AC 2008-321: INTEGRATED VEHICLE SECURITY ALARM WITH WIRELESS TELEPHONE NETWORK

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Integrated Vehicle Security Alarm with Wireless Telephone Network

Abstract

This paper describes the design, features, assembly, and functionality of a wireless integration of a standard electronic vehicle security alarm with the telephone network. Generally, car alarms are usually most effective when the system's warnings are audible or visible to the owner of driver. When the security of the vehicle is breached, time plays a major factor for an immediate and appropriate response to the warning. Due to the dynamics of daily life, it is not unusual for vehicle operators to be away and out of audio and/or visible range. In this system, a trigger circuit is connected to the vehicle alarm. When activated by the car alarm, it will wirelessly alert the owner's cellular phone, and upon a response to the alert, he/she will be able to listen to the audible information being transmitted from the car. In this endeavor, the objective was to develop a simpler and more cost-efficient product than those currently available, by utilizing a timer module. All aspects of the car alarm system were simulated, modified, and subsequently prototyped by students utilizing their knowledge acquired in an electronics engineering technology program as a senior-level control systems course project, and resulted in an efficient, cost-effective, and possibly marketable product. It is anticipated that this design concept will contribute toward better security for vehicles or any other appropriate applications.

I. Introduction

According to Popular Mechanics, the early vehicle alarm system was composed of a horn or bell, which used the drive-shaft to operate it when the car was improperly moved[1]. The horn or bell projected a loud noise that eventually would scare off the thief. Consequently, people began purchasing these systems for the sake of securing their vehicle.

A similar concept continues to be utilized today, even in simple car alarm systems that employ unsophisticated technology that closes the circuit, which in turn, signals the siren to sound off as soon as the car is tampered with[2]. Recent technological advancement has made possible the development of more complex systems that generally consist of the following:

- a computer control unit used to monitor the complete process and eventually sound the alarm (the brain of the system);
- an array of sensors that includes switches, pressure sensors, and motion detectors;
- a siren, which can be set to different sounds;
- a radio receiver used to control the alarm from a wireless key fob;
- an auxiliary battery to operate the alarm even if the main battery is disconnected.

The computer control unit's function is to activate the switches triggered by the power-sensing devices that energize the alarm mechanisms, such as the siren, horn, and/or the headlights.

Further, an alarm system may include sensors such as: an immobilizer, vibration, internal pressure changes (inside vehicle), shock (in event of impact or movement of car), engine and/or steering wheel locking, and fuel pump shut-off, etc.[3]

Next, the siren of a car alarm system is usually an audible warning to the owner that his or her vehicle is being violated, but sometimes false alarms (possibly due to thunder, a passing vehicle, or the accidental touch of the car by another entity) occur and people tend to ignore the audible warning. To address the problems of the ignoring of noisy alerts or in the event of false alarms, manufacturers developed silent immobilizers that are installed on vehicles to prevent the engines from starting unless the proper keys are used, as well as devices to prevent cars from being "hot wired" after an intruder enters a vehicle[4]. Since the innovation of the immobilizer, even more sophisticated devices have been introduced that include a vehicle tracking system that alerts authorities and pinpoints the exact location of the stolen vehicle[3].

Moreover, manufacturers of car alarm systems continue to develop more innovative systems as software, hardware, and manufacturing technologies advance. For instance, cellular telephones are readily available to and popular with consumers, as they have been integrated with other devices such as MP3 players, web browsers, calculators, calendars, digital cameras, voice recorders, and alarm clocks. Therefore, they are ideal to be utilized as part of a wireless alarm monitor for vehicles so that owners/operators have continual real time access to the status of their automobile's security.

Finally, the principal differences among the latest vehicle alarm systems are how the sensors are used and how the different devices are connected into the brain[5]. The main parts of an alarm system are shown in Figure 1.

