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Design and Realization of a GPS Tracker

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الجمهورية الجزائرية الديمقراطية الشعبية
People's Democratic Republic of Algeria
وزارة التعليم العالي و البحث العلمي
Ministry Of Higher Education and Scientific Research

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Telecommunication
Option: Networks and Telecommunication
A Dissertation for the Fulfillment of the Requirement of a

Master's Degree

Design and Realization of GPS Tracker

Presented by:

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Department Field:
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ABSTRACT

This project aims to design and realize a tracking device capable of providing the observer with real-time location coordinates.

Where the system receives GPS location data and sends it to the (observer) server via SMS technology provided by the GSM unit using the Arduino board. The location data is displayed on Google Map on device of observer.

One of the important advantages of this system is that the user can control the system from the cell phone and receive system location information in real time.

Keyword: GPS, GSM, SMS, Arduino, System of traking, device traking.

Dedication

Thank God for who I am now and what I will be

For myparents those who stayed up lateand they were the moon and the sun

I am here thanks to my father's fatigue and my mother's prayers,

As long as you bless and light for me

To myself, I promised that you will be proud of me, and here I am, in the first steps of fulfillingmy promise

To life's obstacles, their good and bad, which made my academic career so special

"Work hard in silence ,let success make the noise"

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and Jury members to have accepted to participate in this defense of the master

- Ms. Tobbech Souad, the Examiner of jury

- Mr. Benelmir Okba, the President of jury

to have accepted to participate in this defense of the master.

I am extremely grateful to **My Parents** *for their love, prayers, caring and sacrifices for educating and preparing me for my future,*

My grandmother "Oma Aicha" to contain me with her love, tenderness and concern,

Also, I express my thanks to my lovely sisters: hadil,kounouz, djawaher

Brothers: Rossafi and sohaib. They were the ones who fueled my passion and were the motivating part of my days to be a special person just as I am now.

The soulmates Sabrina, hassnabouthaina who have shared every moment of my life with meand they made it more unique

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My special thanks go to all the people who have supported me, encouraged me and just help me even with a few words to stand up again and again all the time

"thank of Allah"

TABLE OF CONTENTS

Chapter I: An Overview of Global Positioning System

Chapiter II: An Overview of Global System for Mobile Communication

Chapter III: Realization of a GPS Tracker

Figures List

Chapter I

Chapter II

Chapter III

Tables List

Chapter I

Chapter II

Chapter III

Abbreviations List

GPS: Global Position System.

MCS: Master Control Station.

SA: Selective Availability.

DOP: Dilution of Precision.

GDOP: Gemetric Dilution of Precision.

PDOP: Position Dilution of Precision.

HDOP: Horizontal Dilution of Precision.

VDOP: Vertical Dilution of Precision.

TDOP: Time Dilution of Precision.

RDOP: Relative Dilution of Precision.

DGPS: Differential Global Position System.

ARNS: Aeronautical Radio Navigation Service.

GIS: Geographic information system

WAAS: Wide Area Augmentation System.

ETSI: European Telecommunications Standards Institute.

GSM: Global System for Mobile communication.

SIM: Subscriber identity module.

GPRS: General Packet Radio Service.

IDE: Integrated Development Environment.

USB: Universal Serial Bus.

UART: Universal Asynchronous Receiver-Transmitter

RX/TX: Receiver/Transmitter

CEPT : Conférence Européenne des Postes et Télécommunications

EDGE: Enhanced Data Rates for GSM Evolution

UMTS: Universal Mobile Telecommunications System

SMS: Short Message System

BSS: Base Station Subsystem

NSS: Network Subsystem.

OSS: Operation Subsystem.

BTS: Base Transceiver Station.

BSC: Base Station Controller.

MS: Mobile Station.

MSC: Mobile Switching Center.

VLR: Visitor Location Register.

HLR: Home Location Register.

AUC: Authentication Center.

EIR: Equipement Identity Register.

ME: Mobile Equipement.

TE: Terminal Equipement.

Abstract

This project aims to design and realize a tracking device capable of providing the observer with real-time location coordinates.

Where the system receives GPS location data and sends it to the (observer) server via SMS technology provided by the GSM unit using the Arduino board. The location data is displayed on Google Map on device of observer.

One of the important advantages of this system is that the user can control the system from the cell phone and receive system location information in real time.

Keyword: GPS, GSM, SMS, Arduino, System of traking, device traking.

ملخص

يهدف هذا المشروع إلى تصميم وتحقيق جهاز تتبع قادر على تزويد المراقب بإحداثيات الموقع في الوقت الفعلي.

حيث يتلقى النظام بيانات موقع GPS ويرسلها إلى الخادم (المراقب) عبر تقنية الرسائل القصيرة التي توفرها وحدة GSM باستخدام لوحة Arduino , يتم عرض بيانات الموقع على خريطة جوجل على جهاز المراقب.

من أهم مزايا هذا النظام أنه يمكن للمستخدم التحكم في النظام من الهاتف الخلوي واستقبال معلومات موقع النظام في الوقت الفعلي.

General Introduction

General introduction

In era of globalization and a world driven by technology, we often encounter the term "tracking", or rather surveillance, so that many people always aspire to be constantly aware of their property information in terms of security and privacy.

For example, we notice at the present time that most tend to own cars, and this requires tracking to reduce the phenomenon of theft.

Tracking is not limited to private property only, on the contrary, we find it in various fields, internally and externally, such as ships, airplanes, industry, such as car rental companies, public transport ... and other fields in addition to what we have seen recently, such as protecting children from theft and even the health aspect. GPS and GSM embodied this term.

At the present time, traditional maps are not enough. With the passage of time and the development that we are living in, we cannot be satisfied with the data about the path that was written with the pen by explorers and others, but we need the most complex and accurate. From here comes the role of GPS, which is the modern technology by providing comprehensive information such as location and time and speed and others in most circumstances

The second technology is GSM, among the common communication technologies, which helped spread the term of tracking to provide information every period of time specified in its most popular services "SMS"short message.

Objective

Tracking and managing devices, properties and everything in real time has been an area ofinterest for many scientists and the public, and thanks to modern technology in electronics, it has become an applied reality.

In this study, we will try to design and implement a tracking device that enables us to track a group of vehicles in real time using the Arduino controller, the GPS module to obtain location information, and the GSM module to provide us with the coordinates in the required time.

The Research chapters

We divided the project into three chapters:

Chapter 1: It provides an overview of the Global Positioning System (GPS) like history, components, services, signal structure, errors, updates, and its applications.

Then Chapter II: In this chapter, we highlight the second generation Mobile Global System Communications "GSM" like history, System Architecture, Interfaces, The Short Messaging Service Center.

Finally, **Chapter III:** the most part important in our project is this chapter, we will design and realization of a GPS tracker using the Arduino UNO, GSM and GPS Module.

Chapter I

An Overview of Global Positioning System

I.1 INTRODUCTION:

The development we live in now always begins with a question, then, becomes an idea, then an ambition, the same applies to the question of Where am I? How do I get there? GPS answers these questions.

GPS has made a unique leap in technology by providing continuous real-time navigation and high-resolution positioning.

In this chapter, we will try to provide a comprehensive overview of this system such as history, components, services, signal structure, errors,Modernization, GPS applications.

I.2 The History of GPS

TheGlobal Positioning System (GPS) has a long history of trial and error and refinement and improvement. Its purpose has shifted from being a military strategic asset to commonplace among the general public with its use in traveling, farming, and even banking. The beginning of GPS, introduced with a simple idea, can be traced back to the Soviet Union in the late 1950's.[1]

Below is a brief timeline of the development of the GPS system, including some symbolic dates:

- **1973:** Decision taken to build a satellite navigation system.
- **1974-1979:** System tests are undertaken.
- **1977:** The first receiver tests are carried out even before the first satellites are put into orbit. The tests used transmitters installed on land called pseudolites (pseudo-satellites).
- **02/22/1978:** Launch of the 1st GPS satellite of block 1.
- **1978-1985:** 11 block 1 satellites were already put into orbit during this period. The satellites of block 1 are developed to validate the concept of GPS. No satellite of this generation is yet in use.
- **1980-1982:** The financial situation of the project is critical; its usefulness is questioned by the funders (sponsors).
- **1983:** After a civilian plane from Korean Airline 'flight No. 007 was shot down over the Soviet Union, after having strayed, US President Ronald Reagan proposed opening the system GPS for civilian users around the world.

- **1986:** The ―Challenger‖ space shuttle crash caused a problem for the GPS system. The shuttles were intended to transport the Block 2 GPS satellites to their orbits. Eventually those responsible for the program turned to the Delta rockets to launch the GPS satellites.
- **01/10/1987:** The WGS-84 (World Geodetic System 1984) geodetic system is adopted for all position calculations with GPS.
- **02/14/1989:** The 1st satellite of Block 2 is installed and put into service. This type of satellite is much more precise and can remain 14 days without contact with the monitoring stations while maintaining sufficient precision.
- **1990-1991:** Temporary deactivation of selective availability (SA) during the First Gulf War. Since the number of military GPS receivers available is insufficient, civilian GPS receivers are used. In 07/01/1991 selective availability was reactivated again.
- **12/08/1993:** The Initial Operational Capability is announced (IOC, The Initial Operational Capability). In the same year, it was decided to allow civilian use of GPS free of charge, worldwide.
- **March 1994:** The constellation became complete with the BLOCK 2 satellites.
- **07/17/1995:** The total operational capacity is announced (FOC, Full Operational Capability).
- **05/01/2000:** Definitive deactivation of selective availability and consequently improved accuracy for civilian users, from approximately 100m to 20m.
- **09/26/2005:** Launch of the 1st GPS-2R-M satellite. These new satellites support the new military signal M and the second civilian signal L2C.
- **03/24/2009:** Launch of the 20th satellite of the 2R-M block. It is part of the modernization satellites of the GPS system. It broadcasts the new civilian signal on frequency L5. The integration of the L5 signal on this satellite aims to:
  - ✓ Place an L5 signal transmitter in orbit to prove that it does not interfere with other GPS signals already broadcast.
  - ✓ Allow manufacturers of GPS receivers to have the L5 signal broadcast from space so that they can develop and test their receivers that support the L5 signal.
  - ✓ Serve the L5 frequency for the GPS system in accordance with the specifications of the ITU (International Telecommunications Union). Indeed, the L5 signal had to be broadcast before 08/26/2009; otherwise the frequency can be requested by another country. The satellite started transmitting the L5 signal on 04/10/2009 at 11:58 UTC [2].

I.3 GPS technology

GPS consists of a network of 24satellites in six different 12-hour orbitalpaths spaced so that atleast five are inview from every point on the globe. Thesatellites continuously transmit militaryand civilian navigation data on two L-bandfrequencies. Five monitor stationsand four groundantennas locatedaround the world passively gatherrange data on each satellite's exact position.The system relays this informationto the master control station atSchriever Air Force Base inColorado,which provides overall coordination ofthe network and transmits correctiondata tothe satellites.Each satellite emits radio signals that a receivera miniature device installedtrack, trip distance, distance to destination,and sunrise and sunset time.To obtain an accurate fixon a movingobject or person, GPS determineshow long it takes a satellite signal toreach areceiver, which generates itsown signal. Assuming that the signalsare synchronous, GPScompares thesatellite signal's pseudorandom numbercodea digital signature unique toeachsatellitewith the receiver's PNCto determine the signal's travel time.

The system multiplies this value by thespeed of light to compute the satellite'sdistance from the receiver,because thesatellites are nearly11,000 miles away, miscalculating signaltravel time by even a fewmillisecondscan cause a location errormeasuring as much as 200 miles.Satellites therefore useextremely preciseand expensiveatomic clocks.

A receiver's clock doesn't need to be asaccuratebecause it measures the distanceto a fourth satellite to synchronizeits PNC with the satellitesandcorrect for any timing offset.Because the satellites serve as reference points, accuratelocation trackingrequires knowing exactly where theyare at all times. In addition topseudorandomcode, satellite signals includenavigation data. The monitoring stationsandground antennas, which constantlycheck satellites' speed, position,and altitude, look forephemeris(orbital) errors caused by gravitationalpulls from the moon and sun as well assolarradiation pressure. The monitorsrelay this information back to the satellites,which incorporate itinto the timingsignals.[3]

I.4 Locating a Position with the GPS Receiver

The distance between the position of the GPS satellite and the GPS receiver is calculated by using Equation: **Distance= speed × time**

In other words, a GPS receiver determines the amount of time it takes the radio signal (i.e., GPS signal) to travel from the GPS satellite to the GPS receiver. The GPS signal travels at the speed of light (186 thousand miles per second). Both the GPS satellite and the GPS receiver generate an identical pseudo-random code sequence. When the GPS receiver receives this transmitted code, it determines how much the code needs to be shifted (using the Doppler-shift principle) for the two code sequences to match. Therefore, the shift is multiplied by the speed of light to determine the distance from the GPS satellite to the GPS receiver.

GPS satellites are orbiting the Earth at an altitude of 11 thousand miles. Assuming that the GPS receiver and the satellite clocks are precisely and continually synchronized, the GPS receiver uses three satellites to triangulate a 3D position, then the GPS provides coordinates (X, Y, Z) for a calculated position. However, a GPS receiver needs four satellites to provide a 3D position, as shown in Figure 1.1. Since the GPS receiver clock is not as accurate as the atomic clocks in the satellites, then a fourth variable T for time is determined in addition to the three variables (X, Y, and Z). Moreover, the GPS signals travel from the GPS satellite to the GPS receiver very fast, thus, if the two clocks are off only a small fraction of time, the determined position may be inaccurate.

The DoD can predict the paths of the satellites vs. time with great accuracy. It constantly monitors the orbit of the satellites looking for deviations, known as ephemeris errors, from predicted values. Once these errors are detected for a given satellite, they will be sent back up to that satellite, which broadcasts them to the GPS receivers as a standard message. Nowadays, the GPS receivers store the orbit information, known as an almanac, for all the GPS satellites. Therefore, this information advises about the position of each satellite at a particular time. Moreover, this information in conjunction with the ephemeris error data can help to determine in a very precise way the position of a GPS satellite at a given time.[4]

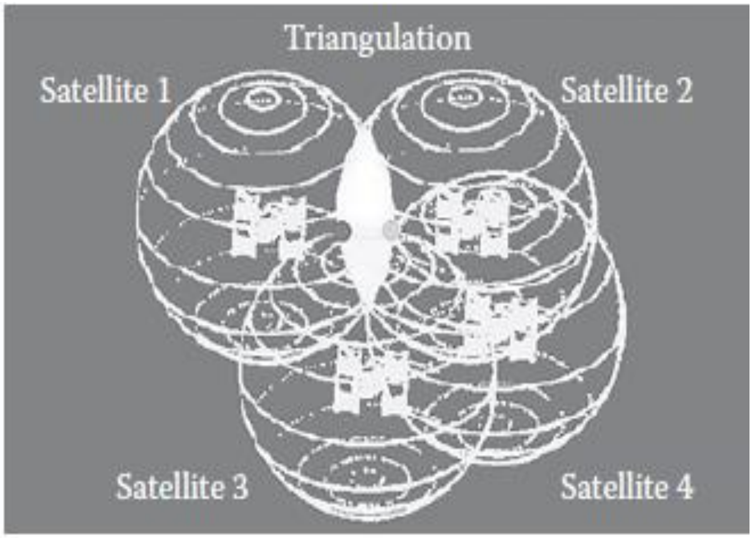


Figure I.1 Basic principle of positioning with GPS [4]

I.5 The Components of GPS (GPS segments)

The global positioning system is divided into three main parts (segments) which is: Space Segment, Control Segment, User Segment(As shown in the figure I.2), we will discuss them in detail below.

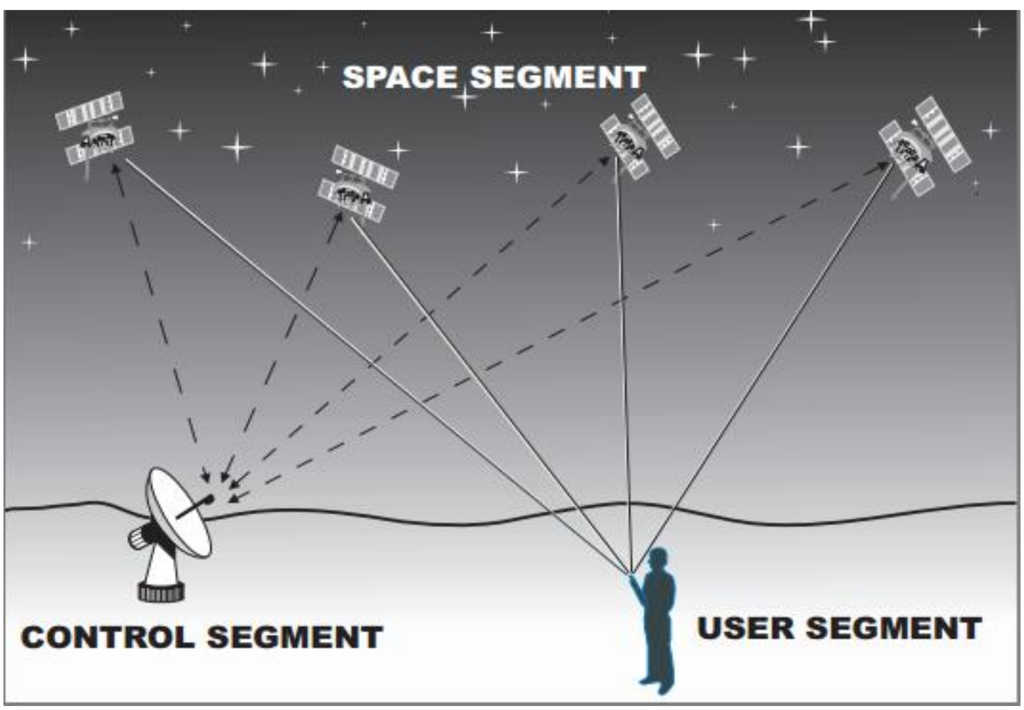


Figure I.2 The three segments of GPS [5]^

I.5.1 The Space Segment:

GPS constellation consists of 24 solar-powered satellites equally-spaced on 6 earth orbit plans above the earth, with altitude about 20, 000 km.

