# DEVELOPMENT OF VEHICLE TRACKING SYSTEM USING GPS AND GSM MODEM

By

PHAM HOANG DAT

FINAL PROJECT REPORT

Submitted to the Department of Electrical & Electronic Engineering

in Partial Fulfillment of the Requirements

for the Degree

Bachelor of Engineering (Hons)

(Electrical & Electronic Engineering)

Universiti Teknologi PETRONAS

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## CERTIFICATION OF APPROVAL

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Approved:

____________________________

Dr Micheal Drieberg

Project Supervisor

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TRONOH, PERAK

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# CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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Pham Hoang Dat

# ABSTRACT

Nowadays, security of personal vehicle has become a crucial part of modern life. The number of stolen car cases has increased annually. Therefore, the development of vehicle tracking system using GPS and GSM project is performed with the aim to help the users to manage over their vehicle better. To solve such problems, the project will be conducted to have such capability that can track vehicle remotely from a distance by using mobile network. The execution of the project will be concerning the study of ublox NEO-6Q GPS receiver, ublox LEON G100 GSM module and Arduino Uno rev3 Microcontroller. In detail, the system will utilize the Global positioning system to obtain the vehicle coordinate and transfer it to user's phone by Global System for Mobile. During the process of development of the project, the outcome has been proven to be positive such as finishing the circuit design of the project, testing the chips and obtaining the coordinate from the chip. In the end, the project was partially successful in such a way that it proves the feasibility of the project.

# ACKNOWLEDGEMENTS

The author would like to give a deep gratitude to Dr Micheal Drieberg for his supervision and for being the author's supervisor during the course of final year project. Without his logical and consistent guide, the author would not be able to troubleshoot some of the major problems that have appeared during the performing course. Furthermore, his suggestion for the Microcontroller and provision for some critical components such as antennas and chips for GSM and GPS have make the project easier in term of programming methodology and time saving for the author to conduct the project.

In addition, the author would like to give a big thank-you to Mr Hasrul, the PCB room technician, Mr ADZ, research lab technician and Mr Yesin, project lab technician for supporting the author with their sincere advices, technical knowledge, and for helping the author to finish printed circuit board (PCB) fabrication and soldering SMD pad after the very first phase of designing the project.

Finally yet importantly, the author would like to thank his family and friends for supporting him with mental stimulation and physical aids during his course of performing the final year project.

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| | |
|---|---|
| CDU | Control Display Unit |
| CAD | Computer Aided Design |
| DDC | Display Data Channel |
| DCE | Data Circuit-terminating Equipment |
| DTE | Data Terminal Equipment |
| DOT | Department Of Transportation |
| DOD | Department Of Defence |
| ESD | Electrostatic Device |
| GPS | Global Positioning System |
| GLONASS | Russian Global Navigation Satellite System |
| GSM | Global System for Mobile |
| IDE | Integrated Development Environment |
| IRNSS | Indian Regional Navigation Satellite System |
| LCD | Liquid Crystal Display |
| NMEA | National Marine Electronics Association |
| NASA | National Aeronautic and Space Administration |
| PIN | Personal Identification Number |
| PCB | Printed Circuit Board |
| RI | Ring Indicator |
| SMS | Short Message Service |
| SMA | Sub Multi Assembly |
| SPI | Serial Peripheral Interface |
| UART | Universal Asynchronous Receiver/Transmitter |
| UTC | Coordinated Universal Time |
| SMD | Surface-Mount Device |

# Chapter 1
# INTRODUCTION

This chapter includes the introduction of the project, which comprises Background of Study, Problem Statement, Objective and Scope of Study, Relevancy of the Project and Feasibility of the Project within the Scope and Time frame.

## 1.1 Background of Study

With the rapid growth of nowadays technology, past navigation system makes a huge step of transformation from using the fifteenth-century quad rand seventeenth-century astrolabe, octant and sextant to utilizing the real-time satellite navigation constellations today, which is the global positioning system (GPS). The GPS was initially developed for the military aim and purpose, but it is soon widened for civilian's use.

GPS was fully operated in 1995 based on the 24 satellites constellation. Other navigation systems can be taken into account as GALILEO (European Union), GLONASS (Russian Global Navigation Satellite System) and BeiDou (Chinese BeiDou System) and IRNSS (Indian Regional Navigational Satellite System). Technically, GPS is comprised of three segments: space segment, control segment and user segment.

Firstly, space segment is the constellation of the satellites, which are used to compute the range that is necessarily useful to determine the coordinate of the craft or people. Satellite in the constellation will send the signal that includes the time at which the signal was transmitted and the position of the satellite at that time.

Secondly, control segment consists of control facilities and equipment such as ground antenna, monitor station that is responsible for monitoring, commanding and controlling the GPS satellite constellation. In detail, the control segment monitors the downlink L-band navigation signals, updates the navigation message and additionally, monitors satellite's state health, manages tasks, battery recharging and commands the satellite payloads.

Thirdly, user segment is the user receiving equipment which generally is GPS receiver, will fetch the L-band signals transmitted from satellites to compute the coordinate. Typically, GPS receiver consists of five basic components: antenna, receiver, processor, input/output (I/O) device such as control display unit (CDU) and power supply.

In conclusion, many applications have been developed to take advantage of the GPS to serve the civilian use such as security, tracking craft, rescuing.

## 1.2 Problem Statement

The Problem Statement will include Problem Identification and Significance of the Project.

### *1.2.1 Problem Identification*

Security has become a crucial part of the daily and with the advance of the technology, securing the vehicle would become easier with the plug-in device which will operate both efficiently, effectively and intelligently.

The development of the project is based on the urge of controlling the vehicle toward the security of it. Certainly, the problem arises when the owner of the vehicle wants to secure the vehicle once it has been stolen. Generally, the system will tell the user the location's coordinate of the vehicle when the owner request. That also helps the owner to keep track on the vehicle when urgent situation turns up.

The scope of development of the project once it has been finished is to apply in many situations of business such as finding stolen vehicle, vehicle lost and found, vehicle logistic management, etc. With the aim of introducing the new generation of GPS and GSM module into performing the project, the project will be developed and further implemented to meet the expectation of business application.

### *1.2.2 Significance of the Project*

The project is significant in term of applying new technologies into problem solving of daily issue and improving the vehicle security. Vehicle tracking system may not be a new application, but adopting up to date cutting-edge chips into the system may prove it worthy and meritorious.

Moreover, the system is developed based on the ublox GPS and GSM chips along with the microcontroller to make it as an effectively fully worked-out and efficiently stand-alone product, which will give the user the simple ease of controlling the system and getting the result. Furthermore, the system also has a convenient size that can be plugged to the vehicle to track the coordinates from a long distance. With the use of GSM, the user can get the location of the vehicle remotely by using the mobile phone to activate the system and receive the coordinate accordingly.

### *1.2.3 Project Objective and Scope of Study*

The goals of the project are:

- To design and develop PCB that will utilize the GPS and GSM to transmit the location of the vehicle to the user.
- To communicate and program the PCB for the system with a microcontroller.
- To achieve practical tracking system that can help improving vehicle security.

Scope of study of the project will be concerning with the ublox GPS Neo-6Q receiver, the ublox GSM LEON G100 module, Arduino Uno rev3 Microcontroller and Arduino Integrated Development Environment.

#### *1.2.3.1 ublox GPS Neo-6Q receiver*

The ublox GPS Neo-6Q receiver is a SMD type chip that has the size of 12.2 x 16.0 x 2.4 mm. It’s operating at voltage of 2.7 to 3.6 V with the current of 50mA. The power of its antenna should be ranging from 15dBm to 50dB. Furthermore, this 24-pin chip has the only capability of getting signal from GSP constellation excluding GLONASS and Galileo system. The receiver uses both UART and SPI as interfaces terminal. Exclusively, it can interact with the ublox LEON G100 module by DDC terminal.


Figure 1.1: ublox GPS Neo-6Q receiver

*1.2.3.2 ublox GSM LEON G100 module*

The ublox GSM LEON G100 module has the size of 18.9 x 29.5 x 3 mm. It's operating at voltage ranging from 3.35 to 4.5 V with the peak current of from 2 to 2.5 A. The power of its antenna should be 10dBm. This SMD-type chip has 50 pins and can be interfaced with UART, SPI. Conveniently, it can communicate with the ublox GPS Neo-6Q receiver by DDC terminal.


Figure 1.2: ublox GSM LEON G100 module

*1.2.3.3 Arduino Uno rev3 Microcontroller*

The Arduino Uno rev3 Microcontroller has the core chip as ATmega328; it's operating at voltage ranging from 7 to 12 V with the nominal DC current of 40mA. Specifically, this Microcontroller has 14 digital pins, 6 analogue pins, 2KB SRAM, 1KB EEROM and 16Mhz clock speed. In addition, Graphic LCD shield and interface will be accompanying with the Uno rev3 Microcontroller.

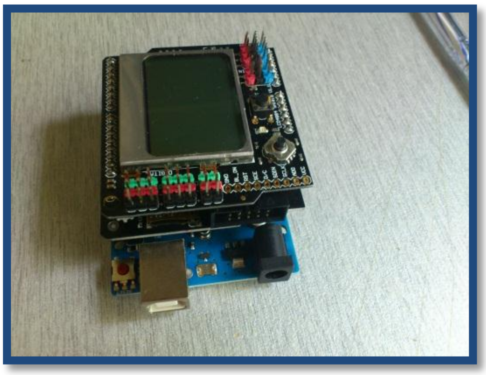


Figure 1.3: Arduino Uno rev3 Microcontroller with graphic LCD and interface

### *1.2.3.4 Arduino Integrated Development Environment*

In order to program the Arduino Uno rev3 Microcontroller, Arduino Integrated Development Environment (IDE) will be used with the open-source C/C# library and command. Technically, the Arduino IDE is a cross-platform application written in Java. Nevertheless, all IDE programs are written in C/C#.

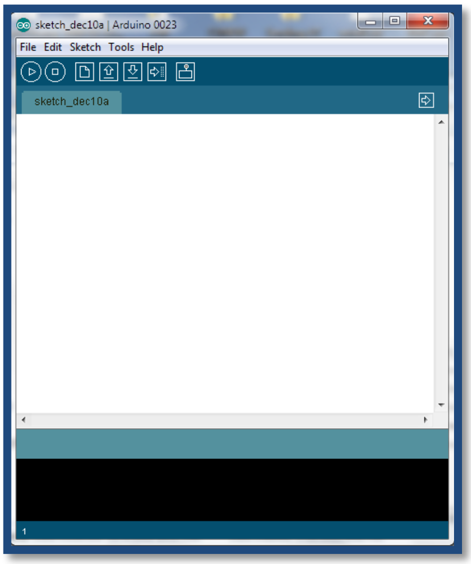



Figure 1.4: Arduino Integrated Development Environment

### *1.2.4 The Relevancy of the Project*

The project adopts the GPS, GSM technology and fuses them together into a stand-alone product that has the capability of tracking the vehicle. Furthermore, the system is developed based on the cutting-edge chips of ublox: the GSM LEON G100 and GPS NEO-6Q chip, which have been proven to be stable and precise. The project can be improved to a low-cost finished product to help it to compete with other products on the market. Further research can be applied in this project to enhance other capabilities. To say the least, this project help to give full insight understanding of how to apply GPS and GSM technology in works and how these chips are combined together to form a competent system. Besides, the application field to the system once finished can be varied to many businesses such as security, craft management, personnel position management, logistic management.

### *1.2.5 Feasibility of the Project*

The project will be performed and accomplished tentatively within two-semester period. The time given is adequate and sufficient for the project to be done roughly with the proper time management and planning if there is no significant problem. The project performance will be divided into two phases. The first phase of the project will be concentrated on the literature review, GPS, GSM and Microcontroller understanding, circuit design and integration. The second phase of the project will be merely about circuit building, soldering works, coding, testing and troubleshooting the project.

The feasibility of the project is possible within the scope and time frame. Nearly over 90 percentage of the workload has been done before the end of the second phase. Nevertheless, unanticipated problem has arisen and delay the project during the course. In detail, the LEON G100 was tested to work successfully but it failed to recognise the SIM card in the holder. When registering the PIN number of the SIM card to it, the chip replies with a message that denoting the SIM card was not inserted.

# Chapter 2
# LITERATURE REVIEW

This chapter includes the Literature Review of the project, which comprises GPS Overview, Space Segment, Control Segment, User Segment, GPS Operation and Vehicle Tracking System and Hardware.

Literature review is the research that has been performed by collecting necessary information from the entire possible source such as the internet, books and manuals. To do this part effectively within the limited time, the information sources should be selected carefully based on the readers' review and the condensed information about the project, for instance, what sweeping fundamental knowledge about the project should be obtained, what part of the project required precise and profound understanding and other relevantly previous projects that are useful. In detail, extensive knowledge of GPS GSM and Microcontroller should be reviewed during this research process; the module settings of ublox GPS, GSM, Microcontroller and IDE should be interpreted in detail in order to execute the project, other necessary information and practice such as C programming; circuit board printing should be known as well, because the ultimate aim of doing research on literature is having the sufficient knowledge and information to accomplish the project.

## 2.1 GPS Overview

Global positioning system (GPS) is satellite systems for three-dimensional position determination, which is a result developed by the several U.S government organizations, including the Department of Defense (DOD), the National Aeronautic and Space Administration (NASA), and the Department of Transportation (DOT) [1]. The GPS was fully in operation in early 1995 when the entire 24 satellite constellation was in place and extensive testing of the ground control segment, and its interaction with the constellation was completed and meeting the criteria established in the 1960s for an optimum positioning system [2]. A new GPS modernization initiative was introduced by the U.S. government in January 1999 that additional two civil signal was added to new GPS satellites, which are the L2C and L5. The L2C signal will be available for non-safety of life applications at the L2 frequency, and the L5 signal was intended for safety-of-life use application [3].

GPS has three segments: satellite constellation, ground-control/monitoring network, and user receiving equipment. Generally, the satellite constellation is the set of satellites in orbit that provide the ranging signals and data messages to the user equipment. The control segment oversees and maintains the space segment which is the satellite constellation in space. Furthermore, the control segment updates and corrects the satellite clocks and ephemerides along with other significant parameters of the satellite. The user segment, or the user receiver equipment, on the other hand, receives the signal from the space segment and computes the navigation, timing and other related functions [4].

## 2.2 Space Segment

The GPS satellite constellation was supported by the U.S government, which currently consists of 24 satellites and was positioned in six Earth-centered orbital planes with four satellites in each plane. The GPS satellite takes one-half of sidereal day or 11 hours, 58 minutes for its orbit period. The orbital radius is approximately 26,600 km. This satellite constellation provides a 24-hour global user navigation and time determination capability [5].

