivity resolution and a sufficient permeation depth for kidney imaging. Antennas are one of the system's core and their properties heavily influence the accomplishment as a whole system.

Kidney stone disease is one of the most painful medial condition of human life. each year more than 500.000 of people go to the emergency room because of kidny stone. The stone illnesses keep unrecognizedat his early stage,

Ahmed Jamall Abdullah Al-Gburi, Center for Telecommunication Research and Innovation (CeTRI), Faculty of Electronics and Computer Engineering (FKEKK), Malacca, Malaysia. E-mail: Engahmed_jamall@yahoo.com
IM Ibrahim, Center for Telecommunication Research and Innovation (CeTRI), Faculty of Electronics and Computer Engineering (FKEKK), Malacca, Malaysia. E-mail: imranibrahim@utem.edu.my
Z. Zakaria, Center for Telecommunication Research and Innovation (CeTRI), Faculty of Electronics and Computer Engineering (FKEKK), Malacca, Malaysia. E-mail: zahriladha@utem.edu.my

DOI: 10.37200/IJPR/V24I2/PR200476
Received: 22 Dec 2019 | Revised: 07 Jan 2020 | Accepted: 18 Jan 2020

that could make casualties the kidney when they grow. In consideration of kidney blocked can be dangerous, investigation of the issue in the primary step is desirable. Ultrasound machine is one of the actually ready-made low in charge and universally applied for detecting kidney ailments[1]. in [2]there is an investigation of detecting the kidny stone by using serum, with the purpose of depicts one existence in an identical medium, minor size of calcium stone have been Brought with several sizes inline to simulate the anomaly. Low profile of patch antenna was simulated and examined at various frequencies such as scientific and medical band: 2.26 GHz, 2.38 GHz, 2.5 GHz, and 2.62 GHz for the Radio frequency (RF) inspection imaging system with the purpose of discover and determine stones in the kidney. however, he had been implemented by using a single of frequency to detect the kidney stone by simulating the patch antenna.

The kidney could be morphological anomalies such as kidney puffiness, otherwise change in location and manifestation. Kidney anomaly could also grow cause to the figuration of stones , tumour cells, inherent monstrosities, interception of urine [3]and especially rise a much painful condition for the sufferer. For surgical it is extremely necessary to determine the precise position of stone in the kidney. The ultra-sound machineis of clow disparity and have a fleck din and can influence human body[4]. This leads the investigation of kidney anomalies partly demanding task. consequently, microwave imaging technique could be a best choice.

Moreover, several ways with various materials have been used in breast cancer detection with same concept as kidney detection, the ordinarily used is the mammography machine, ultrasound imaging and Magnetic resonance imaging (MRI). These machines still have some issues, the instrument is not capable to figure out brest cancer at all stages, the standard of transparency and precision are still very low and expensive in term of cost[5]–[8]. These obstacles encourage researchers to manage a good way that can solve those limitations. thus, a detection system has been progressing by using Ultra-Wide Band (UWB) with a frequency of (3.1-10.6) GHz according to the Federal Communications Commissions (FCC) standard. This technology is called as Ultra-Wide Band (UWB) Microwave Imaging[9]. UWB Microwave Imaging utilizes antenna as an early detection method to transmit microwaves signals from sender to the breast surface. Reflected signals from breast is used by the antenna as a parameter to localize the existence of the tumor. This technique is appropriate for medical applications because it has many features like non ionizing, high sensitivity and low cost and also secure for the patient [10]

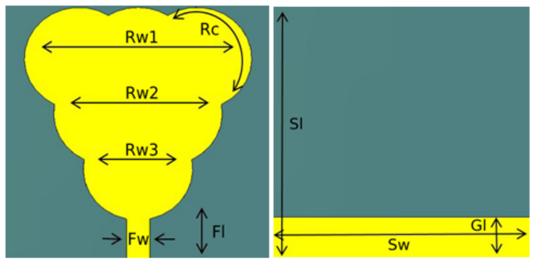
This study has achieved to detect practically the stone’s existence in a kidney by microwave imaging. The human body was constituted by a water with identical density characteristics, human body got 60% he averages adult human body is 50-65% water, averaging around 57-60%,The water is used in the practically measurement in order that it has similar density characteristics as human body, The percentage of water in infants is much higher, typically around 75-78% water. In this article Low profile of uwb monopole antenna was designed and tested at ultra wide and frequency in 3.1-10.6 for the Radio frequency (RF) analysis imaging system with the intention of detect and localize stone within the human body. Ultra wide band frequency is used in the interest of locate the more convenient one eligible to detect the stone's presence work, the corporal experimentation system is prepared. Results and discussion are introduced in the third section and the fourth section is the conclusion.

