www.ijecs.in
International Journal Of Engineering And Computer Science ISSN:2319-7242
Volume 5 Issue 09 September 2016 Page No.17872-17879

A Simple Clutter Canceling Circuit and Background Noise Algorithm Based On Microwave Life Detection System

***K. Anuradha** Assistant professor M.tech, LMISTE* [1] *, **M A Zeba Tabassum** (M.tech)* [2]

Vijay Rural Engineering College, Nizamabad, TS, 503003, INDIA

anureshad@gmail.com[1] zebatabassum3@gmail.com[2]

Abstract

Thousand of persons are being killed as a cause of earthquake. The disaster in the Dhaka City may claim thousands of lives due to Earthquake. It is said if survivors are found and rescued earlier the numbers of victims will be lower. There is no end to the number of lives lost as the result of such disasters as landslides, collapsed tunnels and avalanches. The microwave life detection system is developed for the search and rescue of victims trapped under the rubble of collapsed building during the earthquake or other disasters. In this project, an ultra-sensitive compact portable microwave life-detection device is introduced and implemented with promising results. By utilizing Doppler effect-based systems, vital signs such as heartbeats and breathing can be detected and can be used for finding survivors under earthquake rubble, injured soldiers on battlefields and as lie detection device. This device is tested in both simulated and realistic situations, and it can accurately detect crucial signs of life through highly dense construction materials of about 1.5m thick and standard density materials of about 10m while operating at 1.15GHz center frequency.

Keywords: Doppler shift, Biomedicine, life detection, microwave, transceiver, vital signs, wireless

1. INTRODUCTION

Most of the victims of earthquake or other natural disasters in the various parts of the worlds are trapped under rubble of the collapsed buildings. A detection of the victims can save his life. As in the radar application, the phase of the incident wave can be changed due the body vibrations. Depending upon this fact ”A Revolutionary System to Detect Human Being Buried under the Rubble” used to trap the buried victims under earthquake rubble or collapsed buildings by the utilization of microwave radio frequency has been design.

The history of ”Revolutionary System to detect Human Being Buried Under the Rubble” starts with K. M. Chen who brings out the concept of detection of buried victims using microwave beam in 1985. After the detailed study of microwave signals and Doppler’s effect, Ku Mem chen had been proposed including the basic principle for the operation of life detection system in 1991[2]. A Low Power Hand-Held Microwave Device was made for the Detection of Trapped Human Personnel by W. S. Haddad in 1997. The device, called the Rubble Rescue Radar (RRR) incorporates Micro power Impulse Radar technology which was developed at Lawrence Livermore National Laboratory over the few years.

2. BACKGROUND

(A)Working Principle of Life Detection System

The principle of detection is firstly, microwave is sent through rubble to detect vital signs of life. Microwave is having the property to penetrate through barriers and would reflect back from some objects. These objects include humans. When the beam hits the body, the signal reflected with an additional modulation created by movement of heart and lungs. So, the reception of modulated signals shows the presence of alive human inside the rubble. With the modulated signal there are some signal (commonly known as clutter signal) which are reflected from the immobile object such as rubble or debris. Thus in order to maintain a high sensitivity for this application, the clutter wave reflected from the rubble or the surface of the ground has to be cancelled as thoroughly as possible. For this an automatic clutter cancellation system is used. A Microwave life detection system operated on the radio frequency was proposed in the 1985. This system detects the body oscillations occur due the breathing and heartbeat fluctuations. The system includes the additional subsystem to cancel the unwanted signals receive from the motionless objects such as rubble.

(B) Doppler Radar Technology

A Doppler radar is specialized radar that makes use of the Doppler Effect to produce velocity data about objects at a distance. It does this by beaming a microwave signal towards a desired target and listening for its reflection, then analyzing how the frequency of the returned signal has been altered by the object's motion. This variation gives direct and highly accurate measurements of the radial component of a target's velocity relative to the radar. Doppler radars are used in aviation, sounding satellites, meteorology, police speed guns, radiology, and biostatics radar (surface to air missile).

(C) Microwave Technology

Microwaves are radio waves with wavelengths ranging from as long as one meter to as short as one millimeter, or equivalently, with frequencies between 300 MHz (0.3 GHz) and 300 GHz. The prefix "micro-" in "microwave" is not meant to suggest a wavelength in the micrometer range. It indicates that microwaves are "small" compared to waves used in typical radio broadcasting, in that they have shorter wavelengths. The boundaries between far infrared light, terahertz radiation, microwaves, and ultra-high-frequency radio waves are fairly arbitrary and are used variously between different fields of study.

