A Project Report on

Development of A Container GPS Tracking System To Enhance Supply Chain Security

submitted in partial fulfilment of the requirement of
the degree of

Bachelor of Engineering

by

Russel Dmello	14
Sakshi Kaveri	25
Sanskar Kumar	31
Shreyas Nanaware	42

Under the supervison of

Ms. Freda Carvalho

Guide

Mr. Quentin Desouza

Co-Guide

Department of Electronics and Telecommunication Engineering

Don Bosco Institute of Technology, Mumbai–400 070

University of Mumbai

2023-24

A Project Report on

Development of A Container GPS Tracking System To Enhance Supply Chain Security

submitted in partial fulfilment of the requirement of
the degree of

Bachelor of Engineering

by

Russel Dmello	14
Sakshi Kaveri	25
Sanskar Kumar	31
Shreyas Nanaware	42

Under the supervison of

Ms. Freda Carvalho

Guide

Mr. Quentin Desouza

Co-Guide

Department of Electronics and Telecommunication Engineering

Don Bosco Institute of Technology, Mumbai–400 070

University of Mumbai

2023-24

.

Don Bosco Institute of Technology
(Affiliated to the University of Mumbai)
Premier Automobiles Road, Kurla, Mumbai - 400070

Certificate

This is to certify that the project entitled **“Development of A Container GPS Tracking System To Enhance Supply Chain Security ”** is a bonafide work of
submitted to the University of Mumbai in the partial fulfillment of the requirement for the

Russel Dmello	14
Sakshi Kaveri	25
Sanskar Kumar	31
Shreyas Nanaware	42

award of the degree of **“Undergraduate”** in **“Bachelor of Engineering”**.

(**Ms. Freda Carvalho**)
Guide

(**Mr. Quentin Desouza**)
Co-guide

(**Ms. Namita Agarwal**)
HOD, EXTC

(**Dr. Sudhakar Mande**)
Principal

Don Bosco Institute of Technology

(Affiliated to the University of Mumbai)

Premier Automobiles Road, Kurla, Mumbai - 400070

Project Report Approval for B.E.

This project report entitled **"Development of A Container GPS Tracking System To Enhance Supply Chain Security "** by **Russel Dmello, Sakshi Kaveri, Sanskar Kumar, Shreyas Nanaware** is approved for the degree of **Bachelor of Engineering** in **Electronics** & **Telecommunication Engineering**.

______________ ______________

Internal Examiner External Examiner

Date:

Place: Mumbai

Declaration

We declare that this written submission represents our ideas in our own words and where others' ideas or words have been included, We have adequately cited and referenced the original sources. We also declare that we have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea / data / fact / source in our submission. We understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources that have thus not been properly cited or from whom proper permission has not been taken when needed.

Russel Dmello

Sakshi Kaveri

Sanskar Kumar

Shreyas Nanaware

Date:
Place: Mumbai

Acknowledgement

A project is a teamwork that involves the contribution of many people. We would like to thank everyone who has contributed by taking an interest in our work and motivating us all the way through.

Our sincere thanks to **Ms. Freda Carvalho**, project guide, for guiding us throughout the project and also for helping us with all the difficulties we faced throught out the project work.

We would like to thank **Ms. Namita Agarwal**, Head of Department for supporting us and helping us for project.

We thank **Ms. Freda Carvalho**, Project Coordinator for guiding us with the simulation process and helping us with the difficulties.

We thank **Mr. Quentin Desouza**, CEO, Qdnet Technologies, for providing us the opportunity for working on a industry level project and guiding us throughout the process.

We would also like to thank **Dr. Sudhakar Mande**, Principal and Management of Don Bosco Institute of Technology for allowing us to use the college campus and infrastructure throughout our project.

We would also like to thank all the lab assistants as well for helping us whenever required.

Submitted with regards,

Russel Dmello

Sakshi Kaveri

Sanskar Kumar

Shreyas Nanaware

Date :
Place : Mumbai, Maharashtra, India.

Contents

List of Figures

List of Tables

List of Abbreviations

GSM	Global System For Mobile Communications
GPS	Global Positioning System
GPRS	General Packet Radio Service
STM	STMicroelectronics
NMEA	National Marine Electronics Association
UART	Universal Asynchronous Receiver-Transmitter
PCB	Printed Circuit Board
IDE	Integrated Development Environment
AT	Attention

Abstract

This work proposes a GPS tracking system to prevent shipment theft. The system is less expensive, more durable, reliable, more accurate than previous systems. The system makes use of GSM, GPS modules, and an STM32F302R8 microcontroller. The sensor used is a simple current break sensor that will detect and send an alert to the server via the GSM module. It also allows for live container tracking and intelligent error resolution in false alarms. A tracking system for shipments using GSM, GPS, and a microcontroller serves the following key purposes: Real-Time Location Monitoring, theft prevention, error resolution, cost efficiency.