DOI: 10.37200/IJPR/V24I2/PR200476
Received: 22 Dec 2019 | Revised: 07 Jan 2020 | Accepted: 18 Jan 2020

International Journal of Psychosocial Rehabilitation, Vol. 24, Issue 02, 2020
ISSN: 1475-7192

II. ANTENNA DESIGN

To increase the antenna bandwidth, modifications in the structure have been made. First, the full ground plane has been replaced by a quarter ground plane and its length Gl has been optimized in table.1, the arrangement of the uwb raspberry monopole antenna is indicated in Fig. 1.a, b, the uwb monopole antenna is fabricated on a Rogers RT5880 (Lossy) comes with Dielectric constant of 2.2 and 0.0035 of Loss tangent. The proposed radiating structure comprises of a circular monopole antenna fed by 50 Ω microstrip line The impedance of monopole antenna is matched by means of a quarter wavelength (λ/4) transformer.



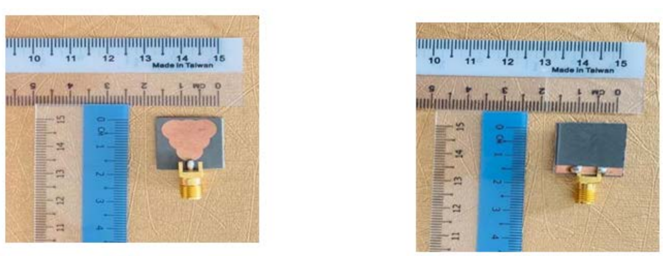
(a) (b)

Fig. 1: Geometry of the proposed antenna: (a) front view, (b) back view

Table 1: Optimized parameter list

Parameters	Value in mm
S1	17.5
Sw	17.5
Rc	3.53
Rw1	13.9
Rw2	10.4
Rw3	6.9
Fw	1.5
Fl	2.7
Gl	2.8

The implemented antenna was considered and simulated using CST electromagnetic field simulation software. Fig.2. (c) front side measured of designed UWB Raspberry Monopole antenna structure Fig.2. (d) shows the back view of the proposed antenna, as shown it's a quarter ground, it helps to achieve an ultra wide band frequency range (3-11) GHz.



(c) (d)

Fig. 2: Measuremt prototype: (a) front view, (b) back view

DOI: 10.37200/IJPR/V24I2/PR200476
Received: 22 Dec 2019 | Revised: 07 Jan 2020 | Accepted: 18 Jan 2020

The experimental measurement of S11 is done by using Anritsu VNA Master MS2038C (3 GHz - 11 GHz). Fig.3 illustrated the simulation and measured comparison of the return loss for UWB monopole antenna, shows that the return loss performance of UWB Raspberry shaped monopole antenna is radiating Ultrawide band range with frequency between 3 GHz and 11 GHz of frequency with 8 GHz of bandwidth performance.

The measurement results in free space are in good agreement with simulation results, compare with the simulation result, it shows that the resonant frequency of measurement result had been shifted. For example, the first resonant frequency at 3 GHz for measurement had been A bit shifted to 2.956 GHz with -9.9 dB of return loss, and ended with frequency of 11.1 GHz instead of 11 GHz for the simulation one with -12 of return loss performance.