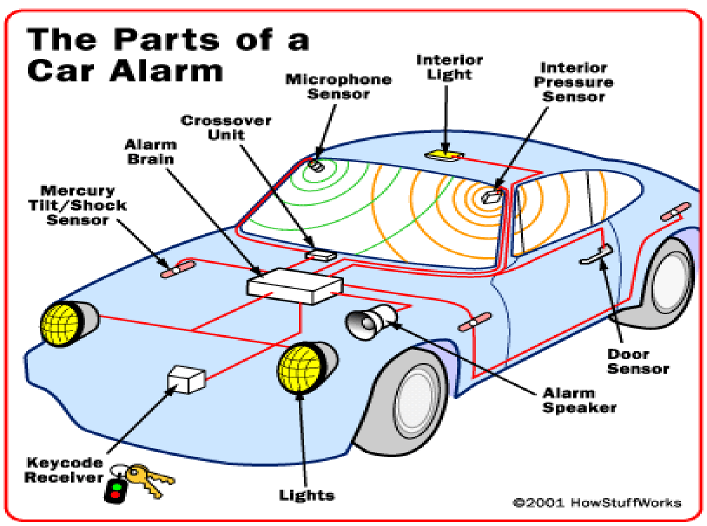

Figure 1. Car Alarm System (howstuffworks.com)[5]

II. Literature Review

A project entitled "Cellular Phone to Car Alarm Interface" was completed by 5 Oregon State University students in 2005, in which two-way communication between the car alarm system and a cell phone was enabled. The resulting prototype allowed consumers to unlock their cars with a cell phone, receive a text message regarding the status of the car's security, and arm/disarm the alarm system via text messaging.

Their system included three vital components: a microcontroller, a GSM (Global System for Mobile Communications) cellular modem, and the car alarm. The microcontroller served as the brain of the system, the GSM cellular modem provided cell phone communication, and the car alarm (Viper 350HV) monitored the security of the car utilizing sensors. The block diagram in Figure 2 exhibits the interconnection of the system.

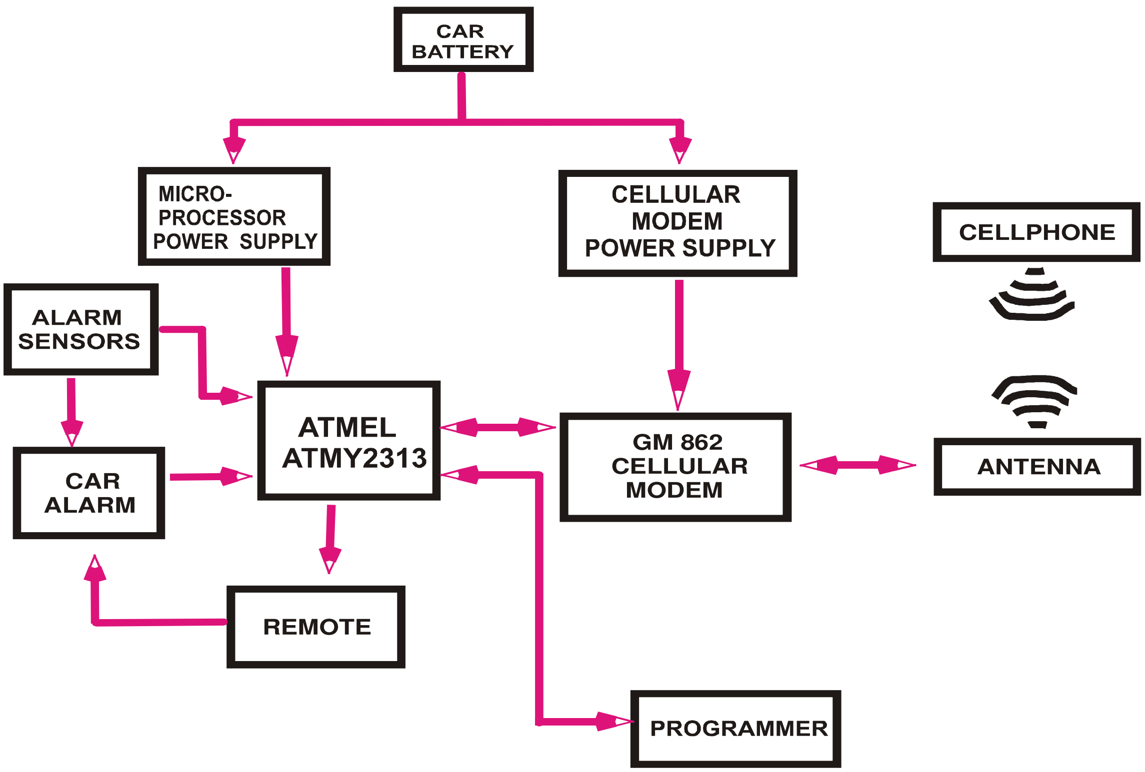

Figure 2. Block Diagram of "Cellular Phone to Car Alarm Interface"[6]

