System for the detection earthquake victims – construction and principle of operation

C. Buzduga, A. Graur, C. Ciufudean and V. Vlad

***Abstract*—**This paper presents a system for detecting and rescuing victim's natural disasters. The system has three components: device for victim detection, device for detecting the number of persons in a building and PC interface that will provide information about the persons rescued or died and where they were found directly on the Internet or Data base.

***Keywords*—**detection, earthquake, electrostatic sensor, natural disasters, receiver, transmitter, victims.

I. Introduction

When we say natural disasters we can mention the following events: earthquakes, landslides etc. The term earthquake or seism is a word used for earth movements that make up the vibrations generated in the internal areas of the Earth, which are propagated in the form of waves in the upper lithosphere. These results in the movement of tectonic plates and is often caused by volcanic activity. The earthquakes at larger scale are very strong disasters that can destroy buildings and construction and can generate various natural disasters such as landslides. Also underwater earthquakes that can cause formation of giant waves, so-called tsunami, which reach up to 30 feet tall and reaching speeds of 800 Km/h. Saving the victims is achieved by classical methods which are slow, chances of finding survivors decreased significantly. To this end we thought a simple and efficient detection much easier and the shortest time victims of such events [1], [2]. Other methods used for prevention and/or salvation of population in the earthquake action area are related in literature as using sonic methods, infrared sensors, technology of Geographical Information System (GIS), or dogs especially trained to find human being blocked in damaged buildings [3], [4]. All these rescue methods are applied for emergence decision-making on the earthquake prevention and life rescue in cities. We notice that previous methods related in the literature are different from our method as up to our knowledge such method is new.

The first part of this paper presents construction hardware and principle to functionality the system for detecting victim's natural disasters.

The second part of this paper presents a model realized in Matlab & Simulink for the electrostatic sensor.

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II. Setup System

The system detection victims of an earthquake are an experimental acting on the basis that if you knows the exact position of a man save to become faster. This system works differently than conventional systems search for victims because it requires implementation in buildings before a disaster so that when this occurs, the system will provide rescuers the location and the exact number of survivors. Block diagram for this system showed in figure 1.

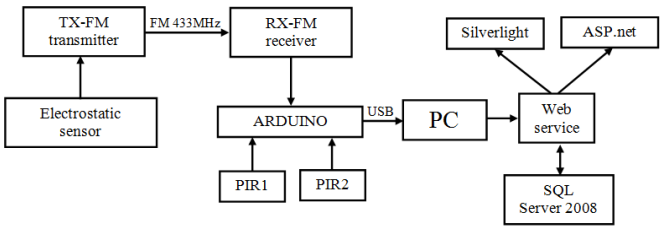


Fig. 1 Block diagram of the system

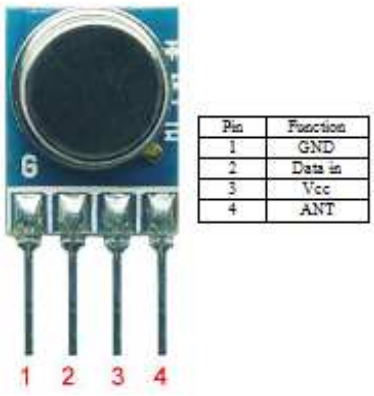
The survivor's detection is done using a special device designed to survive the collapse of a building to fire immediately after. It consists of a metal cylinder with two compartments isolated from each other. The first compartment is an electrostatic sensor that detects if there are people living in its range. This information is transmitted via radio transmitter TX-FM-TWS-DS, which is located in the second half of the cylinder. The device begins to operate with the production of an earthquake, which causes breakage of conductive liquid ampoules, which in turn is still in the metal cylinder [5], [6].

Conductive fluid will link with a 3 V battery will power the device. The signal detection device will be taken by rescuers equipped with a radio receiver composed of receiver RX-FM-RWS-371 and a development kit Arduino UNO or other model, so they will know exactly where to look for survivors. This device will keep the number of people saved and the number of people found dead information to be stored in a database and displayed on the internet when the device is

connected to a PC. The system will permanently take into account the number of persons inside a building using a device consisting of PIR sensors connected to the same acquisition board containing a microcontroller to ATmega28 [7].

A. *The transmitter and receiver*

After an earthquake the electrostatic sensor starts to work and when he finds people have to send this information to rescuers. TX-FM-TWS-DS is a RF transmitter module which transmits the band 433 MHz in ASK modulation. The model for this transmitter is presented in figure 2.



