International Journal of Engineering Processing & Safety Research
Published by Cambridge Research and Publications
Vol. 2 No. 2
December, 2023.

DESIGN AND CONSTRUCTION OF GPS AND GSM VEHICLE TRACKER WITH LOCKING SYSTEM

[1*]FATIMA MUHAMMAD, [2]D.M. NAZIF, [3]IBRAHIM SALIM YALWA, [4]ALIYU MUHAMMAD BELLO, [5]ALIYU ABDULRAHMAN, [6]MUHAMMAD AMINU AHMAD

[1,2,6]Dept. of Electrical and Electronic Engineering Technology, Federal Polytechnic, Bauchi, State, Nigeria; [3,4]Dept. of Electrical and Electronic Engineering Technology, Federal Polytechnic, Kaltungo, Gombe, State, Nigeria; [5]Dept. of Computer Engineering Technology, Federal Polytechnic Bauchi, Bauchi State, Nigeria;*

fatimam.eeet@fptb.edu.ng

Abstract

This paper outlines the design and construction of a GPS and GSM vehicle tracker with a locking system. The motivation for this project stems from the need for a reliable, low-cost vehicle tracking and security system. The design of the proposed system utilizes a microcontroller and a number of peripheral components, including Global Positioning System (GPS) and GSM/GPRS communications, to provide a comprehensive and secure tracking and locking system for vehicles. The hardware components used in the system design include a microcontroller, a GPS receiver, a GSM/GPRS module, an electromechanical locking system, and a power supply. The microcontroller acts as the central component, controlling all of the operations, while the GPS receiver and GSM/GPRS module provide location tracking and remote communication, respectively. The electromechanical locking system is used to secure the vehicle when necessary. The power supply provides the required power to operate the system and the peripherals. The software running on the microcontroller, which is written in C, provides the functionality for the system. The software is designed to collect data from the GPS receiver and GSM/GPRS module, and to control the electromechanical locking system. The software is modular, with separate components handling each of the different tasks. The resulting system is capable of providing accurate location data as well as secure remote locking and unlocking of the vehicle. The system design is cost effective, and is suitable for use in a wide variety of applications. The use of readily available components and a well-designed software platform makes the system scalable and extensible. This paper concludes with a discussion of the system design and implementation, as well as suggestions for future work..

IJEPSR: E-ISSN 3026-9822 P-ISSN 3027-1568

Introduction

Despite advancements in technology, auto theft remains a global issue. Safety and monitoring systems aim to help businesses manage fleets and reduce employee costs and effort (Al-Taee, et al., 2017). Nigeria faces daily road misconduct, requiring reliable security systems for theft, hijacking, and diversion (Muhammad, 2018).

Researchers and companies have developed microcontroller-based vehicle monitoring and tracking devices to reduce vehicle theft risk. These devices monitor theft and location changes, suitable for fleet management and oil and gas tanker owners. They use GPS module receivers and GSM modems for two-way communication, enabling soldier monitoring and tracking theft vehicles. These user-friendly, easily installable, and accessible systems are suitable for various applications (Paul, 2017; Alicia, 2018).

The global issue of increasing crime rates requires urgent attention. Car theft and hijacking have become serious issues over the past decade, making a better security system necessary. A GPS car tracking system via SMS is proposed, using GSM modules for communication and GPS for locating car positions (Muhammad, 2018).

Car Tracking System

Car tracking systems enable instantaneous and historical tracking of vehicles, including speed, routes, stopping points, idling times, providing registry and checkpoint reports (Tamil, 2017).

Figure 1: Car tracking system using GPS and GSM

GPS Technology

GPS is the only fully functional Global Navigation System (GNSS) using a constellation of satellites to transmit microwave signals. It is a key technology for determining location, speed, direction, and time. Developed by the US Department of Defense, GPS is used in military

services and civilian applications. It is widely used for navigation, map-making, land surveying, commerce, and scientific purposes (Muhammad, 2018).

