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Development of a GSM based Vehicle Demobilizer and Tracking System

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Abstract: *Vehicle hijacking remains a pervasive global issue, posing heightened risks, especially when owners face armed hijackers. Concurrently, the disposal of old mobile phones contributes significantly to the escalating electronic waste (e-waste) challenge, emphasizing the imperative of responsible recycling practices. Addressing these concerns, this paper introduces a GSM-based vehicle demobilizer and tracking system, utilizing a cost-effective mobile phone connected to the device through a SIM card and operating with an NE 555 timer IC in bistable mode. In the event of a hijacking, a call to the mobile phone triggers the device, halting the vehicle. In the prototype design presented in this paper, the result of the output is represented by an LED to show that the circuitry actually works. When the device was tested, the LED illuminated when a call was placed to the mobile phone connected to the device which signifies that the circuit works and can achieve its purpose. The resulting design also shows that the vehicle owner can prevent his car from being stolen away even after it has been hijacked without self-endangerment and within a short time frame.*

Keywords: *Anti-theft, Car Security Systems, Global System for Mobile Communication (GSM), Mobile Phone, Vehicular Remote Control*

1. INTRODUCTION

Automobile theft and hijacking are still an issue everywhere in the world. In 2020, 810,400 cars were reported stolen in the US alone, with the equivalent worth of those vehicles being $7.4 billion [1]. According to a survey, over a five-year period, the most car hijacking cases occurred in Zambia (16.1%), Swaziland (14.5%), and South Africa (13.6%) in Africa [2]. Automobiles have been stolen for a variety of reasons, including the transportation of people, the commission of crimes, the reuse or resale of car parts, or the resale of the entire vehicle [3].

As a result of these trends, various technologies have been introduced in recent years to deter car thefts and hijacking. These include car alarms which emit high volume sounds to signal that the vehicle is being tampered with, LoJack System which use in-built transponders for tracking down vehicle and GPS to locate the position of the lost vehicles using global positioning system [4], [5]. Several modern car security systems have been proposed to prevent theft and enhance vehicle safety. In some systems Fingerprint-Based Immobilizers are used, requiring authorized fingerprints for ignition access and incorporating a GPS tracker to send immediate alerts if unauthorized access is detected. In other systems the anti-theft device includes fingerprint recognition, GPS tracking, and wireless communication between the vehicle and a mobile phone. Vehicle Tracking and Accident Alert systems have also been developed integrating GPS and GSM modules to report accidents and track the vehicle's location. Another system utilizes GPS and GSM/GPRS to monitor the vehicle's fuel, orientation, and location, including an immobilizer relay for security. Some other systems employ GSM technology for demobilizing stolen vehicles, capturing audio and picture images of intruders.

Furthermore, old mobile phones contribute to the growing problem of electronic waste (e-waste), containing hazardous materials that pose environmental and health risks if not properly managed during disposal. The improper disposal of these devices can lead to landfill contamination and resource depletion, as valuable materials are lost without recycling. Refurbishing and reusing old phones can help bridge the digital divide and reduce the environmental impact of manufacturing new devices [6].

Thus, this work aims to develop a GSM based vehicle demobilizer and tracking device with remote control capabilities for automobiles, incorporating tracking options. To achieve this, key components of a mobile phone are utilised to construct a GSM modem for an effective vehicle anti-hijack system, integrating a power interface to enhance its functionality, and ensuring the device is both economical and safe for use. A call is placed to the mobile phone to activate the device, which functions by opening the ignition switch and then bringing the vehicle to a gradual halt. In this work, the prototype is developed, and the success of the circuit operation is determined by the illumination of an LED.

While newer technologies using GSM modules and Arduino can replicate this device's functionality as highlighted above, the method suggested in this paper advocates for the long-term reuse of outdated mobile phones. Using the method indicated, obsolete gadgets can be repurposed, contributing to environmental sustainability and reducing electronic waste.

2. LITERATURE REVIEW

Mobile phone vehicular control operates on the principles of radio technology. Early application of radio technology to vehicles were for remote control purposes such as; locking and opening doors, 'warming' the vehicle, alarm control, vehicle location etc.

The Global System for Mobile Communication (GSM) is one example of contemporary technology that utilizes the fundamentals of radio satellite technology. Telephony (teleservices) and data (bearer services) are the two primary service categories provided by GSM [7, 8]. Telephony services are primarily voice services that give users full communication capabilities with other users. This technology is now a need for daily life. Additionally, it is a part of the globalization that is bridging the world and turning it into a global community. It has given its users the ability to accomplish goals that previously seemed insurmountable due to distance.

