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Vehicle Monitoring and Theft Prevention System Using ARM Cortex

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***Abstract*-Automotive theft has been a persisting problem around the world and greater challenge comes from professional thieves. A modern vehicle utilizes remote keyless entry system and immobilizer system as the main weaponry against vehicle theft. But these systems prevent unauthorized access of the vehicle to a certain extent. Smart gravitational lock is used to prevent the theft by providing the air gesture key from key fob to the vehicle which provides high security to the vehicle. When there is no usage of key fob, then the vehicle is secured by touch screen ignition where the software key gesture is given to the touch screen. GPS and GSM technologies enable the vehicle owners to track and monitor the vehicle at anytime from anywhere. During GPS outage environment, inertial navigation sensor is used that contains 3-axis MEMS magnetometer and accelerometer which inform the vehicle positions to the owner by use of dead reckoning method. To restrict the vehicle movement within a particular area, GPS fencing is used in which fence radius can be programmed in the touch screen display. The integrated motions sensing subsystem is used which measures the vehicles 3-D position and detects if vehicle is moved or tilted, when the threshold level is exceeded. In case of auto theft, fuel supply will be made to cut off slowly by sending the message thereby disabling the vehicle.**

***Keyword*-**MEMS Accelerometer, fuel cutoff, GPS fencing, Keyfob, Smart Gravity Lock.

I INTRODUCTION

The automobiles have been stolen for different reasons viz. For using the vehicles for transport, commission of crimes and for reusing or reselling parts dismantled from the vehicles or resale of the vehicle itself. In this paper, an automotive security system to disable an automobile and its key auto systems through remote control when it is stolen is designed. It hence deters thieves from committing the theft. Italso effectively prevents stealing of key auto systems for re-selling by introducing air gesture security key. The details of system design and implementation are described in the paper. To reduce the theft rate of the car and meet the intellectualized auto-guard demand of people, the vehicle is provided with the accelerometer for secret key gesture. GSM Modem Company finished setting and dismissing the prevention of message or call and controlled the car's states remotely. To improve the security and reliability of the vehicle, it has achieved the unity between intellectualized safeguard and remote control.

Various technologies have been introduced in recent years to deter car thefts, for example, Immobilizers to remotely disable the lost vehicles, Microdot Identification to identify auto parts using unique microdots, Electronic Vehicle Identification (EVI) to identify the vehicle against a registration database, lojack System to use in-built transponders for tracking down vehicle, GPS to locate the position of the lost vehicles using global positioning system, and so on.

There are still some security gaps which these technologies do not address. For example, while the immobilizer can prevent a thief from starting a car engine and driving away, it is unable to stop professional thieves from towing the car away. The professional thieves can then dismantle the stolen vehicle and re-sell the components. The thieves will also have the luxury of time to remove the immobilizer and re-sell the car using another identity the EVI approach is efficient when it comes to identification and verification of vehicles since this is done electronically.

However, EVI is less effective against the chop shop scenario where stolen vehicles are dismantled and their parts are re-sold into the market. In addition, the EVI approach is ineffective against thieves who export the stolen vehicles or the chopped car parts to countries which do not implement the EVI system; while lojack Systems may be good at tracking the lost vehicles, it may take a few hours/days/months or even cannot find the stolen vehicle. In addition, they cannot disable an automobile and its key auto systems. Thus, if their radio transponders are removed, the stolen automobiles still function well and the thieves can drive them or sell them. The thieves can also dismantle the auto systems and re-sell auto parts; finally, GPS cannot penetrate forest cover, parking garages, or other obstructions. GPS relying on a short visible antenna can easily be broken off by a thief. Thus, greater challenge comes from professional thieves because they are capable of removing the immobilizers, lojackor GPS parts from the automobile and re-sell the vehicles or auto parts. In short the existing systems are designed to give intimation to the owner only after the car is thefted.

The project proposed here aims to design a next generation auto theft prevention system by adding significant enhancements and modernizing the existing system and thus

try to overcome the above drawbacks. By implementing this techniques, the possibility of a car Theft is very less or no theft. The following modules are implemented in this project.

