AMSE JOURNALS-AMSE IIETA publication-2017-Series: Advances D; Vol. 22; N°1; pp 62-76
Submitted July 2016; Revised Oct.10, 2017, Accepted Nov. 15, 2017

A Novel GSM and GPS Based Vehicle Security System

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Abstract

An integrated global positioning system and global system for mobile communication (GPS and GSM) is developed to track and control vehicles from remote places to assure the maximum security. It is a cost-effective and reliable solution for tracking and monitoring automobiles using the recent advancements of GSM (Global System for Mobile Communication), GPS (Global Positioning System) and Embedded System technology. This paper presents an automotive localization system using GPS and GSM Short message service (SMS). This paper presents an application of low cost solution for automobile position and status, very useful in case of car theft situations, for monitoring adolescent drivers as well as in car tracking system applications. The proposed solution can be used in other types of applications, where the needed information is required rarely.

Key words

Anti-theft, Embedded Systems, GSM, GPS, Real-time monitoring, Telematics,

1. Introduction

An anti-theft system is any device or method used to prevent or detect any unauthorized operation of valuable items. Theft is one of the most common and oldest criminal behaviours.

From the invention of the first lock and key to the introduction of Radio Frequency Identification (RFID) tags and biometric identification, anti-theft systems [1] have evolved to match the introduction of new inventions to society and the resulting theft of them by others. An immobiliser is an electronic security device fitted to an automobile that prevents to get started an engine unless the correct key (or other token) is used. This prevents the car from being hot-wired after entry has been achieved [2]. All Modern vehicle tracking system [3, 4, 5, 6, 7, 9, 10] commonly use GPS technology for locating the vehicle. To achieve automatic vehicle location system the information is transmitted through tracking server using GSM or General Packet Radio Service (GPRS) modem on GSM network [8] by using SMS or using direct TCP/IP (Transmission Control Protocol/ Internet Protocol) connection with tracking server through GPRS. Tracking server also has GSM/GPRS modem that receives vehicle location information via GSM network and stores this information in its database. This information is available to any authorized user of the system via website through internet. D. Shah et. al. [11] presented that, the main objective of the system is to provide security for the vehicle user and also detects the accident if occurred and informs the respective authority through wireless technologies, whereas, P. Singh et.al. [12] described that the principle point of the exploration work is to outline and create a shrewd and strong security framework for vehicles utilizing GPS and GSM innovation, that can avert robbery and give data on mischance. R. Ramani et. al. [13] proposed a method of vehicle tracking and locking system by using GPS and GSM technology, which puts the system into sleeping mode while the vehicle is handled by the owner or authorized person otherwise goes to active mode.

In the present paper, a vehicle tracking system has been designed that uses GPS and GSM technology, which is cheaper than the other sources of tracking system. This technology may be used as an anti-theft system also.

It is an embedded system which is used for tracking and positioning of any vehicle by using GPS and GSM technology. This system will continuously monitor a moving vehicle and report about its status on demand. Thus, it is used for controlling and tracking automobiles. It is useful to provide a solution to avoid car theft at lower cost than advanced security systems and to build an additional feature to the present security system that will warn the owner of the vehicle by sending SMS when there has been an intrusion into the vehicle. It can also change the location of the vehicle and other information to the owner after sending appropriate command to the embedded platform. It has been shown that, the full security against theft and flexibility in monitoring the car status via GSM Communication can be achieved.

2. Method of Approach

In this investigation, the usage of recent modern technology has been successfully implemented. The GPS system works by receiving the radio frequency (RF) signals transmitted by the GPS satellites. The block diagram of the system that represents the vehicle positioning and controlling, is shown in Fig.1.