One major benefit of having this control which is the area of focus for this study is on its application to vehicular anti-theft.

2.1 Car Security Systems

Car security systems help to prevent car theft, vandalism to car or content of the car. The various devices that exist can be broadly categorised into three groups including; Mechanical anti-theft devices, electronic anti-theft devices and Vehicle identification and Vehicle recovery devices [9].

1. **Mechanical anti-theft devices:** Devices that fall in this category aim to impose physical barriers, which would make the effort of stealing the vehicle more difficult. Examples of mechanical anti-theft devices include; Steering wheel bar locks, Hood restraint, Steering column collar, Tire/Wheel lock and also Gear shift lock [9]. These devices would require the thief if not deterred to spend a lot of time in disabling them, which is something that most thieves cannot afford to do. However, for determined thieves, all it takes is some mechanical devices such as bolt cutters or a hacksaw to disable the device. They can cut through the anti-lock anywhere from 15-30 seconds [3].
2. **Electrical anti-theft devices:** Devices here are designed to stop the vehicle from moving or draw attention to the vehicle when tampered with. Examples of electrical anti-theft devices are; Kill switches and car alarms. The disadvantage of the electrical anti-theft devices is that experienced thieves can easily dismantle them or wire around them in seconds, usually by cutting two wires or even disabling the power source [3].
3. **Vehicle identification and recovery:** These devices go beyond theft prevention as they assist authorities in recovering the vehicle. Examples of these devices include the Lojack and Vehicle branding system [9].

2.2 Existing Car Anti-Hijack Systems

1. **Harold Firari and John Werner's Anti-Hijack system:** Harold A. Firari and John A. Werner created this method in January 1996. The gadget has a solenoid valve assembly that is connected to the gasoline line of the car. The solenoid's plunger is connected to a fuel restriction valve. The gadget also has a switch, an audible beeper, and a control mechanism with a timer for managing how the solenoid valve operates in relation to the ignition switch of the car. The beeper will sound, and the timer will begin to clock down to its "off" position as soon as the engine starts. The valve is actuated and moved to its closed position when the timer expires, thus stopping the flow of fuel to the engine. The power brakes and steering will still work, and the engine will keep running, but the car will only be able to travel at very low hesitant speeds. The amount of gasoline flow restriction will influence the vehicle's top speed; the more restriction there is, the slower the vehicle can go [10]. However, the system does not consider a situation where the car can be towed away and as such, provisions were not made for that. So, the car can easily be towed or pushed away. Furthermore, there has to be some drilling to install the hidden switch, wiring the switch to the control unit of the car and some components of the car have to be altered to install the system. This prevents most car owners from installing the system. This is because of the fear and belief that it would tamper with the original functionality of the car. Unaware of both the device and the location of the secret switch, a thief is unable to deactivate it before the fuel-restricting solenoid valve closes. Instead, a remote-control system is added to the push button switch.
2. **Autowatch 68hi Security System:** The Autowatch 68hi is a very efficient security system that was created in South Africa, where car theft is a serious issue. It permits the thief to flee in the automobile but ensures he won't travel too far. The thief hears a brief reminder bleep after 30 seconds. Even though the burglar is now aware that an Autowatch 68hi is installed, he is unaware of the steps necessary to disarm it. The horn will start to play in attention-grabbing blasts after one minute. Power from the engine will start to decline. The horn will sound, the lights will flash, and the vehicle will safely coast to a stop. The thief will have no choice but to flee. The hijack routine is initiated on the opening and closing of the driver side door. After the owner enters and closes the door of the vehicle, he deactivates the immobiliser by depressing the hidden deactivation button before or after starting the vehicle. The immobiliser will now not affect the vehicle in any way [11]. Beneficially, the Autowatch 68hi allows the owner to stand back if somebody demands the vehicle keys. Additionally, the unit has been designed to immobilise the vehicle in a hijack situation, at the same time offering the owner maximum protection by delaying the onset of the hijack routine and thus distancing the driver from the hijacker.

Figure 1: Autowatch 68hi

2.3 Review of Related Work

According to Jashwanth *et al.*, the proposed car security system is a Fingerprint Based Immobilizer for Vehicles using GSM & GPS [12]. The system is designed to prevent unauthorized access to the vehicle's ignition circuit by requiring an authorized user's fingerprint to unlock it. The system is also equipped with a GPS tracking device that can detect the vehicle's location and send an immediate SMS to the registered mobile proprietor if an unauthorized person attempts to access the vehicle. Additionally, the system can turn off the ignition of the vehicle if an unauthorized individual attempts to access it, thereby preventing theft. These features make the system effective in preventing car theft and increasing vehicle security [12].

