Low-cost Car Battery Security Alert System

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Abstract:
This is a technical article that showcases a low-cost car battery security alert system that utilizes a multi-vibrator circuit into a dual-tone multi-frequency (DTMF) output (loud beep sound) alarm to monitor and safeguard the car battery from local theft. The entire circuitry is a simple one and low-cost in production. The incessant cases in which car batteries are stolen especially in developing countries is on the high side. And the cost of replacing car batteries is on the increase daily. Therefore, one needs to secure her car battery from street theft. Using both mechanical fastening and electronic security-based systems one could sleep with two eyes closed. The device serves as an electronic watchdog on the car battery in the car while it is parked outside the owner's residence or elsewhere. The security system is provided with an internal rechargeable battery energizing the alarm circuitry, having a single-pole double-throw (SPDT) relay, and connected cables, with an output sound capable of alerting the neighbourhood. Whenever the car battery is disconnecting from the terminal heads or the loop cable is broken the connected alarm will be triggered and this will call the attention of the neighbourhood and the owner thereby deterring the intruder. The entire system was simulated using Circuit Wizard software with good results. The system was fabricated using discrete semiconductor devices that are relatively simple and available for operation and maintenance, packaged, and tested. The circuit voltage is 11.52 volts and draws a current of 3.79A resulting in a wattage of 44 watts. The device is affordable.

Keywords: *Alarm system; battery thieves, car battery; multi-vibrator; protection system circuits.*

I. INTRODUCTION

Why battery is important in the starting, control, monitoring, and indication applications of a vehicle? Why do petty thieves target these car batteries? Maybe the gain in reselling it or for personal use. This valuable device requires proactive security measures to curb the incessant menace found daily. First of all, let's look at its features; a battery has a wider area of application as an energy storage device (ESD). It discharges its quantity of electricity after duly charged to the connected load. Batteries are valuable components in a vehicle, supplying DC power for starting, controlling, monitoring, and indication systems.

In Johnson (n.d) batteries are presented as a device that converts chemical energy into electricity. The composite chemical and its reactions in a battery produce the flow of electrons from one electrode to another. This flow of electrons provides an electric current that drives a connected load. To turn the starter motor in an automotive engine battery is used as the starter power source. However, rechargeable batteries are frequently employed to give electrical current to car electrical components. Apart from starting the engine via the starter motor, it is one of the most important components of a vehicle system since it stores charges for later usage [1].

Imagine, you just wake up one morning and the car you parked outside is stolen or the all-important, expensive battery is stolen from the car hood. No money in the pocket and you are about to go for work or an emergent use of the vehicle is required. Maybe, you want to take your expectant wife to the hospital; you just name any incident. In as much as mobility is concerned, one is required to have a vehicle for personal or commercial use. There is a tendency to commute through a vehicle. The simple and valuable device (car battery) needs to be protected at least within one reach; replacement cost is high and the inconvenience encountered therefore this low-cost car battery alert system is necessary and affordable even for the least low-income commercial driver. In the literature, various researchers and experiences have been presented using electrical/ electronic systems, and embedded systems put in place to curb the unpleasant situations.

According to CAA (2023), batteries are sources of electrical power that make watches, phones, IR remotes, etc., and even cars operate. Despite car batteries being used for starting the engine (i.e. bringing electricity to the car's ignition system), they also support a few other functions in terms of powering the vehicles' car radio, car air-conditioner, headlights, and wipers. The battery is also helpful in the stabilization of voltage spikes caused by turning on/off accessories that pull a lot of energy. Batteries are the storage powerhouse for use now or later, therefore they need to be secure. Technological advancement is making batteries sophisticated in their application hence, somewhat capitally expensive [2].

Also, in Studentlessonmedia (n.d) a battery is an electro-chemical device that changes chemical energy into electricity. It could be either wet or dry cells. Automotive engines need electrical power to rotate their starter motors, thus a battery is needed to provide that power. Of course, rechargeable

batteries are used to deliver the electric current to the electrical components in the vehicle. Starting, lighting, and ignition (SLI) batteries in most vehicles can provide at least 3% of the battery power to deliver the maximum current required for a short period [3].

Ramos (2022) pointed out that the battery is essential in the car to power the starter when the vehicle is off, but once the starter gives life to the engine, the alternator takes over. That is the alternator in the vehicle now powered the vehicle's electronics accessories. This alternator also charges the battery through a reversal of the processes that led to its discharge [4].

What features do we need to know about this 12-volt lead acid battery? In Vartabedian (1999) the constituent composition of a 12-volt battery was discussed; however, it consists of six 2-volt compartments known as cells that contain a grid of lead plates immersed in sulfuric acid. The reactions through the lead plates with water and the acid generally produce electricity. One by-product of the process is the gaseous hydrogen, an element so highly flammable therefore, we must be on the lookout during charging. And because heat drives up hydrogen output, it should be a concern generally in hot weather days [5].

More so, the uses of batteries in petrol and diesel internal combustion engines as seen in [1], [3], [5] presented some categories of batteries as starting, lighting, and ignition (SLI) batteries for serving the purpose of starting, lighting, and ignition in the vehicles. Fig. 1. (a) and (b) are examples of lead acid batteries used regularly for starting, lighting, and ignition (SLI) purposes.

