

# Vehicle's Interior Movement Detection and Notification System

FAIRUZ R. M. RASHIDI, IKHWAN H. MUHAMAD

Faculty of Electrical & Electronics Engineering

Universiti Malaysia Pahang

26600 Pekan, Pahang

MALAYSIA

fairuz@ump.edu.my, ikhwanh@ump.edu.my

*Abstract:* - Nowadays, there are lots of incident happening in a parked vehicle itself rather than on-the-road-accidents. From leaving a child locked alone in a vehicle to robbers hiding in the backseat are some of the cases that involve incidents occurred in a non-moving vehicle. Even though the vehicle's alarm system has been activated, but the main purpose of the alarm is to keep the car safe from outside intrusion, not inside. The proposed system will detect any motion or movement from the vehicle's interior and informed the owner by sending an SMS alert message. The system has been successfully designed and tested with low-cost material to encourage its installment on almost any type of vehicle.

*Key-Words:* - interior movement, motion detection, PIR sensor, GSM module, vehicle safety.

## 1 Introduction

There are quite a number of cases where a child or baby left in a car and most of them are fatal incidents due to the lack of oxygen or the intense surrounding's temperature [1,2,3]. There are also some cases where car thefts hide themselves in the car's backseat and reacted violence when the owners come in for a drive. All these reports generate a conclusion of owner's careless intention in checking for any passengers left inside before or after the vehicle have been parked. It is also a natural behavior to think that there will be no any other passengers if the driver was driving alone from the beginning. However, cautiousness is still a priority here as it involves human lives.

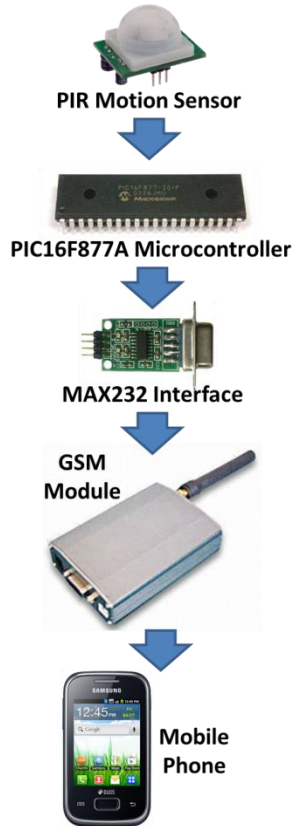
Therefore, a vehicle needs to be equipped with a notification system that can tell and warn the owner or driver about any interior movement occurs during their absence. As the driver is usually left their car in a faraway place such as parking lots or basements, there is no other way to communicate with them except through mobile phone connectivity. Hence, the notification system needs to have access to a long-range phone communication such as GSM (Global System for Mobile Communications, originally Groupe Spécial Mobile). This simple

system just needed a technique on how to detect interior's movement of a parked vehicle and then send an SMS text message to the driver alerting if any movement occurs. Besides the simplicity of the proposed system, the cost will also need to be as low as possible in order to make it affordable to be installed in any kind of vehicles regardless of their quality or brands. In the future, this notification system may be integrated with the vehicle's alarm system where driver can accessed the status of their vehicle, i.e. locked, unlocked, intruder detected and so on, and controlled them by just sending a text message from their mobile phone.

## 2 Design Methodology

The proposed notification system is intently to be a simple and low-cost system so that it can be easily implemented and installed in any types of vehicle [4]. The system will require a microcontroller, a motion detector and a GSM module for its major components. The algorithm will also be kept as simple as possible so that the system can function smoothly without any complex instruction to be performed. The motion sensor needs to be set to trigger when detecting movements that only occurred inside

the vehicle during its parking situation. This situation can be set in several conditions such as the vehicle’s doors have been locked, the engine ignition is off or the transmission-gear is set to ‘P’ in automatic transmission vehicle. When a movement is detected, the microprocessor will generate a command with an alert message to the GSM module to be sent to the driver as an SMS text message. This simple system can be illustrated as in Fig.1.



