DETECTION OF KIDNEY STONE USING UWB MICROSTRIP ANTENNA

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Abstract — **Today antenna designer is paying more focus on microstrip patch antennas, because of its numerous advantages in field of communication, such as high reliability, light weight, ease of fabrication etc. But despite of its bountiful advantages, patch antenna also experiences some drawbacks which is low gain and narrow bandwidth. These drawbacks can be overcome by taking care of some parameters in the design of antenna. There are numerous designing factors affecting the radiating characteristics of antenna such as patch height, feeding techniques substrate used in manufacturing of antenna etc. The substrate material used for the antenna FR-4 having a permittivity value of 4.3. The patch and ground are of copper materials with a thickness of 0.035 mm. Finally, the parameters of the antenna such as S11(reflection coefficient), directivity, gain, VSWR (voltage standing wave ratio) and bandwidth. Hence the brief explanation of the project is about the kidney abnormality may arise due to the formation of stones, congenital anomalies, blockage of urine etc., So, it is important to identify the presence of stone in the kidney for diagnosis. In this the kidney stone detection is developed by using a microstrip patch antenna. This antenna has a very low profile, simple structure, easy to fabricate and lightweight. A microstrip patch antenna scanning system allows to detect the presence of stone in the kidney. This antenna has a very low profile, simple structure, easy to manufacture, and lightweight. The proposed antenna, kidney phantom and stone were designed and simulated in CST Studio.**

Index Terms: **UWB microstrip antenna, CST software.**

1.INTRODUCTION:

Microwave testing and Ultra-Wide Band recognition, commonly used 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 kidney stone detection has many benefits: (i) in the frequency band equivalent to these ultrashort radar oscillations, a relevant disparity seems among the dielectric constant and conductivity of functional tissues and those of malicious muscles. (ii) These oscillations produce a sufficient permeation in-depth inside the kidney and a decision of, at a minimum, one point five centimeters. 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 medical conditions of human life. Each year more than 500.000 people go to the emergency room because of kidney stones. The stone illnesses keep unrecognized at his early stage, which 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. The ultrasound machine is one of the ready-made lows in charge and universally applied for detecting kidney ailments in there is an investigation of identifying the kidney stone by using 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, tumor cells, inherent monstrosities, interception of urine and especially raise a much painful condition for the sufferer. For surgical, it is essential to determine the precise position of stone in the kidney. The ultra-sound machine is of low disparity and has a fleck din and can influence the human body. This leads to the investigation of kidney anomalies, partly demanding tasks. Consequently, microwave imaging techniques could be the best choice. Moreover, several ways with various materials have been used in breast cancer detection with the 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 of figuring out breast cancer at all stages; the standard of transparency and precision are still very low and expensive in terms of cost. These obstacles encourage researchers to manage a good way that can solve those limitations. Thus, a detection system has been progressing by using the 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. UWB Microwave Imaging utilizes the antenna as an early detection method to transmit microwaves signals from the sender to the breast surface. Reflected signals from the breast are 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 serum, with the purpose of depict stone existence in an identical medium, minor size of calcium stone have been Brought with several sizes inline to simulate the anomaly. The 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 Radiofrequency (RF) inspection imaging system with the purpose of discovering and determine stones in the kidney. However, he had been implemented by using a single frequency to detect the kidney stone by simulating the patch antenna.

2. LITERATURE SURVEY:

Mohamad Alwan, Sawsan Sadek "Investigation of Kidney Stone using a Microstrip Patch Antenna Scanning System", Journal of Diagnostics, 2015 Vol.3, No.1, pp.1-10

