

TWO WHEELER VEHICLE SECURITY SYSTEM

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ABSTRACT

Vehicle security system has been a topic of great interest over the years due to the increasing vehicle theft cases reported all over the world. Most of the advanced vehicle security systems best suit the four wheelers. As of the security system for two wheelers is concerned, the systems available in market are of no match to the well equipped thieves. When under attack, these systems can only immobilize the engine and sound a loud alarm. It is a serious limitation. In this paper we propose a reliable and robust design of Two Wheeler Vehicle Security System (TWVSS) with features enhancing the security of the vehicle and ensuring the safety of the rider. In our proposed security system various new features are included in addition to the engine immobilizer and alarm. Few of the important features supported by our system are alerting owner by SMS about the theft attempt, allowing user to control the system remotely by SMS, tracking the location of vehicle using GPS technology, Remote Keyless System, servo motor operated locking system (handle lock, fuel lock and rear wheel lock) and side stand indicator. Redundancy is maintained to make the system reliable even in the worst case scenario, but due to cost constraints a tradeoff between cost and redundancy was necessary. Our system is designed to be compatible with almost all the brands of vehicle.

KEYWORDS: *GPS technology, SMS, Remote keyless system, Redundancy, Compatibility.*

I. INTRODUCTION

According to the report published by National Crime Records Bureau (NCRB), in the year 2011 alone 122,367 two wheeler vehicles were stolen in India. Out of which only 32,826 vehicles were recovered [1]. Typically, two-wheelers are stolen right off streets or apartment parking lots. By the time the police are alerted (which could be a few hours since the theft), the vehicles are made underground leaving almost no traces. Later the vehicles are either dismantled or sold in neighboring states/districts at throw-away prices, leaving the owner and police helpless in bringing the thief to book. The story remains same for rest of the world. The only possible way out of this problem is implementation of security system in the vehicle. The security system should be capable of performing reasonably well even in unfavorable conditions to meet the desired level of security [2], [3]. The price of the security system should be reasonably low or else the automobile manufacturers cannot implement such a system, as it will increase the overall cost of the vehicle by a big margin. If the design of the security system is such that it is compatible with most of the brands and classes of vehicles then it helps reducing the NRE cost. The overall power consumption should be less as the source of supply for the security system is the 12V battery of the vehicle. Keeping these requirements and constraints in mind we propose this new design of Two Wheeler Vehicle Security System (TWVSS). The remainder of this paper is organized as follows. Section 2 gives the insight of the work carried out in this field. Section 3 gives the description of the proposed TWVSS. Section 4 describes the design of hardware module. Section 5 describes the design of software module. Section 6 shows the result of the tests conducted. Section 7 lists some of the future enhancements that could be carried out. Lastly, Section 8 concludes the paper.

II. RELATED WORK

Indeed, we are not the first to observe the flaws and limitations of the present day vehicle security systems. Several researchers have described potential vulnerabilities in automotive security systems [2]. The traditional security systems as priced low, but they merely act as an alarm system and are no match to the well equipped thief. Many security systems have been proposed over the years, e.g. [4], [5], [7], [9], [19], [20], but almost all the recent advanced security systems are designed especially for cars. Several researchers have even used image processing technology to capture the face of driver and compare it with the picture of authorized drivers to detect the intrusion [14], [15]. Whereas some proposed systems include finger print detection system [19] along with face detection. These security systems are complex, costly and cannot be implemented on two wheelers. Two wheeler vehicles offer very less space to install the security module and hence even area is one of the major constraints. The demand is to design a system that performs necessary function, simple to operate, reasonably priced and small enough to be placed under the seat of the vehicle.

III. DESCRIPTION OF PROPOSED TWO WHEELER VEHICLE SECURITY SYSTEM

An overview of the complete system is described in this section before detailing the specifications and the necessity for each module in the system. The general view of operation of the proposed security system is shown in fig. 1. The conventional handle locking system is replaced by a handle lock operated by servo motor and controlled by the Remote Keyless System (RKS) [20]. RKS has a transmitter and a receiver module. The receiver module is installed on the vehicle and the owner of the vehicle has the remote (transmitter module). The RKS remote could be used to lock/unlock the locking system (handle lock, fuel lock and rear wheel lock), switch ON/OFF the engine and to turn off the alarm. Fuel lock replaces the knob at the nozzle of fuel tank. Rear wheel lock is used to jam the sprocket of the wheel.