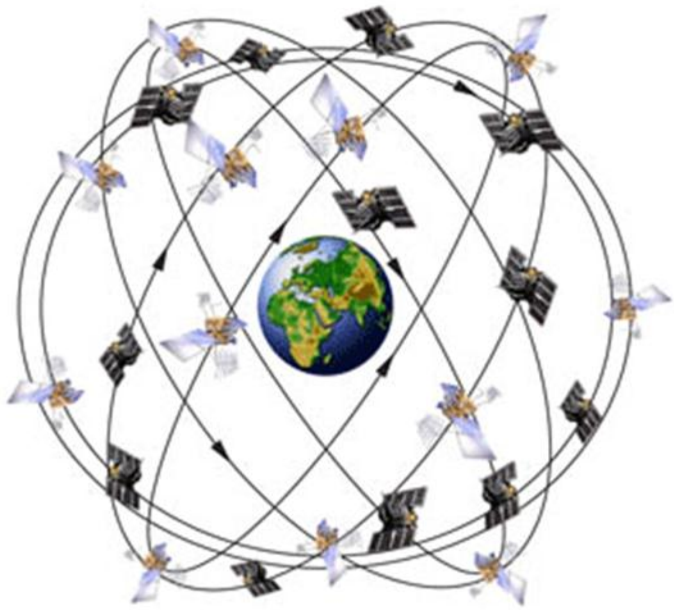


Figure 2.1: Satellite constellation

## 2.3 Control Segment

The control segment is in command of monitoring, commanding, and controlling the GPS satellite constellation. Furthermore, other tasks carried out by control segment are downlink L-band navigation signals, updating the navigation messages, overseeing the satellite's state of health, managing tasks associated with satellite station keeping maneuvers and battery recharging and commanding the satellite payloads. In detail, the major elements of the control segment are MCS, L-band monitor stations and S-band ground antennas. The main operational control system is classified into three facilities: master control station, monitor stations and ground antennas. Master control station's main tasks are resource allocation and scheduling, navigation message generation, satellite health and housekeeping, sv processors' load generation, constellation synchronization steering and GPS system status evaluation and reporting. Monitor stations will perform navigation signal tracking, range and carrier measurement, atmospheric data collection and collecting decoded navigation data provided for the GPS user. Lastly, ground antennas will carry out the SV command transmissions, SV processor load transmissions, SV navigation upload transmission and collecting SV telemetry [6].

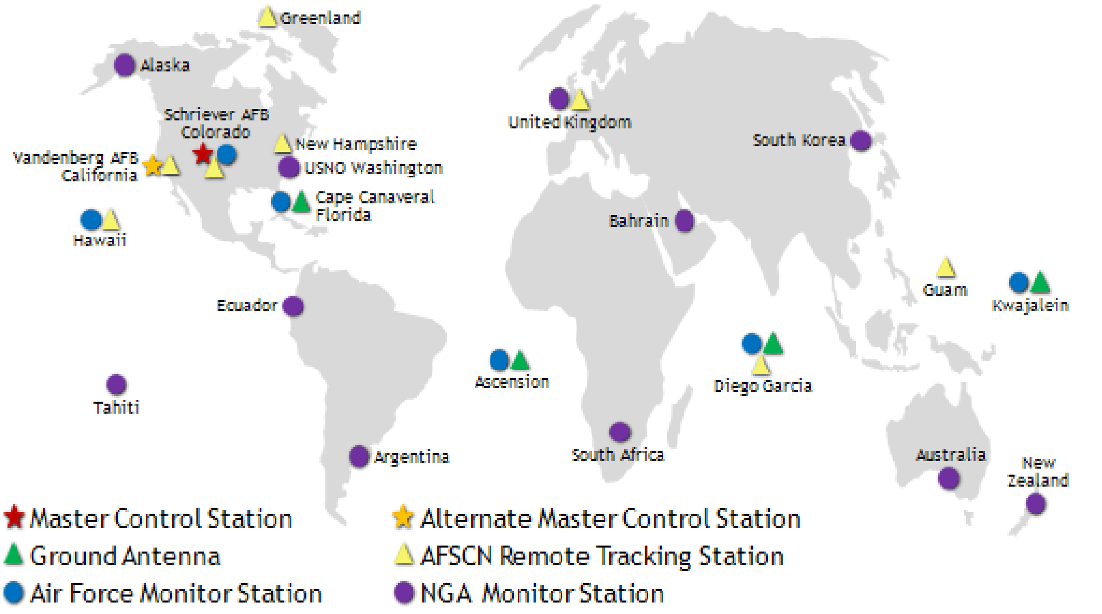



Figure 2.2: Global control segment

## 2.4 User Segment

The user segment, normally referred as GPS receiver, fetches the L-band signals transmitted from the satellites to determine the position, velocity and time (PVT). With the expansion of large-scale manufacturing of components, the GPS receivers become cheap and therefore are embedded in many of the items we use, which may include cellular telephones, PDAs, and automobiles. Unlike the past initial receiving sets produced in the mid-1970s, which are large, bulky and heavy analog devices for military application, nowadays receivers comprise many form factors, including chipsets, handheld units, and compatible cards. The principal block diagram of a GPS receiving set can consist of five principal components: antenna, receiver, processor and input/output (I/O) device such as control display unit and power supply [7].

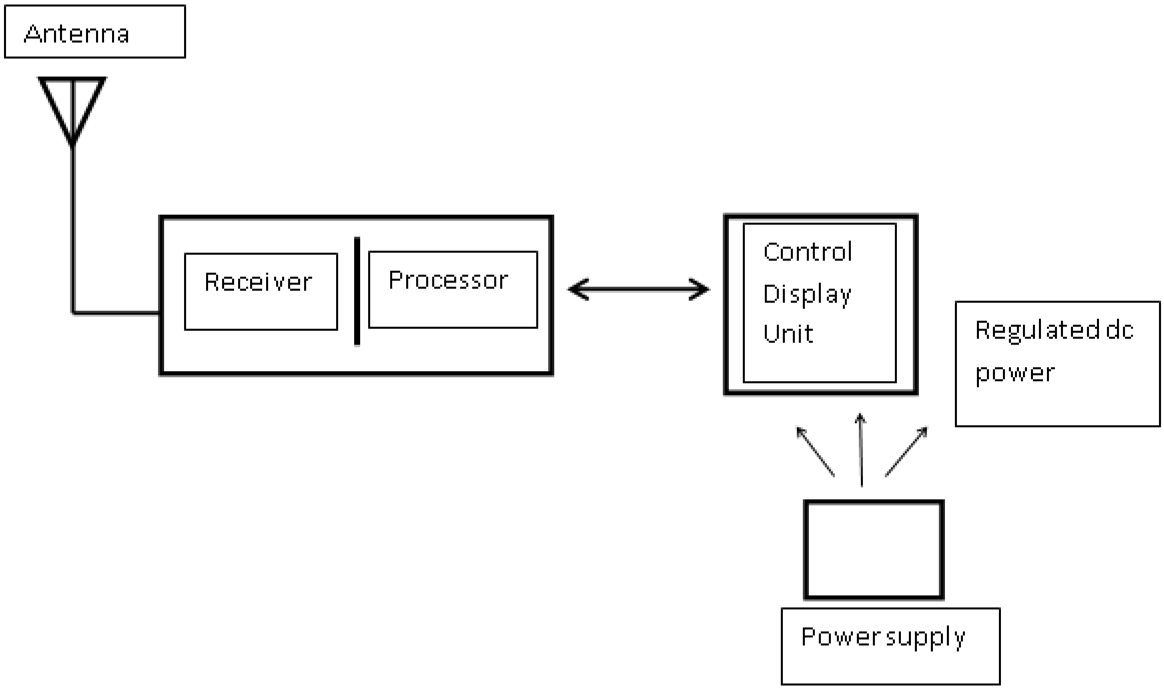



Figure 2.3: GPS receiver connection

## 2.5 GPS Operation

The GPS system delivers three-dimensional position and velocity information to a user via receiving equipment. GPS also utilizes a form of Coordinated Universal Time (UTC). Furthermore, service can be provided to an unlimited number of users since the user receivers only receive the signal. The system introduced the concept of one-way time of arrival (TOA) ranging. This technology will measure the time it takes for a signal transmitted by an emitter at a known location to reach a user receiver. The time interval, as known as signal propagation time, will be multiplied by the speed of the signal to obtain the pseudo-range. Normally, with the utilization of four satellites, these four pseudo-ranges will make up to four spheres that intersect at the user location. The GPS time base is in sync with the high accurate atomic frequency standards onboard of the satellites. A technique called code division multiple access (CDMA),which which comprises the two frequencies L1 (1,575.42 MHz) and L2 (1,227.6 MHz), will be used in the satellites broadcast ranging codes and navigation data. These frequencies with different ranging codes will be transmitted by each satellite. The satellite will select these codes because they have low cross-correlation properties with respect to one another. A short code will be generated as the course/acquisition or C/A code and precision code or P(Y) code.

This information will help to determine the location of the satellite and the range from satellite to user. A crystal clock will be normally equipped in the user receiver to minimize the cost and, thus, normally four satellites will be required to yield four measurements to compute user latitude, longitude, height and receiver clock offset. GPS has dual use, which are for civil and for military. These two systems are Standard Positioning Service (SPS) and the Precise Positioning Service (PPS). The PPS is used to provide a predictable accuracy of at least 22m while the SPS is available for all users worldwide with accuracy of better than 13m [8].

## 2.6 Vehicle Tracking System and Hardware

Nowadays, the automobile manufacturing technology is advanced toward focusing from basic transportation to the design of features that make the vehicle safer, more comfortable, and handy. Utilization of GPS has been applied in tracking the distance traveled on a trip, vehicle mileage, and speed. It can keep the record of driving activity, including address of each destination; names of streets traveled, and how long the vehicle remained at each location, to allow owners to monitor the user of their vehicles by other drivers.

In additional, one microcontroller is used to control the two chips of GPS and GSM, which are the NEO-6Q-O/LEA-6H-O and LEON-G100. Currently, there are many families of the microcontroller in the market such as PIC form Microchip, Atmel, HC family and Arduino main boards. For this project, the Arduino Uno Rev3 main board, which is popular on the market, is used to communicate these two GPS and GSM chips.

As the supplementation of the project design, the manuals from the manufacturer are taken into account as a reference for designing the GPS NEO-6Q receiver and GSM LEON G100 module. These reference schematics are attached in Appendix A and B. Furthermore, as one of the most significant key factors which are carefully considered, is how to detect the signal from the ublox GSM LEON G100 module when the user wants to activate the tracking system. Therefore, the pin number 10 of the 50-pin LEON module, which is the Ring Indicator (RI), will raise some signal whether someone calls or sends SMS to the module. The RI signal behavior is attached in Appendix C.

Chapter 3

# METHODOLOGY

This chapter includes the Methodology of the project, which comprises Research Methodology, Project Activities, Key milestone, Gantt Chart and Tools.

## 3.1 Research Methodology

The methodology of the research is the crucial process of the project development that acts importantly on the provision of sufficient information, characteristic, layout of the project idea and project components. As mentioned earlier, the project development process is divided into two parts in accordance with the time frame of each semester. Another significant part can be taken into account is the review with supervisor to ensure the project procedure flows in the correct path. The project block diagram describes the methodology of the project as in figure.

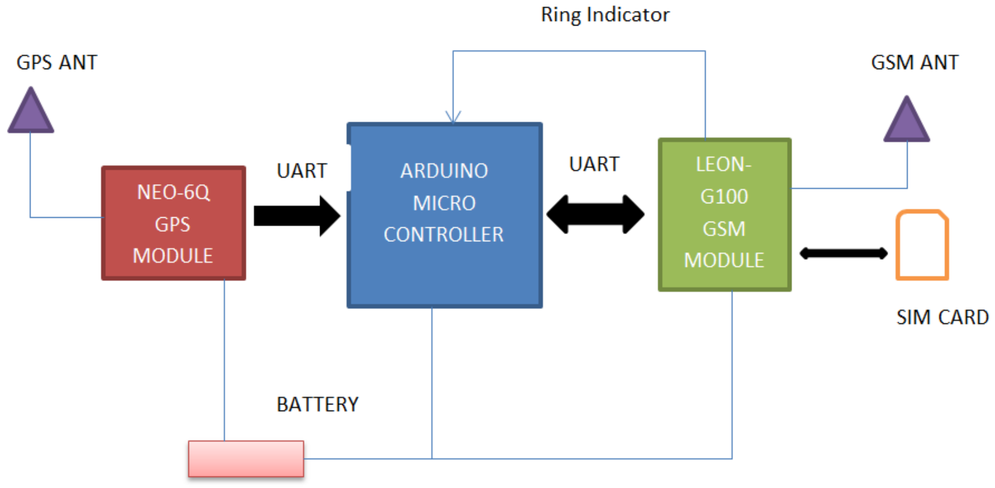
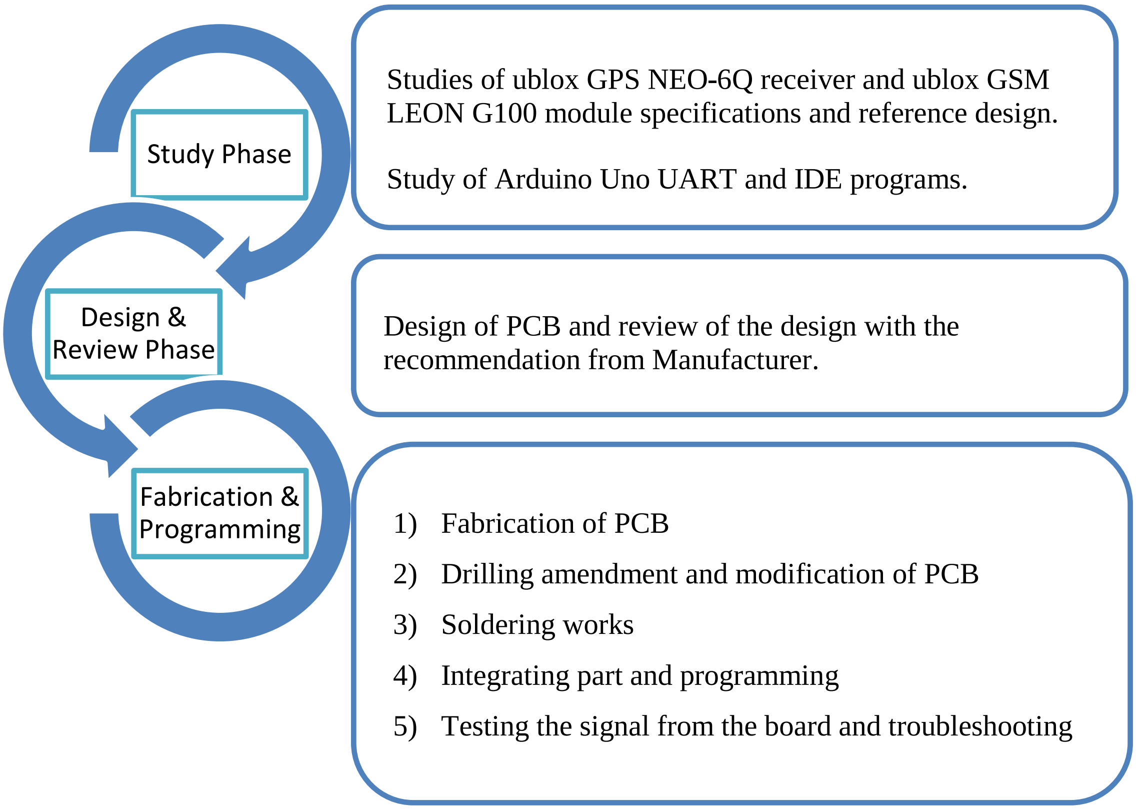



Figure 3.1: Project block diagram

The below process flow shows how the research methodology will be carried out:




## 3.2 Description of study phase

The study and research were done to gain understanding on how to design the PCB using ublox GPS NEO-6Q module and ublox GSM LEON-G100 module. Furthermore, the research also includes study of the Arduino Uno rev3 Microcontroller and Arduino Integrated Development Environment.