Pin	Function
1	GND
2	Data in
3	Vcc
4	ANT

Fig. 2 Model for TX-FM-TWS-DS

Although the transmitter is located in another section of metal casing, thus electrostatic sensor is isolated it is fed to the same battery of 3V and transmits only when the sensor detects persons. In order to transmit the needs of the input terminal voltage may vary from 2,1V to 3.2V. The electrostatic sensor had more than enough of 2.4V forward voltage thus ensuring a strong transmission without interference of any kind. RX-FM-RWS-371 is an ASK modulated digital data receiver with technical characteristics: frequency range 433.92MHz, modulate mode ASK, date rate 4800 bps, selectivity -108 dBm, channel spacing ±500KHz, supply voltage 5V and is directly compatible with the transmitter TX-FM-TWS-DS with technical characteristics: frequency Range 433.92 MHz, modulate mode ASK, date rate: 8Kbps, supply voltage 1.5~12V [8], [9].

The operations of transmission-reception module are simulated in Matlab using mathematical formulas for carrier wave (1) and ASK modulation (2) [10].

$$C(t) = A_c \cdot \cos(2\pi \cdot f_c \cdot t) \tag{1}$$

and

$$S_{ASK}(t) = m(t) \cdot C(t) = m(t) \cdot A_c \cdot \cos(2\pi \cdot f_c \cdot t) \tag{2}$$

where: $C(t)$ – carrier wave
A_c – amplitude
f_c – frequency carrier
t – time
$m(t)$ – signal modulation

For example we obtained the operations of transmission-reception module in ASK modulate and demodulate mode in Matlab. This graphic is presented in figure 3.

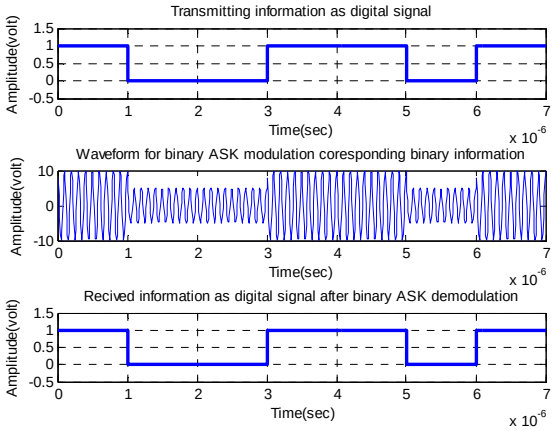


Fig. 3 The operations of transmission-reception module.

This receiver was chosen in part because the work requires a supply voltage of 5V can be supplied easily by development kit Arduino UNO, thus eliminating the need for extra batteries. The model for this receiver RX-FM-RWS-371 showed in figure 4.

Pin	Function
1	GND
2	Digital output
3	Linear out
4	Vcc
5	Vcc
6	GND
7	GND
8	ANT (about 13 cm)

Fig. 4 Model for RX-FM-RWS-371

B. *Electrostatic sensor*

In order to detect people under the ruins of a building our system uses a sensor to be placed inside of an electrostatic metal cylinder to not be affected by the earthquake. Electrostatic sensor is showed in figure 5. The JFET is the sensor of electrostatic field and the other components ensure the gain and adapt the impedance with the wireless transmitter TX-FM-TWS-DS mentioned before.

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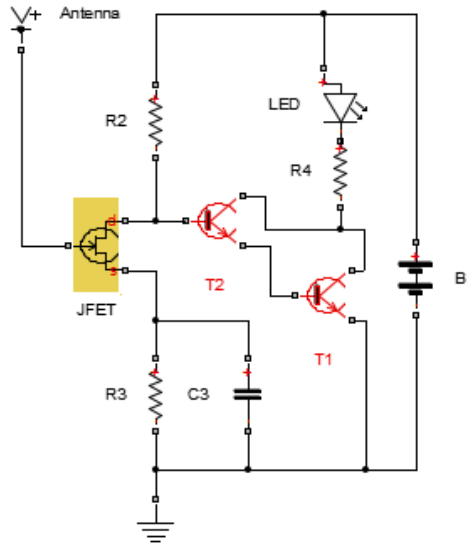

Fig. 5 Electrostatic sensor

It is noted using a field effect transistor (JFET), which presents the rest of the source and drain junction, crossing resistance of very low value of 200 Ω. This transistor has the following output characteristics:

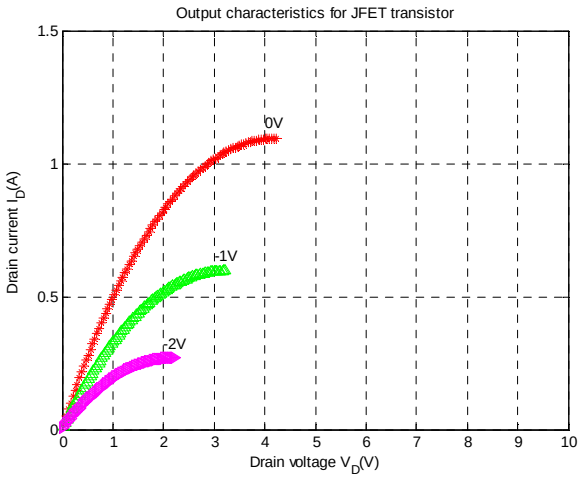

Fig. 6 Output characteristics for JFET transistor

The two NPN transistors with silicon are capable of blocking polarized as they are to drive. Existence 5 kΩ resistor is not sufficient to ensure conduction, because it forms the junction with resistance source - drain field effect transistor, a voltage divider with a voltage to the base of transistor T_2, only 100…200 mV, opening times for transistor T_1 and T_2 respectively coupled Darlington require a voltage of 0.5 V.

This occurs when an electrostatic field is applied gate field effect transistor; when the junction between the source and drain resistance increases considerably, therefore the voltage divider is changed, leading to the opening of transistors T_1 and T_2, resulting in LED lighting, or if our system start transmission transmitter.

The songs used are: JFET can be a BF 245 and BF 256, TIS 34 or any equivalent. The transistor T_1 and T_2 may be of BC 170…173 or equivalent or BC 517 which is a direct Darlington transistor. Electrolytic capacitor must be of good quality without loss [5], [6].

The installation is done on a plastic plate coated with copper foil. For antenna sensor using a piece of copper wire, insulated with polyvinyl of 0,35..1 mm diameter and 10..15 cm long, straight stick with one end terminal of FET's gate. To obtain a higher sensitivity, you can try using a longer antenna, up to half a meter long, extending sensitivity 2…3 meter radius around the antenna.

When making commissioning of the installation, if the pieces are of good quality, light turns on and stays on for a minute, because strong excitation caused by the presence of the user. When he departs, the pilot light goes out; but any approach or production of electrostatic field sensor reacts immediately by switching lights that remain lit as long as the sea was proportionately electrostatic field excitation [10]-[12].

Antenna

C. PIR sensor

To detect the number of people in a room I used a pair of PIR sensors positioned at the entrance so that in the order of their activation system will deduce how many people are in a room. Infrared motion detection may be performed by using:

a) Infrared barrier

b) PIR passive sensor

PIR Passive Infrared (PIR), also known as thermal infrared detects the natural radiation emitted by warm objects. Also extremities moving bodies emit infrared radiation more passive than the background that is. People living beings in general and cars with hot engines emit thermal radiation that a PIR detector senses both day and night. The passive infrared radiation should not be confused with the near infrared emitted by remote controls TV; Passive Infrared does not emit any radiation that could be harmful, but we can say that it is a "dark view". Passive infrared radiation is detected by the pyro-electric sensor. This sensor detects changes in temperature of up to one-thousandth of a degree of 10 m caused by the movement of a person. Pyro-electric sensor detectors can be equipped with different types of lenses: volume, Pet, or type curtain corridor, in addition, some detectors and detection using microwave radar principle, be used when there is a risk of false alarms.

A PIR sensor comprises an optical system and a Fresnel lens made of semiconductor crystal that generates electrical charges on their surface when subjected to heat caused by the infrared radiation with a wavelength specific warm-blooded bodies. The tasks collected on the surface of the crystal are applied to a first-stage transistor amplifier with an FET made usually with the sensor encapsulated in a capsule TO5. The capsule is provided with a window covered with a filter which passes radiation in the infrared range (4..8) μm, giving a minimum attenuation for λ=9.4μm wavelength infrared radiation characteristic organisms "Blood warm ". Diagram for PIR sensor is showed in figure 7.

