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Enhanced BankVault (Strong Room) Security System Design

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Abstract: ***As Security is one of the most needed and concerning factor while building a vault system, whereby vaults areintended to protect their contents from theft, unauthorized use, fire, natural disasters, and other threats. With lack of more efficient security a vault can be vulnerable to some number of attacks or disasters. The fact that most of the systems are human based supportive security protocol, Then the main purpose of this paper is to propose the design of a microcontroller based automated security system of the bank vault that can give an instant protection against any break-in by hackers or any unauthorized physical intrusion, reacts bylocking the vault door and alerting the control room while sending a warning signal to the law enforcement team immediately. The system consists of the twoworking together microcontrollers PIC16F690&ATmega328that associated with Ultrasonic sensorHC-SR04, 2x Infra-red(IR)sensors FC-51, passive infrared (PIR)sensor, LDR, GSM/ GPRS & GPS shield, Piezo Buzzer and Optical Fingerprint sensor with display panel.***

Keywords: Vault (Strong-room),Ultrasonic Ranging Module HC-SR04,IR (Infra-Red) sensor FC-51,Passive Infra-Red Sensor (PIR Sensor), Arduino Uno

1. Introduction

A **vault** is a secure space where money, valuables, records, and documents are stored, in which theircontents are intended to be protected from theft, unauthorized use, fire, natural disasters, and other threats, almost similar like a safe. But unlike safes, vaults are an integral part of the building within which they are built, using armored walls and a tightly fashioned door closed with a complex lock.

Historically, **strong-rooms**were built in the basement of a building where the ceilings were vaulted, hence the name. They are common in potential buildings where valuables are kept such as banks, mining site offices, post offices, grand hotels, rare book libraries and certain government ministries. Vault technology developed in a type of arms race with robbers. Modern vaults may be coming up with a wide array of alarms and anti-theft devices (heat sensors, motion detectors, etc.)

The system described in this paper cited particularly for bank vault environment where it should function forthat strong-room while sending feedback to the control room (IT room) under both conditions for securing the vault when the bank is empty and also secure the access when the bank is fully functional. It is cheap, easy to install and cover maintenance. The power consumption is very low; the system doesn't need any operator once it is installed, hence the system is very economic and ideal for any organization who wants full proof effective security system.

This full system contains a motherboard having the micro controllers, motor controller interface with H-bridge circuitry, display interface, Optical Fingerprint interface, Input interfaces for the sensors connection. Such sensors like PIRs (Passive Infra-Red sensors) often referred to as PIR, "Passive Infrared", "Pyroelectric", or "IR motion" sensorsare used for thermal movement detection and counting people by using the on-off output signal of PIR sensors& LDR (Light Dependent Resistor –simply a Photo Resistor) sensors are used to detect unauthorized door movement. Each PIR can cover 10m-45m (32ft-147ft) at an angle of ±15 degrees. Whereby under the condition of protecting a large area, the number of PIR sensors can be increased.While Sensors such as Ultrasonic Ranging ModuleHC-SR04 is a commonly used ultrasonic sensor which is capable to detect obstacles in a range of 2-300cm. The sensor looks like a small PCB having two metal cylinders on the front-side and a small circuit on the back-side. This Ultrasonic sensor together with 2 x IR (Infra-Red) sensor FC-51 named a and b specially needed for counting the number of people traversing them towards or away from the vault door ,were all both used for enhancing the first security layer established just before the Vault's door.

Since project is purposely for ensuring the unbreakable system so it is entirely based on the microcontroller. The fact that the microcontroller is code protected then no one except the vendor / owner can override the system bychanging password or anything else. In this system the two privileged microcontrollers are used, one is ATmega328 & another is PIC16F690. The first one (ATmega328) was used for threefunctions;

1) Get inputs from the Ultrasonic HC-SR04, 2 x IRs FC-51, PIR & LDR sensors,
2) Interface the Optical Fingerprint and a 16x2 LCD display.
3) Gives alertingoutputs to the GSM/ GPRS& GPS shield& Buzzer sensors.

The second one (PIC16F690) was used to drive the H-bridge for the operation of the automatic vault door.