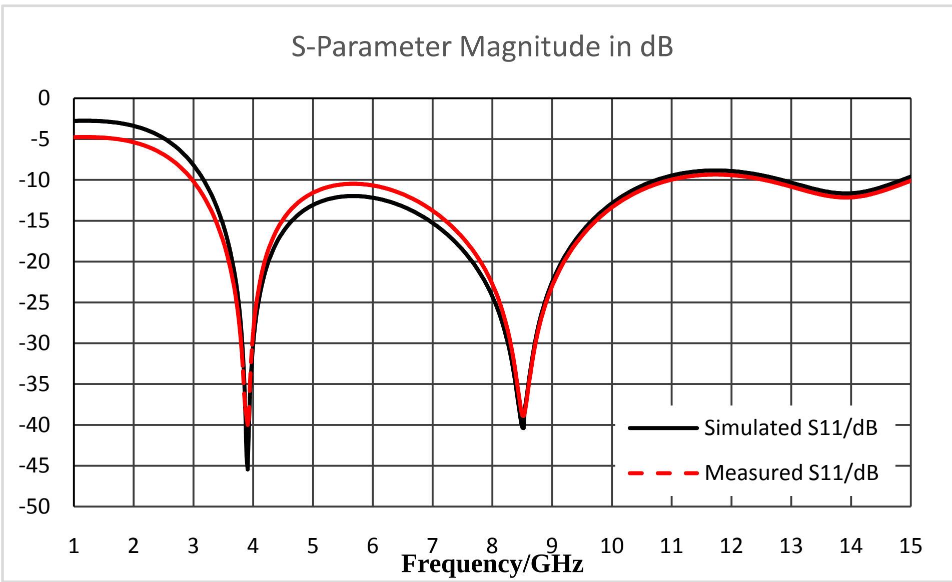


Fig. 3: Simulated and Measured Reflection coefficient results of UWB Raspberry Monopole antenna

Fig.4 illustrate the performance of UWB Raspberry shaped monopole antenna. Compare with the simulation result of the antenna gain, it shows that the measured result had been decreased. For example, at the first resonant frequency at 3GHz (lowest gain), the gain reduced from -0.861 dB to -1.67 dB. This also shown in the second (max gain) resonant frequency at 11 GHz, reduced from 5.2 dB to 4.82 dB of antenna gain.

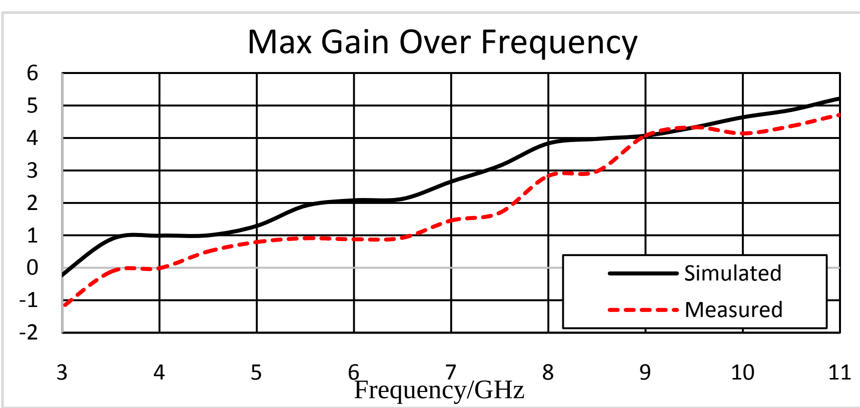


Fig. 4: Simulated and Measured gain results of UWB Raspberry Monopole antenna

DOI: 10.37200/IJPR/V24I2/PR200476
Received: 22 Dec 2019 | Revised: 07 Jan 2020 | Accepted: 18 Jan 2020

III. THEORETICAL STUDY

An monopole antenna placed straight over z orientation, a Transverse mode (TM)is deployed in the XY coordinate plane and the Helmholtz's the linear partial differential equation is Staelin, et al. [12]:

$$(\nabla^2 + k^2)\mathrm{A} = 0$$

Where

$$K^2 = k_0^2(\varepsilon_r + i\frac{\sigma}{\omega\varepsilon_r})$$

$$K_0 = \omega\sqrt{\mu_0\varepsilon_0}$$

In the upper equations, ∇^2 is the Laplacian provider, k is the wave number, A is the amplitude may represents as electric field(Ez)in the z direction, , εr is the relative dielectric constant of a material is its (absolute) , σ is an medium conductivity, ω is the angular frequency, ε0 is the free space dielectric constant, and μ0 is the permeability.