**Fig.1: Architecture of A Vehicle’s Interior Movement Detector and Notification System**

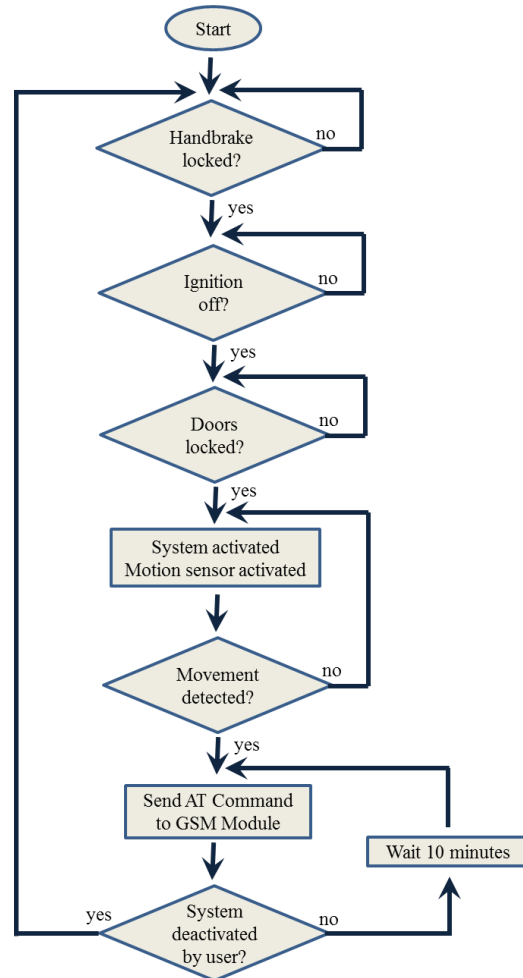
### 3 System’s Algorithm

As mentioned in the previous section, the algorithm to operate this system is kept short and simple in order to make the function run smoothly without performing any complex instruction. The system will be activated when all of the listed conditions are true:

- Doors are locked
- Ignition is off

- Hand brake in lock position (additional transmission-gear in position ‘P’ for automatic transmission vehicle)

When all of the above operation has been fulfilled, the system will be in standby mode where the motion detector will detect any movement within its range. If there is a movement detected, the motion detector will triggers a binary code to the microcontroller. By receiving this code, the microcontroller will generate a command code inserted with an alert message to the GSM module [7]. Finally, the driver needs to deactivate the system manually and upon locking back the vehicle’s doors after self-checking for any passenger left, the system will be activated automatically once again. If the driver did not come to deactivate the system, the system will wait for 10 minutes and send the same warning message again. The flow of the system’s algorithm is illustrated as in Fig.2.



**Fig.2: Flowchart of the System’s Algorithm**

## 4 System's Hardware

As mentioned before in the previous section, the system only requires a motion detector, a microcontroller and a GSM module as its major components. As for that, the discussion of the system's hardware will be divided into three sections according to three major components needed for a full operation of the system.

### 4.1 Motion Detector

PIR Motion Sensor is chosen as the motion detector's component which is functioned to detect any movement in a specific range. As regards to its name (PIR means passive infrared), infrared light is the measuring parameter of the motion sensor. Infrared light is the portion of the electromagnetic spectrum that falls between microwaves and visible light. It has wavelengths longer than visible light but shorter than microwaves. Humans, at normal body temperature, radiate most strongly in infrared light, at an approximate wavelength of 10. With this fact, PIR sensor or motion detector is the most adequate device with having least false detection. An example of a PIR Motion Sensor is shown in Fig.3.