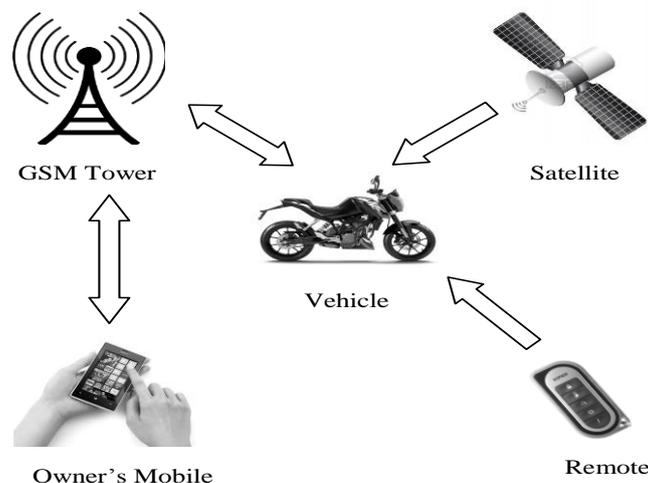


Figure 1: General view of TWVSS operation.

The vehicle owner's cell phone with the registered Subscriber Identity Module (SIM) number acts as the master key of the security system. It is given higher priority over RKS and hence it can override the instructions from RKS. A Short Message Service (SMS) is sent to the registered SIM via the Global System for Mobile communication (GSM) module whenever the vehicle is unlocked using the RKS remote. Owner can in turn send a SMS to initiate the locking sequence, if he/she feels an unauthorized person has unlocked the vehicle [13]. Global Positioning System (GPS) module is used to track the location and monitor the speed of the vehicle. Piezoelectric sensors are used as vibration sensors to detect any tampering with the vehicle. Two sensitivity levels are chosen so as to nullify the chance of false alerting [20]. The owner is alerted by an SMS and loud alarm is activated, if there is any physical tampering with the vehicle or if the vehicle has been moved from the place where it was

parked (>15m). The owner can, anytime, request the security system of the vehicle for its status by sending an SMS. The status message sent in response to request includes the lock status, location coordinates and the speed of the vehicle. Infra Red (IR) sensors are used as side stand indicators, until and unless the side stand is not pulled up engine cannot be started.

IV. HARDWARE MODULE

3.1. Remote Keyless System (RKS)

RKS module is designed to operate at a frequency of 433 MHz with a half duplex communication link. The Remote consists of a 433 MHz transmitter, encoder, power supply and a simple loop antenna. The receiver module consists of 433 MHz receiver, decoder, power supply and a simple loop antenna. As shown in fig. 2, the receiver module is interfaced with the MCU. As shown in fig. 3, the remote consists of four buttons, each associated with different operation. The chosen pair of encoder and decoder should have same number of addresses and data format. We used 4 bit hot code to represent each button. The 12 bit parallel data is encoded to serial data for transmission through RF transmitter. These 12 bits are divided into 8 address bits and 4 hot code bits. This 8 bit address data is unique to every pair of receiver and transmitter module as stated earlier. The received serial data is decoded to parallel data. The 8 bit address data is compared with the local address data three times continuously. If these two address bits matches, the 4 bit hot code is made available to the MCU. For our design (under standard conditions), we obtained maximum communication range of approx. 100m, justifying the use of low cost simple loop antenna.