Non-zero magnetic field components are derived from Ez by using Faraday's law in frequency domain as follows:

$$H_x = -i\frac{1}{\omega\mu_0}\frac{dE_z}{dy}$$

$$H_y = i\frac{1}{\omega\mu_0}\frac{dE_z}{dx}$$

The dispersive dielectric characteristics of human body are needed to be determined as opposed to frequency. Debye conceptualisation of the first or second order has been mightily used to pattern the dispersive communications[11]. This pattern turns the equation coefficients to the calculated data and measures the correlation among the electric flux density(D) and electric field (E). First-order Debye pattern is of the form:

$$\varepsilon_{rc}(\omega) = \varepsilon_r(\omega) + i\frac{\sigma(\omega)}{\omega\varepsilon_0} = \varepsilon_\infty + \frac{\varepsilon_s - \varepsilon_\infty}{1 - i\omega\tau} + i\frac{\sigma_s}{\omega\varepsilon_0}$$

Where εrc is the relative complex dielectric constant, ω is the angular frequency, εr is the ratio relative to the vacuum permittivity, σ is the power, ε0 is the electric dielectric constant of free space., ε∞ dielectric constant at the high frequency limit, εs is the static low frequency permittivity,τ is the relaxation time constant, and $\sigma_s$is the static power.

IV. MEASUREMENT PROCESSES

The calcium stones applied in the measurement are place in a vial filled with water of ¼ litter (60 ml). Uwb monopole antenna is placed at 1.5 cm from the water surface with a view to check and to identify the stones, AC-DC Switching Power Supply with UPS/ Backup Battery Charging Feature - 12V has been added to convert electrical power efficiently, another device has been used to control the speed rotation called DC motor controller (speed only), the speed of a DC motor can be controlled in by varying the supply voltage and By varying the flux, that can varying the current through field winding, the vial was placed on the base of DC motor to make the flask rotate 360 degree , the read on behind this rotation is to make the stone detection more accurate at all stages . The uwb monopole antenna is scanned on the water surface using an sylendering motor rotation with the purpose of shift on

DOI: 10.37200/IJPR/V24I2/PR200476
Received: 22 Dec 2019 | Revised: 07 Jan 2020 | Accepted: 18 Jan 2020

the destination range in x, y coordinates. The micro-conrller was setted up The vector analyzer will be used to calculate the antenna respond at unattached points together the target domain. The reflection coefficient dimensions are carried for every x, y coordinates location detailing. for the sake of measure, the reflection coefficient (S11), we used a portable Vector Network Analyzer (VNA) View going up to 12 GHz with a tracking generator which allowed us to perform reflection measurements. Therefore, the antenna is connected to the VNA and then the measured data is collected with the portable VNA that is as well linked to a portable computer to investigate and exhibit outcomes. Fig. 1 demonstrates the shot workbench for the antenna wiping system for early detection.

Fig. 5: Early detection process system for kidney stone

V. Detecting Outcomes And Consideration

The first experiment is done by putting the antenna (1.5 cm) away from an empty vial to inspect the resonance of antenna between 3-5 GHz of frequency ranges, when the vial is empty there is no reflection comes from the stone, however, the antenna not detecting the stone, the return loss (S11) at frequncy3.8 GHz is -80 dB of antenna performance as illustrate in fig.6.