Each satellite circles the Earth twice a day. The 24 satellites can ensure that there are at least four satellites in view from any point on the earth planet.[6]

Each GPS satellite transmits a signal with several components:

two sine waves (or carrier frequencies) modulated by two digital codes and a navigation message. The carriers and the codes are used mainly to determine the distance from the user's receiver to the GPS satellites. The navigation message contains information about the satellites coordinates and other information such as the satellite status, time, clock corrections, signal characteristics, etc. [7]

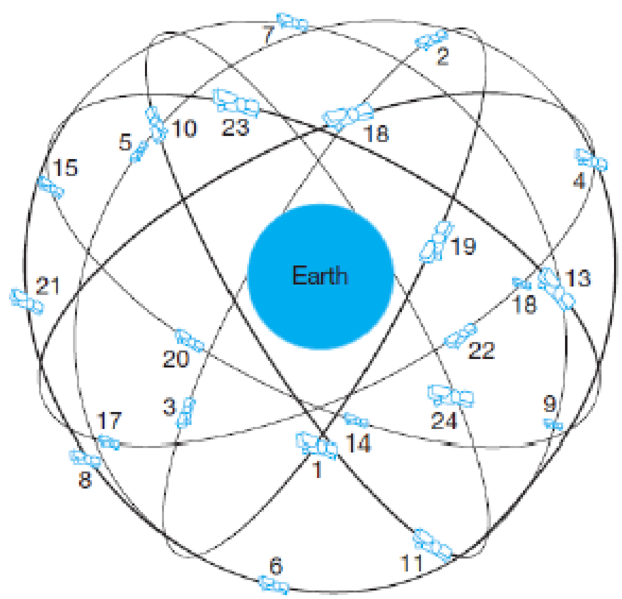


Figure I.3GPS satellites in space[8].

I.5.2 The Control Segment:

The control segment of the GPS system consists of a worldwide network of tracking stations, with a master control station (MCS) located inthe United States at Colorado Springs, Colorado. The primary task of theoperational control segment is tracking the GPS satellites in order to determine and predict satellite locations, system integrity, behavior of the satellite atomic clocks,atmospheric data, the satellite almanac, and otherconsiderations. This information is then packed and uploaded into theGPS satellites through the S-band link.

The CS has responsibility for maintaining the satellites and their proper functioning. This includes maintaining the satellites in their proper orbital positions (calledstationkeeping) and monitoring satellite subsystem health and status.

The CS alsomonitors the satellite solar arrays, battery power levels, and propellant levels usedfor maneuvers. Furthermore, the CS activates spare satellites (if available) to maintain system availability. The CS updates each satellite's clock, ephemeris, and almanac and other indicators in the navigation message at least once per day.

Updatesare more frequently scheduled when improved navigation accuracies are required.(Frequent clock and ephemeris updates result in reducing the space and control contributions to range measurement error).

Several analysesand studies have shown that users benefit from reduced navigation errors withmore frequent uploads, thus reducing the upload age of data and accompanyingbroadcast navigation message errors.)The ephemeris parameters are a quasi-Keplerian representation of the GPS satellite orbits and are valid only for a time interval of 3 or 4 hours with the once-per-day normal upload schedule. Navigation message data can be stored for at leasta 60-day duration with time validity intervals that grow progressively longer butwith decreased accuracy in the event that an upload cannot be provided for an extended period.The almanac is a reduced precision subset of the ephemeris parameters. Almanac data is used to predict the approximate satellite position and aid in satellitesignal acquisition. Furthermore, the CS resolves satellite anomalies, and collects pseudorange and carrier phase measurements at the remote monitor stations todetermine satellite clock corrections, almanac, and ephemeris. To accomplish theabove functions, the CS is comprised of three different physical components: themaster control station (MCS), monitor stations, and the ground antennas [9].

I.5.3 The User Segment:

The user segment includes all military users (i.e., U.S. and alliedmilitary users) of the secure GPS Precise Positioning Service, all civilian users, all GPS receivers and processing software, and commercialand scientific users of the Standard Positioning Service.

With a GPS receiver connected to a GPS antenna, a user can receivethe GPS signals, which can be used to determine their position anywhere in the world.

Public users apply the GPS for navigation, surveying, time andfrequency transfer, and other uses.GPS is currently available to all users worldwide at no direct charge[4].

I.6 Services

I.6.1 PPS

The PPS service is based on the use of two frequencies, L1 (1575.42 MHz) and L2(1227.60 MHz), as well as on the P (Y) code, which is modulated on these two frequencies.This service is mainly intended for armed forces and government agenciesUnited States, but it is also made available to other governments, such asNATO allies, at the discretion of the US government. In any case,its access is controlled. The P code can also be transformed into a Y code (encrypted) in order toto offer protection against possible malicious attempts at corruptionGPS signals.

The P code offers better performance than the C / A code in terms ofmeasurement and resistance to jamming and interference. In addition, the P code being broadcast on the frequencies L1 and L2, the PPS receivers can perform a correction.ionospheric errors thanks to dual-frequency measurements. The precision of the PPS serviceis therefore better than that of the SPS service. However, it remains reserved for users authorized[10].

I.6.2SPS

SPS, however, is less precise than PPS. It uses the second transmitted GPS code, known as the C/A-code, which is available free of charge to all users worldwide, authorized and unauthorized. Originally, SPS provided positioning accuracy of the order of 100m for the horizontal component and 156m for the vertical component (95% probability level). This was achieved under the effect of selective availability. With the recent presidential decision of discontinuing the SA, the SPS autonomous positioning accuracy is presently at a comparable level to that of the PPS.[11]

I.7 Signal structure

As the GPS satellites are orbiting, each continually broadcasts a unique signal on the two carrier frequencies. The carriers, which are transmitted in the L band of microwave radio frequencies, are identified as the L1 signal with a frequency of 1575.42 MHz and the L2 signal at a frequency of 1227.60 MHz These frequenciesare derived from a fundamental frequency, f0, of the atomic clocks, which is 10.23 MHz The L1 band has frequency of 154f0 and the L2 band has a frequency of 120f0 [8]**,**as shown in the following:

L1 = 154 x f0 = 1575,42 MHz (19 cm de longueur d'onde)

L2 = 120 x f0 = 1227,6 MHz (24,4 cm de longueur d'onde)[2]

The availability of the two carrier frequencies allows for correcting a major GPS error, known as the ionospheric delay. All of the GPS satellites transmit the same L1 and L2 carrier frequencies. The code modulation, however, is different for each satellite, which significantly minimizes the signal interference. The two GPS codes are called coarse acquisition (or C/A-code) and precision (or P-code). Each code consists of a stream of binary digits, zeros and ones, known as bits or chips. The codes are commonly known as PRN codes because they look like random signals (i.e., they are noise-like signals).

But in reality, the codes are generated using a mathematical algorithm. Presently, the C/A-code is modulated onto the L1 carrier only, while the P-code is modulated onto both the L1 and the L2 carriers. This modulation is called biphase modulation [11].

The P code is called the Precise code. It is a particular series of ones and zeroes generated at a rate of 10.23 million bits per second. It is carried on both L1 and L2, and it is very long.

Each GPS satellite is assigned a part of the P code all its own and then repeats its portion every seven days.

Thisassignment of one particular week of the 37week long P code to each satellite helps a GPS receiver distinguish one satellite's transmission from another [12].

The P-code is protected by encryption against decoying (anti-spoofing), against deliberate transmission of an erroneous GPS signal. The encrypted P-code is called a Y-code[2].

The C/A code is also a particular series of ones and zeroes, but the rate at which it is generated is 10× slower than the P(Y) code. The C/A code rate is 1.023 million bits per second.

Not only does each GPS satellite broadcast its own completely C/A code, but it also repeats its C/A code every millisecond. The legacy C/A code is broadcast on L1 only. It used to be the only civilian GPS code but no longer. The legacy C/A has been joined by a new civilian signal known as L2C that is carried on L2.[12]

I.8 Errors

I.8.1 Selective availability (SA)

It is a voluntary degradation imposed by the American government acting on the on-board clocks and on the broadcast ephemeris. Selective access or SA (selective availability) can present up to 70 m of position error. The SA has been deactivated since May 1, 2000, but can be put back into service at any time

I.8.2 The clock precision

According to the GPS measurement principle (calculation of the signal propagation step), it is necessary that the satellite clock and that of the receiver have the same precision. Each satellite is equipped with four high precision atomic clocks, but the receiver clock is less precise and therefore generates a fairly large offset error. This error is corrected by using a fourth satellite to calculate the three-dimensional position.

I.8.3 Atmospheric errors (ionosphere and troposphere delays)

The ionosphere and the troposphere refract GPS signals differently. This refraction disturbs the speed of the signals which becomes variable in space. The receiver uses atmospheric correction models to estimate these delays in order to correct the errors. Tropospheric delay depends on temperature, pressure, humidity, as well as the elevation of the satellite. This delay is about 2 m if the satellite is at the zenith and can reach 30 m for an elevation of 5 °. In the ionosphere, the signal is slowed down by refraction on the ionized particles. The ionospheric delay can reach up to 30 m (possibly 50 m) at the horizon.

This error can be reduced by selecting the satellites with an elevation mask. In this case the receiver will not take into account the signals from satellites located less than 15 ° above the horizon.

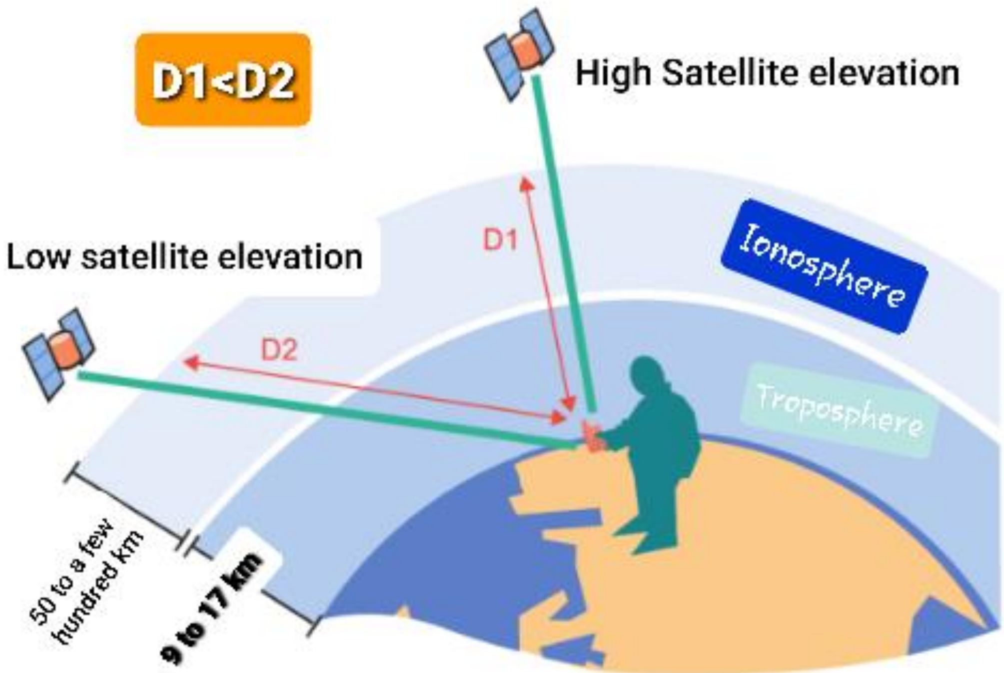


Figure I.4 Sources of error due to atmospheric effects [13].

I.8.3 Ephemeris errors

Ephemeris errors are linked to the deviation of the satellite from its theoretical trajectory, caused by gravitation of the Sun and the Moon as well as by the influence of solar radiation[13].

I.8.4 Multipath error:

The antennae used with GPS receivers are designed to track satellites over wide areas and cannot be made directional[14], cannot penetrate solid objects like buildings and thick tree canopies. Instead, these objects deflect them, causing the signals to bounce around This deflection is known as multipath interference [15].

The reflected signals can interfere with those arriving directly from other satellites and can cause errors of up to 1 m. More importantly, multipath errors can also cause a receiver to lose lock on a satellite because it cannot process the reflected signal.

Surfaces such as tall buildings (especially those with glass sides) have been found to cause serious multipath errors (errors of 15 m or more), and one way of reducing these, especially in built-up areas, is to choose antenna locations for receivers that are as far as possible from reflective surfaces.

Multipath effects are worse at low elevation angles and other ways of dealing with these is to use specially made antennas that stop reflected signals from reaching the receiver, to automatically detect them in the receiversoftware or to use a combination of these [14].

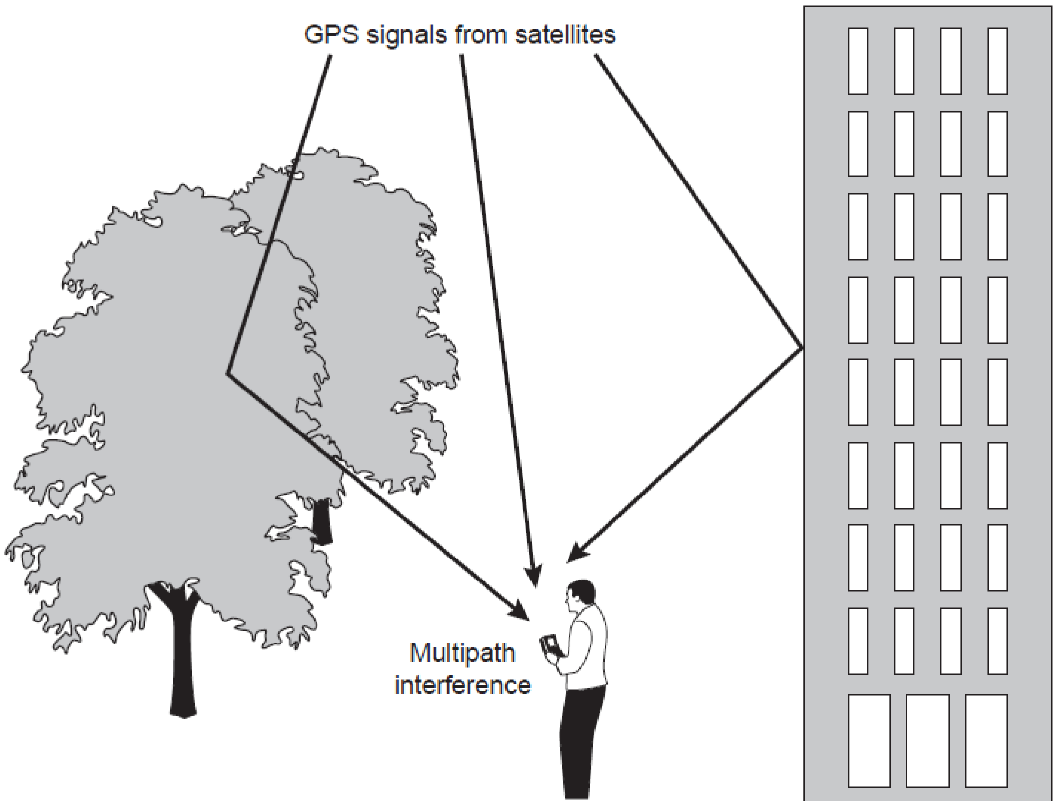


Figure I.5 Effects of buildings and solid objects on the satellite signals[15].

I.8.5 The geometry of satellites

Another source of error is the geometry of the satellites which affects the accuracy of position calculations. Indeed, the grouped satellites generate a position with poor precision and on the contrary, the satellites well dispersed in the sky give good precision.

To qualify the quality of the precision of a calculated position, there are several terms (values without unit) which give estimates of this precision. These values are grouped together under the English term DOP (Dilution of Precision).

- ❖ GDOP, Gemetric DOP: gives an idea about the quality of the 3D position and the time.

- ❖ PDOP, Position DOP: Quality of the 3D position.
- ❖ HDOP, Horizontal DOP: Quality of the 2D or horizontal position (Latitude and longitude).
- ❖ VDOP, Vertical DOP: Quality of vertical precision or altitude.
- ❖ TDOP, Time DOP: Quality of the hour (Timing).
- ❖ RDOP, Relative DOP: Quality of the differential correction. [2].

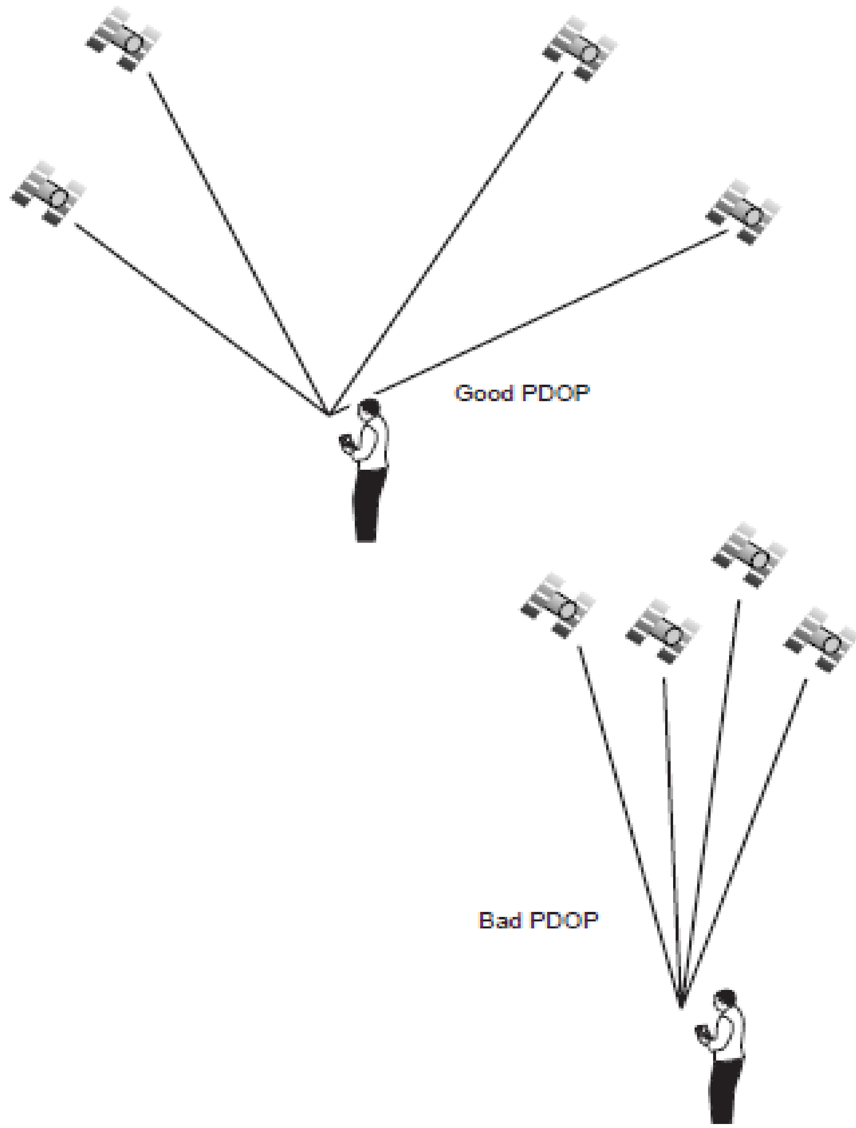


Figure I.6PDOP in satellite engineering [15]

I.9 DGPS

GPS accuracy can be considered sufficient to locate on a map, there are cases where much more precise guidance is required such as locating land vehicles, assisting in aircraft landing, mapping surveys, trajectography, assistance in meeting space vehicles, etc. For these particular cases, differential GPS has been developed.