The aforementioned project, however, required a code to provide communication between the main devices. The microcontroller served as the bridge between the modem and the car alarm, the modem interfaced the cellular phone with the microcontroller, and the car alarm linked the vehicle to the microcontroller. The only functions of the cell phone interface were to lock/unlock the vehicle and to arm/disarm the security system. Also, the project was more complicated than the authors' approach outlined in this paper, as it required extensive software programming which resulted in "bugs" that generated false alarms or non-response to the alerts. Furthermore, the resulting prototype was not cost effective due to the expenses involved in acquiring the necessary microcontrollers and buffer IC's[6].

In addition, another alarm configuration, the GTAuto Car Security System, manufactured by Topkodas Company, is presently available in the market. The same concept of utilizing a cell phone to manipulate certain functions when the car alarm is triggered was used. The GTAuto system allows the user to receive SMS (Short Messaging Service) and call notification when an event triggers the alarm. This mechanism employs a GSM module integrated with a modem that monitors the sensors of the alarm system and sends information to the vehicle owner via a GSM network. Figure 3 shows all the parts of this system.

Figure 3. GTAuto Car Security System (Topdokas Company)[7]

The GTAuto Security System requires a special software called "SERA" that is used to configure the GSM module. This system requires the user to have very detailed knowledge of software editing, calibration, and installation. Also, it is very expensive and necessitates the vehicle owner to have a computer[7].

III. Procedure and Methodology

The objective in this endeavor was to design and prototype a simple yet efficient and cost-effective car security system, and the authors envisioned accomplishing it by using a timer module rather than complex computer programming and costly hardware.

Initially, a block diagram demonstrating how the proposed system would function was developed prior to assembly of the components (as exhibited in Figure 4). The diagram consists of the interconnection of all the components in each circuit and the control sequence of the system's operation.

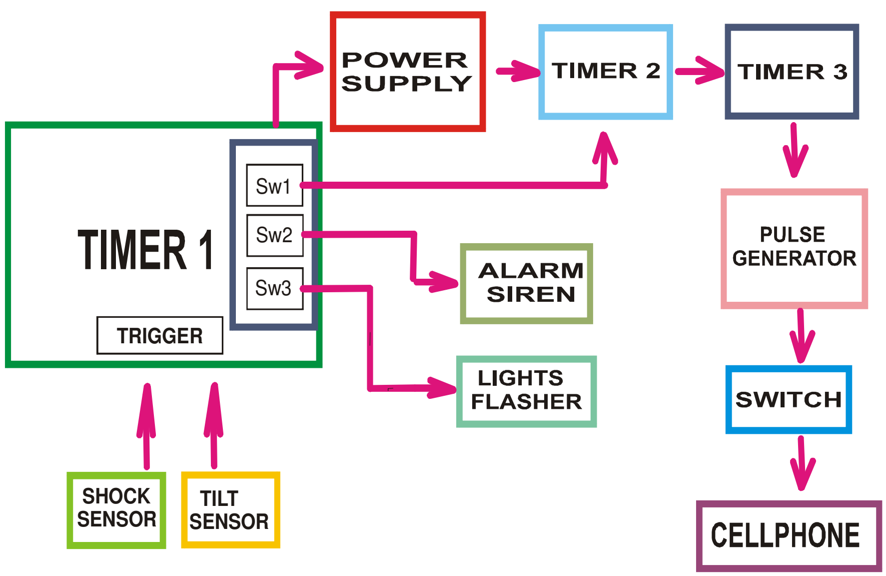

Figure 4. Block Diagram of Proposed System

This undertaking incorporates three different systems working together, and includes a Vehicle Security Alarm, Timer Module, and Cell Phone Module as described below.

A. Vehicle Security Alarm System (VSAS)

To maintain simplicity, the authors' proposed method utilizes Shock/Vibration Sensors to detect electromechanical sounds and/or shocks occurring from or around the vehicle. The Touch/Tilt Sensors are used to respond to any touch/tilt through the exposed metal surfaces of the vehicle. Upon activation of the sensors, the audible (siren) and visual (light/LED flasher) alerts are set off.