Fig.1. (a)

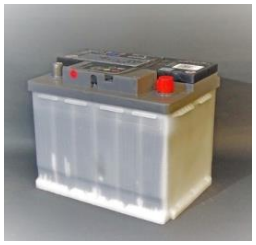

Fig. 1. (b)

Fig. 1. (a) and (b) Starting, Lighting and Ignition Battery (Adapted from [1],[7]).

When the electrical parts in a vehicle require excess power above the supply of the charging system the SLI battery supplies the extra power needed during the starting of the engine. SLI is widely used in automotive as mentioned earlier. Just as its name implies, it is used for starting a car - providing power to the ignition. The battery also powers other electrical components such as radio, headlights, screen wipers, etc., in a vehicle as seen in [3], [5].

According to Wikipedia, there are other special types of battery used to power electric hybrid cars and of course, they are high-voltage electric batteries, but the automotive battery can also be used as well. This allowed the use of standard automotive electrical parts that are designed to run on 12 volts. These types of batteries are also called supporting batteries as seen in [3], [6].

From the foregoing, we have seen the functions and composition of this car battery making it very useful both in car application and home use. Thus, any vulnerable car battery attracts street boys for unlawful making money ventures. Now, the idea in this article is to protect these expensive batteries from being stolen by street boys – the hoodlums.

In Klapan (2019) an online article expressed that car batteries are frequently the target of trivial thieves in almost all countries because of the usefulness of the device in general. It is observed that whether commercial or private cars are packed in an unsecured environment, the battery in the car being unprotected is prone to stealing. Thieves just have to open the car engine bonnet/hood, disconnect the battery terminal head, and cart away the battery in that car [7].

Cars, trucks, etc., batteries are very expensive typically between 20,000 Naira to 100,000 Naira, etc., for a single unit in Nigeria depending on the capacity of the battery and make.

In the article, it is also revealed that the activities of these bandits, often time, the stolen batteries are easily sold to recycling yards or black marketers (scrap buyers) as seen in most countries. It has been observed that theft usually revisit the place where they stole a car battery, believing that the car owner must have replaced it with a new battery. A stolen car battery has to be replaced for the operation of the car ignition and other DC power-requiring systems. Repeated theft is common therefore; the car battery should be properly protected or removed from the car. The latter is a common practice carried out by taxi transporters and others whose car(s) is/are parked in an unsecured environment.

To secure one's car battery, it requires additional tasks to secure the car battery that is positioned under the hood; some special keys open some car doors unnoticed to car owners, and as such the area bandit can cart away very important items apart from the car battery. It is seen that a regular car battery thief will jump into a parking lot for easier targets, avoiding those cars that are properly secured in any special way. Some security measures were mentioned in [7].

As stated in Chesonis (2023) car battery theft is a growing problem affecting vehicle owners across all nations. The sudden loss of a battery not only disrupts the daily routine but can also lead to costly repairs and replacements. The article presented some ways thieves use to steal car batteries. And to curb the menace of these car battery thefts, the home security expert pointed out that, battery thieves use mechanical tools like wrenches and pliers to quickly take away batteries from vehicles and frequently target cars parked in poorly lit or isolated areas. Securities measures can be put in place to prevent battery theft by safeguarding the 'car battery' using clamps gates or locks, parking in well-lit areas, and also applying an alarm system with a hood trigger or any other system to scare off the bandit trying to steal to battery [8].

In Abdul (2023) it is seen that, with the innate value and relative ease of theft, automotive batteries are a target for thieves. Car batteries are frequently accessible and easily

removed in contrast to bigger and more securely placed vehicle components such as engines or gearboxes. Thieves seeking fast cash or items for personal use find them to be attractive targets due to their small size and mobility.

Battery theft can have a variety of motivations, but two main things stand out: the lucrative illicit market and individual utility. Due to demand from dishonest purchasers, stolen automotive batteries can be sold through illegal channels for high prices. Thieves have a way to covertly earn from their illicit black markets. Some criminals may go after automobile batteries for their purposes, especially if they require a replacement for their car or another power source for inside uses.

Installing security cameras and motion sensors, ensuring well-lit parking areas, and implementing physical barriers like gates or fences are some efficient methods for enhancing battery security at home. Using immobilisers or alarm systems are advanced application to deter bandits [9].

Biobaku (2023) also added that the issue of car battery thieves is everywhere in the world. At the moment, Oshodi is on the high side of car battery invaders. Several scenarios were reported and posted in an online blog/news & trends stating that residents of Oshodi are in deep fear of the incidences of thieves stealing car batteries frequent within the neighbourhood; just in less than one month, more than 15 car batteries were stolen from cars parked outside several homes within different streets in Oshodi in Lagos state. A source also revealed that in November 2018, a minimum of 11 cars parked outside owners' houses were all vandalized and had their car batteries stolen. So frustrating that, he envisaged that technical ways of preventing the car battery from being stolen should be explored using a lock box and key to house the car battery otherwise applies an electronic car alarm system in the car hood. The protection system should be put in place in such a way that its alarm system comes **ON** and alerts the neighbourhood of the nefarious activities carried out by an intruder trying to tamper with the hood [10].