Chapter 1

Introduction

The main priority is to keep the containers and its valuables within safe at all times during the transit. The tracking system will help in tracking the location in real-time and make sure the safe logistics of the materials as planned. If the customers know the precise locations of their containers, there will definitely be the trust factor from the client side due to the reliable mode of business.Thiswork can prevent delay and and also provides anti theft solution, thus reducing the time and ensuring increase in the efficiency.
The proposed project aims to develop a container GPS tracking system that will help prevent theft and improve the security of the supply chain. With the use of GPS technology, the system will enable companies to track the location of their containers in real-time and receive alerts if any unauthorized activity is detected.
This project addresses various aspects given as follows :

- Integrity
- Trust
- Safety of Equipment
- Social Reference

By implementing this system, businesses can safeguard their precious shipments, ensure seamless logistics, and elevate overall customer satisfaction.

1.1 Motivation

In today's world customers have expectations when it comes to knowing where their goods are, at any given moment. By providing increased security measures and efficient tracking systems businesses can gain an edge. Also, with the maintenance of a predestined route for transport, the efficient utilisation of the fuel and other resources are thus ensured. The global supply chain faces risks such as theft, tampering, natural disasters and geopolitical disturbances. These vulnerabilities can result in losses and disruptions, in the movement of goods. By reducing theft incidents and improving the efficiency of the supply chain we can not contribute to sustainability goals. Also minimize emissions and waste during transportation.

1.2 Scope of the Project

This project can be scaled to a level where multiple containers can be tracked individually and simultaneously by converting this into a full-fledged system. A predefined route of transport can be generated and the adherence to it can be tracked as a proof of safety of goods.

1.3 Problem Statement

Develop and implement a low-power container GPS tracking system for real-time monitoring and tracking of container locations and preventing theft to enhance supply chain security and ensure safe transportation of goods.

1.4 Objectives

- To create a reliable GPS tracking solution for shipping containers.
- Setup UART-GSM communication to send collected data to the server.
- Efficiently designing and fabricating the PCB
- To design an closed circuit system for alerting any theft attempt
- To optimize power consumption to extend the tracking system's battery life
- To create data analysis algorithms for processing and interpreting GPS data on a Web server

1.5 Outcomes

- To enhance supply chain security
- To ensure minimum Power requirement
- To provide live tracking of container
- To detect theft alerts and location of theft
- Publications of Paper

Chapter 2

Literature Survey

2.1 Limitation of Existing System or Research Gap

Several constraints and research opportunities exist in the realm of container tracking systems. Current systems suffer from limited real-time visibility, providing only intermittent updates instead of a continuous stream of data. To enhance supply chain transparency, researchers can concentrate on designing systems with more precise and real-time tracking capabilities. Additionally, environmental conditions, such as harsh temperatures, humidity, and exposure to seawater, can impact device durability and efficacy. Further research into more resilient and weather-resistant tracking technology is necessary to circumvent these challenges. Batteries are the backbone of many tracing systems, but their effectiveness dwindles when it comes to tracking long-distance and global shipments. This situation is mainly due to their power consumption limit. To overcome this problem, research can be conducted into energy-harvesting technology or low-power tracking resolutions.

2.2 Comparative Analysis of various existing systems

Container tracking systems that rely on GPS and GSM modules have gained adoption, for the management and monitoring of shipping containers. However they do present challenges and issues. Some of the concerns associated with existing container tracking systems utilizing GPS and GSM modules are as follows;

1. Limited Coverage in Remote Areas; In offshore locations GSM networks may not offer sufficient coverage making it challenging to track containers accurately.[1] This can lead to spots and a lack of real time data.

2. Battery Life; The power requirements of GPS and GSM modules can quickly drain the battery especially when containers need to be tracked for periods without access to a power source. This limitation restricts the effectiveness of systems, for long distance shipments.[3]

3. Theft and tampering pose risks, for containers. In case the GPS or GSM module is easily reachable it could be. Removed by thieves, which would render the tracking system ineffective.[4]

4. For shipping firms that lack massive resources, it can be pretty daunting to foot the bill that comes with installing and upkeeping GPS and GSM tracking systems. This is especially the case for small and medium-sized organizations- the hardware alone can be pretty huge, coupled with other bills such as subscription payments.[2]

5. High data transmission expenses might arise when transmitting GPS data over GSM networks, especially for global shipments with potential roaming charges.[5]

6. Inaccuracies in tracking data can result from various factors, including weather, tall buildings, or nearby electronic devices interfering with GPS signals. So, it's important to be aware of potential issues with data accuracy.[2]

7. Container tracking necessitates powerful data storage and analysis to manage the bulk of data generated. The storage and processing capabilities should be robust to address the challenges that arise.[1]

8. Handling a vast number of containers through container tracking systems can be a challenging and intricate task, often calling for a considerable investment in infrastructure. The issue of scalability arises when expanding these systems to accommodate such a volume.[4]