First a new Innovative car key is designed, the car key transfers a random data by providing the air gesture each and every time the car is unlocked. The transaction of password from key to car is known only to these devices and any intermittent unit cannot diagnose the transaction as each and every time the data is changing. The cryptographic technique is used which provides encrypted data transmission and reception.

A dual layer keying approach is followed during vehicle ignition process. This consists of software and hardware keys. A unique touch gesture is made on the 65K Color Touchscreen TFT Display that acts as the software key. The system verifies this and then accepts the hardware key which is the actual key fob normally used. This feature can be temporarily disabled and enabled via SMS sent by the owner. This is useful in situations such as when someone (like a mechanic) other than the owner wants to handle the vehicle and the owner does not want the other person to know the secret onscreen password. A serial EEPROM memory is used to store the password

The vehicle unit constantly monitors the vehicle motion after being armed (locked). The integrated motion sensing subsystem measures the vehicles three dimensional position and detects any unauthorized motion if the vehicles is moved or tilted that exceeds a threshold level. The sensitivity of this function can be adjusted on the touchscreen display GUI to effectively avoid any false warnings that are common with existing vehicle security systems. When someone tries to break into the vehicle forcibly, the alarm triggers the siren and head lamps and sends an SMS to the owner.

GPS and GSM technologies enable the vehicle owners to track and monitor the vehicle with cellphone at anytime from anywhere. The important enhancement in this feature is its ability to inform the vehicle position even during a GPS outage using dead reckoning method. This is achieved with the help of Inertial Navigation Sensors that consists of a 3-axis MEMSMagnetometer and a 3-axis MEMS Accelerometer which will act as a tilt compensated compass module.

When the owner approaches the vehicle, the system automatically verifies the code from remote key and the vehicle emits a head light flash and horn beep to show its presence. This feature is known as car finder and it assists the owner to locate the vehicle in a parking lot where several vehicles are parked.

GPS Fencing is used to restrict the vehicle movement within a particular area. For example, if the owner wants the car to move only within a particular city, once it moves out of city borders the owner would immediately receive an SMS alert as to the current location of the vehicle. The interesting feature here is the fence radius can be programmed by the user in the touchscreen display. This flexibility allows the user to set a virtual fence that can be at building level, street level, city level or state level.

Remote Fuel Cut-off is very useful especially in case of auto theft. If the vehicle is somehow hacked into and taken, you can send message that will slowly cut-off the fuel supply, thereby disabling the vehicle. A Servo Motor controlled valve is used to cut the fuel supply.

