# Microcontroller-based Vehicle Security System with Tracking Capability using GSM and GPS Technologies

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**Abstract –** *The security of vehicles is extremely essential for vehicle owners especially to those whose hard-earned income was used to avail of one or simply, its loss would mean inconveniences to family and work. With these, it becomes the major problem of every vehicle owner. This thesis, Microcontroller-based Vehicle Security System with Tracking Capability using GSM and GPS Technologies, is a system that can be used to increase vehicle security, as it can track location of missing vehicle, and help authorities have credible evidence that the vehicle is stolen. The project uses the Global System for Mobile (GSM) and the Global Positioning System (GPS) technology, which includes the use of GPS receiver module, GSM module, and microcontroller as its primary components. It also uses a vibration sensor that senses vehicle movement and a buzzer that sends an alarm when sensors are triggered. A confirmation message is sent to the vehicle owner of the vehicle by the device. The system also features capability of tracking the location of the vehicle with the help of the GPS receiver which gives data to the location of the vehicle by way of coordinates. These coordinates provide exact location of the motor vehicle. The SMS message that the vehicle owner will send to the device attached to the vehicle should follow correct format of limitation for successful use and the use of the four character password followed by the command. The command is for power switching or activating automatically the key switch, engine and alarm. If not observed, the device would not work. The project is deemed to provide vehicle owners the security of their vehicle. The system will not only ensure vehicle security but also lessen the threats on vehicles.*

**Keywords –** *Global Positioning System(GPS), Global System for Mobile(GSM), Microcontroller.*

## INTRODUCTION

The safety of vehicles is extremely essential for every private and public vehicle owner. One of the major problems that motorists face is the robbery or theft of vehicles. It is also considered as one of the biggest fears of every vehicle owner aside from crashing. Vehicles typically get stolen for several reasons. Some people steal them simply to joyride around, and the theft is one opportunity. Others steal vehicles to commit additional crimes while others steal vehicles to strip them of parts or to sell them. One type of vehicle found easy to steal is the motorcycle [1, 2].

Professional thieves often find the vehicle they want to steal by following the user of the vehicle to where they park during the day or night. Then they size up the situation and come back with what they need to bag the vehicle. So, as user approaches the destination, especially at home, thieves just grab it or find ways to have it. Most of the time, locking the vehicle and placing chains are the only way to make vehicles secured. When motorists are far from the place where they park their vehicle they always tend to check if it is still there. Sometimes, thieves put the vehicle inside a van or a cargo truck to transport if it is small. There is adequate and no easy way for the owners to find their vehicle than to call for a help from active respondents like the police [3]. However, the police may take a long time to find the vehicle for lack of source or devices that will easily locate the vehicle. There are no alarms that make them aware that vehicles are being stolen or users are in emergency situations. Fast response is very much needed in these kinds of situations.

In the Philippines, vehicle owners use an alarm to alert them that somebody is moving the vehicle. Alarms may seem like a good way to attract attention of someone's attempt on the vehicle, but people have

gotten so used to false alarms that they do not investigate or even bother to check why the alarm went on. This is because the alarm sensors are so sensitive that even dragging noisy vehicles raise the car's alarm. Another common way of securing vehicle is by locking it using its key when the owner leaves it at a parking place, however in just a minute a thief can easily control and destroy its lock, simply by using other tools that can run the vehicle [4]. At home, placing chains is done by the owner to ensure the safety of the vehicle but again, by using a heavy tool for cutting the chain, the vehicle may be taken away from the owner.

The project is geared to help vehicle owners to become more comfortable and secured with their vehicle using. GSM and GPS technologies. With the sensor, the owner no longer needs to constantly check if the vehicle is still in the parking area as when the sensor is triggered, the security alarm is activated and the device will send messages that can alert the owner. There is likewise no need to place chains because the device can control the functions of the vehicle. It can automatically turn the engine off/on and the main switch of the vehicle. With the help of this anti-theft device, vehicle owners will no longer need to worry when they leave their vehicle in a public or private place because the GSM module enables communication between the vehicle and the owner. When the vehicle gets stolen, the GPS receiver module will give the reliable location of the vehicle through coordinates which will help locate the stolen vehicle [5]. Summing up, the project may reduce the possibility of stealing vehicles and increase the possibility of catching vehicle thieves.