1. Police Siren for Audible Alarm

The siren sound circuit based on the 555 timer IC is used to provide an audible sound to the alarm system of the car. If desired, an audio amplifier may be connected to the output of the siren circuit to boost the audio level in conjunction with a horn speaker. The siren circuit is modified and reconstructed utilizing Multisim[8] and exhibited in Figure 5.

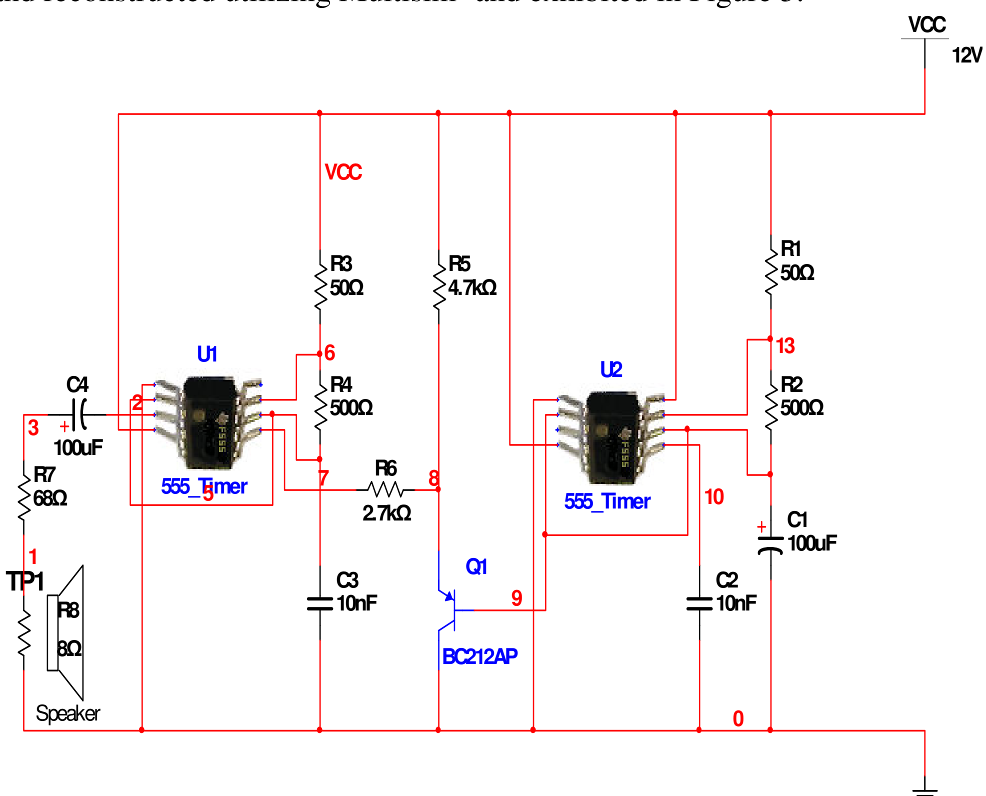

Figure 5. Police Siren Circuit[9]

At TP1, the above circuit will cause the 8 ohm speaker or siren to sound off. A potentiometer was incorporated in the prototype circuit in place of the 68 Ω resistor (R7) to adjust the volume of the speaker to a desirable level. An oscilloscope was connected at TP1 and the waveform shown in Figure 6 resulted.