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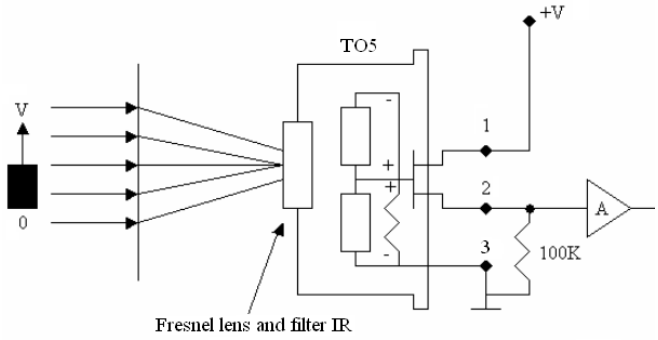

Fig. 7 Diagram for PIR sensor

The drain of the transistor FET is connected to a DC voltage potential and steady and the filter 3 to 15 V and the source is connected to a load resistor of 100 KΩ. The pass band of the amplifier thus produced is limited to 10 Hz, in order to remove high frequency noise. A strong disturbance may generate false alarms, is solar infrared radiation, which is captured as a result of unwanted reflections from the environment. To remove this source of interference, which fortunately has a little speed variation, PIR sensor consists of two crystals that are serially connected differential. The radiation collected by the two crystals in the same point in time, is canceled due to the differential series. In the case of a hot moving body, the two crystals are interlaced in turn, give the information useful here [12], [13].

The optical system for the PIR sensor is a combination of a Fresnel lens made of a plastic film generally translucent white with a thickness of 0.4… 0.5 mm. Specifically Fresnel lens has a series of concentric grooves inclined walls. To understand the role of Fresnel lens optical system made to imagine a source of infrared radiation that travels at a velocity V_0 parallel to the surface S of a PIR sensor. In front of the sensor, suppose there is a C body opaque to infrared radiation. The body C is located a very short distance from the surface of the sensor S is equal with 20…30 mm. In this situation to approximate that both source and the shadow projection on the surface S, moving on circular trajectories with radii R respectively r. How angular velocities of the source are equal that shadow moving in the opposite source speed is:

$$V_v = V_0 \cdot \frac{r}{R} \tag{3}$$

Presence in front of the sensor to a Fresnel lens that focuses the image source S its surface will cause the appearance of a slide "warm" the source, superimposed the background of "cold" ambient, just as many moving shadows generated for your body C is in the form of a grating. If the ambient background is as warm as the source PIR sensor will not cause any electrical signal.

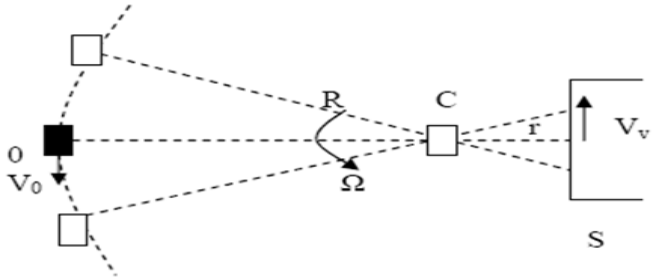

Fig. 8 Trajectory IR rays

The infrared motion detection's principle is precisely scanning performed using Fresnel lens sensor surface contrasts between hot and cold. Channels shape, their number, distribution several Fresnel lenses allow obtaining fascicular-type features, the curtain, etc.

Regardless of the type or characteristic of the detector itself (peripheral alarm system, lighting shutter, door control sensory element to shopping centers, etc.) in most cases using one or more PIR followed floors higher amplification factors of the amplifier and an output validation number of applications depending on the ambient light.

Fig. 9 PIR sensor

D. The Arduino UNO Kit

For information processing system uses the kit Arduino UNO which contains a microcontroller from ATmega328. It takes the information sent by the device to detect people via the receiver RX-FM-RWS-371 such alarm that gives survivors and recover as they are storing this information that is transmitted over the Internet when connected to a PC. Arduino UNO is also responsible for gathering information from the PIR sensor information with which determines how many people were in the building at the time of the earthquake and this information will be transmitted over the Internet.

Arduino UNO is a processing platform open-source software and hardware based on flexible and easy to use. Platform consists of a small (6.8 cm x 5.3 cm - the most common one) built around a signal processor and is able to retrieve data from the environment through a series of sensors and perform actions environment through lights, motors, actuators, and other mechanical devices. The processor is able to run code written in a programming language which is very similar to C ++.

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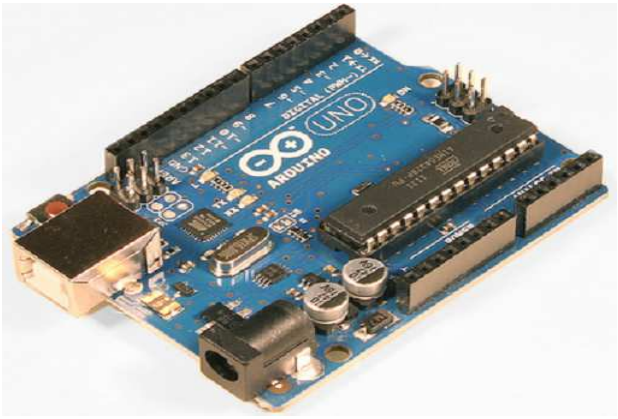

Fig. 10 Arduino UNO

This kit has 14 digital pins of which 6 PWM and 6 analogical pins. Maximum speed program execution allows you to perform hardware and software testing in real time [20].