## OBJECTIVES OF THE STUDY

After careful analysis of the present situation of vehicle security systems, the researcher came up with this study that aimed to design and develop a microcontroller-based vehicle security system with tracking capability using GSM and GPS technologies.

Specifically, this project study aimed to work on these objectives: select the most appropriate components needed in the construction of the device as to Microcontroller Unit, Global System for Mobile Technology and Global Positioning System Technology; design the required circuits capable of securing and interacting with the vehicle and tracking the location of the vehicle; develop the program of the microcontroller used in interfacing with the different module hardware's of the device; and test and evaluate the developed vehicle security system.

## MATERIALS AND METHODS

Relevant information for the design of the device and its functional specifications were obtained. The developer gathered enough information needed to establish and develop the system. Also, the researcher created numerous solutions to the problem and studied different alternatives regarding the materials that were used to construct the project design. The developer tested and evaluated the solution to determine quality of the project design. The developer performed troubleshooting to identify errors produced by the project design.

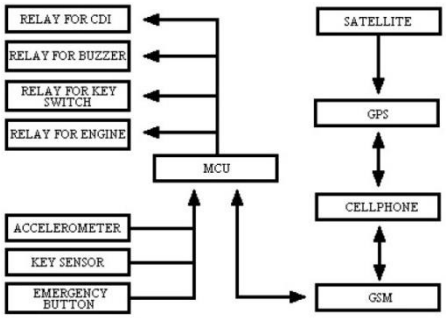


*Figure 1. Block and Process Diagram of the Design Process*

The block diagram shows the devices used in the system and their interconnection

### Owner texting procedure

The text messages that the owner will send to the GSM module of the device serve as the command for the microcontroller-based vehicle security system. The owner must follow the correct format of text to be sent to the GSM module of the device in order to activate the right actions that must be taken by the device. Once the owner sends the wrong format of text messages to the GSM module, it will be neglected or no action will be performed by the device. If it follows the correct password but wrong command, then the owner will receive an "invalid keywords" from the device attached to the vehicle. The correct format is in the form of SMS message with four character password followed by space then keyword. The keyword should include a capital letter 'S" then 1 or 0 for the enabling and disabling the vibration sensor, another character "1" for enabling the ignition switch and another 1 or 0 for enabling and disabling the key switch. Example: **1234 Sab1.** 1234 is the four character password, **Sab1** is the command keyword,

and in this case, character "1" after "b" is set to switch ON the key switch. If that keyword is changed to **Sa1** then that means the ignition is enabled. If it is S1, it means activating the vibration sensor that once triggered will create an alarm. Changing the character "1" to "0" means to switch OFF what was turned ON.

Table 1. Materials of the Project

| Quantity | Components |
|---|---|
| 1 pc | GSM Module |
| 1 pc | GPS Module |
| 1 pc | 4x4 Relay Module |
| 1 pc | PIC16F877A |
| 1 pc | PICI6F876 |
| 1 pc | 22PF CERAMIC CAP |
| 1 pc | 10K Array Resistor |
| 1 pc | 7805 Voltage Regulator |
| 1 pc | WIBA Rectifier Diode |
| 1 pc | 2 Pins Terminal Block |
| 1 pc | Horn |
| 1 pc | HC881 Casing |
| 1 pc | Push Button |
| 1 pc | Vibration Sensor |
| 1 pc | 12V Battery |
| 2 pcs | Flasher relay |

## RESULTS AND DISCUSSION

Different electronic components were chosen and used in the construction of the device that is capable of providing the required output of the project. Figure 13 below shows the different modules inside the device. It includes the main components of the device, the GPS, GSM, PIC microcontroller, sensor and the relay module. This classified the components of the device as modular.