II BLOCK DIAGRAM

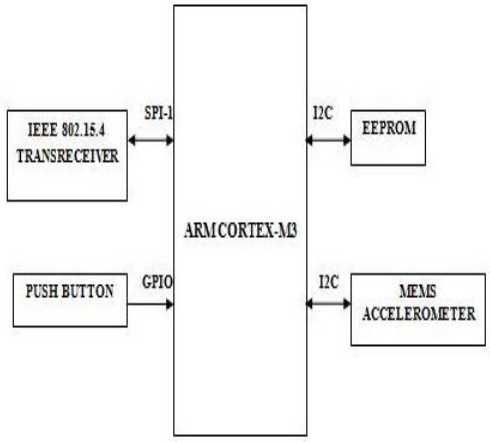

Fig.1. Keyfob unit block diagram

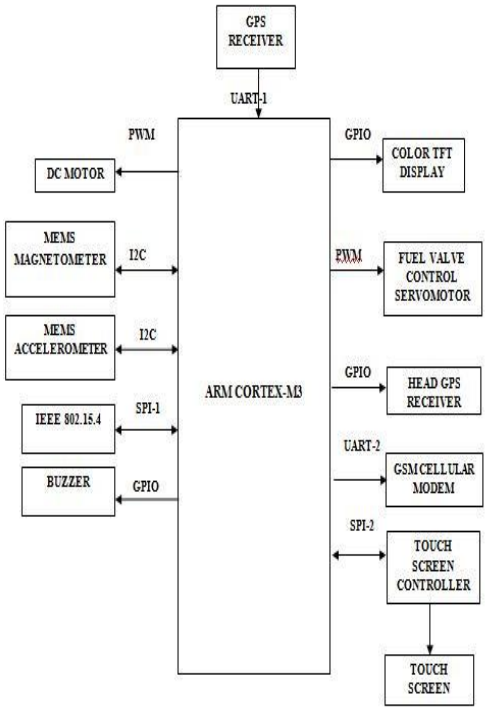

Fig.2.Vehicle Unit block diagram

III GESTURE RECOGNITION

The MEMS Accelerometer MMA7660 IC is used shown in fig 3. This gives the three dimensions (x, y, and z) readings of a particular object. It is a low power, low profile capacitive 3-axis accelerometer commonly called as free fall detection sensor. Because of a sleep mode pin on the accelerometer makes it ideal for the handheld battery powered electronics. The program memory of the Arm controller is coded in such a way that it recognizes the values in the tilt register of the accelerometer connected through I2C bus. So if we move the key fob in any direction then the corresponding values are noted by the accelerometer. Through embedding the MEMS Accelerometer the vehicle can be armed by gesture performance in the air.

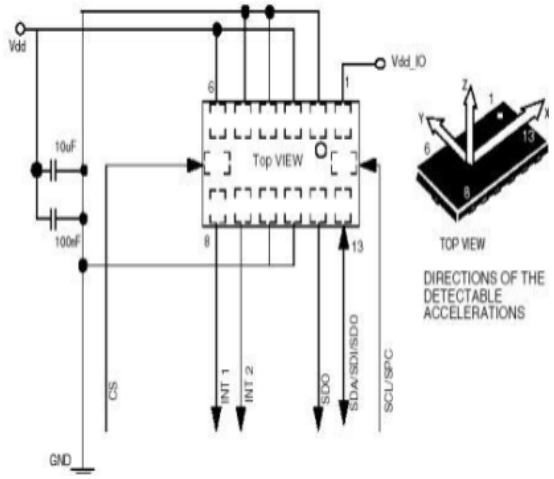

Fig.3. MEMS accelerometer

The application of this three axis accelerometer is interfaced with the ARM Cortex-M3 micro controller which could recognize the hyper terminal input instructions can perform functions controlled by gesture. We need to move the accelerometer in a particular set of directions then it will recognize one of the directions and the vehicle is locked/ unlocked by performing the secret gesture. The accelerometer consists of a tilt register which give the orientation logic of the gesture. First the values are defined for the gesture performance. The Arm controller is processed in such a way that depending up on the orientation logic performed by the accelerometer the tilt values keep on changing. These values are read through the SCL, SDA and the INT lines which are interfaced to one of the port in Arm controller LPC 1300. Apart from sending the gesture key, they are also displayed on the LCD interfaced to the Arm 7 micro controller.

The gesture key is transmitted to the vehicle through the IEEE 802.15.4 wireless transreceiver. The vehicle recognizes this key with the already stored key and verifies it. If these key matches then it allows the vehicle door to open to prevent the wireless key transmission from theft persons. The cryptographic keyless entry scheme is used. Here RC4 algorithm is used to encrypt and decrypt the sending data during transmission.

A. IEEE 802.15.4

The Microchip MiWi™ P2P Wireless Protocol is a variation of IEEE 802.15.4, using Microchip's MRF24J40 2.4 GHz transceiver and any Microchip 8, 16 or 32-bit microcontroller with a Serial Peripheral Interface (SPI).