GPS is a U.S. space system providing reliable positioning, navigation, and timing services to civilians worldwide. Originally designed for military purposes, it was made available for civilian use in the 1980s. GPS handsets enable individuals to locate their position and navigate to desired destinations (Muhammad, 2018).

Active and Passive Tracking

Vehicle tracking devices are classified as passive and active, storing GPS location, speed, heading, and trigger events. Passive systems, like auto download, transfer data via wireless download for evaluation (Kishore, 2017).

Active devices also collect the same information but usually transmit the data in real-time via cellular or satellite networks to a computer or data center for evaluation.

Passive GPS trackers do not monitor real-time movement; requiring computer downloads to view tracking details, limiting tracking visibility to last move (Hapsari, 2016).

Passive GPS trackers are reliable and less expensive than active trackers, making them affordable. They allow real-time tracking data viewing from home or office, making them ideal for monitoring vehicles at regular intervals. Active GPS trackers offer reliable interfaces and excellent software for efficient vehicle tracking, allowing real-time monitoring from home computers, enabling real-time observations of stops and idling (Fan, 2016).

Types of Tracking System

Major types of GPS vehicle tracking that are widely used, use active devices. They are:

i. **Automatic Vehicle Location (AVL) system**- It is an advanced method for tracking and monitoring remote vehicles using GPS satellites. It consists of a PC-based tracking software, a radio system, a GPS receiver on the vehicle, and GPS satellites. The GPS tracking method relies on vehicle location information, transmitting data every 60 seconds, costing $1-$2/day. It faces limitations in dense urban areas, indoors, and RF-shadowed environments, making position fixes impossible (Rindt, 2020).

ii. **Assisted GPS (AGPS) system-** The AGPS system uses a terrestrial RF network to enhance GPS receiver performance by providing information about the satellite constellation directly to GPS receivers. AGPS uses mobiles and cellular networks to provide accurate positioning information, detecting vehicle locations with accuracy between 3m and 8m and 1km speed. It offers continuous updates and data storage for up to 1 year, but costs the GSM network (Rindt, 2020).

2.0 Literature Review

A car tracking system relies on a mobile phone and GSM network. The software sends a request to a private car ID, which is a SIM stored in a secret device. The system analyzes the data, GPS locations, and position of the vehicle based on the collected information (Parvez 2017).

GPS is a popular tool for tracking and monitoring vehicles, with numerous systems designed to enhance their functionality. This work proposes a "control system GPS vehicle" that monitors employee behavior, prevents theft, and integrates recovery devices and alarms. The system offers two end-user applications: a web and mobile version (Rindt, 2020).

Fan (2016) worked on the development and design of GPS and how GSM depends on car tracking and alarm. This system helps transport companies to reach and track their vehicles at any time and an alarm system is used to provide information about any robbery or accidents.

Hapsari (2016) a car tracker is a security system that apply efficiency by preventing car theft. The main system consists of the GPS and GSM. Customers respond by using this system in their cars to find their position using Google Maps. (Moreover, car owners can determine the coordinates and current location of their cars by using Google Maps using the GPS locator, via the SMS from the GSM network to a GSM modem attached to a laptop or PC.

Muhammad, (2018) published a research on design and development of GPS-Based Tracking System with Google Map-Based Monitoring. The system consists of a microcontroller-based GPS and GSM system, enabling two-way communication between the GPS device and a GSM modem. The system uses a web application on Google Maps to locate targets, ensuring vehicle security. The hardware includes an ATMega 16 microcontroller, MAX 232 MAX 232, and 16 x 2 LCD. The GSM mobile uses the WAMP server to acquire vehicle position, and the system is HTML-based and PHP-based for some modifications.

Paul, (2017) presented implementation of microcontroller-based vehicle location tracker using GSM and GPS. A tracking system using an Arduino Uno, GPS receiver, GSM module, and 16-character LCD was used. It can be interconnected with a vehicle and alerts the user's mobile phone. The system is divided into two parts, focusing on interfacing and hardware testing.