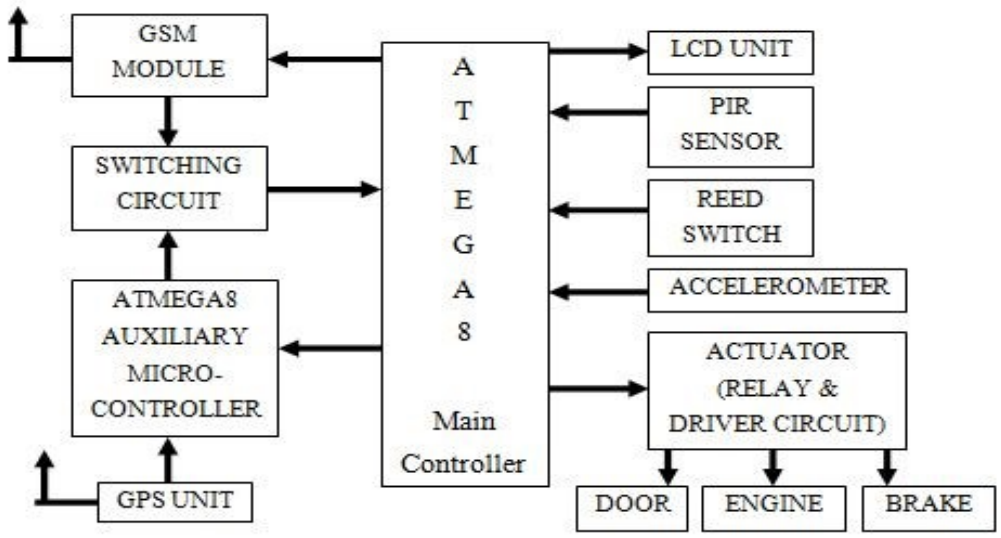

Fig1. Block Diagram of the System

When the system is switched on, the main microcontroller continuously searches for incoming SMS received by the GSM module. When it receives instruction to lock the car, it activates the door lock relay and starts monitoring if there is any valid input signal from the sensors like Passive Infrared Sensor (PIR), 3-Axis Accelerometer and Magnetic Reed Switch.

If any valid input signal is detected from the sensors while the system is in active mode or monitoring mode, the microcontroller sends an interrupt signal to the GPS data decoding auxiliary microcontroller. The auxiliary controller then processes the data which is received from the GPS and sends the data to the main microcontroller. After receiving the location information, the main controller sends command to the GSM module. The modem then sends the formatted data and intrusion type to the owner via short messaging service. After identifying the position of the car and if the owner thinks that the vehicle has been theft, he can send the commands through SMS to stop the engine of the vehicle and lock the brake of the car. After retrieving the car, the owner sends command to unlock the car. Then the monitoring system will be deactivated and the main microcontroller will again search for new incoming SMS for further processing.

3. Design

The scheme consists of embedded system, GSM & GPS technology. The whole system is divided into two parts, hardware and software. Atmega8, GSM Module-SIM300, GPS Unit-GTPA010, Switching Circuit, Relay board, Accelerometer-ADXL335, PIR Sensor, Magnetic Reed Switch, display Unit are the basic hardware used in this system as shown in Fig.2. AVR Studio 6 is used as the main software.