3. PROPOSED METHOD

Fig. 1 shows the complete schematic of the proposed system. Since there is a difference of 0.1Hz to 50Hz between radiated and reflected waves, an extremely low phase noise radiated wave is needed. There are two main solutions: use phase-locked oscillators (PLL-based) or utilize comb generator multipliers. This paper utilizes the second approach due to better phase noise compared with the PLO.

In Block 1, comb generator multiplier consists a signal amplifier that amplifies the output signal of an oven-controlled crystal oscillator (OCXO) with 115MHz center frequency (OX-175 from Vectron) and a step recovery diode (SRD). As shown in Fig. 2, diode is driven by OCXO. Simulated behavior of SRD in Fig. 3(a) shows peaks that can be considered as high frequency short pulses and SRD voltage spectrum used in proposed life detection system is shown in Fig. 3(b). In the spectrum 10 th harmonic lie at 1150MHz frequency that is desired and can be selected by utilizing appropriate filter at SRD output.

The measured phase noises of 115MHz (reference signal) and 1.15GHz (output signal) are demonstrated in Fig. 4. The measurement results show that for 1Hz and 10Hz offset, phase noise of OCXO is -80dBc/Hz and -105dBc/Hz respectively. A two-stage amplifier (Gali5 by Mini Circuits and AH102 from Agilent) is then utilized to boost the output power to 26.5dBm. In order to eliminate other harmonics produced by the SRD, a microstrip-based interdigital filter has been used with 70MHz bandwidth. As a result attenuation is 22dB at 1035MHz and 23dB at 1265MHz

DOI: 10.18535/ijecs/v5i9.14

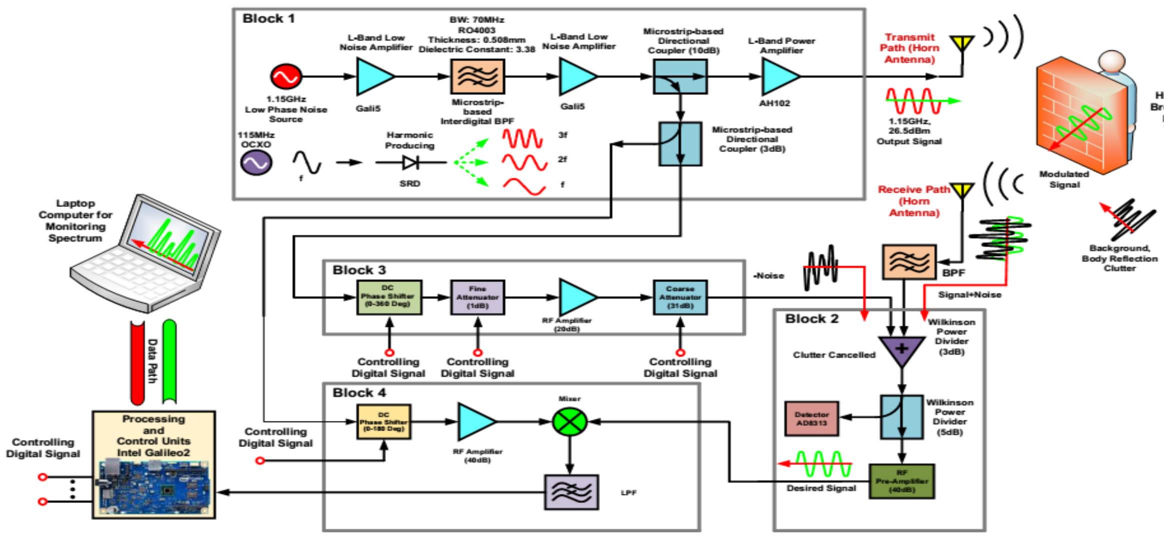


Figure 1: The schematic of the proposed system

The second block consists of two power dividers (balanced and unbalanced), a detector and an RF LNA. Both balanced and unbalanced power dividers use the Wilkinson topology. The RF detector used in this block has dynamic range of 70dB with very high accuracy (±1 dB) and bandwidth from 0.1GHz to 2.5GHz. Since the dynamic range of the utilized detector is around 70dB, subsequent amplifiers can be implemented for further amplification.