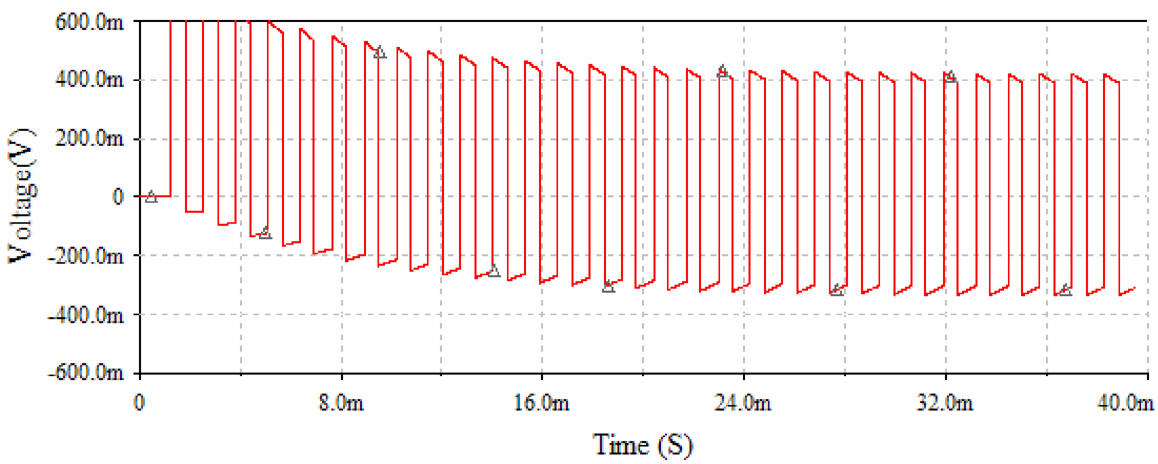

Figure 6. Police Siren Waveform

2. Lights / LED Flasher

The lights flasher circuit depicted in Figure 7, reconstructed and modified using Multisim[8], is directly triggered by the alarm system, and its main function is to control the lights or LED that provide an obvious visual alert so that the vehicle may be easily located among other vehicles.

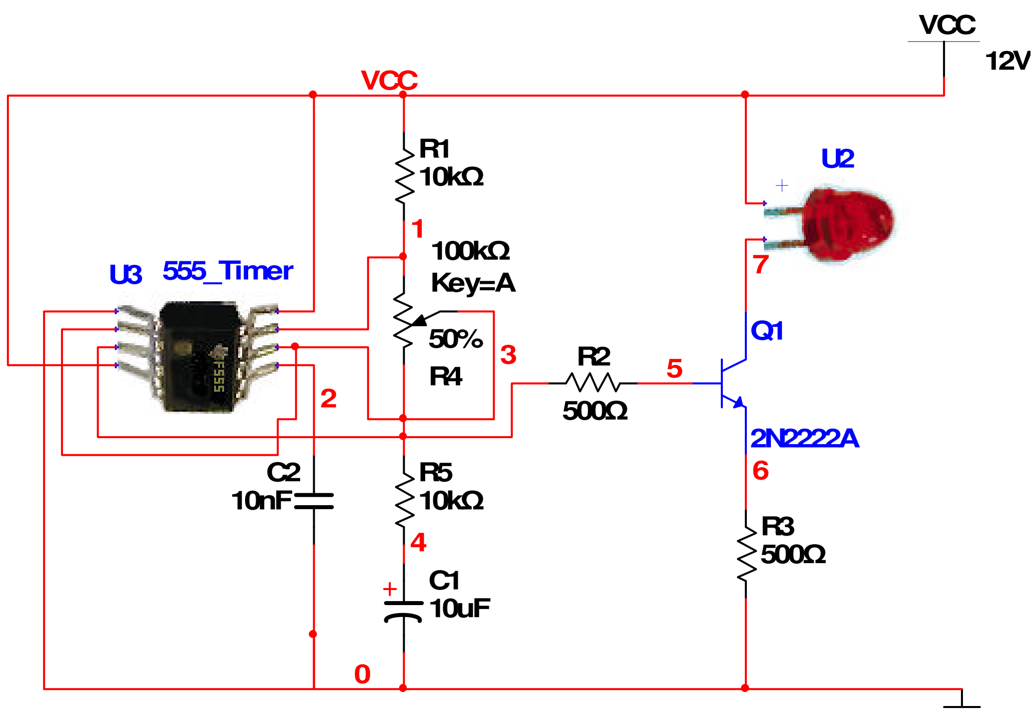

Figure 7. Lights Flasher Circuit[10]

The lights flasher circuit activates the LED to go on and off, and this circuit was reconstructed and modified by substituting a 2N2222A transistor for the NTE 47 transistor. Also, other circuit components, such as resistors and capacitors, were modified to meet the design objectives.

Furthermore, in the prototype, four lights (headlights and tail lights) were necessary and were connected in parallel, instead of the one LED shown in the above Figure 7. Lastly, an oscilloscope was placed at U2 to observe the output waveform and is displayed in Figure 8.

