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INTRUDER GLASS-BREAK DEFECTING SYSTEM USING COMPUTER INTERFACE

Izz Kadhum Abboud [1], * Alaa Hussain Altimimy[2]

1) Lecturer, Computer & Software Engineering Department, Al-Mustansiriayah University, Baghdad, Iraq.
2) Assist Lecturer, Computer & Software Engineering Department, Al-Mustansiriayah University, Baghdad, Iraq.

Abstract: An obvious shortage appears in local market of security system especially glass-break system. A trial to construct a primary prototype of glass-break system capable to expand to other tasks is attended. Like using variation in apparent distance that measured by Ultrasonic device as a way to estimate temperature of the room. Arduino Uno microcontroller using Ultrasonic sensor with mobile phone to communicate to a predefined phone number for alarm is constructed and tested with the aid of Lab Top computer using USB interface.

Keywords: *Intruder Glass Break, Ultrasonic Device, Distance Measurement, Arduino, Microcontroller*.

نظام كشف سرقة كسر الزجاج باستخدام رابط بيني بحاسبة

الخلاصة: هناك نقص واضح في الانظمة الامنية وخصوصاً نظام الحماية من السرقة عن طريق كسر الزجاج في السوق المحلية. هنا محاولة لبناء نظام حماية اولي لكشف كسر الزجاج قابل للتوسع الى مهام اخرى. كاستخدام تغير المسافة الظاهرية التي تقيسها اداة الابتعاث فوق السمعي كوسيلة لتحديد درجة حرارة الغرفة. كما تم استخدام مسيطر "اردیونو" مايكروي نوع "اونو" يتعامل مع كاشف موجات فوق السمعية ومرتبط الى تليفون موبايل يتصل برقم مسبق التعريف، لتنبيه حدوث تحطم الزجاج، هذه المنظومة تم بناؤها وفحصها بالاستعانة بحاسبة "لاب توب" وباستخدام رابط بيني "يو. أس. بي.".

1. Introduction

In early citizens big gates and many guards are used to protect people from intruders to attack them especially in royal palace in Rome, Egypt and Greece, until modern centuries.

Many helpful discoveries make security system applicable, like measuring speed of sound and manufacturing devices for generating Ultrasound and receiving it, constructing many types of sensors like smock detectors, temperature sensors and flame sensing devices. While advances in electronic circuits and the theory of controllers let security system small, cheap and available for domestic and small offices usage.

*Corresponding Author aaltimimy@yahoo.com

initiated to premeasured distance, the difference in time between thearrivals times are a measure of speed of sound, by considering the speed of light is instantaneous travel. [1]

Isaac Newton measures speed of sound, by find the distance of a wall in order to obtain an echo within 0.5 – 1 sec. He obtained the value 968 feet per second = 294.2 meter per second. A second attempt is obtained 979 feet per second = 297.76 meter per second. [2]

Pierre Simon Laplace, in 1802 had resolved the old Newtonian dilemma. The speed of sound do not held constantan because pressure and then temperature of air are changing therefor the speed of sound is raised.

More attempts are down in nineteenth and twentieth centuries especially in water and different materials, accurate values are obtained. [3]

While Greek philosopher Pythagorus may study sound properties at 6th Century B.C. while Aristotle assumed that sound waves are travelling by resonating air in 4th century BC. [4]

Galileo Galilei (1564-1642) elevated the study of vibrations and the correlation between pitch and frequency of the sound source to scientific standards ($c = f\lambda$).

The era of modern ultrasonic with Langevin's use of high-frequency acoustic waves for submarine detection about 1917. [5]

The first electro-magnetic alarm system was built at 21 June 1853 in the name of a man called Augustus Russell Pope, an inventor from Sommerville in Boston. Doors and windows were connected as independent units by a parallel circuit.

Holmes for business purposes uses the New York City telephone network as an alarm control system. In the 1970s, engineers integrated the first motion detectors in their alarm systems. The 80s and 90s alarm systems become a standard feature of building security. Later a wireless alarm systems technology came on the market at a practical level. [6]

The aim of the project is to use advances in electronic circuits and microcontrollers with the simplifications of connecting it to microcomputer –Lab Top- plus suitable IDE software interface to programming security system toward larger integrated smart domestic and small office applications. Ultrasonic device is used to service two aims, detect glass break and calibrate measuring distance of glass with room temperature. Then using modified small mobile phone to send alarm to predefined address when glass break.