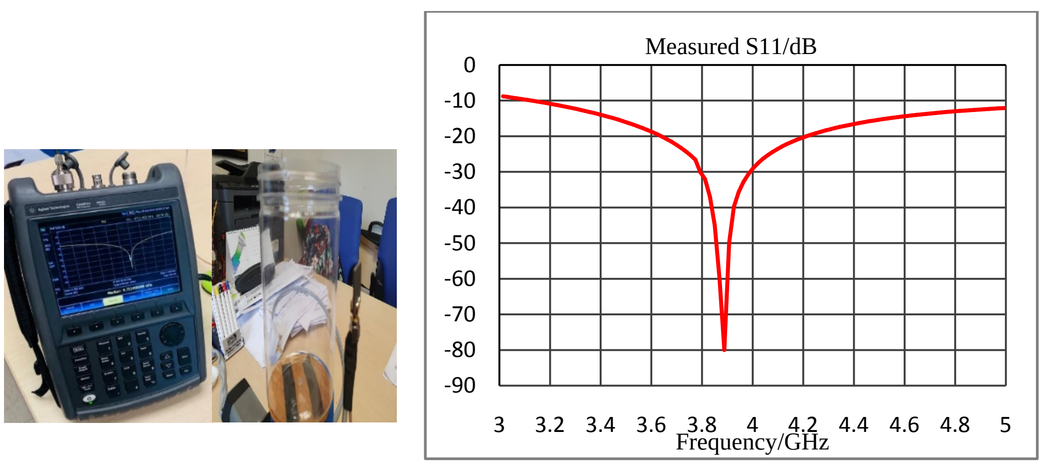


Fig. 6: Measured Reflection coefficient (S11) on an empty flask

The further stage is to fill the flask with water (¼ litter (60 ml)) (4 cm of thickness) which represents a symmetrical human body. As shown in Fig. 7. illustrates the measured S11. We realize that at 3.8 GHz of resonant frequency the reflection loss (S11) is -40.4, the S11 is Increased due to the density of water.

DOI: 10.37200/IJPR/V24I2/PR200476
Received: 22 Dec 2019 | Revised: 07 Jan 2020 | Accepted: 18 Jan 2020

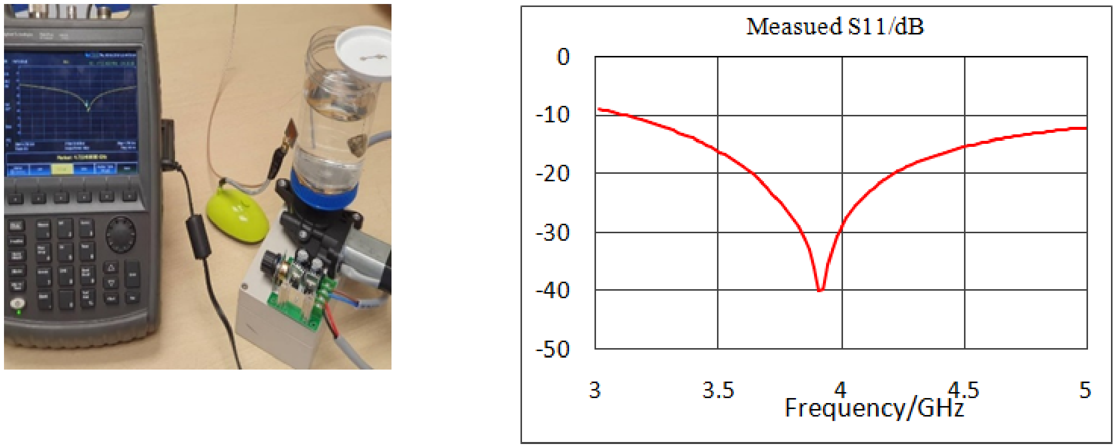


Fig. 7: Measured Reflection coefficient (S11) fill with water

The final stage is to fill the vial with water (¼ litter (60 ml)) and put the stone inside it as shown in. Fig. 8. The frequency travel into the flask and hit a boundary between flask and the stone, Some of the frequency get reflected back to the antenna, while some travel on further until they reach another boundary and get reflected, The reflected frequency are picked up by the antenna and relayed to the VNA. From the results Fig. 3 illustrates the measured S11. From the graph We see that the resonant frequency at 3.8 GHz is rising as a result of the stone with reflection loss (S11) of -28dB.