The abnormalities of the kidney can be identified by ultrasound imaging. The kidney may have structural abnormalities like kidney swelling, or change in its position and appearance. Kidney abnormality may also arise due to the formation of stones, congenital anomalies, blockage of urine etc. For surgical operations it is very important to identify the exact and accurate location of stone in the kidney. The ultrasound images are of low contrast and contain speckle noise and could affect human body in some situations like pregnancy. This makes the detection of kidney abnormalities rather challenging task. Thus, microwave imaging could be a good alternative. A microstrip patch antenna scanning system allows to identify the exact and accurate location of stone in the kidney. A physical testing system will be developed in order to generate antenna response surfaces on material which could represent the human body. The serum is used in the experimental measurement because it has similar dielectric properties as human body. In order to represent stone presence in a homogenous medium, small calcium stone bearings of different sizes embedded are used to simulate the abnormality. Compact microstrip patch antenna was designed and tested at different frequencies in ISM band: 2.26 GHz, 2.38 GHz, 2.5 GHz, and 2.62 GHz for the RF investigation imaging system in order to detect and localize stones in the kidney.

Ahmed Jamal Abdullah Al-Gburi,, IM Ibrahim, Z. Zakaria " A Miniature Raspberry Shaped UWB Monopole Antenna Based on Microwave Imaging Scanning Technique For Kidney Stone Early Detection" International Journal of Psychosocial Rehabilitation, Vol.24, No. 2, pp.1755-1763, 2020.

A small size of monopole antenna is presented and experimentally discussed for kidney stone early detection at an ultrawide band frequency range (3-11) GHz. The malformation of the kidney can be specified through ultra-sound machine. the kidneys may have an atomic anomaly like kidney malformation, in turn develops in its location and semblance kidney 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 position of stone in the kidney. The ultra-sound machine is high ionizing 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. An authentic 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.

S, D.G., Nesasudha, M. Microstrip antenna for early stage breast cancer detection—a survey. Health Technol. 11, 1191–1204 (2021). https://doi.org/10.1007/s12553-021-00573-3

Microstrip antennas are finding growing application in medical fields mostly for imaging, diagnosis, and treatment purposes. Antenna is a key component for detection of abnormality in biological signals and can be designed to be utilized on skin as well as implanted inside body. To form a bio communication system between medical devices and exterior instruments, low power compact antennas can be designed. A specific application of microstrip antenna in microwave breast imaging is considered in this paper. Conventional methods for breast cancer detection like X Ray mammography, ultrasound and MRI has some limitation. Microwave Breast Imaging (MBI) is a promising solution to obtain precise information about breast tissues and promises accurate and safer modality for regular breast scanning. Methods to reduce effects of backscattering by placing antenna in contact with breast skin is utilized where skin can be considered as a layer of antenna substrate. This technique helps to reduces signal scattering which helps to increase tumor detection sensitivity.

Rabia Çalışkan, S. Sinan Gültekin, Dilek Uzer, Özgür Dündar, A Microstrip Patch Antenna Design for Breast Cancer Detection, Procedia - Social and Behavioral Sciences, Volume 195, 2015, Pages 2905-2911

Breast cancer affects many women and has fatal conclusions if it does not cure correctly. Early diagnosis is the most important parameter to detect and interfere with cancer tissue. Some of methods for breast cancer detection are X-ray mammography, MRI and ultrasound. However, they have some limitations. For example; between 4 and 34% of all breast cancers are missed because of poor malignant/benign cancer tissue contrast. Microwave imaging to detect breast cancer is a promising method and there are many works in this area. All materials have different permittivity and conductivity. In this work, a 3D breast structure has different permittivity and conductivity is modelled in HFSS by using Finite Element Method (FEM) to solve electromagnetic field values and a microstrip patch antenna operating at 2.45 GHz is designed and substrate material is FR4 ($\varepsilon_r = 4.4$ F/m). Slotting on microstrip patch and modifying ground plane, imaging quality is increased. About this, electric field, magnetic field distribution and current density on the antenna are evaluated.

Kahwaji, H. Arshad, S. Sahran, A. G. Garba and R. I. Hussain, "Hexagonal microstrip antenna simulation for breast cancer detection," 2016 International Conference on Industrial Informatics and Computer Systems (CIICS), 2016, pp. 1-4, doi: 10.1109/ICCSII.2016.7462400.