2. Type of Alarms:

Many Types of alarms are available today like Fire Alarm,both smoke and heat detectors are used in fire alarm. Visual or audio siren is triggered; this system may be complicated with intelligent controller. [7]Many prototype detectors are available in electronic market. Also, car alarm with an electronic device is used to deter vehicle theft or its contents. A loud and high-pitched siren is emitted in combination with the car's headlights. [8]Civil Defense Siren alarm is to alert entire communities of approaching danger like air raids or bad weather conditions like tornadoes and sea storms. These systems are used specially at war, to announce enemy plains attacks. The use of civil

defense sirens is worldwide and cangenerate a sound of up to about 130 decibels (dB). [9]Alarm system of glass breakage detectors are sophisticated and may be integrated with camera and monitoring system not only to detect the breakage of glass but also monitors and records events.Glass breakage detectors are normally mounted near accessible glass doors or windows atthe exits of thehouses or offices.[10]

3. Ultrasonic Sensor

3.1. Introduction

Ultrasonic sensors use sound waves, making them ideal for stable detection of uneven surfaces, liquids, clear objects, and objects in dirty environments. These sensors work well for applications that require precise measurements between stationary and moving objects.

Ultrasonic sensors are based on measuring speed of sound waves with frequency above the human audible range. They are based on Time of flight, Doppler Effect and Attenuation of sound waves.

Ultrasonic sensors are non-intrusive in that they do not require physical contact with their target, and can detect certain clear or shiny targets otherwise obscured to some vision-based sensors. On the other hand, their measurements are very sensitive to temperature and to the angle of the target. [11]

3.2. Specifications

☼ Voltage: 5V DC ☼ maximum Current: 15 mA ☼ frequency: 40 KHz ☼ Output: 0-5V ☼ Sentry Angle: 15 degree maximum ☼ Distance Range: 2cm - 500cm ☼ Accuracy: 0.3cm ☼ Trigger Pulse: 10µs Impulse TTL level to device ☼Echo: PWL signal TTL level from device ☼ Size Dimensions: Length = 45mm, Width = 20mm and Height = 15mm. [12]

Ultrasonic sensor manufactured to fit Arduino kit,Fig. 1.

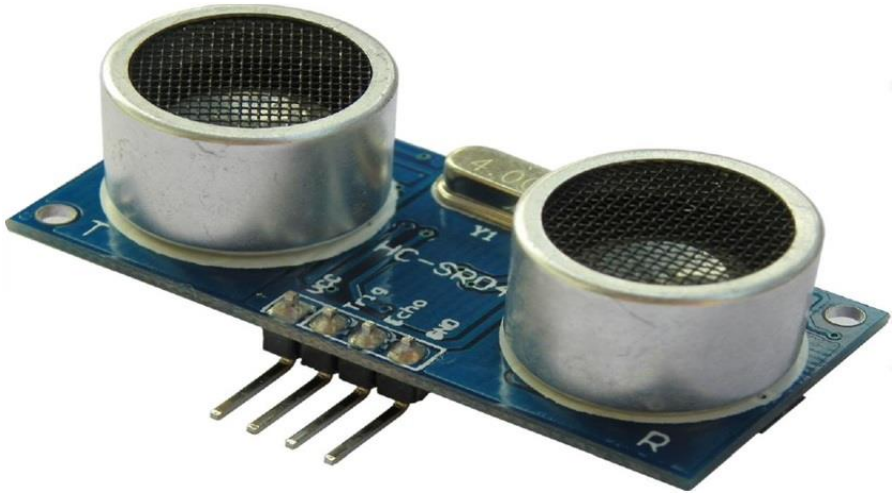

Figure (1) Ultrasonic Sensor.

3.3. Electronic Circuit Of Ultrasonic Sensor

Ultrasonic sensor is constructed of electronic oscillator as 555 timer/oscillator connected to a quartz crystal which has a piezoelectric property and ceramic surface, the piezo material is attached to the acoustic surface, oscillation of timer, will be converted to a mechanical vibration introducing pressure waves in air as ultrasonic waves, these ultrasonic waves are traveled at the speed of sound, when these waves face an obstacle, a reflection occurs and redirected towards wave source, again another quartz crystal and ceramic surface as a receiver catches echo waves and converts pressure waves to electrical oscillations, electronic circuit amplifies it by a gain of 2500 in order to reduce the noise effect, and reshapes them as an output signal whose duration is proportional to traveling time of the wave.