9. Regular GPS and GSM maintenance is essential for keeping the modules operational.[5]

10. GPS data transmission expenses can be excessively high, especially when dispatching internationally as extra fees may apply due to roaming charges over GSM networks.[3]

Chapter 3

Methodology

3.1 Methodology of the project

In developing a research project, it is essential to establish a strategy that reflects the methodology. This involves gaining a deep understanding of prevalent methods employed in your field and the associated theories and principles, towards designing an approach that suits your objectives. Thus, the methodology or steps for this proposed project is given as follows :

1) Initialize the GPS module

2) Establish UART communication between GPS and STM32 microcontroller

3) Retrieve data in the form of NMEA snetences and convert it into a suitable format

4) Initialize the GSM module with the help of AT commands

5) Establish UART communication between GSM and STM32 microcontroller

6) To send the collected data from the STM32 to the server via GSM

7) Repeat steps 3 to 7 at hourly intervals for continuous tracking and updating the location

8) Sensor integration is done through the means of wire breaking alert mechanism

3.2 Approach & Analysis

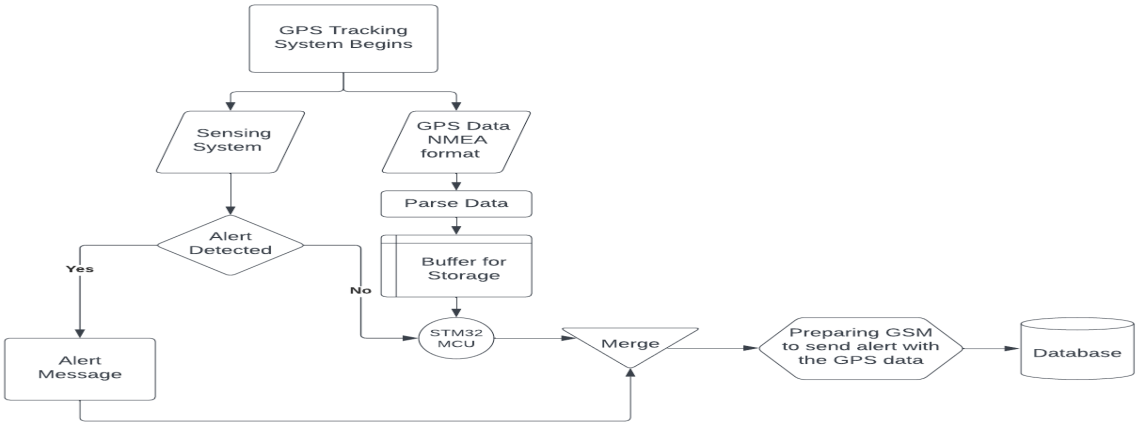


Figure 3.1: Flowchart for Approach used

The GPS module is responsible for giving precise co-ordinates in terms if latitude , longitude and time as well in a suitable NMEA format to the micro-controller which will store all this data in its buffer memory. This data is then being sent to the GSM module who is responsible for transmitting it to the database and server where we can see the real time location of the container shipment.

In case of a break-in attempt, the lock mechanism will generate and trigger the alert message consisting of the co-ordinates of the location where the incident has happened. This message then goes to the micro-controller and eventually to GSM module reaching the database and giving warning of a theft attempt.

Development of a tracking system using GPS, involves addressing of various false positive alarms and as we make progress towards the implementation. These are nothing but the different scenarios where the tracking system might be vulnerable. One such probable vulnerability we addressed is that in a scenario where the system might show the same location of the container system for an extended duration of time which might be concerning. Now whether this is an error or a break-in attempt where the container shipment is hijacked and is made stationary or even being taken off the desired path or is the container shipment is just being stuck in traffic in case the shipment is taken by roadways logistics method. The first thing that is to be done is to put the modules into low power or sleep mode in order to ensure minimum to absolute no power consumption whatsoever. Secondly, setting up geo-fencing or virtual boundaries based on predetermined path of the container so as to get a better idea of what the exact location is. Third is to make use of motion sensors and existing maps services in order to make sure any break-in attempts is being carried out or not. Thus, the summary of analysis section is given as follows :

1) The system's behavior depends on factors like traffic for location updates

2) It has provisions to prevent false alerts during traffic delays

3) Geo-fencing allows setting up the virtual boundaries for alerts when the container deviates from its route

4) Modules can enter low power mode during extended stationary periods to save power

5) Motion sensors act as a security measure to detect break-in attempts when the container is stationary