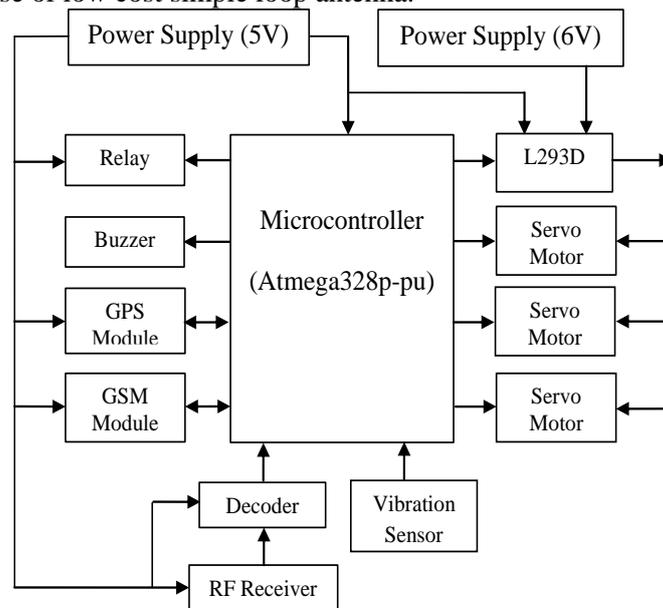


Figure 2: Block diagram of TWVSS hardware module to be installed in the vehicle.

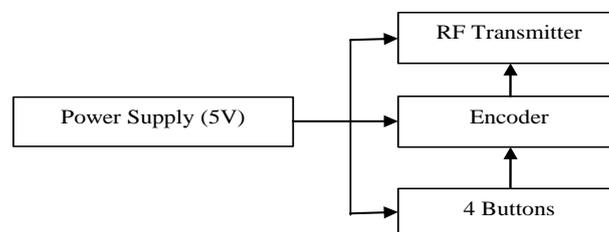


Figure 3: Block diagram of RKS transmitter module.

3.2. Locking system

The handle, fuel and rear wheel locking systems are operated by servo motors. Servo motor is chosen because the output shaft can be rotated to a specific angular position by sending it a pulse width modulation (PWM) signal through the control wire [17]. Atmega328p-pu MCU has 6 inbuilt PWM

channels which are used to generate the PWM signal to control the servo motor. Operational voltage of 6V and current of 1A is supplied from the driver IC (L293D) as shown in fig. 2. While parking the vehicle, the rider should align the handle to the extreme left and press the lock button on the remote. This initiates the locking sequence of the handle, fuel and rear wheel lock. To avoid the fuel theft, a lock is placed at the nozzle of the fuel tank. This lock acts as a valve. Once the vehicle is locked, fuel lock blocks the nozzle, disrupting the fuel flow in the tube. As there is no fuel flowing into the engine, it cannot be started, thus serving two purposes. Another lock is placed at the rear side of the vehicle, to jam the sprocket of wheel. Once the sprocket is jammed, the wheel cannot rotate. This ensures redundancy in the proposed security system. Owner can control the locking system from his/her mobile phone (sending a SMS) or RKS remote.

3.3. GPS Module

Gsm-u1LP GPS module is used for tracking of the vehicle. It utilizes MediaTek GPS MT3329 that supports up to 66 channels of satellite searching with -165dBm sensitivity and 10Hz maximum update rate for precise GPS signal processing under low receptive and high velocity conditions. It has a power saving switching mode power supply (SMPS) that helps reduce the overall GPS power consumption. We used the National Marine Electronic Association (NMEA) 0183 protocol [9], [10], which is a worldwide accepted standard. The Recommended Minimum Navigation Information GPRMC sentence is decoded to get the coordinates, speed, UTC time, date month, year and other necessary information. (A sample of GPRMC sentence: \$GPRMC,064951.000,A,2307.1256,N,12016.4438,E,0.03,165.48,260406,3.05,W,A*55).

3.4. GSM Module

The GSM module is required to establish a communication link between the owner of the vehicle and the security system [8], [17]. We used SIM300 GSM module in our system. AT commands were used to control this module. SIM300 is a Tri-band GSM/GPRS engine that works on frequencies EGSM 900 MHz, DCS 1800 MHz and PCS1900 MHz. SIM300 also provides General Packet Radio Service (GPRS). The current consumption is as low as 2.5mA in SLEEP mode. SIM memory is used to store messages. The SIM300 module communicates with the MCU using asynchronous serial communication with a baud rate of 9600. The owner of the vehicle can send SMS to lock down the bike. Owner can also disable the remote keyless system if the remote is stolen. These features becomes very useful if incase duplicate or stolen remote is used to unlock the vehicle. Thus the cell phone of the owner with the registered SIM acts as the master key, which can override the instructions from the remote.