3.4. Beam Pattern of Ultrasonic Device

Direction and separating angle pattern of the beam of ultrasonic waves , Fig. 2.
An angle of cone is about 30°C where amplitude of wave > 70.7% the power of the signal (-3dB) is effective, the plops outside will be considered as a noise. Although Sainsmart HC-SR04 ultrasonic sensor uses a metal cylindrical container covered by a grid to narrow the emission and reacceptance angles within 30°C.This precaution limits the effect of side loop waves from interferes as possible. [13]

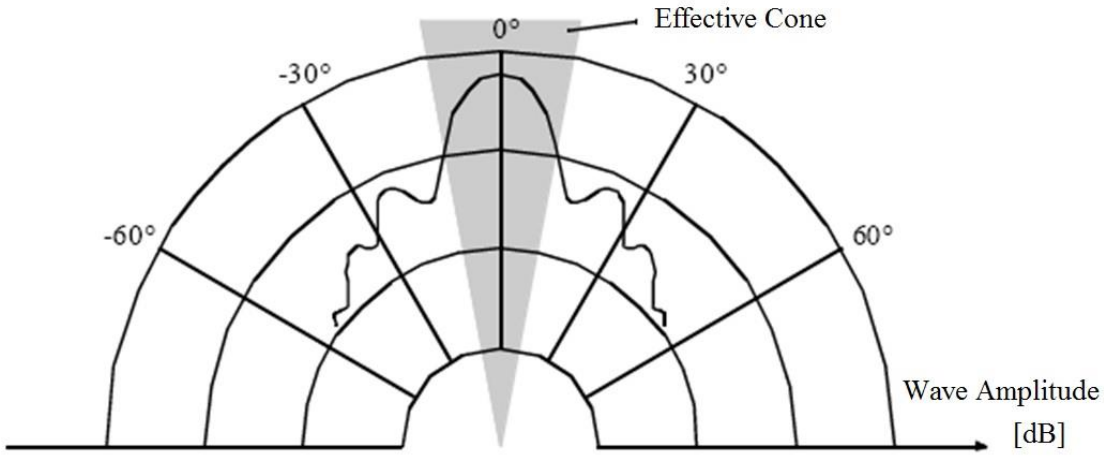

Figure (2): Beam pattern of Ultrasonic wave device.

3.5. Ultrasonic Device Techniques to Measure Distance

Ultrasonic generator sends high-frequency waves, when waves are colliding with an object or barrier such waves are reflected as an echo Fig. 3.[11]

Fig. 4trigger input must be no less than 10 µsecond to initiateultrasonic device to purist 8 ultrasonic pulses at 40KHz, that is out of range of human hearing (20 –20KHz). [14]

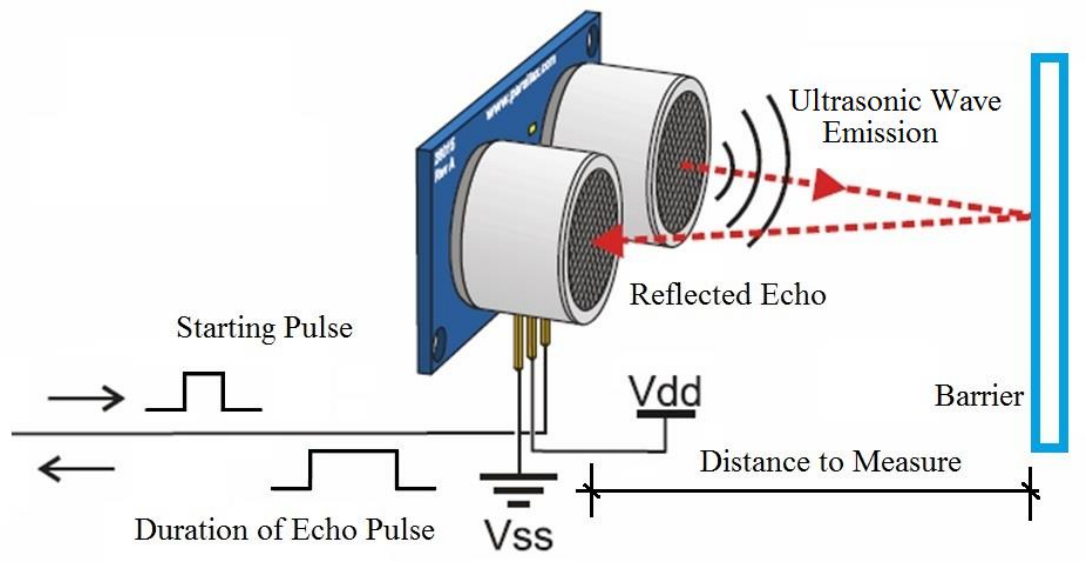

Figure (3) Mechanism of Ultrasonic Sensor.

