Research Journal of Medical Sciences 10 (5): 517-520, 2016
ISSN: 1815-9346

Design of Printed Antenna for Heart Failure Detection

[1]T. Pranaya Krishna, [1]C. Manoj Reddy, [1]P. Srinivas Reddy and [2]M. Neelaveni Ammal
[1]Department of ECE, SRM University, Chennai, India
[2]Department of Electronics and Communication, SRM University, Chennai, India

Abstract: The main aim of this project is to detect heart failure at the early stages using a printed array antenna. A printed antenna which is specifically designed for an early heart failure detection system operating at the ultra-high frequency band, is presented. The design procedure starts with a array structure that includes a printed antenna and a loaded patch. To significantly improve the antenna's working at various frequency the array structure is used. The array antenna used is of dimensions 27.0×35.8×1.6 mm. The polarization used is linear polarization and antenna operates in a frequency of 1-5 GHz, mainly utilizing the frequency at 2.4 GHz for the intended project outcome. The final tested antenna achieves a peak gain of -6.83 and directivity of 5.69 db. The antenna in addition to a compact microwave transceiver and an adjustable platform are then used to build a monostatic-radar-based heart failure detection system. The system is tested on an artificial torso phantom to verify the potential of such a system in the early detection of heart failure. The system detects the difference in the applied waves and the scattered waves from the human body.

Key words: Printed antenna, unidirectional antenna, ultra-high frequency antenna, array antenna, corporate feed antenna

INTRODUCTION

Unlike the traditional diagnostic system, microwave imaging systems have the potential to provide low cost, portable and non-ionizing tools for the detection and monitoring of various diseases such as breast cancer and heart failure. In the latter application which is the topic of this letter, the microwave techniques can be utilized to detect that change in the properties as an early indication of congestive heart failure.

Heart failure remains largely unexplored in general population and among people. Heart failure accounts for 30% of hospitals admissions in specialized cardiovascular units and 3-7% in general internal medicine. Over 11% of adults with heart failure have diabetes. Prevention, management and outcomes of heart failure are less well known, recent data suggest improvement in the management of risk factors in clinical settings. It's is estimated that 66,000 new cases of the heart failure are diagnosed each year in the UK and that 912,000 of the population aged 45 year and over have definite/probable heart failure. Life expectancy is increasing and the incidence of heart failure in the 75-84 year age group is 7 and 15% in those aged 85 year and above. A total of 20 studies conducted in managed care population were reviewed 5 in patients with congestive heart failure, 9 in hypertensive patients and 6 in hyperlipidemia and/or coronary artery disease patients. Management of CHF involved multifaceted programs that included the participation of multiple health care professionals, patients and physician education, promotion of intensive drug therapy and lifestyle modifications and close patient monitoring (Hu *et al*., 2008).

Microwave-based heart failure detection system require antennas operating within the ultra-high frequency band for a reasonable compromise between the required penetration in the human torso and resolution. However, the physical size of antennas operating in this frequency range will be large, while they should be compact for a portable imaging system. Moreover, the designed antennas should provide direction radiation for the efficient use of the allowed microwave power and to minimize the interference from nearby systems and objects (Zaker et al., 2009).

There are several types of antennas proposed for UHF medical application. However, those antennas either have omnidirectional radiation, need a matching layer to operate or have a large size or narrow operating bandwidths.

In this letter, a combination of loop, dual-monopole structures and loaded parasitic patch is used to initially build a planar antenna that has a wide operating bandwidth. To reduce the size of the antenna and cancel the backward radiation without using a large reflector, a

Corresponding Author: T. Pranaya Krishna, Department of ECE, SRM University, Chennai, India

folding process is applied to defined edges of the planar design, making it three-dimensional. The antenna is then tested to ensure its wide operating bandwidth and unidirectional radiation (Sankaralingam and Gupta, 2010).

The antenna is then integrated with a compact microwave transceiver and an adjustable platform to build a microwave system for heart failure detection. A computing tool is used for signal processing, image reconstruction and display. The integrated system is tested on a artificial phantom of the human torso emulating healthy and sick cases. The designed antenna is used to vertically scan the torso from the backside. The received signals are then process to form an image that indicates any fluid accumulation in lungs (Hertleer *et al*., 2007).