In a related development, Rahnamei et al. (2012) proposed a mobile phone-based design for an automobile anti-theft system to ensure that car owners prevent car theft situations and, if it does occur, the mechanism can locate the stolen vehicle [11]. As seen from the work, their design addresses the complete vehicle. However, petty burglars may not be interested in the entire vehicle but rather take interest in the (lighting, starting, and control system) - the car battery, which is a crucial component for the operation of the vehicle. In the same scenario, Behringer et al. (2016) proposed a model for a car break-in alert system. The system used text messages (SMS) instead of internet access via smartphone accelerometers. Their car alert system could use an old smartphone that was kept aside but in good condition. This forgotten old phone is kept aside because a new phone is acquired and now the former becomes relevant for the alert system. Under operation, the old phone is hidden in the vehicle to be protected to interact with the owner's main new phone. Once there is a break-in in the vehicle, the old smartphone sends messages to the new smartphone having installed MIT app the owner can interact with the old phone and finally locate the stolen vehicle. The challenge encountered here was the connection to a power source for charging the old smartphone battery in the vehicle under protection; however, this vehicle car battery could perform the charging task through a charging circuit [12].

Laguador et al. (2013) presented an Android phone-based anti-car theft system intending to protect a car from being stolen and if stolen, a mechanism to recover the stolen car. According to them, once an intruder tries to open the car driver's door and sit in the driver's seat a test message will be received by the owner of the car via a microcontroller-based device with an SMS module put in place at the driver's car door. The system's app and accessories can view inside the car and see whoever is inside and also can estimate the location of the car via GPS protocol [13]. This system will require a significant machine and software interface which will be somewhat expensive, however, it seems sophisticated too.

In a similar security work presented by Akinwumi et al. (2021), their research looked at using passive infrared (PIR) motion sensors with microcontrollers to provide home security systems. The system is programmed in such a way that the PIR recognizes motion and sends a signal to the Arduino. The LED indicator is signalled by the Arduino followed by a buzzer to sound a disturbing noise to alert the owners [14]. Matthew et al. (2018) applied high radio frequency identification readers and tags techniques to configure a more secure way of operating an automobile's ignition system. This protection scheme was on the ignition system using a keypad and code after RFID had been activated to immobilise the vehicle from being stolen by a theft [15]. Conversely, there are car battery theft and vehicle theft in every neighbourhood, especially in developing countries. In a like manner, a remotely operated vehicle anti-theft system over a GSM network was used by Alli *et al*. (2015), Vijay et al. (2021) to construct a trustworthy and effective auto security system. While working, they installed a system that allowed users to send SMS messages to the automobile subsystem. The GSM/GPRS modem module receives the SMS commands and requires them to function properly [16],[17]. Also, Eze *et al*. (2018) presented an RFID-enabled Arduino Uno module anti-theft system for automobile protection. They created their first design using Proteus software, which built the electrical circuit. Through a serial communication line, the Arduino and RFID are connected. An immobiliser was also included as an additional safety safeguard to guarantee that the vehicle's engine switches off in the unlikely event that other security measures fail [18]. A GPS and GSM module-based vehicle tracking system was shown by Yekini et al. (2016), Khanam (2019) in an attempt to allay security worries expressed by automobile owners. The device was designed to track the whereabouts of cars and contains audio surveillance features. A microcontroller device with an embedded application houses a GPS and GSM unit [19],[20].

A. *Statement of Problem*

The increasing rate of car battery theft from packed cars during the day or night, especially in developing countries is worrisome. There are so many scenarios where a packed car at night; in the daytime, it is discovered that someone has carted away the car battery unnoticed. It is extremely painful; imagine a situation for an emergency call such as a medical situation, fire, just name it, one would not be able to drive out because the valuable power source for the car is suddenly stolen by street boys (the area boys). Bandits are inevitable in society as seen by various authors. Therefore, there is a need to provide a security system that protects the car battery from authorized remover or theft. The fastening of the car battery in the hood as compared to other mechanical systems in the car is not the same. It is much easier in most cars to remove it and put it back.

B. *Aim of the project*

This technical project aims to provide a low-cost car battery security alert system that proffers a solution for protecting car batteries in a low-cost manner.

C. *Objectives of the project*

i) Study-related literature concerning the battery and its security;
ii) Design appropriate circuits for low-cost applications;
iii) Source for circuit components for practical implementation;
iv) Soldering and testing of the circuit under consideration;
v) Packaging and re-testing of the security system upon 12Volts 75Amps car battery in a packed car.

D. *Scope of the project*

The scope of this project entailed protecting the 'car battery' from being stolen by bandits using an inexpensive security system.