On the other hand, this phase also is comprised of the study of designing software for the PCB fabrication. The design work was completed by using design software Eagle. Eagle is a computer-aided design (CAD) program that runs on Microsoft Windows and was developed by CADSoft Company. However, the designed board needs to be processed in CAM possessor in order to transform it into an acceptable fabrication file, which is the gerber format.

## 3.3 Description of Design and Review phase

### *3.3.1 Ublox NEO-6Q GPS receiver module*

The ublox NEO-6Q GPS module is a 24-pin chips, which can be classified as a SMD chip. Therefore, in order to manipulate the pin connection of the module in the circuit, PCB with chip pads need to be fabricated correctly. The detail of the 24 pins can be seen in the figure below.

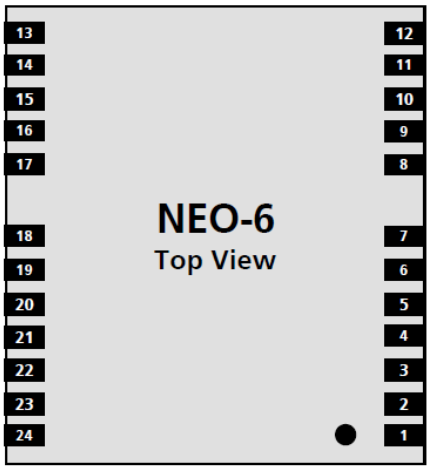



Figure 3.2: ublox NEO-6Q top view [source: ublox]

Table 3.1: Specification of the NEO-6Q pins

| Function | Pin | No | I/O | Description |
|---|---|---|---|---|
| **Power** | VCC | 8 | I | Supply voltage |
| | GND | 1,10,12 | I | Ground |
| | V_BCKP | 6 | I | Back-up voltage |
| **Antenna** | RF_IN | 11 | I | GPS signal from antenna |
| | VCC_RF | 14 | O | Output voltage RF |
| | ANTON | 13 | O | |
| **UART** | TxD1 | 2 | O | Serial port 1 |
| | RxD1 | 3 | I | Serial port 1 |
| **System** | TIMEPULSE | 4 | O | Timepulse signal |
| | EXTINT0 | 5 | I | External Interrupt |
| | SDA2 | 16 | I/O | DDC |
| | SCL2 | 17 | I/O | DDC |
| | Reserved | 18 | | |
| | VCC_IO | 7 | I | |
| | V_RESET | 9 | I | VRESET |
| | Reserved | 15 | | |

Furthermore, unlike some conventionally popular chips, the ublox NEO-6Q GPS module has the SMD pin. The module needs to be stuck on the PCB pad with the precise scale. As a result, the PCB design has to be clearly taken into consideration with defining the new NEO-6Q module library based on the manufacturer's chip footprint ( see figure 3.3).

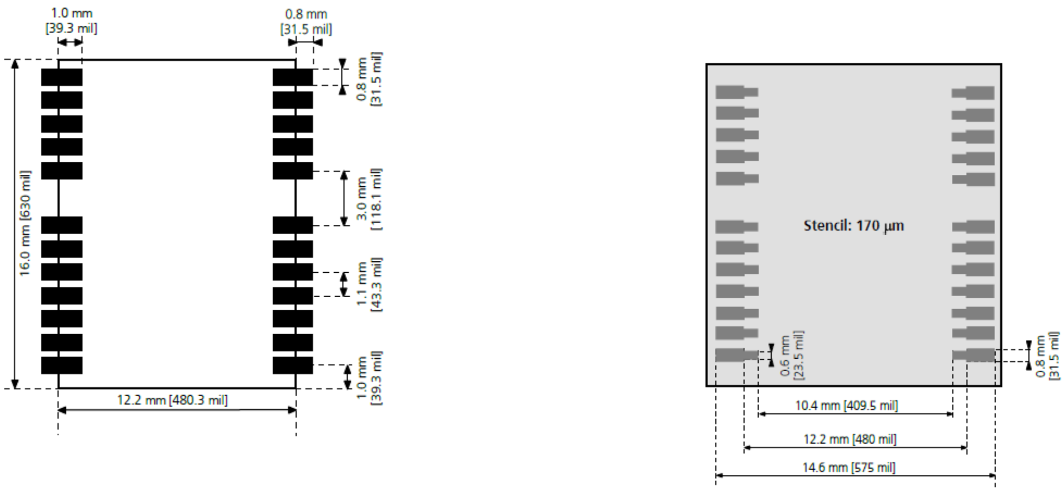



Figure 3.3: NEO-6Q footprint and paste mark [source: ublox]

Lastly, the recommended schematic connection provided by the ublox manual is carefully taken into consideration in order to have the chip functioning precisely and properly. For detail of reference circuit of the ublox NEO-6Q module, referring to Appendix A.

### *3.3.2 Ublox GSM LEON-G100 module*

Ublox GSM LEON-G100 module has 50 pins; it also has the SMD pad, which can be pasted directly with soldering stick on the PCB. Moreover, specification of the chip pins can be useful when designing the module ( see figure 3.4 and table 3.2).

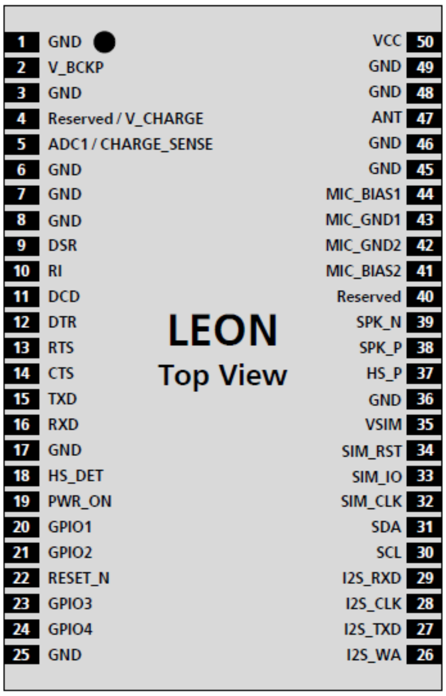



Figure 3.4: LEON G100 top view [source: ublox]

Table 3.2: Pin specification of LEON G100 module

| Function | Pins | Remark |
|---|---|---|
| **RF Antenna In/Out** | ANT | 50 Ohm impedance |
| **DC supply** | VCC | Wide and short |
| **Analog Audio** | | Avoid coupling with noise |
| **Audio Inputs** | MIC_BIAS1, MIC_GND1, MIC_BIAS2, MIC_AUDIO2 | |
| **Audio Outputs** | SPK_P, SPK_N, HS_P | |
| **Ground** | GND | Provide proper grounding |
| **Charger** | V_CHARGE, CHARGE_SENSE | Check charger line width |
| **Backup voltage** | V_BCKP | |
| **A to D converter** | ADC1 | |
| **Power on** | PW_ON | |
| **SIM card interface** | VSIM, SIM_CLK, SIM_IO, SIM_RST | Follows common practice for digital pins |
| **Digital Audio** | I2S_CLK, I2S_TXD, I2S_RXD, I2S_WA | |
| **DDC** | SCL, SDA | |
| **UART** | TXD,RXD, CTS, RTS, DSR, RI, DCD, DTR | |
| **External Reset** | RESET_N | |
| **General purpose I/O** | GPIO1, GPIO2 | |

In order to design the device library for LEON G100, the footprint and paste mark of the module is reviewed in accordance with the manufacturer's released information. See figure 3.5 for LEON G100 footprint and paste mark.

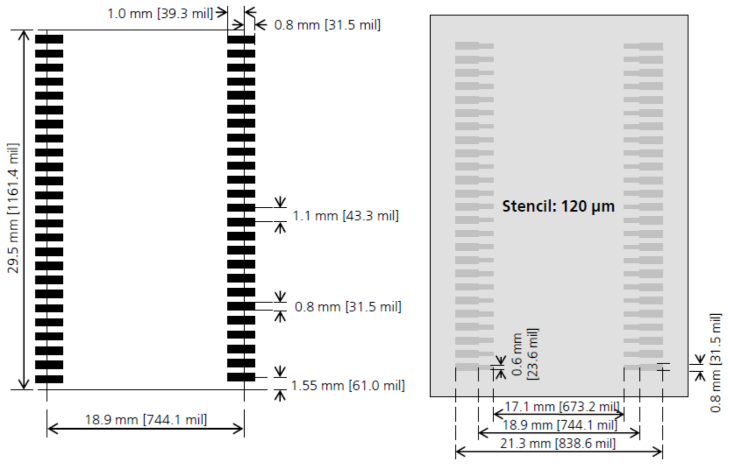



Figure 3.5: Ublox LEON G100 module footprint and paste mark [source: ublox]

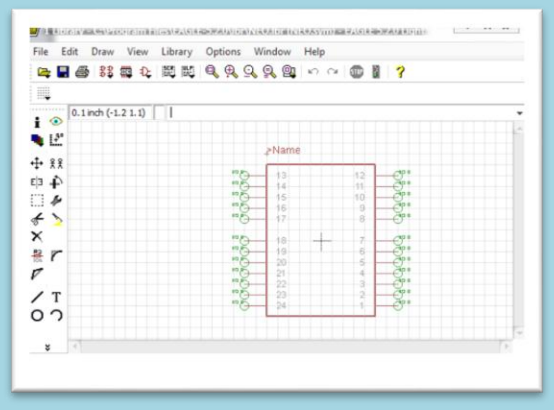
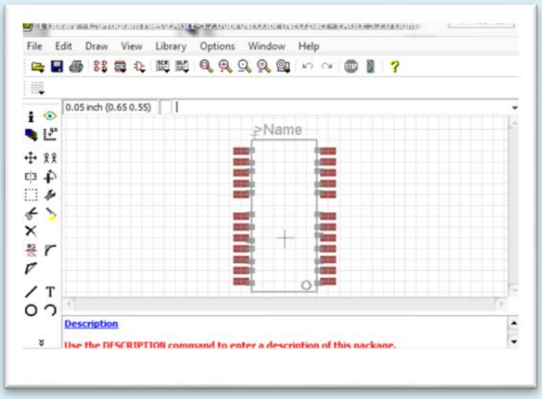
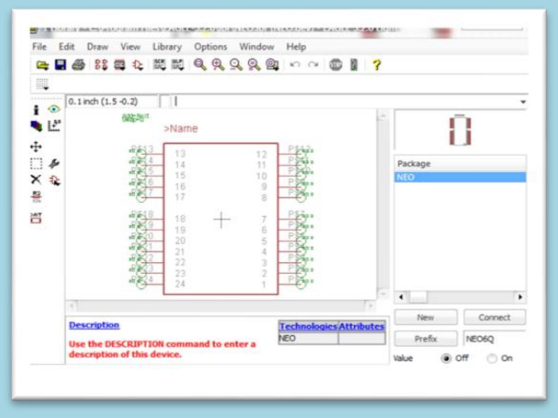
The recommended schematic of the ublox LEON G100 module design is reviewed before conducting the PCB process. For detail of the reference schematics, see Appendix B.

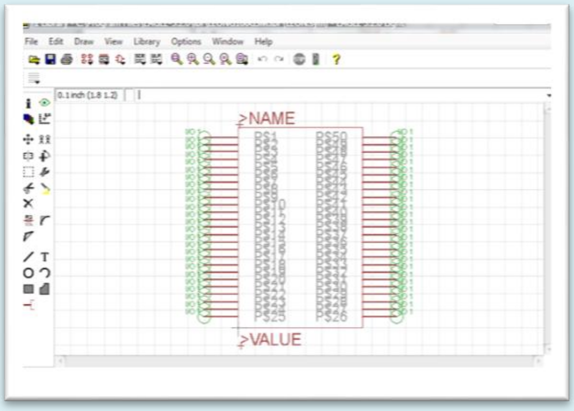
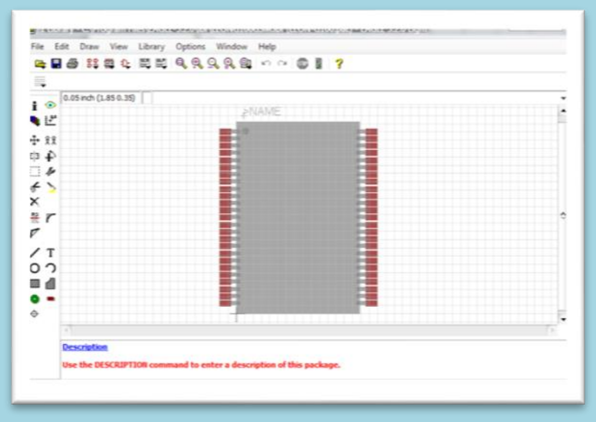
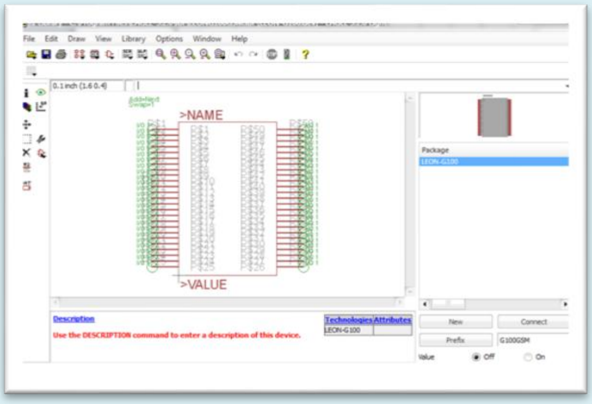
### *3.3.3 PCB design with Eagle*

Eagle software is useful for designing the PCB with the entire known and unknown component. It can be processed in CAM processor to deliver the gerber format files that later is used for fabrication of the real prototype. Cadsoft Eagle software has rich libraries that are predefined for user to design simply. Nevertheless, the ublox NEO-6Q GPS module and ublox LEON G100 GSM module are not available in the library of the software. Therefore, these modules should be newly defined with the precise footprint as provided by the manufacturer in order to fabricate the PCB, which is later easily soldered with the ublox SMD modules.

In order to define a new library for a new component, it has to be followed with three steps as each component library has three parts: symbol, package and device. The symbol is used by the Eagle schematic to manipulate in the diagram; the package is used to be manipulated in the Eagle board and the device is the integration of the package and symbol for routing signal of the pins.

Table 3.3: Designing library for NEO-6Q and LEON G100

| Name | Part | Detail |
| --- | --- | --- |
| Ublox NEO-6Q GPS module | Symbol: Drawing chip symbol and number of pins; setting name and centre point |   |
| | Package: Drawing module pads (red) that later are replaced with copper in PCB fabrication. The distance between pads is carefully measured according to foot print manual |   |
| | Device: connecting symbol pins with package pads |   |

| | | |
|---|---|---|
| Ublox LEON G100 GSM module | Symbol: Drawing chip symbol and number of pins; setting name and centre point |  |
| | Package: Drawing module pads (red) that later are replaced with copper in PCB fabrication. The distance between pads is carefully measured according to foot print manual |  |
| | Device : connecting symbol pins with package pads |  |

Final work of design process is to draw the complete circuit on the Eagle board, transform it in gerber format and submit it to the PCB fabrication room (see figure 3.6 and 3.7 for complete schematic).