3.3 Circuit Schematics

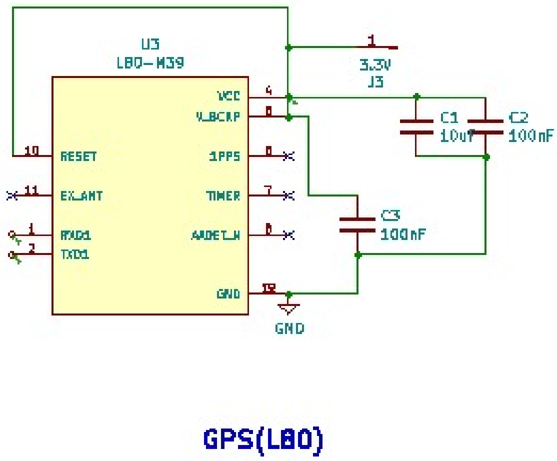


Figure 3.2: GPS module schematic

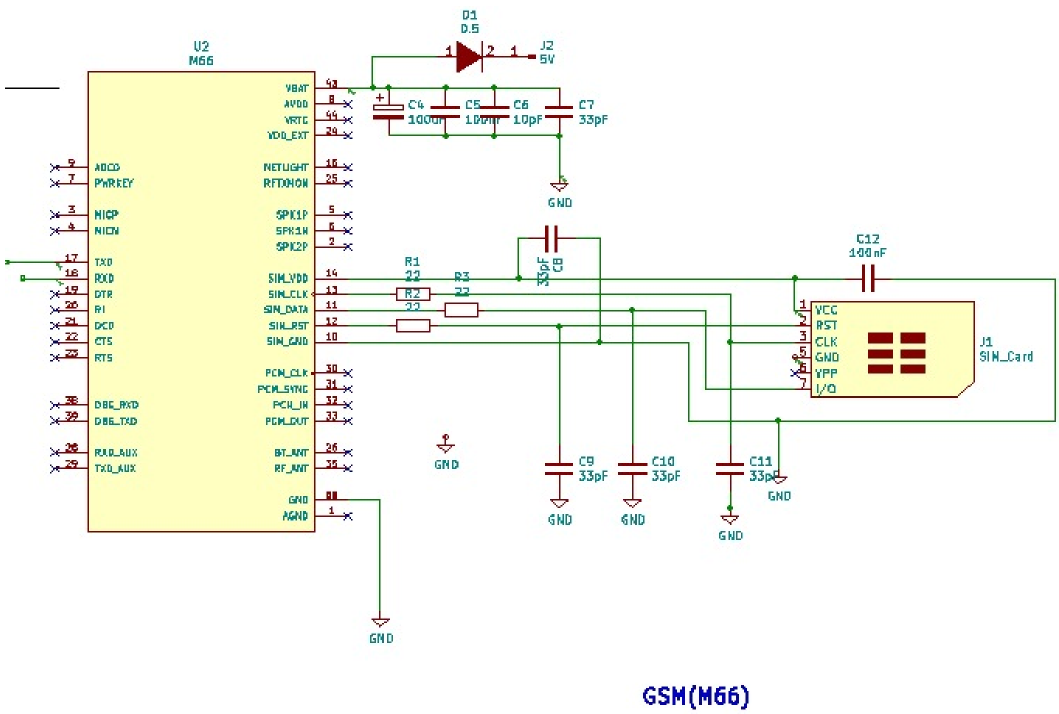


Figure 3.3: GSM module schematic

The circuit schematic represented above shows the connections for both the GPS and the GSM module respectively. The schematics are made in an open source free software named KiCad. Based on datasheets and as per required application, the required connections are made in the circuit. Each and every value of every component has been verified by going through the datasheet thus ensuring proper caliberation of the circuit.

3.4 Block Diagram

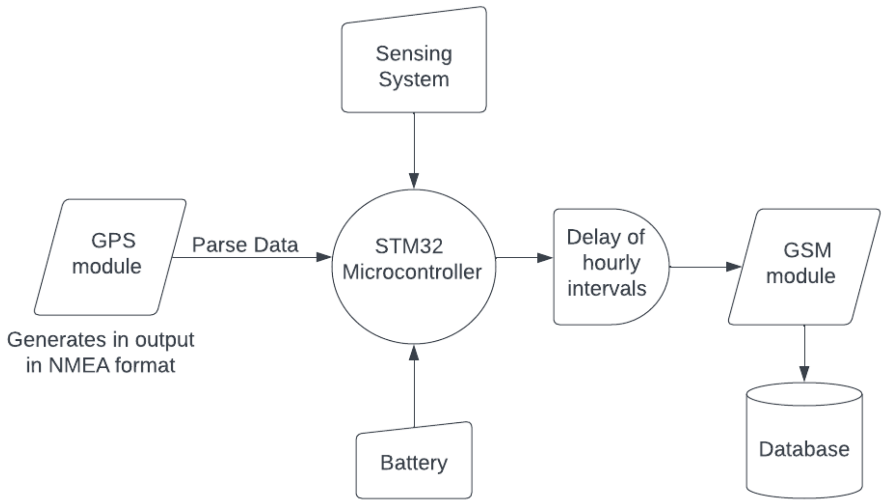


Figure 3.4: Block Diagram

This is our block diagram of the tracking system. First, we have the GPS module who is responsible for getting the exact co-ordinates of the container in real time that is the latitude, longitude along with the time as well. The co-ordinates will then be processed and sent to the STM32 microcontroller which will make the output store in its buffer memory in a suitable format which can be further sent to the database and the end user.