The RF LNA used in this block consists of two subsequent Gali5 and Gali74 amplifiers and overall block has 3dB noise figure and at least 35dB power gain. In order to achieve better performance, a resonance-based bandpass filter with 4MHz bandwidth and 10% tuning range across the center frequency of 1.15GHz with the aid of adjustment screw, is used in the receive path to filter undesired signals. The structure of this filter is shown in Fig. 5(a). A metallic shaft is placed in a cylindrical tube to form a coaxial transmission line.

The transmission line is grounded from one side and has inductive characteristics since its length is less than λ/4. On the other side, there are two-adjustment screws that form a capacitance with the internal metallic shaft. The dimensions of the external tube and the internal metallic shaft are chosen to form a coaxial transmission line with 75Ω characteristic impedance for the highest available quality factor. By utilizing this simple structure, an ultra -high quality factor ($Q = f0 /BW \approx 230$) band-pass filter can be implemented at an extremely low cost. Fig. 5(b) shows the measured insertion loss of the fabricated BPF.

The third block consists of a 0-360° phase shifter and attenuators (HMC307QS16G). Both shifter and attenuator are controlled digitally. The phase shifter with 0.1°/step is implemented using an analog phase shifter and a digital to analog converter (D/A). The analog phase shifter is designed with nonlinear transmission lines using voltage-controlled reverse-mode varactor diodes. The fine attenuator consists of a PIN diode-based (HSMP3814) voltage-controlled attenuator and a D/A with 0.1dB attenuation steps. Varactors used in analog phase shifter can produce harmonics if the attenuation is low in the signal path.

A micro strip-based low pass filter with 1.2GHz cut-off frequency can be utilized to eliminate these undesired harmonics. Fig. 2. Applying the output of OCXO to SRD along with two-stage amplifier The fourth block consists of a mixer (LRMS-5H), a digitally-controlled 0-180° phase shifter, RF amplifier, and a low pass filter. Both transmit and receive paths have same aluminum horn antennas with 11.5dB free space gain at 1.15GHz center frequency.

The horn antenna has a wideband structure thus; its return loss near the earthquake rubble is nearly constant. Also, antenna's receiving factor is independent of the distance between antenna and the rubble. Fig. 6 shows the designed horn antenna's 3D radiation pattern, return loss, 2D radiation

DOI: 10.18535/ijecs/v5i9.14

pattern and efficiency. (a) (b) Fig. 3. (a) Voltage of SRD pulses containing high frequency components (b) output spectrum of SRD voltage in the proposed life detection system. OCXO 115MHz OX-175 Vectron 4.7nF 1.2KΩ 2.7KΩ +12V 220nH 10nF 47nH 39pF 2N5109 150Ω 10nF +5V

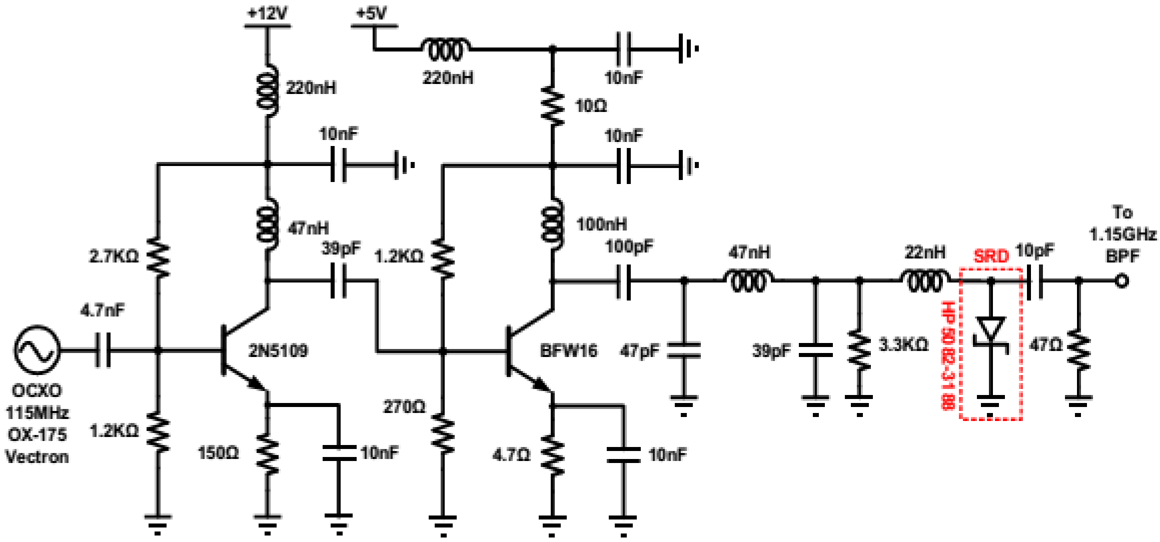
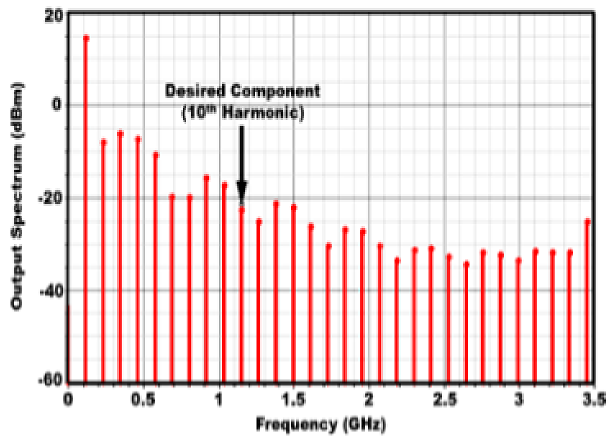