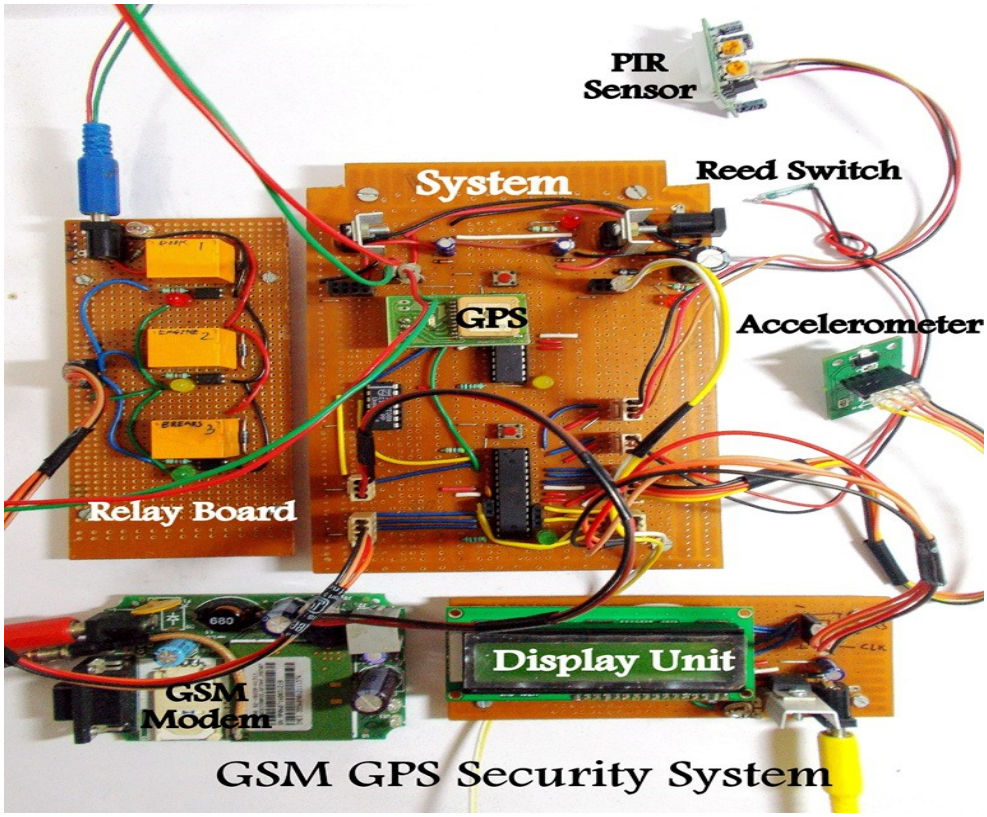

Fig 2. Architecture of the System

The system architecture is based on a multi-processor operation technique. Both the Atmega8 microcontrollers are configured to use the internal 8-Mhz oscillator. The main controller handles the SIM300 GSM unit, 16X2 LCD (Liquid Crystal Display) display driver unit, digital PIR sensor (the viewing angle of the sensor is 100°), ADXL335 analog accelerometer, magnetic Reed Switch and a 12V (JQC-3FC/T73) relay interface for the automobile control purpose. The auxiliary controller only handles the GPS NMEA (National Electrical Manufacturers Association) data acquisition technique. The GTPA010 GPS device continuously transmits the local positional data via USART (Universal Synchronous Asynchronous Receiver Transmitter) protocol. A 74HCT08N “AND” Gate is used as a switching

circuit to feed the final acquired data and the received SMS data to the main controller. Two LEDs are connected to indicate the data collection and SMS sending acknowledgment. Two RESET switches are used for troubleshooting purpose. Two 7805 voltage regulators are connected in parallel which is used to supply the total current of 1A to the system. Bypass capacitors are incorporated to minimize the supply voltage fluctuations. 12V mains supply is needed for the system to work. The circuit diagram of the whole system is shown in Fig.3. The project has been designed, developed and successfully tested.