E. *Significance of the project*

i) This project provides a medium for mitigating battery theft, especially in automobiles and like devices.
ii) It provides a segmented supervised security alarm system, reliable in operation and inexpensive to build.
iii) It provides an improved alarm system that will alert the neighbourhood of nefarious activities rather than a metal cross-arm and lock on the battery.
iv) It reduces or eliminates the stress of removing batteries from and to the car every day because of theft activities especially cars parked outside owners' houses (street).

F. *Limitations of the project*

This project is like other security systems but cannot communicate to the car owner via any remote wireless protocols like; RFID, WIFI, GSM, or Bluetooth in smartphones. Hence if the owner of the car is not around the surroundings in which the car is parked, he or she may get lost in the alarm sound and might lack knowledge of what is going on. However, smart GSM models can be incorporated into it and this will increase the production cost.

II. MATERIALS AND METHOD

A. *Materials*

This is an electronic device; therefore, the following electronic components applied here are a 12V/ 75Amp lead-acid rechargeable battery (to be protected in the car) and for the monitory circuitry we used: 9 - 12V horn/buzzer; 12V Single pole double throw (SPDT) relay; voltage regular IC, Diodes; Capacitors; Resistors; Transistors; Thyristors; LEDs; NE555 timer IC; connecting wires, Simulation software – Circuit wizard, etc.

B. *Method Utilised*

Some vehicles are incorporated with engine immobilizers and anti-theft alarms basically for the immobilization of the vehicle. However, some invaluable operating devices such as the car battery need to be protected from hoodlums because it is the starting, lighting, indicating, and control power source of the vehicle. To achieve this low-cost system; a *close-terminal-watch'* of the car battery is utilised. We know that the conventional internal combustion engine uses the attached alternator to boost (charge) the car battery while running. Productively, the operational mechanism here is an electronic configuration that uses a multi-vibrator circuit using a timer IC, relay, internal rechargeable battery, etc. In its simplest form, the car battery security system is configured in a way that the horn/buzzer is connected to the alarm circuit having the internal rechargeable battery through a continuous loop of cable to the items to be protected (the SLI car battery) fitted in the engine hood. When the car battery is unduly disconnected or disconnecting, rapid square wave output is set in action to trigger the buzzer/horn attached.

Fig.2. shows the operating system block diagram as it's applied. The connecting wire under the hood should be unnoticed so that it triggers and closes the normally opened (NO) relay terminals thereby actuating the horn/buzzer when someone is tampering with the terminals of the battery. Hopefully, the sound will be enough to scare a thief away which is the main function of this low-cost security project. In cases of maintenance of the vehicle, it is the discretion of the owner to disable the battery security system during repair and engage the security system unnoticed by anyone.

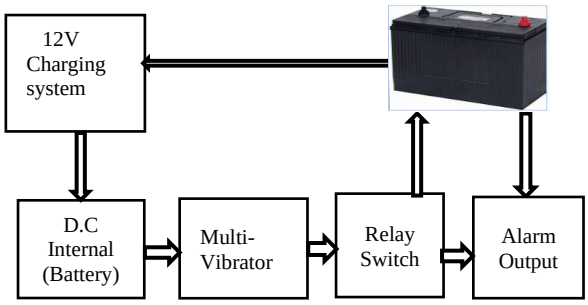

Fig.2. Operational system block diagram for 12 Volt Car battery under proposed protection

III. CIRCUIT DESCRIPTION AND OPERATION

A. System Circuit Diagrams and Operations

Two operational circuits (the operational system's internal battery charger circuit and the main system operating circuit using 555 timer IC) are put in place to electronically provide anti-theft protection for the car battery. These circuits have a very simple working principle. The circuit is modelled using Circuit Wizard electronic software.

The internal rechargeable battery is within (9-14.8V) lithium-ion batteries banked in this manner: 3 serially connected by 2 strings of the series connection (each battery voltage is 3.7V) to constantly power the 555-oscillator circuit. This 555 timer multi-vibrator IC is connected in an Astable configuration having a duty cycle of 50% in its timing state. As in Electronics-tutorials (n.d) the timing configuration output of a 50% 555 Astable oscillator has **ON** state equals **OFF** state (i.e. high state equal to low state), see in [21].

Resistor VR1 (variable or fixed value) is used to certify that the capacitor charges up fully to the same value as the supply voltage. However, when the output from the 555 oscillator is HIGH, the capacitor charges up through VR2 and when the output is LOW, it discharges through VR2 rather than pin 7 of the discharge. The charging and discharging period for the 50% Astable oscillator is given by equation (1).

$$T = 0.693(2\ R2\ C1) \quad sec \qquad (1)$$

$$T = 1.386\ (R2\ C1) \quad sec \qquad (2)$$

Also,

$$T = t1 + t2 \quad sec \qquad (3)$$

Where: T is the periodic time of the output waveform equals (t1+t2) in seconds, t1 is the output high duration, t2 is the output low duration, f is the frequency of the output waveform. R2 in kilo-ohms and C1 in micro-farads, adapted from [21].

$$f = \frac{1}{T} = \frac{1}{[1.386(R2\ C1)]}\ Hz \qquad (4)$$

Where: f is the output frequency in Hz

$$Duty\ cycle\ , D = \frac{T_{ON}}{T_{ON}+T_{OFF}} \quad Pu\ or\ \%$$

For 50% duty cycle of oscillation, $T_{ON} = T_{OFF}$ (i.e. High = Low duration of the waveform).