The power supply or the battery is connected to the system. The simple lock system ensuring the anti-theft mechanism is acting as a sensor and this input we are feeding to the microcontroller so that in case of any unwanted activity the alert can be sent immediately.

There is a delay added after the microcontroller. We are currently sending the data at an hourly interval. IT means that the data will be transmitted for only 1 min every hour which will help save the power a lot and thus extending the overall capacity and reliability of the system. The modules will be in sleep mode or a low power mode for most of the time thus ensuring minimum to absolutely no power consumption. Battery calculations will be done for the modules and the entire system which will give an idea as to what exactly the power requirements are of the system and how to make it a low power system as we had previously mentioned before in our objectives section.

The co-ordinates which are in the form of NMEA strings is then passed on the the GSM module who is mainly responsible for the transmission of these values to the database and server where the location is being tracked in real-time.

Chapter 4

Implementation or Simulations

Following are our simulation results that we got for the GPSmodule testing when we worked on it using docklight and arduino ide console.

```
$GPGGA,080158.085,,,,,0,0,,,M,,M,,*41<CR><LF>
$GPGSA,A,1,,,,,,,,,,,,,,,*1E<CR><LF>
$GPGSV,1,1,02,31,,,37,27,,,27*7D<CR><LF>
$GPGLL,,,,,080158.085,V,N*73<CR><LF>
$GPTXT,01,01,02,ANTSTATUS=OPEN*2B<CR><LF>
$GPRMC,080159.085,V,,,,,0.00,0.00,170923,,,N*4B<CR><LF>
$GPVTG,0.00,T,,M,0.00,N,0.00,K,N*32<CR><LF>
$GPGGA,080159.085,,,,,0,0,,,M,,M,,*40<CR><LF>
$GPGSA,A,1,,,,,,,,,,,,,,,*1E<CR><LF>
$GPGSV,1,1,02,31,,,37,27,,,27*7D<CR><LF>
$GPGLL,,,,,080159.085,V,N*72<CR><LF>
$GPTXT,01,01,02,ANTSTATUS=OPEN*2B<CR><LF>
$GPRMC,080200.085,V,,,,,0.00,0.00,170923,,,N*44<CR><LF>
$GPVTG,0.00,T,,M,0.00,N,0.00,K,N*32<CR><LF>
$GPGGA,080200.085,,,,,0,0,,,M,,M,,*4F<CR><LF>
$GPGSA,A,1,,,,,,,,,,,,,,,*1E<CR><LF>
$GPGSV,1,1,02,31,,,37,27,,,26*7C<CR><LF>
$GPGLL,,,,,080200.085,V,N*7D<CR><LF>
$GPTXT,01,01,02,ANTSTATUS=OPEN*2B<CR><LF>
$GPRMC,080201.085,V,,,,,0.00,0.00,170923,,,N*45<CR><LF>
$GPVTG,0.00,T,,M,0.00,N,0.00,K,N*32<CR><LF>
$GPGGA,080201.085,,,,,0,0,,,M,,M,,*4E<CR><LF>
$GPGSA,A,1,,,,,,,,,,,,,,,*1E<CR><LF>
$GPGSV,1,1,02,31,,,37,27,,,26*7C<CR><LF>
$GPGLL,,,,,080201.085,V,N*7C<CR><LF>
$GPTXT,01,01,02,ANTSTATUS=OPEN*2B<CR><LF>
$GPRMC,080202.085,V,,,,,0.00,0.00,170923,,,N*46<CR><LF>
$GPVTG,0.00,T,,M,0.00,N,0.00,K,N*32<CR><LF>
```

Figure 4.1: NMEA sentences on Docklight

Contained within GPS receivers, NMEA sentences are a common format of data output that feature diverse pieces of data, spanning from time to altitude, to speed and beyond, which are segmented using commas within messages. Concluding with Carriage Return and Line Feed after beginning with a dollar sign, NMEA sentences also possess a checksum, which works as a means of ensuring the accuracy of the data presented. Essentially, NMEA sentences are utilized as a tool to send and receive GPS-produced information.

GPS modules are employed to receive signals from GPS satellites and disseminate information regarding the position, time, and speed of the device. The output of a GPS component is typically composed of NMEA statements. These sentences describe the location, time, and other specifications in a standardized manner.