The principle of Differential GPS (DGPS, Differential GPS) consists of using two receivers, one fixed and one mobile. The fixed receiver serves as a reference for the mobile. It is based on the fact that these two GPS receivers located in close proximity to each other observe a satellite with the same errors. It is in fact considered that the distance between the two receivers is negligible compared to the distance which separates them from the satellites. We can therefore say that the signals arriving on the two devices have passed through the same layers of atmosphere. The fixed receiver is located on a site whose coordinates are known with great precision. It calculates the distances which separate it from the satellites in sight. It subtracts from each calculated distance, the corresponding measured pseudo-distance to obtain correction information.

The correction information, one per pseudo-distance, is transmitted to a second receiver which applies it to its own measurements. As the errors are correlated, the most important ones are attenuated or disappear. The gain provided by the differential mode is a function of the distance between the two receivers because the correlation of the errors decreases with the distance. This correlation is linked to the spatio-temporal properties of the errors. This technique is the simplest and the most used.

Figure I.7 shows the typical architecture of a differential GPS system. It consists of a reference (or base) station and the user equipment. There can be several user equipment's. Each terminal (station or user) is equipped with a GPS receiver and a radio communication device. [2]

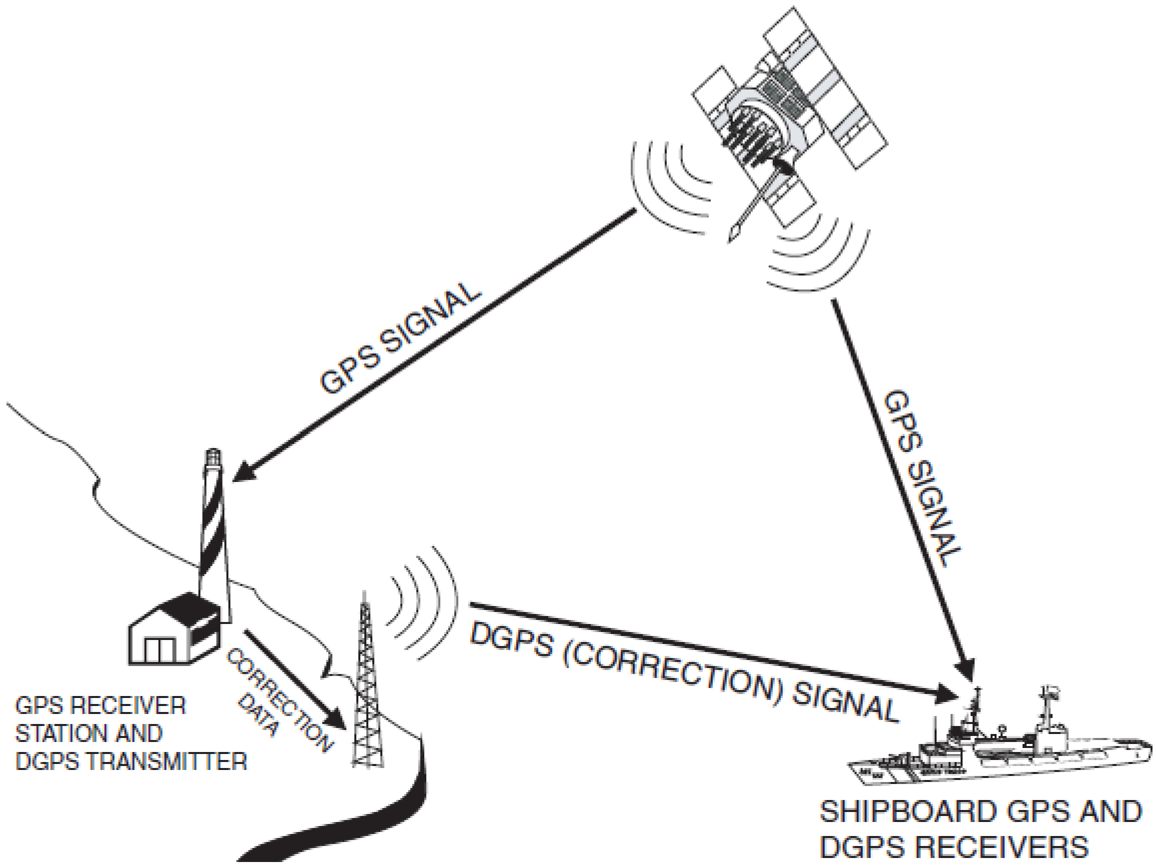


Figure I.7 How DGPS works[5].

I.10 Modernization of the GPS system

In January 1999, the United States government embarked on an initiative to modernize the GPS system. It consists in particular of adding two civilian signals (L2C and L5) and a military signal (M). The military signal is added to the signals already broadcast on the two frequencies L1 and L2. It features spectral separation and increased signal power, so as to improve the protection, prevention and preservation capacity of the GPS system. The civilian L2C signal is added to the L2 frequency which was reserved only for the military. The civil signal L5 is broadcast on the frequency 1 176.45 MHz This frequency is in the frequency band reserved for aeronautical navigation (ARNS, Aeronautical RadioNavigation Service).

These two new signals improve the accuracy, availability and redundancy of the signal.Civilian benefits would include a second civilian frequency for ionospheric correction and redundancy, a third, more robust signal for safety-of-life rescue and rescue applications in a protected spectrum, and which would also provide high precision. and advantages for real-time applications. Among these improvements, we cite in particular the addition of a civilian frequency L5 (1176.45 MHz), an addition of a civilian signal on the L2 carrier (increase in signal power, increase in the number of monitoring stations on the ground and number of downloads of ephemeris and almanac).

The first satellite (GPS 2R-M-1) broadcasting the military signal (M) and the civil signal L2C was launched on 09/26/2005. As of April 10, at 11:58 am (UTC) [35], the GPS satellite SVN49 (GPS 2R-M-7) began transmitting the third civil signal (demonstration) on frequency L5. This signal will allow civilian users to benefit from the ionospheric correction and consequently from a marked improvement in the accuracy of the GPS.

A program called GPS III, aims to modernize the GPS system to meet the needs of military and civilian users in 2030. This system includes a new generation of satellites (block III) that have more functionality. It is expected that the system will provide sub-meter accuracy [2].

I.11Applications of GPS:

The Global Positioning System GPS is a turning point and development for several applications in various areas of life, the most important of which will be mentioned below:

I.11.1 Agriculture

The combination of GPS and GIS has given rise to the site-specific farming an approach to precision agriculture.

GPS based applications in precision farming are used for:

Farm Planning, Field Mapping, Soil Sampling, Tractor Guidance, Tractor Scouting, Yield mapping, it also helps farmers to work in bad weather conditions such as rain dust fog and darkness when visibility is quiet low. With the help of Precision agriculture, gather the Geographic information regarding the Plant-Animal-Soil requirements before hand and then applying the relevant treatment in order to increase the productivity.

The collaboration of GPS and GIS with better quality of fertilizers and other, weeds, pesticides can help a farmer greatly in protecting the natural resources in a long run.

The location information is collected by GPS receiver for mapping field boundaries, roads, irrigation systems, and problem areas in crops such weeds and disease[16].

Figure I.7GPS in Agriculture [17].

I.11.2 Aviation

GPS provides for better safety and efficiency in flight by providing three-dimensional position determination for all phases of flight. Aircraft and pilots arenow able to fly their prefered routes rather than basing them on ground-basedway points.

This is specifically helpful when flying over data sparse areas suchas oceans.

GPS can also improve approaches to runways which increasessafety and operational benefits. With the implementation of the Wide AreaAugmentation System (WAAS) and the new L5 frequencies, Errors in GPS dueto the ionosphere are greatly reduced improving all aspects of aviation [1].

I.11.3 Environments

In order to sustain earth's environment with the human's needs, there is a need for better decision making in association with more updated information. Such decisions are supposed to be taken by Government & Private Organizations but both of them are facing the biggest

challenge of gathering accurate & timely information. GPS is the tool which helps greatly in this situation.

Some of the benefits which are provided by GPS to Environment are:

- In order to provide a comprehensive analysis of environmental concerns, GPS data collection system are complimented with GPS packages.
- Environmental Disasters such as fires and oil spills can be more accurately tracked.
- Precise positional data from GPS can assist scientists in crustal and seismic monitoring.
- Monitoring and preservation of endangered species can be facilitated through GPS tracking and mapping.[16].

I.11.4 Marine

A GPS receiver provides high accuracy for boats and ships. It allows captains to navigate through unfamiliar harbors, shipping channels, and waterways without running aground or hitting known obstacles. Moreover, a GPS receiver is used to position and map dredging operations in rivers, wharfs, and sandbars. Therefore, boat captains know precisely where it is deep enough for them to operate [4].

Figure I.9GPS in Marine [17].

I.11.5 Public Safety and Disaster Relief

"Knowing the precise location of landmarks, streets, buildings, emergencyservice resources, and disaster relief sites reduces that time and saves lives." (Public Safety and Disaster Relief, GPS.gov). GPS has played a critical role in providing relief for many natural disasters as well as wildfire management. It is helping scientist determine fault lines and anticipate earthquakes. For localemergency response systems, it has provided better navigation and travel tomany medical emergencies providing better response times [1].

I.11.6 Railways

Rail systems throughout the world use GPS to track the movement of locomotives, rail cars and maintenance vehicles in real time. When combined with other sensors, computers, and communications systems, GPS improves rail safety, security, and operational effectiveness. The technology helps to reduce accidents, delays as well as operating costs and thus increases customer satisfaction and cost effectiveness [18].

I.11.7 Roads and Highways

One of the most obvious uses for GPS is of course navigation, but GPS can aid in much more than getting you from point A to B. It can provide details on road congestion and direct you onto more efficient routes to decrease travel time and increase travel safety. It is also an essential part of the future of travel with the use of automated vehicles. Although, not in public use yet, automated vehicles use GPS to navigate through large cities and vast deserts with incredible precision [1].

I.11.8 Military

The GPS system was originally developed by the United States Department of Defence for use by the US military, but was later made available for public use. Since then, GPS navigation has been adopted by many different military forces around the world, including the Australian Defence Force. Some countries have even decided to develop their own satellite navigation networks for use during wartimes. Today, GPS is used to map the location of vehicles and other assets on various battlefields in real time, which helps to manage resources and protect soldiers on the ground. GPS technology is also fitted to military vehicles and other hardware such as missiles, providing them with tracking and guidance to various targets at all times of the day and in all weather conditions [17].

Figure I.8GPS in Military[17].

I.11.9 The Mapping and Surveying

Surveyors are responsible for mapping and measuring features on the surface of the earth and under water with high accuracy. This includes things like defining the boundaries of the land, observing changes in the shape of structures or mapping the sea floor. Surveyors have historically required a line of sight between their devices in order to do such work, but the availability of high-precision GPS receivers has reduced the need for this. GPS can be set up on a single point to generate a bookmark, or it can be used in a moving configuration to set limits for various features.

Thisdata can then be transferred to mapping software to create fast and detailed client maps[18].as well as map various lines such as phone lines, water faucets and server lines using GPS.

Images of various locations can be transferred easily and quickly with GPS technology [16].

Figure I.9GPS inThe Mapping and Surveying [17].

I.11.10 Science:

GPS receivers are used by scientists to conduct a wide range of experiments and research, ranging from biology to physics to earth sciences. Traditionally, scientists had to tag animals with metal or plastic bands to track their various locations and monitor their movement. Nowadays, scientists can fit animals with GPS collars or tags that automatically log the animal's movement and transmit the information via satellite back to the researchers. This will provide them more detailed information about the animal's movements without having to relocate specific animals.

On the other hand, earth scientists have installed high-accuracy GPS receivers on physical features (glaciers or landslips)

This will allow them to observe and study both the speed and direction of movement, helping them to understand how landscapes change over time.

A GPS receiver can also be installed on solid bedrock to help understand very small and very slow changes in tectonic plate motion across the world[4].

Figure I.10GPS in science[17].

There are many uses other than the ones we mentioned, such as:

space, Communications technology, Tourism,sport, Time measurement, Commerce and industry...etc. Which represent many different tasks that contribute to embodying GPS technology with all its advantages.

I.12 GPS Module:

The NEO-6MV2 is a GPS (Global Positioning System) module and is used for navigation. The module simply checks its location on earth and provides output data which is longitude and latitude of its position. It is from a family of stand-alone GPS receivers featuring the high-performance u-blox 6 positioning engine. These flexible and cost-effective receivers offer numerous connectivity options in a miniature (16 x 12.2 x 2.4 mm) package. The compact architecture, power and memory options make NEO-6 modules ideal for battery operated mobile devices with very strict cost and space constraints. Its Innovative design gives NEO-6MV2 excellent navigation performance even in the most challenging environments[19].

Figure I. 13 GPS Module

I.12.1 NEO-6MV2 GPS Module Pin Configuration

The module has four output pins and we will describe the function each pin of them below. The powering of module and communication interface is done through these four pins [19].

Table I. 1the functions of output pins [19]

Pin Name	Description
VCC	Positive power pin
RX	UART receive pin
TX	UART transmit pin
GND	Ground

I.12.2 Features and Electrical Characteristics

- Power Supply Range: 3 V to 5 V
- Model : GY-GPS6MV2
- Ceramic antenna
- EEPROM for saving the configuration data when powered off
- Backup battery
- LED signal indicator
- Antenna Size : 25 x 25 mm
- Module Size : 25 x 35 mm
- Mounting Hole Diameter : 3 mm
- Default Baud Rate: 9600 bps [20]

I.13 Conclusion

In this chapter, we tried to give an overview and the most important elements of the global positioning systemGPS that serve our project.

In the next chapter, we will deal with the second part of the project"the Global System forMobile".

Chapter II

An Overview of Global System for Mobile Communication

II.1 Introduction

Until this moment, the idea of making the world a village so that it Communication anywhere, with anyone, at any time is an idea that attracts the attention of scientists and gets more and more important day in day in society.

With the tremendous advancement in microelectronics, computers and software technology, embodimenting the idea is possible and not just an aspiration but a fact we live in, the world has witnessed this fact to a large extent through mobile phone networks that differ from each other over generations, because of the diversity of technologies.

In this chapter, we will highlight the second generation"The Global System for Mobile communications, GSM" which has contributed to myriad numbers to materialize the idea, and we will try to take a detailed look at the systemofGSM.

II.2 History

- **In 1982:** the development of a pan-European standard for digital cellular mobile radio was started by the Groupe Special Mobile of the CEPT (Conférence Européenne des Administrationsdes Postes et des Télécommunications). Initially, the acronym GSMwas derived from the name of this group [2].
- **In 1985**: the European Commission announced the imposition of the GSM standard.
- **In 1987:** the choice was made on the AMR digital transmission.
- **In 1989:** the work of the Special Mobile Group "GSM" was transferred to the "SMG" committeeof the European Telecommunications Standards Institute (ETSI), which pursues the tasks ofstandardizations. Note that it is this committee that will develop the identity moduleSIM subscriber.
- The "GSM" group then changes its meaning: from "Groupe Special Mobiles" it becomes"Global System for Mobile communications"
- **In 1991:** the first communication was made between a mobile and a fixed subscriber. Thefirst terminals are represented at the Salon Telecom in Geneva that same year. Then weattend the opening of the test systems in Paris.
- And it was in 1992 that the ITINERIS GSM system from France Telecom was opened, joining morelater by SFR of the Cegetel group and by Bouygues Telecom (1994).
- The explosion of the mobile market, its sustained growth and the appearance of new services bring current GSM networks to their limit. The speed of 9.6 kb / s, originally defined, is

insufficient to cover new data transfer needs and acts as a brakethe distribution of multimedia content.

- The first WAP applications (standard allowing the display of Web pages onMobile) on wireless networks still suffer from too long connection and response times,especially when calls are billed by duration. In addition, the quality of service is stilland the reliability of communications needs to be improved.
- The new broadband telephony standards, such as GPRS, EDGE and UMTS shouldsolve these problems and ultimately upset the possibilities [21].

II.3GSM Technology

GSM (Global System for Mobile communications: originally from Group Special Mobile) is the most popularstandard for mobile phones in the world. Its promoter, theGSM Association, estimates that 82% of the global mobilemarket uses the standard. Its ubiquitymakes international roaming very common between mobilephone operators, enabling subscribers to use their phones inmany parts ofthe world. GSM differs from its predecessors inthat both signaling and speech channels are digital, and thus isconsidered a second generation (2G) mobile phone system.This has also meant that data communication was easy to buildinto the system.

The ubiquity of the GSM standard has been anadvantage to both consumers (who benefit from the ability toroam and switch carriers without switching phones) and also tonetwork operators (who can choose equipment from any of themanyvendors implementing GSM). GSM also pioneered alow-cost (to the network carrier) alternative to voice calls, theShort message service (SMS, also called "text messaging"), which is now supported on other mobile standards as well [22].

II.4 GSM System Architecture

The GSM network is divided into three sub-systems Architecture which are:

- The Base Station Subsystem BSS
- The Network Subsystem NSS.
- The Operation Support Subsystem OSS.
- Also, we have The Mobile Station (MS) subsystem, but is usually considered to be part of the BSS (Figure II.1).