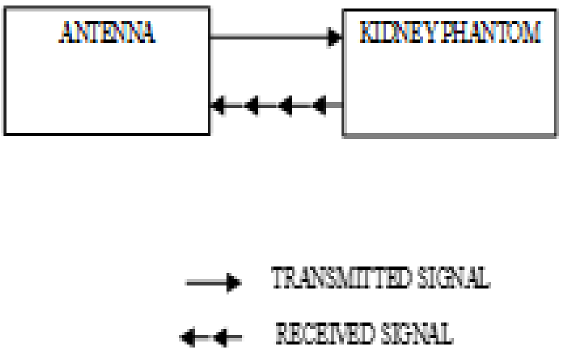
As an emerging technology, Ultrawide Band (UWB) wireless communications provides a very different approach to the antenna technology compared to narrow band systems, which has been a very attractive choice for medical antenna development. In this paper presents the design and simulation of a hexagonal microstrip antenna along with a breast phantom simulation. The antenna is simulated by introducing a hexagon slot in the center of the patch an impedance bandwidth nearly 5 GHz is achieved. The presented antenna has been designed and simulated successfully. The simulation analysis of designed antenna is carried out using HFSS software. The obtained results with this antenna make it a suitable antenna for UWB systems and portable applications.

R. Karli, H. Ammor, R. M. Shubair, M. I. AlHajri, R. Alkurd and A. Hakam, "Miniature planar ultra-wide-band microstrip antenna for breast cancer detection," 2016 16th Mediterranean Microwave Symposium (MMS), 2016, pp. 1-4, doi: 10.1109/MMS.2016.7803808.

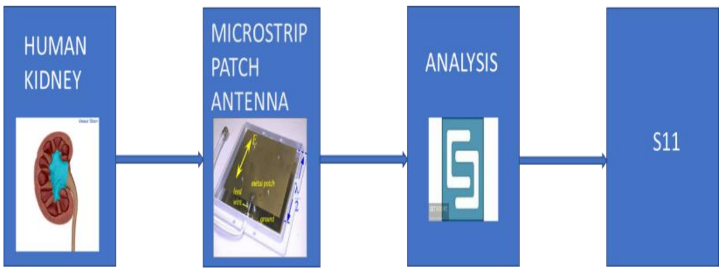
Microwave imaging is explored as an imaging modality for early detection of breast cancer. When exposed to electromagnetic waves, the breast tumor has electrical properties that are substantially different from those of healthy breast tissue. This paper for the detection of breast cancer. We examine the ability to detect tumors by a UWB microstrip antenna operating at 6 GHz. Using a simple model in the form of a cone. This model consists of the breast skin, fat, and tumor tissues. The study is done according to several distances between the patch antenna and the model of the breast. Simulation and measured results are presented, namely, reflection coefficient, gain and radiation pattern of the antenna and the current density in the breast skin, fatty tissue and the tumor to give us a clear insight into the concept studied.

3. PROPOSED METHOD:

The block diagram depicted in the below figure gives information about the system to be used in the detection of the kidney stone. The basic principle behind the system is as same as radar. The microwave input signal in the ultrawideband is sent through the patch antenna designed. Microwaves are transmitted to the kidney phantom located in front of the antenna. Microwaves undergo various phenomena like scattering, reflection and absorption when passed through any medium. The reflected signal from the kidney phantom is collected back in the antenna. Based on the changes in the reflected signal power to that of the transmitted signal power the kidney stone presence will be decided since the dielectric properties of the normal tissue varies to that of the kidney stone.

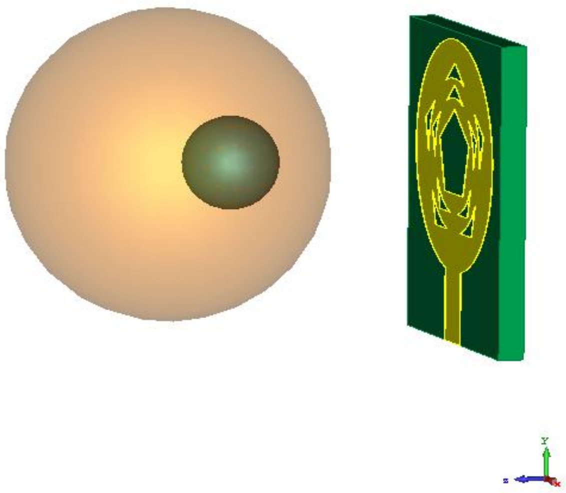


Proposed method for the detection of kidney stone:



Step-1: Kidney phantom need to be designed
Step-2: Proposed antenna need to be designed
Step-3: Radiate antenna towards the kidney phantom
Step-4: Collect backscattered signal (S11)
Step-5: Analyze and compare S11 for both kidney with & without stone

Once kidney phantoms and proposed antenna are designed, the simulation is started in CST. The simulation set up is shown in below figure.

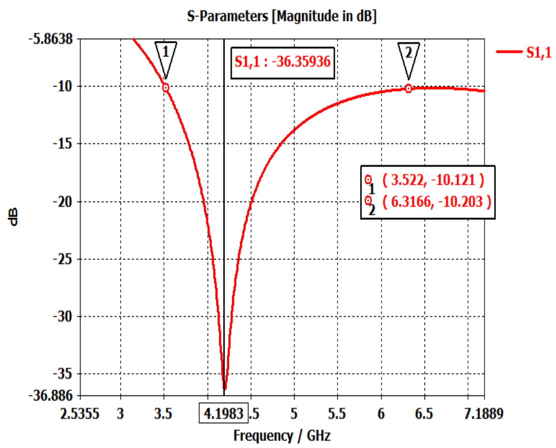


Simulation setup in CST

The kidney phantom is kept at a distance of 20 mm above the antenna, so that power of the signal reaching the phantom does not exceed the permissible limits. The simulation setup is shown in the above figure . The homogeneous phantom is taken for experimentation since there are only two dielectric profiles. The power required to find such small change in dielectric profiles is high. In CST an antenna is excited through a 1W rms Gaussian signal. After proper procedures, transient solver is executed to generate the results.

Reflection Coefficient (S11)

The S11 for the proposed antenna is illustrated in the below figure. The proposed antenna has a resonant frequency at F= 4.1 GHz. The proposed antenna produces a bandwidth from 3.5 GHz to 6.3 GHz. The return loss obtained for the resonant frequency is around -36.35 dBi.

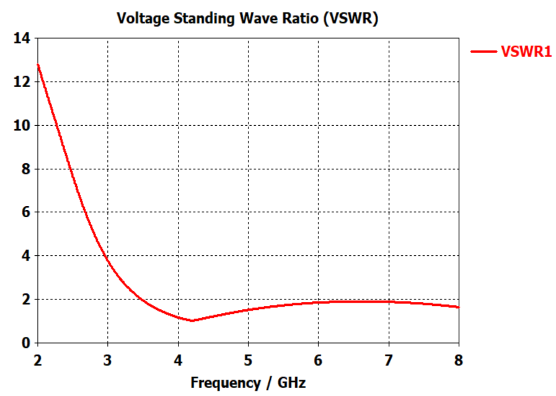


S11 for proposed antenna

VOLTAGE STANDING WAVE RATIO (VSWR)

VSWR (Voltage Standing Wave Ratio), is a measure of how efficiently radio-frequency power is transmitted from a power source, through a transmission line, into a load (for example, from a power amplifier through a transmission line, to an antenna). In an ideal system, 100% of the energy is transmitted. The VSWR is always a real and positive number for antennas. The smaller the VSWR is, the better the antenna is matched to the transmission line and the more power is delivered to the antenna. The minimum VSWR is 1.0. In this case, no power is reflected from the antenna, which is ideal.