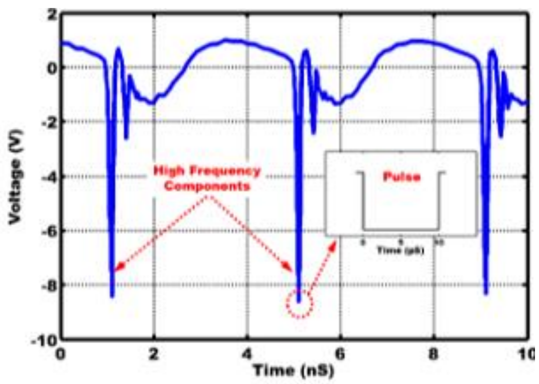
Figure 2: Applying the output of OCXO to SRD along with two-stage amplifier

The fourth block consists of a mixer (LRMS-5H), a digitally-controlled 0-180° phase shifter, RF amplifier, and a low pass filter. Both transmit and receive paths have same aluminum horn antennas with 11.5dB free space gain at 1.15GHz center frequency. The horn antenna has a wideband structure thus, its return loss near the earthquake rubble is nearly constant. Also, antenna's receiving factor is independent of the distance between antenna and the rubble.

Fig. 6 shows the designed horn antenna's 3D radiation pattern, return loss, 2D radiation pattern and efficiency.

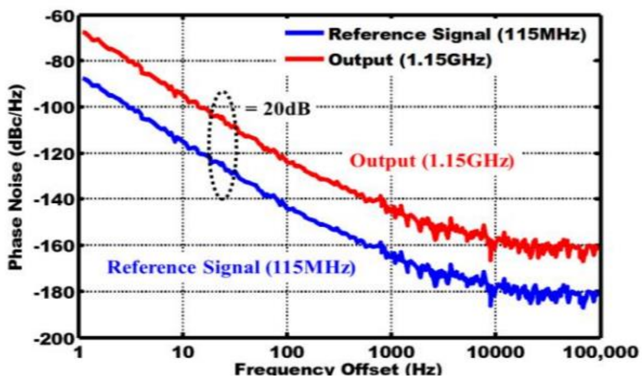


(b)



(a)

Figure 3: (a) Voltage of SRD pulses containing high frequency components (b) Output spectrum of SRD voltage in the proposed life detection system.