Alicia, (2018) worked on Vehicle Tracking System Using GPS-GSM Technology. The system includes a GPS module, GSM modem, PIC16F72 Microcontroller, LCD, and power supply for monitoring moving vehicles. It sends location coordinates to the owner's mobile phone, while the GPS module provides data in Latitude, Longitude, and time. The system monitors the vehicle's status and reports to the owner's registered number.

Methodology

Materials

Materials used for the system are basically electronic components ranging from the microcontroller, battery, relay, GSM module, GPRS tracker, resistor, capacitor and so on.

IJEPSR: E-ISSN 3026-9822 P-ISSN 3027-1568

Design

The design of this system can be classified into hardware design and software design.

Block diagram

The system block diagram is as shown in figure 3 below. The power supply unit supplies regulated DC (Direct Current) power to the whole circuitry of the System. The GPS module receives signal from the NEO-6 satellite and send it to the microcontroller for storage at the EEPROM. The microcontroller (Atmega328) will send the received data via the GSM Module to the programmed mobile phone number upon request from the user. The location of the system using Google map can be tracked with the android application. The user can also switch OFF/ON the vehicle ignition remotely.

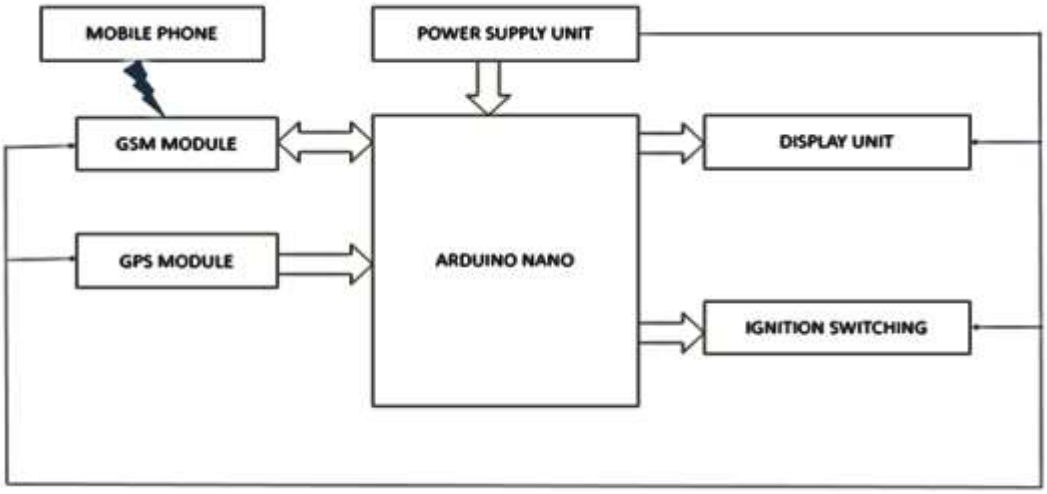

Figure 2: System block diagram

Hardware design:

This involves the technical details and design consideration for the power supply unit, control unit and the sensor unit. Other key parts include the GPS and the GSM. All the details will be the basis for the selection of the system components. Description of the circuit diagram and components placement is covered in this section.

i. **Battery:** A battery is an external source providing direct current for various devices, with two terminals: the cathode and the anode, where electrons flow from the negative terminal to the positive terminal. The battery has a working voltage of 3.7 V and a current of 2.85Ah. Four pieces of the batteries are connected in series to get a total of 14.8V which is enough to power the whole system. Figure 3.2 shows a typical lithium ion battery.

