International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 4, Issue 11
November 2017

UWB Radar as a Life Detection System-A Review

Miss. Shweta Ulhas Revankar
PG Student, MTech Embedded System,
Sanjay Ghodawat University, Kolhapur, Maharashtra.
Mrs. Shubhangi C. Deshmukh
Assistant professor, MTech Embedded System,
Sanjay Ghodawat University, Kolhapur, Maharashtra.
Dr. B.B. Godbole
Associate professor, Department of Electronics,
K.B.P College of Engineering, Satara, Maharashtra

ABSTRACT:
Ultrawide band RADAR has been applied in the through-wall life detection since it has high spatial resolution and better wall penetration capability. This paper represents theoretical study of the UWB RADAR as life detection system and its definition. The UWB Radar can be applied in the applications to detect the human trapped inside the rubble. Excellent materials penetration is a fundamental advantage to UWB RADAR. This point can be used to detect the signals of life without touching anyone. In this paper, we discuss a through wall detection of human's motions using UWB RADAR. This paper presents the various types of methods used for the detection of the human behind the wall and the detection of the human's behind various types of wall.

Keywords—UWB RADAR, Breath detection, Through wall detection, Microwave life detection, UWB RADAR in monostatic mode, UWB P220, Nimurra RADAR, Respiration, Human target detection.

I.INTRODUCTION:

A RADAR is a system for detecting the presence, direction, distance, and speed of aircraft, ships, and other objects, by sending out pulses of radio waves which reflected off the objects back to the source. UWB technology is a wireless technology for transmitting digital data at very high rates, using very low power.

Ultra-wideband RADARs are used nowadays for different applications such as subsurface sensing, classification of aircrafts, collision avoidance, etc. In theseapplications, the ultra-high resolution of UWB RADARs is essentially used. One of these applications is detection of humans trapped in buildings on fire, in collapsed buildings, or avalanche victims [5].

Detecting human survivors in disaster areas such as earthquakes, fires, heavy smoke and darkness is a real need in life saving organizations, search and rescue organizations. Despite relatively small scope of this application, it has large social importance. Very similar to the human detection application is another UWB RADARapplication, namely remote cardiography (measurements of heart beats). Both applications are based on similar principles [5].

Detection of human beings with RADAR is based on movement detection. Heart beating and respiratory motions cause changes infrequency, phase, amplitude, and arrival time of reflected from a human being electromagnetic wave. Generally speaking, the changes of amplitude are negligible. Therefore, only frequency, phase, and arrival time changes can be used for human being detection. Based on these three features the RADAR system is developed [5].

Human's motions show periodic features including respiration,swinging arms and legs,and fluctuations of the torso.Detection of human targets is based on the fact that there is always periodic motion due to breathing or other body movements like walking. The RADAR can gain the reflection from each human body part and add the reflections at each time sample. The periodic movements will cause micro-Doppler modulation in the reflected RADAR signals. As the responses from targets with body motions contain nonlinear and nonstationary signal component's,time-frequency domain analysis can provide useful information for the target detection [4].

Microwave life detection system uses the same technology used by UWB signals. Furthermore, we discuss about the microwave signal used for the life detection system.This paper presents the different methods that can be used for the life detection.

We have several advantages of using UWB such as;

- It has the ability to share the frequency spectrum.
- It has the large channel capacity
- Ability to work with low signal to noise ratio.
- Resistance to jamming.

II.LIFE DETECTION SYSTEM:

The UWB RADAR life detection system has four major components. They are a Radio wave circuit which generates, amplifies and distributes radio /micro wave signals to different microwave/radio components. A dual antenna system, which consist of two antennas where both the antennas are energized sequentially. A clutter cancellation system, which creates an optimal signal to cancel the clutter from the rubble [3]. Life detection system is shown in fig 1(a) as in [3].

A. BLOCK DIAGRAM:

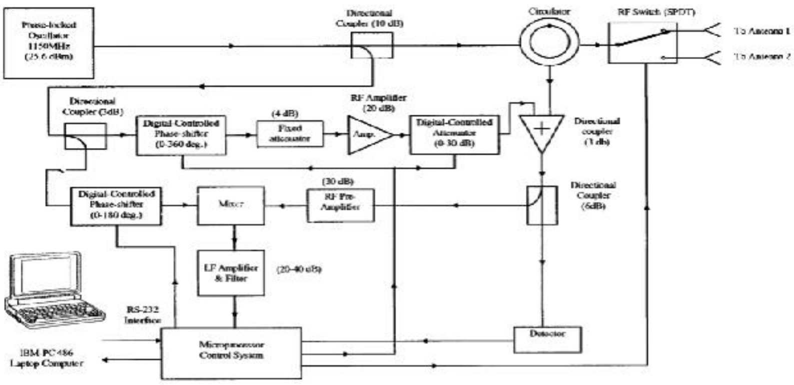


Fig 1(a): Life detection system [3].

