Detection of Live Human behind the Wall- A Review

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Abstract- In this paper a new revolutionary method using microwaves called microwave life detection system which can be used to detect human subjects behind the barrier, wall or under earthquake rubble is discussed. In the past when victims were trapped under earthquake rubble, collapsed debris, there was a little chance they would found. This was due to fact that rescue techniques such as optical devices, acoustic devices or robotic systems were found limited applications for the detection of buried victims. 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 collapsed debris. A microwave life detection system operates at appropriate frequencies lies in X-band, L or S band.

Keywords- Microwave life detection system, Breathing & Heartbeat signals, earthquake rubble

I. INTRODUCTION

An earthquake causes loss of many human lives every year as humans are trapped under collapsed debris or earthquake rubble. Some existing methods for detecting such victims are the utilization of dogs or some optical devices, acoustic life detector & the rescue robot. These existing devices are ineffective in recovering human victims lying much below a few feet, especially for the cases where the victims are completely trapped below or very weak to respond to the signals sent by the rescues.

The above problem have been efficiently solved by using life detection system operates at microwave frequency [2]. The basic physical principle for the operation of microwave life detection system is very simple and shown in fig.1.

When microwave beam of appropriate frequency (L or S band to X-band) is aimed at a pile of earthquake rubble or debris under which a human subject is buried, the microwave beam can penetrate through it to reach the subject. When the human subject is illuminated by the microwave beam, the reflected wave from the subject will be modulated by subject’s body movements, which includes breathing and heartbeat. If the reflected wave from the stationary background can be cancelled and the reflected wave from subject body is properly modulated, the breathing and the heartbeat signals of subject can be extracted. Thus human subjects buried under earthquake rubble or debris or behind the wall can be detected.

II. MICROWAVE SYSTEM

The system to detect human being buried under rubble starts with K.M.Chen who brings out the concept of life detection using microwaves in 1985[1]. The detection system developed by Chen later can radiate continuous electromagnetic wave at 10 GHz (X-band)[1]. Such X-band beam cannot penetrate earthquake rubble or collapsed building debris sufficiently deep to locate the buried human victims. For an EM wave to penetrate deep (up to 10 ft.) in to the rubble the frequency of EM wave need to be in the L or S band range. For this reason later Chen has constructed two systems, one operating at 450 MHz and other at 1150 MHz [3]. The block diagram of microwave life detection system is shown below.
Fig. 2. Schematic diagram of the 1150-MHz microwave life-detection system.

The microwave life-detection system has four major components: 1) a microwave circuit system which generates, amplifies, and distributes microwave signals to various microwave components; 2) a microprocessor-controlled clutter-cancellation system which creates an optimal signal to cancel the clutter from the rubble and the background; 3) a dual-antenna system which consists of two separate antennas energized sequentially; and 4) a laptop computer which controls the microprocessors and acts as the monitor for the output signal. The system is operated by a portable battery unit.

To generally describe the systems, it must first be initially said that both frequencies were tested on the same situation to see how each fairied. Power of 400mW or 25.6Dbm is generated and projected from a phase-locked oscillator generator and subsequently fed into a 10dB directional coupler and circulator, from there it flows into the RF switch and finally to the antenna.

Regarding the antennae, three different types have since been developed; the reflector, the patch and the probe. On a functional and performance perspective the reflector and the patch antennae are very similar. Both radiate and receive microwaves from the same plate and from the surface. The differences being that the reflector can be folded and has an adjustable dipole antenna as its main driving component. This particular situation essentially forms a half wave length electric dipole antenna.

The difference with the patch antennae is that it is connected to an aluminum ground plane, which is fed by a coaxial cable. The patch (plate) itself is insulated from the ground.

The probe antennae, however, is slightly different. Physically it is not on the surface but is lowered down via a boredrilled hole or through naturally prevalent fissures. It consists of 2 half-wavelength dipoles separated by an inductor in the center. And a slightly shorter piece of wire, called the parasitic element, is placed next to the 2 dipoles purely for the reason of increasing the bandwidth. A diagram of a probe antenna is shown below.

Fig. 3. Probe Antennae
As it was stated early in 1991, that lower frequencies exhibited better capabilities to penetrate homogenous barriers [2]. In addition to this in the same article written by Chen, experiments were elaborated on where he included moisture ladden bricks. Here too lower frequencies showed signs of greater penetration and resistance to the elements. Higher frequencies seemed to be severely affected, and penetration was greatly mitigated [3].