3.5. Engine Immobilizer

This module is used to control the ignition system of the vehicle, there by controlling the engine. The capacitive discharge ignition (CDI) module [12] uses capacitor discharge current output to fire the spark plugs. The capacitive discharge ignition (CDI) module has 6 pins in common. Of these 6 pins, one pin is for ignition trigger pulse, one pin is to be connected to 12V ignition coil, one pin is for supply of ignition power to spark plugs, one pin is to be connected to kill switch and the remaining two pins are to be grounded. If the kill pin is grounded then the ignition power pin does not supply 20,000V to the spark plug, which is essential to produce a spark in the power stroke. A relay is used to accomplish this function. Relay is used in “normally open mode”, one terminal is connected to kill pin and another is grounded. Whenever the engine has to be immobilized the microcontroller unit (MCU) activates the relay coil which shorts the kill pin to the ground.

3.6. Vibration sensor

Piezoelectric sensor is used for this application, as the cost of this sensor is very less and it has reasonably good sensitivity. The chassis runs throughout the vehicle and it is made of metal, so the vibration in any part resonates all over it. Piezoelectric sensors are placed on the chassis [16], one at front end and another at rear end. As and when there is a vibration (because of the intruder tampering with the vehicle), it is transferred to the piezoelectric film and there is a proportional voltage developed at the terminals of the piezoelectric sensor. The analog voltages are converted to digital

values by the inbuilt 10 bit Analog to Digital Converter (ADC) of Atmega328p-pu MCU. The voltage produced is directly proportional to the intensity of vibration. A threshold value is set to distinguish between the high and low intensities.

3.7. Side stand indicator

IR sensor is chosen for this application, as it consumes very less power, less area and has low cost. This sensor is placed below the chain guard, aligned with side stand (pulled up). If the side stand is pulled up IR radiations emitted from led are reflected back which falls on the phototransistor, else IR radiations are not reflected back. The resistance across the phototransistor is in the range of mega ohms when no IR radiations fall on it. Its resistance greatly reduces when IR radiations fall on it. Voltage drop across phototransistor is directly proportional to its resistance. The voltage drop across the phototransistor is fed to the comparator circuit. If the voltage drop is greater than the threshold then the output is logic high else it is logic low. If the side stand is not pulled up warning indication (Buzzer) is given and the engine is turned OFF. This feature ensures the security of the rider.

V. SOFTWARE MODULE

The Arduino integrated development environment (IDE) v1.52 was used for writing the code. The Arduino programming language is an implementation of Wiring, a similar physical computing platform, which is based on the Processing multimedia programming environment [11]. Arduino is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. Arduino Uno R3 board was used as programmer to dump the boot loader and the code into the MCU (Atmega328p-pu). In this section the flowchart for individual module is described. These are basically the subroutines which are called from the main program whenever the particular task is to be performed. Once the subroutine is executed, the control returns to the main program.

5.1. Remote Keyless System (RKS) subroutine

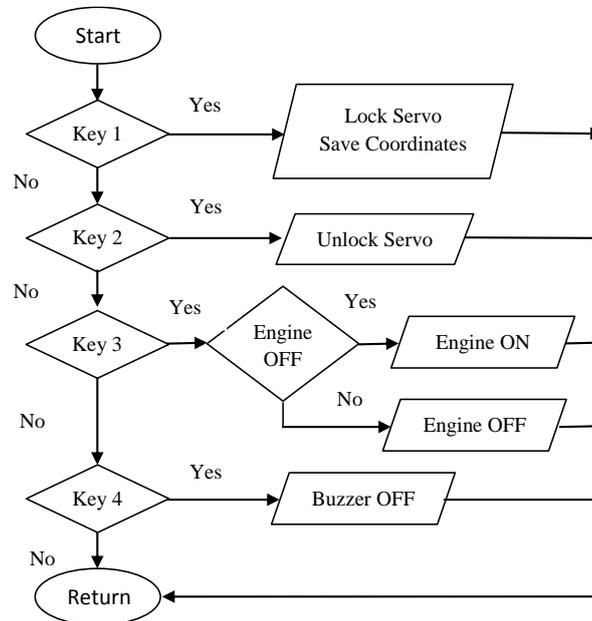


Figure 4: Flow chart of Remote Keyless System (RKS) subroutine.