2. Methodology

The system has5 steps security layers to ensure the safety of the vault system; The first part of security layer is Obstacles detection& Counting. People are detected as obstacles as a person enters the area covered by Ultrasonic HC-SR04 set up to detect any obstacle within its range, whereby the ultrasonic sensor will be parallel mounted very close to the optical fingerprint sensor that is also mounted beside the vault door. In this way it detect the presence or absence of a person within range just before the vault door. Meanwhile with the two IR (Infra-Red) sensors FC-51named as IR-a & IR-b, their Transmitters(T) mounted parallel to each other and both opposite to their Receivers (R) respectively that their infrared beams being perpendicular to the triggered sound waves from ultrasonic sensor within its range. To know if a person who had already come close to the vault door for further access to the system has entered inside vault or got away from the vault, the presence of Ultrasonic and both IR-a & IR-b sensors is used to analyses the situation for further decisions such as;

- If the ultrasonic sensor is no longer triggered and IR-b is triggered before IR-athen this person will be considered as has moved away from ahead of the vault door as the number of people traversing them deducted by one each time IR-b is triggered before IR-a. So the system will lock the door and secure security.
- If the ultrasonic sensor is no longer triggered and IR-b isn't triggered before IR-a then this person is considered as has moved behind the vault door which means has entered the vault. So the system will lock the door and secure security. And,
- If the ultrasonic sensor is still triggered and IR-a is triggered before IR-b then this will be considered as number of people traversing IR sensors towards ahead of the vault door has increased by one each time IR-a is triggered before IR-b then the vault system will deny all further access by lock the door and secure security as the situation violate the security condition set up by restricting a single person to have access of coming to the vault door at a time.

The second part of security layer is Fingerprint Authentication. In this security layer the two basic requirements are needed for using the optical fingerprint sensor; first,the people required to have access to the vault door will need to enroll fingerprints, which means assigning ID numberto each print so that they can query them later.Once they've enrolled all their prints, they can easily 'search' the sensor, asking the sensor to identify which ID (if any) is currently being photographed. This pre-programmed identification can be saved & modified if necessary by the people authorized for accessing the system, only authorized persons will be having the access to open the vault door. So each time after scanning the registered fingerprint on the optical fingerprint sensor, if the fingerprint is accepted, the door will open and will disable all the alarm systems. If the fingerprint is not accepted it will ring a warning sound & alert the user. If wrong fingerprint is inserted more than 3 times, it will secure the door & alert the control room (IT Room) and the law enforcement team.

The Third part of the security layer is Physical interrupt alarm. A 'Laser' near to the door is aimed at a LDR sensor. If by any chance, it happens anyone cut the bolts of the door or blows it away, the broken particle of the door or the door itself will cut the laser & will trigger the alarm.

The Fourth part of the security protection scheme is Thermal security system. If it happens as anyone plans to get into the vault by breaking the vault floor or wall, then the PIR sensor will detect the thermal movement & will trigger the alarm instantly. But the third and fourth part of the protection scheme are only activated under the condition that the door is locked & de-activated when the door is unlocked. The fifth part of security layer is alarm and alerting signal system. This layer is responsible for releasing the triggered reactions to the corresponding output devices, the alarm will be sent to the control room via piezo buzzer and the law enforcement team will receive an alert (SMS/ Call) via GSM/ GPRS & GPS shield.

3. General Description of Equipments

3.1 General Description for Arduino

Arduino is an open source physical computing platform based on a simple input/output (I/O) board and a development environment that implements the Processing language (www.processing.org).

Arduino can be used to develop interactive objects, taking inputs from a variety of switches or sensors and controlling a variety of lights, motors and other physical outputs. By equipping the Arduino with sensors, actuators, lights, speakers, add-on modules (called shields), and other integrated circuits, you can turn the Arduino into a programmable "brain" for just about any control system. Arduino projects can be stand-alone, or they can be connected to (collaborate with) software on your computer (such as Flash, Processing, VVVV, Proteus and Max/MSP). The boards can be assembled by hand or purchased preassembled; the open source IDE (Integrated Development Environment) can be downloaded for free from (www.arduino.cc). The Arduino IDE can run on Windows, Macintosh, and Linux.

To program the Arduino (make it do what you want it to) you also use the Arduino IDE (Integrated Development Environment), which is a piece of free software, that enables you to program in the language that the Arduino understands. In the case of the Arduino the language is C. The IDE enables you to write a computer program, which is a set of step-by-step instructions that you then upload to the Arduino. Then your Arduino will carry out those instructions and interact with the world outside. In the Arduino world, programs are known as 'Sketches'.