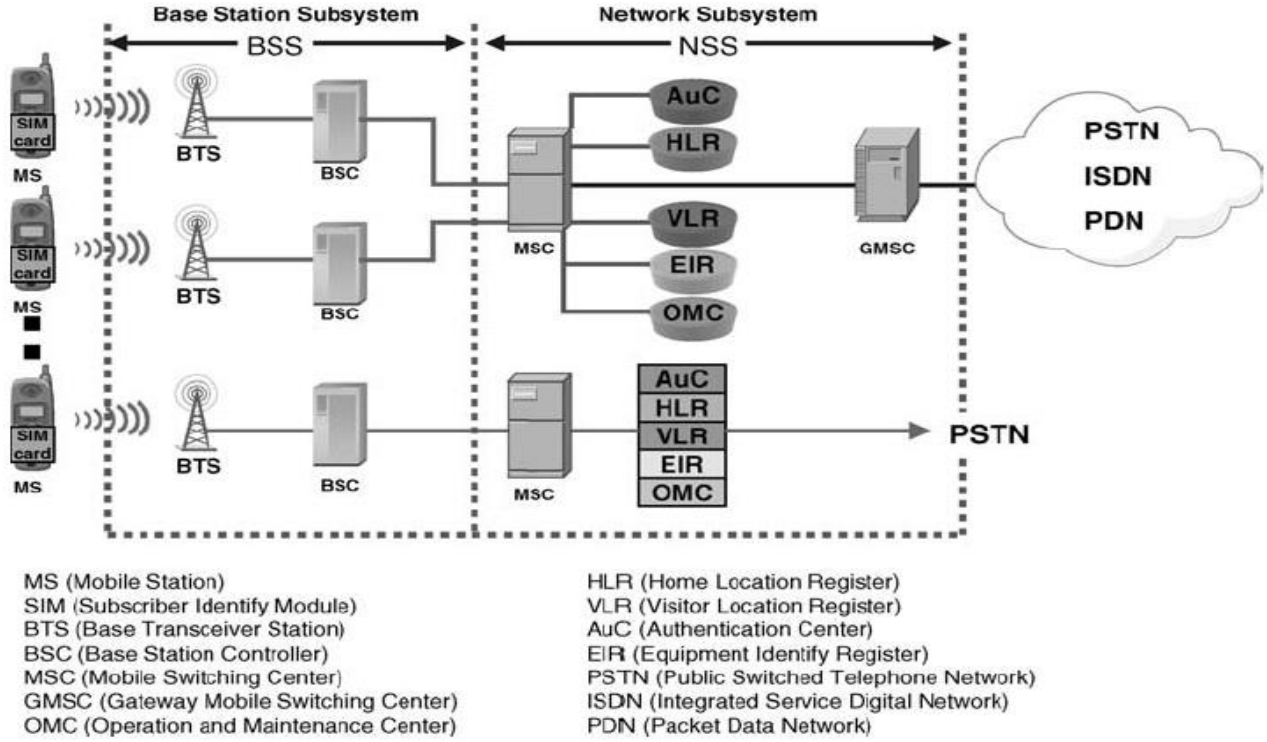


Figure II. 1 GSM System Architecture [23].

II.4.1 Base Station Subsystem (BSS)

The Base Station Subsystem (BSS) consists of the Base Transceiver Station (BTS) and the BaseStation Controller (BSC). The BSS ensures transmission and management of radio resources [23].

II.4.1.1 Base Transceiver Station (BTS)

- The Base Transceiver Station has radio transceivers that define a cell and handles the radio-link protocols with Mobile Station (MS)
- BTS serves one or more cells in the cellular network and contains more than one transceiver (TRXS)[24], the TRX that is responsible for handling the transmission and reception of signals. A single BTS can have several TRXS with a unique frequency allocation to each. The principle of frequency hopping is applied in BTS to introduce frequency diversity and reduce probability of interference. Under the frequency hopping scenario, the TRX frequency changes in every frame. In general, if there is single TRX in every sector, then every TRX radio frame has 8 timeslots of which seven are used for voice and data transmission while one is used for administrative purposes. If the number of TRX in a sector is increased, then for the second TRX, no time slot per frame is reserved for admin purpose, that is, in a 2TRX system, the number of timeslots available for voice and data transmission per sector is 15 [25].

Also, it's runs several services among them:

- Management of time multiplexing and management of frequency hopping.
- Encryption operations.
- Radio measurements to check the quality of service; these measures are
- Transmitted directly to the BSC.
- Management of the data link (traffic and signaling data) between themobile and BTS.
- Management of the traffic and signaling link with the BSC.

The typical maximum capacity of a BTS is 16 carriers, that to say 112 communicationssimultaneous. In urban areas where the coverage diameter of a BTS is reduced, thiscapacity can go down to 4 carriers or 24 communications [26].

II.4.1.2 BSC

BSC is the BSS component that server as a controller of multiple BTS [7], the BSC carries out the following functions:

- Digital signal processing to improve the quality of information flow is done at the BSC stage BSC acts as a controller for the activities of BTS.
- The radio frequencies are allocated for various BTS by means of using suitable radio resource management strategies.
- In certain design, handoff management and its control is carried out by BSC.
- BSC provides the control algorithm for power control to their respective BTS [27].

The interface between BTS and BSC is called Abis interface, The Abis interface is used for intercommunication between BSC and BTS. This interface is defined by GSM equipmentmanufacturer. It carries traffic and control channel data. [24].

II.4.1.3 The mobile station (MS)

Mobile stations (MS) are pieces of equipment which are used by mobile service subscribers for access to services. They consist of two major components: The Mobile Equipment and the Subscriber identity Module (SIM). Only the SIM of a subscriber turns a piece of mobile equipment into a complete mobile station with network usage privileges, which can be used to make calls or receive calls. In addition to the equipment identifier IMEI, the mobile station has subscriber identification and call number (IMSI and MSISDN) as subscriber-dependent data[28].

The Subscriber Identity Module (SIM) provides mobile equipment with an identity. Certain subscriberparameters are stored on the SIM card, together with personal data used by the subscriber.

The SIM cardidentifies the subscriber to the network. To protect the SIM card from improper use, the subscribers haveto enter a 4-bit Personal Identification Number (PIN) before using the mobile. The PIN is stored on thecard. If the wrong PIN is entered three times in a row, the card blocks itself and may only be unblockedwith an 8-bit personal blocking key (PUK), also stored in the card[29].

II.4.1.3.1 Mobile Station ISDN Number (MSISDN)

The MSISDN is the unique phone number of the subscriber in the public telephone network. The MS ISDN consists of Country Code (CC), the National Destination Code (NDC), which defines the regular GSM provider of the subscriber, and the subscriber number. The MS ISDN should not be longer than 15 digits.

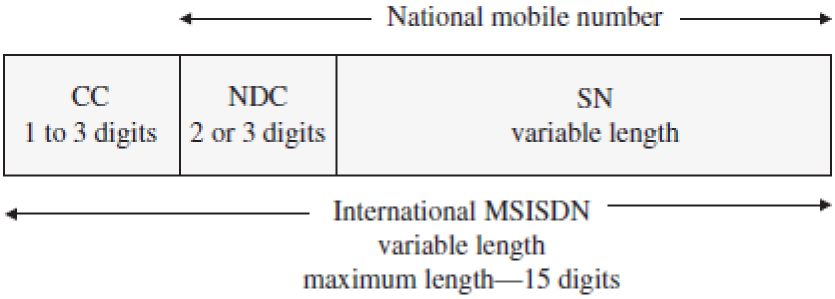


Figure II. 2MSISDN format. [30]

II.4.1.3.2 International Mobile Subscriber Identity (IMSI)

When registering for service with a mobile network operator, each subscriber receive a unique identifier, the International Mobile Subscriber Identity (IMSI).

This IMSI is stored in the SIM; the IMSI uses a maximum of 15 decimal digits and consists of threeparts:

- Mobile Country Code (MCC): three digits, internationally standardized;
- Mobile Network Code (MNC): two digits, for unique identification of mobile networks within a country.
- Mobile Subscriber Identification Number (MSIN): a maximum of 10 digits, identification number of the subscriber in their mobile home network.

A three-digit MCC has been assigned to each of the GSM countries and two-digit MNCs have been assigned within countries (505 as the MCC for Australia and MNC 01, 02 and 03 for the networks of Telstra, Optus and Vodafone, respectively) [31].

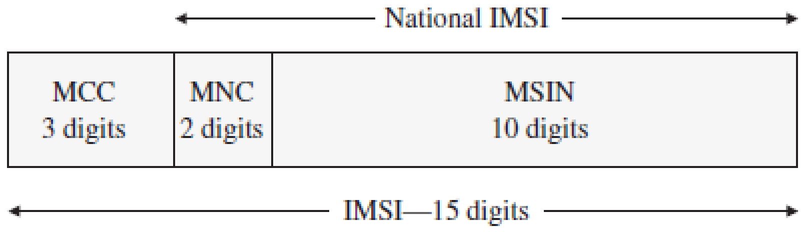


Figure II. 3IMSI format [30]

II.4.1.3.3 International Mobile Station Equipment Identity (IMEI)

The IMEI is a means of identifying hardware. The actual mobile device. Let us note here that the three identity numbers described above are all either permanently or temporarily associated with the subscriber. In contrast, the IMEI identifies the actual MS used. It consists of 15 digits: six are used for the Type Approval Code (TAC), which is specified by a central GSM entity; two are used as the Final Assembly Code (FAC), which represents the manufacturer; and six are used as a Serial Number (SN), which identifies every MS uniquely for a given TAC and FAC[32].

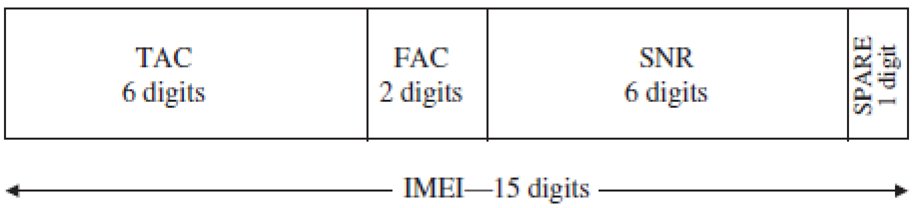


Figure II. 4 IMEI format [30]

II.4.2 The Network Subsystem (NSS)

The network subsystem acts as an interface between the GSM network and the public networks, PSTN/ISDN. The main components of the NSS are MSC, HLR, VLR, AUC, and EIR. which are described in more detail below [33].

II.4.2.1 Mobile Switching Centre (MSC)

The MSC (or switch as it is generally called) is the single most important element of the NSS, it controls call signaling and processing, and coordinates the handover of the mobile connection from one base station to another as the mobile roams around. The MSC manages the roles of inter-cellular transfer, mobile subscriber visitors, and interconnections with the PSTN. The combined traffic of the mobile stations in their respective cells is routed through the MSC. Several databases mentioned above are available for call control and network management. Those supporting elements include the location registers consisting of HLR, VLR, EIR, and AUC. Each MSC is connected through GMSC to the local Public SwitchedTelephony Network (PSTN or

ISDN) to provide the connectivity between the mobile and the fixed telephone users. The MSCmay also connect to the Packet Data Networks (PDN) to provide mobiles with access to data services [23]

II.4.2.2 The Visitor Location Register (VLR)

Each MSC has an associated Visitor Location Register (VLR), which holds the record of eachsubscriber that is currently served by the MSC these records are only copies of the original records, which are stored in the HLR. The VLR is mainly used to reduce the signaling between the MSC and the HLR. If a subscriber roams into the area of an MSC, the data are copied to the VLR of the MSC and are thus locally available for every connection establishment. The verification of the subscriber’s record at every connectionestablishment is necessary, as the record contains information about the services that areactive and the services from which the subscriber is barred. Thus, it is possible, for example,to bar outgoing calls while allowing incoming calls to prevent abuse of the system. While thestandards allow implementation of the VLR as an independent hardware component, all vendorshave implemented the VLR simply as a software component in the MSC. When a subscriber leaves the coverage area of an MSC, his record is copied from the HLRto the VLR of the new MSC, and is then removed from the VLR of the previous MSC [34].

II.4.2.3 Home Location Register (HLR)

The HLR contains the information related to each mobile subscriber. Each subscriber mobile has some information that contains data such as the kind of subscription, services that the usercan use, the subscriber’s current location and the mobile equipment status.

The database in theHLR remains intact and unchanged until the validity of thesubscription [35].

II.4.2.4 Authentication Centre (AUC)

The Authentication Centre (AUC or AC) is the ‘responsibility’ for the policing actions in thenetwork. This has all the data that is required to protect the network against false subscribers and protection of the calls of the regular subscribers.

There are two major keys in the GSMstandards, for example one which is the encryption of the mobile users and the other which is“authentication” of the mobile users. The encryption keys are held both in the mobile equipmentand the AUC and the information is protected against non-authorized access [35].

II.4.2.5 Equipment Identity Registers (EIRs)

Each item of mobile equipment has its own personal identification, which is denoted by a number known as the International Mobile Equipment Identity (IMEI). This number is installed during the manufacture of the equipment itself, stating the conformation to the GSM standards. Thus, whenever a call is made, the network would check the identity number and if this number is not found on the approved list of the authorized equipment, the access is denied.

The EIR contains this list of the authorized numbers and allows the IMEI to be verified [35].

II.4.3 The Operation and Support System (OSS)

The operations and maintenance center (OMC) is connected to all equipment in the switching system and to the BSC. The implementation of OMC is called the operation and support system (OSS). The OSS is the functional entity from which the network operator monitors and controls the system.

The purpose of OSS is to offer the customer cost-effective support for centralized, regional and local operational and maintenance activities that are required for a GSM network. An important function of OSS is to provide a network overview and support the maintenance activities of different operation and maintenance organizations Additional [36].

II.5 GSM Interfaces

The A interface between BSS and MSC is used for the transfer of data for BSS management, for connection control, and for mobility management. Within the BSS, the Abis interface between BTS and BSC and the air interface Um have been defined. An MSC which needs to obtain data about a mobile station staying in its administrative area, requests the data from the VLR responsible for this area over the B interface. Conversely, the MSC forwards to this VLR any data generated at location updates by mobile stations. If the subscriber reconfigures special service features or activates supplementary services, the VLR is also informed first, which then updates the HLR.I This updating of the HLR occurs through the D interface. The D interface is used for the exchange of location-dependent subscriber data and for subscriber management. The VLR informs the HLR about the current location of the mobile subscriber and reports the current MSRN. The HLR transfers all the subscriber data to the VLR that is needed to give the subscriber his or her usual customized service access. The HLR is also responsible for giving a cancellation request for the subscriber data to the old VLR once the acknowledgement for the location update arrives from the new VLR. If, during location updating, the new VLR needs data from the old VILR, it is directly requested over the G interface. Furthermore, the identity of subscriber or equipment can be verified during a location update; for requesting and checking the equipment identity, the MSC has an interface F to the EIR.

An MSC has two more interfaces besides the A and B interfaces, namely the C and E interfaces. Charging information can be sent over the C interface to the HLR. Besides this, the MSC must be able to request routing information from the HLR during call setup, for calls from the mobile network as well as for calls from the fixed network. In the case of a call from the fixed network, if the fixed network's switch cannot interrogate the HLR directly, initially it routes the call to a gateway MSC (GMSC), which then interrogates the HLR. If the mobile subscriber changes during a conversation from one MSC area to another, a handover needs to be performed between these two MSCS, which occurs across the E interface [28].

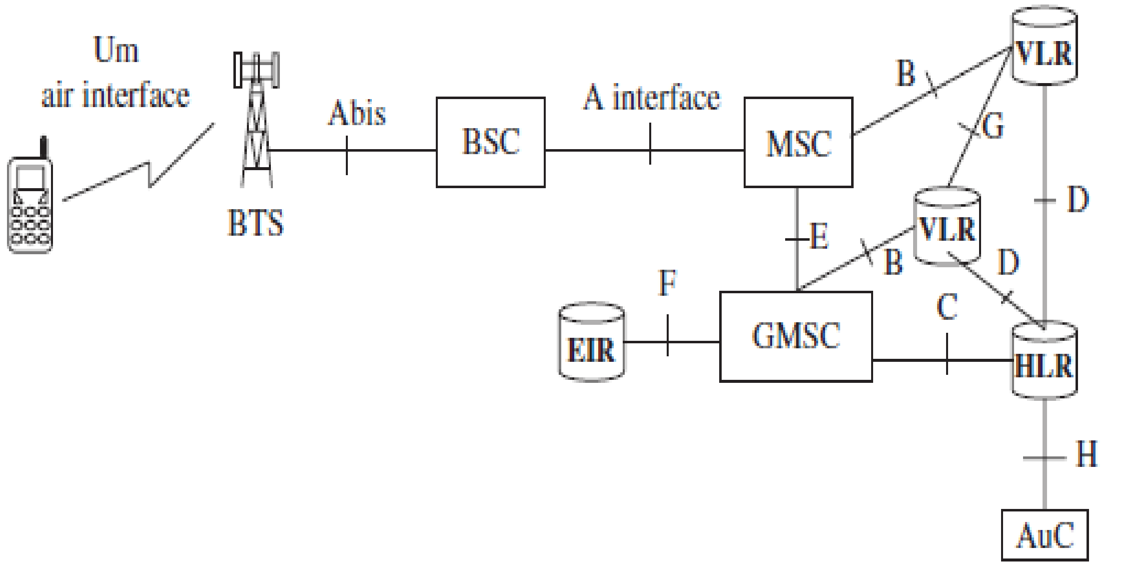


Figure II. 5GSM Interfaces[30].

II.6 The Short Messaging Service Center (SMSC)

Another important network element is the Short Messaging Service Center (SMSC),which is used to store and forward short messages. The SMS was only introduced aboutfour years after the first GSM networks went into operationMost industry observers were quite skeptical at thattime as the general opinion was that if it was necessary to convey some information, itwould be done by calling someone rather than by the more cumbersome method oftyping a text message on the small keypad.

However, they were proved wrong and todaymost GSM operators (still) generate a significant amount of their revenue from theshort message service, despite a trend towards replacing SMS messaging with otherforms of mobile-Internet-based IM.

SMS can be used for person-to-person messaging as well as for providing notification of other events such as a missed call that was forwarded to the voice mail system. The transfer method for both cases is identical.

The sender of an SMS prepares the text for the message and then sends the SMS via a signaling channel to the MSC as a signaling channel is used, anSMS is just an ordinary DTAP SS-7 message and thus, apart from the content, verysimilar to other DTAP messages, such as a Location Update message or a Setup messageto establish a voice call.

Apart from the text, the SMS message also contains the MSISDNof the destination party and the address of the SMSC, which the mobile device hasretrieved from the SIM card. When the MSC receives an SMS from a subscriber, ittransparently forwards the SMS to the SMSC. As the message from the mobile devicecontains the address of the subscriber's SMSC, international roaming is possible and the foreign MSC can forward the SMS to the home SMSC without the need for an international SMSC database.

To deliver a message, the SMSC analyzes the MSISDN of the recipient and retrieves its current location (the MSC concerned) from the HLR. The SMS is then forwarded tothe MSC concerned. If the subscriber is currently attached, the MSC tries to contact themobile device, and if an answer is received, the SMS is forwarded. Once the mobiledevice has confirmed the proper reception of the SMS, the MSC notifies the SMSC aswell and the SMS is deleted from the SMSC's data storage.

If the subscriber is not reachable because the battery of the mobile device is empty, network coverage has been lost temporarily or the device is simply switched off, it is notpossible to deliver the SMS. In this case, the message waiting flag is set in the VLR andthe SMS is stored in the SMSC. Once the subscriber communicates with the MSC, theMSC notifies the SMSC to reattempt delivery [37].