Existed system: In existed system, the antenna used is a folded antenna but here we are using a more cost friendly printed antenna. At present we are using printed array antenna that can be used as a substitute for the existing folded dipole antenna which is harder and costlier to implement. The antenna is made to work in a frequency band of 1-5 GHz so that it can be used for various medical applications.

Ying Hu, David R . Jackson, Jeffery T. Williams, Stuart A. Long "Characterization of the input Impedance of the Insert-Fed Rectangular Microstrip Antenna", IEEE Trans.

This study investigates on the input impedances and radiation pattern of the antenna and shifted cosine-squared function depend on the notch width for a given. Reza Zacker, Changiz Ghobadi and Javad Nourinia "Bandwidth Enhancement of Novel Compact Single and dual band Notched Printed Monopole Antenna with a pair of L-Shaped slots," IEEE trans.

This study explains microstrip fed radiation patch and dual band notched antenna, HFSS simulation tool and optimum radiation characteristics for both the antennas. S. Sankaralingham and Bhaskar Guptha, "Determination of dielectric constant of fabric materials and their use as substrates for design and development of antennas for wearable applicatons, " IEEE trans. Instrumentation and Measurement.

This study provides explanation about coaxial feed techniques and dielectric constants of various fabrication materials available. This study helps in determining the fabrication material. Carla Hertleer, Anneleen Tronquo, Hendrick Rogier, Senior Member, IEEE, Luigi Vallozzi and Lieva Van Langenhove, "Aperture-Coupled Patch Antenna for Integration Into Wearable Textile Systems," IEEE Antennas and Wireless Prop.

This study provides a comprehensive survey on aperture coupled feeding technique in textile application and the use of ADS simulation tool suitable for wireless communication based on Zigbee, Bluetooth.

Ee Lee, Kin Meng Chan, Peter Gardner, Senior Member, IEEE and Terence E. Dodgson, "Active integrated antenna design using a contact-less, proximity coupled differentially fed technique," IEEE Trans. Antennas Propagation.

This study provides insight on the proximity coupled feeding and CST microwave stidio which is a 3D EM simulation software.

Proposed work: In the proposed system, we are going to implement an affordable heart failure detection system using a printed antenna which helps detection of heart failure at early stages. The designed antenna's performance is compared with simulated and measured values. The proposed system will be implemented in two stages. The first stage has four steps (Lee *et al*., 2007).

MATERIALS AND METHODS

Numerical analysis of planar antenna: Initially the numerical analysis has to be done for the planar antennas. The numerical analysis of the antenna enables to find the various parameters that are vital in the implementation of the antenna. The desired values re obtained and he corresponding antenna is implemented in a software tool like ADS.

A antenna that has a wide operational band unidirectional radiation and compact size has been presented. It includes an array structure and is desired to operate in UHF band as needed for radar based heart failure detection (Mohammed *et al*., 2014).

Mathematical coordinate entry of the printed antenna: The mathematical coordinates entry has to be done after the numerical analysis is done The coordinates for the antenna are to be found to implement the design in the software tool. The coordinates are plotted in a Cartesian coordinate system (Fig. 1).

Design of printed antenna using ADS: ADS is a very useful software antenna simulation tool. ADS is an electronic design automation software system produced by key sight Technologies. It provides an integrated design environment to designers of wireless systems, Radar systems, etc.

Design of printed antenna using advanced design system is the stage where the coordinates that have been calculated in the previous step are loaded in the software (Celik *et al*., 2011) (Fig.2).