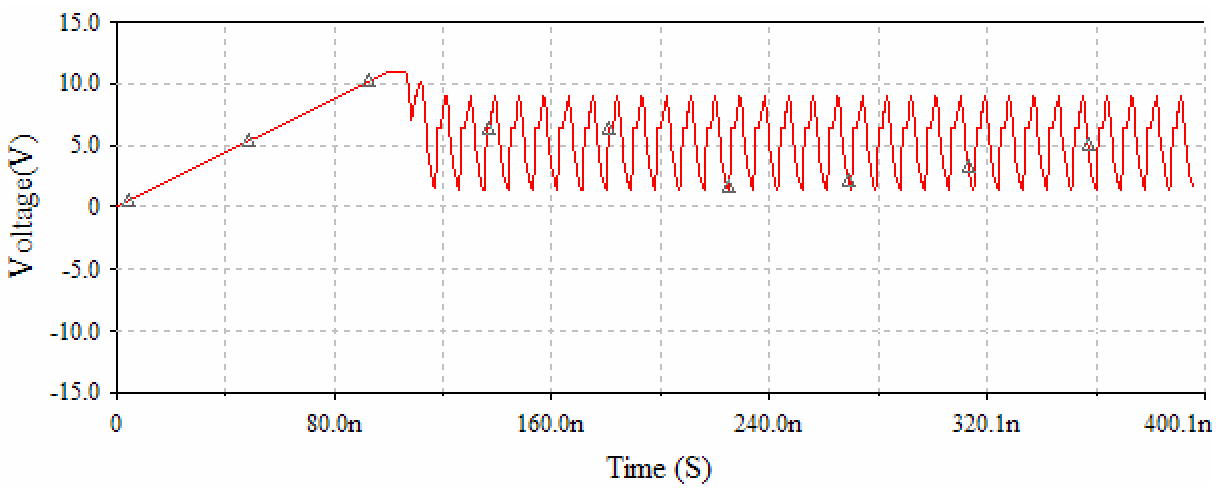

Figure 8. Lights Flasher Waveform

B. Timer Module System

The Timer Module consists of three timers that control the timing sequence of the alarm system. Whenever any of the auto security sensors trigger the alarm, a relay switch connected to the audible alarm is activated and sets off the Main Timer module, which normally remains in a standby mode to conserve the vehicle's battery power.

The Main Timer (Timer 1 shown in Figure 4) triggers the Second Timer (that activates the alarm siren and light flasher) through a relay switch, and consequently switches on the Third Timer. The Third Timer's function is to time the pulse generator. The single pulse generator circuit provides a single pulse to the transmitter circuit to send a search signal that activates the owner's cellular receiver module. In this endeavor, a lights flasher circuit is used as a pulse generator.

All three timers have different timing lengths determined by their control sequence in the system. The Main Timer is adjustable and may be set to provide sufficient time for the system to execute all functions, and therefore, needs no microcontroller to perform any functions. Instead, the Main Timer in the proposed system uses a digital circuit (modified and reconstructed using CircuitLogix[11] software) that incorporates a 555 timer IC chip with a power-saving advantage, since it only works when triggered. Figure 9 exhibits the 555 timer circuit in which M, B, and S indicate switch terminal designators for NO (normally open), NC (normally closed), and N (neutral). In the prototype circuit, the Main Timer utilizes three relay switches connected in parallel to meet the design objectives.