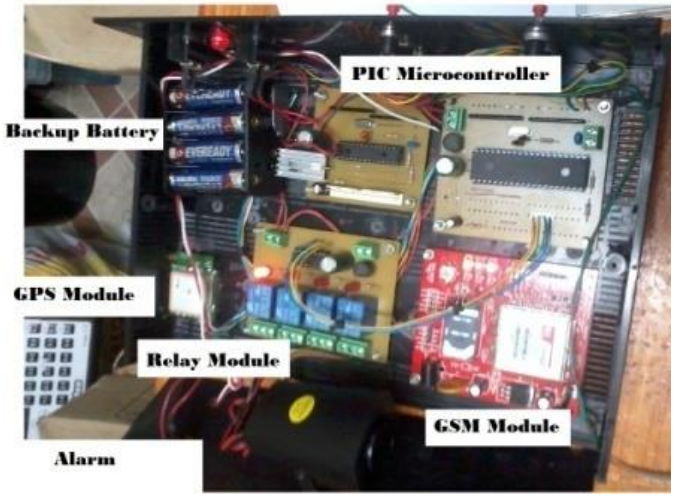


*Figure 2. Components of the Device*

The output device is composed of different modules that are interconnected using a microcontroller. These modules are the GSM, GPS and relay module. Figure 3 shows the finished device with different cables to be installed to the vehicle. It includes the three different buttons to be used for cell phone number registration, Registration of the cell-phone number of the relatives or recipient of the text message is done by "pressing and holding" the button followed by sending to the device the correct password and keyword. There are also another two buttons that are used for manual switching or activating the alarm.

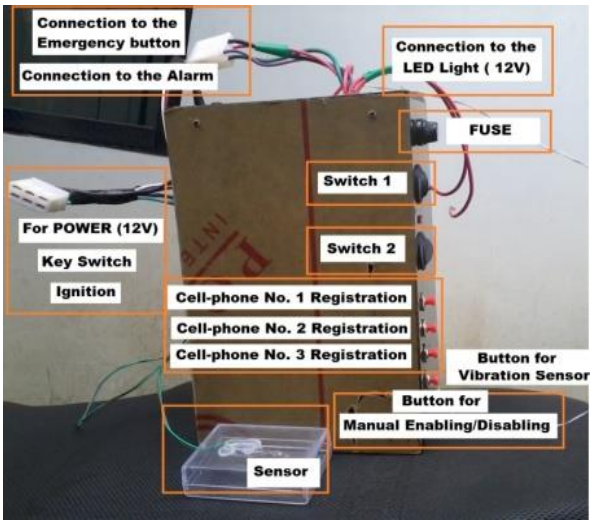


*Figure 3. Parts of the Device*

### Tracking the location of the vehicle

The GPS technology allows the owner of the vehicle to pinpoint the location of his vehicle that has been enabled for tracking and monitored through a PC, Smart Phone or a personal tracking device. In the design project the device will send an SMS message to the preferred user. Part of the SMS message is composed of latitude and longitude coordinate values, Example: LAT:13.52.9088 LONG:120.54.5848. This follows the format of degrees.minute. In order to get the exact degree value, minute value should be divided by 60, as 1 degree = 60min. So for the particular example, The LAT:13.52.9088 is LAT:13.881813 and the LONG: 120.54.5848 is LONG:120.90808 which gives the exact place of the motor vehicle.

Online data communication or the Internet is required to use the features of the project. The device to be used in tracking should be supported by an active internet connection. The location of the vehicle

can easily be seen using Google maps, Google Earth and other website place finder using latitudes and longitudes values. Examples are shown in Figures 4 and 5.