Note in the circuit configuration and simulation, where variable resistors: VR1= R1 and VR2 = R2 and using equation (2).

Now, assuming the output of the 555-timer circuit to stay for 0.3 sec when it is triggered, and HIGH state =LOW state for 50% duty cycle. That is the Period, T = 0.3 sec. Let C1=10μF and the design value for R2 can be determined from equation (2), thus:

$$R2 = \frac{T}{1.386\ C1} = \frac{0.3}{1.386\ x10x10^{-6}} = 21.64k\Omega$$

$$f = \frac{1}{T} = \frac{1}{(1.386\ x21.64x10^{3}\ x\ 10x10^{-6})} = 3.33\ Hz$$

In Fig.3. the black arrow is pointing at the ***12V car battery under protection*** from street hoodlums; the battery terminals' heads are closed. Assume no *theft action* at this point. Note that SW2 and SW3 in the circuit diagram represent the terminal heads for disconnection of the battery as used in the simulation. The circuit current flow is indicated by the thick line. The internal battery is charging. Let's break this main circuit (Fig.3.) into two sections (A and B) as shown in Fig. 4 and Fig. 5.

B. System Operation

The 'car battery' is constantly energizing the relay coil while the horn/buzzer is connected to the common terminal of the relay as shown in (Fig.3), hence the common terminal of the relay is deflected to the "NO" (normally open). Recall from the circuit diagram the relay "NO" is not connected to anything, hence at this state the circuit is balanced and the horn/buzzer is disconnected by default. When the car battery terminal head is disconnected without switching the hidden SW1 off, relay coil (RL2) at the proposed secured car battery side gets de-energized and losses its energy and the common terminal of relay (RL2) deflects to the normally closed (NC) terminal to close the loop wire between the output of the 555-timer oscillator and the horn/buzzer thereby notifying the neighbourhood that someone has interfere or is trying to steal the car battery in the car. To reset the circuit, we turned off switch SW1. These will cut off the power supply to the timer circuit, so the horn/buzzer sound will be stopped. Caution: SW1 must be hidden from unauthorized sight (person).

Fig. 4 shows the part circuit (Section A) which enables the internal rechargeable battery circuit with a voltage range (9-14.8V) to be recharged to keep the alarm circuit alive. A Zener diode is base-biased with BC548B, NPN transistor for the battery voltage level monitoring. Once the battery voltage level is more than the reference Zener diode voltage, the battery charging current is diverted through the Zener diode, Resistor, R5, BC 548B through dual light emitting diode to the ground. The overall power source is from the 'car battery' (under protection). The car battery obtains its charging from the car alternator when the engine is running.

Fig.5. shows (Section B) which constitutes the Astable 555 oscillator configuration with the proposed **car battery under protection**. Variable resistors are used here to bias the 555 input sections to vary the behaviour of the waveform concerning the equality of the HIGH and LOW (50% duty cycle) duration under consideration.

Fig.6. shows the simulated entire system, when the 'protected car battery terminal' SW3 is opened. The output waveform is the same as when SW2 is opened for the horn/buzzer to sound.

Fig. 7 shows a practical test picture of the car battery security system on a 12V/7.2 Ah rechargeable battery. The red-black attachment of the cased circuit is a 12V alarm as used here. Fig. 8 shows the car battery security system under practical test on a 12V/75 Ah car battery in a car. The system works perfectly.