DOI: 10.18535/ijecs/v5i9.14

Figure 4: Measured phase noises of output and reference signals

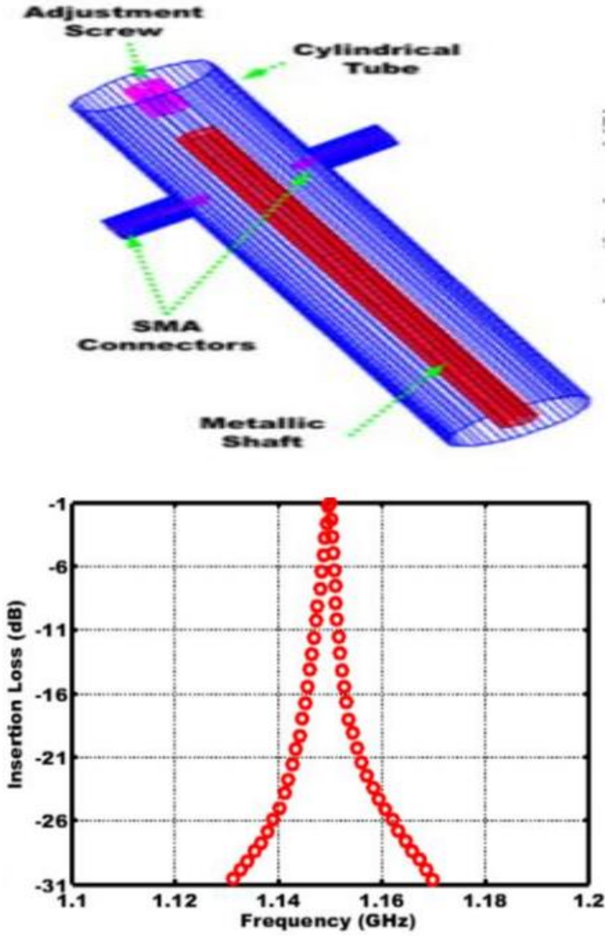
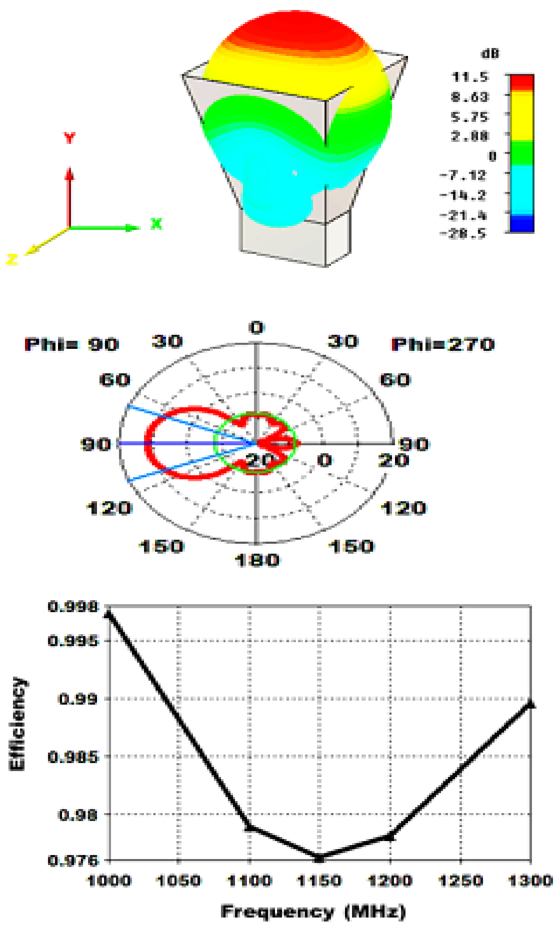


Figure 5: (a) Proposed band-pass filter in the receive path (b) Measured insertion loss of the proposed BPF

The micro strip antenna with 7dB free space gain is utilized in the receive path in order to compare with horn antenna. Calculations and measurements show that required micro strip antenna must have large dimensions (13cm×10cm) for better efficiency. Large dimensions introduce background noise (walking interference) that significantly degrades operation of the detector. Algorithms like horn antenna help in eliminating this noise.

Table I lists benefits of horn antenna over micro strip. Direct coupling between transmitter and receiver has been reduced by utilizing two separate antennas. Coupling can also be seen as clutter and its effect is removed in the clutter cancelling circuit. If the coupling is high and clutter cancelling circuit is unable to perform properly, antennas can be distanced from each other. Through experiment it was observed that distance of 50cm between both antennas is acceptable. One of the key features of this design is simple structure of the demodulator. Demodulator consists of a mixer which has an LO signal of cos(ω0t+ø) and an RF signal of cos(ω0t-ωdt), where ω0 is the radian frequency of the transmitted signal, ø is a constant phase and ωd is the radian Doppler frequency.

Mixer output after low pass filtering is proportional to cos (ωdt+ø). Phase shifter in the LO path of mixer makes the ø, phase difference between RF and LO, nearly zero to increase sensitivity. To detect the Doppler frequency shift due to a human body vibration (breathing and heart pumping), one can take Fourier transform of the sampled output mixer. The near carrier phase noise of the transmitting signal and the low frequency flicker noise of the diodes in the mixer can mask the output signal and set the limit for detection. Use of low phase noise transmitting signal and low flicker noise Schottky barrier diodes in the double balance mixer increases performance of the life detection system.