Figure 3: Lithium Ion battery

Figure 4: Relay Module

ii. **Relay:** A relay an electromagnetic device which is used to isolate two circuits electrically and connect them magnetically. They are very usefully device and allow one circuit to switch another one while they are completed separated. The required current to run the relay coil is more than can be supplied by various integrated circuits like operation amplifier, etc. Figure 5 illustrates relay device.

iii. **POWER SUPPLY UNIT:** The power supply unit is made up of batteries, voltage regulators, capacitors, resistor and light emitting diode. The Arduino Nano board requires 9vdc (LM7809), the LCD and the GPS module both requires 5vdc (LM7805) for normal operations. The GSM module requires 3.7vdc which was supplied by LM2596 variable voltage regulator. All this powers are provided by the power supply unit.

iv. **Voltage regulator:** A voltage regulator is an IC that maintains a constant output voltage despite changes in load or input voltage. It adjusts resistance through a feedback loop, accounting for load and input changes. This project uses three voltage regulators: LM7805, LM7809, and LM2596, with one regulator providing 5vdc.

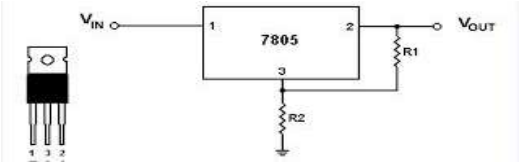

Figure 5: LM7805 voltage regulator

Figure 5: Diode

v. **Diode:** Diode is a two-terminal electronic component with asymmetric conductance; it has low (ideally zero) resistance to current in one direction, and high (ideally infinite resistance in the other. 1n4007 diode was used as a flywheel diode in this project work.

Figure 7: Capacitor

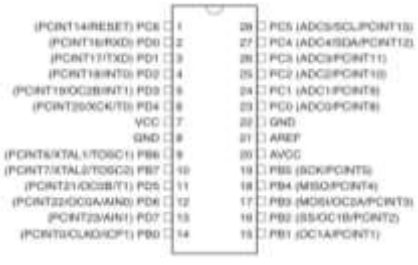

Fig. 8: ATmega328 Pin Configuration

IJEPSR: E-ISSN 3026-9822 P-ISSN 3027-1568

vi. ***Control unit:*** The microcontroller (ATMega328 Microcontroller) is the heart of the system, controlling the car's on/off and LCD display. It's a standalone computer with a single silicon chip, optimizing control applications and reducing external device read/write time.

viii. **Capacitor:** A capacitor is a passive electrical component that stores electrical energy in an electric field. Its effect is called capacitance and is designed to enhance it for various applications. An ideal capacitor has a single constant value, expressed as the ratio of electric charge Q on each conductor to potential difference V. Capacitance values range from 1Pf-1mF.

ix. ***Sensor Unit***

NEO-6 GPS Module: GPS modules contain tiny processors and antennas that directly receive data sent by satellites through dedicated RF frequencies. From there, it'll receive timestamp from each visible satellite, along with other pieces of data**. If the module's antenna can spot 4 or more satellites, it's able to accurately calculate its position and time.**

Figure 9: GPS Module

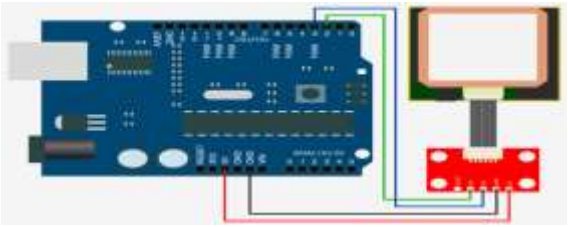

Figure 10: Connecting GPS to Arduino

The system measures distances between satellites and receivers using satellite information and calculations. The GPS modem board has four output connectors and a regulator for voltage regulation from 5V to 3.3V.

The GPS modem is connected to the microcontroller digital pins 2 and 3, with four input/output connectors: RX, TX, VCC, and GND. A jumper wire or breadboard can be used to connect the GPS to the Arduino. The GPS pins are connected to the Arduino's GND pin and VCC pin for power. The RX pin is used for receiving and sending information, while the TX pins are connected to the RX pin on the Arduino.

x. **GSM Module:** The GSM\GPRS shield is a device that resembles a mobile phone, allowing Arduino to connect to the internet using the GPRS network. By plugging in the shield and inserting a SIM card, the Arduino board operates as a GSM modem, sending instructions and alerts to the vehicle owner via SMS.