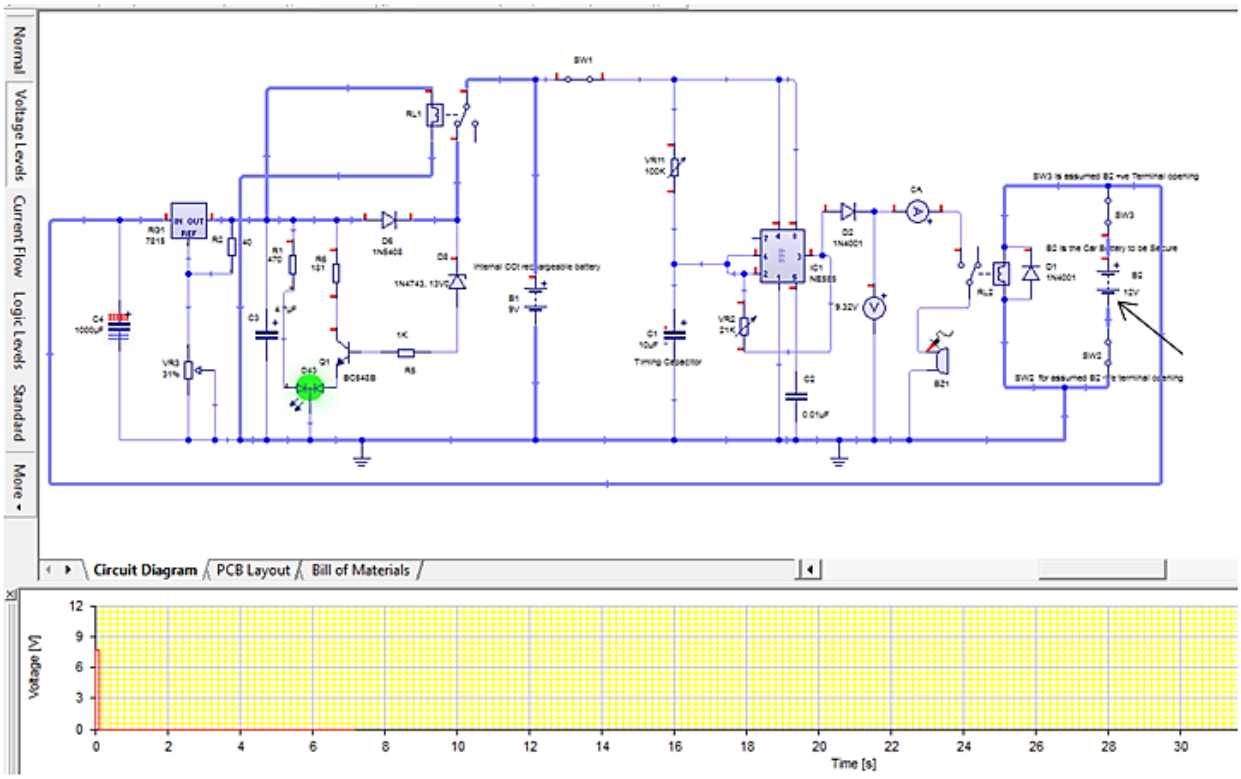

Fig.3. Simulated entire operating system circuit diagram (when "secured battery terminals heads" are closed)

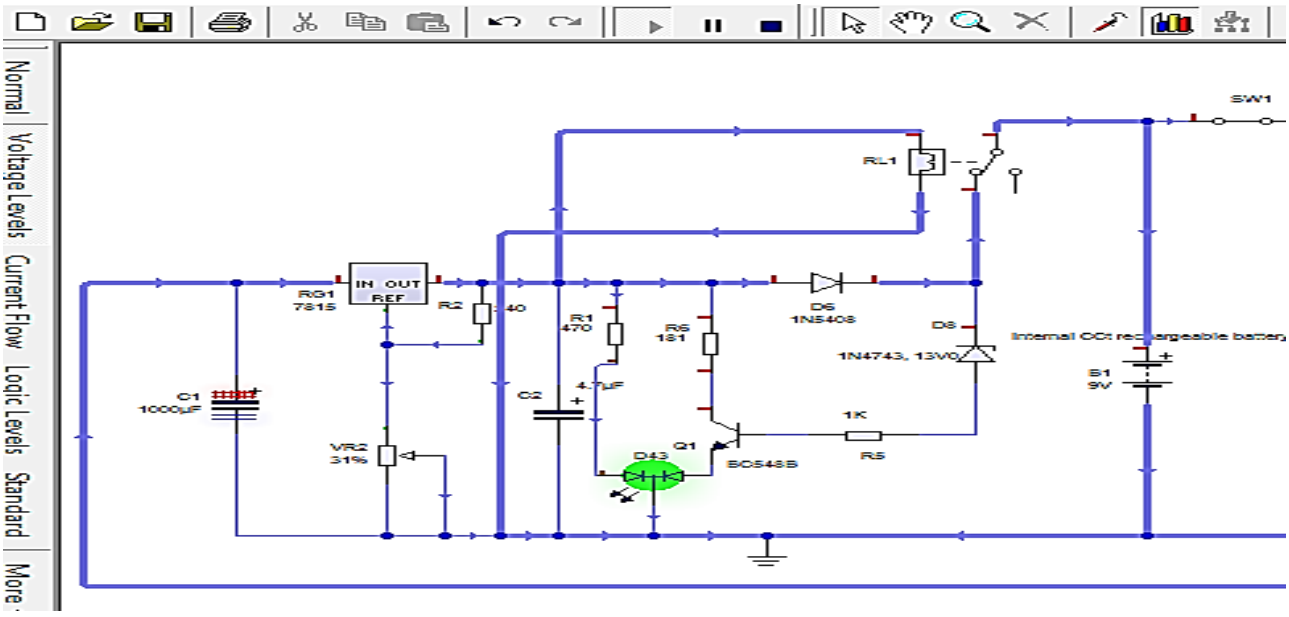

Fig.4. Section A: Internal rechargeable battery charging circuit (undercharging condition).