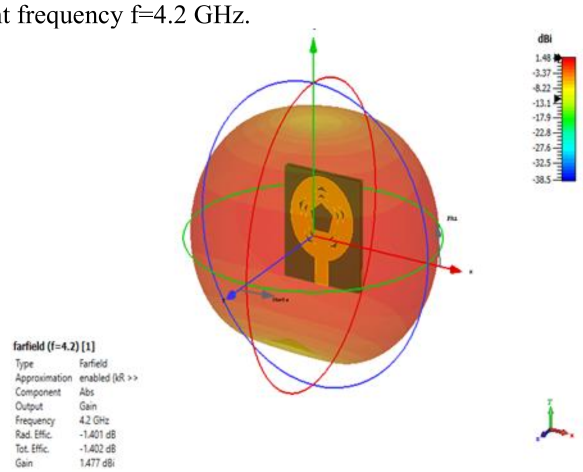
Often antennas must satisfy a bandwidth requirement that is given in terms of VSWR. For instance, an antenna might claim to operate from 100-200 MHz with VSWR<3. This implies that the VSWR is less than 3.0 over the specified frequency range. This VSWR specifications also implies that the reflection coefficient is less than 0.5.



VSWR for proposed antenna

GAIN OF PROPOSED ANTENNA DESIGN

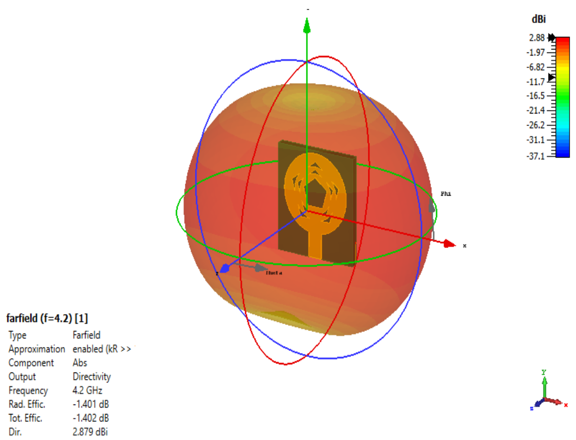
The obtained gain for the proposed antenna design is around 1.47 dBi. The 3d view of the antenna gain is shown in the below figure. The gain is calculated for the resonant frequency f=4.2 GHz.



Obtained Gain for proposed Antenna

DIRECTIVITY OF PROPOSED ANTENNA DESIGN

The obtained directivity for the proposed antenna design is around 2.87 dBi. The 3d view of the antenna directivity is shown in the below figure. The directivity is calculated for the resonant frequency f=4.2 GHz.



Obtained Directivity for proposed antenna

RADIATION PATTERN OF PROPOSED ANTENNA

The energy radiated by an antenna is represented by the Radiation pattern of the antenna. Radiation Patterns are diagrammatical representations of the distribution of radiated energy into space, as a function of direction. The radiation patterns can be field patterns or power patterns. The field patterns are plotted as a function of electric and magnetic fields. They are plotted on logarithmic scale. The power patterns are plotted as a function of square of the magnitude of electric and magnetic fields. They are plotted on logarithmic or commonly on dB scale. The major part of the radiated field, which covers a larger area, is the main lobe or major lobe. This is the portion where maximum radiated energy exists. The direction of this lobe indicates the directivity of the antenna. The other parts of the pattern where the radiation is distributed side wards are known as side lobes or minor lobes. These are the areas where the power is wasted.

H-PLANE RADIATION PATTERN OF PROPOSED ANTENNA DESIGN

The H-plane radiation pattern is generated by selecting (phi=90) and the corresponding graph is shown in the below figure. In this radiation pattern the shape is in donut shape and the main lobe is directed towards 164^0 at frequency f=4.2Ghz.