The Arduino platform consists of two components:

1) The hardware – A physical programmable circuit board, also known as the microcontroller. Simply a simple open source hardware board designed around an 8-bit Atmel AVR microcontroller, or a 32-bit Atmel ARM. There are different types of Arduino boards.
2) The Software – The Integrated Development Environment (IDE) that runs on the computer, used for writing and uploading programming codes to the physical board. Simply a standard programming language compiler and a boot loader that executes on the microcontroller.

An Arduino board consists of an 8-bit Atmel AVR microcontroller with complementary components to facilitate programming and incorporation into other circuits. An important aspect of the Arduino is the standard way that connectors are exposed, allowing the CPU board to be connected to a variety of interchangeable add-on modules known as shields. Some shields communicate with the Arduino board directly over various pins, but many shields are individually addressable via an I²C serial bus, allowing many shields to be stacked and used in parallel. Official Arduinos have used the megaAVR series of chips, specifically the ATmega8, ATmega168, ATmega328, ATmega1280, and ATmega2560. A handful of other processors have been used by Arduino compatibles. Most boards include a 5 volt linear regulator and a 16 MHz crystal oscillator, although some designs such as the Lily Pad run at 8 MHz and dispense with the onboard voltage regulator due to specific form-factor restrictions. An Arduino's microcontroller is also preprogrammed with a boot loader that simplifies uploading of programs to the on-chip flash memory, compared with other devices that typically need an external programmer [1], [2].

At the heart of every Arduino there is an Atmel microcontroller unit (MCU). Most Arduino boards, including the Arduino Uno, use an AVR ATMega microcontroller. The Arduino Uno in Figure 1, uses an ATMega 328p. The Due is an exception; it uses an ARM Cortex microcontroller. This microcontroller is responsible for holding all of your compiled code and executing the commands you specify. The Arduino programming language gives you access to microcontroller peripherals, including analog-to-digital converters (ADCs), general-purpose input/output (I/O) pins, communication buses (including I2C and SPI), and serial interfaces. All of this useful functionality is broken out from the tiny pins on the microcontroller to accessible female headers on the Arduino that you can plug wires or shields into. A 16 MHz ceramic resonator is wired to the ATMega's clock pins, which serves as the reference by which all program commands execute. You can use the Reset button to restart the execution of your program. Most Arduino boards come with a debug LED already connected to pin 13, which enables you to run your first program (blinking an LED) without connecting any additional circuitry.[6]. Simply, The Arduino IDE is based on the Processing language, which was developed to help artists create computer art without having to first become software engineers. Arduino was designed for artists, designers, and others who want to incorporate physical computing into their designs without having to first become electrical engineers.

Figure 1: Arduino Uno Components

3.2 General Description for Optical Fingerprint Sensor

Optical fingerprint sensor is an electronic device used to capture a digital image of the fingerprint pattern. The captured image is called a live scan. This live scan is digitally processed to create a biometric template (a collection of extracted) which is stored and used for matching.This type of sensor is, in essence, a specialized digital camera. The top layer of the sensor, where the finger is placed, is known as the touch surface. Beneath this layer is a light-emitting phosphor layer which illuminates the surface of the finger. The light reflected from the finger passes through the phosphor layer to an array of solid state pixels (a charge-coupled device) which captures a visual image of the fingerprint.Optical fingerprint shown in figure 2.

This kind of sensor type was used for fingerprints authentication to secure the vault door with biometrics - this all-in-one optical fingerprint sensor makes adding fingerprint detection and verification super simple. These modules are typically used in safes - there's a high powered DSP chip that does the image rendering, calculation, feature-finding and searching. Can be connected to any microcontroller or system with TTL serial, and send packets of data to take photos, detect prints, hash and search. With it I can also enroll new fingers directly - up to 162 finger prints that can be stored in the onboard FLASH memory. There's a red LED in the lens that lights up during a photo to indicate that it's working. I preferred to this particular sensor because not only it is easy to use, but also it comes with fairly straightforward Windows software that makes testing the module simple, so it is possible to even enroll using the software and see an image of the fingerprint on the computer screen.

Supply voltage: 3.6 - 6.0VDC Operating current: 120mA max
Peak current: 150mA max
Fingerprint imaging time: <1.0 seconds
Window area: 14mm x 18mm
Signature file: 256 bytes
Template file: 512 bytes
Storage capacity: 162 templates
Safety ratings (1-5 low to high safety)
False Acceptance Rate: <0.001% (Security level 3)
False Reject Rate: <1.0% (Security level 3)
Interface: TTL Serial
Baud rate: 9600, 19200, 28800, 38400, 57600 (default is 57600)

Working temperature rating: -20C to +50C
Working humid: 40%-85% RH
Full Dimensions: 56 x 20 x 21.5mm
Exposed Dimensions (when placed in box): 21mm x 21mm x 21mm triangular
Weight: 20 grams

Figure 2: Optical Fingerprint Sensor

3.3 General Description For 16X2 LCD Display

I've used a LCD display to show the instructions & indications to the user. It is a 2 line 16 Character Display driven by the ATmega328 micro controller. [3]. Figure 3 shows a 16x2 LCD panel.