Pulses will be traveled across the distance until reflected by a body, (Stand still or moving), pulses will be back with some distortion that can be neglected for application purposes, to ultrasonic sensor, ultrasonic pulses travel an instance of time because of the limited speed of sound, thedevice will generate output pulse whose duration isproportional to the time delay occurs.

The ultrasonic detector yielded a large range of 3- 500 cm and 15 degrees to either side.

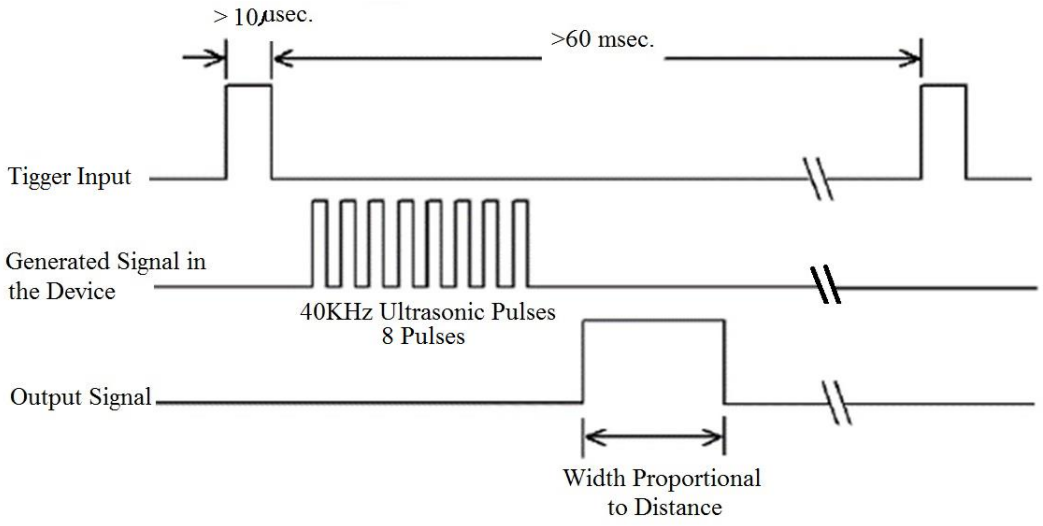

Figure (4) Timing Diagram of Ultrasonic Sensor.

So, the distance is calculated by:

$$\text{Distance } measured\ in\ meters = \frac{\Delta t\ sec.}{2} * 334\ m/sec. \text{At 20 °C.} \quad (1)$$

3.6. Calculating Temperature against Change in Speed of Sound

Sound waves are elastic waves within a deformable medium. The wave velocity depends on the medium‘s elastic properties. A relative accuracy of the order of an accuracy of 0.1 °C on temperature can be easily achieved for few meters distances in environment that controlled carefully. [15]
For dry air considered as an ideal gas property, the speed of sound is accordingly expressed, a commonly used good approximation formula as: [16]

$$S\ (T)\ =\ (331.3 + 0.6 * (T_c - T_0)\ )m/sec$$ Where T_0 = 0°Celsius. (2)

Comparing estimating speed of sound according to the two terms of Tyler series expansion and heat capacitive values is doneFig. 5. [17]
Approximation in a range of (-100 to +100) °C is acceptable (≈ 3/264 ≈ 1.136% at -100 °C and ≈7/392 ≈ 1.78% at +100 °C)