The anti-theft vehicle security system presented by Akinwole is designed to prevent theft and track the location of a remote vehicle, while also allowing authorized persons to start the engine using their fingerprint [13]. The system consists of a power supply, GPS receiver, GSM/GPRS module, optical fingerprint scanner/reader module, RTC module, vehicle immobilizer relay, and the NodeMcu ESP32S development board. The system is made up of two parts viz the anti-theft vehicle security system and the user interface (mobile phone) which communicates via a wireless connection. The algorithm of the system is generated using C++ programming language and is graphically represented using flowcharts [13].

The vehicle tracking and accident alert system (VTAA) described by Musa *et al.*, works by integrating GPS and GSM modules with a microcontroller (Arduino) to detect and report accidents and track the location of the vehicle [14]. When an accident occurs, the system sends an alert message to a central emergency dispatch server using the automatic alert system. The message is sent through the GSM module, and the location of the accident is detected with the help of the GPS module. The exact location of the vehicle is sent to remote devices (mobile phones) using the GSM modem. The system is also capable of tracking the vehicle in case of theft and can send an SMS alert regarding the accident. The Arduino controls the entire operation, and the system is powered by a 5-volt power supply. The result shows high sensitivity and accuracy of the system, and it is user-friendly and reliable [14].

The vehicle security system developed by Sneha and Anitha, works by utilizing GPS and GSM/GPRS technology to track and monitor the vehicle [15]. The microcontroller STM32 is interfaced with the GSM and GPS through the Universal asynchronous receiver/transmitter (UARTs). The fuel level sensor is used to attain dependable statistics about contemporary fuel quantity in the automobile tank and to outline the vehicle fuelling volume. The accelerometer sensor MMA8653FC is interfaced to the controller through Inter-Integrated Circuit I2C for real-time orientation detection of the vehicle. The system also includes an immobilizer relay that automatically ceases the conveyance ignition when an unauthorized person accesses the vehicle. The GPS location of the conveyance is perpetually tracked by the satellite and data is sent from GSM to the server. The authorized user can get the location of data in the mobile application from the server. If any intrusion in x, y, or z-axis is detected, an alerting message will be sent from the microcontroller to the user's mobile [15].

The car security system discussed in Okundamiya *et al*, utilizes GSM technology to demobilize stolen vehicles. It has identification capability that provides and stores audio and picture images of the culprits (intruders) for identification and possible prosecution [16]. The system can be controlled with a GSM handset and can conveniently deactivate the car. The equipment is hidden within the vehicle, making it difficult for thieves to locate and disable it. Overall, the system provides a mechanism that can conveniently secure automobile cars from theft, and in case of theft, can transmit the audio signal and picture image of the occupants of the car to the owner's phone and shutdown the car in four (4) minutes to enable the owner to recover it [16].

The vehicle theft control unit proposed by Prakash and Sirisha, works by using GSM and CAN technology. The system consists of two modules: the first module retrieves the location of the vehicle using GPS and sends an SMS to the owner's number with the coordinates of the location. The second module controls the vehicle engine by either locking or unlocking it based on the owner's response to the SMS. The system checks and verifies the owner's number and performs the corresponding action based on the SMS sent. The control unit displays messages on an LCD screen to indicate whether the engine is on or off. The various control units of the vehicle are connected to one another through CAN Bus [17].

3. MATERIALS AND METHODOLOGY

In this section, the materials and methodology used in implementing the project are described. The block diagram showing the input and output of the vehicle demobilizer device is illustrated in Figure 2. The diagram shows a mobile phone serving as an input to the device in the form of a telephone signal from the ringing tone of the phone. The device is powered by the car battery which also charges the phone. The device is connected to the relay coil of the car which is responsible for the ignition of the car.