Figure 3: 16x2 LCD Panel

3.4 General Description For Infrared Sensor (IRs) FC-51

The basic concept of IR (Infrared) obstacle detection is to transmit the IR signal (radiation) in a direction and a signal is received at the IR receiver when the IR radiation bounces back from a surface of the object. Figure 4 shows the IR sensor.

An object can be detected with an infrared system consisting of an infrared transmitter and a receiver. More in detail an **IR transmitter**, also known as IR LED, sends an infrared signal with a certain frequency compatible with an **IR receiver** which has the task to detect it. There are different kind of IR sensors for different type of application. IR technology is used, for example, in proximity sensors to detect a near object, in contrast sensors to find a path or in counting sensors to count objects.

-IR transmitter and IR receiver
The IR transmitter is a particular LED that emits radiation in the frequency range of infrared, invisible to the naked eye. An infrared LED just works as a simple LED with a voltage of 3V DC and a current consumption of about 20mA. The IR receiver, such as a photodiode or a phototransistor, is capable of detect infrared radiation emitted from the IR transmitter. Aesthetically it is similar to a LED but the external capsule can be wrapped by a dark color film.

-Principle of operation
The IR transmitter sends an infrared signal that, in case of a reflecting surface (e.g. white color), bounces off in some directions including that of the IR receiver that captures the signal detecting the object.When the surface is absorbent (e.g. black color) the IR signal isn't reflected and the object cannot be detected by the sensor. This result would occur even if the object is absent.

In thisbank vault security system design, in order to make a bidirectional counter for restricting the number of people coming close to the vault door, the two IR sensors were used. It is a 0 to 9 counter in which the first sensor (IR-a) is used to count ingoing people, the second (IR-b) those outgoing.
Features:

1) There is an obstacle, the green indicator light on the circuit board
2) Digital output signal
3) Detection distance: 2 ~ 30cm
4) Detection angle: 35 ° Degree
5) Comparator chip: LM393
6) Adjustable detection distance range via potentiometer:
   - Clockwise: Increase detection distance
   - Counter-clockwise: Reduce detection distance

Specifications:

1) Working voltage: 3 - 5V DC
2) Output type: Digital switching output (0 and 1)
3) 3mm screw holes for easy mounting
4) Board size: 3.2 x 1.4cm

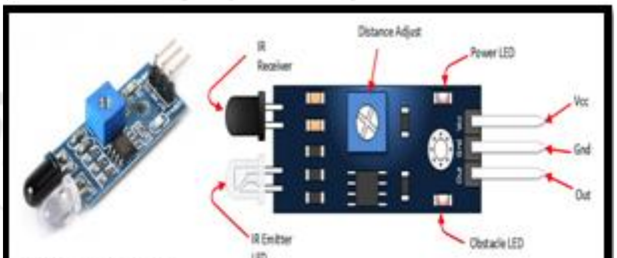


Figure 4: IR (Infrared) Obstacle Detection Sensor Module 2 - 30cm FC-51

Pin,Control, Indicator	Description
Vcc	3.3 to 5 Vdc Supply Input
Gnd	Ground Input
Out	Output that goes low when obstacle is in range
Power LED	Illuminates when power is applied
Obstacle LED	Illuminates when obstacle is detected
Distance Adjust	Adjust detection distance. CCW decreases distance. CW increases distance.
IR Emitter	Infrared emitter LED
IR Receiver	Infrared receiver that receives signal transmitted by Infrared emitter.

3.5 General Description For Ultrasonic Sensor HC-SR04

HC-SR04 is a commonly used ultrasonic sensor which is capable to detect obstacles in a range of 2-400cm or 1" to 13 feet. The sensor looks like a small PCB having two metal cylinders on the front-side and a small circuit on the back-side (see Fig.5).