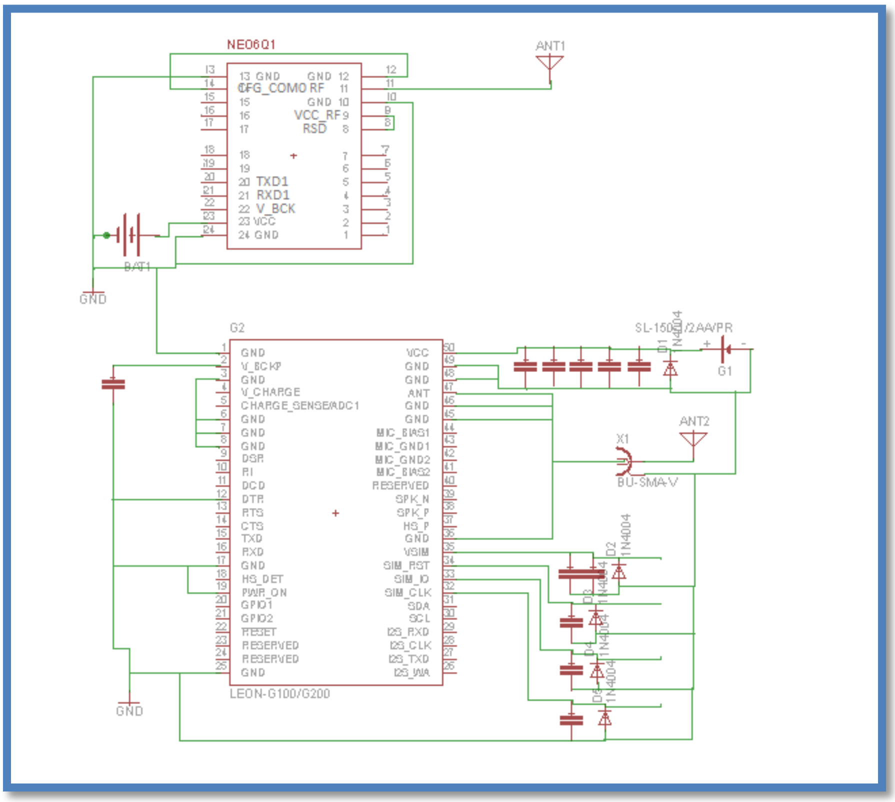



Figure 3.6: Project schematic

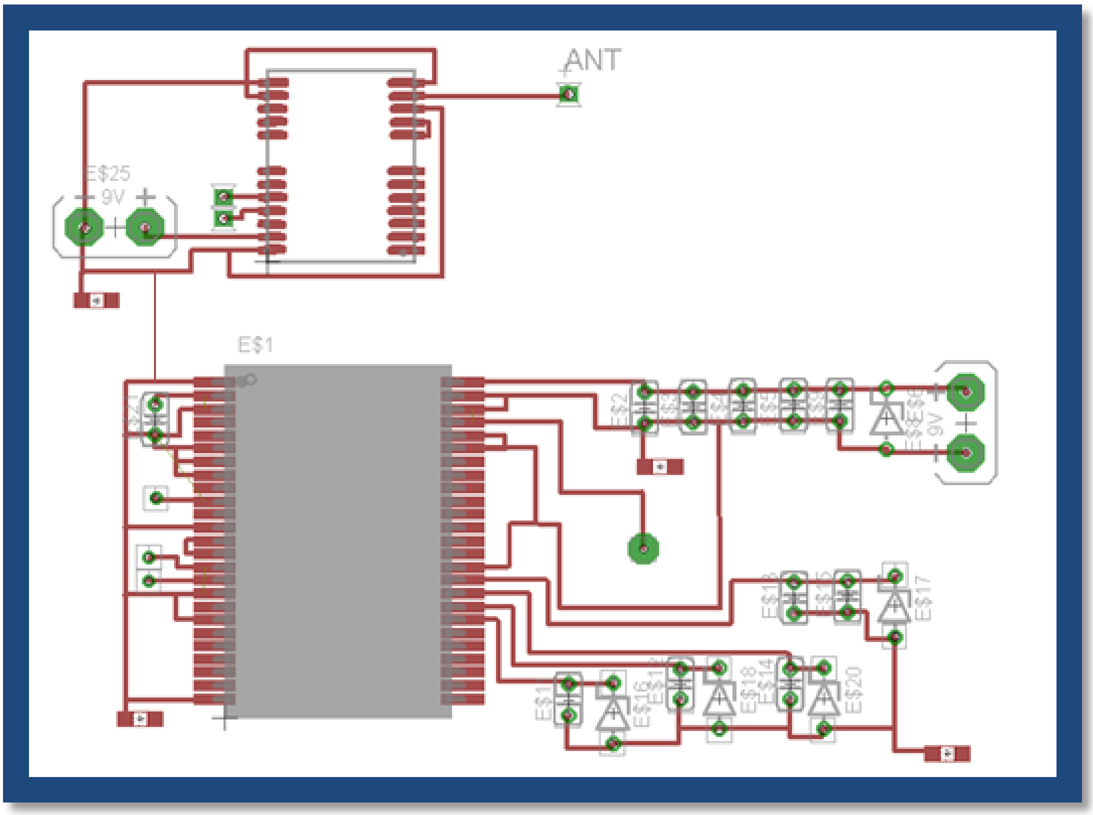



Figure 3.7: PCB designed board

## 3.4 Project ativities and tools

Table 3.4: Project activities description

| No | Works | Location | Tools |
|---|---|---|---|
| **1** | Review system design | Hostel | Microsoft and Adobe applications |
| **2** | Design PCB | Hostel | Eagle Software |
| **3** | Processing PCB fabrication | PCB room | PCB machine |
| **4** | Troubleshooting PCB defects | PCB room | PCB machine |
| **5** | PCB modification and redesign | PCB room | PCB machine |
| **6** | Drilling works performed in PCB | Electrical workshop | Hand drill |
| **7** | Soldering work for ESD sensitive device :NEO-6Q and LEON module | Research lab | Hot air gun, soldering iron and ublox modules |
| **8** | Soldering work and finishing the PCB | Project lab | Soldering iron, SMA connector, capacitors, simcard holder, wires, battery holder, ESD diodes |
| **9** | Testing circuit connection and pin connection | Project lab and research lab | Multimeter |
| **10** | Testing Arduino Uno and LCD display | All | Arduino IDE |
| **11** | Programming and testing NEO-6Q UART | All | Arduino IDE, project board |
| **12** | Programming and getting GPS signal from NEO-6Q | All | Arduino IDE, project board |
| **13** | Programming and testing LEON G100 UART | All | Arduino IDE, project board |
| **14** | Troubleshooting for LEON G100 UART | All | Arduino IDE, project board |
| **15** | Programming LEON G100 for network registration | All | Arduino IDE, project board |
| **16** | Programming LEON G100 for calling and sending message | All | Arduino IDE, project board |
| **17** | Developing the system to work accordingly | All | Arduino IDE, project board |

## 3.5 Gantt chart and Milestone

Table 3.5: FYP 1 Gantt Chart

| No. | Detail/Week | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1** | Selection of Project Topic | | | | | | | | | | | | | | |
| **2** | Preliminary Study & Research Work | | | | | | | | | | | | | | |
| **3** | Submission of extended proposal | | | | | | | | | | | | | | |
| **4** | Project work commences (design) and study of ublox modules | | | | | | | | | | | | | | |
| **5** | Submission of proposal defence | | | | | | | | | | | | | | |
| **6** | Proposal defence | | | | | | | | | | | | | | |
| **7** | Project work continues focusing on design PCB | | | | | | | | | | | | | | |
| **8** | Submission of draft report | | | | | | | | | | | | | | |
| **9** | Submission of Interim report | | | | | | | | | | | | | | |

Table 3.6: FYP 2 Gantt Chart

| No. | Detail/Week | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1** | **Project Works** | | | | | | | | | | | | | | |
| **1.1** | Find and purchase all major parts and components | | | | | | | | | | | | | | |
| **1.2** | Finishing fabrication PCB | | | | | | | | | | | | | | |
| **1.3** | Soldering components into to PCB | | | | | | | | | | | | | | |
| **1.4** | Testing connection of the circuit | | | | | | | | | | | | | | |
| **1.5** | Programing and testing circuit signal | | | | | | | | | | | | | | |
| **1.6** | Developing and troubleshooting | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2** | **Submission deadline** | | | | | | | | | | | | | | |
| **2.1** | Submission of progress report | | | | | | | | ■ | | | | | | |
| **2.2** | Poster exhibition | | | | | | | | | | | ■ | | | |
| **2.3** | Submission of draft report | | | | | | | | | | | | | ■ | |
| **2.4** | Submission of final report | | | | | | | | | | | | | | ■ |
| **2.5** | VIVA | | | | | | | | | | | | | | ■ |

**Legends**

Technical work

Submission & Milestone

Chapter 4

# RESULTS AND DISCUSSION

This chapter will include the outcome of the project with regard to the previous research and design.

## 4.1 Printed circuit board prototype

As a result of the PCB fabrication, the outcome prototype has been integrated all the recommended connection of the system. Picture of the prototype can be observed in the figure 4.1 captured below. Nevertheless, the PCB room in Universiti of Teknologi PETRONAS was merely capable of processing and delivering a single side PCB. Therefore, other connections were manually manipulated with direct wire on the other side of the PCB. Other than that, the SMD modules, ublox NEO-6Q GPS receiver and ublox LEON G100 GSM module, must be soldered and stuck to one specific side of the PCB that has the copper pads. Hence, one side of the PCB was occupied with ublox NEO-6Q GPS receiver, ublox LEON G100 GSM module, simcard holder, cell battery holder and soldering lead (see figure 4.2), and the other side was accommodated for wires, capacitors and SMA connectors (see figure 4.3).

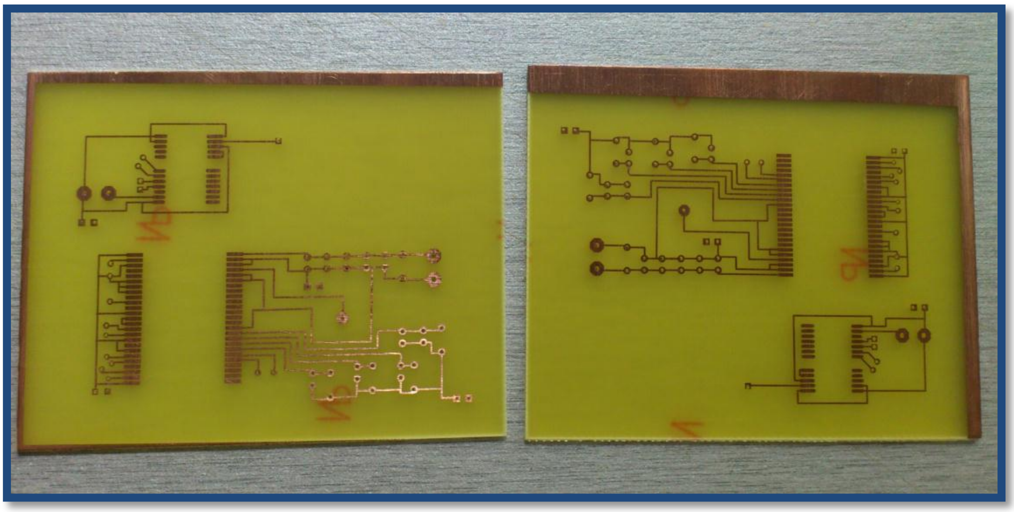


Figure 4.1: Crude printed circuit board prototype

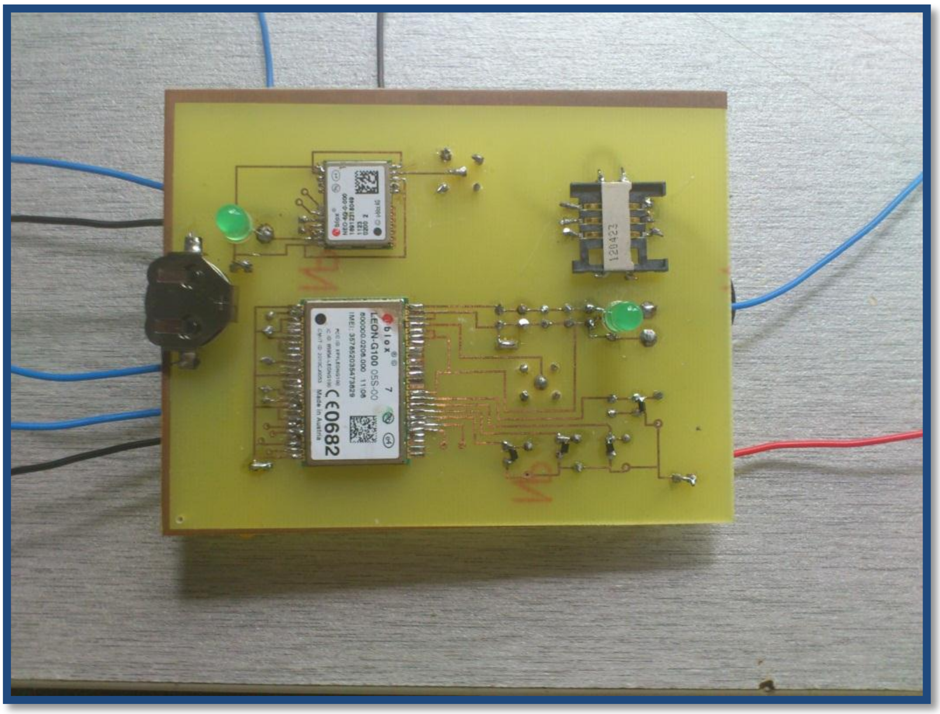



Figure 4.2: Soldered PCB prototype (front side)

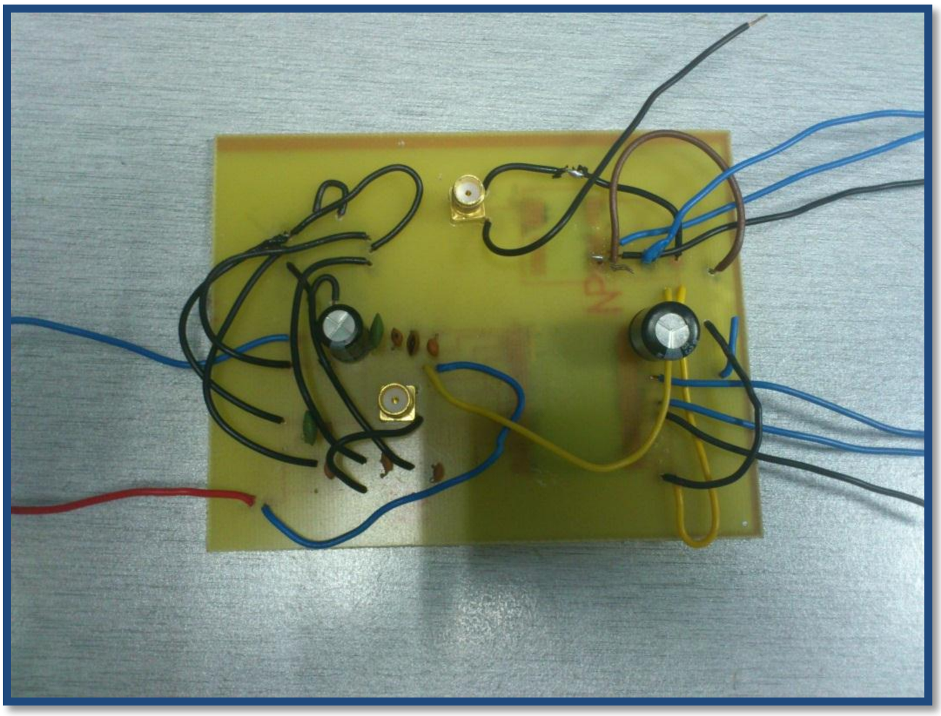


Figure 4.3: Soldered PCB prototype (back side)

To make sure the circuit will be operating properly, recommendation of the manufacturer was referred precisely. The reference schematics of the modules are provided in the manual and design specification slides. These can be studied in the Appendix A for ublox NEO 6Q GPS module and Appendix B for ublox LEON G100 GSM module. In addition, the ublox modules are stated to be sensitive to electrostatic and using improper soldering iron can cause damage on the chips. For this reason, the soldering works for these SMD modules were performed in the postgraduate research lab, where the hot air gun and soldering iron with adjustable temperature can be used to perform such tasks. On the other hand, the process of conducting the connection test on the circuit was successful; all the pins and wires in the PCB prototype are signalling cooperatively according to the predetermined design.

