Abstract: In the past, when victims were trapped under earthquake rubble, there was a little chance that they would found. This was due the fact that rescue techniques such as optical devices, acoustic devices or robotic systems were found limited application for the detection buried victims. If victim was unconscious and was unable to shout for help then the existing rescue system found to be failed. With the help of microwave signals the life signs can be detected as it is able to sense the heart beat and breathing signals of human being trapped under collapse debris. A life detection system based on microwave frequency detects the human body vibration by Doppler shift effect. The life detection system has been implemented with simulated rubble and several humans by illuminating microwave beam on their different body position and it is found that phase shift occurs in the illuminated beam on front side of human body was maximum at chest and minimum at forehead. This phase shift may help rescuer to saves human lives.

I. INTRODUCTION

An earthquake causes loss of many human lives every year as humans are trapped under collapsed debris or earthquake rubble. During rescue operation while shifting or falling of rubble also cause death of trapped victims [3]. The disaster in the New York City at ‘World Trade Center’ claimed lives of more than 5000 people. It was said if survivors has been found and rescue earlier the numbers of victims have been lower. There is no end to the number of lives lost as the result of such disasters as landslides, collapsed tunnels and avalanches [3]. Various conventional and existing technologies are available for detection of such trapped victim. But these techniques have major limitations. Like initially trained dogs were used but they detect dead victims also which consumes precious time.

calculate the speed of stars by observing the change in frequency of their light Heart Rate Variability (HRV) provides the information about the time interval between heartbeats and consequently emotional state of human being. Heart beat and breathing provides the periodic chest movement of victim. According to the Doppler theory, the reflected signal has phase shift by periodic movement of human body [8]. The phase change is proportional to the displacement of the human body surface. Doppler radar system can use for heart rate extraction with the sufficient accuracy.

II. METHODOLOGY

Fig 1: Operation of Life Detection System

Apparatus Used: The NV9000 microwave test-bench introduced was use to implement microwave life detection system. The NV 9000 X band waveguide is having inner dimension 22.86 mm length and 10.16 mm. Life detection system consists of various waveguide.
components such as reflex klystron, isolator, hybrid and circular tee, horn antenna and diode detectors. A reflex klystron generates the microwave beam of 8 GHz to 9 GHz. Isolator is used to avoid any reflection because of noise. When it is required to combine two or more signals or split a signal into two or more parts in a waveguide system, tee shape junction must be used. There are two types of tee junction H-plane tee and E-plane tee. Tuners are used to match the load impedance with the source impedance. A horn antenna is used to transmit radio waves from a waveguide out into space, or collect radio waves into a waveguide for reception. A microwave circulator is a nonreciprocal ferrite device which contains three or more ports. The input from port n will come out at port n + 1 but not out at any other port. A three-port ferrite junction circulator, usually called the Y-junction circulator, is most commonly used. To observe the microwave signal on CRO, detector mount has been used. Detector mount contains a diode which is mounted to provide complete dc path without upsetting the RF fields in the waveguide. During the experiment an operating frequency was kept at 8 GHz, repeller voltage was taken 190V-210V, beam voltage was 250-300V, beam current was 20-25mA and antenna’s dimension was length = 7 inches, outer aperture = 4 inches, inner aperture = 1 inch.

**EXPERIMENTAL METHOD**

**Simulation of Rubble:** A series of experiments are conducted in the environment of depicted in Fig. 3. Various layers of bricks were used to simulate the thickness of rubble. The bricks used are of concrete material having thickness of 3 inch. Initially beam is illuminated on an only brick then thickness of rubble was increased upto 5 layers of bricks. The several experiments were also perform by taking non-uniform rubble which includes two 12mm wooden sheet, a water bottle, two concrete bricks and two thick note books. The thickness of non-uniform rubble was 10 inch.

**Subjects:** Several experiments have been conducted on ten different human being (S. T.: F 20, S.A: M 23, A.B.K.: M 24, S.S.B.: M 25, P.P.T.: F 26, A.A.: M 28, A.O.V.: F 29, S.B.: F 30, N.N.M.: M, 40) are participated While detecting the presence of trapped victim, the received signal will have phase shift, this amount of phase shift is vary depending upon the orientation of human being under rubble. So, phase shift for the different orientation of human being were measured. The beam was illuminated on face, neck, chest and stomach from four directions of human being. This also helps to predict the position of trapped victim trapped under rubble.