The HC-SR04 ultrasonic sensor uses sonar to determine distance to an object like bats do. It offers excellent non-contact range detection with high accuracy (the ranging accuracy can reach to 3mm) and stable readings in an easy-to-use package. Its operation is not affected by sunlight or black material like Sharp rangefinders are (although acoustically soft materials like cloth can be difficult to detect). It comes complete with ultrasonic transmitter and receiver module. (The modules includes ultrasonic transmitters, receiver and control circuit)

Features

- Power Supply :+5V DC
- Quiescent Current : <2mA
- Working Current: 15mA
- Effectual Angle: <15°
- Working Frequency: 40Hz
- Ranging Distance : 2cm – 400 cm/1″ – 13ft
- Resolution : 0.3 cm
- Measuring Angle: 30 degree
- Trigger Input Pulse width: 10uS TTL pulse
- Echo Output Signal : Input TTL lever signal and the range in proportion
- Dimension: 45*20*15mm

Attention:

- The module is not suggested to connect directly to electric, if connected electric, the GND terminal should be connected the module first, otherwise, it will affect the normal work of the module.
- When tested objects, the range of area is not less than 0.5 square meters and the plane requests as smooth as possible, otherwise ,it will affect the results of measuring.

Sensor

Figure 5: Ultrasonic Sensor HC-SR04

Pins

The sensor has 4 PIN:

1) **VCC**, which must be connected to 5V;
2) **Trig**, which is an input PIN to trigger the measurement; (Trigger Pulse Input)
3) **Echo**, which is an output PIN which sent out a square wave ;(Echo Pulse Output)
4) **GND**, which must be connected to ground.

Note that, user manual specifies which GND must be connected first since a floating 5V could permanently damage the sensor.

How it works:

The two cylinders are actually an ultrasonic receiver (R) and an ultrasonic transmitter (T) which are driven by the circuitry. The working principle is quite simple: when triggered the transmitter shoots some pulses. When sound encounters an obstacle it is echoed back and detected by the receiver.

The basic principle of work:

1) Using IO trigger for at least 10us high level signal,
2) The Module automatically sends eight 40 kHz and detect whether there is a pulse signal back.
3) If the signal back, through high level , time of high output IO duration is the time from sending ultrasonic to returning. Test distance = (high level time×velocity of sound (340M/S) / 2,

How to use it:

If **Trig** is set as high for at least 10us the sensor will shoot 8 pulses of sound. For the whole time required by the sound to make the road trip **Echo** will be high.

The logical steps to get a measure would be:

1) Set the Input Capture Unit to measure the high period of a square wave on the **Echo** pin;
2) Pull up **Trig** signal for at least 10 us;
3) Convert the measured time in a distance using the previous formula.

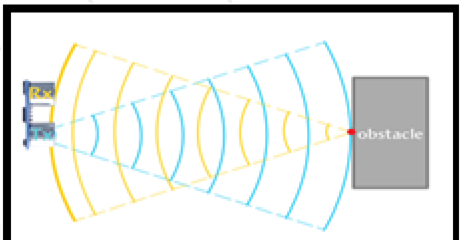


Figure 6

In Figure 6-An example of obstacle detection using an HC-SR04

Since the speed of sound is almost constant, the information about the distance is strictly related the elapsed time from the shoot to the receiving. Indeed, sound has to travel twice the distance (roundtrip). Known the elapsed time the distance to obstacle is by equation (1)

$$d = \frac{v \cdot t}{2} \quad (1)$$

Where

- **d** is distance between the obstacle and the sensor
- **v** is the speed of sound (about 340 m/s)
- **t** is time elapsed

Note that, here I am not discussing about accuracy of the measurement which is affected from different factors:

- Speed of sound is not constant: it depends on material medium, temperature, pressure and humidity.
- Time measurement accuracy: the measure is made by on board circuit and we don't have control on this.
- The obstacle may not have a flat surface and there could be multiple diffraction or spurious echo.

3.6 General Description For Passive Infrared Sensor

A Passive Infrared sensor (PIR sensor) is an electronic sensor that measures infrared (IR) light radiating from objects in its field of view. PIR sensors are often used in the construction of PIR-based motion detectors. They are commonly called simply "PIR", or sometimes "PID", for "passive infrared detector". The term "*passive*" in this instance refers to the fact that PIR device doesn't generate or radiate any energy for detection purposes. They work entirely by detecting the energy given off by other objects. PIR sensors don't detect or measure "heat"; but merely they detect the infrared radiation emitted or reflected from an object. And the term *"Infra"* meaning below our ability to detect it visually, and "Red" because this color represents the lowest energy level that our eyes can sense before it becomes invisible. Thus, infrared means below the energy level of the color red, and applies to many sources of invisible energy. [4]. Figure 7 shows a Passive Infrared Sensor (PIR)