$GPGGA,123519,4807.038,N,01131.000,E,1,08,0.9,545.4,M,46.9,M,,*47

This sentence contains the following information:

$GPGGA: Sentence identifier 123519: UTC time (12:35:19)

4807.038,N: Latitude 48 deg 07.038' N

01131.000,E: Longitude 11 deg 31.000' E

1: Fix quality (0 = invalid; 1 = GPS fix; 2 = DGPS fix)

08: Number of satellites in view

0.9: Horizontal dilution of precision (HDOP)

545.4,M: Altitude (in meters) above mean sea level

46.9,M: Height of geoid (in meters) above WGS84 ellipsoid

(empty field): Time in seconds since last DGPS update

(empty field): DGPS station ID number

*47: Checksum

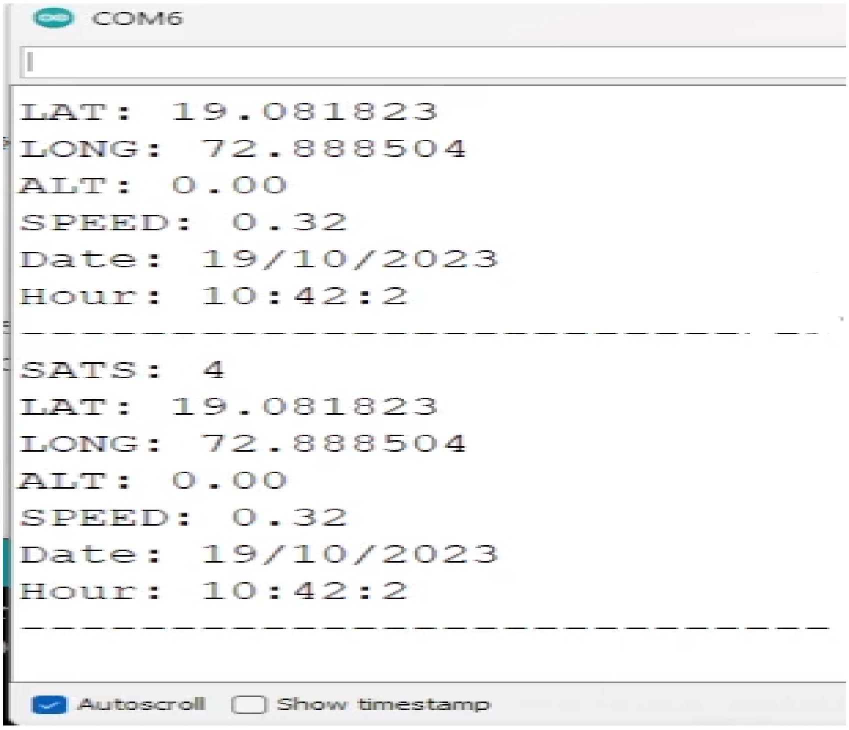


Figure 4.2: GPS-Co-ordinates along with time showing the exact location on Arduino console

As we can see from the above image, when we connected the GPS module for testing, we were able to extract the GPS co-ordinates that is the latitude, longitude and the date and time as well.

There are some additional parameters data present as well such as the altitude at which we are operating, the speed and the number of satellites present their at that particular instant of time.

Chapter 5

Results

Results of work till semester VII

Table 5.1: Bill of Materials

Components	Quantity	Price(Rs.)
GSM (M66) module	1	1,549.04
GPS (L80) module	1	450
STM32F302R8 microcontroller	1	912.91
Fabrication cost	1	10,000