## 4.2 Developing the system programs

Prior to the development of the system programs that can be fully functioning; small programs were written in order to test each integrative parts of the whole system. Also, these subsystem programs were used to achieve certain milestones of the project and to develop the system programs that later can operate based on these sub main programs. Moreover, all the programs were developed on the Arduino Integrated Development Environment (IDE).

### *4.2.1 Program for testing Arduino mainboard*

The Arduino mainboard was set up with Arduino Uno rev3 Microcontroller, interface and graphic LCD shield (see figure 4.4). The Uno rev3 Microcontroller was built on the ATmega328 Microprocessor with 2KB SRAM and 1KB EEROM; the interface was integrated with UART, SPI, I2C interfaces, SD card and TCL5940; the graphic LCD shield has the graphic display with one reset button, which is used later for displaying received information and commands.

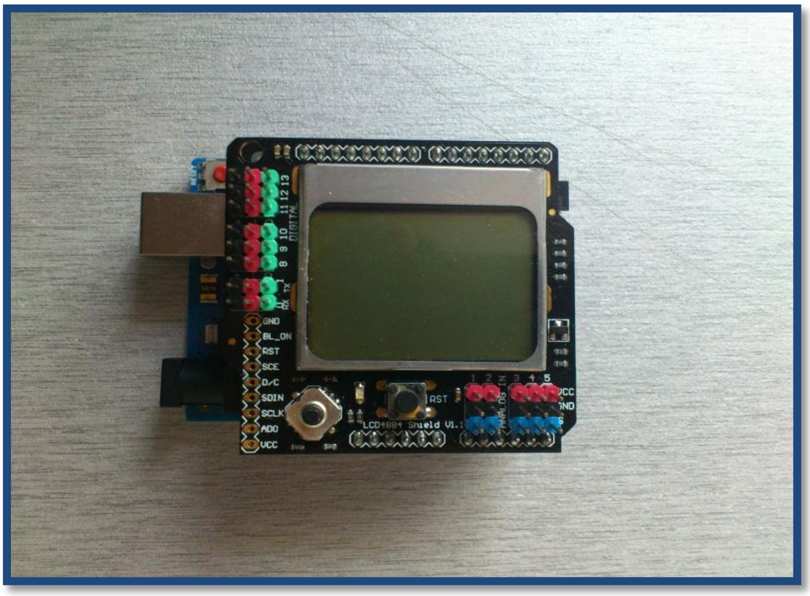



Figure 4.4: Stacked Arduino Mainboard

A simple program is written to test the Microcontroller and LCD display (See Appendix D for the code). After compiling the code and upload it from the IDE to the Arduino Uno rev3, the program is ready to run. The code will make the Arduino GLCD displaying some words and a running number from 1 to 1000 (see figure 4.5).

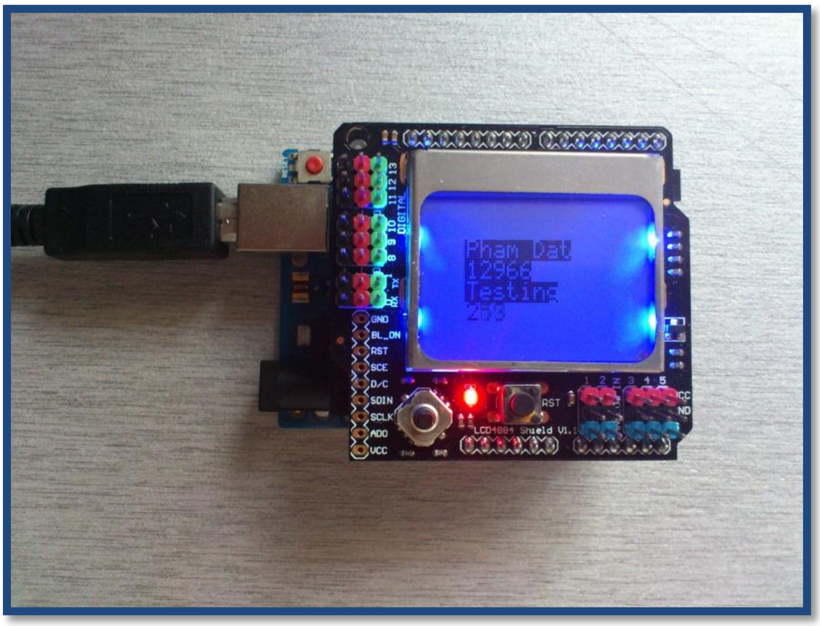



Figure 4.5: Graphic LCD display

### *4.2.2 Program for testing ublox NEO-6Q GPS module*

Prior to programing, the connection must be studied well to ensure the problem is minimized. As planned, the Arduino Uno rev3 Microcontroller will communicate with the NEO-6Q module through the UART port. Since the UART port of both the Arduino uno rev3 Microcontroller and NEO-6Q module are set up in TTL level (0 to VCC), both module and Microcontroller can communicate to each other without intermediate TTL to RS232 converter. In order to receive the signal from the ublox NEO-6Q GPS module, its TxD line is simply connected to RxD line of the Arduino Uno rev3 Microcontroller (see figure 4.6).

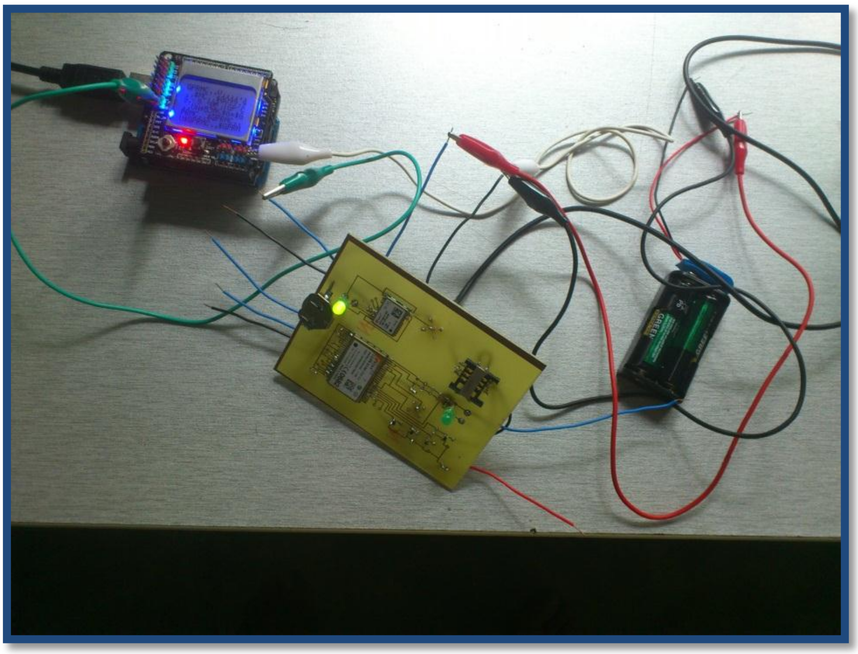


Figure 4.6: Connection of ublox NEO-6Q and Arduino Uno

After uploading the program to the Arduino Uno rev3, the graphic LCD screen will have some string displaying. See attached Appendix E for the program code.

When disconnecting the module from antenna, the module also has to send some signal through the UART serial port. The message is as described in figure 4.7. It has a series of strings which began with $GPTXT. In general, this message is part of the NMEA protocol that the module's due to send; it contains the status of the chips and also other figures such as internal memory. For detail of this TXT message structure, see attachment of Appendix E.

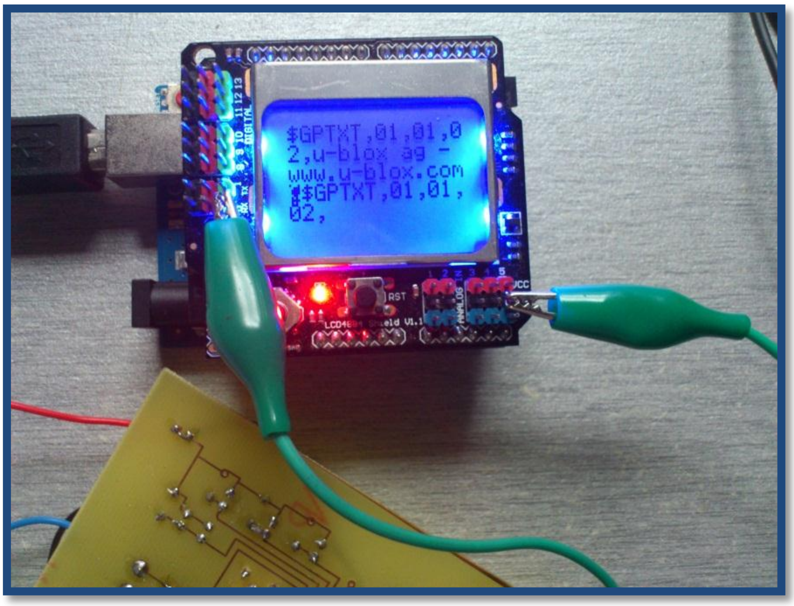



Figure 4.7: Receiving status message TXT

With the connection of the antenna in or near an open place, the GPS coordinate can be obtained from the NEO-6Q module after a few minutes for boot start. Normally, the module has three kinds of boot start: warm start, cold start and cool start. These boot start will be running depends on the environment and without the back-up battery. If the user wants to store some previous coordinate in internal memory, back-up battery needs to be installed for remaining some small energy for storing purpose in the chip.

After the boot start, the NEO-6Q module will deliver some full messages as parts of the NMEA protocol, which are GSV, RMC, GSA, GGA, GLL, VTG, and TXT (see Appendix F for NMEA full list of message). Some messages may contain the coordinate from the satellite such as RMC, GGA, and GLL. The procedure for fetching the GPS coordinate from the satellite can be observed as: boot start, getting UTC time and date ( see figure 4.8), getting GPS coordinate any other auxiliary figure such as number of satellite used.(see figure 4.9)

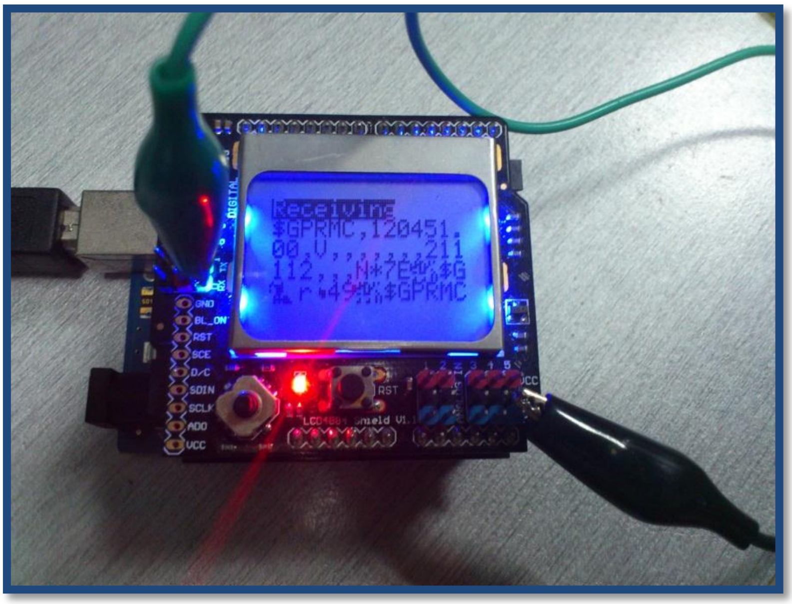



Figure 4.8: GPS message containing UTC time

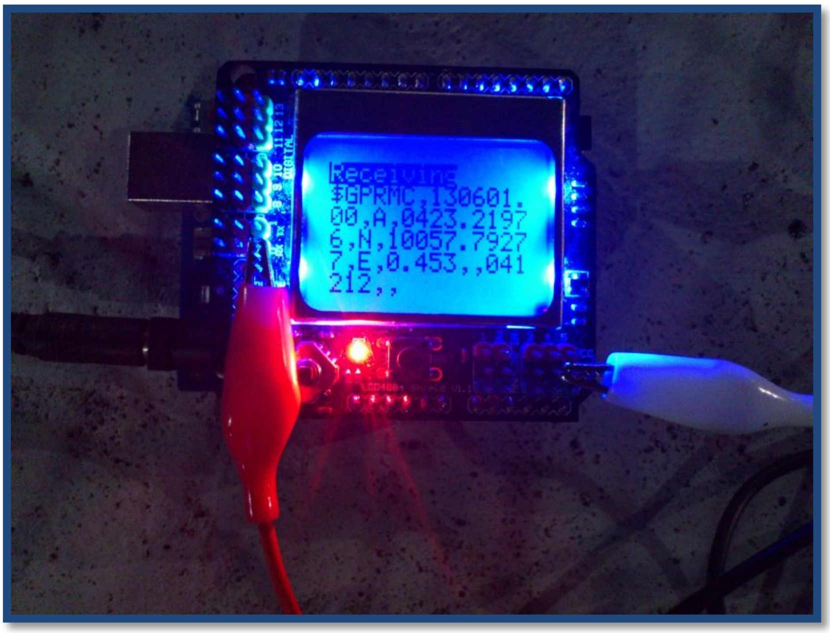



Figure 4.9: Full GPS message

In the above figures, the RMC message was displayed, which stands for Recommended Minimum data; the RMC message contains 14 fields, each fields were separated by comma. In detail, the UTC time and date are located in field 1 and 9 ( field 0 is $GPRMC); the coordinate is located in field 3,4,5 and 6 (see Appendix G for RMC message structure and Appendix H for all messages received); in every message including RMC, there is one field containing a character that denotes whether one specific data from satellite is valid, which is the Position Fix Flags ( see

Appendix I for this issue); for this RMC in figure 4.9, the character in field 2 is A, denoting that data is valid; but in figure 4.8, the character is V, denoting that data is invalid. On the other hand, some character may be displayed properly due to some reason such as that specific character is not received well, stack overflow in graphic LCD that is usually open or the delay time is too short for the signal to be received or displayed, which will rarely result in a summation of the received signal.

### *4.2.3 Program for testing ublox LEON G100 GSM module*

The Arduino Uno rev3 Microcontroller can also communicate with the LEON G100 module through the UART port. Since the UART port of both the Arduino uno rev3 Microcontroller and NEO-6Q module are designed with TTL level (0 to VCC), both module and Microcontroller can communicate to each other without intermediate TTL/RS232 converter. Nevertheless, the LEON G100 module is operating as a Data Circuit-terminating Equipment (DCE) and the Arduino Uno rev3 Microcontroller is a Data Terminal Equipment. Therefore, the LEON G100 module's UART port will be connected to Arduino Uno rev3 Microcontroller as recommended by ublox in figure 4.10.