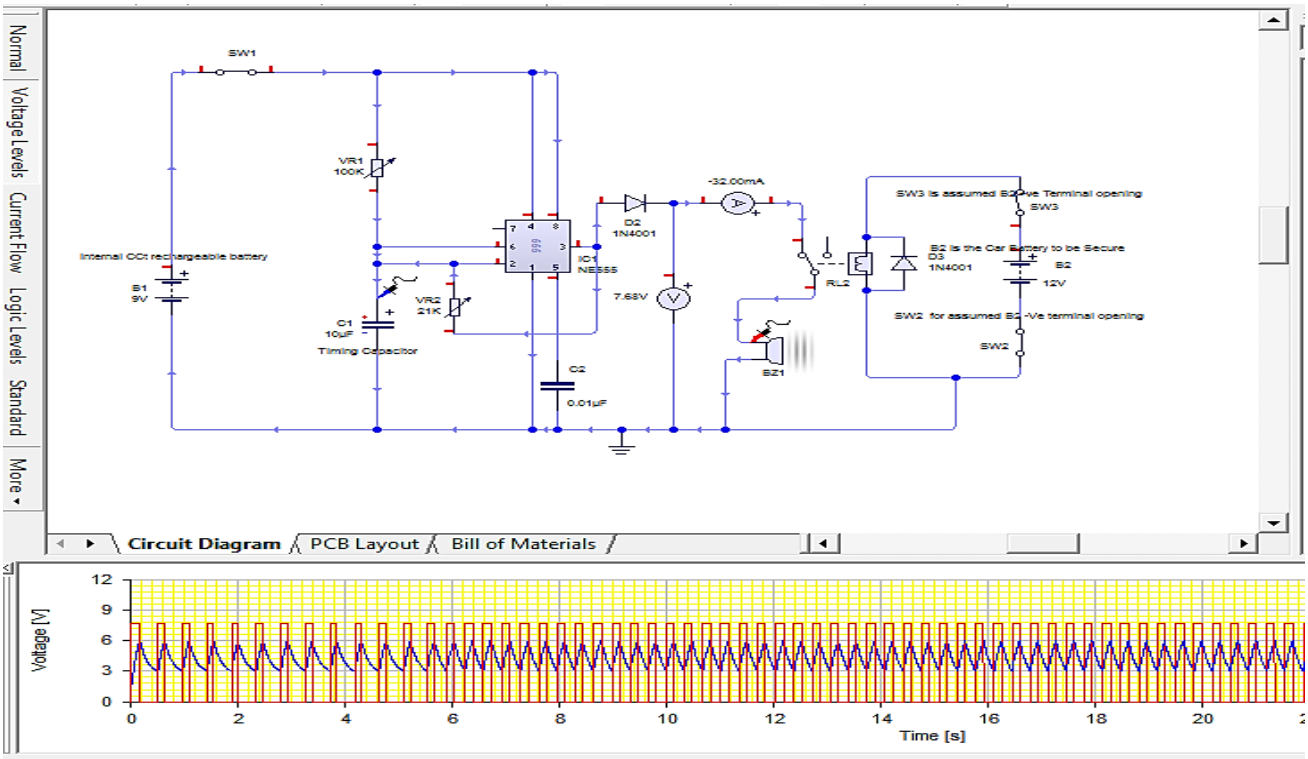

Fig.5. Section B: Simulation of the Astable oscillator with the proposed **car battery** under protection.