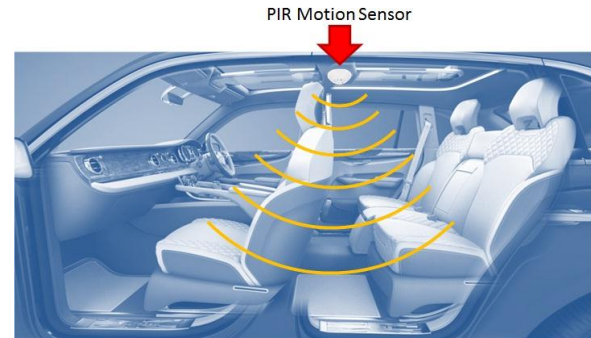


**Fig.3: PIR Motion Sensor**

PIR Motion Sensor generates a simple binary code of either 1 or 0 depending on its jumper setting for active HIGH or active LOW output. In the proposed system, active LOW output was used and a pull-up resistor needs to be connected to the output terminal and 5V power. The reason for this is that its output pin is an open-collector, meaning that it is virtually not connected to anything at all when there is no output. When a movement is sensed, it connects the pin to ground (0V). As for that, the use of the pull-up resistor is to pull-up any values read

from the output pin up to HIGH (5V) if no motion was detected.

The sensor is placed at the vehicle's ceiling as shown in Fig.4. This placement was chosen as it is a suitable place to detect the overall interior movement. In reality, this sensor will be embedded together with the vehicle's interior light. For a larger vehicle, the sensor can be multiplied and placed according to the vehicle's row to give more reliable results.

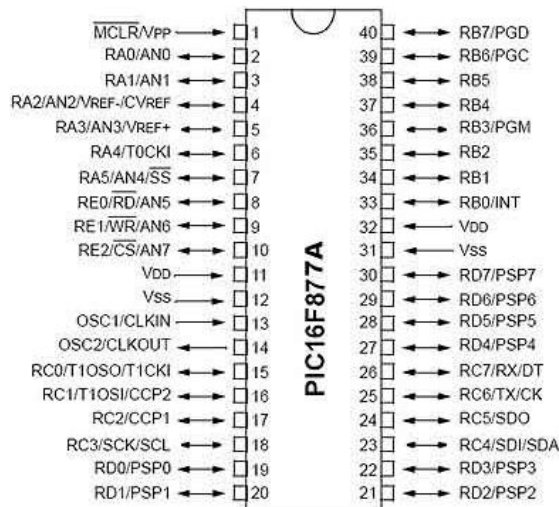


**Fig.4: PIR Motion Sensor placement**

### 4.2 Microcontroller

Microchip PIC16F877A is chosen for the system's microcontroller. This chip is chosen due to its low-cost and easily found in almost any component store. Furthermore, the chip is well-known for its flexibility in functioning as a simple controller and it can be written in a simple PIC BASIC language. PIC is a family of Harvard architecture microcontrollers made by Microchip Technology. The name PIC initially referred to "Programmable Interface Controller", but shortly thereafter was renamed "Programmable Intelligent Computer".

Nowadays, almost all microcontroller chips are programmed through flash memory built inside, and so does the PIC16F877A. It has 8K words or program memory which is more than enough to write the system's uncomplicated algorithm. It can be operated using a 4.5V to 6.0V DC voltage which can be easily derived from a commercial battery or wired directly to the vehicle's battery. In the proposed system, it is operated at 5.0V power which can be regulated by a simple circuit connection consisting of an LM7805 chip. PIC16F877A chip can be illustrated in its pin diagrams shown in Fig.5.



**Fig.5: Microprocessor PIC 16F877A pin diagram**

**4.3 GSM Module**

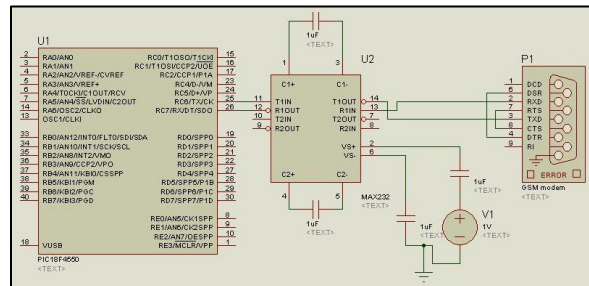
MOD 9001-D GSM/GPRS modem is chosen for the wireless communication to inform the owner or driver with the alert text messages. This modem fits the need of data transfer with SMS data communication, circuit switch for data connectivity, TCP/IP and etc. The AT Command Set and RS232 interface offered by GSM modem provide easy data connection without any extra circuit [5]. However, a MAX232 chip needs to be connected as an interface between PIC microcontroller and GSM module through this RS232 connection. This GSM module supports a wide range of GSM bandwidth including 900 MHz and 1800 MHz which is used broadly in Malaysia. It uses a 5V DC voltage which is the basic power supply for all the other components in the proposed system, making it easier to be powered up with a shared battery. Fig.6 shows an image of the GSM module that is used in the proposed system.