B. WORKINGPRINCIPLE:

The principle of detection is firstly, microwave or radio wave is sent through rubble to detect vital signs of life. Radio wave is having the property to penetrate through all the sort of barriers and would reflect back from some objects. These objects include humans. When the beam hits the body, the reflected signal is obtained with an additional modulation i.e. is produced by the movement of heart and lungs. So, the reception of modulated signals shows the presence of alive human inside the rubble or debris. With the modulated signal, there are some other signal generally known as clutter signal, which are reflected from the motionless 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 must be cancelled as thoroughly as possible. For performing these cancellations automatic clutter cancellation system is being used. A microwave life detection system operated on the radio frequency was proposed in the 1985 i.e. such system is known as the UWB Radar. This system detects the body oscillations occur due the breathing and heartbeat fluctuations [3]. Principle of operation as shown in fig 1(b).

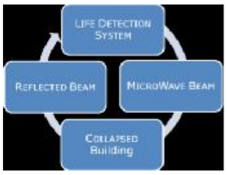


Fig 1(b): Principle of operation [3].

2.1 UWB RADAR AS LIFE DETECTION SYSTEM BY FILTERING METHOD AND ITS RESULTS:

Most of the materials exhibit rapidly increasing attenuation with frequency, UWB RADAR has a very significant advantage in materials penetration. Tests in [2] show that 200ps pulses freely penetrate through gypsum, wood and concrete walls without any obstructions. Excellent materials penetration is a keyadvantage to UWB RADARand allow their installation behind walls and above ceilings and below floors, so usage of the RADAR wave of UWB as the media of the life-detection is most widely done [1]. UWB Radar for life detection using filter shown in fig 2.as in [1].

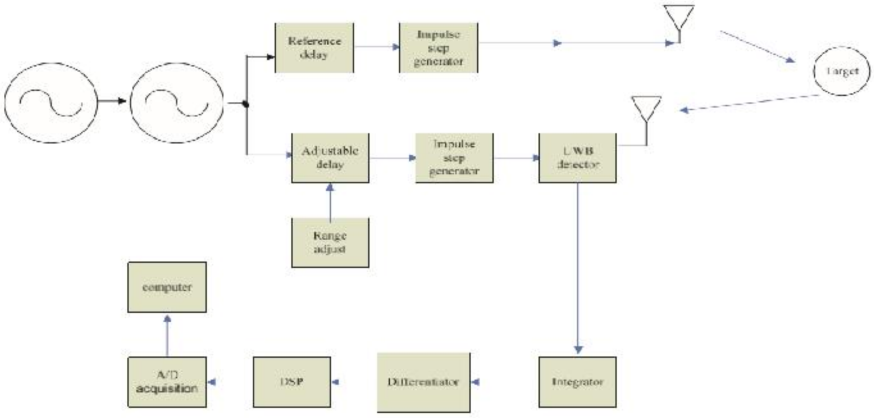


Fig2: Life detection by filtering [1].

We studied in [1] that the reflected signals of the chest wall of the movement is integrated, magnify, and filtered. And then these filtered signals through A/D gathering cardwill be sent to the computer processing. So, that the method of the digital signal processing can be applied to the undefined the feeble signals from the reflected wave of the cardinal signs such as respiration and heartbeat. The computermanages the control of the electro-circuit delay. In this way, the distance between human and the RADAR can be accurately obtained[1].

The principle block diagram as shown in Fig2. [1]. The impulse oscillator produces 6mhz pulses. These pulses go through the process of the ordering form and with this the fast pulse concrete circuit generates 250ps narrow pulses. The narrow pulses are thensent through the transmitting antenna. The echo/rebound signal reflected from chest wall movement by the body will be received by the sampling circuit [1].