The protocol provides reliable direct wireless communication via an easy-to-use programming interface. The MiWi P2P protocol is a variation of IEEE 802.15.4 and supports both peer-to-peer and star topologies. It has no routing mechanism, so the wireless communication coverage is defined by the radio range. The MiWi P2P stack uses only a portion of the IEEE 802.15.4 specification's rich PHY and MAC layers' definitions as shown in fig 3. The specification defines three PHY layers, operating on a spectrum of 868 MHz, 915 MHz and 2.4 GHz. The MRF24J40 radio operates on the 2.4 GHz, ISM band – freely available worldwide. The total bandwidth for the IEEE 802.15.4, 2.4 GHz ISM band is, theoretically, 250 kbps. In reality, for reliable communication, the bandwidth is 20-30 kbps.

There are two ways to transmit a message: BROADCAST AND UNICAST. Uncast transmissions have only one destination and use the long address as the destination address. The MiWi P2P stack requires Acknowledgement for all unicast messages. If the transmitting device has at least one device that turns off its radio when Idle, the transmitting device will save the message in RAM and wait for the sleeping device to wake-up and request the message. This kind of data transmitting is called indirect messaging**.**

In the MiWi P2P stack, only the messaged device will be notified by the radio. If the messaged device turns off its radio when Idle, it can only receive a message from the device to which it is connected. IEEE 802.15.4 deals with only PHY layer and portion of Data link layer. The higher-layer protocols are left to industry and the individual applications.

IV CRYPTOGRAPHIC KEYLESS ENTRY

RC4 is a stream cipher, symmetric key algorithm. The same algorithm is used for both encryption and decryption as the data stream is simply XORed with the generated key sequence. The key stream is completely independent of the plaintext used. It uses a variable length key from 1 to 256 bit to initialize a 256-bit state table. The state table is used for subsequent generation of pseudo-random bits and then to generate a pseudo-random stream which is XORed with the plaintext to give the cipher text.

The algorithm can be broken into two stages: initialization, and operation. In the initialization stage the 256-bit state table, **S** is populated, using the key, **K** as a seed. Once the state table is setup, it continues to be modified in a regular pattern as data is encrypted. This algorithm produces a stream of pseudo-random values.

The input stream is XORed with these values, bit by bit. The encryption and decryption process is the same as the data stream is simply XORed with the generated key sequence. If it is fed in an encrypted message, it will produce the decrypted message output, and if it is fed in plaintext message, it will produce the encrypted version [6].

V VEHICLE SECURITY SYSTEM

A vehicle security system combines the installation of an electronic device in a vehicle, or fleet of vehicles, with purpose designed computer software at least at one operational base to enable the owner or a third party to track the vehicle's location, collecting data in the process from the field and deliver it to the base of operation. Modern vehicle tracking systems commonly use GPS technology for locating the vehicle, but other types of automatic vehicle location technology such as MEMS accelerometer and magnetometer, adjustable alarming system, fuel cut-off can also be used.

The GPS and GSM technologies enable the vehicle owners to track and monitor the vehicle with cellphone at anytime from anywhere. The block diagram for vehicle unit security system is shown in fig 5. The protocols such as I2C, SPI, UART are used to interface the security devices to the ARM processor.

A. GPS

The Global Positioning System (GPS) is a space-based global navigation satellite system (GNSS) that provides reliable location and time information in all weather and at all times and anywhere on or near the Earth when and where there is an unobstructed line of sight to four or more GPS satellites. It is maintained by the United States government and is freely accessible by anyone with a GPS receiver.

GPS satellites are orbited high enough to avoid the problems associated with land based systems, yet can provide accurate positioning 24 hours a day, anywhere in the world. Uncorrected positions determined from GPS satellite signals produce accuracies in the range of 50 to 100 meters. When using a technique called differential correction, users can get positions accurate to within 5 meters or less. GPS receiver will automatically collect this information and store it for future reference.

B. GPS Fencing

GPS fencing notifies the system when a vehicle is equipped with the tracking device crosses a virtual boundary. The notification can be sent to the owner's cell phone . It usually includes the time, date and location that the virtual boundary was crossed, allowing for an immediate investigation or response to the situation. GPS fencing is suitable for keeping vehicles out of prohibited areas e.g. Sacred Sites, blast zones, environmentally sensitive areas, construction zones. Automatically speed limiting vehicles in designated areas. This feature restricts the vehicle movement within a particular area. For example, if the owner wants the car to move only within a particular city, once it moves out of city borders the owner would immediately receive an SMS alert as to the current location of the vehicle. The interesting feature here is the fence radius can be programmed by the user in the touchscreen display. This flexibility allows the user to set a virtual fence that can be at building level, street level, city level or state level.