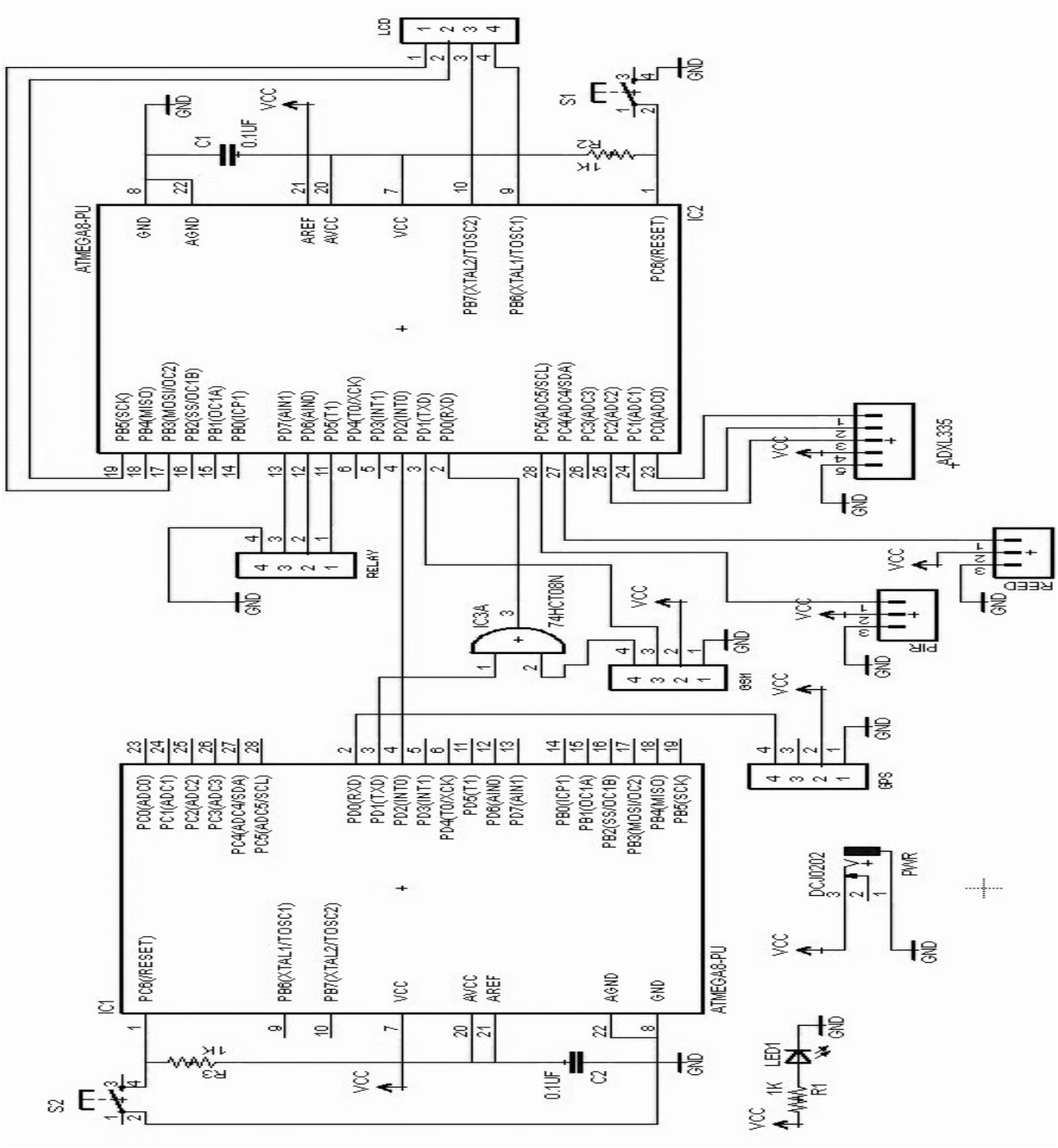

Fig.3. Circuit Diagram of the whole System

4. System Operation

The idea of the system is very contemporary and the demand of this kind of security system is growing day by day. The functional diagram of this GSM-GPS security system and its implementation as anti-theft system in automobiles is shown in Fig.4. The results are satisfactory and show good repeatability. With the help of this flexible and upgradable microcontroller system, many more features can be added later according to the need.