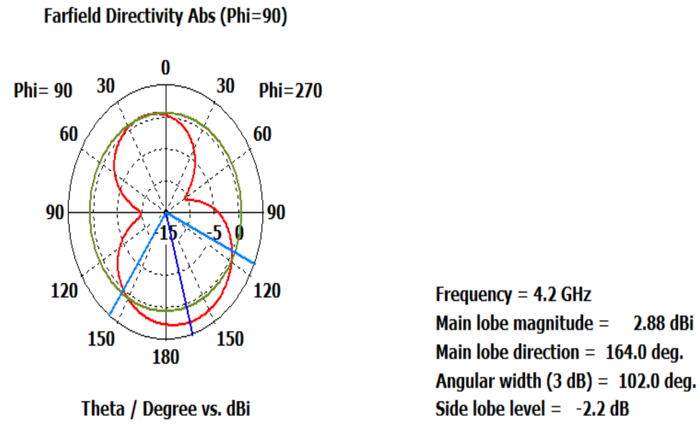


Fig. H-plane radiation pattern of Proposed Antenna

E-plane radiation pattern of Proposed Antenna

The E-plane radiation pattern is generated by selecting (phi=0) and the corresponding graph is shown in fig 6.7. In this radiation pattern the shape is in donut shape and the main lobe is directed towards 180^0 at frequency f=4.2Ghz.

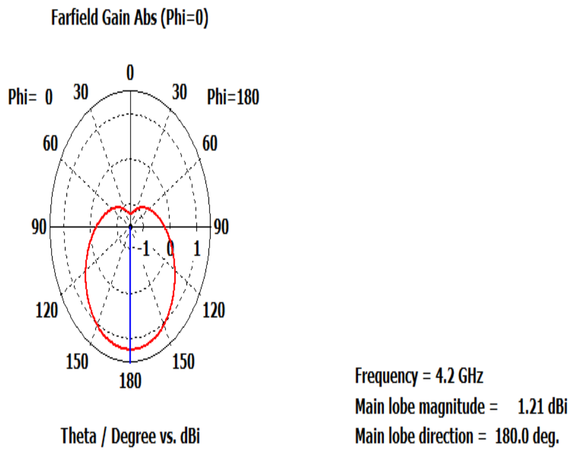


Fig. E-plane radiation pattern of proposed antenna

DETECTION OF KIDNEY STONE USING VARIATION IN RETURN LOSS:

The detection of kidney stone was based on the difference in return loss value of S11 graph for kidney without stone and kidney with stone. The S11 graph for kidney without stone and kidney with stone is illustrated in the below figure.

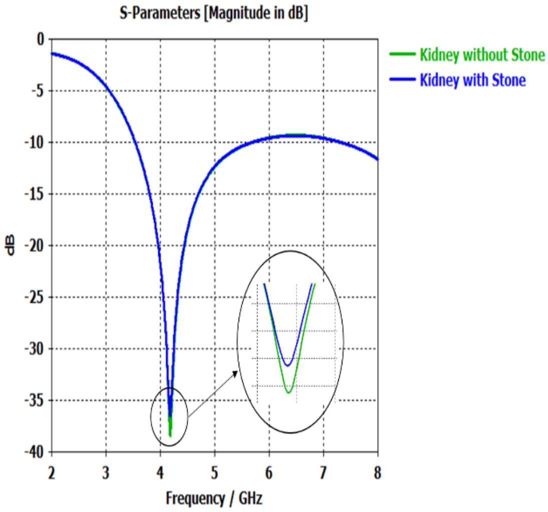


Table 6.1 return loss value for kidney with & without stone

Resonant Frequency	Types of Phantoms	reflection coefficient (S11) [dB]
4.2 GHz	Kidney without Stone	-38.46
	Kidney with Stone	-36.50

At frequency f=4.2 GHz, the return loss for kidney without stone is about -38.46 dBi and the return loss for kidney with stone is about -36.50 dBi respectively. It is observed that the return loss is lesser for kidney with stone due to the dielectric change as compared with kidney without stone. This significant change is used for the detection of kidney stone.

CONCLUSION:

A method for detecting kidney stone using UWB microstrip antenna is proposed in this work. A novel circular microstrip antenna is designed along with a kidney phantom which resembles the actual human kidney properties. The designed antenna abled to resonate at 4.2 GHz frequency and produce a gain and directivity of 1.47 and 2.87 dBi respectively. The detection mechanism is purely based on the variation in S11 value. The S11 value for kidney without stone is -38.46 dB and for kidney with stone is -36.50 dB. The kidney without stone is having lesser return loss value compared with kidney with stone. This is the key to the scientific world to develop a diagnosis device using our proposed technique to find the kidney stone in an early stage.

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