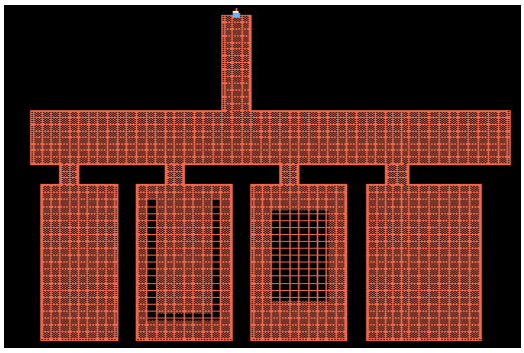

Fig. 1: Layout of the proposed antenna

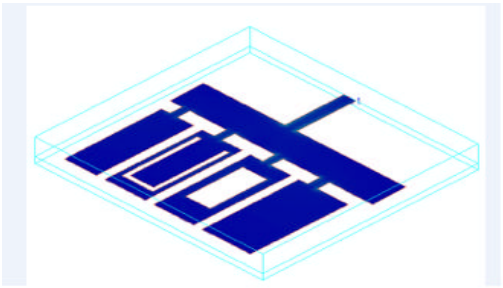

Fig. 2: Simulated antenna structure in ADS

RESULTS AND DISCUSSION

Simulation of printed antenna using ADS: The simulation is done for the antenna and the results are analysed. Other designs are also loaded and the results are analysed and the best suited antenna with the appropriate parameters for the desired project is used (Fig. 3 and 4).

Stage 2: Fabrication of the Antenna

Converting pcb design into gerber format: The Gerber format is an open ASCII vector format for 2D binary images. It is used by printed circuit board industry software to describe the PCB images.

Fabrication of patch antenna: Once the Gerber file is obtained the antenna design is initially printed on a photo plot film. This Photo plot film is used as the blueprint for the fabrication process and the fabrication is done by the etching the substrate by process of photo lithography. The substrate used for the fabrication process is an FR4 substrate (Li *et al*., 2014).

Testing: The antenna is tested by connecting the SMA probe at the line feed and the Coaxial Cable is connected to a network analyser to study the performance of the antenna. The antenna is then used to build a heart failure detection system by including a compact transceiver and an adjustable platform. The system is tested on an artificial torso phantom to verify the potential of such a system in the early detection of heart failure of healthy and sick subjects. The obtained images indicate the feasibility of the system in detecting early heart failure (Rezaeieh et al., 2013a)(Fig. 5 and 6).

Specifications of antenna: Sepecification of antenna shown in Fig. 6.

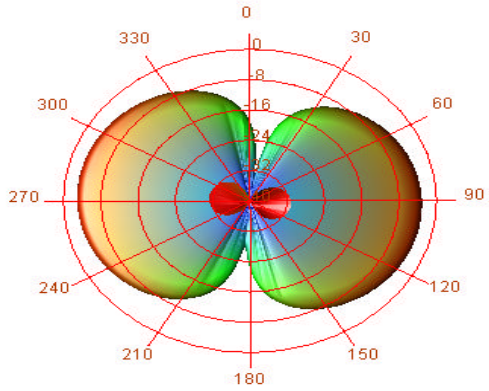

Fig. 3: Main lobe of the antenna simulated

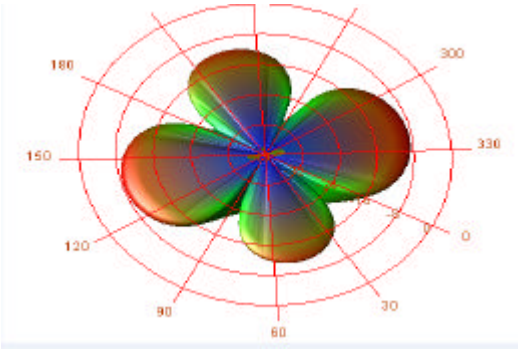

Fig.4: Side lobes of the antenna simulated

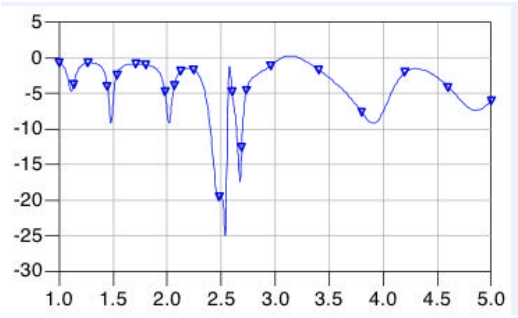

Fig. 5: Return loss(y) vs frequency(x) graph

Power radiated (Watts)		4.56225e-06
Effective angle (Steradians)		3.17129
Directivity(dB)		5.97974
Gain (dB)		-11.1791
Maximim intensity (Watts/Steradian)		1.43861e-06
Angle of U Max (theta, phi)	0	0
E(theta) max (mag,phase)	0.0261232	-38.5452
E(phi) max (mag,phase)	0.0200378	140.063
E(x) max (mag,phase)	0.00432095	146.022
E(y) max (mag,phase)	0.0326384	-39.1491
E(z) max (mag,phase)	0	180