MOD 9001-D GSM/GPRS modem supports AT Command Set which is the basic language for almost all wireless communication module and system. For an easy access and settings, the GSM module can be interfaced with standard normal computer with RS232 serial port. By using several AT commands, the user can first test and configure the GSM module’s SIM card number.

As discussed earlier, a MAX232 chip needs to be connected together with the GSM module in order to communicate with PIC microcontroller through its serial port. Only a simple connection is required where the GSM is connected by DB-9 connector while the PIC microcontroller is connected by serial TX-RX port. The connection can be illustrated as in Fig.7.



**Fig.6: MOD 9001-D GSM/GPRS Modem complete with antenna and RS232 cable**



**Fig.7: MAX232 chip as the interface between PIC microcontroller and DB-9 connector of a GSM Module**

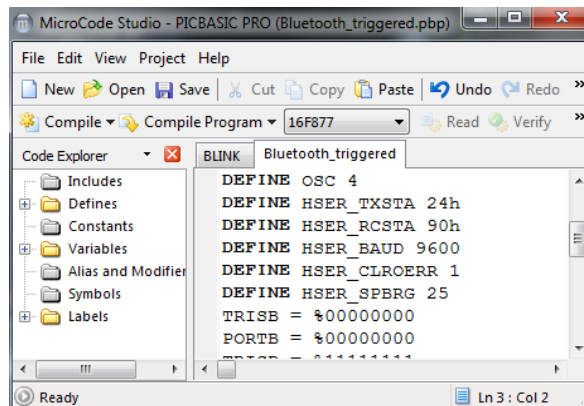
**5 Software Tools**

PIC microcontroller is a special-purpose integrated circuit designed to perform one or a few dedicated function depending on the program code that has been written on it. Usually, a microcontroller will become the main “brain” for a complete system with its hardware and mechanical parts. The program code is written in programming language such as C or BASIC that provides a structured mechanism for defining pieces of data, and the operations or transformations that to be carried by microcontroller. The proposed system is written in PIC BASIC language which is actually a



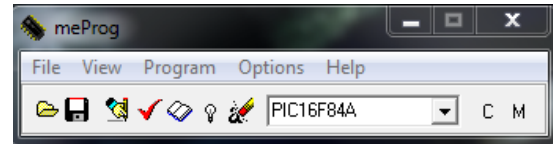
BASIC language but with special additional instruction set assigned to PIC. These codes are written and compiled by using MicroCode Studio PICBASIC PRO Compiler IDE which basically converts them into machine codes. Machine codes are actually HEX-numbered codes which can be further break up as binary codes. The PIC microcontroller will execute tasks from these binary codes according to the instruction set that it has been equipped with.

The PICBASIC PRO Compiler that has been developed exclusively for the PIC microcontroller has a generous library of built-in functions, preprocessor commands, and ready-to-run example programs to quickly jump-start any project. It has Microsoft Windows-based Integrated Development Environment (IDE) compiler that capable to aid in program designing and editing. Features of the IDE include color syntax editor, RTOS, linker, and a New Project Wizard for peripherals and drivers. Fig.8 shows an example of PICBASIC codes written in PICBASIC PRO Compiler.