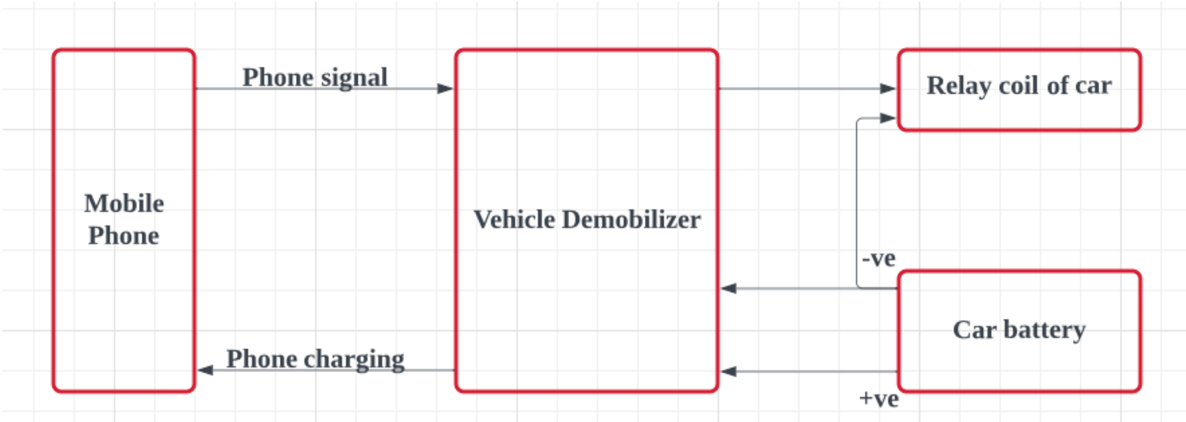

Figure 2: Block diagram of vehicle demobilizer inputs and outputs

In this project, the actual device is represented by a prototype depicted in the block diagram of Figure 3. The device consists of an NE 555 timer, an LED, reset switch, voltage regulator as well resistors and capacitors to aid the circuit connections. When a call is placed to the mobile phone, it serves as an audio signal input which triggers the 555 timer which signals the thyristor connected to it to close in order to energise the relay connected to the car's ignition circuit.

In the event of a car theft, the owner of the vehicle places a call to the mobile phone incorporated in the device. The audio signal generated from the ring tone goes to the trigger of the 555 timer operating in bistable mode, which makes the output of the 555 timer go high. The signal from pin 3 goes to the gate of the thyristor which in turn activates the relay. This opens the ignition switch thereby bringing the vehicle to a gradual halt. The ignition circuit can then be reactivated by pushing a secret button on the device, which resets the device allowing the automobile to start once again.

To control the ignition system, the vehicle demobilizer is connected between the supply and the distributor coil. When the ignition system is activated, it works normally as would be expected but when the relay is energized; after a phone call has been made, there will be a cut in supply to the spark plugs, thus bringing the automobile to a gradual halt. This is the operation for an internal combustion engine. For a diesel engine, the device is connected in a manner that it will interrupt the fuel injector coil to interrupt the function of the diesel engine.

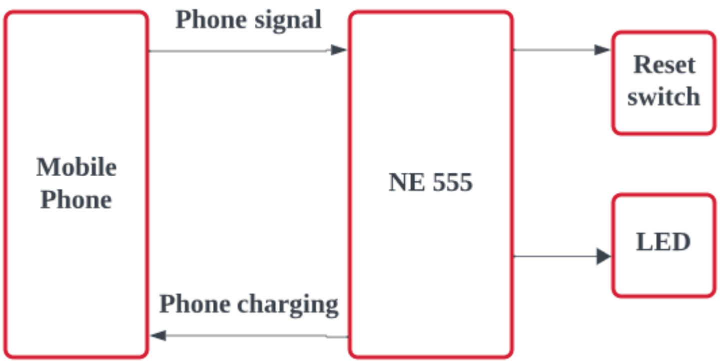

Figure 3: Block diagram of prototype vehicle demobilizer device

3.1 Circuit Design

The circuit design consists of an audio signal from a mobile phone, which feeds a 555 timer in bistable mode and triggers the gate of a thyristor. The circuit diagram is shown in Figure 4.

When a call is placed to the phone an audio signal is sent to the input of the device which is the pin 2 of a 555-timer operating in bistable mode. This audio signal is transferred through an earpiece connected to the audio jack of the phone. The 555 timer functions as a basic flip-flop when in bistable mode. On a 555, pins 2 and 4 represent the trigger and reset inputs, respectively. Pin 6 represents the threshold input, and it is simply grounded. In this set up, the audio signal temporarily pulls the trigger to ground, serving as a "set," and changes the output pin (pin 3) to Vcc (high state). On the circuit layout shown in Figure 4, capacitor C1 grounds the control input (pin 5).