4. Arduino UNO Microcontroller

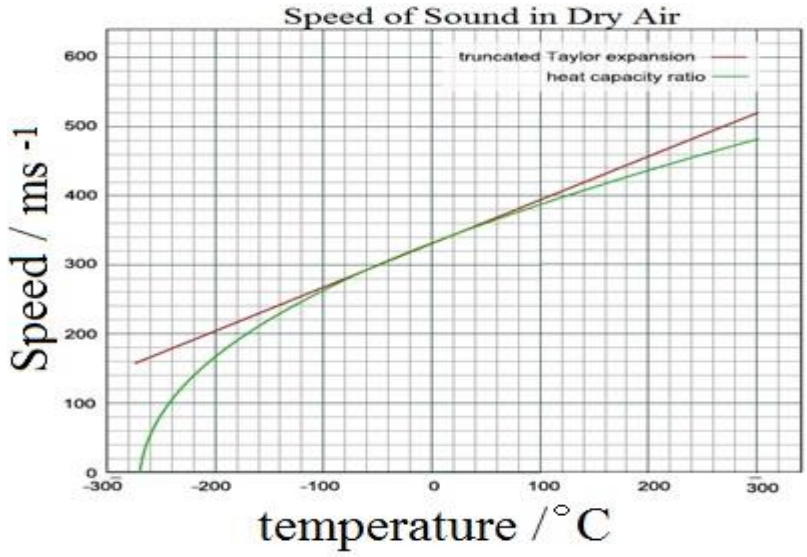

Figure (5) Approximation of the speed of sound.

Arduino UNO is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs,a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. programmed as a USB-to-serial converter. Fig.6. [18]
For stand-alone operation, the board is powered by a 9 V battery.

Arduino UNO software was programmed to read voltages generated from the sensors and convert these voltages into a distance. The sensors were then hooked up to the specific software on a laptop through a USB cable. Distance across the room are measured and set into Lab top program. Then the measured distances were compared with the distance being reported by the sensor. Any change in the distance will be

recorded as an intruder cross the room. Ultrasonic sensor (Sainsmart HC-SR04), Arduino UNO software is used. [19]

5. Arduino Programming:

One of benefits using Arduinomicrocontroller is (Interface) IDE (Integrated Development Environment) that can downloaded from the official site of Arduino company "ardunio.cc", Interface is a program package let the end-user to write program in simplified C/C++ language, although it has a good library which can be loaded when demand as included header files to drive any hardware attached to microcontroller that is motors, Wi-Fi, Ethernet, infrared, ultrasonic, etc. these libraries adapt an easy instruction for end-user to write program without dealing with any details.

A lot of examples and programs are available across the net; help to overcome probable obstacle faces the programmer. Although more sophisticated program can be written in Assembly language specifies with 8-bits AT-mega © processor.

After writing C/C++program, it is downloaded via USB cable suited with Arduino microcontroller kits into EROM memory. The system can be tested and verified, if any bugs discovered, rewrite the program within IDE interface, the process will be repeated until the program executed properly. Since that Arduino microcontroller works independent of computer

Three main areas are used in writing program:

(1) Include, define and declaration area to define general variables.

(2) Setup area: to set the initial values of any device, start it if necessary, once.

(3) Loop area: code in this area will be executed repeatedly making an endless loop. . [18-20]

6. Project Preparations And Applications

6.1. Calibrating Distance Of Glass With Ultrasonic Device

Ultrasonic wave device measures distance to glass of window or door, if glass breaks the distance will be changed, or distance across the room is addressed, if an intruder crosses the room, ultrasonic sensor detects difference in distance measured or motion detection occurs, so alarm will be applied.

General formula to calculate speed of sound S according ambient temperature T:

$$S(T) = 331.3 + 0.6*T \quad (3)$$

Time t measured by ultrasonic device according distance D:

$$t = 2*D/S \quad (4)$$

If a reference temperature T0 is used then measured speed of sound S0:

$$S(T0) = S0 = 331.3 + 0.6*T0 \text{ m/sec.} \quad (5)$$

Time t0 measured by ultrasonic device according reference distance D0:

$$t = 2*D0/S0$$

$$t0 = 2*D0/(331.3 + 0.6*T0) \text{ sec.} \quad (6)$$

Time tx measured to the same distance with Tx temperature:

$$tx = 2*D0/(331.3+0.6*Tx) \text{ sec.} \quad (7)$$

Apparent distance Da is:

$$Da = tx*S0/2 = 2*D0/(331.3 + 0.6*Tx)*(331.3 +0.6*T0)/2$$

$$Da = D0 * \frac{(331.3 + 0.6*T0)}{(331.3 + 0.6*Tx)} \quad (8)$$

$$(331.3 + 0.6 * Tx) = \frac{D0}{Da} * (331.3 + 0.6 * T0)$$

$$Tx = \frac{T0*D0}{Da} + \frac{331.3}{0.6} * \frac{D0-Da}{Da}$$

$$Tx = \frac{D0}{Da}(T0 + \frac{331.3}{0.6} * \frac{D0-Da}{D0}) \quad (9)$$

If the distance used about 2meters at 30°C speed S (T):