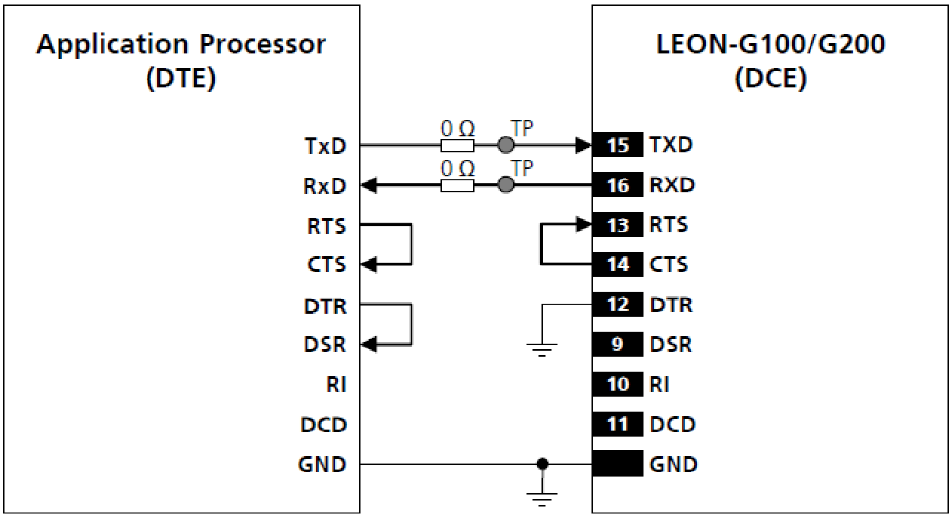



Figure 4.10: UART connection of LEON G100 and Arduino Uno rev3 [source: ublox]

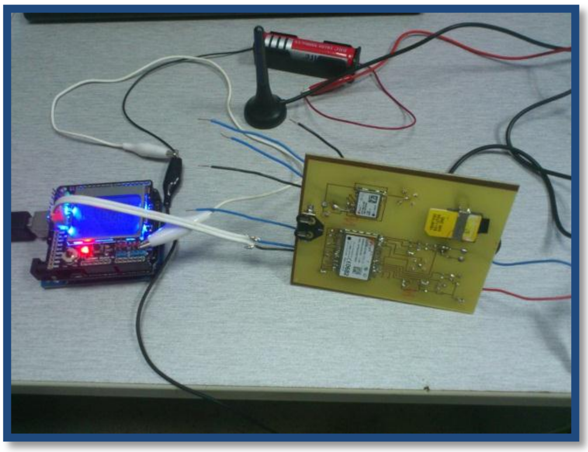


Figure 4.11: Circuit connection for ublox LEON and Arduino Uno

Next action is to write the program to get the characters from the UART port of the LEON and display in graphic LCD terminal. See attachment of Appendix J for the program code.

In order to know whether the module is working, a simple command is sent to the UART port of the LEON. The replied character of the module will determine the chip function is working or not. For instance, “AT” command will be sent and the supposed response of the LEON is “OK” (see figure 4.12). However, the response message also contains initial function characters LF (new line) and CR (carriage return) which are not properly displayed since they are non-alphabet characters

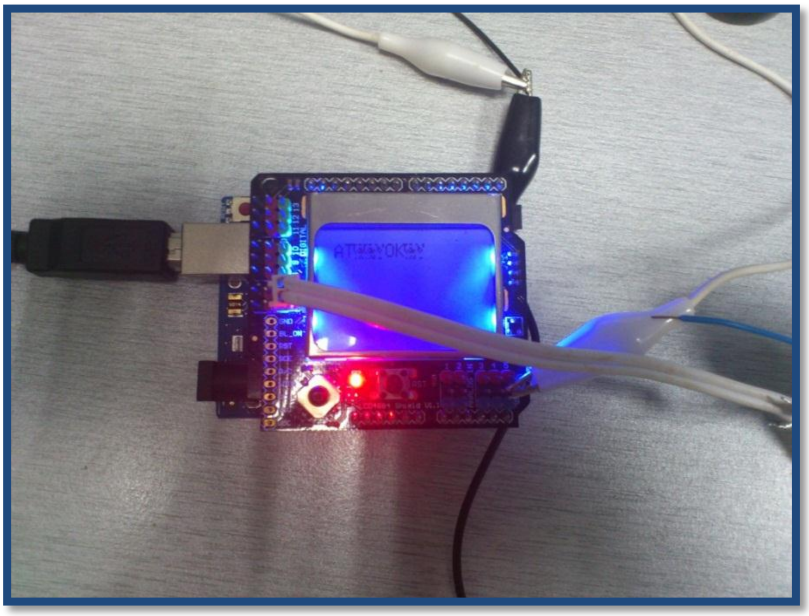


Figure 4.12: Response of the LEON G100 module

After receiving positive feedback from the ublox LEON G100 GSM module, next step is proceeded to get the status of the network registration, to register the module in the network and to check the status of the sim card.

The initial action is to set up the sim card and get the status of the sim card by using the command “AT+CPIN?” The feedback of the LEON-G100 module seems positive with “+CPIN: READY   OK” as in figure 4.13.

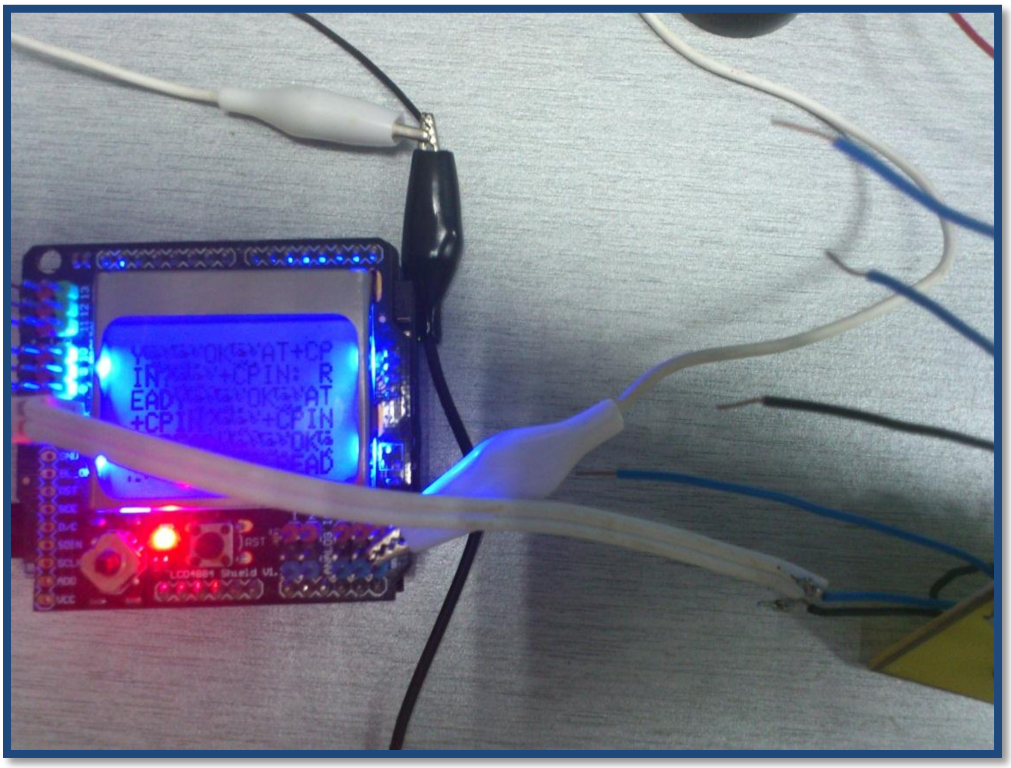


Figure 4.13: Response of the LEON G100 module for checking sim status

Next step is to check the registration status of the module in the mobile network; usually, the LEON G100 GSM module will automatically register itself on the network. The action is performed by sending “AT+CREG?” to the module and receiving response.

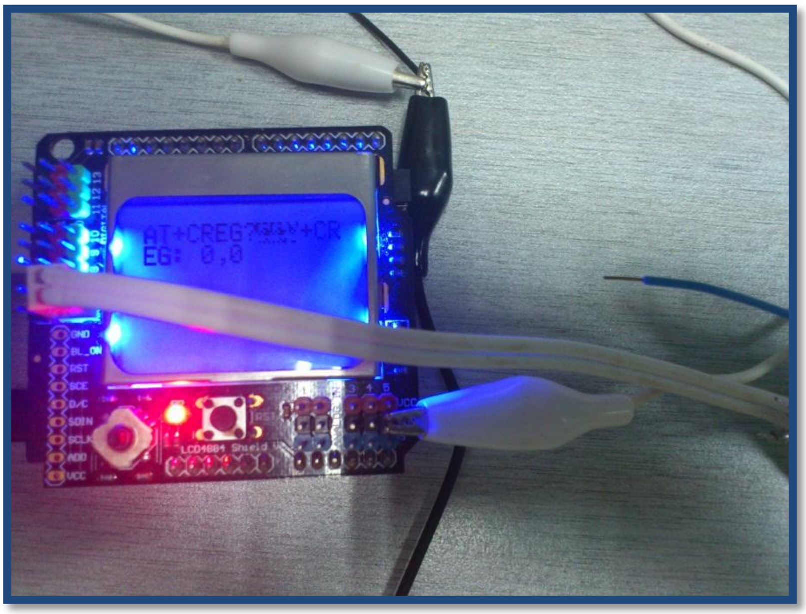



Figure 4.14: Response of LEON G100 module for registration status

As in the figure, the reply from the module is "+CREG: 0,0". The second 0 denotes that the system is not registered on the network, or on the other hand, the automatic registration has failed. As a result, the module has to be forced to register under the mobile network; a command will be send to the module with the following structure "AT+COPS=0".

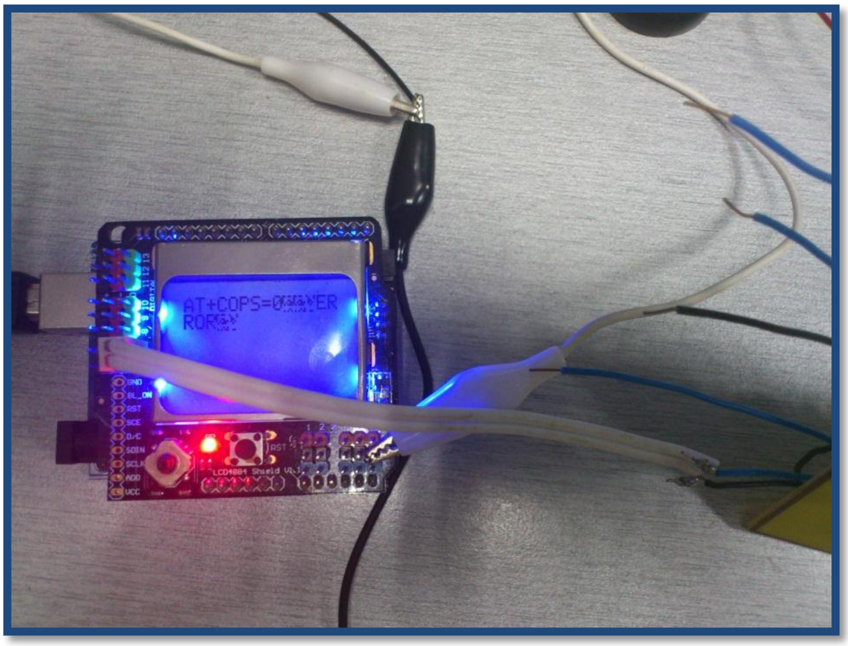



Figure 4.15: Forcing the module to register

However, the module response “ERROR” as the system has faced some problem on registration process. This problem needs troubleshooting in advance to register the module over the mobile network as the final step of sending short message service (SMS) couldn’t be performed without registration.

### 4.2.4 *Discussion on development of system function and behavior*

All the findings and necessary discussion are integrated in the results of the project. The section will discuss further configuration, function and behavior of the system that has not been mentioned earlier.

The configuration that has been set for the ublox NEO-6Q GPS receiver can be described as: CFG_COM1 is left open since it is by default internally lifted high for logic 1, CFG_COM0 is pulled to ground (GND) for logic 0. The CFG_GPS0 is normally left open for logic 1. Hence, the module is set to self-powered with UART baud rate of 384000 and will be operating in maximum performance mode and there’s no restriction for power saving and satellite scanning.

| CFG_COM1 | CFG_COM0 | Protocol | Messages | UARTBaud rate | USB power |
|---|---|---|---|---|---|
| **1** | **1** | **NMEA** | **GSV, RMC, GSA, GGA, GLL, VTG, TXT** | **9600** | **BUS Powered** |
| 1 | 0 | NMEA | GSV, RMC, GSA, GGA, GLL, VTG, TXT | 38400 | Self Powered |
| 0 | 1 | NMEA | GSV[14], RMC, GSA, GGA, VTG, TXT | 4800 | BUS Powered |
| 0 | 0 | UBX | NAV-SOL, NAV-STATUS, NAV-SVINFO, NAV-CLOCK, INF, MON-EXCEPT, AID-ALPSERV | 57600 | BUS Powered |

NEO-6 modules include a **CFG_GPS0** pin, which enables the boot-time configuration of the power mode. These settings are described in Table 7. Default settings in bold.

| CFG_GPS0 | Power Mode |
|---|---|
| 0 | Eco Mode |
| **1** | **Maximum Performance Mode** |

Figure 4.16: Ublox NEO-6Q module configuration [source: ublox]

All other pins of the ublox NEO-6Q GPS module are appropriately set up in order to reach the working situation. For reference, see Appendix A.

Table 4.1: Pins connection for NEO-6Q

| No | Pins | Pin number | Connection |
|---|---|---|---|
| **1** | VCC | 24 | Battery/ power source |
| **2** | GND | 13, 12, 10, 24 | Ground |
| **3** | CFG_COM0 | 14 | Ground |
| **4** | TXD1 | 20 | DTE UART |
| **5** | RXD1 | 21 | DTE UART |
| **6** | VCC_RF | 9 | RSD pin No 8 |
| **7** | RSD | 8 | VCC_RF |
| **8** | RF | 11 | Antenna SMA connector |
| **9** | V_BCK | 22 | Battery holder |
| **10** | Others | Others | Left open |

Ublox LEON G100 GSM module was set up in normal operation but without the speaker, head phone or microphone. It is designed just for receiving call and sending SMS purpose. Hence, sim card holder and SMA connector, capacitors and ESD diodes are the only external component that will be connected to the LEON G100 module beside the pin configuration. The full connection that covers all the interfaces can be seen in Appendix B.