The RKS [20], subroutine is called when the MCU picks up the signal from the decoder, indicating a button has been pressed. As shown in fig. 4, every button is associated with a particular set of operation. If the first button is pressed, the locking sequence is activated and location coordinates are stored. If the second key is pressed, the unlocking sequence is activated. If the third button is pressed,

the engine is turned ON/OFF depending on the current state of engine. If the fourth button is pressed then the buzzer, activated when the intrusion attempt was detected, is deactivated.

5.2. Side stand indicator subroutine

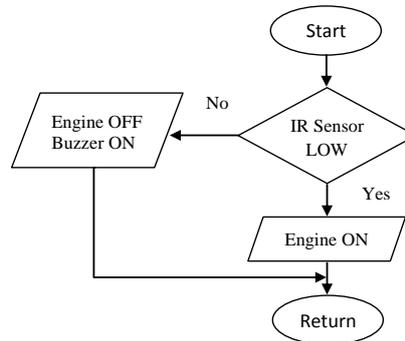


Figure 5: Flowchart of side stand indicator subroutine.

The side stand indicator subroutine is called only when the engine is in ON state. As shown in fig. 5, the IR sensor is activated (transmits IR rays) and MCU checks for the output signal. If the side stand is not pulled up, the IR sensor output is a logic high signal, so a warning indication is given and the engine is turned off for the safety of the rider and control returns to the main program. If the side stand is pulled up completely then the IR sensor output is a logic low signal, so the engine is turned ON and control returns to the main program.

5.3. GPS subroutine

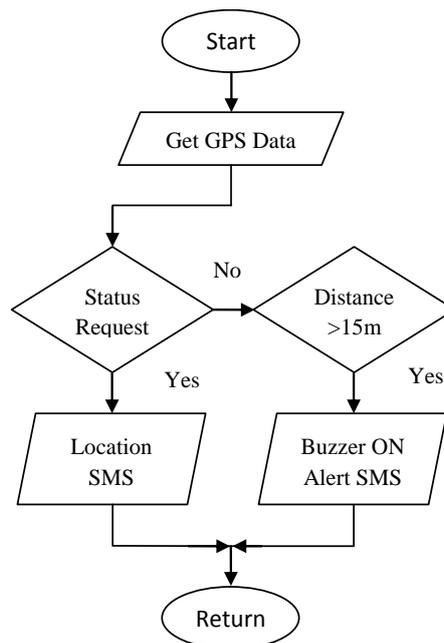


Figure 6: Flow chart of GPS subroutine.

The GPS subroutine is called from the main program if either of the following case arises:

- At the request of the owner for the status of the vehicle.
- At regular intervals of time, if the vehicle is in locked state (routine check).

As shown in fig. 6, the location coordinates are fetched from the satellites. If there is a status request from the owner then the location coordinates [6], [9], are sent. If it is a routine check then the latest location coordinates are compared with the reference coordinates (stored when the vehicle was locked). If the difference between the coordinates is greater than 15 meter then owner is alerted and buzzer is activated. Before fetching the next coordinates the microcontroller unit waits for a small interval of time.

5.4. Servo motor subroutine

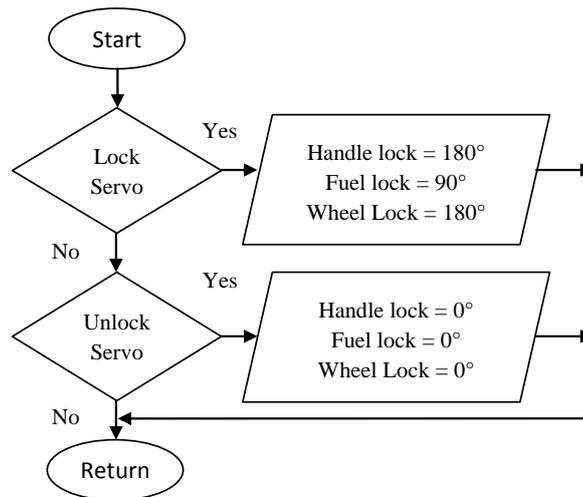


Figure 7: Flow chart of Servo motor subroutine.