$$S (30) = 331.3+0.6*30 = 349.3 \text{ m/sec.} \quad (10)$$

So, Time T(S) is:

$$T (30) = 4/349.3 = 11.45 \text{ msec.} \quad (11)$$

If temperature changed to 50 c:

$$S (50) = 331.3 + 0.6*50 = 361.3\text{m/sec.} \quad (12)$$

Time measured:

$$T(50) = 4/361.3 = 11.07 \text{ msec.} \quad (13)$$

So, if S(30) is used as a speed in formula, Ultrasonic sensor reads distance D as:

$$D1 = T*S /2= (11.07 * (349.3))/2 = 1.933 \text{ m.} \quad (14)$$

That is 3.33% lesser difference error.
And at S (-20):

$$S(-20) = 331.3 - 0.6*20 = 319.3 \text{ m/sec.} \quad (15)$$

$$T(-20) = 4/319.3 = 12.527 \text{ msec.} \quad (16)$$

So, if S (30) is used as a speed in formula, Ultrasonic sensor reads distance as:

$$D2 = T*S/2 = (12.527 * (349.3))/2 = 2.1878 \text{ m.} \quad (17)$$

That is 9.39% greater distance error.
These values can be fitted in Estimated Temperature graph Fig. 7.

These differences do not compare if the glass break which may be 100% or more difference. Variation in appearing distance can be used to measure room temperature at the same time.

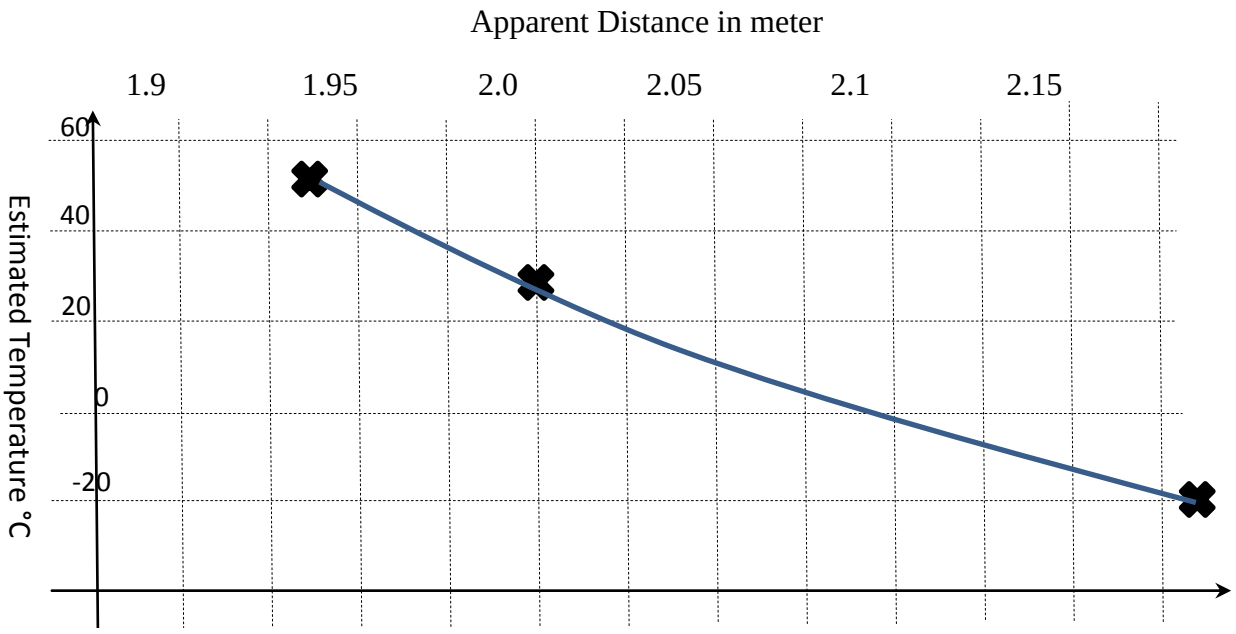

Figure (7) Estimated Temperature is calibrated with 2meters distance at 30 °C.

6.2. Circuit Diagram of Glass Break Defection System

A prototype of electronic circuit has been built,Fig. 8.