C. GSM Modem

Global system for mobile communication (GSM) is a globally accepted standard for digital cellular communication. GSM is the name of a standardization group mobile cellular radio system operating at 900 MHz.A GSM modem as shown in fig 4 is a wireless modem that works with a GSM wireless network. A wireless modem behaves like a dial-up modem. The main difference between them is that a dial-up modem while a wireless modem sends and receives data through radio waves.

Fig.4.GSM modem

The working of GSM modem is based on commands, the commands always start with AT (which means Attentions) and finish with a <CR> character. For example, the dialing command is ATD<number>; ATD3314629080; here the dialing command ends with semicolon. The AT commands are given to the GSM modem with the help of PC or controller. The GSM modem is serially interfaced with the controller with the help of UART.

D. MEMS Magnetometer & Accelerometer

The important enhancement in this feature is its ability to inform the vehicle position even during a GPS outage using dead reckoning method. This is achieved with the help of Inertial Navigation Sensors that consists of a 3-axis MEMS Magnetometer and a 3-axis MEMS Accelerometer which will act as a tilt compensated compass module. It is interfaced with ARM using I2C protocol.

E. Servo Motor

If the vehicle is made theft or misused by the driver or vehicle is taken to the places without the knowledge of the owned, then the owner can be able to control their car through GSM. This feature is very useful especially in case of auto theft. The control message is send to the processor by the owner. Now the processor intimates the servo motor that

wills slowly cut-off the fuel supply, thereby disabling the vehicle. It uses the PWM technique to control the value. The servo motor is shown in fig 5.

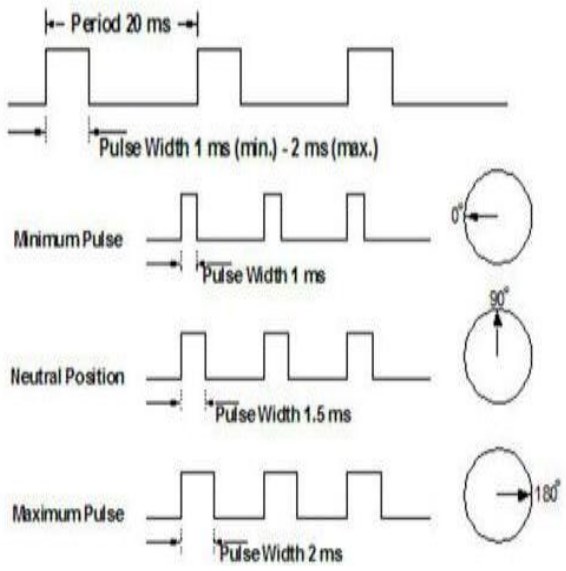

Fig.5. Servo motor rotation diagram

VI CONCLUSION

This paper describes a air gesture recognition system by using MEMS accelerometer. The innovative vehicle key is designed in which gesture key from key fob is compared with the stored key to secure opening of the vehicle door. This provides more protection to the vehicle even when the key fob is stolen. Secondly a navigation device for land vehicle involves the MEMS accelerometer and magnetometer integrated with the GPS, so during GPS outage the vehicle is navigated using navigation sensor. The adjustable motion alarm is used which helpful to intimate the vehicle owner about the intentional touch given by the thief. When there is no usage of key fob, the touch screen is used to ignite the vehicle through software key that is given to the screen.GPS fencing is implemented to restrict the vehicle within the particular area by the owner. Remote fuel cutoff is used to reduce or cut the fuel when the vehicle is hacked by thief or misused by the other persons. Thus the techniques presented in this paper provide high security and reliability to the vehicle.

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