IJEPSR: E-ISSN 3026-9822 P-ISSN 3027-1568

Figure 11: GSM (sim800l) Module

At first, the SIM card is inserted into the holder. Then, put the GSM modem pins into their positions on the Arduino and use the USB to connect the Arduino to the computer. After connection, the program is uploaded to the Arduino to activate the GSM. When the red LED turns on, it means the modem is powered on, and it directs its connection to the network. The GSM/GPRS has a number of pins. Digital pins 2 and 3are used to communicate with the M10. These pins are connected to the M10 Pin 2 TX Pin and Pin 3 RX pin. The PWRKEY pin for this modem is connected to pin 7 on the Arduino.

Software design / Programming

The Arduino IDE is a cross-platform Java application for program development and debugging, supporting the ATmega328 microcontroller and STK500 protocol. Proteus 8.6 software is used for system simulation. The vehicle tracking system was written using C programming language, starting with the "START" symbol. Initialization was done, and the GPS and GSM module status was checked. The system tracked GPS and received user requests to send location or switch engine. Longitude and latitude, along with a URL, were sent to authorize users.

Flow Chart Design for Source Code Implementation

This is a pictorial representation that represents an algorithm or workflow of how the software design shall be used to coordinate the hardware component of the project. This diagram shall be using several symbols with each having its intricate meaning. This is shown below in Figure. 14. The system program was developed using the popular Arduino IDE, the GPS and GSM libraries were downloaded from Arduino website, installed on the IDE and use for the system programming.

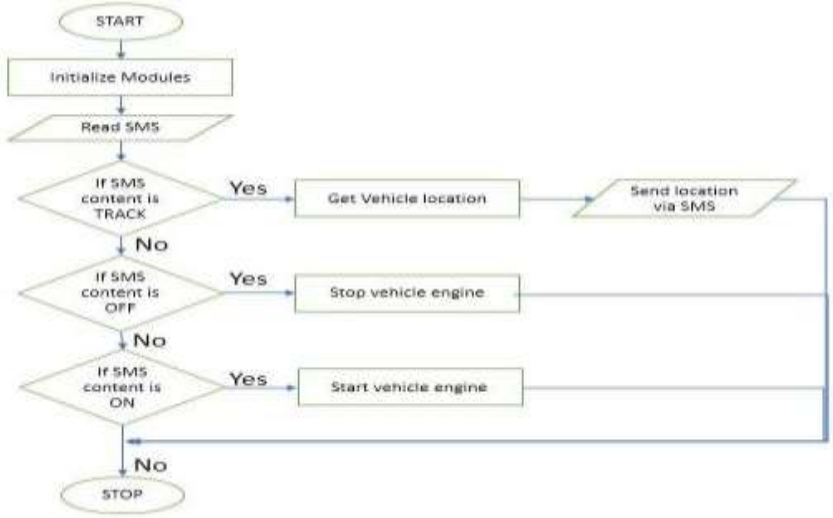

Figure 13: System flowchart

Circuit Diagram

The circuit diagram in figure 3.11 shows the visual display of the electrical circuit using industry standard symbols. The circuit sketch was achieved using the Proteus software. The circuit diagram comprises of power supply, display unit, sensor unit, switching unit and control unit.