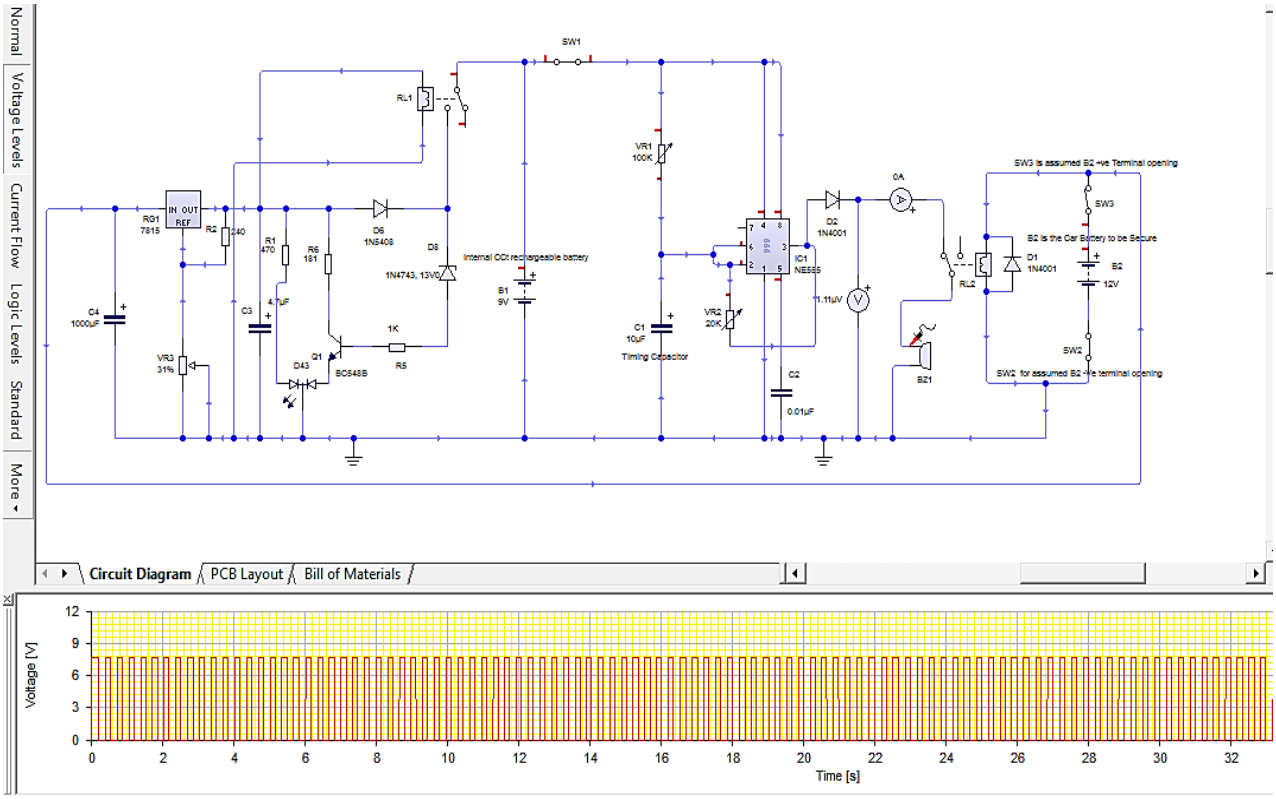

Fig.6. Simulated entire system operating circuit diagram (when “protected battery terminal head” is opened at SW3)

Fig. 7: Security system on 12V, 7.2Ah rechargeable battery under protection.

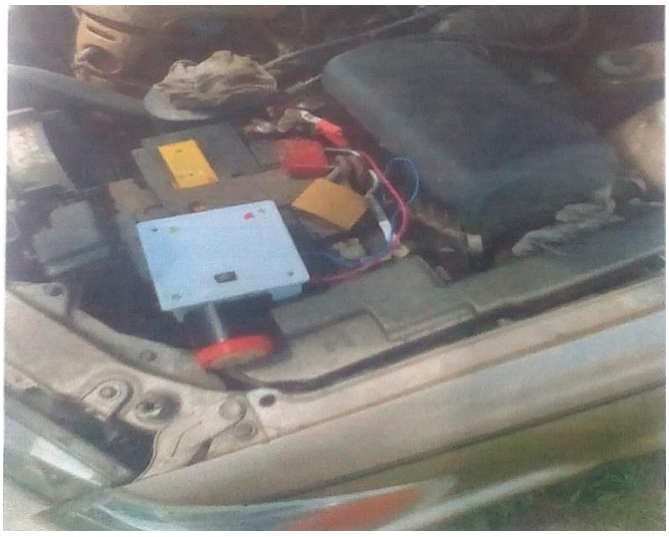

Fig. 8: Security system under test on 12V,75Ah battery in a car

IV. Conclusion

Based on the subject, a low-cost car battery security alert system is designed to alert the owner or the neighbourhood when an unauthorised person is trying to tamper with the car battery. A successful operation of the circuit depends on the Astable mode of the 555-timer oscillator. Indeed, the oscillating circuit must be powered by a rechargeable DC power supply to keep the circuit alive. The entire system cost is minimal when compared with GSM, GPS, and embedded system categories. This module has a minimum total wattage of 44 watts, 11.52 volts/3.79A. Six cells of a 3.7V lithium-ion rechargeable battery provide the internal battery operation for the oscillation circuit. In contrast to GSM networks-based categories using RFID, GSM, and GPS as well as the mobile network if the network is interrupted, it will be difficult to access the stolen vehicle at that particular period. Also, the receiving-end mobile phone must always be in good condition, out of reach from any bandit, and must be charged otherwise we wouldn't be able to track the stolen vehicle. Some thieves go after the car battery, not the entire vehicle therefore, the car battery as well must be protected. Note also that, no internet is required as well as data in this system, the issue of the network not being reachable is eliminated, receiver phone stolen or not accessed is also eliminated.

V. RECOMMENDATIONS

This system has a wide range of applications as it serves as an essential retail security product. However, this project can be used for any commercial or private vehicle. Some street thieves only target the car battery rather than the entire vehicle keeping in mind that the vehicle may be ignition-protected. Some are aware of wireless technologies yet they make advances sometimes and succeed. Protecting the vehicle using different modular security gadgets will safeguard the vehicle and its important devices. This system is very affordable for low-income earners. Some protecting gadgets may be mechanical, mechatronic, or electrical/electronic all to secure the vehicle and its accessories. Therefore, take proactive action to keep the battery secure also within a minimal cost rather than losing it to thieves to ruin your mobility and drain one's savings. In support of the above one needs to do this further if possible:

i) Employing stringent security approaches, such as parking in well-lit places and setting up motion-activated cameras;
ii) Physical barriers like gates or fences can be used to increase security and make it more difficult for criminals to gain access to the car battery;
iii) Having real-time location updates provided by GPS tracking devices built inside batteries, which can help with stolen battery recovery;
iv) Nowadays, community cooperation is crucial in the fight against battery theft. Arranging for neighbourhood watch volunteers could be of help.
v) Car owners can greatly reduce financial losses and guarantee continuous mobility at all times by combining physical deterrents, technology solutions, community cooperation, etc, [1],[2],[7],[8],[9].

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