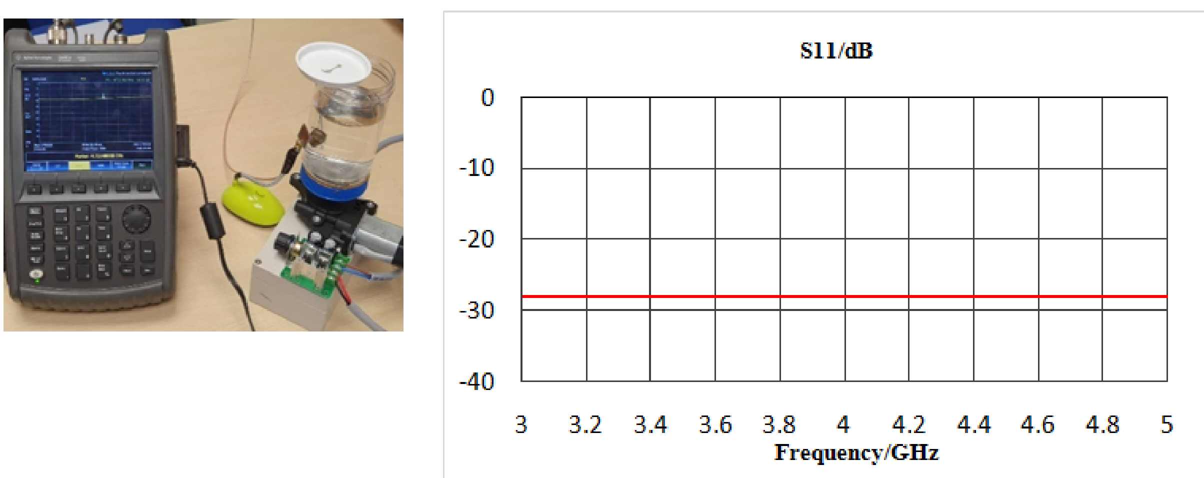


Fig. 8: Measured Reflection coefficient (S11) dip by stone

Many tests were done on 3.8 GHz of resonant frequency with an antenna to discovers the stones. In the measurmant, we submerge 3 cm calcium stone in the vial. For the uwb monopole antenna that has a resomant frequency at 3.8 GHz, we evaluate the reflection coefficient for three environments: empty vial, then with water, finally with calcium stone is immerse. Fig.9. demonstrates the reflection coefficients of the three environments related to the Uwb frequency range from (3-11) GHz.

DOI: 10.37200/IJPR/V24I2/PR200476
Received: 22 Dec 2019 | Revised: 07 Jan 2020 | Accepted: 18 Jan 2020

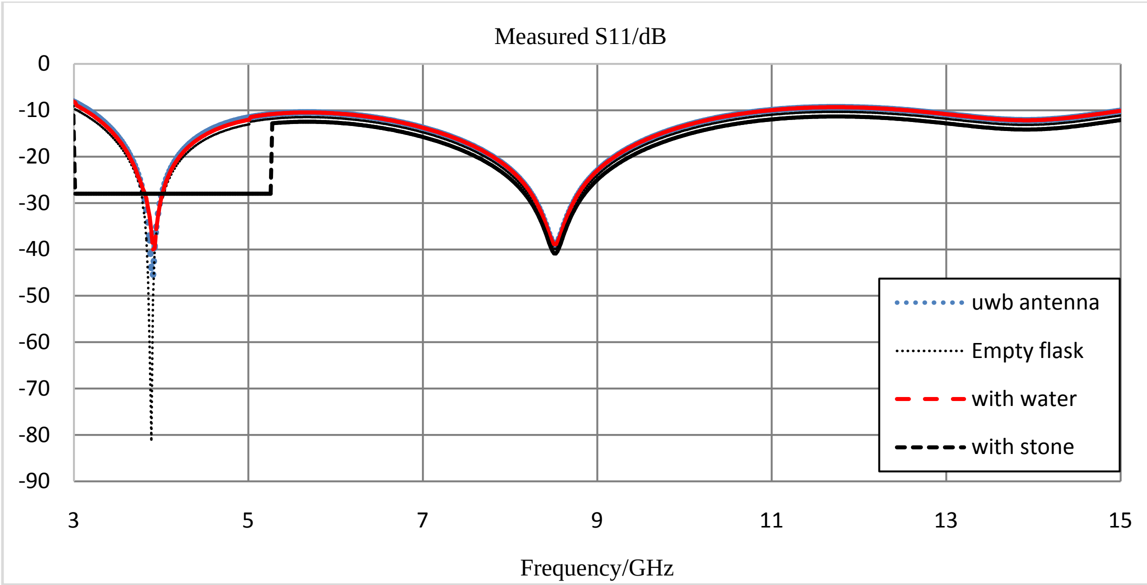


Fig. 9: Simulated and measured Reflection coefficient (S11)over ultrawide band

Around resonant frequency of 3.8 GHz, a reflection coefficient magnitudes are given in the table1. Once the antenna discovers the kidney stone the, reflection coefficient is raised to -28 dB.