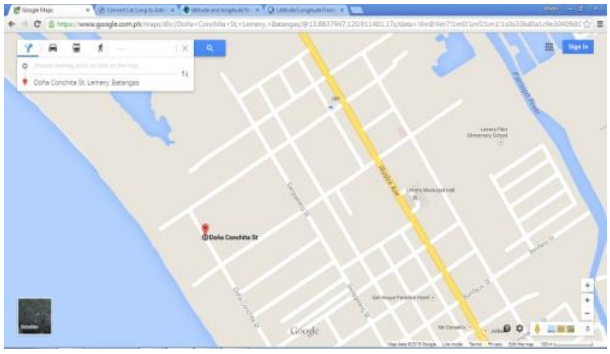

*Figure 4. Tracking using Google Maps*

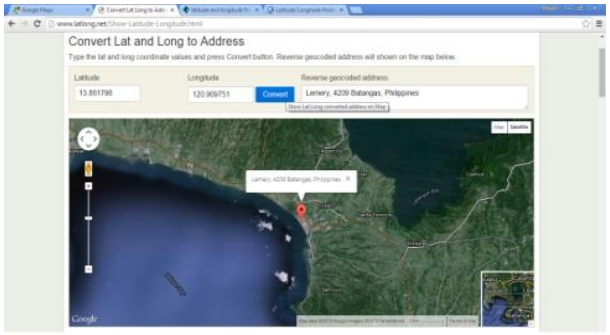


*Figure 5. Tracking using www.latlong.net*

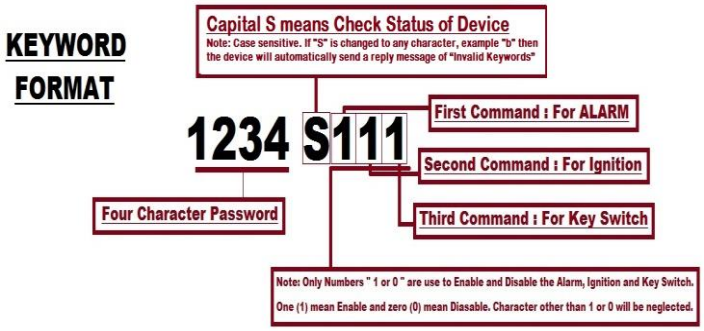


*Figure 6. Correct SMS command format*

The project was evaluated by checking the functions of every component's purpose and the result of the input process output sequence. The developer tested the system to determine its accuracy, effectiveness and reliability. A series of testing was done to provide an accurate result. Tables 2 to 9 show data on the tested features.

Table 2 shows result of testing the GSM module from a distance of 1 to 20 km. In this table, there were four trials conducted in different locations of the owner and location of the GSM module.

Table 2. Experiments and Result in Communicating with the GSM Module

| Trial | Location of the Owner | Location of the GSM Module | Result |
|---|---|---|---|
| 1 | Lemery Batangas | Agoncillo, Batangas | Success |
| 2 | BatStateU-Lemery | BatStateU-Balayan | Success |
| 3 | Lemery, Batangas | Batangas City | Success |
| 4 | Bucal, Lemery Batangas | Brgy. Iba, Taal, Batangas | Success |

During the testing of this module, it was observed that in these locations mobile network signal of the SIM responded to its preferred network provider, it's because the network tower is wirelessly capturing the signal of the GSM module. As a result the owner can communicate successfully with the module. The vehicle responded successfully to the command of the user.

Table 3. Experiments and Results in Triggering the Sensor

| Trial | Action | Result * | Result ** |
|---|---|---|---|
| 1 | Triggering the sensor | Failed | Failed |
| 2 | Triggering the sensor | Success | Failed |
| 3 | Triggering the sensor | Failed | Success |
| 4 | Triggering the sensor | Success | Success |

** RESULT in Turning On the Alarm*
*** RESULT by Sending message to the owner*

Table 3 shows the result while triggering the vibration sensor during testing the device. It should activate the alarm automatically and send an SMS notification to the registered mobile number of the owner. The first attempt failed because of the low sensitivity of the sensor; due to this, the sensitivity was adjusted which made the fourth and the following trials successful.