III. The Simulation Electrostatic Sensor

The simulation is realized in Matlab & Simulink using the circuit in figure 11, [16], [17], [21].

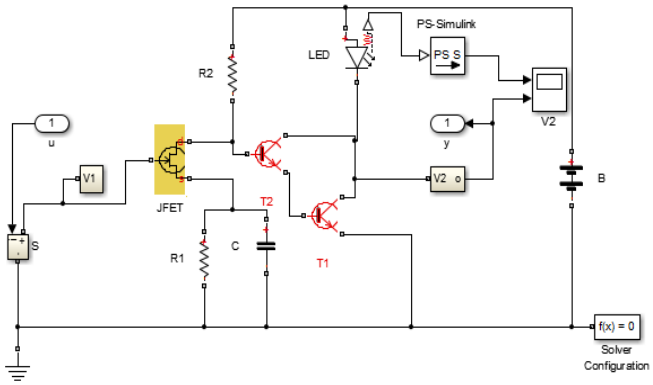

Fig. 11 Circuit for simulation in Matlab & Simulink

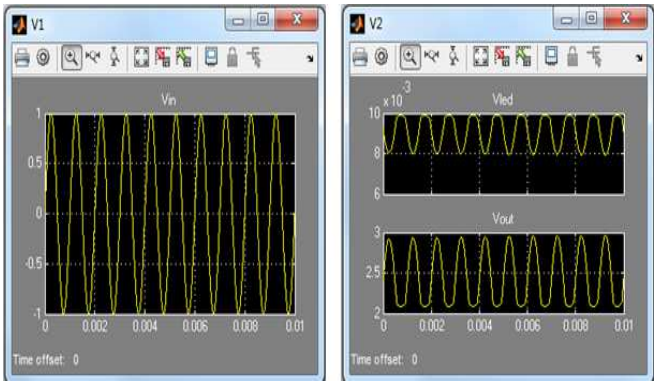

Fig. 12 Signal input, signal for LED and signal output

Simulation results are shown in figure 12. In order to verify the system performance bode diagrams we plotted in figure 13 [21]. From this representation closed loop system is stable with temperature and differs according to humidity and electrostatic field intensity.

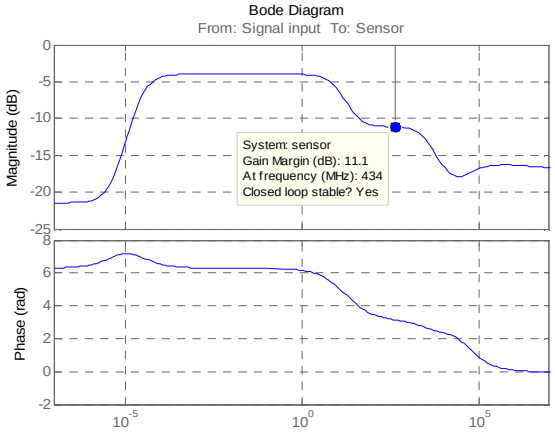

Fig. 13 Bode diagrams for this electrostatic sensor

The device continuously transmits the number of people detected a database that will be displayed on the internet. Web page will be submitted this information graphically displays the relative position of all persons in the room, both those found in life and what could not be saved. In figure 14 is presented a print screen for the internet interface.

Fig. 14 Internet interface.

IV. Conclusion

The detection of victims of an earthquake, or land gliding is a revolutionary device's acting differently from existing similar. The principle that was designed argues that when a person knows the exact position of his salvation becomes faster. The difference with classical search systems is to implement his victims in buildings so that when a disaster occurs, the system acts rescuers providing vital information: the location and the exact number of survivors will always be available to anyone. This system is simple and has a low cost with a minimum set of components.

The development of this system will be focused on improvement of placement mode of the electrostatic sensor.

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This problem is very important because the position as effectively will give more accurate results.

It should be adapted to the dimensions of the room where the sensor is placed, through the increase or decrease the radius of action. If it is not possible the increase or decrease enough the radius of action, thus four sensors may be mount in each corner of the room and then we have a network of sensors, this method is useful in large buildings. It is also necessary to find a method for the sensor to consume power just when it is necessary.

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