DOI: 10.18535/ijecs/v5i9.14

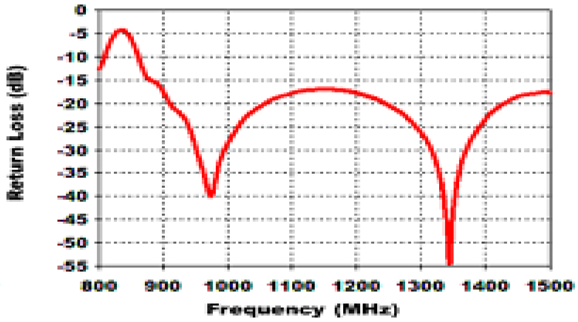


Figure 6: The proposed horn antenna's (a) 3D radiation pattern (b) return loss (c) 2D radiation pattern (d) efficiency

4. RESULTS

To detect the victim, one antenna should be placed at the top of the rubble and other antenna should be kept near the rubble. Surrounding area can be scanned by changing the direction of antennas.

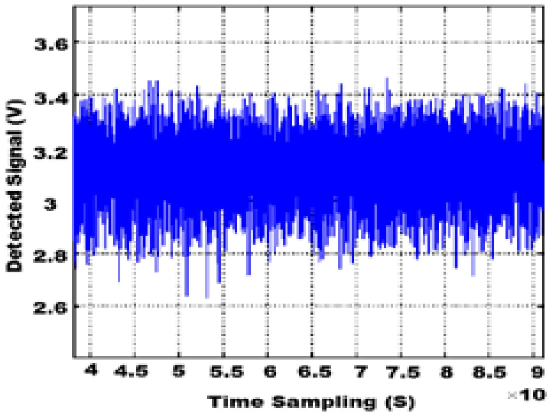


Figure 7: Environment noise received with nobody inside the cavity (Time Domain)

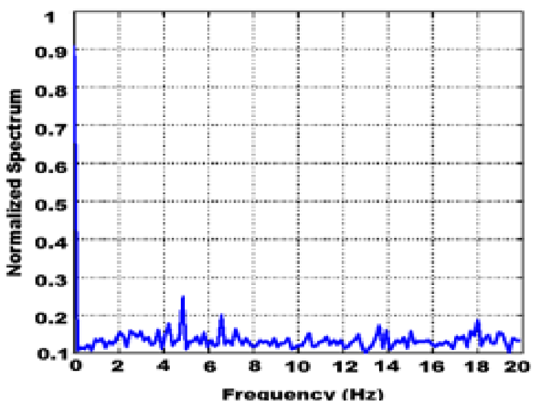


Figure 8: Environment noise received with nobody inside the cavity (Spectrum)

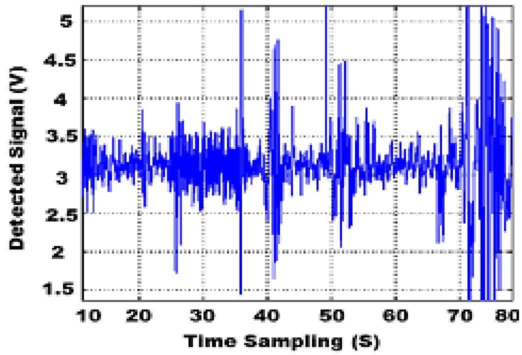


Figure 9: Detected breathing and heartbeat with their spectrum under 70cm, thickness with subject breathing normally (Time domain)

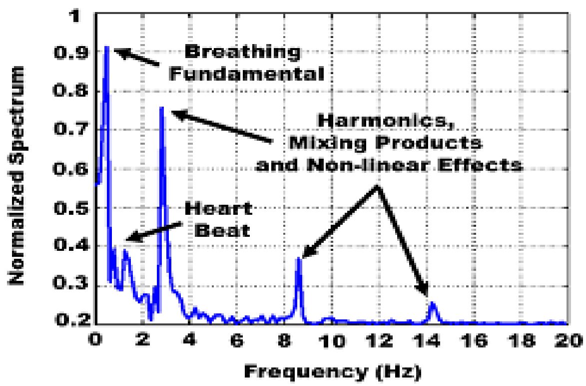


Figure 10: Detected breathing and heartbeat with their spectrum under 70cm thickness with subject breathing normally (Spectrum)