Table 4 shows sample of SMS message action that the owner sends to the device to turn OFF the alarm with their result. After the third trial, all the following trials were successful.

Table 4. Experiments and Results in Switching Off the Alarm

| Trial | Action | Result * | Result ** |
|---|---|---|---|
| 1 | Sending SMS "1234 S0__" | Failed | Failed |
| 2 | Sending SMS "1234 S0__" | Success | Failed |
| 3 | Sending SMS "1234 S0__" | Success | Success |
| 4 | Sending SMS "1234 S0__" | Success | Success |

** Result in Turning Off the Alarm;*
*** Result by Sending message to the owner*

Table 5. Experiment and Results in Switching On the Key Switch of the Vehicle

| Trial | Action | Result * | Result** |
|---|---|---|---|
| 1 | Sending SMS "1234 S__1" | Failed | Failed |
| 2 | Sending SMS "1234 S__1" | Success | Failed |
| 3 | Sending SMS "1234 S__1" | Failed | Success |
| 4 | Sending SMS "1234 S__1" | Success | Success |

** Result in Turning On the Key Switch;*
*** Result by Sending message to the owner*

Table 5 shows sample of SMS message Action that the owner sends to the device to turn ON the key switch with their result. The first three trials failed because of Network signal delay and out of load balance of SIM card. After a successful fourth trial, all the following trials were successful.

Table 6. Table of Experiment and Result in Switching Off the Key Switch and Engine of the Vehicle

| Trial | Action | Result * | Result ** |
|---|---|---|---|
| 1 | Sending SMS "1234 S__0" | Failed | Failed |
| 2 | Sending SMS "1234 S__0" | Success | Failed |
| 3 | Sending SMS "1234 S__0" | Success | Success |
| 4 | Sending SMS "1234 S__0" | Success | Success |

** Result in Turning Off the Key Switch/Engine ;*
*** Result by Sending message to the owner*

Table 6 shows sample of SMS message Action that the owner sends to the device to turn OFF the key switch with their result. The first two trials failed because of the absence load balance of the SIM of the device, putting credit loads in the SIM make the following trials all successful.

Table 7. Experiment and Result in Turning on the Engine of the Vehicle

| Trial | Action | Result * | Result ** |
|---|---|---|---|
| 1 | Sending SMS "1234 S_1_" | Failed | Failed |
| 2 | Sending SMS "1234 S_1_" | Success | Failed |
| 3 | Sending SMS "1234 S_1_" | Failed | Success |
| 4 | Sending SMS "1234 S_1_" | Success | Success |

** Result in Turning On the Engine*
*** Result by Sending message to the owner*

Table 7 shows sample of SMS message Action that the owner sends to the device to turn ON the engine of the vehicle and its status. Failure of the first two trials was caused by Low Power Supply and absence of Network Signal. After the fourth trial all the following trials are successful.

Table 8. Table of experiment and result in checking the Status of the Vehicle

| Trial | Action | Result * | Result ** |
|---|---|---|---|
| 1 | Sending SMS "1234 S___" | Failed | Failed |
| 2 | Sending SMS "1234 S___" | Success | Failed |
| 3 | Sending SMS "1234 S___" | Failed | Success |
| 4 | Sending SMS "1234 S___" | Success | Success |

** Result in Checking Vehicle Status*
*** Result by Sending message to the owner*

Table 8 shows sample of SMS message Action that the owner sends to the device to check the status of the vehicle. Failure of the first two trials was caused by absence of the SIM load and network signal problem. Applying solutions make the next and following trials successful.

Table 9. Table of Experiments and Results in Switching on the Emergency Button

| Trial | Action | Location of the Owner and the device | Result* |
|---|---|---|---|
| 1 | Switching ON the Emergency button | Lemery, Batangas | Failed |
| 2 | Switching ON the Emergency button | Lemery, Batangas | Failed |
| 3 | Switching ON the Emergency button | Lemery, Batangas | Success |
| 4 | Switching ON the Emergency button | Lemery, Batangas | Success |

*** Result by Sending message to the owner*

Table 9 shows sample of SMS message Action that the owner sends to the device when an emergency happen. The result show two failure on the first two trials but the next and following trials were all successful.