The fact that, all objects with a temperature above absolute zero emit heat energy in the form of radiation. And usually this radiation can't be visible to the human eye because it radiates at infrared wavelengths, but it can be detected by electronic devices designed for such a purpose.So Apparent motion is detected when an infrared source with one temperature, such as a human, passes in front of an infrared source with another temperature, such as a wall. This is not to say that the sensor detects the heat from the object passing in front of it but that the object breaks the field which the sensor has determined as the "normal" state. Any object, even one exactly the same temperature as the surrounding objects will cause the PIR to activate if it moves in the field of the sensors.

Operation:
An individual PIR sensor detects changes in the amount of infrared radiation impinging upon it, which varies depending on the temperature and surface characteristics of the objects in front of the sensor.[2] When an object, such as a human, passes in front of the background, such as a wall, the temperature at that point in the sensor's field of view will rise from room temperature tobody temperature, and then back again. The sensor converts the resulting change in the incoming infrared radiation into a change in the output voltage, and this triggers the detection. Objects of similar temperature but different surface characteristics may also have a different infrared emission pattern, and thus moving them with respect to the background may trigger the detector as well.

PIRs come in many configurations for a wide variety of applications. The most common models have numerous Fresnel lenses or mirror segments, an effective range of about ten meters (thirty feet), and a field of view less than 180 degrees. Models with wider fields of view, including 360 degrees, are available and typically designed to mount on a ceiling. Some larger PIRs are made with single segment mirrors and can sense changes in infrared energy over thirty meters (one hundred feet) away from the PIR. There are also PIRs designed with reversible orientation mirrors which allow either broad coverage (110° wide) or very narrow "curtain" coverage, or with individually selectable segments to "shape" the coverage.

Figure 7: Passive Infrared Sensor (PIR)

3.7 General Description For Light Dependent Resistor (LDR)

A photo resistor or light dependent resistor is a resistor whose resistance decreases with increasing incident light intensity. Light Dependent Resistors (LDR) are also called photo resistors.;In other words, it exhibits photoconductivity. They are made of high resistance semiconductor material. A photo resistor is made of a high resistance semiconductor. If light hits on the device is of high enough frequency, photons absorbed by the semiconductor give bound electrons enough energy to jump into the conduction band. The resulting free electron (and its hole partner) conduct electricity, thereby lowering resistance. A photoelectric device can be either intrinsic or extrinsic. An intrinsic semiconductor has its own charge carriers and is not an efficient semiconductor, e.g. silicon. In intrinsic devices the only available electrons are in the valence band, and hence the photon must have enough energy to excite the electron across the entire band gap. Extrinsic devices have impurities added, also called dopants, whose ground state energy is closer to the conduction band; since the electrons do not have as far to jump, lower energy photons (i.e., longer wavelengths and lower frequencies) are sufficient to trigger the device. If a sample of silicon has some of its atoms replaced by phosphorus atoms (impurities), there will be extra electrons available for conduction. This is an example of an extrinsic semiconductor. Photo resistors are basically photocells. [5]. Figure 8 shows a typical Construction of LDR

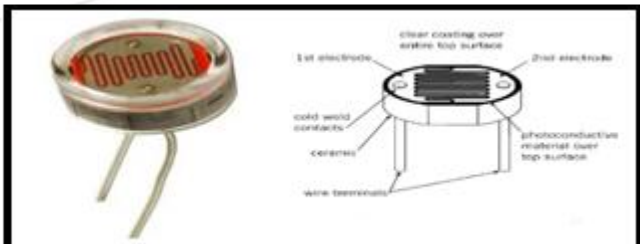


Figure 8: Typical Construction of a Plastic Coated Photocell

3.8 General Description for GSM/ GPRS, GPS Shield

Firstly, GSM is an international standard for mobile telephones. It is an acronym that stands for Global System for Mobile Communications. Sometimes referred to as 2G, as it is a second-generation cellular network. And Among other things, GSM supports outgoing and incoming voice calls, Simple Message System (SMS or text messaging), and