II.7 GSM Shield

II.7.1 presentation

The GSM shield used in this project is the(GSM/GPRS Shield). This modulewas selected because it is specially built for interfacing with Arduino microcontrollers,as well as other capabilities such as allowing users to connect to the internet, sendSMS, receive SMS and make voice call; someof which are essential for this project.[18]. Shields of this kind could stand uponthe microcontrollerplatform, but they must be compatible.Two basics connections of this shield are TX and RX pins, which allow the microcontroller to connect with the GSMshield sending serial data

[19]. The TX pin of GSM module is connected to Rxpin of Arduino (namely Rx and Tx) and Rx pin of GSM module is connected to Tx pin of Arduino.

GSM TX –> Arduino Rx

GSM RX –> Arduino Tx [38].

GSM operatewith a SIM card. The SIM requires asubscription, with a mobile communication provider. Basedonthis, the user can get access to the mobile network. The UART (Universal Asynchronous Receiver Transmitter) Interface codes and decodes data between the parallel and serial formats. It takes bytes of data and transmits them in asequence of bits. Thus, the data can be sent, in a serial mode, through TX to the microcontroller, or through an antenna tothe network.

The RF PAD reduces the power of the signal, without appreciably distorting its waveform, in order to ensure that the radio signal level in the correct one. Alternative shields can provide also GPRS module and they support TCP/UDP and HTTP protocols, through a GPRS connection. [39]

Figure II .6the module GSM/GPRS Shield V3.0 [40].

II.7.2Description of the module:

The figure below shows a description of the module GSM/GPRS Shield:

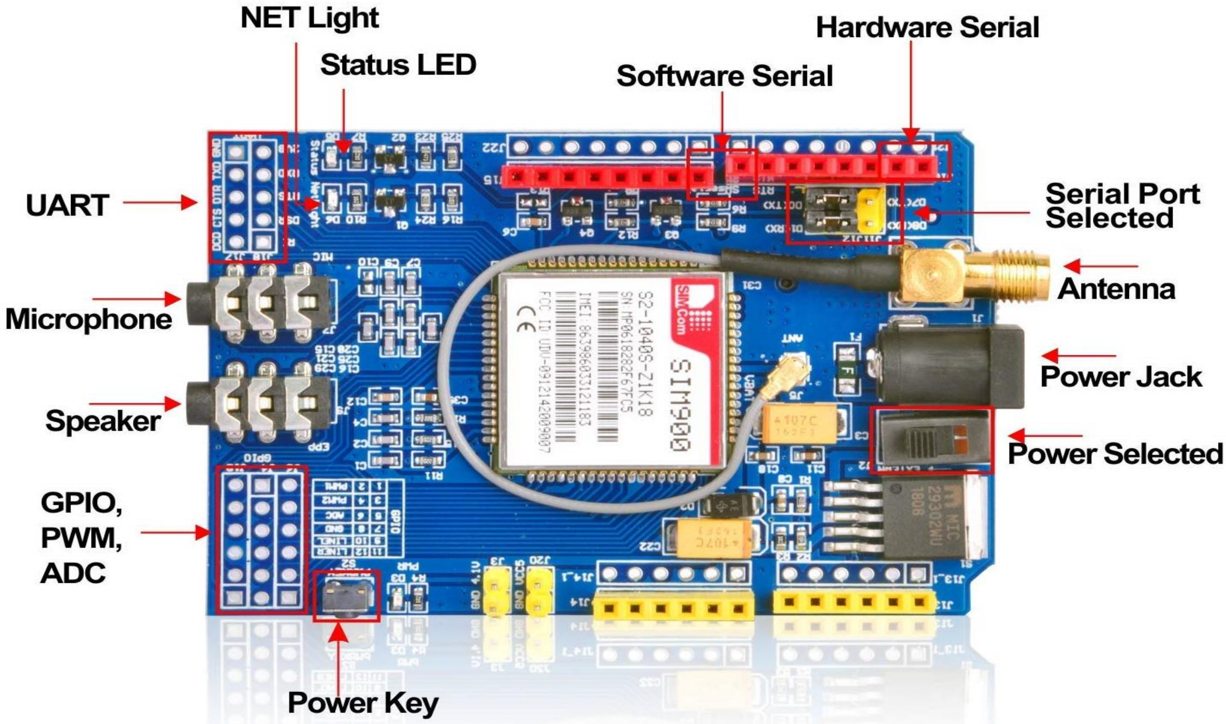


Figure II.7 Description of the module GSM/GPRS Shield [40].

II.7.3 The Main characteristics

- Quad-Band 850/900/1800/1900 MHz
- GPRS multi-slot class 10/8.
- GPRS mobile station class B.
- Compliant to GSM phase 2/2+.
- Class 4 (2 W @850/ 900 MHz).
- Class 1 (1 W @ 1800/1900MHz).
- SAIC (Single Antenna Interference Cancellation) support.
- Dimensions: 24 x 24 x 3 mm.
- Weight: 3.4g.
- Control via AT commands (GSM 07.07 ,07.05 and SIMCOM enhanced AT Commands)
- Supply voltage range: 3.2 ... 4.8V.
- Low power consumption: 1.0mA (sleep mode&BS-PA-MFRMS=9).
- Operation temperature: -40°C to +85 °C[37].

II.7.3.1 Serial link

The choice of pins allowing communication between the GPRS shield and the Arduino board via the linkseries is achieved via two jumpers.

The serial link must be set with a speed of 19200 bits / s [40]

- Software serial link: Rx=D7 and Tx=D8
- Hardware serial link: Rx=D0 and Tx=D1

II.7.3.2 Power up

- The shield is powered up in hardware using the "POWER" button.
- This betenergized can also be done in software by applying a high logic level on pinD9

II.7.3.3LEDs

the indications given by the 3 LEDs are:

Table II.1 the indications of the 3 LEDs[41]

LED	Status	Function
Power-on indicator (Green)	Off	Power of GPRS Shield is off
Status Indicator (Red)	On	Power of GPRS Shield is on
	Off	Power off
Net indicator (Green)	On	Power on
	Off	SIM900 is not working
	64ms On/800ms Off	SIM900 does not find the network
	64ms On/3000ms Off	SIM900 finds the network
	64ms On/300ms Off	GPRS communication

II.7.3.4 SIM900 module

SIM Com presents an ultra-compact wireless module andreliable-SIM900. This is a full quad band GSM / GPRS module ofSMT type and designed with a very powerful single chip processor integrating theARM926EJ-S core, allowing us to benefit from small dimensions andeconomical and cost-effective solution.

Equipped with a standard interface, the SIM900 offers GSM / GPRS performance850/900/1800 / 1900MHz for voice, SMS, data and fax in onereduced size and with low energy consumption. With atiny configuration, the SIM900 can meet almost any needspace in our applications, especially for thin applications andcompact in design. And the following figure shows us the shape of theSIM900 module [42].

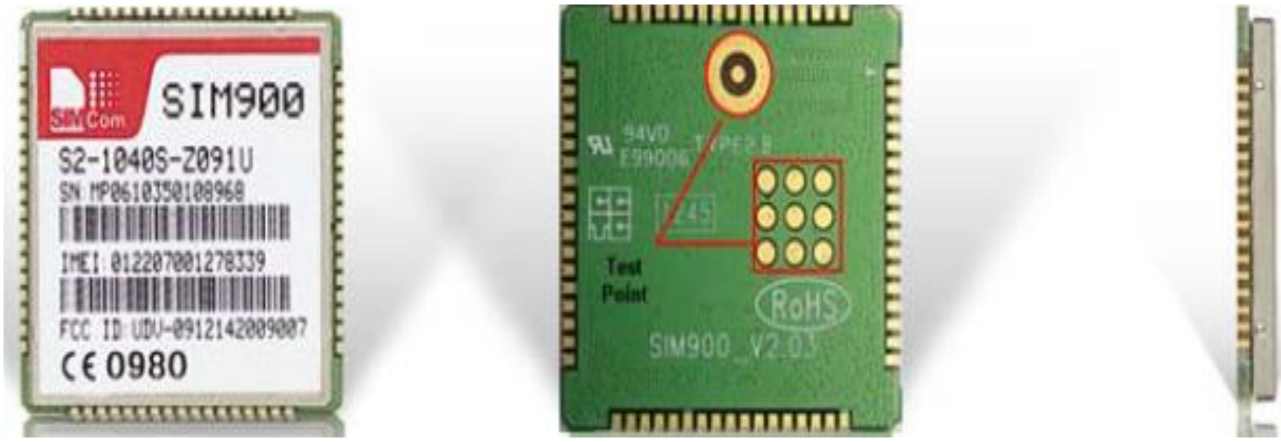


Figure II. 8top, bottom side view of sim900 [43].

Figure II. 9SIM information [43].

Table II.2 Illustration of module information [43].

Article	Description
A	Logo of SIMCOM
B	Module Name
C	Module part number
D	Module serial number and bar code
E	Module IMEI and bar code
F	FCC authenticated ID
G	CE authenticated logo

II.7.4COMMANDES « AT »

II.7.4.1 Presentation

There is a European telecommunications standard (ETS) which specifies a list of AT commands that allow access tofunctions of a mobile phone through a terminal.

These commands are strongly inspired by the Hayes standard,from the name of the American company that in the 1970s defineda list of universal commands allowing to control amodem. Each instruction begins with ASCII characters.

"AT" taken from the abbreviation "ATtention " and ends with a carriage return, CR: Carriage Return, hence the name often given to this series of commands: "AT" statements. You can effectively think of a cell phone as a wireless modem, so it makes sense that it uses instructions similar to the fixed modem found on our PCs. Manufacturers owe it to themselves to manufacture cell phones that meet these standards. The first, called GSM07.07, allows access to the general functions of the telephone, the second GSM07.05 concerns the management of SMS. In the official texts dealing with GSM we find the terms ME for Mobile Equipment which corresponds for example to a mobile phone, TE for Terminal Equipment which physically can be a computer or a microcontroller and TA for Terminal Adaptator which provides the link between the ME and TE, not to be confused with serial cable. In practice there are three possibilities regarding the arrangement of the different elements (figure II.10)

- TA, ME and TE are three separate entities.
- TA and ME form a single entity, which is the most frequent case. For example, a standard mobile phone or a GSM terminal contains both the TA and the ME in its housing. The TE forms aseparate entity, for example it may be a PC-type computer that has a serial port or an electronic circuit based on a µC that implements a serial port
- TA, ME and TE form a single entity [44].

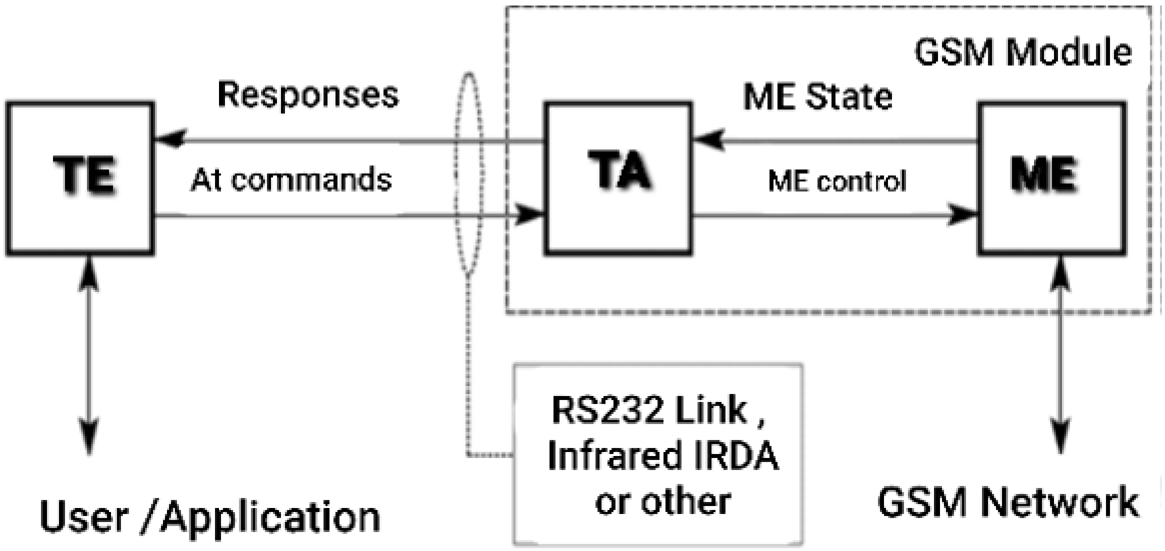


Figure II.10 diagram of the operation of AT commands [44].

II.7.4.2General principles

These commands always start with the AT sequence except for the repeat command of the last command (A /). The module (SIM900) includes both upper- and lower-case commands. Each command must end with an end of line character. The repeat command (A /) does not require an end character. The back-space character (08H) is used to cancel, when sending a command, the last character sent to the module. The maximum length of a command string is 128 characters including the AT and the carriage return. If there are more than 128 characters, the module returns an error message and does not execute the command. If the module detects an error in the chain, it interprets the string until the error is detected; it sends an error message without processing the commands that may be behind the command that caused the error. With the extended AT commands, functions such as: Reading, writing and deleting SMS can be performed.

- Sending SMS. Signal strength monitoring.
- Checking the state and charge level of the battery.
- Reading, writing and searching for directory: entries [45].

II.7.4.3 STANDARD GSM07.07

The GSM07.07 standard groups together around 80 commands allowingto access all functions of theME. We will notdetail all of these commands but only those thatwill be of interest to us in the following chapters (table II.3) [44].

Table II. 3 The commands allowing to access all functions of the ME [44]

ATCOMMAND	FUNCTION
AT+CGMI	Manufacturer identification
AT+CGMM	Model identification
AT+CGMR	Identification version
AT+CGSN	Serial number identification (IMEI)
AT+CIMI	International Mobile Identity Information (IMSI)
AT+CLIP	Presentation of issue
AT+CSCS	Alphabet used by TE
AT+CPAS	Phone activity status
AT+CPIN	Enter PIN
AT+CBC	Battery state of charge
AT+CREG	Network registration
AT+CSQ	Signal quality
AT+CIND	Control indicators
AT+CPBS	Select a phone book
AT+CPBR	Reading the phone book
AT+CPBF	Search for an entity in the telephone directory
AT+CPBW	Writing in the telephone book
AT+CCLK	Clock
AT+CALA	Alarm
AT+CMEE	Signaling an error

II.7.4.4 STANDARD GSM07.05

The GSM07.05 standard specifies the AT commands allowing theSMS management (Table II.4) [44]

Table II.4 the AT commands allowing the SMS management [44].

Command	Function
AT+CSMS	Message service selection
AT + CPMS	Selection of the memory zone for SMS storage
AT + CMGF	Selection of SMS format (PDU or TEXT)
AT + CSCA	Definition of the message center address
AT + CSDH	Displays SMS settings in TEXT mode
AT + CSAS	Save the settings
AT + CRES	Restoration of default setting
AT + CNMI	Indication concerning a new SMS
AT + CMGL	List the SMS stored in memory
AT + CMGR	Reading an SMS
AT + CMGS	Send an SMS
AT + CMSS	Sends an SMS stored in memory
AT + CMGW	Writing an SMS
AT + CMGD	Delete an SMS
AT+CPBF	Search for an entity in the telephone directory
AT+CPBW	Writing in the telephone book
AT+CCLK	Clock
AT+CALA	Alarm
AT+CMEE	Signaling an error

II.8 Conclusion

In this chapter, we tried to give an overview and the most important GSM elements that serve our project. In the next chapter, we will discuss the design and realization of our project in more detail.

Chapter III

Realization of a GPS Tracker

I.1 Introduction

In this chapter we will cover designing and realizing a GPS tracker using the Arduino UNO, GSM and GPS Module. The Arduino microcontroller is discussed in detail in this chapter.

The project will be implemented using Proteus simulator, which is an integrated environment that contains all the tools we need for a realistic simulation. Proteus VSM also provides great tools and amazing features for every student aspiring to build his own laboratory, which will provide him with a practical and realistic experience and looking for tools to help solve any problem he faces while working and studying.

Finally, several points will be covered in this chapter, including:

The Arduino microcontroller is discussed in detail, the reasons for choosing Arduino, how to use it with the rest of the units, as well as the codes that will help us in the project, and the steps are explained one by one.

III.2 General Description of the project

The proposed system for this project is designed for the purpose of tracking by monitoring any specific device for specific purposes such as cars.

This system uses the latest two tracking technologies, the first of which is the Global Positioning System (GPS).

The global Positioning system that provides us with location and time information, anywhere and anytime. The second system is Global System for Mobile Communications (GSM)who provide us with this information at the specified time, as shown in the figure III.1

The Following figure shows the components of the system and how it works, so we find a GPS receiver that provides us with the coordinates and sends them to the main control unit Arduino, then the Arduino uploads this data to the GSM unit that sends it in the form of a text message to the phone or the main office to Track the group of cars.

Figure III. 1 The block diagram of GPS tracking system

III.3.The Arduino Module

III.3.1 A Brief History

In 2005, building upon the work of Hernando Barragan (creator of Wiring), MassimoBanzi and David Cuartielles created Arduino, an easy-to-use programmable devicefor interactive artdesign projects, at the Interaction Design Institute Ivrea in Ivrea, Italy. David Mellis developed the Arduino software, which was based on Wiring.

Before long, Gianluca Martino and Tom Igoe joined the project, and the five areknown as the original founders of Arduino. They wanted a device that was simple,easy to connect to various things (such as relays, motors, and sensors), and easy toprogram. It also needed to be inexpensive, as students and artists aren't known forhaving lots of spare cash.

They selected the AVR family of 8-bit microcontroller(MCU or µC) devices from Atmel and designed a self-contained circuit board witheasy-to-use connections, wrote bootloader firmware for the microcontroller, andpackaged it all into a simple integrated developmentenvironment (IDE) that usedprograms called "sketches." The result was the Arduino.

Since then the Arduino has grown in several different directions, with some versionsgetting smaller than the original, and some getting larger. Each has a specificintended niche to fill. The common element among all of them is the Arduino runtimeAVR-GCC library that is supplied with the Arduino development environment,and the on-board bootloader firmware that comes preloaded on the microcontrollerof every Arduino board.

The Arduino family of boards use processors developed by the Atmel Corporationof San Jose, California. Most of the Arduino designs utilize the 8-bit AVR series ofmicrocontrollers, with the Due being the primary exception with its ARM Cortex-M332-bit processor.[47]

III.3.2What is an Arduino?

Arduino is an open-source platform used for building electronics projects. Arduino consists of both a physical programmable circuit board (often referred to as a microcontroller) and a piece of software, or IDE (Integrated Development Environment) that runs on your computer, used to write and upload computer code to the physical board.