The pulse oscillator circuit generates a signal with the delay of 200ps the narrow gate pulse which is considered as the received signal. The signal after receiving output sampling will go into the integrator to amass the received signal.Thesignal passes through the amplifier circuit and band-pass filter circuit to detect breathing and heartbeat. Finally, it reaches A/D acquisition card to display the detected signals and use the digital signal range gate into the control. The adjustable delay circuit controls the distance of ultra-wideband RADAR, and the pulse width produced from the distance gate determines the spatial resolution of UWB RADAR. The methods described along with the results below are as in [1].

SIGNAL ANALYSIS OF HUMAN LIFE:

Taking detecting the body’s respiratory signal as an example, we assume that the human body’s chest wall movement is a simple harmonic motion whose frequency is ω_z and margin is A.

$X(t)=A\cos(\omega t)$ (1)

The chest wall movement velocity is,

$V=dx(t)/dt = -A\omega\cos(\omega t)=V_s\sin(\omega t)$ (2)

in this formula $V_1= -A\omega$.

The interval between the two adjacent plane is;

$d_1=d-TV\sin(\omega t)$ (3)

The cycle time of reflected pulse repeat is;

$$T_s = d-TV\sin(\omega t)/c \quad (4)$$

So the frequency is;

$$f_s = \frac{1}{T_s} = \frac{c}{d - TV_s\sin(\omega_s t)} = \frac{f}{1 - \frac{V_s\sin(\omega_s t)}{c}} \quad (5)$$

The below shown graphical representation is of the waveform obtained of the typical respiration;

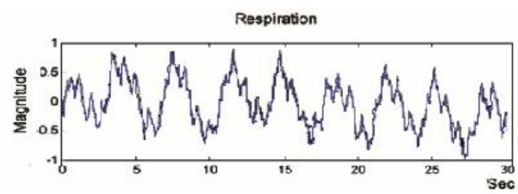


Fig 3: Waveform of typical respiration.

The below shown graphical representation is of the waveform obtained of the respiration after filtering;

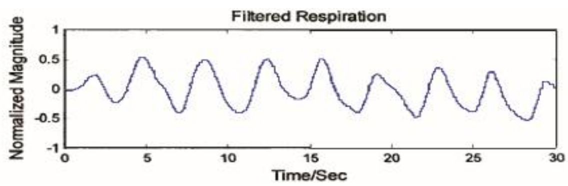


Fig 4: Waveform of respiration after filtering.

The below shown graphical representation is of the waveform obtained of the heartbeats after filtering;

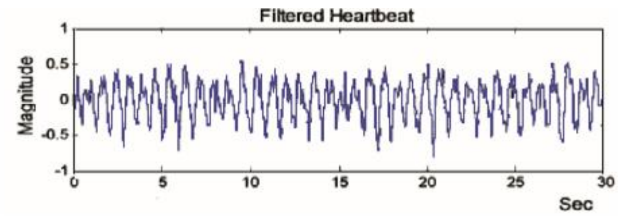


Fig 5: Waveform of the typical heartbeats.

The below shown graphical representation is of the waveform obtained of the Respiration and heartbeats in frequency domain;

International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 4, Issue 11
November 2017

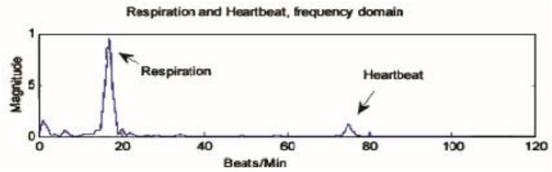


Fig 6: The waveform of heartbeats and respiration in frequency domain.

The above all equations and results are as in [1].

2.2 P220 UWBRADARAS A LIFE DETECTION SYSTEM USING DOPPLER METHOD AND ITS RESULTS:

This paper presents P220 UWB RADAR in monostatic mode (shown in Figure 7) where waveform pulses are transmitted from a single Omni-directional antenna and the scattered waveforms are received by a collocated Omni-directional antenna. The two antenna ports are used for the transmit and receive antennas in P220. An Ethernet cable used to connect the radio to the PC and RADAR. There are some radio application software's in the P220 UWB RADAR for performing the controlling.The P220 UWB RADARpresented here has centre frequency of 4.3 GHz with a 10-dB bandwidth of 2.3 GHz. This RADAR provides a resolution of 6.5 cm [2].

Fig 7:UWB P220 in monostatic mode [2].