Table 4.2: Pin connection for LEON G100

| No | Pins | Pin No | Connection |
|---|---|---|---|
| **1** | VCC | 50 | Parallel of capacitors: 10pF,39pF,100nF,330mF, ESD and battery or power source |
| **2** | GND | 1,3,6,7,8,17,25,49,48,46,45,36 | Ground |
| **3** | V_BCK | 2 | 100 mF and ground |
| **4** | DTR | 12 | Ground |
| **5** | RI | | DTE (Arduino uno) digital input |
| **6** | RTS | 13 | CTS pin No 14 |
| **7** | PWR_ON | 19 | Ground |
| **8** | ANT | 47 | Antenna 50 impedance wire |
| **9** | VSIM | 35 | Parallel capacitors: 47pF,100nF, ESD and pin 1 and 6 of sim card |
| **10** | SIM_RST | 34 | Parallel capacitors 47pF, ESD and pin 2 of sim card |
| **11** | SIM_IO | 33 | Parallel capacitors 47pF, ESD and pin 7 of sim card |
| **12** | SIM_CLK | 32 | Parallel capacitors 47pF, ESD and pin 3 of sim card |
| **14** | Others | Others | Float |

Another important pin that needs to be taken into account is the Ring Indicator (RI) signal (refer to Appendix C). The pin was internally set high (logic 1) by default; when incoming SMS is received, the pin will be pulled to low (logic 0) for a period of 1 second. After 1 second, the RI was immediately pulled back to logic 1. When an call is detected, RI will be set to low (logic 0), pulled back to logic 1 after 1 second and then pulled back to logic 0 after next 4 second. This process keeps going until the call is over. Taking advantage of this when an incoming call or SMS is received and the RI is set to 0 as a result, Arduino Uno Rev3 Microcontroller will detected based on this RI behavior with the context that the RI pin is connected to Microcontroller's digital input, and it will activate the system accordingly if user has sent a SMS or made a command of calling the system.

Chapter 5

# CONCLUSION AND RECOMMENDATIONS

## 5.1 Conclusion

It is possible to complete the project within the given period if a significant raised problem is not troubleshooting properly. Basically, more than 90 percentage of the workload has been done and proven to be working precisely. However, the main problem that the system is tackling now is that it failed to register the SIM card over the mobile network even though the SIM card has been set up and well detected. Previously, numerous problems has been coped in order to improve the project such as problems come from SMD soldering, PCB fabrication and design, SMA connector, ESD diode, etc. Moreover, the project was developed completely from the new ublox modules and other bare components.

Furthermore, such kind of this system is not quite popular in the market. As a result of the development process, the system can be put into commercial activities once it has been completed. Further design on multilayer PCB can help reducing the wire on the prototype and improving the aesthetic view of the project. The study and the development have to continue in order to improve the stability and facility of the system.

## 5.2 Recommendation

The next action of the project is to troubleshoot the arisen problem and complete the one last step, which is compiling all the codes, and test the system behaviour. Further study should be carried out on using direct microprocessor to streamline the Arduino Uno Rev3 mainboard. Moreover, the continuation of the project can be done to develop much smaller scaled of the prototype with multilayer PCB for better facility. Case fabrication should be performed to connect all part of the system and make it become a stand-alone product.

Design of the system required deep research on the ublox modules functions and reference connection. Further research can be carried out on signal behaviour of each pin and install necessary components in order to stabilise function and prevent module from being damaged by ESD or other noisy components. Once the system is complete, the vehicle tracking system has the potential to be commercialised as the product can earn market share since its facility is not quite popular.

# REFERENCES

[1] Elliott D., Christopher J., Understanding GPS Principles and Application, ARTECH HOUSE, 2006, pp. 1-2.

[2] U.S. Department of Defense/Department of Transportation, 1994 Federal Radio navigation Plan, Springfield, VA: National Technical Information Service, May 2005.

[3] McDonal, K., Navigation Satellite Systems-A Perspective, Proc. 1st Int. Symposium Real Time Differential Applications of the Global Positioning System, Vol. 1, Braunschwig, Federal Republic of Germany, 1991, pp. 20-35

[4] Arthur J., Peter M., Elliott D., and Lawrance F., chapter 3 " GPS System Segment", Understanding GPS Principles and Application, ARTECH HOUSE, 2006 , pp 67.

[5] Bate, R., et al., Fundamentals of Astrodynamics, New York: Dover Publications, 1971.

[6] Parkinson, B., et al., Global Positioning System: Theory and Applications, Vol. I, Washington, D.C.: American Institute of Aeronautics and Astronautics, 1996.

[7] Arthur J., Peter M., Elliott D. and Lawrance F., chapter 3 " GPS System Segment", Understanding GPS Principles and Application, ARTECH HOUSE, 2006 , pp 103-104.

[8] Elliott D., GPS Overview, Understanding GPS Principles and Application, ARTECH HOUSE, 2006, pp 3-4.

[9] Ahmed E., R., Introduction to GPS: The Global Positioning System, Artech House, 2002.

10] James S., The Global Positioning System: Theory and Application, Volume 1, AIAA, 1996.

[11] Wellenhof H., Herbert L., James C., Global Positioning System: theory and practice, Springer-Verlag, 1997.

[12] George T., Geoff B., Intelligent positioning: GIS-GPS unification, John Wiley, May 22, 2006.

[13] Pratap M., and Per E., Global Positioning System: Signals, Measurements, and Performance, second edition, Ganga-Jamuna Press, 2011.

[14] Universal asynchronous receiver/transmitter, 2012, www.wikipedia.org

[15] RS-232, 2012, www.wikipedia.org

[16] Microcontroller UART, 2012, http://www.societyofrobots.com

[17] Arduino Uno, 2012, http://www.arduino.cc/

[18] Arduino IDE, 2012, www.wiki.archlinux.org.

[19] LEON G100 G200 System Integration Manual, ublox, 2012.

[20] LEON G100 G200 Datasheet, ublox, 2012.

[21] NEO-6 Datasheet, ublox, 2012

[22] LEA-6 NEO-6 MAX-6 Hardware Integration Manual, ublox, 2012

[23] AT Commands Examples Application Note, ublox, 2012

[24] Receiver Description Protocol Spec, ublox, 2012

# APPENDIX A

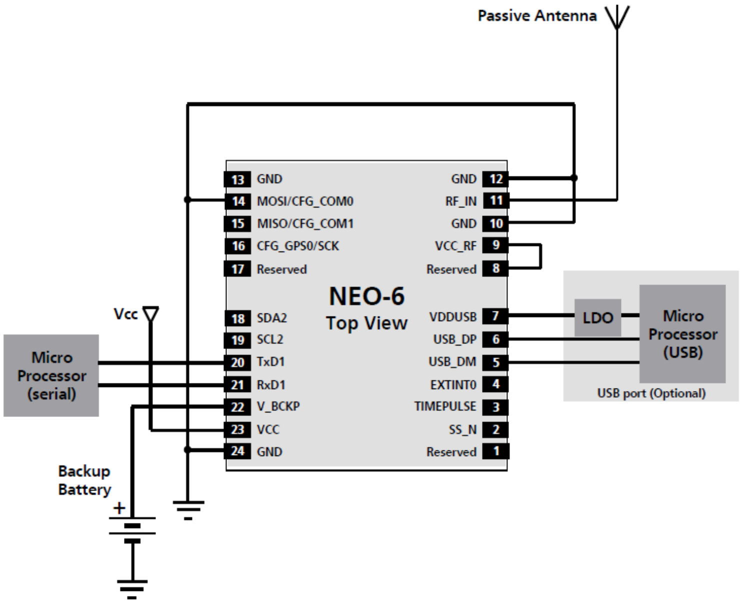



Figure 5.1: NEO-6Q design with passive antenna [source: ublox]

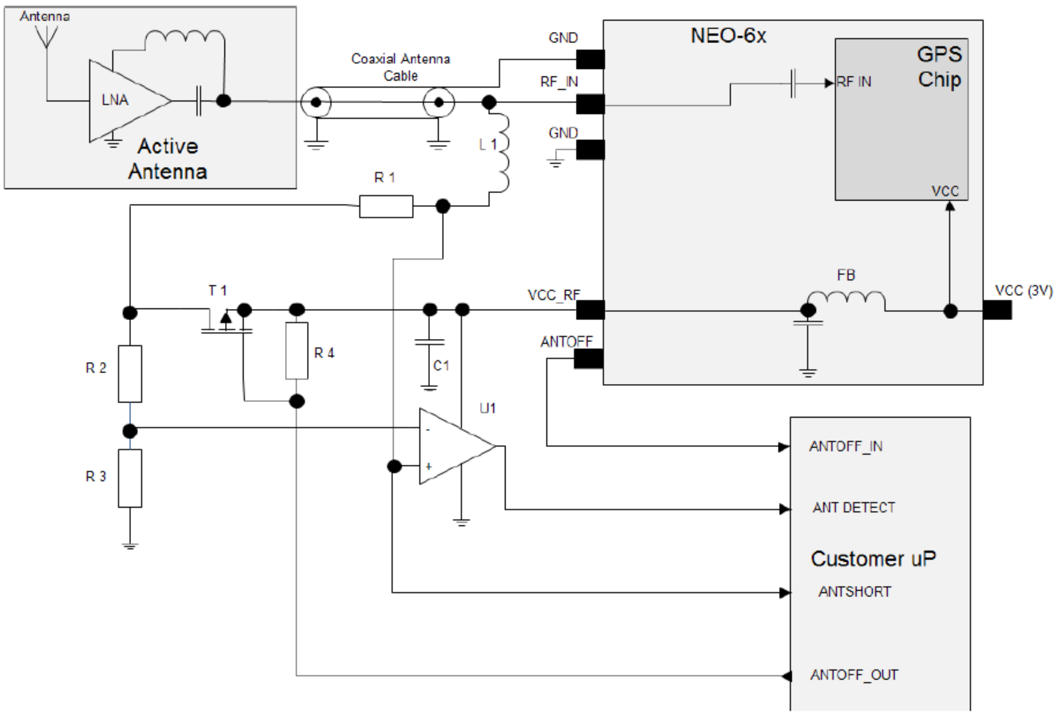



Figure 5.2: NEO-6 design with active antenna and ANTOFF [source: ublox]

# APPENDIX B

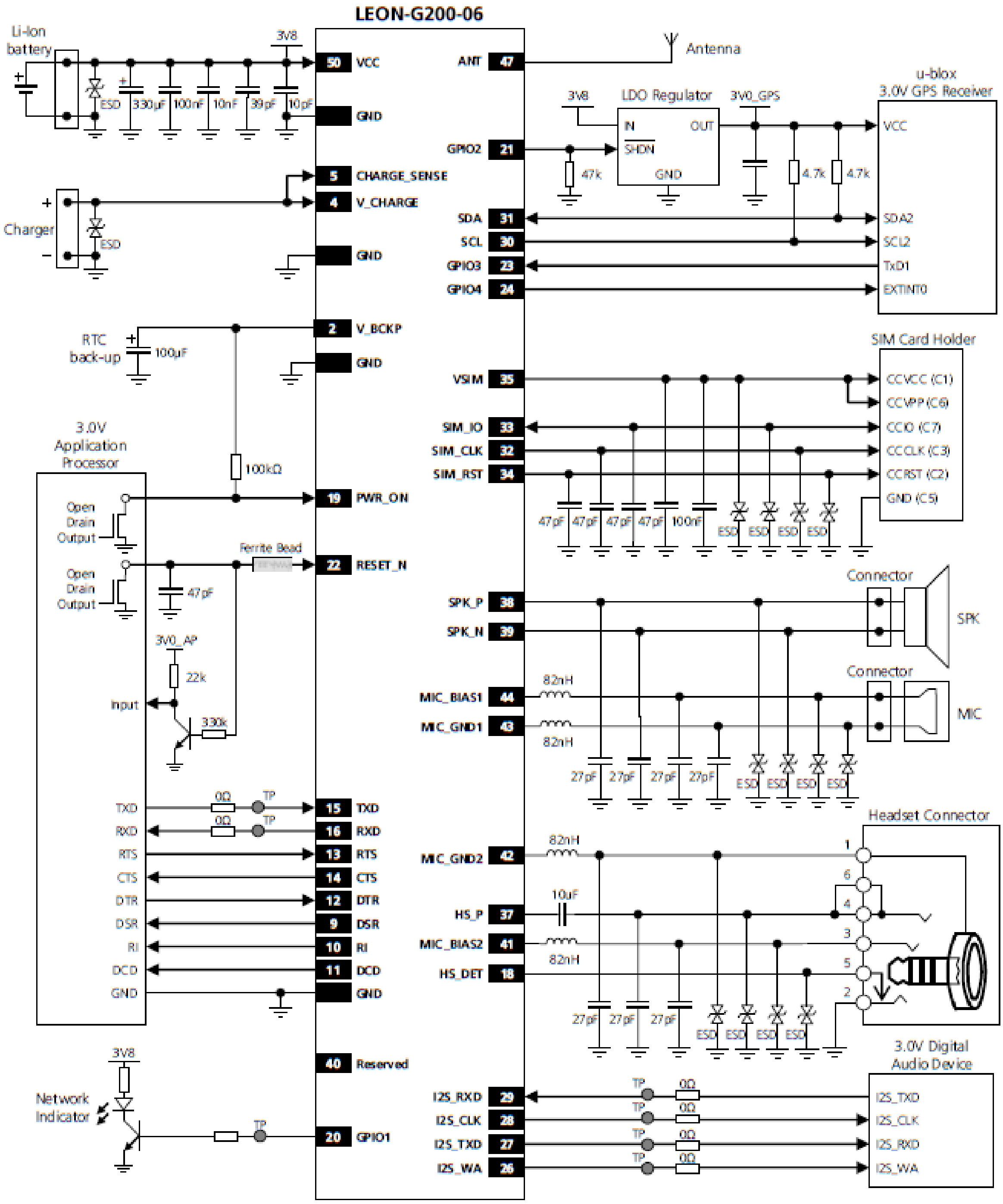
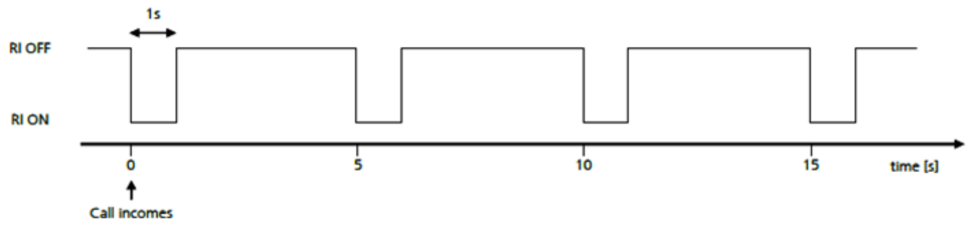



Figure 5.3: LEON G100 design [source: ublox]

# APPENDIX C

- Incoming call




- In coming SMS

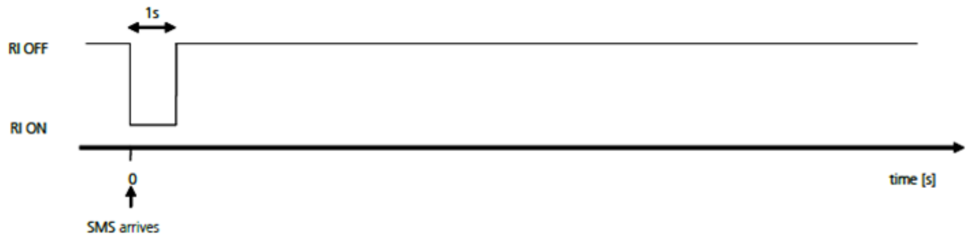



Figure 5.4: Ring Indicator signal [source: ublox]