5.1 Timelines

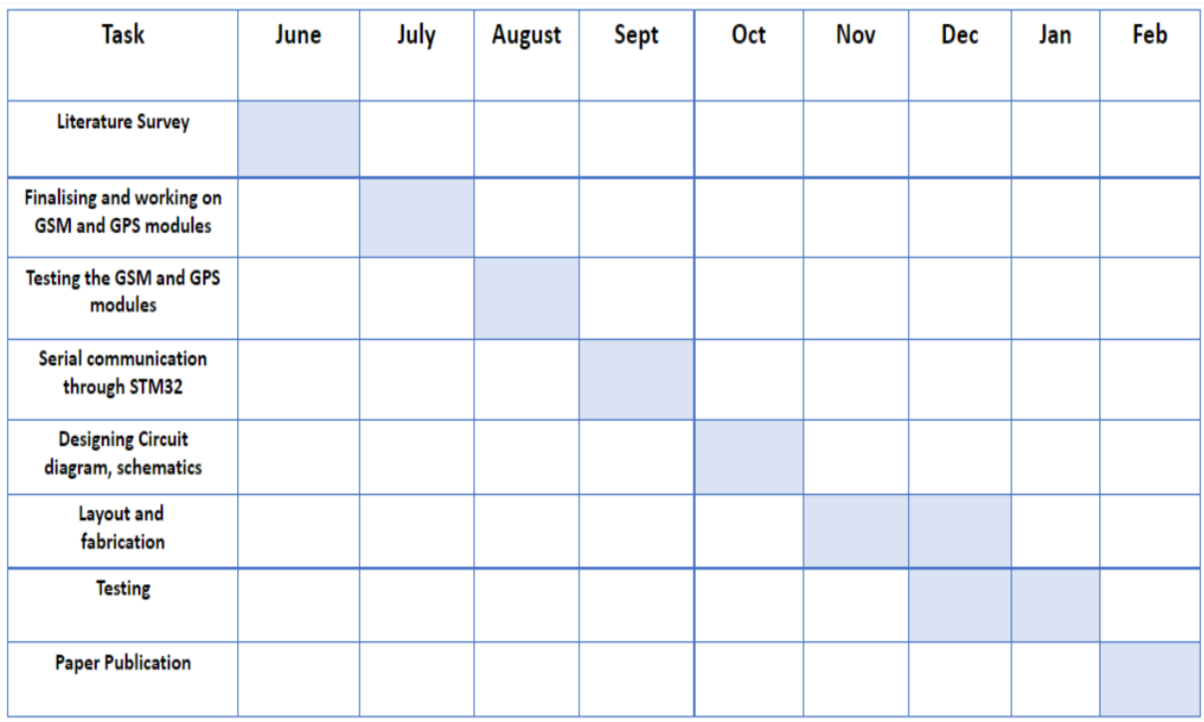


Figure 5.1: Timeline or Gantt Chart

5.2 Plan for Semester VIII

In the second phase of this project, we are primarily prioritising to get the layout and fabrication of the PCB to be done first. Careful layout can optimize space utilization, thus making the overall tracking system more compact. The proper design of the circuit ensures that electronic components are positioned correctly, which enables the intended function to occur. Well-planned arrangements facilitate the identification and replacement of corrupt components, this facilitates both maintenance and repair.

1) GPS Testing:

- Signal Acquisition: Ensure that the module is able to acquire GPS signals and calculate accurate position information.
- Accuracy assessment: Evaluate the accuracy of the location data provided by the module in comparison to other data or known locations.
- Time Synchronization: Ensure that the module is capable of precisely following GPS time signals.
- Cold/Warm/Hot Start Testing: Review the amount of time it takes for the module to begin and receive signals in different scenarios.
- Power Consumption: Measure the amount of power consumed by the module in different states of operation in order to maximize energy efficiency.
- Antenna compatibility: make sure the module is compatible with the specified antenna and that it has a high degree of sensitivity to signal strength.
- Data Transmission: Test the capacity of the module to transmit location data to a central platform or device.

2) GSM Testing:

- Network Registration: Ensure that the module will successfully register with the GSM network and receive a valid card with a SIM.
- SMS functionality: Ensure the module's capacity to send and receive messages in text.
- Data Connector: Review the module's capacity to create and maintain a GPRS/3G/4G data bond for the purpose of internet access.
- Power Management: Evaluate the amount of power consumed in various states, including the standby and active modes.

Chapter 6

Conclusion

Overall, the project that has resulted in the creation of a GPS system using GPS and GSM components in conjunction with an STM32 microcontroller has been completed successfully. This system provides instantaneous tracking and monitoring capabilities, it provides accurate GPS data regarding location, and it enables communication via GSM networks. The combination of the STM32 microcontroller with the system increases the capacity and control of the system. The project demonstrates the practical application of embedded systems and wireless communication technologies, it exhibits the potential for various tracking and monitoring applications, including vehicle tracking to asset management and beyond.
The project aims in implementing the following :

- Live tracking of the containers will be possible through the transmission of data by GSM module. The transmission of the data will be optimised for both power and duration
- The GPS module will be interfaced to provide location information
- A simple sensing mechanism will be integrated to detect theft
- A long lasting and smart solution for theft detection will be designed and developed

Appendix

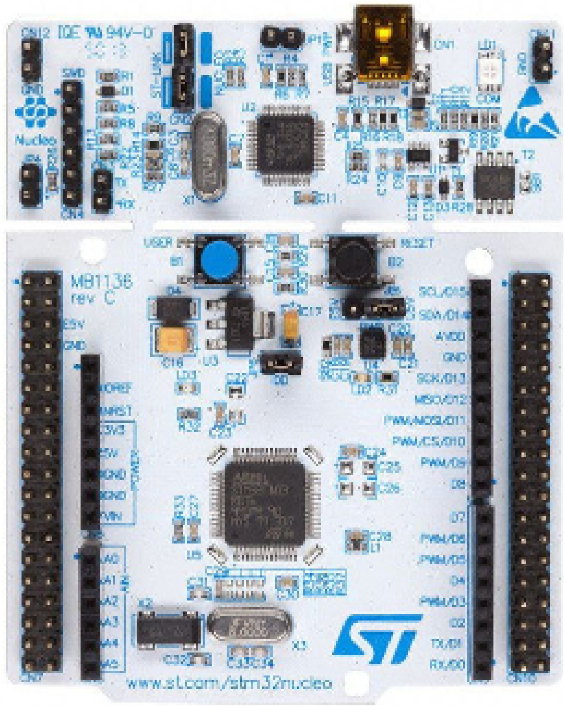


Figure 6.1: STM32F302R8 Microcontroller

STM32 microcontrollers is known for playing an important role in various sectors across various industries. Some of the areas it is used in are engine control, safety systems, etc. In our proposed system we are using STM32F302R8 as our microcontroller which will be responsible for taking the data sent by the GPS module and making it in suitable format before storing it in the buffer memory so that it can be sent to the GSM module which will further pass it on to the dedicated database and server created which will hold all the data for displaying it to the user at all times.