Servo motors controls the locking system of the vehicle, hence the servo motor subroutine is called only when the vehicle is to be locked or unlocked [17], [20]. As shown in fig. 7, whenever the locking sequence is initiated by the MCU, the servo motors rotate for a particular angle and locks the handle, fuel and rear wheel. Similarly if the unlocking sequence is initiated then the servo motors rotate for a particular angle, unlocking all the three locks.

5.5 Vibration sensor subroutine

Vibration sensor subroutine is called only if the vehicle is in locked state. The piezoelectric sensor [16] gives the analog value which is converted to digital value by the inbuilt ADC of the MCU. As shown in fig. 8 if the vibration intensity is less than the threshold value then the buzzer is activated twice for a small interval of time. If the vibration of low intensity persists or if a vibration of higher intensity is registered then the owner is alerted by a SMS and the buzzer is activated to seek the attention of nearby people and the control is returned to the main program.

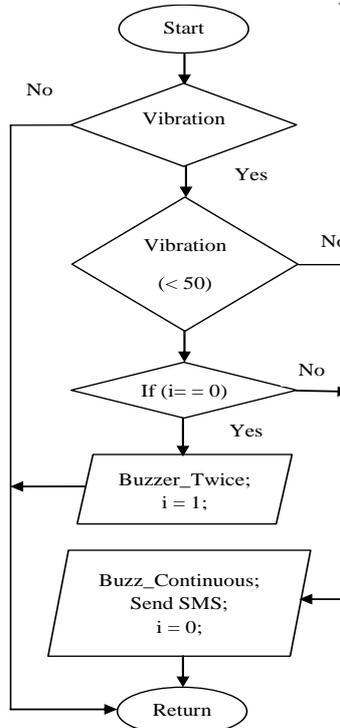


Figure 8: Flow chart of vibration sensor subroutine.

5.6. GSM subroutine

GSM subroutine is called only when the GSM hardware receives a SMS from the registered SIM number [17], [18]. As shown in fig. 9, every SMS is associated with a particular set of operation. If the status request is made by owner then status of locking system, location and speed is sent in response. If Lock SMS is sent by owner then the lock sequence is initiated and RKS remote is disabled. If Unlock SMS is sent by owner then the unlock sequence is initiated. If the Enable SMS is sent then the remote is reactivated. If the Buzzer SMS is sent then the buzzer is deactivated. Thus the GSM module enables the owner to control the security system of the vehicle remotely.

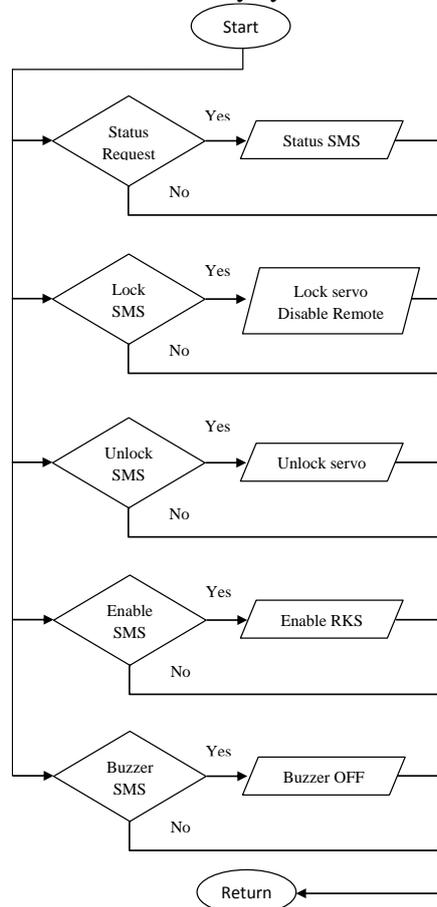


Figure 9: Flow chart of GSM subroutine.