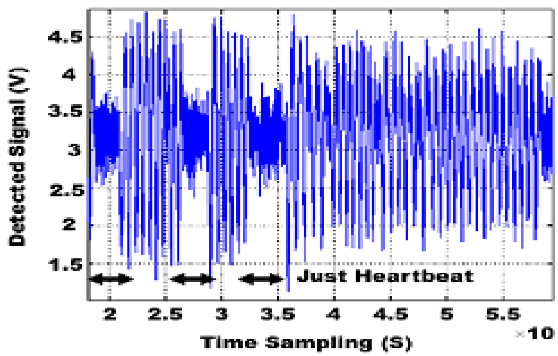


Figure 11: Detected breathing and heartbeat with their spectrum under 70cm thickness with subject breathing normally and 80cm thickness with subject asked to hold his breath for 3 periods each lasts 30s (Time domain)

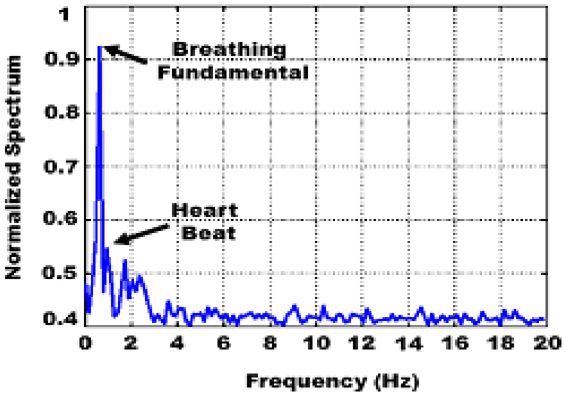


Figure 12: Detected breathing and heartbeat with their spectrum under 70cm thickness with subject breathing normally and 80cm thickness with subject asked to hold his breath for 3 periods each lasts 30s (Spectrum)

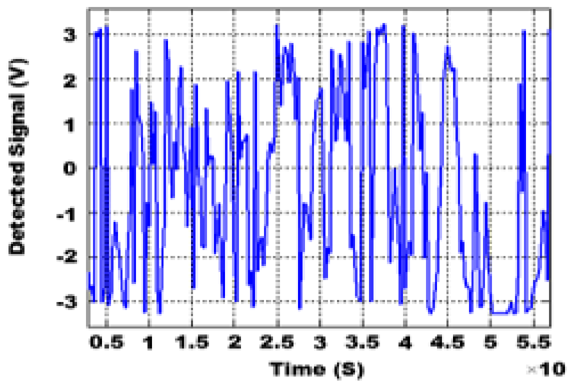


Figure 13: Detected breathing signal and its spectrum with 150cm thickness (Time domain)

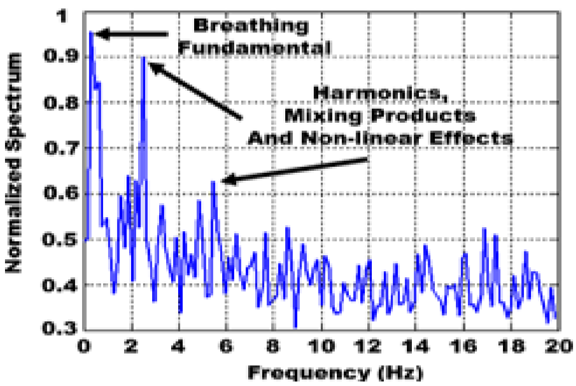


Figure 13: Detected breathing signal and its spectrum with 150cm thickness (Spectrum)

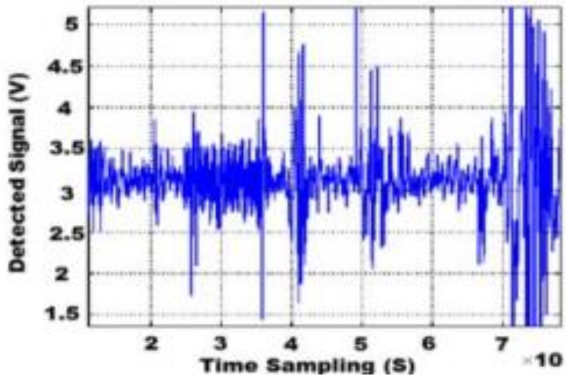


Figure 14: Detected breathing signal and its spectrum with 10m thickness (Time domain) (Right) Spectrum