In this method, we look at few important related parameters related to radio configuration. These parameters are chief in analysing captured scans. Integration is the number of radio pulses that RADAR combines to increase the signal-to-noise ratio. It is the total number of UWB pulses per waveform (scan) sample. Window Size (ft.) is the width of the 'window', in which motion can be detected. Pulses Per Waveform is the number of UWB radio pulses required for the entire waveform, divide this by the pulse rate to determine the theoretical maximum scan rate. Step Size (pS) is the waveform scan resolution (step size between points), in picoseconds (1 bin = 3.18 pS) [2].

A. UWB RADAR PENETRATION THROUGH WALL: As per the electromagnetic theory, lower frequencies have the better penetrating properties than the higher frequencies. UWB RADAR uses the combination large spectrum with lower frequencies which makes it suitable for applications such as ground penetrating RADAR, foliage penetrating RADAR and short-range RADAR to detect hidden objects behind walls. The penetration property of the UWB Radar is also of great importance for indoor location systems [2].

B. HUMAN TARGET DETECTION: Life detection with RADAR is completely dependent on movement detection performed by human being i.e. walking chest movements due to breathing or heartbeat. Respiratory motions and the heart beats cause changes in the parameters as such frequency, phase, amplitude, and arrival time of reflected signal from a human being. In case of through wall human target detection, these changes in the parameters can be very small, especially for a brick or concrete walls. Detection process faces challenges as the reflected UWB signal is highly sensitive to human posture. For example, the signal reflected from the breathing human causes changes in received waveform shape. An efficient and effective human detection method requires a model of UWB RADAR waveform propagation and scattering, e.g., interaction with the human body [2].

C. DETECTION OF BREATHING MOVEMENTS: This approach is based on detection of small chest movements associated with a breathing motionless human. This motion is very small and results in very weak radar echo. However, since it is periodic motion it can be detected by application of signal processing techniques which enhances the 'breathing' signal from noise. Breathing motion will cause periodic changes in the received signal at a distance where target is located. This periodic change is reflected across multiple scans. Thus, an N × M matrix A is constructed using 'M' scans, each of length 'N', as columns of matrix A. Then difference is taken between successive columns of matrix A, which captures changes from one scan to another and helps to suppress the static clutter signal [2].

Finally, DFT is performed on each row of the resulting matrix which clearly shows the breathing human target. This approach is summarized below.

Step 1. Matrix A constructed using 'M' scans arranged in columns [2].

$$A = \begin{bmatrix} \text{Scan 1} & \text{Scan 2} & \text{Scan 3} & \cdots & \text{Scan } M \\ \text{sample1} & \text{sample1} & \text{sample1} & \cdots & \text{sample1} \\ \text{sample2} & \text{sample2} & \text{sample2} & \cdots & \text{sample2} \\ & & & \ddots & \\ \text{sample}N & \text{sample}N & \text{sample}N & \cdots & \text{sample}N \end{bmatrix}$$

Step 2. MatrixD is the difference between successive columns of A [2].

$$D = \begin{bmatrix} \text{Scan1} - \text{Scan2} & \text{Scan2} - \text{Scan3} & \text{Scan}(M-1) - \text{Scan}M \\ \text{sample1} & \text{sample1} & \text{sample1} \\ \text{sample2} & \text{sample2} & \text{sample2} \\ \vdots & \vdots & \vdots \\ \text{sample}N & \text{sample}N & \text{sample}N \end{bmatrix}$$

Step 3. Take Discrete Fourier Transform of each row of the Matrix D [2].

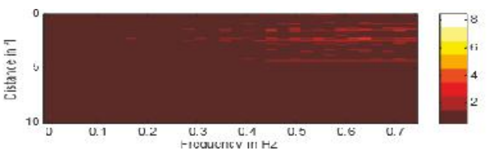
This technique works for gypsum wall, wooden door, and brick wall. Below are the observations for these cases [2].

D. TYPES OF WALL FOR DETECTION:

1. GYPSUM WALL:

Fig 8:Human target and UWB RADAR for gypsum wall.

Figure 8, shows the location of the RADAR and Human target positioned on different sides of a 1 feet thick portioned Gypsum wall. Person is standing at a distance of 6.5ft. from the RADAR on the other side of the wall and the height of the antennas from ground is 3'4". [2]. The DFT scanned graph for the no target behind wall and the target behind the wall in [2].