**Fig.8: GUI for PICBASIC PRO Compiler**

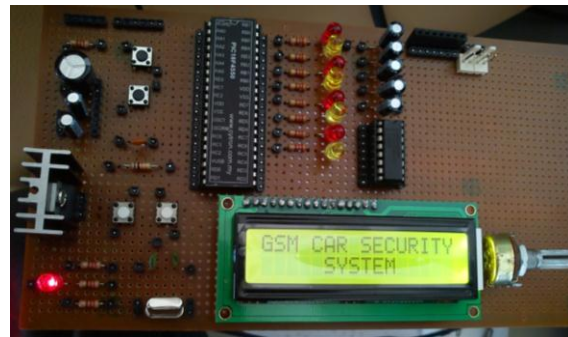
After the algorithm has been successfully compiled into machine codes, the codes will be downloaded or written on the PIC microcontroller's flash memory. Software called MELabs Programmer is used to run this specific task. MELabs Programmer was developed by microEngineering Labs Inc. which is an attached tool for the PICBASIC PRO Compiler. It can also do several memory-related tasks such as retrieving, erasing and editing data in the flash memory. The MELabs Programmer Windows's interface is shown in Fig.9.



**Fig.9: Melabs Programmer Software**

## 6 Results and Discussion

The result of the proposed system is its prototype on a proto-board such is Fig.10. The PIR Motion Sensor is placed somewhere else as it should be attached to a vehicle's ceiling. The proposed system was previously known as 'GSM Car Security System' and the attached LCD module is used for testing purpose to display the text message that supposed to be displayed at driver or owner's mobile phone. The text message is sent via GSM module with SMS format and received by the driver just as in Fig.11.



**Fig.10: The main prototype system on proto-board**



**Fig.11: SMS text message received by the driver**

As discussed before, when PIR Motion Sensor detects a movement in the vehicle's interior during parked situation, the PIC Microcontroller will trigger an AT command to the GSM Module where an SMS text message displaying 'WARNING! INTERIOR MOVEMENT DETECTED' will be sent to the mobile phone. The exact message received by the mobile phone is captured and shown in Fig.12.



**Fig.12: A warning message received from GSM Module**

## 7 Conclusion

The Vehicle's Interior Movement Detection and Notification System have been fully developed and successfully prototyped to provide an additional notification to inform the owners or drivers about any movement occurred inside the vehicle during their absence. This system consists of very basic and low-cost components as an encouragement for automobile's maker to install it as an added security system. Furthermore, the algorithm has been kept simple so that the system can act and respond faster without getting a system internal halt or failure which is a very important key in saving human lives. Finally, this system can be upgraded with linkage to the vehicle's security system, which can activate the alarm whenever the driver accidentally locking the doors while there are still passengers inside [6].

## References:

- [1] John N. Booth III, Gregory G. Davis, John Waterbor, Gerald McGwin Jr., "Hyperthermia deaths among children in parked vehicles: an analysis of 231 fatalities in the United States, 1999–2007", *Forensic Sci Med Pathol*, Vol. 6, pp: 99-105, 2010.
- [2] Andrew Grundstein, John Dowd, Vernon Meentemeyer, "Quantifying the Heat-Related Hazard for Children in Motor Vehicles", *American Meteorological Society*, pp. 1183-1191, 2010.
- [3] Catherine McLaren, Jan Null, James Quinn, "Heat Stress from Enclosed Vehicles: Moderate Ambient Temperatures Cause Significant Temperature Rise in Enclosed Vehicles", *PEDIATRICS: Official Journal of the American Academy of Pediatrics*, Vol. 116, pp. 109-112, 2005.
- [4] Ruchita J. Shah, Anuradha P. Gharge, "GSM Based Car Security System", *International Journal of Engineering and Innovative Technology (IJEIT)*, Vol. 2, pp. 203-206, 2012.
- [5] Visa M. Ibrahim, Asogwa A. Victor, S. Y. Musa, "GSM Based Anti-theft Security System Using AT&T Command", *International Journal Of Computational Engineering Research (IJCER)*, Vol. 2, pp. 1534-1537, 2012.
- [6] Visa M. Ibrahim, Asogwa A. Victor, "Microcontroller Based Anti-theft Security System Using GSM Networks with Text Message as Feedback", *International Journal of Engineering Research and Development (IJERD)*, Vol. 2, pp. 18-22, 2012.
- [7] Jiwa Abdullah, "The Design of Mobile Control Car Security System", *IACSIT International Journal of Engineering and Technology*, Vol. 3, pp. 254-262, 2011.