The Arduino platform has become quite popular with people just starting out with electronics, and for good reason. Unlike most previous programmable circuit boards, the Arduino does not need a separate piece of hardware (called a programmer) in order to load new code onto the board, you can simply use a USB cable. Additionally, the Arduino IDE uses a simplified version ofC++, making it easier to learn to program. Finally, Arduino provides a standard form factor that breaks out the functions of the micro-controller into a more accessible package.[48]

III.3.3Arduino Board

An Arduino Board can be classified into two parts:

Hardware: The Arduino board hardware consist of many components that combine to make it work, but we are going to discuss the main component on the board such as follows:

- USB Plug: This is the first part of the Arduino because it is used to upload a programme to the microcontroller and has a regulated power of 5volts which also power the Arduino board.
- Reset button: This button resets the Arduino when it when its pressed in case you have uploaded another command and want the Arduino to do it.
- Microcontroller: This is the device that receiveand send information or cammand tothe respective circuit.
- Analog Pins(O-5): This are analog input pinsfrom AO to A5.
- Digital I/O Pins: This are the digital input,output Pins 0 to13.
- Digital and analog Ground pins
- Power Pins: we have 3.3 and 5volts powerpins etc.[49]
- The microcontroller: is the heart of this device. A microcontroller is a small computer on a single integrated circuit that contains a processor core, data memory, A / D converter, and

programmable I / O accessories. In this device, the microcontrollers are smaller and simplified so that they can accommodate all required functions on a single chip. Owning a microcontroller is very beneficial, as it has a low design cost and adds intelligence to the system.[50]

- PWM (8): You may have noticed the tilde (~) next to some of the digital pins (3, 5, 6, 9, 10, and 11 on the UNO). These pins act as normal digital pins, but can also be used for something called Pulse-Width Modulation (PWM). We have a tutorial on PWM, but for now, think of these pins as being able to simulate analog output (like fading an LED in and out).
- TX RX LEDs: TX is short for transmit, RX is short for receive. These markings appear quite a bit in electronics to indicate the pins responsible for serial communication. In our case, there are two places on the Arduino UNO where TX and RX appear -- once by digital pins 0 and 1, and a second time next to the TX and RX indicator LEDs (12)**.** These LEDs will give us some nice visual indications whenever our Arduino is receiving or transmitting data (like when we're loading a new program onto the board)[48].

Software (IDE):IDE stands for "Integrated Development Environment": it is an official software introduced by Arduino.cc, that is mainly used for editing, compiling and uploading the code in the Arduino Device. Almost all Arduino modules are compatible with this software that is an open source and is readily available to install and start compiling the code on the go. This environment supports both C and C++ languages [51].

This IDE contains the following parts in it:

- Console Toolbar: This is the area where you have the menu items such as File, Edit, Sketch, Tools, Help and Icons like Verify Icon for verification, Upload Icon for uploading your programme, New, Open, Save and Serial Monitor used for sending and receiving of data between the Arduino and the IDE.
- Coding Area: This is where you write your code which uses a simplified version of the C++ programming language that makes it easierto write your programme, which is also called a sketch. When writing your code there are mainly two important parts:

  - ❖ The setup function: Before the setup you need to intialize the variables you intend to use and assign them. Then the setup routine begins, this is where you set the intial condition of your variables and run preliminary code only once.

❖ Loop routine: This is the loop that runs or execute your main code over and over again.

- Message Window Area: This shows message from the IDE in the black area, mostly on varification on your code [49].

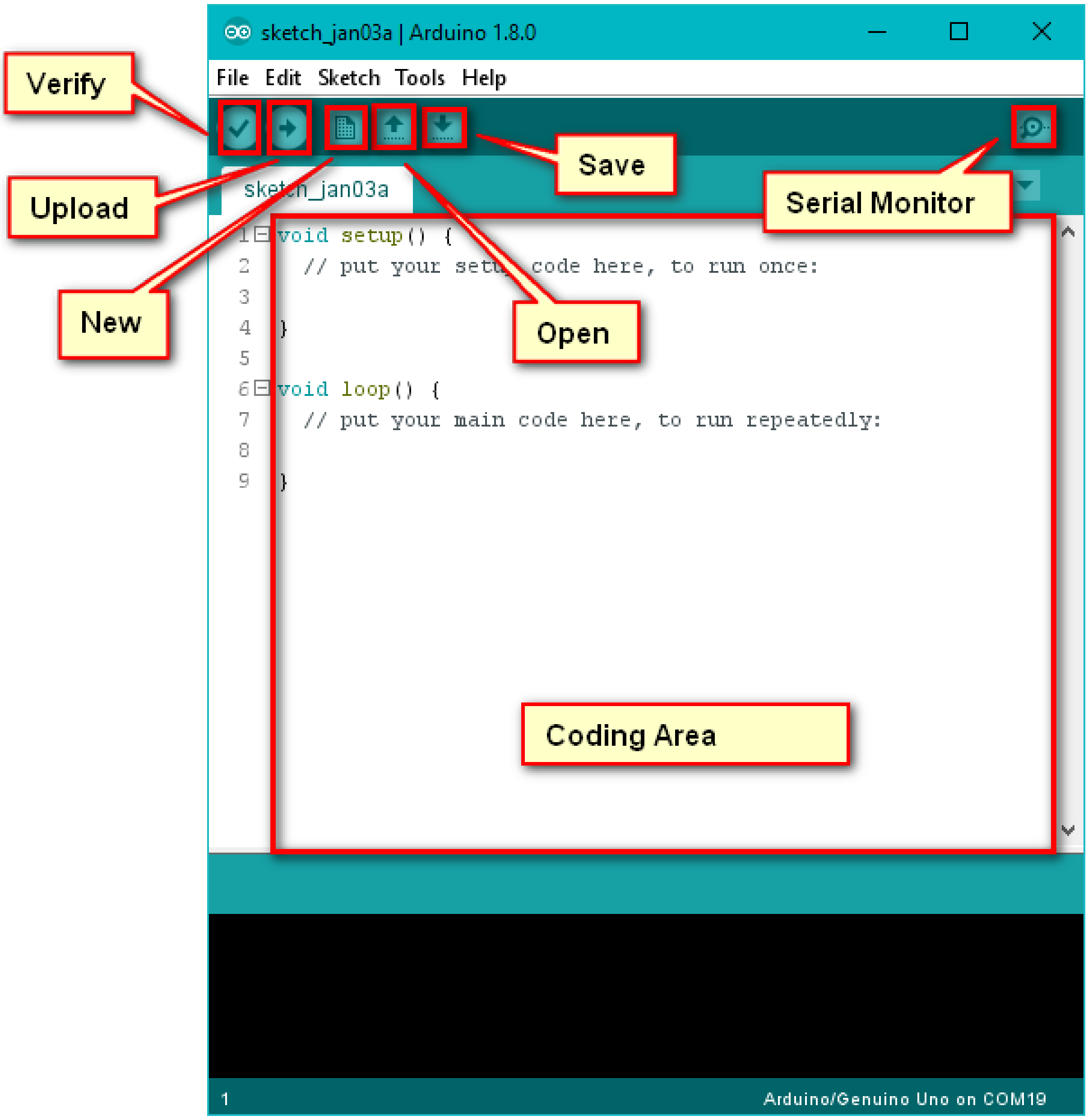


Figure III. 2 Interface of Arduino IDE

III.4 The Arduino Uno

The Arduino UNO is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started.

The UNO differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip.

Instead, it features the Atmega16U2 (Atmega8U2 up to versionR2) programmed as a USB-to-serial converter [52].

III.4.1 Arduino Uno Technical Specifications

Table III. 1 Arduino Uno Technical Specifications [53]

Microcontroller	**ATmega328P –8bitAVRfamily microcontroller**
Operating Voltage	5V
RecommendedInput Voltage	7-12V
Input Voltage Limits	6-20V
Analog Input Pins	6 (A0 – A5)
Digital I/O Pins	14 (Out of which 6 provide PWM output)
DC Current on I/O Pins	40 mA
DC Current on 3.3V Pin	50 mA
Flash Memory	32 KB (0.5 KB is used for Bootloader)
SRAM	2 KB
EEPROM	1 KB
Frequency (Clock Speed)	16 MHz
Dimensions	68,6mm x 53,3mm

III.4.2 The Microcontroller

It is important to understand that the Arduino board includes a microcontroller, and this microcontroller is what executes the instructions in your program. If you know this, you won't use the common nonsense phrase "Arduino is a microcontroller" ever again.

The ATmega328 microcontroller is the MCU used in Arduino UNO R3 as a main controller. ATmega328 is an MCU from the AVR family; it is an 8-bit device, which means that its data-bus architecture and internal registers are designed to handle 8 parallel data signals.

ATmega328 has three types of memory:

- **RAM memory:** 2KB volatile memory. This is used for storing variables used by the application while it's running [54].
- **The Flash memory:** size is 32 Kilo Bytes, and stores real program written by user in chip's memory. The user program must not exceed this size.
- **The EEPROM memory:** size is 1 Kilo Bytes, and used to store frequently changing data such as user preferences, last selected value etc. in semi-volatile memory for later access. (EEPROM: Electrically Erasable Programmable Read Only Memory) [55].

Atmega328P is pre-programmed with bootloader. This allows you to directly upload a new Arduino program into the device, without using any external hardware programmer, making the Arduino UNO board easy to use [56].

III.4.3Power

The Arduino Uno can be powered via the USB connection or with an external power supply. The power source is selected automatically.External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery.The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector.

The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however,the 5V: pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

The power pins are as follows:

- **VIN:** The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.

- **5V:** This pin outputs a regulated 5V from the regulator on the board. The board can be supplied with power either from the DC power jack (7 - 12V), the USB connector (5V), or the VIN pin of the board (7-12V). Supplying voltage via the 5V or 3. 3V pins bypasses the regulator, and can damage your board. We don't advise it.
- **3V3:**A 3,3volt supply generated by the on-board regulator. Maximum current draw is 50 mA.
- **GND:** Ground pins [52]

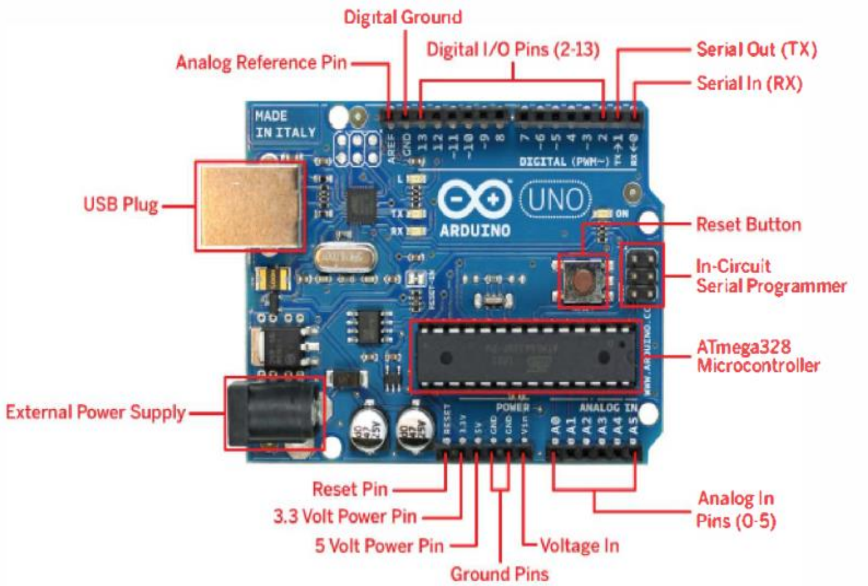


Figure III. 3 Description of ARDUINO UNO Board [57].

III.4.4 Communication

Arduino can be used to communicate with a computer, another Arduino board or other microcontrollers.

The ATmega328P Microcontroller provides UART TTL (5V) serial communication which can be done using digital pin 0 (Rx) and digital pin 1 (Tx). An ATmega16U2 on the board channels this serial communication over USB and appears as a virtual com port to software on the computer. The ATmega16U2 firmware uses the standard USB COM drivers, and no external driver is needed. However, on Windows, a .inf file is required.

The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the Arduino board. There are two RX and TX LEDs on the arduino board which will flash when data is being transmitted via the USB-to-serial chip and USB connection to the computer (not for serial communication on pins 0 and 1). A SoftwareSerial library allows for serial communication on any of the Uno's digital pins. The ATmega328P also supports I2C (TWI) and SPI communication. The Arduino software includes a Wire library to simplify use of the I2C bus.[53]

III.4.5 Why Arduino UNO

Many electronic panels are available to fine-controlled units for programed electronics. All of these tools support complex programming details and integrate them into an easy-to-use presentation [58].

The Arduino family contains many types such as:

- Arduino Leonardo.
- Arduino Ethernet.
- Arduino Mega 2560.
- ArduinoMini.
- ArduinoMicro.
- Arduino due Lilypad.
- Arduino Pro.
- Arduino Robot.
- ArduinoEplera.
- Arduino Yun.
- Arduino Tre.
- Arduino Zero.

Here we will look at the reasons for our Arduino selection:

- **The price (reduced):** Arduino boards are relatively inexpensive compared to other platforms. The cheapest versions of the moduleArduino can be assembled by hand, (pre-assembled Arduino boards cost less than 2500 Dinars).
- **Multi-platform:** The Arduino software, written in JAVA, runs on Windows, Macintosh and Linux operating systems. Most microcontroller systems are limited to Windows.
- **A clear and simple programming environment:** The Arduino programming environment (the Arduino IDE software) is easy for beginners to use, yet flexible enough for advanced users to take advantage of as well.
- **Open Source and extensible software:** The Arduino software and the Arduino language are released under an open source license, available to be supplemented by

experienced programmers. The Arduino module programming software is a multi-platform JAVA application (running on any operating system), serving as a code editor and compiler, which can transfer the program through the serial link (RS232, Bluetooth or USB depending on the module).

- **Open source and extensible hardware:** Arduino boards are based on Atmel microcontrollers ATMEGA8, ATMEGA168, ATMEGA 328, module schemas are published under a creative license Commons, and experienced circuit designers can their own version poured Arduino boards, supplementing them and improving them. Even relatively inexperienced users can manufacture the plate version of the Arduino board, which aims to understand how it works to save cost [58].

III.5 Proteus Simulation Software:

The simulation software named Isis Proteus is an application development and simulation program with a simple and interactive graphical environment. It consists of a main window and a set of toolbars. In addition to the classic menu that allows file management, display and project options.

III.5.1 Proteus Program:

Proteus Professional is a software suite for the electronics. Developed by the company Labcenter Electronic, the software included in Proteus Professional enable CAD (Computer Aided Construction) in the electronics field.

Two main software packages make up this software suite: (ISIS, ARES, PROSPICE) and VSM. This software suite is well known in the field of electronics. Many companies and training organizations (including high school and university) use this software suite. Besides the popularity of the tool, Proteus Professional has other advantages:

- Package containing easy and fast software to understand and use.
- The technical support is efficient.
- Virtual Prototype Tool Reduces Hardware and Software Costs When Designing a Project.

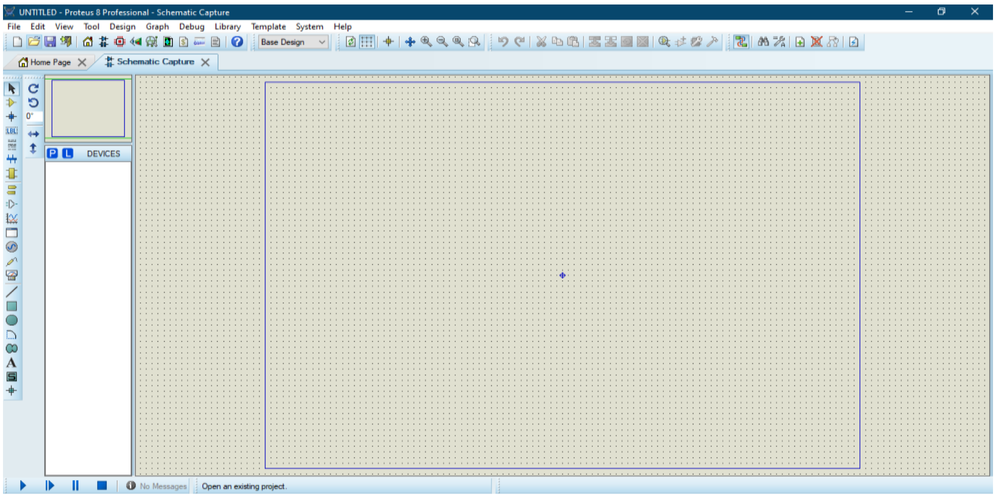


Figure III.4 proteus software interface.

III.5.2 ISIS

Proteus Professional ISIS software is primarily known for editing electrical schematics. In addition, the software also makes it possible to simulate these diagrams, which makes it possible to detect certain errors at the design stage.

Indirectly, the electrical circuits designed by this software can be used in documentation because the software allows to control the majority of the graphical aspect of the circuits.

III.5.3 ARES

ARES software is an editing and routing tool that perfectly complements ISIS. An electrical diagram made on ISIS can then be easily imported on ARES to realize the PCB (Printed circuit board) of the electronic board.

Although editing a printed circuit board is more efficient when done manually, this software allows you to automatically place the components and perform the routing automatically.[59]

III.6 Simulation and Realization of a GPS tracker

III.6.1GSM900D

- First, we need to download and install "The GSM library for Proteus" in Proteus because Without it we cannot use the GSM module in the Proteus ISIS.
- Next, we will design the circuit as shown in the following figure:

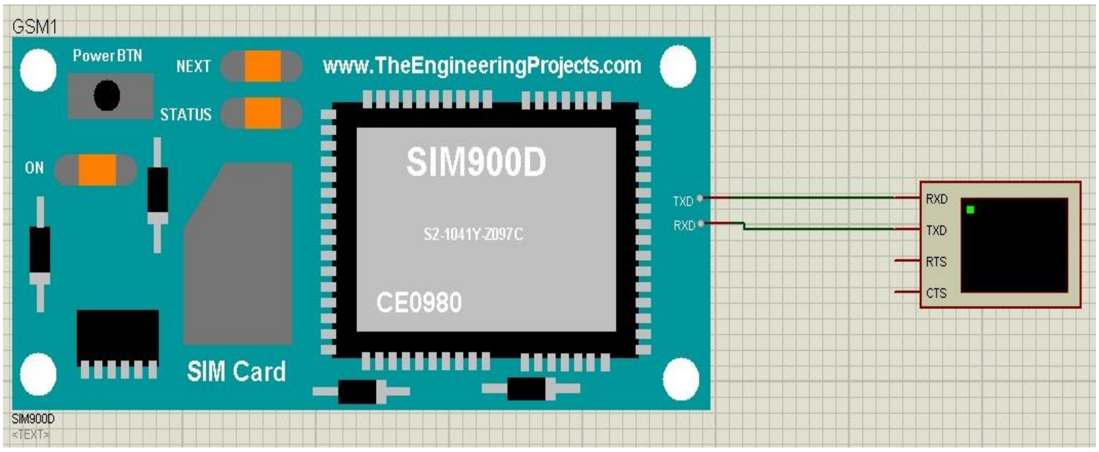


Figure III. 5GSM circuit in PROTEUS.