The experiments show the performances and reactions made by the device from different commands invoked by the user, and how the hardware of the device interacted in the different locations between the user and the device installed in the vehicle.

The performance testing of the system was conducted for more than a month because the developer worked on trial and error in analyzing the behavior of the system. During the failed result, the developer checks the program codes, its hardware wiring connections and other possible reasons why it failed. Some parts, procedure and process of the project passed the testing procedure and were able to meet the requirements needed, but, other parts and processes of the project failed the testing process.

Some of the problems occurred includes network signal failure, low sensitivity of sensor and battery failure. From this problem the developer apply a solution by adjusting the sensitivity of sensor, changing the battery of the vehicle and identifying area for a good network signal. Through this, the developer was able to succeed and reduce or eliminates each error.

## CONCLUSION

The section of the most appropriate components such as GSM, GPS, relay and microcontroller unit makes feasible the development of a vehicle security system which adopts the GSM and GPS technologies. The device will surely help its owner to safeguard his/her vehicle wherever it goes.

The design of the device enables it to communicate and track location of missing vehicles. The sensor alarm and the GPS receiver are significant features which alert vehicle owner and provide coordinates much needed in vehicle tracking. The design, however; relies strongly on internet availability and Network provider signal without which no tracking and communications may be done.

The program of the microcontroller used in interfacing with the different module hardware's runs accordingly in tracking, receiving and sending SMS notification to the user and switching on and off the key switch, engine and the alarm. The different software's enabled the construction and test the developed program. This shows that the expected outputs have been achieved by the microcontroller.

The testing and evaluation of the developed system help to make the desired output of the project. The developed device is functional, reliable, usable, efficient and sustainable.

## RECOMMENDATION

The size of the casing of the device should be considered. Additional technology like Radio Frequency (RF) and some touch screen based application can also be adopted. The wiring connections of the device to the motor vehicle may also be considered.

Translating latitude and longitude coordinates to an exact address using software or develop software that can translate the coordinates to the exact location in order to lessen the effort of the vehicle owner in decoding the coordinates and make the GPS data more readable.

Study the ways on how the GSM modem and GPS receiver may provide a very good signal even in an isolated area to establish a communication between the vehicle and the owner.

Consider implementing a Keypad Module to input numbers for registration of SIM numbers and use of Biometrics for the identity of user.

## LIMITATION

The project uses only the existing technology of GSM and GPS in tracking and communicating with the vehicle. The project will not check the load balance of the SIM. This means that the device cannot check if the device still has load. The owner must also insert the SIM card to another cellular phone in order to check the load balance of the SIM. The network problem greatly affects the execution of process of the device. When the device network provider is out of coverage area or the SIM card (a prepaid SIM card) has insufficient load it cannot send message to the owner of the vehicle when the alarm is activated. The delay of receiving text messages of the owner and the device is caused by the network provider and not by the device. Also the device will not identify the cause of vibrations or movements of the vehicle. This only means that the device cannot distinguish the source of movements or vibrations whether it is caused by a person, things or animals because the sensor used in the device will only be for movements and vibrations.

Moreover, the GPS signal problem may affect the transferring of data to the device. Disturbances with the communication between the satellite and GPS receiver will affect the process of the device that will lead to interruption or delay of process of the device. GPS signal is also directly affected by an orbital error, satellite geometry, and artificial degradation of the satellite signal, noise in the radio signal, atmospheric effects, and natural barriers to the signal that can hinder and affect the GPS data.

Another limitation is that the device is for vehicles only that use automatic transmission because the device only controls the power switching of the the key switch and ignition. Only the motorcycle vehicle was used during testing of the project. Also electrical wiring connections of the vehicle should be considered

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