The signal from the output of the 555 timer passes through a 330Ω resistor and goes straight to the gate of the thyristor D2 setting it in forward conducting mode. The thyristor will remain conducting until the forward current drops below a threshold value known as the "holding current". From [18], the gate current of the thyristor BT151 at 4.5V is 170mA. The

330Ω resistor is used and when energised it drops the value of the gate holding current to 13.6mA as shown in Equation (1) below.

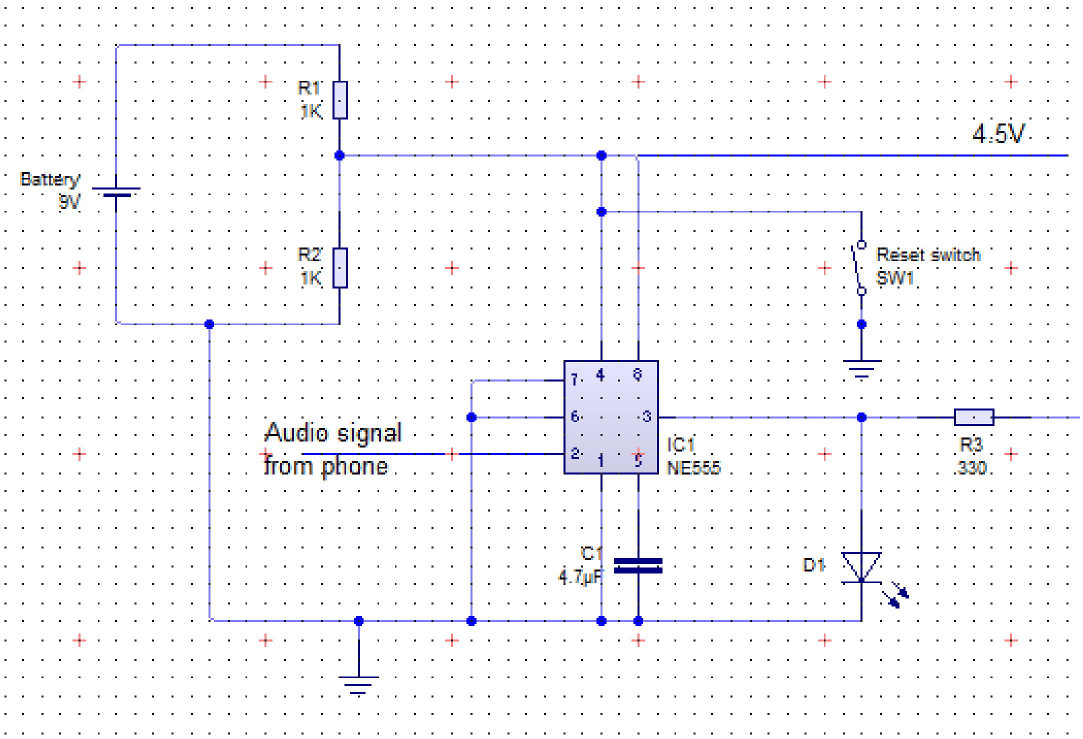

Figure 4: Circuit diagram of the device

$$Gate\ current = \frac{4.5}{330} = 13.6mA \quad (1)$$

For this study, the connection to the vehicle is represented by an LED D1. The LED switches on when the circuit is activated signifying that the device has been triggered and the vehicle is expected to come to a gradual halt.

The thyristor D2 is connected to a relay which will be connected in the ignition circuit between the ignition switch and ignition coil which will be normally closed under normal conditions when the car is running. On receiving the signal from the thyristor, the relay coil is energized, switching the ignition circuit to normally open thereby bringing the vehicle to a gradual halt. This functionality of the device is represented by the circuit diagram in Figure 5.