- Then add the GSM library in GSM module as shown in the following figure:

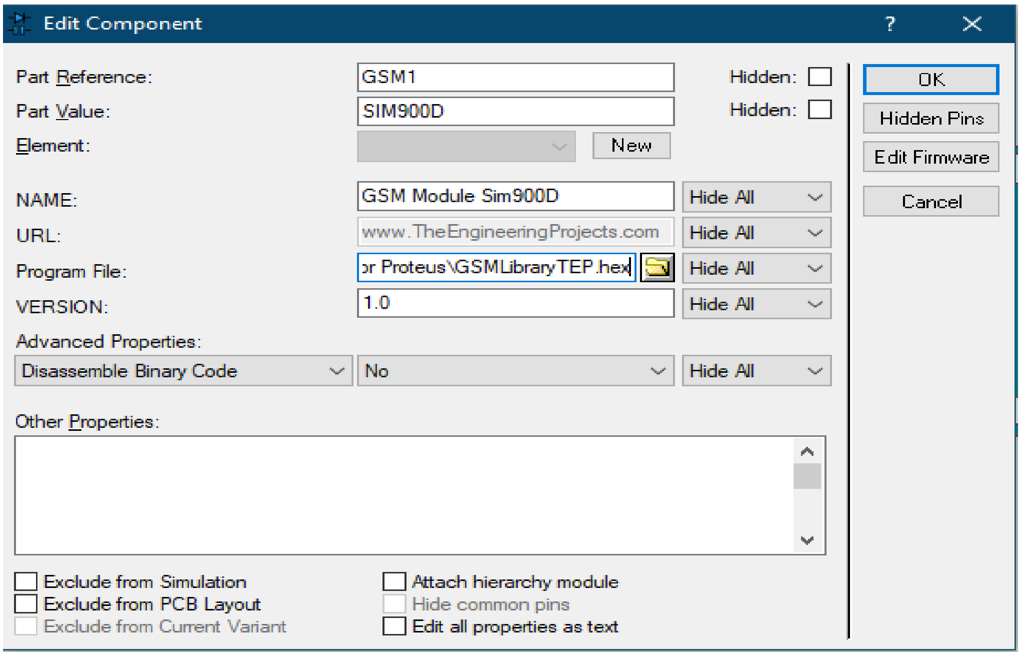


Figure III. 6 the GSM library in GSM module.

- next we need to run the simulation, in our virtual terminal we will send these commands as shown in the following figure:

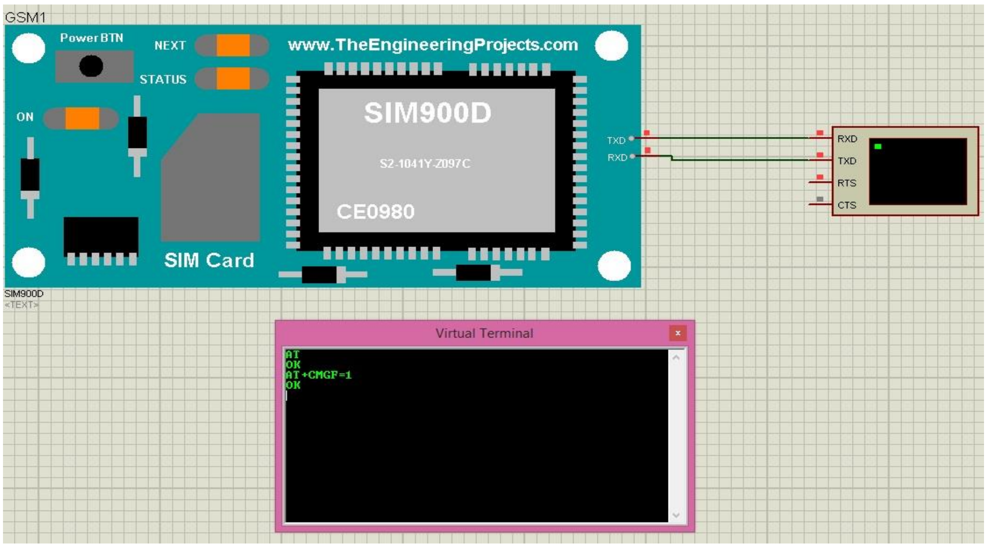


Figure III. 7 The commands which test the GSM.

- AT command is for testing our GSM module,when given OK in reply so it means its working correctly.
- AT+CMGF=1 is for converting our GSM module to text messages, when given us OK in reply that means it has accepted correctly.
- Now we are ready to send our SMS.
- AT+CMGS="+213*********" we can use this command Specifies the number to send messages to.


```
#include <SoftwareSerial.h>
SoftwareSerial SIM900(2, 3);
void setup()
{
 SIM900.begin(2400);
 Serial.begin(9600);
 delay(2000); // give time to log on to network.
}

void loop()
{
 SIM900.print("AT+CMGF=1\r");
Serial.print("AT+CMGF=1\r"); // AT command to send SMS message
 delay(2000);
 SIM900.println("AT + CMGS = \"+213658018230\"");// recipient's mobile number
 Serial.println("AT + CMGS = \"+213658018230\""); // recipient's mobile number
 delay(1000);
SIM900.println("Hello, world"); // message to send
Serial.println("Hello, world");
delay(200);
SIM900.println((char)26); // End AT command with a ^Z, ASCII code 26
Serial.println((char)26);
delay(200);
SIM900.println();
delay(5000); // give module time to send SMS

}
```

Figure III. 8code of GSM

III.6.2 GSM with ARDUINO in Simulation:

- First, we will design the circuit as shown in the following figure:
- Then we will put the following code in Arduino:

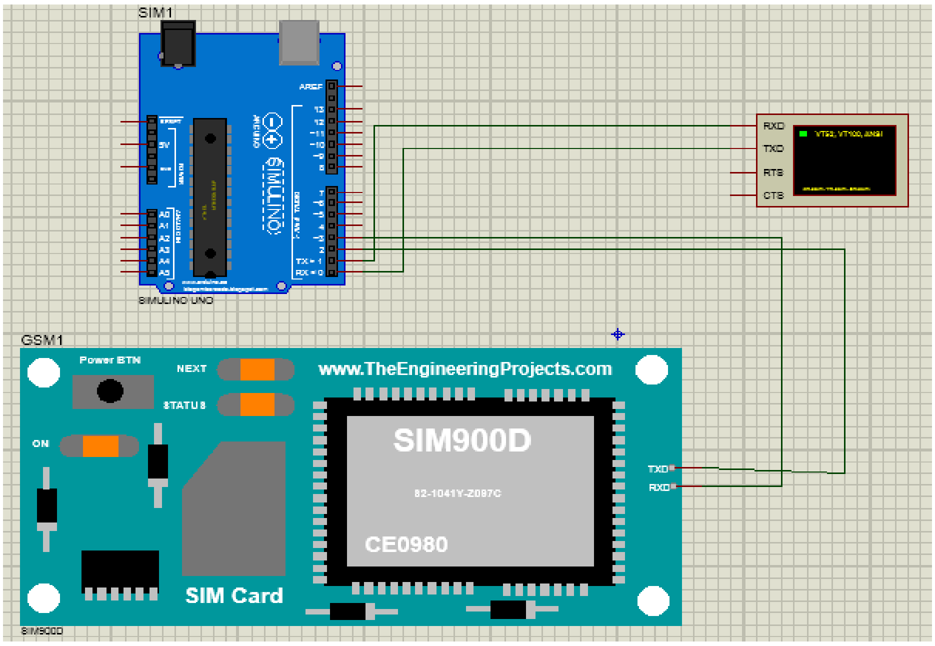


Figure III. 9GSM and ARDUINO UNO circuit in PROTEUS

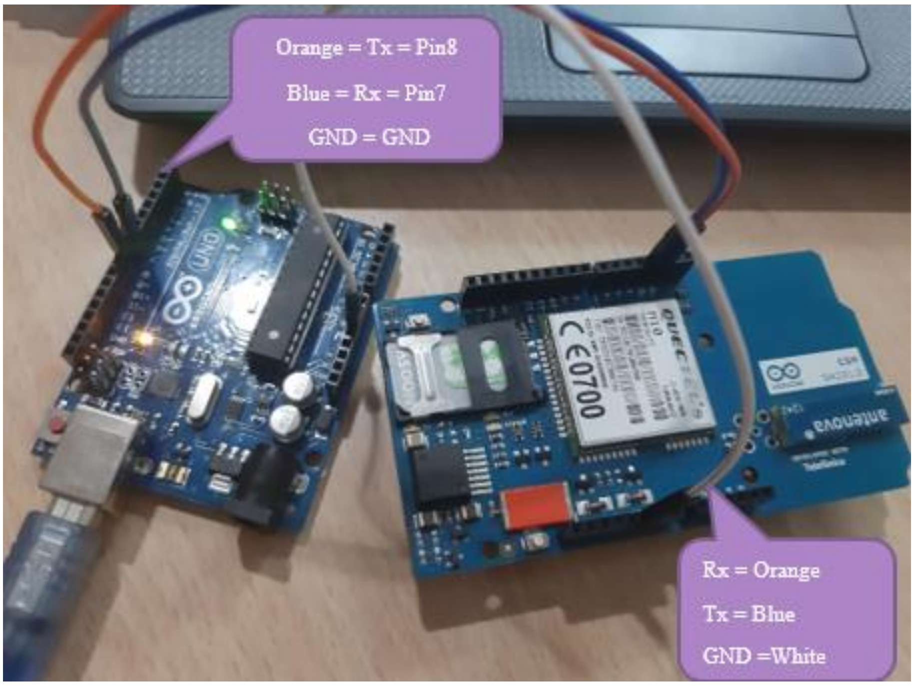


Figure III. 10GSMwith Arduino in Real

III.6.3 GPS with ARDUINO UNO Simulation

- First, we will design the circuit as shown in the figure III.11
- Next, we have used Virtual terminal to show values getting from the GPS Module. We are getting data from the GPS Module via RX pin of the Arduino and then sending this data to Serial Terminal via TX pin.
- Now we need to download the below code in our Arduino board.

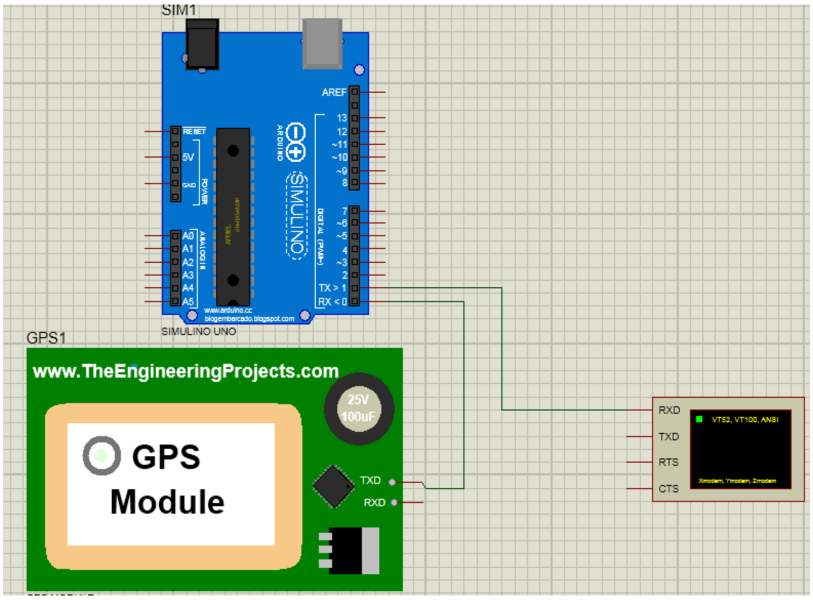


Figure III. 11 GPS and ARDUINO UNO circuit in PROTEUS

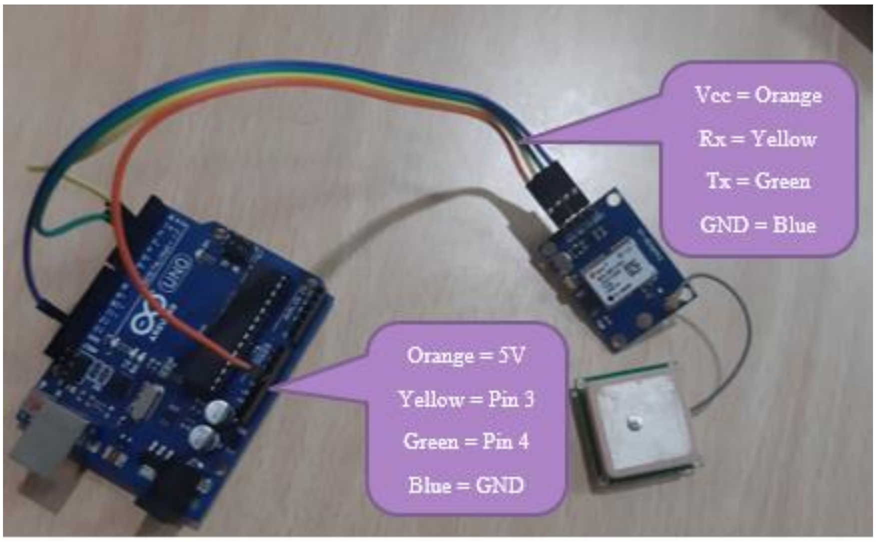


Figure III. 12 GPS with Arduino in Real gps | Arduino 1.6.6

Fichier Édition Croquis Outils Aide

gps §

```
#include <TinyGPS.h>
TinyGPS gps;  //Creates a new instance of the TinyGPS object
void setup()
{
  Serial.begin(9600);
  Serial.print("Simple TinyGPS library v. "); Serial.println(TinyGPS::library_version());
  Serial.println("Testing GPS");
  Serial.println("Designed by: www.TheEngineeringProjects.com");
  Serial.println();
}
void loop()
{
  bool newData = false;
  unsigned long chars;
  unsigned short sentences, failed;

  // For one second we parse GPS data and report some key values
  for (unsigned long start = millis(); millis() - start < 1000;)
  {
    while (Serial.available())
    {
      char c = Serial.read();
      //Serial.print(c);
      if (gps.encode(c))
        newData = true;
    }
  }
```

```
        newData = true;
    }
  }
  if (newData)      //If newData is true
  {
    float flat, flon;
    unsigned long age;
    gps.f_get_position(&flat, &flon, &age);
    Serial.print("Latitude = ");
    Serial.print(flat == TinyGPS::GPS_INVALID_F_ANGLE ? 0.0 : flat, 6);
    Serial.print(" Longitude = ");
    Serial.print(flon == TinyGPS::GPS_INVALID_F_ANGLE ? 0.0 : flon, 6);
  }

  Serial.println(failed);
}
```

Figure III. 13 Code of GPS

- After you run the simulation, we will get the results shown in the figure below:

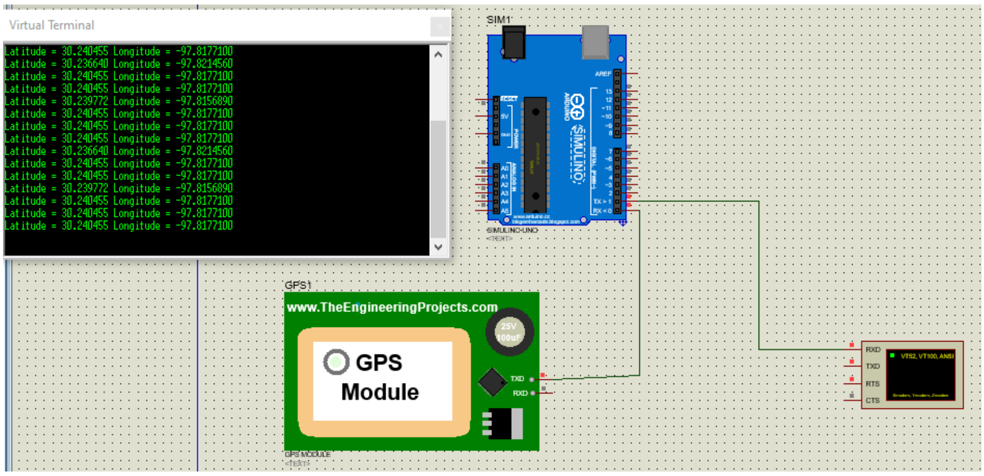


Figure III. 14the results of GPS and ARDUINO UNO

III.6.4 GPS TRACKER

The laststepis our GPS TRACKER, we need to connect the Arduino UNO with the GPS module to get the information (latitude and longitude) to send it in a message with the GSM module.

- First,we will design the circuit as shown in the figure III.14
- Second, we will uploadThe PreviousCodes in GSM and GPS module.