VI. RESULTS

The hardware module was tested on Hero Honda CBZ 159cc (2001 model), TVS Victor GL 110cc (2003 model), Bajaj Discover 125cc (2006 model) and Yamaha FZ 153cc (2013 model). Purposefully vehicles of different company and segments (100cc, 125cc and 150cc) were chosen to demonstrate the compatibility of the hardware module. The module was placed under the seat in all the above test vehicles. All the three, servo motor operated, locks were fixed in their respective positions. The 12V battery of the respective vehicle was the power source to the module. The RKS remote could transmit signals to the receiver module, as far as 100m (maximum) from the vehicle. The Atmega328p-pu MCU was interfaced with the computer via the Arduino Uno R3. Arduino Uno R3 converts a USB connection into Serial TX and RX which is in turn connected to MCU serial pins. The MCU communicates with the computer at a baud rate of 38,400. The Arduino IDE serial window was used to observe the states displayed by the MCU. Two screen shots of Arduino IDE serial window are shown below as examples to illustrate values of different parameters in different states. Fig. 10 shows that initially vehicle was in locked state, unlock button on RKS remote is pressed, the unlocking sequence is performed (Lock OFF), SMS is sent about unlock activity and MCU checks for

any new SMS from owner. Fig. 11 shows that initially vehicle was in unlocked state (Lock = 0), lock button on RKS remote is pressed, the locking sequence is performed (Lock = 1), GPS coordinates are fetched (reference value), MCU keeps checking for new SMS and for vibrations (0 indicates no vibrations sensed).

```
Checking New SMS ...
Lock : 1      Eng : 0      HSrv : 180      FSrv : 91      WSrv : 180
Lock Off
Send SMS Unlock
Checking New SMS ...
Lock : 0      Eng : 0      HSrv : 0      FSrv : 0      WSrv : 0
Checking New SMS ...
Lock : 0      Eng : 0      HSrv : 0      FSrv : 0      WSrv : 0
Checking New SMS ...
Lock : 0      Eng : 0      HSrv : 0      FSrv : 0      WSrv : 0
Checking New SMS ...
```

Figure 10: Screenshot of Arduino IDE serial window (unlocked state).

```
Checking New SMS ...
Lock : 0      Eng : 0      HSrv : 0      FSrv : 0      WSrv : 0
Lock On
getting gps
Fuel Resv Off
getting gps
0
Checking New SMS ...
Lock : 1      Eng : 0      HSrv : 180      FSrv : 91      WSrv : 180
0
0
0
```

Figure 11: Screenshot of Arduino IDE serial window (locked state).

VII. FUTURE ENHANCEMENTS

- a. Hopping code algorithm could be used in Remote Keyless System (RKS) for added security.
- b. Presently only SMS feature is available, we can include the Call feature for ease of operation. Like for example giving miscall would lockdown the vehicle.
- c. SIM 300 even supports GPRS coding schemes hence data network could be used to send alerts and receive control messages.
- d. Microphone could be interfaced to the GSM module so that during theft activity voice call could be established with the owner enabling him/her to be able to listen and record the conversation of people around the vehicle.
- e. Hall Effect sensor could be used to find the position of gear, which could be displayed with a single seven segment display.

VIII. CONCLUSIONS

Our proposed Two Wheeler Vehicle Security System is the advanced, reliable and robust version of security mechanism for two wheeler vehicles. The proposed security system also gives space, in terms of hardware and software, to add up custom applications to make the product even more user-friendly. Proposed TWVSS can be installed on two wheeler vehicle of any class or company, thereby creating a huge market for the product. Stress was laid in designing a cost efficient system so that it could also be even bought by the owners of the low end bikes. Small size of the module allows it to be placed under

the seat of the vehicle, there by needing no physical changes to be done to the vehicle. We believe the frequency of the two wheeler vehicle thefts that are encountered these days could be highly suppressed by installing our proposed security system.

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