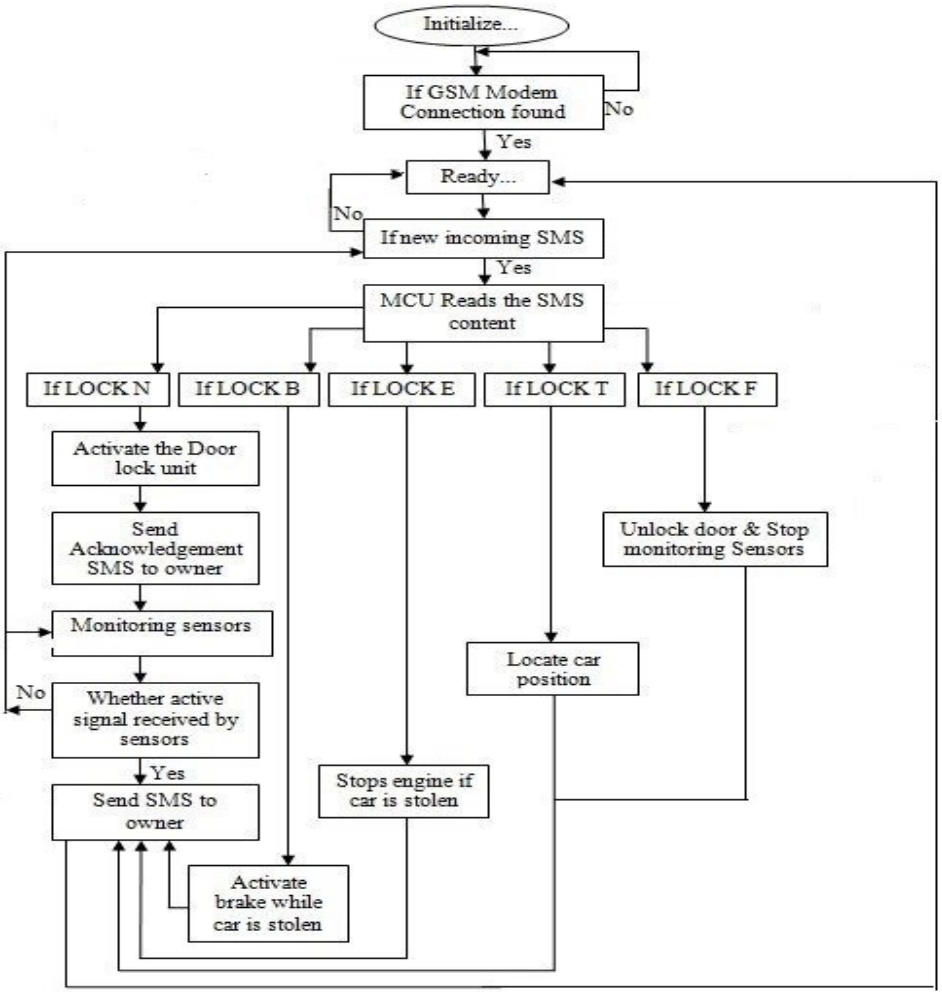

Fig.4. Functional Flowchart of GSM-GPS Security System

When the system is switched ON, it takes at least one or two minutes to establish the connection of GSM Module, GPS and most importantly PIR sensor for auto calibration. Human interference in the PIR sensor visible area should be avoided during the calibration process, otherwise the system can behave in an undesired manner.

The main AtMega8 microcontroller is interfaced serially to a GSM Modem and the auxiliary AtMega8 microcontroller to GPS Receiver. A GSM unit is used to provide continuous data about the position (Latitude and Longitude) of the vehicle from a remote place. The same data is sent

to the mobile at the other end from where the position of the vehicle is demanded. When the request by the user is sent to the number at the GSM modem, the system automatically sends a return reply to that mobile indicating the position of the vehicle in terms of latitude and longitude in real time.

The switching circuit is needed to separate the incoming signals from both GSM and GPS units. It is made of a 74HCT08N "AND" gate. At the 2 inputs of the "AND" Gate, both GSM and extracted GPS data (from Auxiliary Controller) are fed. Now, when any of the devices (GSM or GPS Auxiliary controller) is idle, it reflects a logic "0" that means HIGH for serial communication. At that moment if the other device is sending data to the controller section, it can easily pass through the "AND" Gate.