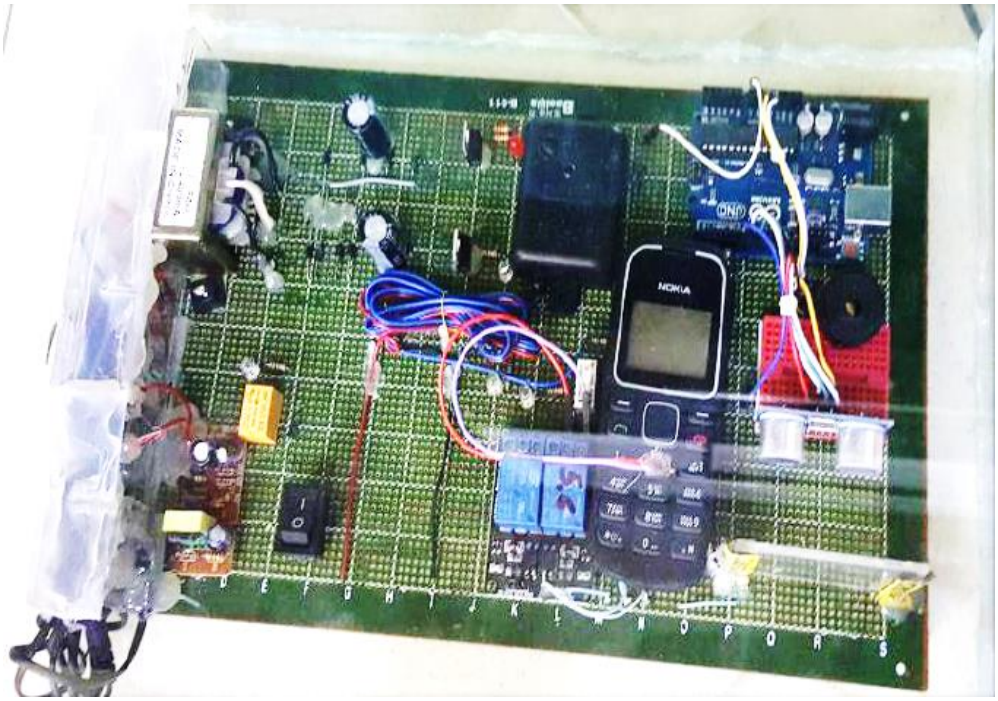

Figure (8) Snapshot of Glass Breaking Electronic Circuit Prototype.

Classical Standalone Electronic Circuit with Shock Sensor:

Fig. 9, a traditional electronic circuit can be used as a device to detect a shock action of breaking glass of window or door under consideration. Abridge rectifier (REC1) with a center taped transformer (TR1) and electrolytic capacitor (CAP1 = 1000µF) are used to full rectification and smoothing rappels. Regulator (REG7812) is used to get steady voltage value at 12V.

The detecting circuit has a shock sensor detecting shock waves of breaking glass, it

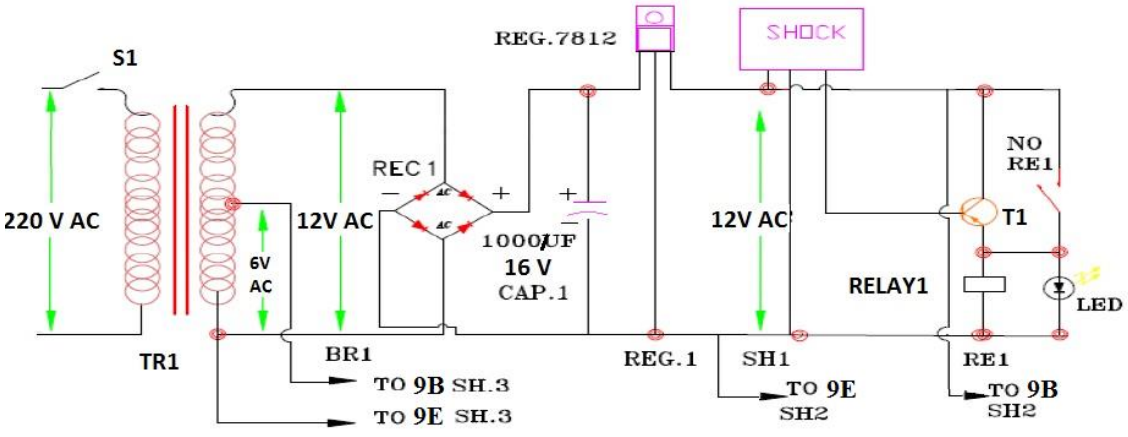

Figure (9) Standalone Glass Breaking Circuit with Shock sensor.

derives PNP (base) transistor (T1) that in its role derive a relay (RELAY1), and then an indication LED sign is used, because the shock sensing unit sense to the vibrations or shocks a latch circuit in the work is used, therefore the LED stay in the open state.