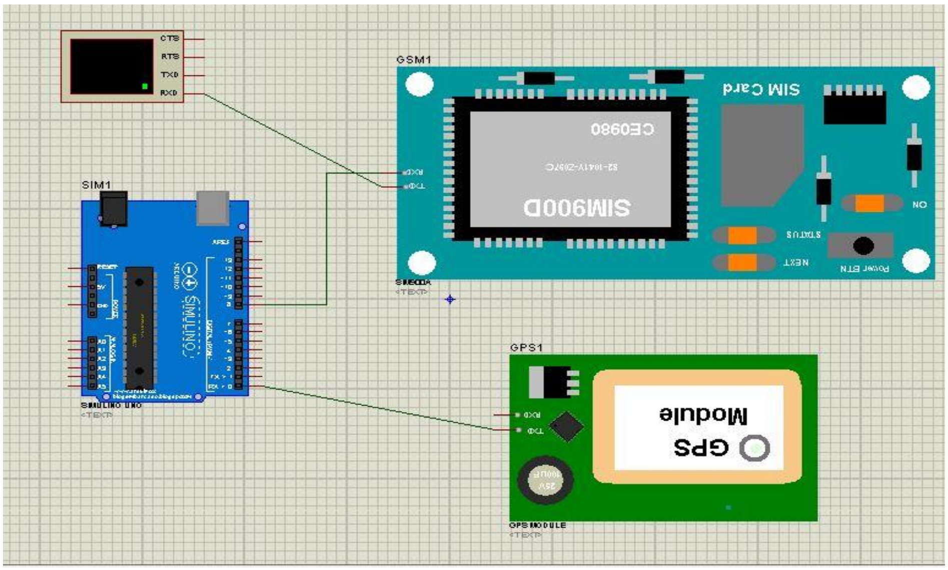
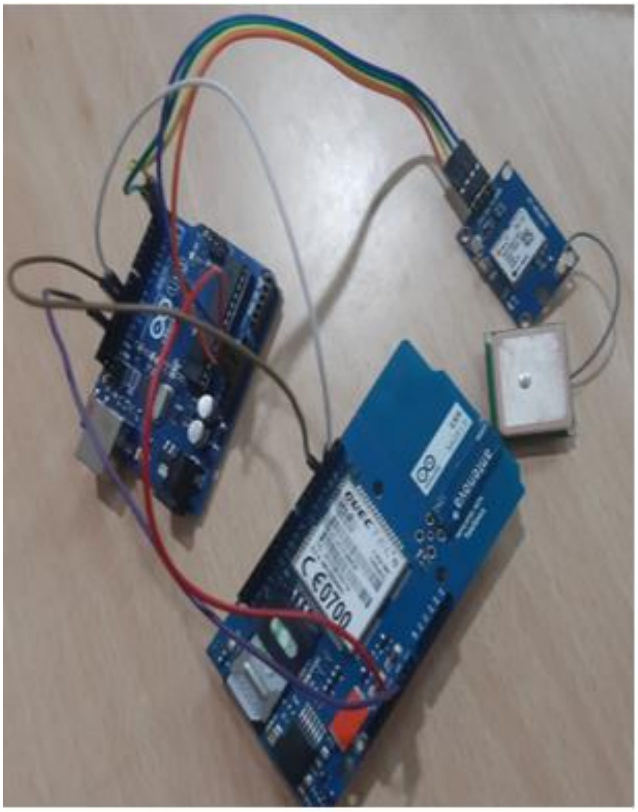


Figure III. 15GPS Tracker circuit in PROTEUS



GSM Module to Arduino

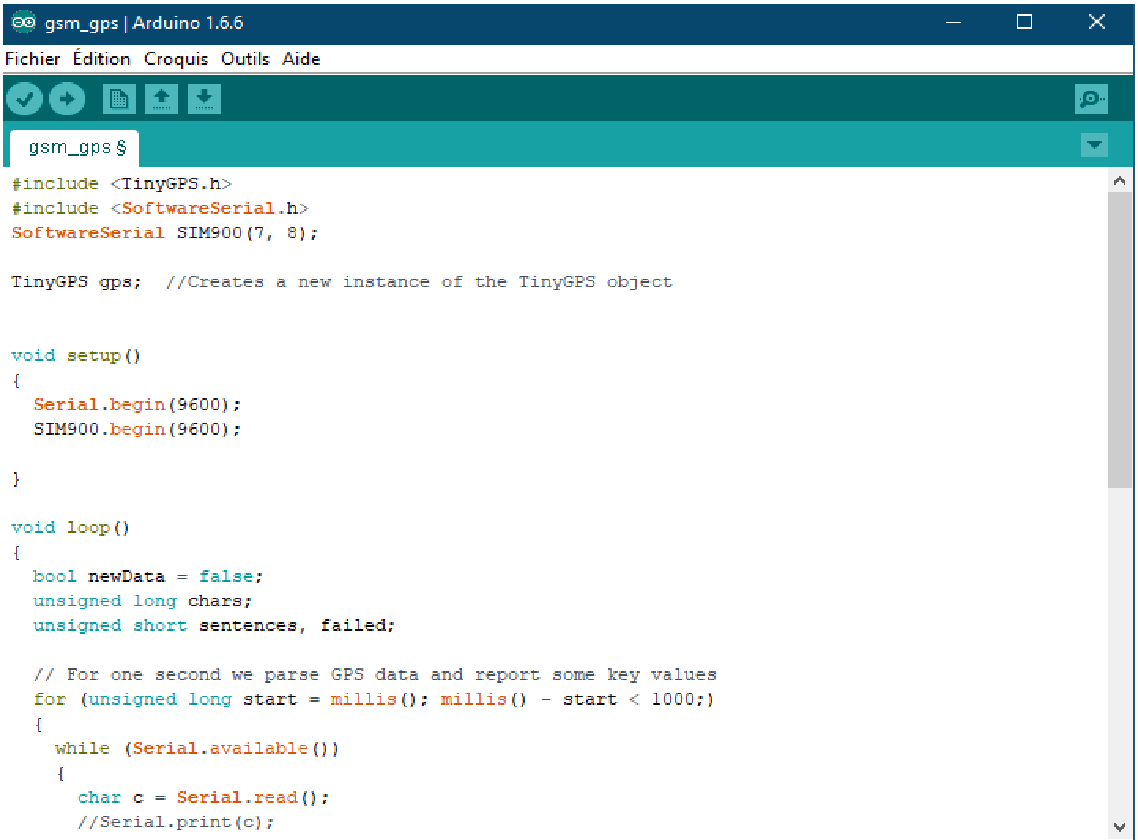
- TX connected to pin 11
- RX connected to pin 10
- 5V from the module to 5V of Arduino
- two Grounds from the module to the Ground to Arduino

GPS Module to Arduino

- Vcc connected to 5V of Arduino
- RX from the module to the TX of Arduino (pin 1)
- TX from the module to the RX of Arduino (pin 2)
- GND to GND

Figure III. 16GPS Tracker in Real

- Finally, we have to upload the below code in our Arduino board:




```
#include <TinyGPS.h>
#include <SoftwareSerial.h>
SoftwareSerial SIM900(7, 8);

TinyGPS gps;  //Creates a new instance of the TinyGPS object


void setup()
{
  Serial.begin(9600);
  SIM900.begin(9600);

}

void loop()
{
  bool newData = false;
  unsigned long chars;
  unsigned short sentences, failed;

  // For one second we parse GPS data and report some key values
  for (unsigned long start = millis(); millis() - start < 1000;)
  {
    while (Serial.available())
    {
      char c = Serial.read();
      //Serial.print(c);
```

```
      //Serial.print(c);
      if (gps.encode(c))
        newData = true;
    }
  }
  if (newData)      //If newData is true
  {
    float flat, flon;
    unsigned long age;
    gps.f_get_position(&flat, &flon, &age);
    SIM900.print("AT+CMGF=1\r");
    delay(400);
    SIM900.println("AT + CMGS = \"+213*********\"");// recipient's mobile number with country code
    delay(300);
    SIM900.print("Latitude = ");
    SIM900.print(flat == TinyGPS::GPS_INVALID_F_ANGLE ? 0.0 : flat, 6);
    SIM900.print(" Longitude = ");
    SIM900.print(flon == TinyGPS::GPS_INVALID_F_ANGLE ? 0.0 : flon, 6);
    delay(200);
    SIM900.println((char)26); // End AT command with a ^Z, ASCII code 26
    delay(200);
    SIM900.println();
  }
  Serial.println(failed);
 // if (chars == 0)
   // Serial.println("** No characters received from GPS: check wiring **");
}
```

Figure III. 17 Code of GPS Tracker

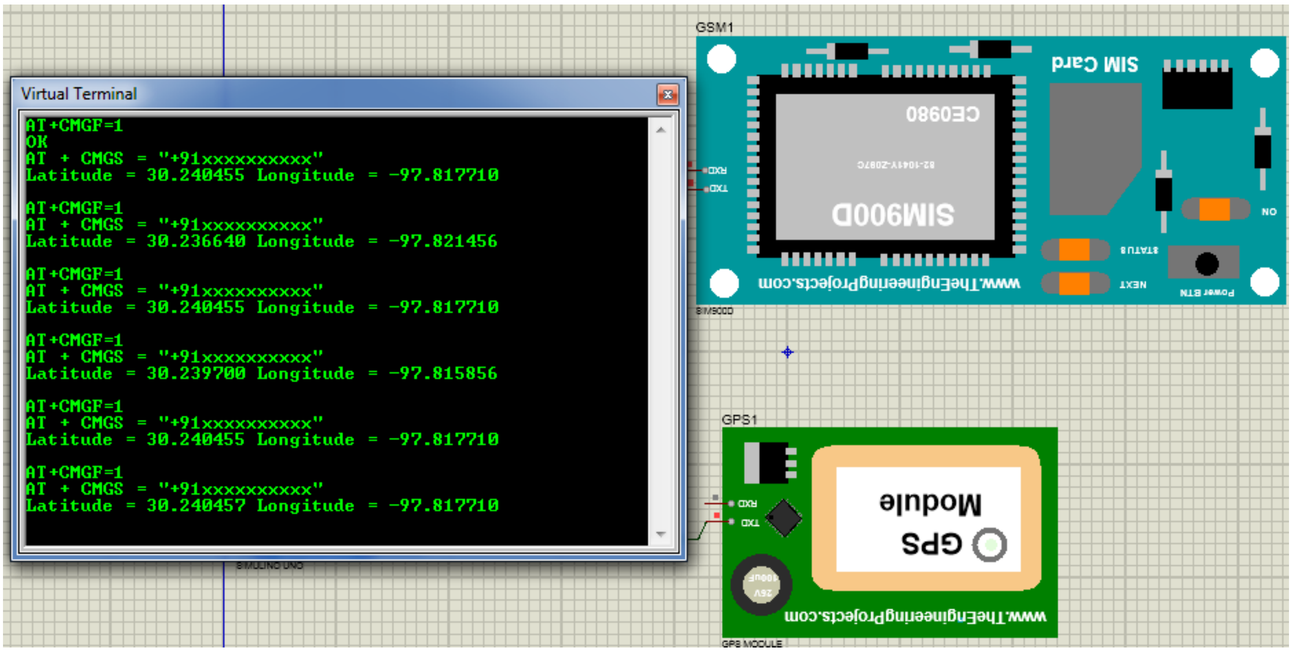


Figure III. 18the Result of GPS Tracker

- ➢ The previous figure shows us the results of the tracking device, so that it gives the coordinates and sends them to the number specified in the code .

III.7The Tracking System

The tracking system shown in the following figure shortened our project so that when the observer needs to position a car, he sends the SMS location request to that vehicle. When the number you mean receives this short message, it replies with an SMS with its coordinates (its latitude, longitude, time, etc.) via the tracker placed in each car. Then, the GSM Shield module at the monitor receives this pampering and pass it to the computer through the Arduino microcontroller. The computer extracts the coordinates from this short message and displays them on the screen on the map in a manner appropriate for the observer.

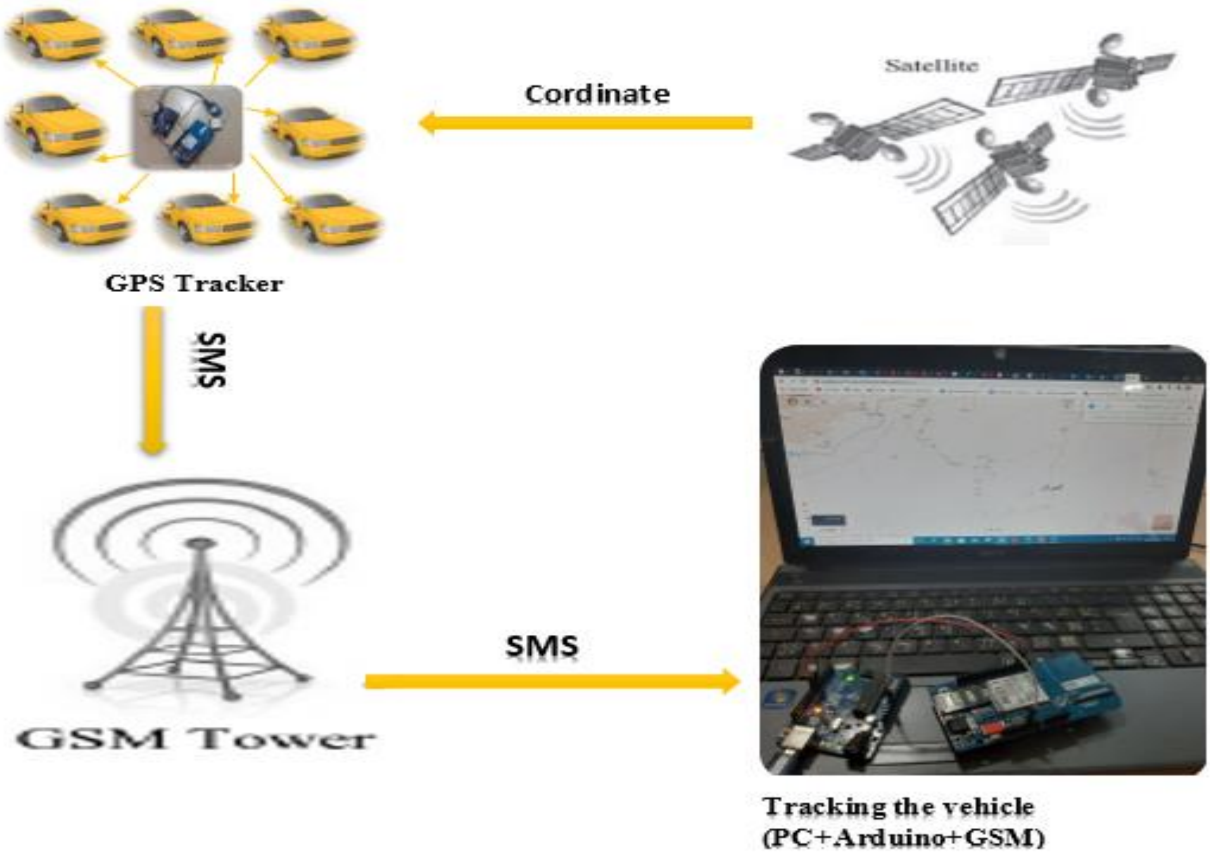


Figure III. 19 The Tracking System

III.7 Conclusion

In this chapter, we covered Arduino and all aspects of his and her mission in our project

Due to satisfactory conditions and time-consuming conditions, we were unable to achieve the project on the ground.

We only simulated the Proteus program, connecting each simulation to its shape on the ground and explaining the steps one by one, and finally getting somewhat satisfactory results.

General Conclusion

General Conclusion

In this end-of-study project, a tracker design that relies on an Arduino microcontroller has been proposed to send geolocation coordinates that come via GPS and send them via text message to the user's phone using GSM. We can see that geolocation is a real tool for navigation in many civil applications and other fields as it provides services such as monitoring cargo and truck fleets, monitoring people with Alzheimer's disease or other diseases, monitoring wild animals in the forest to know their movement, safety related servicesEtc.

We focused on the example of cars.

The project was simulated in Proteus as a start to understanding the technology and ascertaining how well it works in the modules used.

Among the difficulties and obstacles that we faced with the satisfactory conditions that were the biggest obstacle to disrupting the project, the lack of time, in order not to obtain the full results, so we were satisfied with their achievement in simulating and explaining the project steps step by step

In the end, we suggest expanding this study and working on it more due to its importance in most fields and keeping pace with the era of globalization.

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Annex

Code of GSM in Arduino

```
#include <SoftwareSerial.h>

SoftwareSerial SIM900(2, 3);

void setup()

{

 SIM900.begin(2400);

 Serial.begin(9600);

 delay(2000); // give time to log on to network.

}

void loop()

{

 SIM900.print("AT+CMGF=1\r");

Serial.print("AT+CMGF=1\r"); // AT command to send SMS message

 delay(2000);

 SIM900.println("AT + CMGS = \"+213xxxxxxxx\"");// recipient's mobile number

 Serial.println("AT + CMGS = \"+213xxxxxxxxx\""); // recipient's mobile number

 delay(1000);

SIM900.println("Hello, world"); // message to send

Serial.println("Hello, world");

delay(200);

SIM900.println((char)26); // End AT command with a ^Z, ASCII code 26

Serial.println((char)26);

delay(200);

SIM900.println();

delay(5000); // give module time to send SMS
```

```
}
```

Code of GPS in Arduino

```
#include <TinyGPS.h>

TinyGPS gps;  //Creates a new instance of the TinyGPS object

void setup()

{

  Serial.begin(9600);

  Serial.print("Simple TinyGPS library v. ");

Serial.println(TinyGPS::library_version());

  Serial.println("Testing GPS");

  Serial.println("GPS here");

  Serial.println();

}

void loop()

{

  bool newData = false;

  unsigned long chars;

  unsigned short sentences, failed;


  // For one second we parse GPS data and report some key values

  for (unsigned long start = millis(); millis() - start < 1000;)

  {

    while (Serial.available())

    {

      char c = Serial.read();
```

```
      //Serial.print(c);
      if (gps.encode(c))
        newData = true;
    }
  }
  if (newData)      //If newData is true
  {
    float flat, flon;
    unsigned long age;
    gps.f_get_position(&flat, &flon, &age);
    Serial.print("Latitude = ");
    Serial.print(flat == TinyGPS::GPS_INVALID_F_ANGLE ? 0.0 : flat, 6);
    Serial.print(" Longitude = ");
    Serial.print(flon == TinyGPS::GPS_INVALID_F_ANGLE ? 0.0 : flon, 6);
  }
  Serial.println(failed);
}
```

Code of GPS Tracker in Arduino

```
#include <TinyGPS.h>
#include <SoftwareSerial.h>
SoftwareSerial SIM900(7, 8);
TinyGPS gps;
void setup()
{
```

```
  Serial.begin(9600);
  SIM900.begin(9600);
}
void loop()
{
  bool newData = false;
  unsigned long chars;
  unsigned short sentences, failed;
  // For one second we parse GPS data and report some key values
  for (unsigned long start = millis(); millis() - start < 1000;)
  {
    while (Serial.available())
    {
      char c = Serial.read();
      //Serial.print(c);
      if (gps.encode(c))
        newData = true;
    }
  }

  if (newData)      //If newData is true
  {
    float flat, flon;
    unsigned long age;
    gps.f_get_position(&flat, &flon, &age);
```

```
    SIM900.print("AT+CMGF=1\r");
    delay(400);
    SIM900.println("AT + CMGS = \"+213xxxxxxxxx");// recipient's mobile number with country
code
    delay(300);
    SIM900.print("Latitude = ");
    SIM900.print(flat == TinyGPS::GPS_INVALID_F_ANGLE ? 0.0 : flat, 6);
    SIM900.print(" Longitude = ");
    SIM900.print(flon == TinyGPS::GPS_INVALID_F_ANGLE ? 0.0 : flon, 6);
    delay(200);
    SIM900.println((char)26); // End AT command with a ^Z, ASCII code 26
    delay(200);
    SIM900.println();
  }
  Serial.println(failed);
 // if (chars == 0)
   // Serial.println("** No characters received from GPS: check wiring **");
}
```