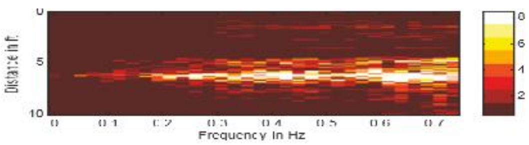


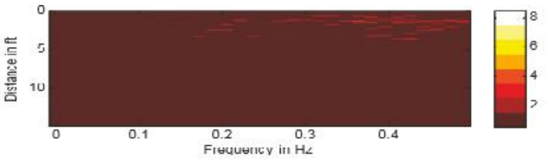
Fig 9: DFT scans no target for gypsum wall .Fig 10: DFT scans target, person moving hands behind gypsum wall.

International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 4, Issue 11
November 2017

2. WOODEN DOOR:

Fig 11: UWB RADAR and human target for wooden door.

Figure 11, shows the location of the RADAR and Human target on different sides of a 4-cm wooden door. Person is standing at a distance of 7’6” from the RADAR on the other side of the door and the height of the antennas from ground is 3’4 “ [2].The DFT scanned graph for the no target behind wall and the target behind the wall in [2].



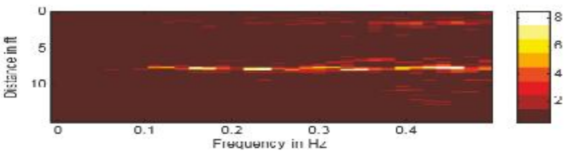


Fig 12: DFT scans no target for wooden door.Fig 13: DFT scans target, moving hand for wooden door.

3. BRICK WALL:

Fig 14: UWB RADAR and human target position close to bench farther away in image for brick wall.

Figure 14, shows the location of the RADAR and Human target on different sides of a 12-cm Brick wall. Person is standing at a distance of 8’ from the RADAR on the other side of the door and the height of the antennas from ground is 3’4” [2].The graph for the target behind wall in[2].

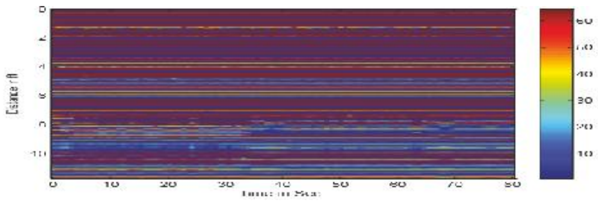


Fig 15: Target behind the brick wall.

III. CONCLUSIONS:

This paper represents the importance of the life detection system and the applications advantages of the life detection system using UWB RADAR. This paper also elaborates the various methods that can be used for the detection. By studying these methods, we find the method based on ultra-wideband radar signal detection of human life(respiratory and heartbeat) is effective. We also find it very reasonable. It can also detect the signal of the blood flow, etc.

In the second method, i.e. Doppler effect we studied the life detection using UWB RADAR. Some sets of the measurements were taken by [2] using the RADAR in monostatic mode. Data were collected for different types of walls and doors. From [2] we studied that the heart beat detection using Doppler approach works for wooden door, gypsum, and brick wallthen singular value decomposition is used to reduce clutter and this works for brick and gypsum wall.From [2] we observed that after applying STFT and SVD method based on the idea that the received signal in case of presence of target will result in difference in frequency response compared to no target case.

IV. REFERENCE:

[1] The Study of UWB Radar Life-Detection for Searching Human Subjects, Wu Chunming, Ding Guoliang Information Engineering College,Northeast Dianli University, Jilin, China.
[2] Sense through wall human detection using UWB radar, Sukhvinder Singh1*, Qilian Liang1, Dechang Chen2 and Li Sheng3.
[3] MODERN MICROWAVE LIFE DETECTION SYSTEM FOR HUMAN BEING BURIED UNDER RUBBLE 1Miss Zade Gauri N., 2Mr. Badnerkar S.*S.
[4] Detection of human's motion through a wall using UWB Radar, Qi Lu, Cai Liu, Zhaofa Zeng, Jing Li, and Xuebing Zhang College of Geo-Exploration Science and Technology, Jilin University 130026, Changchun, China.
[5] UWB Radar for Human Being Detection, A.G.Yarovoy, L.P. Ligthart Delft University of Technology& J. Matuzas, B. Levitas GeoZondas, Ltd.
[6] Qilian Liang, Biologically-Inspired Target Recognition in Radar Sensor Networks, EURASIP Journal on Wireless Communications and Networking, Paper ID: 523435, vol. 2010.