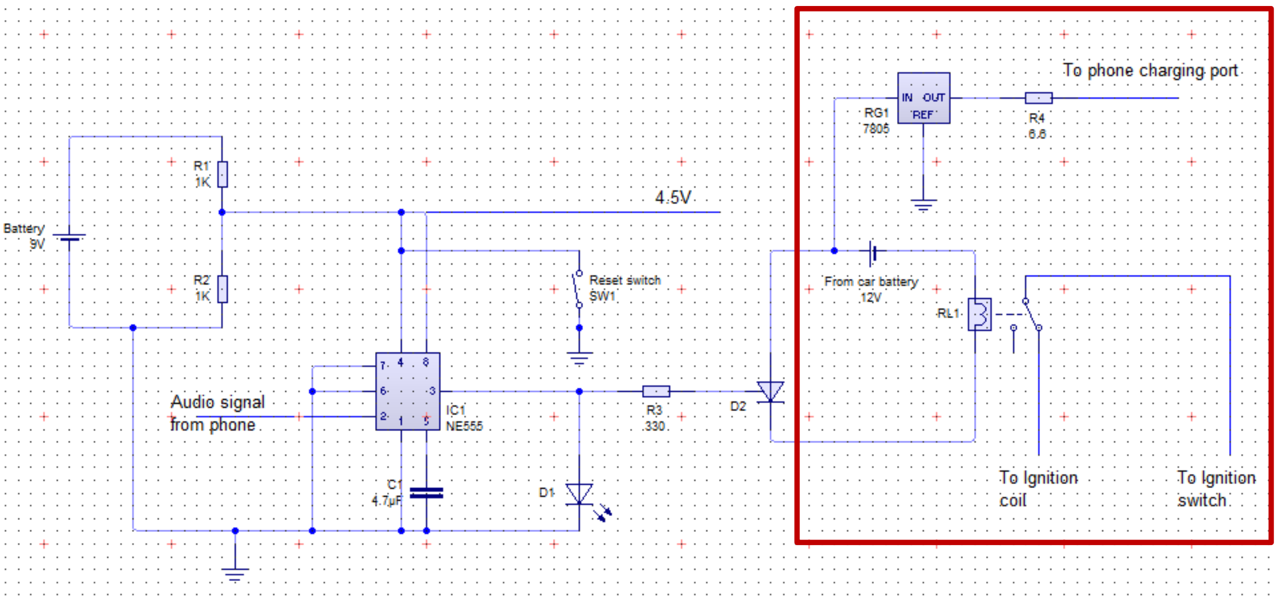

Figure 5: Representation of the connection of the device to the car

3.2 Power Supply

The power supply to the circuit is DC which is provided by a 9 V battery incorporated in the device. The power supply suitable for the device is 4.5 V and this is achieved according to the voltage divider rule by connecting two 1 KΩ resistors in series with the 9 V battery as shown in Equation (2).

$$V_2 = V \times \frac{R_1}{R_1 + R_2} \tag{2}$$

$$V_2 = 9 \times \frac{1000}{1000+1000} = 4.5V$$

3.3 Power Interface for the Mobile Phone

Power supply is needed by the mobile phone to charge its battery. This power supply is to be drawn from the 12 V car battery. The voltage rating of the phone battery is 3.7 V [19], therefore a voltage regulator can be used to reduce the car battery's voltage to the voltage suitable to charge the phone. The power interface is represented in Figure 6.

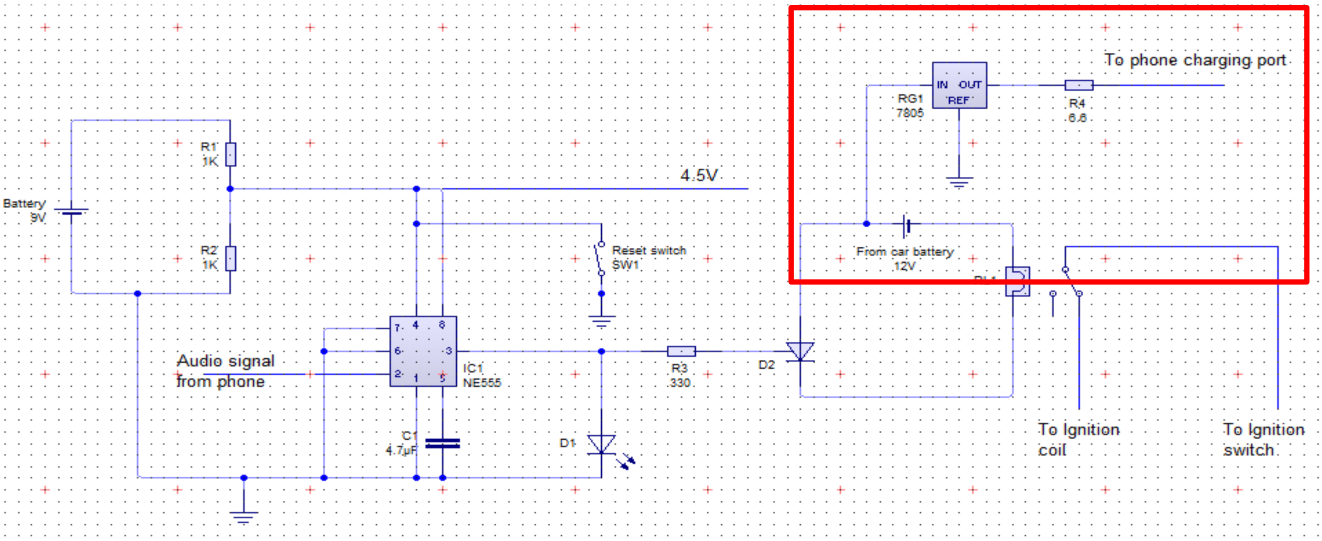

Figure 6: Power Interface for the mobile phone indicated by the part in the red box

The power from the battery is passed through a 5 V voltage regulator (AN7805) connected in series with a 6.6 Ω resistor which is connected to the terminals of the charger of the phone.