Fig. 10, the contact of the relay in state of normally open (this mean when the coil of the relay1 is activated indication will be occurs. The terminal from 9E sh.1 provides power with 6volt to the Arduino, the terminal from 9f sh.1 providesGND to the Arduino. 5V and GND also supply the ultrasonic and relay. Echo of theultrasonic is connected to the terminal 9 and the trigger is connected to terminal 8 to Arduino microcontroller respectively, buzzer is connected to terminal 10 and GND, the control-in is connected to terminal 7 of microcontroller.

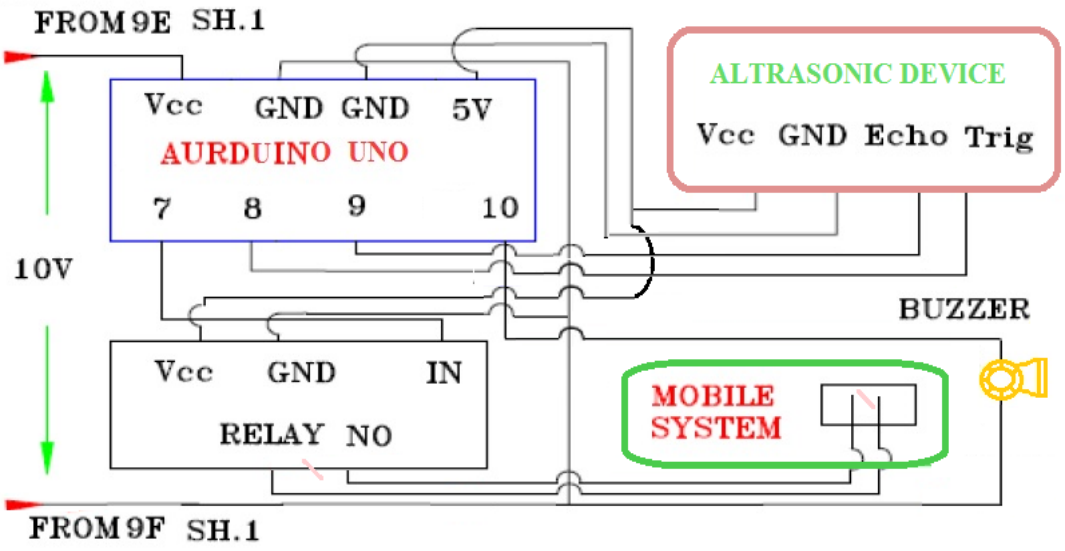

Figure (10) Arduino Microcontroller Connected to Ultrasonic and Mobile Phone.

Normally open relay is connected to the button of the mobile .
When an intruder breaking the glass, ultrasonic sensor sends trigger back as an Echo showing that the distance become greater than setting distance during Arduino programming. Arduino microcontroller will activate buzzer and send activated signal to relay which operates mobile as shown.

6.3. Application Program: Algorithm And Downloading

Using IDE of Arduno microcontroller C++ program is written, in two steps: first to read distance of glass automatically once (2 meters for example) and set it, second Arduno microcontroller read distance via Ultrasonic device all the time within 100 milliseconds, if any limited changes in reading distance, temperature in room will be estimated according to calibrated equation, and if distance measured is too different (4 meters or more according glass break) Arduino will initiate a signal to trigger a cell phone which makes a phone call to predefined number and send a message to monitor program in IDE installed in Lab Top via USB connection.

7. Conclusion

Using Arduino microcontroller in a verity controlling systems, has an advantage of ability to rewrite the controller program and downloaded it easily, so, software functions can be more and more flexible and intelligent.Reprogram microcontroller can

expand and develop its services, without any hardware addition. As a temperature can be measured using the same system only reprogram microcontroller.Flexibility of electronic circuit can made it easy to reconstruct with more elements to perform an integrated job.

Using a computer connected via serial or network node makes microcontrollers more intelligent, since monitoring and more complicated tasks cannot be offered by microcontroller where its EPROM and RAM are limited, also integrated tasks of different types can be achieved within network of automatic homes or small offices.

The main trained of the world towards domestic applications especially intelligent home for security, fire alarms, intelligent controllers as luminance control and coffee made heaters, inspire this paper.

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