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**Fig. 2 Schematic of X band Microwave Life Detection System [K M Chen]**

NV 9000 X Band reflex klystron oscillator generates a very stable microwave at 8.5 GHz to 9.8 GHz with an output power of 400mW at beam voltage 300V, beam current 25mA and -190V repeller voltage supplied by the klystron power supply. This wave was fed to a NV 304 isolator. The NV 232 was a magic tee whose main arm couples the signals with the tuner and one of the auxiliary ports was connected to detector mount. The NV 209 detector mount had 50 Ohm RF probe connector. The last port was terminated using flange. The tuner was attached to first port of the port NV 209 Y-circulator. The port2 was connected with the pyramidal horn antenna and port3 was attached with the detector mount to take out the output signal. The wave was radiated into open space via horn antenna. The same antenna was used as a receiving antenna also.

When the microwave beam incident into earthquake rubble, a beam penetrates into it up till it detect any vibration or oscillation [9]. After detecting any kind oscillation the beam was reflected back from that oscillating surface with phase shift. If incident wave is given as \(A_1 \cos(\omega t + \phi)\) then received signal reflected from alive human being will be \(A_1 \cos(\omega t + \phi + \Delta \phi)\) which shows that the reflected signal is phase modulated due to body oscillation, where \(A_1\) and \(A_2\) are the amplitude of incident and reflected signals respectively and \(\phi\) denote the phase shift occurs according to the Doppler shift effect [2].

The phase shift between two signals can be measured with the help of Lissajous pattern. Both the input and output signals are given to 60MHz cathode ray oscilloscope on channel 1 and channel 2 simultaneously. Fig.3 shows the lissajous pattern (a) in absence of human being and (b) in presence of human being. The phase shift \(\phi\) can be calculated by following formula:

\[
\phi = \sin^{-1} \left( \frac{B}{A} \right)
\]
The phase shift was clearly observed up to three layers of bricks i.e. 12 inches and for non-uniform rubble of 10 inches from four direction of victim. But for four layers of bricks the phase change was very small. The X band microwave beam illuminated on an overhead, face, neck, chest and stomach from front, left, right, and backside of victim. The phase change was observed for each orientations and it was found that different phase shift were obtained for different human body position. Fig. 5 shows various phase change occurred when beam was illuminated on human victim with rubble width of one bricks. While measuring the phase shift for all orientations it was observed that the phase change was more when the beam was penetrating from front side of victims as shown in Fig. 5. Also, phase shift was less for forehead position then it is gradually increases till chest and then decreases i.e. the maximum phase shift is occur at chest when beam is illuminated from front side. In spite of the amount of phase shift, the same nature of change of phase shift were observed for two, three and four layers of bricks as shown in Fig. 5 (a), Fig. 5 (b), Fig. 5 (c) respectively. Fig. 5 (e) shows various phase change for different orientations of human being with 10 inches of non-uniform rubble width. For non-uniform rubble also same variation of phase were obtained. Here also maximum phase shift occurred at chest when beam is illuminated from front side. The phase shift from left and right sides are nearly same. The lowest phase shift occurred when beam is illuminated from back sides of victim. From the obtained observation it is cleared that if rescue sends microwave beam in rubble and if there is alive victim then reflected signal will be phase modulated. Also by penetrating a microwave beam at immediate next position of rubble the orientation of trapped can be predicted and it will helpful for rescuer to save’s that trapped victim’s lives.

IV. 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. Thus, the system operating at 10-GHz with 190-230V repeller voltage may be used to detect the breathing and heartbeat signals of living subjects through rubble having width of about four layers of bricks. From the result it is observed that phase shift between transmitted and received signals are increases from forehead to heart and then decreases. It is believe that through the development of similar and related techniques for life detection system, it may be possible to overcome the current fundamental problems in detecting buried victims and save many precious lives.

REFERENCES


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Fig. 4 Variation of Phase Shift With Orientation of Subjects For Rubble Width of (A) One Brick (B) Two Bricks (C) Three Bricks (D) Four Bricks And (E) 10 Inches With Non-Uniform Rubble