Table 1: Comparison of reflection coefficient (S11) for different medium

Resonant frequency	**Medium**	**reflection coefficient (S11) [dB]**
3.8 GHz	Empty phial	-80
	Water	-40
	Water/ Calcium stone	-28

VI. Conclusion

Microwave-imaging through uwb monopole antenna wiping technique is an optimistic way for the detection of stones interior the human body, particularly in the kidney. The antenna is immersing1.5 centimeters over the purpose vial for the detection of stone's existence in water environment. In the article, we elaborated the dielectric characteristics of the human body and the First order Debye pattern. On The Basis Of the water pattern, reflection coefficient on the symmetrical water are measured. The unsymmetrical shown by stones is identified using antenna over the vial scope. Low profile UWB Raspberry Monopole antenna were simulated and measured and tested at an ultrawide band antenna (3-11) GHz for the purpose of detecting the stone. first tests proved that when the antenna resonant frequency reduced, the increasing in Reflection coefficient (S11)between symmetrical water and water with stone’s existence expand More investigates will be carried out on two stages: antenna resonsnt frequency and extra genuine pattern of kidney of human organism.

References

[1] T. Rahman and M. S. Uddin, “Speckle Noise Reduction and Segmentation of Kidney Regions From Ultrasound Image,” pp. 0–4, 2013.
[2] M. Alwan and S. Sadek, “Investigation of Kidney Stone Using A Microstrip Patch Keywords :,” vol. 3, no. 1, pp. 1–10, 2016.
[3] K. Viswanath, “Design and analysis performance of Kidney Stone Detection from Ultrasound Image by

DOI: 10.37200/IJPR/V24I2/PR200476
Received: 22 Dec 2019 | Revised: 07 Jan 2020 | Accepted: 18 Jan 2020

Level Set Segmentation and ANN Classification," pp. 407–414, 2014.

[4] W. M. Hafizah, E. Supriyanto, and J. Yunus, "Feature Extraction of Kidney Ultrasound Images based on Intensity Histogram and Gray Level Co-occurrence Matrix," pp. 115–120, 2012.

[5] S. Adnan, C. H. See, H. I. Hraga, I. T. E. Elfergani, and D. Zhou, "A Compact UWB Antenna Design for Breast Cancer Detection," pp. 6–8, 2010.

[6] L. K. Ragha and M. S. Bhatia, "Numerical Assessment of UWB Patch Antenna for Breast Tumor Detection," vol. 01, no. 03, pp. 2–6, 2010.

[7] M. El-shenawee, "Electromagnetic Imaging for Breast Cancer Research," pp. 55–58, 2011.

[8] N. Tavassolian, S. Nikolaou, and M. M. Tentzeris, "Microwave Tumor Detection Using a Flexible UWB Elliptical Slot Antenna with a Tuning Uneven U-shape Stub on LCP I . Introduction II . Geometry of the Problem III. Sensitivity to different gland arrangements," pp. 257–260, 2007.

[9] B. Borja, J. A. Tirado, and H. Jard, "An Overview of UWB Antennas for Microwave Imaging Systems for Cancer Detection Purposes," vol. 80, no. May, pp. 173–198, 2018.

[10] A. M. Hassan, S. Member, M. El-shenawee, and S. Member, "Breast Cancer Detection," vol. 4, pp. 103–118, 2011.

[11] O. P. Gandhi, B. Gao, and J. Chen, "A Frequency-Dependent Finite-Difference Time-," vol. 41, no. 4, 1993.

[12] D. H. Staelin, A. W. Morgenthaler, and J. A. Kong, Electromagnetic waves. *Englewood Cliffs, NJ: Prentice-Hall*, 1994.

DOI: 10.37200/IJPR/V24I2/PR200476

Received: 22 Dec 2019 | Revised: 07 Jan 2020 | Accepted: 18 Jan 2020