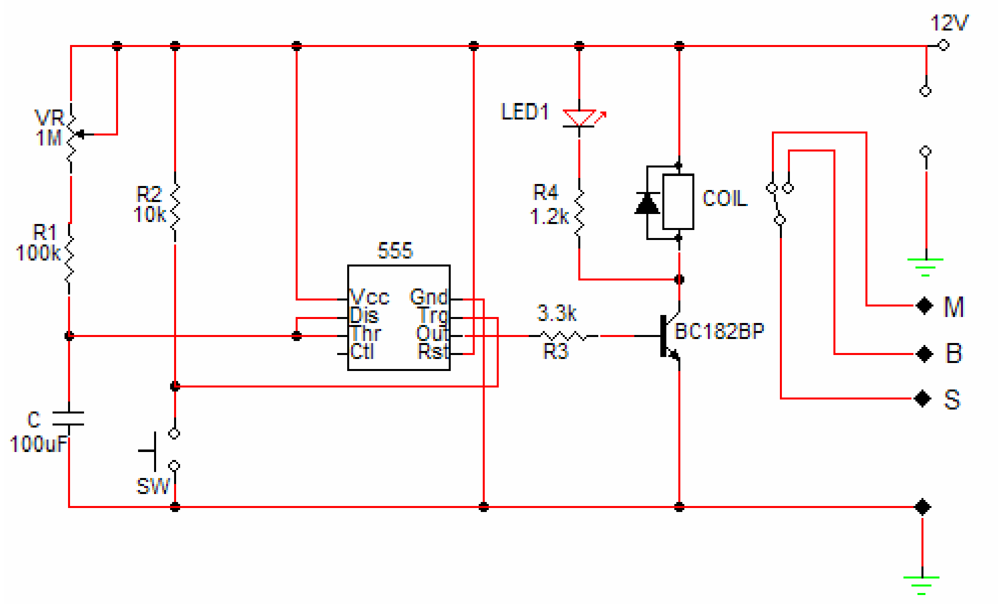

Figure 9. Main Timer Circuit Utilizing 555 timer IC[12]

C. Cell Phone Module System

For the proposed system, a Nokia cell phone handset was used as a wireless communication interface to the alarm system. The handset was disassembled and a switch connected to the call/send button, which was then linked to the pulse generator via a relay switch. The pulse generator required two pulses to achieve the equivalent of pushing the call/send button twice.

IV. Sequence of Operation of Proposed Methodology

To conserve energy, the overall system is always in the "off" position, except for the sensors that are continually in standby mode for the purpose of instant activation. In this application, the vibration sensor triggers a pulse to the Main Timer switch whenever the security of the vehicle is breached.

A. Main Timer

The Main Timer is the overall event timer for the entire control sequence. At its reaction to the vibration sensor, the siren and flashing lights are activated. The Main Timer is basically a timed relay with dual switches (SM ⇔SB) designed to control and distribute the overall power load when the system's circuits are on.

1. Police Siren and LED/Flashing Lights

As soon as the Main Timer triggers power on, both the police siren and LED/Flasher are turned on simultaneously and remain engaged for the same length of time, predetermined by the setting of the Main Timer, until the power is switched off. Of course, the siren emits an audible alarm, and the LED/Flasher's purpose is to control the lights for a visual alert to aid in locating the car.

B. Second Timer

The Second Timer is always on but does not function until triggered by the second switch of the dual switches (SM ⇔SB) on the Main Timer. The second timer's main role is to turn on and control the duration of time that power is supplied to the pulse switch.

1. Pulse Switch

This circuit remains in "off" position and only functions when it is powered by the relay switch of the Second Timer, and is usually "on" for only a short length of time. The function of this circuit is to provide repeated switching action that activates a cellular phone.

C. Third Timer

This timer is always on, and requires a switching signal from the Second Timer to operate. Its main function is to turn power on or off to the second pulse generator. The second pulse generator switch provides switching control to the cellular telephone to carry out the text messaging function of its system. This is the final operation executed by the system prior to the Main Timer turning off the power.

D. Cellular Telephone

The cellular phone must be preprogrammed, adapted, and linked to the pulse generator switches that call and send text messages to the owner's phone regarding vehicle security alerts. The cellular phone is controlled by the repeated activation of the switches from signals generated by the pulse generators. The control sequence is as follows:

1. A call is made to the vehicle owner through two pulses on the send button achieved by proper timing utilizing the Second Timer;

2. A text message is sent, from a text template to the cell phone, in the following sequence: the first pulse is sent to the *menu*, another to the *select* button to select *messaging*, a third pulse to select *options* for text templates, and yet a fourth pulse to select the *first text* template. Finally, a pulse is directed to the *send* button and an ultimate pulse is sent to *confirm send.*

V. Results and Prototyping

Figure 10 shows the circuit board, and Figure 11 exhibits the prototype of the completed project. A car model was used to simulate a situation where a vehicle's security is breached. The tilt and shock sensors were also installed in the car model, so if any vibration was detected, the alarm was activated and called the number that had been preprogrammed into the cell phone. The results of the project had a desired outcome as the timers worked sequentially, the circuits operated as expected, and it proved to be cost effective.