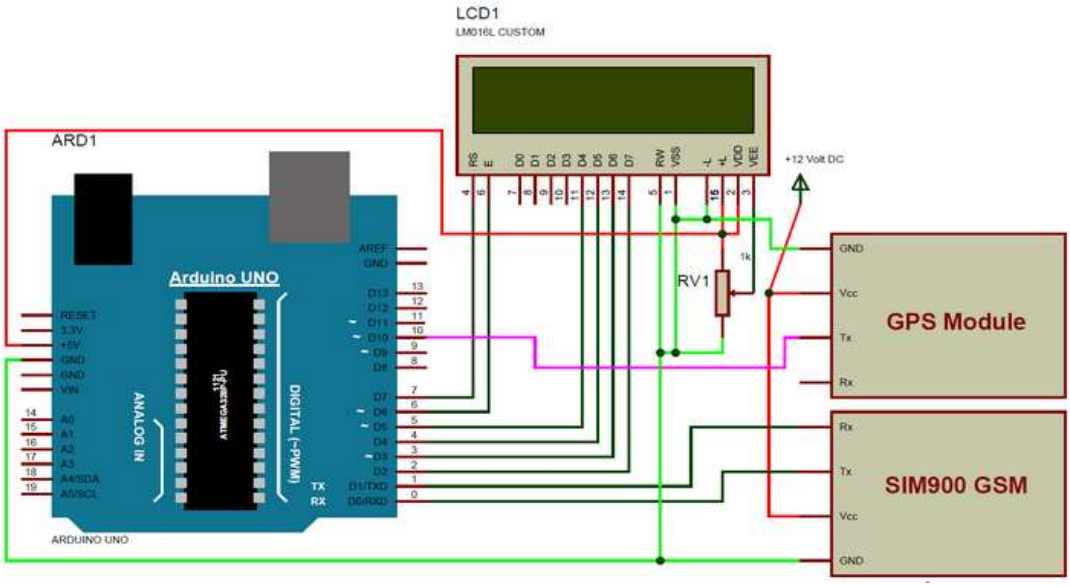

Figure 14: Circuit diagram

Test, Results and Discussion

Test Conducted

The components used for the implementation of this project were tested on breadboard for better performance, and were later transferred to the Vero board and soldered. The heat applied during soldering was just moderate to avoid damage of the Vero and the components since most of the components have low heat resistance. The test equipment includes;

i. Breadboard-To assemble and test individual components
ii. Digital multi meter to measure voltage, current, resistance and check for continuity
iii. Light emitting diodes
iv. Arduino sketch

Power Supply Unit Test

Result obtained for power supply test is shown in the table below;

Table 1: Power Supply Unit Results

Transformer	Theoretical Voltage(V)	Measured Voltage(V)
Output voltage	12	11.7
Rectifier LM2596	4.2	4.18
Rectifier LM7805	5	4.8
Input voltage	12	11.7
Output voltage	10.79	10.65
	5	4.8

The table displays test results for power supply unit circuits, revealing a 5V difference in theoretical input voltage for transformers and 0.3V difference in output voltage for regulators. Theoretical input voltage values differ from measured values, while regulators exhibit similar variations. The reason for these variations might be do loss of electrical energy. Voltage Regulation (V.R) is given as

$$V.R = \frac{V_{NL} - V_{FL}}{V_{NL}} \times 100\,\%$$

Where; $V_{NL} = No - load\ voltage$ and $V_{FL} = Full - load\ voltage$

For the unit operating on +5V,

$$V.R = \frac{5.0 - 4.8}{5.0} \times 100\% = 4.00\%$$

Reason for the variation is that the theoretical laws stated have some assumptions in order to obtain ideal value of DC Voltage source through measurement such as constant pressure, temperature, mechanical strains etc. But when experiment is performed and current passes through the conductor, it leads to heating up of conductor and temperature does not remain constant does leading to some error.

GSM Module Test

Six separate tests were conducted on the GSM module (sim900A) and the results are shown in the table below;

Table 2: GSM module test results

SMS	LOCK	UNLOCK	TRACK
1	Delivered	Delivered	Delivered
2	Delivered	Delivered	Delivered
3	Not Delivered	Not Delivered	Not Delivered
4	Not Delivered	Not Delivered	Not Delivered

IJEPSR: E-ISSN 3026-9822 P-ISSN 3027-1568

5	Delivered	Delivered	Delivered
6	Delivered	Delivered	Delivered

GPS Module Test

Six separate tests were also conducted on the GPS module and the results obtained are shown in the table below;