The PIR sensor, 3-Axis Accelerometer and magnetic Reed Switch are used to detect the Intrusion, crash and door monitoring respectively. The PIR sensor gives a signal when human intrusion happens into the car though it is locked. It detects living being by the emitted infrared radiation. The viewing angle of the sensor is 100°. The PIR Sensor requires a 'warm-up' time in order to function properly. This is due to the settling time involved in 'learning' its environment. This is around 30 seconds. During this time, there should be as little motion as possible in the sensors field of view. To detect sudden vibration or crash, the accelerometer is activated. The sensor gives an analog output value to the main controller. 10-bit ADC (Analog to Digital Converter) is used for this sensor. If it detects acceleration more than the value of 3G, the controller will declare it as a crash. The ADC value for such condition is 100< ADC Value <500.

5. Experimental Results

The circuit diagram and experimental setup are shown in Fig.3 and Fig.4 respectively. When the system is power on by applying +12V, the on board LEDs (Light Emitting Diode) will glow. The main and auxiliary microcontroller will set up its I/O pins, baud rate and other types of primary settings. GSM modem & GPS unit will be activated. When the GSM modem finds a valid mobile network, the LCD unit will show "READY". Now,

The behaviour of the system using all types of commands has been given in tabular form in Table1

Table 1. Behaviour of the System for different command

Commands / Input	LCD	Behaviour
LOCK N	Car Lock Successful	Activates Door lock, PIR & Accelerometer & sends Acknowledgement SMS

If any of the 3 sensors detect active Signal during locked state	Door Broken/ Intrusion Detected/ Crash Detected	Acknowledgement SMS With GPS Location
LOCK F	Car Unlock Successful	Acknowledgement SMS
LOCK T	Car Position...	Sends GPS information to owner Immediately via SMS
LOCK B	Car Brake Successful	Activate Brakes & sends SMS
LOCK E	Stop Engine Successful	Stops the Engine & sends SMS

All types of activities of the system like sending SMS by the owner, LCD display and acknowledgment through receiving SMS with respect to the commands are explained in APPENDIX.

6. Conclusion

The experimental flow chart is found to have quite good response. The results are satisfactory and show good repeatability. When any of the sensors detect intrusion or accident, it sends SMS immediately. It takes about 5 to 10 seconds to receive the SMS in cell phone. Two consecutive commands must be sent after an interval of 10 to 15 seconds. In the relay board, Opto-couplers are used to completely separate two power sources and protect the controller system. Decoupling capacitors are used in this system to stabilize the I/O characteristics. Fly back Diodes are used in the relay circuit for protecting the system by removing the spikes when the power of the relay coil is suddenly removed or disconnected. Performance factors will highly vary according to the signal strength of the GSM communication, GPS satellite visibility etc. Unwanted service SMS can create disturbance in the system.

Design of low cost anti-theft embedded system is a unique idea of researchers for real-time monitoring of the vehicle through SMS. So far, the research work has been gone through to monitor the vehicle but, in this novel work the system is able to control the vehicle too through SMS by the owner to avoid theft.

7. Discussion

Human interference in the PIR sensor visible area should be avoided during the calibration process, otherwise the system can behave in an undesired manner. Source code can be improved to stop the potential interference caused by the GSM modem during the positional data acquisition process. Magnetic reed switch can be replaced by some more precise and reliable sensors with digital output. Instead of 2 controllers, only one can be incorporated but in that case, the data acquisition process may be more troublesome. A good GPS antenna can be employed for

better reception of GPS signals. With the help of this flexible and upgradable microcontroller system, many more features would be added in future according to fulfil the purpose of the owner.

It is also useful in many other applications, such as, Asset Tracking system where companies need to track valuable assets for insurance or other monitoring purposes. They can now plot the real-time asset location on a map and closely monitor movement and operating status. This system can be implemented in banking sector, accident situations & small scale industrial purpose also.