# APPENDIX D

Code for testing graphic LCD display

```
#include "LCD4884.h"
#define MENU_X  10      // 0-83
#define MENU_Y  1       // 0-5
int counter = 0;
char string[10];
void setup(){
  lcd.LCD_init();
  lcd.LCD_clear();
  //menu initialization
  init_MENU();}
void init_MENU(void){
  byte i;
  lcd.LCD_clear();
  lcd.LCD_write_string(MENU_X, MENU_Y, "Pham Dat", MENU_HIGHLIGHT );
  lcd.LCD_write_string(MENU_X, MENU_Y +1 , "12966", MENU_HIGHLIGHT );
  lcd.LCD_write_string(MENU_X, MENU_Y +2 , "Testing", MENU_HIGHLIGHT );}
void loop(){
  if(++counter < 1000){
    itoa(counter,string,10);
    lcd.LCD_write_string(MENU_X, MENU_Y + 3, string, MENU_NORMAL);
  }
  else  counter = 0,init_MENU();
  delay(10);}
```

# APPENDIX E

Code for ublox NEO-6Q GPS receiver

```
#include "LCD4884.h"

#define MENU_X  0      // 0-83

#define MENU_Y  0       // 0-5

char disp[60];

char dip[60];

int input1;

int i=-1;

int j=0;

int k=0;

char data;

void(* resetFunc) (void) = 0; //declare reset function @ address 0

void setup()

{

  Serial.begin(38400);

  lcd.LCD_init();

  lcd.LCD_clear();

  //menu initialization

  init_MENU();

}

void init_MENU(void){

  lcd.LCD_clear();

  //lcd.LCD_write_string(MENU_X, MENU_Y , "Receiving", MENU_HIGHLIGHT );

}

void loop(){

  char *input ="AT";
```

```
  Serial.println(disp);
  delay(100);
  if(Serial.available()>0){
  data = Serial.read();//read data
  i=i+1;
  disp[i]=data;//store data
  if(disp[i-2]=='T' & disp[i-1]=='X' & disp[i]=='T'){ resetFunc();}
  if(disp[i-1]=='$' & disp[i]=='G' & i>3 ){k=k+1;i=1;disp[0]='$';disp[1]='G';}
  if(disp[i-12]=='C' & disp[i-13]=='M' & disp[i-14]=='R' & disp[i]=='A'){dip[j]=disp[i];
j=j+1;}
  if(k==10){
  k=0;
  i=-1;
  resetFunc();  //call reset
  }
  }
  lcd.LCD_write_string(MENU_X, MENU_Y+1, disp, MENU_NORMAL);
}
```

# APPENDIX F

List of NMEA messages

| *Page* | *Mnemonic* | *Cls/ID* | *Description* |
|---|---|---|---|
| | **NMEA Proprietary Messages** | | **Proprietary Messages** |
| 64 | **UBX,00** | 0xF1 0x00 | Lat/Long Position Data |
| 66 | **UBX,03** | 0xF1 0x03 | Satellite Status |
| 68 | **UBX,04** | 0xF1 0x04 | Time of Day and Clock Information |
| 69 | **UBX,05** | 0xF1 0x05 | Lat/Long Position Data |
| 71 | **UBX,06** | 0xF1 0x06 | Lat/Long Position Data |
| 74 | **UBX,40** | 0xF1 0x40 | Set NMEA message output rate |
| 75 | **UBX,41** | 0xF1 0x41 | Set Protocols and Baudrate |
| 73 | **UBX** | 0xF1 0x40 | Poll a PUBX message |
| | **NMEA Standard Messages** | | **Standard Messages** |
| 51 | **DTM** | 0xF0 0x0A | Datum Reference |
| 52 | **GBS** | 0xF0 0x09 | GNSS Satellite Fault Detection |
| 53 | **GGA** | 0xF0 0x00 | Global positioning system fix data |
| 54 | **GLL** | 0xF0 0x01 | Latitude and longitude, with time of position fix and status |
| 55 | **GPQ** | 0xF0 0x40 | Poll message |
| 56 | **GRS** | 0xF0 0x06 | GNSS Range Residuals |
| 57 | **GSA** | 0xF0 0x02 | GNSS DOP and Active Satellites |
| 58 | **GST** | 0xF0 0x07 | GNSS Pseudo Range Error Statistics |
| 59 | **GSV** | 0xF0 0x03 | GNSS Satellites in View |
| 60 | **RMC** | 0xF0 0x04 | Recommended Minimum data |
| 61 | **TXT** | 0xF0 0x41 | Text Transmission |
| 62 | **VTG** | 0xF0 0x05 | Course over ground and Ground speed |
| 63 | **ZDA** | 0xF0 0x08 | Time and Date |

Table 5.1: List of NMEA messages [source: ublox]

# APPENDIX G

Recommended Minimum Data (RMC) structure list

Message Structure:

```
$GPRMC,hhmmss,status,latitude,N,longitude,E,spd,cog,ddmmyy,mv,mvE,mode*cs<CR><LF>
```

Example:

```
$GPRMC,083559.00,A,4717.11437,N,00833.91522,E,0.004,77.52,091202,,,A*57
```

| *Field No.* | *Example* | *Format* | *Name* | *Unit* | *Description* |
|---|---|---|---|---|---|
| 0 | $GPRMC | string | `$GPRMC` | - | Message ID, RMC protocol header |
| 1 | 083559.00 | hhmmss.sss | `hhmmss.ss` | - | UTC Time, Time of position fix |
| 2 | A | character | `Status` | - | Status, V = Navigation receiver warning, A = Data valid, see Position Fix Flags description |
| 3 | 4717.11437 | ddmm.mmmm | `Latitude` | - | Latitude, Degrees + minutes, see Format description |
| 4 | N | character | `N` | - | N/S Indicator, hemisphere N=north or S=south |
| 5 | 00833.91522 | dddmm.mmmm | `Longitude` | - | Longitude, Degrees + minutes, see Format description |
| 6 | E | character | `E` | - | E/W indicator, E=east or W=west |
| 7 | 0.004 | numeric | `Spd` | knots | Speed over ground |
| 8 | 77.52 | numeric | `Cog` | degrees | Course over ground |
| 9 | 091202 | ddmmyy | `date` | - | Date in day, month, year format |
| 10 | - | numeric | `mv` | degrees | Magnetic variation value, not being output by receiver |
| 11 | - | character | `mvE` | - | Magnetic variation E/W indicator, not being output by receiver |
| 12 | - | character | `mode` | - | Mode Indicator, see Position Fix Flags description |
| 13 | *57 | hexadecimal | `cs` | - | Checksum |
| 14 | - | character | `<CR><LF>` | - | Carriage Return and Line Feed |

Table 5.2: RMC message structure [source: ublox]

# APPENDIX H

Messages received from NEO-6Q module

$GPRMC,124224.00,A,0423.24145,N,10057.84930,E,1.252,,101212,,,A*70

$GPRMC,124224.00,A,0423.24145,N,10057.84930,E,1.252,,101212,,,A*70

$GPRMC,124224.00,A,0423.24145,N,10057.84930,E,1.252,,101212,,,A*70

$GPRMC,124224.00,A,0423.24145,N,10057.84930,E,1.252,,101212,,,A*70

$GPRMC,124224.00,A,0423.24145,N,10057.84930,E,1.252,,101212,,,A*70

$GPRMC,124224.00,A,0423.24145,N,10057.84930,E,1.252,,101212,,,A*70

$GPVMC,124224.00,A,0423.24145,N,10057.84930,E,1.252,,101212,,,A*70

$GPVTC,124224.00,A,0423.24145,N,10057.84930,E,1.252,,101212,,,A*70

$GPVTG,124224.00,A,0423.24145,N,10057.84930,E,1.252,,101212,,,A*70

$GPVTG,,T,,M,100,A,0423.24145,N,10057.84930,E,1.252,,101212,,,A*70

$GPVTG,,T,,M,1.0,A,0423.24145,N,10057.84930,E,1.252,,101212,,,A*70

$GPVTG,,T,,M,1.2,A,0423.24145,N,10057.84930,E,1.252,,101212,,,A*70

$GPVTG,,T,,M,1.252,N,2.319,K,A*,10057.84930,E,1.252,,101212,,,A*70

$GPVTG,,T,,M,1.252,N,2.319,K,A*210057.84930,E,1.252,,101212,,,A*70

$GPVTG,,T,,M,1.252,N,2.319,K,A*2E0057.84930,E,1.252,,101212,,,A*70

$GPVTG,,T,,M,1.252,N,2.319,K,A*2E

$GPVTG,,T,,M,1.252,N,2.319,K,A*2E

$GPVTG,,T,,M,1.252,N,2.319,K,A*2E

$GPVTG,,T,,M,1.252,N,2.319,K,A*2E

$GPGTG,,T,,M,1.252,N,2.319,K,A*2E

$GPGGG,,T,,M,1.252,N,2.319,K,A*2E

$GPGGA,,T,,M,1.252,N,2.319,K,A*2E

$GPGGA,,T,,M,1.252,N,2.319,K,A*2E

$GPGGA,1T,,M,1.252,N,2.319,K,A*2E

$GPGGA,12,,M,1.252,N,2.319,K,A*2E

$GPGGA,124,M,1.252,N,2.319,K,A*2E

$GPGGA,1242M,1.252,N,2.319,K,A*2E

$GPGGA,12422,1.252,N,2.319,K,A*2E

$GPGGA,124224.00,04N,2.319,K,A*2E

$GPGGA,124224.00,042,2.319,K,A*2E

$GPGGA,124224.00,04232.319,K,A*2E

$GPGGA,124224.00,0423..319,K,A*2E

$GPGGA,124224.00,0423.2319,K,A*2E

$GPGGA,124224.00,0423.2419,K,A*2E

$GPGSV,3,3,11,29,07,141,,30,14,202,15,31,51,247,15*40

$GPGSV,3,3,11,29,07,141,,30,14,202,15,31,51,247,15*40

$GPGSV,3,3,11,29,07,141,,30,14,202,15,31,51,247,15*40

$GPGSV,3,3,11,29,07,141,,30,14,202,15,31,51,247,15*40

$GPGSV,3,3,11,29,07,141,,30,14,202,15,31,51,247,15*40

$GPGSV,3,3,11,29,07,141,,30,14,202,15,31,51,247,15*40

$GPGSV,3,3,11,29,07,141,,30,14,202,15,31,51,247,15*40

$GPGLV,3,3,11,29,07,141,,30,14,202,15,31,51,247,15*40

$GPGLL,0423.24003,N,1005,30,14,202,15,31,51,247,15*40

$GPGLL,0423.24003,N,1005730,14,202,15,31,51,247,15*40

$GPGLL,0423.24003,N,10057.0,14,202,15,31,51,247,15*40

$GPGLL,0423.24003,N,10057.8,14,202,15,31,51,247,15*40

$GPGLL,0423.24003,N,10057.8514,202,15,31,51,247,15*40

$GPGLL,0423.24003,N,10057.85673,E,124201.00,A,A*61

$GPGLL,0423.24003,N,10057.85673,E,124201.00,A,A*61

$GPGLL,0423.24003,N,10057.85673,E,124201.00,A,A*61

# APPENDIX I

List of NMEA position fix flags interpretation

| NMEA Message: Field | No position fix (at power-up, after losing satellite lock) | Valid position fix, but user limits exceeded | Dead reckoning (linear extrapolation) | Dead reckoning (ADR with external sensors, or map matching) | 2D position fix | 3D position fix | combined GPS/SFDR position fix (ADR with external sensors) |
|---|---|---|---|---|---|---|---|
| GLL, RMC: Status | V | V | A | A | A | A | A |
| | A=Data VALID, V=Data invalid (Navigation Receiver Warning) | | | | | | |
| GGA: Quality Indicator | 0 | 0 | 6 | 6 | 1 / 2 | 1 / 2 | 1 / 2 |
| | 0=Fix not available/invalid, 1=GPS SPS Mode, Fix valid, 2=Differential GPS, SPS Mode, Fix Valid, 6=Estimated/Dead Reckoning | | | | | | |
| GSA: Nav Mode | 1 | 1 | 2 | 2 | 2 | 3 | 3 |
| | 1=Fix Not available, 2=2D Fix, 3=3D Fix | | | | | | |
| GLL, RMC, VTG: Mode Indicator | N | N | E | E | A / D | A / D | A / D |
| | N=No Fix, A=Autonomous GNSS Fix, D=Differential GNSS Fix, E=Estimated/Dead Reckoning Fix | | | | | | |
| UBX GPSFixOK | 0 | 0 | 1 | 1 | 1 | 1 | 1 |
| UBX GPSFix | 0 | >1 | 1 | 1 | 2 | 3 | 4 |

The following list shows how u-blox implements the NMEA protocol, and the conditions determining how flags are set in version 2.2 and below.

| NMEA Message: Field | No position fix (at power-up, after losing satellite lock | Valid position fix, but user limits exceeded | Dead reckoning (linear extrapolation) | Dead reckoning (ADR with external sensors, or map matching) | 2D position fix | 3D position fix | combined GPS/SFDR position fix (ADR with external sensors) |
|---|---|---|---|---|---|---|---|
| GLL, RMC: Status | V | V | A | A | A | A | A |
| | A=Data VALID, V=Data invalid (Navigation Receiver Warning) | | | | | | |
| GGA: Quality Indicator | 0 | 0 | 1 | 1 | 1 / 2 | 1 / 2 | 1 / 2 |
| | 0=Fix not available/invalid, 1=GPS SPS Mode, Fix valid, 2=Differential GPS, SPS Mode, Fix Valid | | | | | | |
| GSA: Nav Mode | 1 | 1 | 2 | 2 | 2 | 3 | 3 |
| | 1=Fix Not available, 2=2D Fix, 3=3D Fix | | | | | | |
| GLL, RMC, VTG: Mode Indicator. This field is not output by this NMEA version. | | | | | | | |
| UBX GPSFixOK | 0 | 0 | 1 | 1 | 1 | 1 | 1 |
| UBX GPSFix | 0 | >1 | 1 | 1 | 2 | 3 | 4 |

Table 5.3: Position Fix Flags [source: ublox]

# APPENDIX J

Code for testing AT command with LEON-G100 GSM module

```
#include "LCD4884.h"
#define MENU_X  0      // 0-83
#define MENU_Y  0       // 0-5
char disp[20];
char dip[20];
char input[10];
int input;
int flag=0;
int i=-1;
int j=0;
char data;
void(* resetFunc) (void) = 0;
void setup()
{
  Serial.begin(38400);
  lcd.LCD_init();
  lcd.LCD_clear();
  //menu initialization
  init_MENU();
}
void init_MENU(void){
  lcd.LCD_clear();
}
void loop(){
  Serial.print("AT\r");
```

```
 delay(100);
 delay(200);
 Serial.print("AT+CPIN?\r");
 Serial.print("AT+COPS?\r");
 Serial.print("AT+CREG=1\r");
//delay(100);
 Serial.print("AT+CREG?\r");
Serial.print("AT+CMEE=2\r");
 delay(200);
 Serial.print("AT+COPS=0\r");
Serial.print("AT+CMGF=1\r"); //Set text mode
Serial.print("AT+CMGS="); //Send message
Serial.write((byte)0x22); //"
Serial.print("0149048916"); //Phone no
Serial.write((byte)0x22); //"
Serial.write((byte)0x0D); //Enter
Serial.print("Hai, I'm DAT");//Text message
Serial.write((byte)0x0D); //Enter
Serial.print("Reply, if you receive this message");//Text message
Serial.write((byte)0x1A); //Ctrl+Z]
lcd.LCD_write_string(MENU_X, MENU_Y , disp , MENU_NORMAL);
 if(Serial.available()>0)
 {
   i=i+1;
 data = Serial.read();//read data
 disp[i]=data;//store data
}}
```