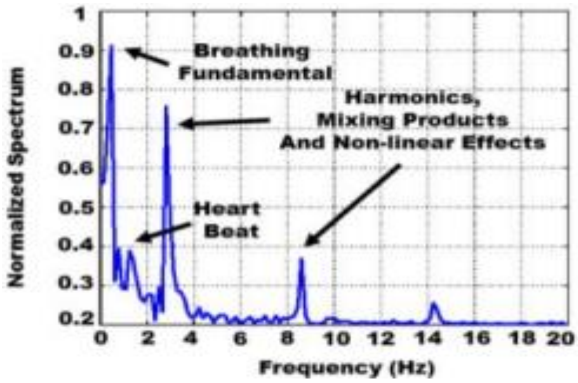


Figure 15: Detected breathing signal and its spectrum with 10m thickness (Spectrum)

5. CONCLUSION

The strategy for detecting trapped alive victim under earthquake rubble was implemented in which a microwave beam was illuminated into rubble to receive essential information about life under rubble. A simple structured, ultra-sensitive Doppler effect-based portable life detection system with 1.15GHz operating frequency has been introduced and examined with promising results. Use of two antennas eliminate the need for a circulator and simplifies the search process of a victim by changing the position of the receiving antenna. Also, a simple clutter canceling circuit and background noise algorithm is used. The system is able to detect human subjects trapped under earthquake rubble with thicknesses up to 1.5m in replicated test environment and 10m in realistic situations. The device was operated with a dry-cell battery to demonstrate portability.

DOI: 10.18535/ijecs/v5i9.14

REFERENCES

[1] H. R. Chuang, H. C. Kuo, F. L. Lin, T. H. Huang, C. S. Kuo, and Y. W. Ou, "60 GHz Millimeter-Wave Life Detection System (MLDS) for Noncontact Human Vital-Signal Monitoring," IEEE Sensors Journal, vol. 12, no. 3, March 2012.

[2] J. C. Lin, "Microwave sensing of physiological movement and volume change: A review," Bioelectromagn., vol. 13, pp. 557–565, 1992.

[3] K. M. Chen, D. Misra, H. Wang, H.-R. Chuang, and E. Postow, "An X-band microwave life-detection system," IEEE Trans. Biomed. Eng., vol. 33, no. 7, pp. 697–702, Jul. 1986.

[4] H. R. Chuang, Y. F. Chen, and K. M. Chen, "Automatic clutter-canceller for microwave life-detection system," IEEE Trans. Instrum. Meas., vol. 40, no. 4, pp. 747–750, Aug. 1991.

[5] K. M. Chen, Y. H. Huang, J. Zhang, and A. Norman, "Microwave lifedetection systems for searching human subjects under earthquake rubble or behind barrier," IEEE Trans. Biomed. Eng., vol. 27, no. 1, pp. 105–114, Jan. 2000.

[6] K. M. Chen, Y. Huang, A. Norman, and J. Zhang, "Microwave life-detection system for detecting human subjects through barriers," in Proc. Progress in Electromagnetic Research Symp., Hong Kong, Hong Kong, Jan. 6–9, 1997.

[7] Q. Zhou, J. Liu, A. H. Madsen, O. B. Lubecke, V. Lubecke, "Detection of Multiple Heartbeats Using Doppler Radar," ICASSP 2006 Proceedings, vol. 2, pp. 1160-1163, May 2006.

[8] L. Chioukh, H. Boutayeb, D. Deslandes, K. Wu, "Noise and Sensitivity of Harmonic Radar Architecture for Remote Sensing and Detection of Vital Signs," IEEE Transactions on Microwave Theory and Techniques, vol. 62, no. 9, pp. 1847-1856, Sept. 2014.

M A Zeba Tabassum has completed graduation (B.tech.) in Electronics and Communication Engineering (ECE) from Vijay Rural Engineering College affiliated to JNTU (HYD) in 2014. At present she is pursuing her Post-Graduation (M.tech) in same college specialized in ECE. Her research interests include Analog communications, Image processing, advanced digital communications and Electronic circuits

K. Anuradha has completed graduation (B.tech.) in Electronics and Communication Engineering (ECE) from Vijay Rural Engineering College affiliated to JNTU (HYD) in 2010. She completed her Post-Graduation (M.tech) in 2013. Currently she is working as assistant professor in Vijay Rural Engineering College. Her research interests include Electronic measurements & instruments, advanced digital communications and Electronic circuits