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Appendix

When the anti-theft system is powered on it takes 1-2 minutes time to initialises itself as well as communicates with GSM –GPS module to get “Ready…” and display on the LCD module as shown in Fig. 5 subject to condition that GSM modem is connected with the mobile network. When the owner sends SMS to activate the lock (LOCK N) as shown in Fig.6, the system receives a command SMS as shown in Fig.7 in LCD display. The acknowledgment is displayed in the liquid crystal display (LCD) as shown in Fig.8, when the car is locked through car door lock relay and finally a confirmation SMS is sent to the owner as shown in Fig.9. Now the main controller starts to monitor the sensor and if any valid signal is received, the system will alert the owner through SMS. When PIR sensor detects the intrusion as shown in Fig.10, it sends a message to the owner like “Intrusion Detected” as shown in Fig.11.When the door lock is broken by unauthorized person as shown in Fig.12, then the owner will receive an SMS like “Door Broken” as shown in Fig.13 or if the car is crashed as shown in Fig.14, the owner will receive an SMS “Crash Detected” as given in Fig.15. So, when the owner gets intimation through SMS like “Intrusion Detected” or “Door Broken” with present location (GPS) then the owner can send SMS immediately for stopping the engine (LOCK E) and locking the brake (LOCK B) of the car one by one. Simultaneously, the owner will get a return SMS which will confirm the same. But in case of road accident of car, the owner will be informed through SMS as shown in Fig.16. Then he will send SMS command to unlock the car immediately (LOCK F) as shown in Fig.17, so that, the passengers can save themselves. The owner can get the actual car position (after theft or accident) by sending the command SMS (LOCK T)

Fig.5. Initialization of the system

Fig.6. Sending SMS to activate the lock

Fig.7. SMS received for activating the LOCK

Fig.8. Acknowledgment of Car Locking

Fig.9. Acknowledgment SMS is being sent to the owner

Fig.10. Intrusion Detection

Fig.11. Sending Intrusion alert to owner

Fig.12. Door Broken

Fig.13. Sending Door alert to owner

Fig.14. Crash Detected

Fig.15. Sending Crash alert to owner

Fig.16. Sending Command to turn off the Lock

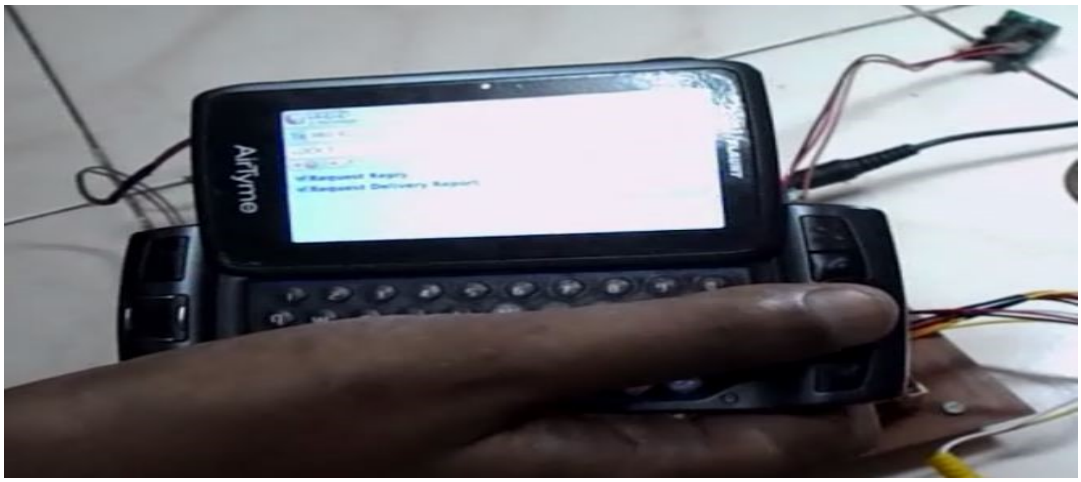

Fig.17. SMS received for Deactivating the LOCK