Then experiments were conducted where an increasing distance and thickness of barriers were placed between the human signal and that of the microwave transceiver. In addition to this thickness, three sub-situations were incorporated. The test subject acted normal, she held her breath and finally was removed completely from the test site. Of the first and second case, a distinct heart beat and breathing signal was detected. However on in the third situation (where the test human was not present) the received signal was very small but still picked up life signs. It is believed that these are the signals of the operator taking the measurement. Physical results are shown below [3]:

![Graph](image1.png)

Fig. 4 : Breathing and heartbeat signals of a female human subject under simulated rubble. A reflector antenna was placed on top of the rubble. Radiated power was about 300mW. The 450-MHz life detection system was used.

![Graph](image2.png)

Fig. 5 : Heartbeat signal of a human female under simulated rubble. Again the reflector antenna was placed on top of the rubble. While the subject was in the rubble cavity, she was holding her breath. The 450 MHz life detection system was used.
The possible shortcoming of the system is the effect of background noise created by the environment and operators. Interference caused by background random noise created by the environment and operator can produce spurious peaks around 0.7, 0.3 and 1.3 Hz and may cause misjudgment in the rescue effort [3].

To avoid such interference new system was developed in 2008 by Chi-Wei Wu who uses EM pulse instead of continuous wave as a radiation source of microwave life detection system [4]. In this life detection system, the amplitude and sign of echo from particular target will depend on the phase of the echo signal relative to that of local oscillator signal. Since wavelength of EM wave is is very short, approximately 3 cm for a carrier frequency of 10 GHz, the phase of the echo can change greatly if the target moves even slightly. Based on this physical behavior the components of pulse radar system can be rearranged to work as a life detection system.

An experimental result shows that the said system can easily recognize several of a human subject’s movement including breathing. It also detects human subjects blocked by simulated earthquake rubble wall and presents sampling echo signals directly in the time domain.

A research paper published [5] shows that a life-detection system with a microprocessor-based automatic clutter cancellation subsystem can be invented for special rescuing robots. This system can operates at 2-G Hz and it will be used remotely to detect the breathing and heartbeat signals of alive subjects through rubble or some other barriers about 3ft in thickness. The microprocessor-based automatic clutter-canceling increases the efficiency of system. The clutter canceller uses an adjustable attenuator and phase shifter to cancel the transmitting power leakage from the circulator and background reflection clutter to enhance the detecting sensitivity of the weak vital signals.

The advantages of the system are:
1) Remote life sensing could be a powerful tool in applications where it is not desirable to disturb a subject’s physiological and/or emotional state during detection or in other situations where access to the subject is limited.
2) The frequency 2.45 GHz i.e. L-band frequency and this is free for use by commercial applications, so we expect a minimum interference with other devices during our tests.
3) No need to use heart beat and the breathing sensor.

The disadvantages of the system are:
1) Project is expensive but once it is implemented the expenses can be reduce lower extend. 2) The L-band frequency is unable to penetrate more metal like structure but it can penetrate over 10 layers of bricks. 3) The involvement of clutter signal may destroy the vital information of life signs. But if the proper demodulation is used one can receive the vital signs efficiently.

In other paper [6] microwave life detection system using microwave test bench is discussed as shown below.

The NV9000 microwave test-bench introduced was used to implement microwave life detection system. The NV9000 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 9GHz.

When the microwave beam incident into earthquake rubble, a beam penetrates into it up till it detect any vibration or oscillation. After detecting any kind oscillation the beam was reflected back from that oscillating surface with phase shift. If incident wave is given as $A_0 \cos(\omega t)$ then received signal reflected from alive human being will be $A_T(\omega t + \phi)$ which shows that the reflected signal is phase modulated due to body oscillation, where $A_T$ and $A_T$ are the
amplitude of incident and reflected signals respectively and $\varphi$ denote the phase shift occurs according to the Doppler shift effect. 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 channel1 and channel2 simultaneously. Fig.7 shows the lissajous pattern (a) in absence of human being and (b) in presence of human being. The phase shift $\varphi$ can be calculated by following formula:

$$\varphi = \sin^{-1} \left( \frac{B}{A} \right)$$

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.

Recent Literature [7] shows microwave life detection system using microcontroller based clutter cancellation circuit operating either at L (or) S band (or) UHF band can detect the breathing and heart beat signals of human beings through earthquake rubble and this technique stands better rather than searching in depth to the core to obtain relevant information and diagnosing it. This analyzing methodology proves to be an efficient solution and can be implemented with an ease of build and doesn’t require any skilled labor for its usage.

III.CONCLUSIONS

Recent detection systems developed using microwaves operating on X-band, L or S Band, UHF band. Most of the systems were expensive also various experimental and simulated work has been done. Still there is a challenge to construct simple efficient and inexpensive life detection antenna system which operates at lower frequencies below 1 GHz. 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