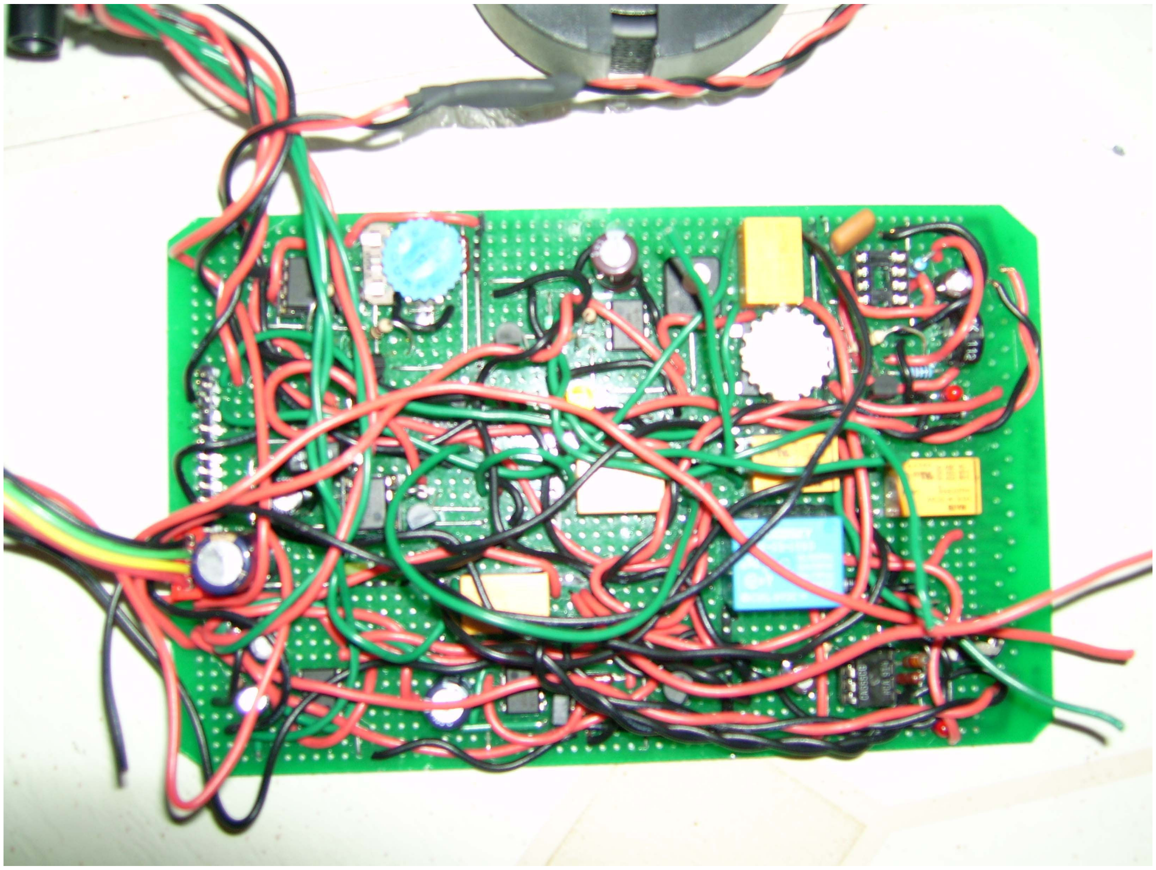

Figure 10. Circuit Board of Prototype Model

Figure 11. Prototype of Completed Project

VI. Conclusion

Nowadays, cell phones are one the most popular wireless devices with numerous capabilities, and the concept of using a cell phone to alert owners of security breaches to their vehicles has been used in similar projects in the past. However, the results of this project verified that the same goal can be accomplished by employing a timer module to provide the equivalent functions of the more expensive and complex systems that require extensive computer programming code(s) and/or hardware to operate properly. Furthermore, production cost and effectiveness of this idea were the major parameters of this project, and the timer module proved to be an inexpensive alternative that efficiently assisted in accomplishing the objective. The authors plan to continue researching the application of timer modules in other areas of security devices.

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