Fig. 6: Parameters of antenna simulated

CONCLUSION

The project presented a new approach in the detection of heart failure. Heart failure detection system was proposed, designed and successfully implemented in this study. The detection will be at early stages which increases the possibility of a person surviving heart failures. A prototyped antenna with the compact size 27.0×35.8×1.6mm shows a peak gain -6.83 and directivity of 5.69 db. The antenna is then used to build a heart failure detection system by including a compact transceiver and an adjustable platform. Using the virtual array concept, the system was used to image an artificial human torso emulating the cases of healthy and sick subjects. The obtained images indicate the feasibility of the system in detecting early heart failure.

RECOMMENDATIONS

The design is then converted into Gerber format and then the design is printed over an photo plot film. This photo plot film is used in the process of fabrication of the antenna (Sabban, 2013).

Once the antenna is fabricated then the SMA probe is soldered to the feed and the antenna is tested. This tested antenna is used for the implementation of heart failure detection system. The torso on which the antenna is scanned has an radar system and the heart failure is detected (Rezaeieh *et al*., 2013b).

IMPLEMENDATIONS

The implemented antenna is then used to build a heart failure detection system by including a compact transceiver and an adjustable platform. Using the virtual array concept, the system was used to image an artificial human torso emulating the cases of healthy and sick subjects. The obtained images indicate the feasibility of the system in detecting early heart failure.

REFERENCES

Celik, N., R. Gagarin, H.S. Youn and M.F. Iskander, 2011. A noninvasive microwave sensor and signal processing technique for continuous monitoring of vital signs. IEEE. Antennas Wirel. Propag. Lett., 10: 286-289.

Hertleer, C., A. Tronquo, H. Rogier, L. Vallozzi and L.V. Langenhove, 2007. Aperture-coupled patch antenna for integration into wearable textile systems. IEEE. Antennas Wirel. Propag. Lett., 6: 392-395.

Hu, Y., D.R. Jackson, J.T. Williams, S.A. Long and V.R. Komanduri, 2008. Characterization of the input impedance of the inset-fed rectangular microstrip antenna. IEEE. Trans. Antennas Propag., 56: 3314-3318.

Lee, E., K.M. Chan, P. Gardner and T.E. Dodgson, 2007. Active integrated antenna design using a contact-less, proximity coupled, differentially fed technique. IEEE. Trans. Antennas Propag., 55: 267-276.

Li, X., M. Jalilvand, Y.L. Sit and T. Zwick, 2014. A compact double-layer on-body matched bowtie antenna for medical diagnosis. IEEE. Trans. Antennas Propag., 62: 1808-1816.

Mohammed, B.J., A.M. Abbosh, S. Mustafa and D. Ireland, 2014. Microwave system for head imaging. IEEE. Trans. Instrum. Meas., 63: 117-123.

Rezaeieh, S.A., Y.Q. Tan, A. Abbosh and M.A. Antoniades, 2013a. Equivalent circuit model for finding the optimum frequency range for the detection of heart failure using microwave systems. Proceeding of the 2013 International Symposium on IEEE Antennas and Propagation Society (APSURSI), July 7-13, 2013, IEEE, Canberra, Australia, ISBN: 978-1-4673-5317-5, pp: 2059-2060.

Rezaeieh, S.A., A. Abbosh and M.A. Antoniades, 2013b. Broadband UHF antenna for heart failure detection system. Proceeding of the International 2013 IEEE Symposium on Antennas and Propagation Society (APSURSI), July 7-13, 2013, IEEE, Canberra, Australia, ISBN:978-1-4673-5317-5, pp: 2089-2090.

Sabban, A., 2013. New wideband printed antennas for medical applications. IEEE. Trans. Antennas Propag., 61: 84-91.

Sankaralingam, S. and B. Gupta, 2010. Determination of dielectric constant of fabric materials and their use as substrates for design and development of antennas for wearable applications. IEEE. Trans. Instrum. Meas., 59: 3122-3130.

Zaker, R., C. Ghobadi and J. Nourinia, 2009. Bandwidth enhancement of novel compact single and dual band-notched printed monopole antenna with a pair of L-shaped slots. IEEE Trans. Antennas Propag., 57: 3978-3983.