data communication (via GPRS). Whereby the Arduino GSM shield is a GSM modem. From the mobile operator perspective, the Arduino GSM shield looks merely like a mobile phone. While from the Arduino perspective, the Arduino GSM shield looks merely like a modem. So to use GPRS for internet access, and for the Arduino to request or serve webpages, it needs to obtain the Access Point Name (APN) and a username/password from the network operator.
Whereas GPRS is a packet switching technology that stands for General Packet Radio Service. It might provide idealized data rates in a range of 56-114 Kbit per second. Since a number of technologies such as SMS rely on GPRS to function. Then with the GSM shield, it's also possible to leverage the data communication to access the internet. Also similar to the Ethernet and Wi-Fi libraries, the GSM library allows the Arduino to act as a client or server, using http calls to send and receive web pages. In addition to the GSM shield and an Arduino, a SIM card is needed. The SIM represents a contract with a communications provider. The communications provider that sells the SIM has to either provide GSM coverage where the SIM card is used, or have a roaming agreement with a company providing GSM coverage in your location. Though there are a few different sizes of SIM cards, the GSM shield can accepts cards in the mini-SIM format (25mm long and 15mm wide). In this vault security system, the GSM/ GPRS &GPS Shield for Arduino Uno used to alert the law enforcement team by sending SMS or callas one of the security protection scheme. And since the use of GPS (Global Positioning System) technology makes it easy for determining the precise location of bank vault system.This device is based on a GSM/GPRS module with included GPS. And its main function is to detect and communicate its own geographical position using, on the choice, the cellular phone reference system or the GPS. In figure 9 the GSM/ GPRS & GPS Shield for Arduino Uno is shown.

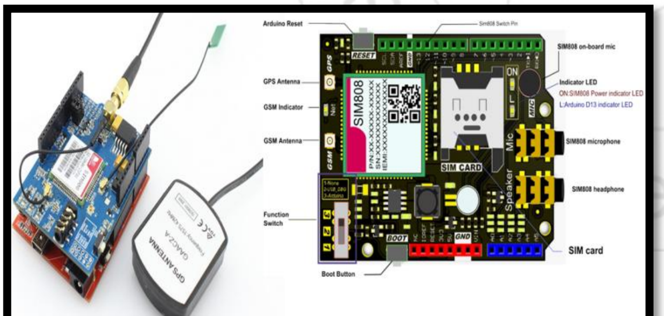


Figure 9: GSM/ GPRS &GPS Shield For Arduino

3.9 General Description For Buzzer Sensor

A **buzzer** or **beeper** is an audio signaling device, that might be piezoelectric, mechanical or electromechanical. Buzzers and beepers are typically used in alarm devices, timers, and confirmation of user input such as a mouse click or keystroke. Meanwhile, a**Piezo buzzer** is an electronic device commonly used to produce sound. With Light weight, simple construction and low price make it usable in various applications like car/truck reversing indicator, computers, call bells etc.
Usually a Piezo buzzer is based on the inverse principle of piezo electricity discovered in 1880 by Jacques and Pierre Curie, which is the phenomena of generating electricity when mechanical pressure is applied to certain materials and the vice versa is also true. Whereas such materials are called piezo electric materials. These Piezo electric materials can be either naturally available or manmade. As Piezo ceramic is class of manmade material that poses piezo electric effect and is widely used to make disc, the heart of piezo buzzer. So when subjected to an alternating electric field they normally stretch or compress, in accordance with the frequency of the signal thereby producing sound. Figure 10 and 11shows the piezo electronic symbol and the piezo buzzer respectively.

Hence in this bank vault security system the piezo buzzer is usedto produce the alarm as anotheralerting way of the output reaction in the protection scheme in accordance to the triggered conditions. Since each buzzer operates in different voltages and current, then the choice of a buzzer depending on its working voltage and current specifications should be taken into consideration as it determines the kind of connection with Arduino Uno. If a buzzer operates from a low enough voltage and draws low enough current, it can be interfaced directly to an Arduino Uno pin. Otherwise the extended buzzer circuit that can work with Arduino Uno should be designed to connect with.