3.4 Major Component: NE 555 timer

The 555 Timer IC, an integrated circuit, serves various timer and multivibrator functions. Housed in an 8-pin mini dual-in-line package (DIP-8), the standard 555 package incorporates over 20 transistors, 2 diodes, and 15 resistors, with variants like the 556 (combining two 555s) and the 558 (combining four modified 555s). The timer's core function relies on a voltage divider created by three resistors across the power supply, with comparators monitoring voltage at 1/3 and 2/3 of the supply, influenced by the control voltage input. Widely utilized, the 555 timer is integral to various electronics, from quartz watches for timekeeping to AM radio receivers tuning in through resonators, and in microprocessors measuring clock speed in megahertz.

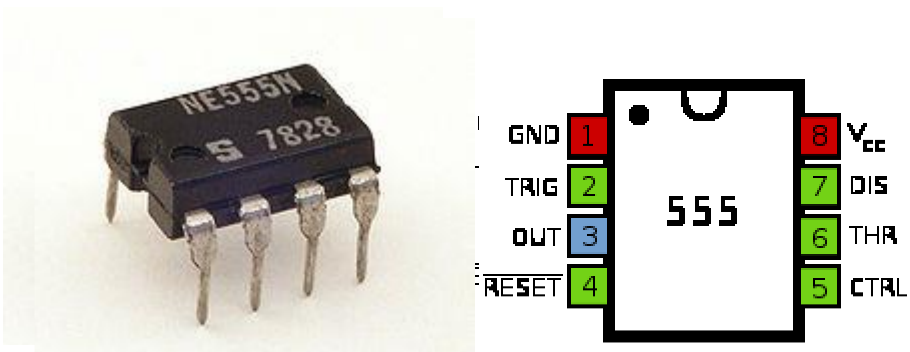

Figure 7: NE 555 timer and pinout diagram

Pin	Name	Purpose
1	GND	Ground, low level (0 V)
2	TRIG	OUT rises, and interval starts, when this input falls below 1/3 VCC.
3	OUT	This output is driven to +VCC or GND.
4	RESET	A timing interval may be interrupted by driving this input to GND.
5	CTRL	Control access to the internal voltage divider (by default, 2/3 VCC).
6	THR	The interval ends when the voltage at THR is greater than at CTRL.
7	DIS	Open collector output; may discharge a capacitor between intervals.
8	V+, VCC	Positive supply voltage is usually between 3 and 15 V.

555 Bistable (flip-flop) mode - a memory circuit

The circuit is termed bistable due to its stability in two states: output high and output low. In bistable mode, the 555 timer functions as a basic flip-flop, with trigger (pin 2) and reset (pin 4) inputs held high via pull-up resistors, while the threshold input (pin 6) is grounded. Pulling the trigger to ground momentarily functions as a 'set,' transitioning the output pin (pin 3) to Vcc (high state), while pulling the reset input to ground acts as a 'reset,' transitioning the output pin to ground (low state). Capacitors are unnecessary in a bistable configuration, and pins 5 and 7 (control and discharge) are left floating.

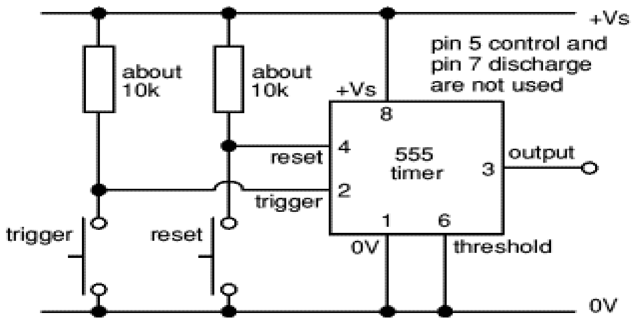

Figure 8: 555 bistable circuit

4. RESULTS AND DISCUSSION

The NE 555 timer previously mentioned in section 3 and other components such as resistors, capacitors, voltage regulator, LED are connected in accordance with the circuit diagram shown in Figure 4. The physical connection on the breadboard is shown in Figure 9.