Table 3: GPS module test results

S/N	LONGTITUDE	LATITUDE
1	10.27	9.79
2	10.27	9.79
3	0.00	0.00
4	10.27	9.79
5	0.00	0.00

Locking/Unlocking System Test

The following tests were conducted on the DC motor to show how the locking/unlocking works, it is ON when the START message is sent to the GSM module and OFF when the STOP message is sent to and received by the GSM module. The results obtained from this test are shown in the table below;

Table 4: Locking/Unlocking test results

SMS	LOCK	LCD DISPLAY	STOP	LCD DISPLAY
1	Delivered	Engine Start	Delivered	Engine Stop
2	Delivered	Engine Start	Delivered	Engine Stop
3	Not Delivered	Not Delivered	Not Delivered	Not Delivered
4	Not Delivered	Not Delivered	Not Delivered	Not Delivered
5	Delivered	Engine Start	Delivered	Engine Stop

The tests on power supply units (PSU) and GSM modules, GPS modules, and DC motors showed minimal variation between theoretical and measured voltage values. The Arduino Nano serves as the heart of the system, connecting to the GSM network, SIM800 for instructions, and GPS for GPS satellite data acquisition. Technology has significantly impacted human life, making it essential in various aspects of daily life.

IJEPSR: E-ISSN 3026-9822 P-ISSN 3027-1568

Conclusion

In order to track the vehicle using GPS and remotely manage the engine using a cell phone, this project attempts to build a vehicle system. The system's primary goal is to stop vehicle theft and offers security via SMS warnings. To provide remote management and vehicle tracking, the system includes a SIM800 modem for communication between the mobile station and microcontroller. For effective vehicle position viewing and messaging, the system depends on SIM network service, internet accessibility, and GPS module coordinates. GPS coordinates are also used by other systems for communication.

References

Al-Taee M. A., Khader O. B., Al-Saber N. A., (2017), "*Remote Monitoring of Vehicle Diagnostics and Location Using a Smart Box with Global Positioning System and General Packet Radio Service*", Electrical and Computer Engineering, IEEE International Conference, vol. 53, pp. 385–388.

Rindt C. R., Mcnally M. G., Doherty S., (2020), "*A GPS Enhanced in-Vehicle Extensible Data Collection Unit*", Univ. California, Irvine, vol. 28, pp. 1-23.

Hapsari A. T., Syamsudin E. Y., Pramana I., (2016), "*Design of Vehicle Position Tracking System Using Short Message Services*", in Proc. Conference on Asia South Pacific Design Automation, vol. 41, pp. 285-288.

Fan X., Xu W., Chen H., Liu L., (2016), "*A Composite Communication Scheme for Mobile Object Management System*", In Advanced Information Networking and Applications, IEEE International Conference, vol. 2, pp. 235-239.

Tamil E. M., Saleh D. B., Idris M. Y. I., (2017), "*A Mobile Vehicle Tracking System with GPS/GSM Technology*", in Proc. 5th Student Conference on Research and Development, pp. 398-402.

Kishore T. K., Vardhan T. S., Narayana N. L., (2017), "*Vehicle Tracking Using a Reliable Embedded Data Acquisition System with GPS and GSM*", Int. Journal of Computer Science and Network Security, vol. 10, no. 2, pp. 286-291.

Parvez M. Z., Ahmed K. Z., Mahfuz Q. R., Rahman M. S., (2017), "*A Theoretical Model of GSM Network Based Vehicle Tracking System*", Electrical and Computer Engineering, IEEE International Conference, vol. 47, pp. 594-597.

Muhammad R. A. F., Micheal D., (2018), "*Remote Vehicle Tracking System using GSM Modem and Google Map*", Utilization and Development in Engineering and Technology, IEEE International Conference, pp. 15- 19.

Paul E. C., (2017), "*History of Modern Computing*", MIT press Publishing, England, pp.179.

Alicia M. G., (2018), "*New Media Art Design and the Arduino Microcontroller*", PhD Thesis, School of Art and Design, Pratt Institute, United States America, pp. 23. http://arduino.cc/en/Main/ArduinoGSMShield. (Data Download Date: 15 November 2017).