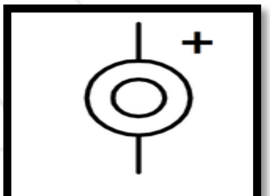


Figure 10: Piezo Buzzer Electronic Symbol

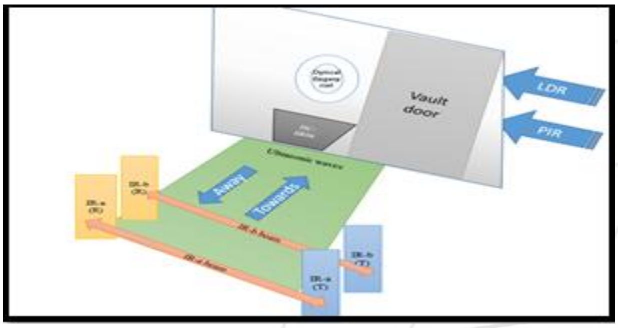
Figure 11: Piezo Buzzer

4. Features of Bank Vault Security System

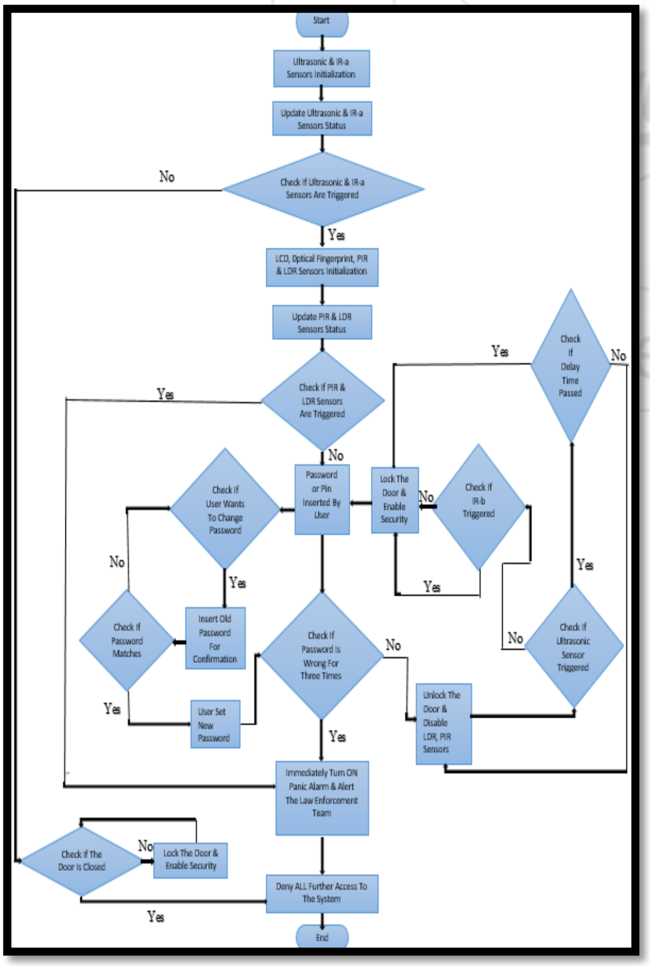
1. Full proof security system.
2. Can be monitored & controlled from distant control room by wireless module.
3. Five layers security system.
4. Reliable & Durable.
5. Can be applicable to Mining industry's strong room, Home Security System or in Museum as well as Bank Vault.
6. Low power consumption.
7. Doesn't need to keep eye on surveillance continuously.
8. Alert sound and can call law enforcement team if necessary.
9. Battery operated, can be backed up and also mains operated.
10. 24X7 time online protection.
11. The heavy duty vault door is controlled by geared motor
12. Highly movement detection and obstacle counting sensors

13. It is an auto locking & turning on the Alarm after shutting the vault door.
14. The fingerprintscan be encrypted & the microcontroller can be code protected.
15. Highly sensitive thermal sensor for burglars.
16. Every PIR sensors can cover 10-45 m.
17. More PIRs can be connected parallel for larger space.
18. The Physical interrupt system for blown door particle & man made interruption.
19. It is a Low cost operating system using Arduino module [ATmega328] in C programming language.
20. Motor driver using PIC16F690 & two high current capacity H-bridge circuits.
21. Overall cost effective and devices are easily available on the market.

5. Layout of Vault System Security Layers



6. Flow Chart of the System



7. Conclusion

Since this project was aimed at enhancing the bank vault security system that use popular installation of Password security system, then it involves the use of some other security features especially different sensors to make it more secured hence the name Enhanced Bank Vault Security System.

This paper is not only about the fingerprints authentication security method established at the vault door for the entrance access to the vault, but also for monitoring the movements by detecting and control the number of people (regards as obstacles) that comes close the vault door for further access of getting inside the vault (strong room), and providing vault in-door protection scheme by the thermal& physical interruption alarm, so it extend the efficiency of bank vault security system and also it is cheaper technology since it makes use of just different sensors arrangement. Beside that it can be applicable to secure other places such as Museum, Libraries, and strong rooms in mining industries. This protection system will stop thieves, robbers & any kind of intruders & will notify the law enforcement team instantly.

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