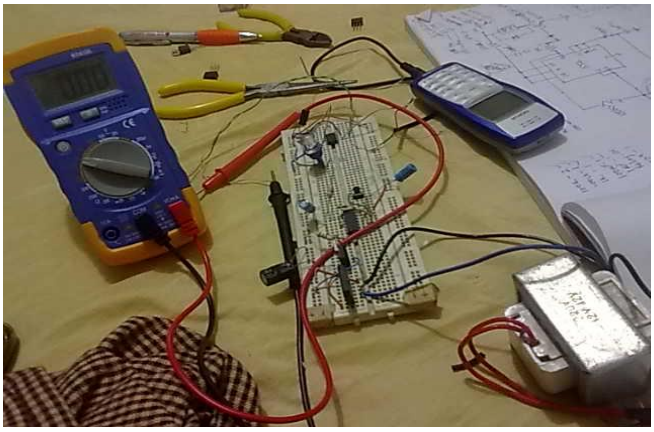

Figure 9: Prototype of the device on the bread board

4.1 System testing

After the connections were verified on the breadboard, the components were soldered unto a vero board and tested finally. This is shown in Figure 10. During the test, a call was placed to the number in the mobile phone, when it rang, the LED in the device became illuminated as shown in the picture signifying that the circuit actually works and can serve the intended purpose. The completed device is shown in Figures 11 and 12.


Figure 1: Arrangement of components on the vero board

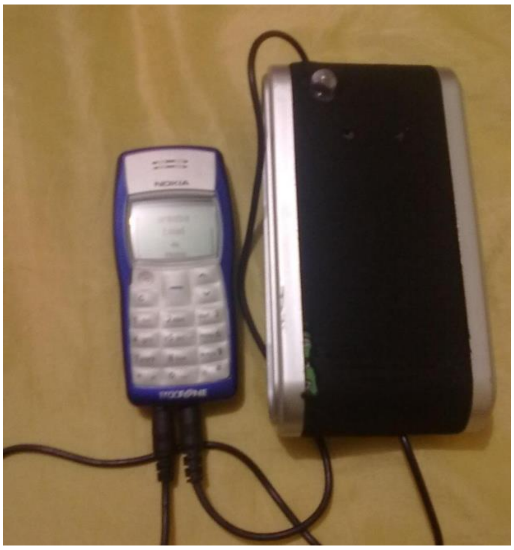
Figure 2: The complete enclosed device


Figure 12: Completed device side views showing the ports to the vehicle and the reset button

This device's primary advantage over other antihijack systems lies in its capability to remotely control your automobile from considerable distances. It offers tracking options for stolen vehicles, aiding recovery by contacting the network provider to locate the subscribed mobile device within the car. The device features a convenient power interface for mobile phone charging, eliminating the need for separate charging. Its simple and affordable design allows for easy implementation, and it extends applications to areas like home automation and security. However, operational limitations exist, such as dependency on mobile network coverage, potential delays during network congestion, and reliance on the service provider's disclosure policies for location information. Additionally, the device's vulnerability to theft through unplugging and potential network jamming should be considered in its deployment. The study emphasizes the practicality of using mobile phones for device control, particularly in the context of reducing car hijacking, with a focus on simplifying existing systems and optimizing circuit design for cost-effectiveness.

5. CONCLUSION

This paper addresses the persistent global issue of vehicle hijacking and theft, highlighting the increased risks faced by owners, especially when confronted by armed hijackers. The presented GSM-based vehicle demobilizer and tracking system offer a practical solution, empowering owners with the ability to remotely control their vehicles and prevent theft. The use of a cost-effective mobile phone, integrated with an NE 555 timer IC in bistable mode, forms the core of the device's functionality. Upon a hijacking incident, a simple phone call triggers the device, causing the vehicle to come to a halt promptly, as demonstrated in the prototype with an LED indicator. The comprehensive details of the circuit design and construction provided in this paper contribute to the understanding and implementation of the proposed system. Ultimately, this design assures vehicle owners that they can thwart theft even after a hijacking, ensuring their safety in a timely and effective manner. While modern approaches involving GSM modules and Arduino can replicate the functionality of this device, the method proposed in this study advocates for the sustainable reuse of old mobile phones. By employing the technique outlined, outdated devices can be repurposed, contributing to environmental sustainability and minimizing electronic waste.

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