Figure 6.2: TTL Converter

Transistor-Transistor Logic, or TTL, is a type of serial communication that is frequently used in modern microcontrollers using the UART (universally asynchronous receiver/transmitter) transmission technique. In order to receive data on your PC, it converts a serial protocol, such as UART, to USB protocol. It resembles something like a microcontroller that has been configured to convert data from USB to UART and vice versa based on the flow of the data.

Figure 6.3: Quectel M66 GSM module

The M66 is a quad-band GSM/GPRS 2G module with LCC castellation packaging that measures 17.7mm 15.8mm 2.3mm. It is developed for low-power IoT use cases that run in challenging environments and is based on the most recent 2G chipset. It is optimized for data, SMS, and voice transmission. The M66 employs surface mounted technology, which makes it perfect for large-scale manufacturing, which can have stringent cost and efficiency requirements. The M66's ultra-compact profile makes it particularly suitable for applications that have a strict requirement for size, and the module can be used in a variety of settings, including wearable technology, automobiles, PDAs, asset tracking, point-of-sale systems, smart meters, and telematics. The GSM module will take the data sorted out by the STM32 micrcontroller that it received from the GPS module and the sensing system and GSM module is thus responsible for sending this data to the database for storing purposes.

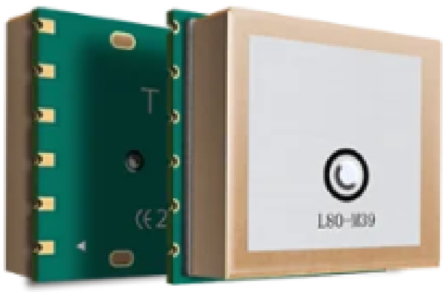


Figure 6.4: Quectel L80 GPS module

The L80 is a GPS POT (Patch on Top) module that is incredibly small and has a patch antenna that is 15.0 x 15.0 x 4.0mm. L80 is the ideal module for the little gadgets because of its compact design. When coupled with a patch antenna and adopted by the LCC package, the L80 exhibits remarkable performance in both acquisition and tracking. GPS is responsible for receiving the co-ordinates in the NMEA(National Marine Electronics Association). The NMEA format basically contains a string which has the co-ordinates in the form of latitude, longitude along with the time as well.

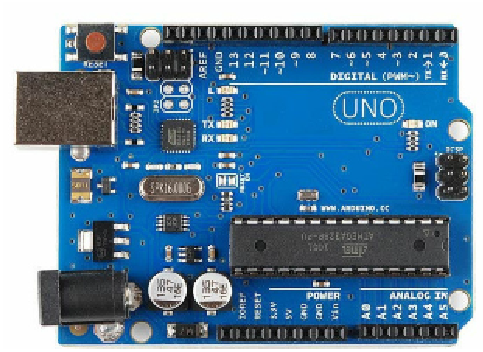


Figure 6.5: Arduino UNO

Arduino UNO is a microcontroller board based on the ATmega328P. 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 a AC-to-DC adapter or battery to get started.

Here is the list of softwares that we have worked on up until this point of time :

1) STM32 Cube IDE : Designed for programming and developing applications for STM32 microcontrollers

2) Arduino IDE : Development environment for programming Arduino microcontrollers, thus simplifying development of embedded projects

3) Docklight : Docklight is a testing, analysis and simulation tool for serial communication protocols

4) KiCad : KiCad is an open-source electronic design automation (EDA) software suite for creating schematics and printed circuit boards (PCBs)

An important point to be noted is that all the above softwares used are open source and free of cost which means anyone can install it on their systems and work on it to develop applications free of cost.

3.18 Universal synchronous/asynchronous receiver transmitter (USART)

The STM32F302x6/8 devices have three embedded universal synchronous receiver transmitters (USART1, USART2 and USART3).

The USART interfaces are able to communicate at speeds of up to 9 Mbit/s.

All USARTs support hardware management of the CTS and RTS signals, multiprocessor communication mode, single-wire half-duplex communication mode and synchronous mode.

USART1 supports SmartCard mode, IrDA SIR ENDEC, LIN Master capability and autobaudrate detection.

All USART interfaces can be served by the DMA controller.

Refer to *Table 8* for the features available in all USARTs interfaces.

Table 8. USART features

USART modes/features(1)	USART1	USART2	USART3
Hardware flow control for modem	X	X	X
Continuous communication using DMA	X	X	X
Multiprocessor communication	X	X	X
Synchronous mode	X	X	X
SmartCard mode	X	-	-
Single-wire half-duplex communication	X	X	X
IrDA SIR ENDEC block	X	-	-
LIN mode	X	-	-
Dual clock domain and wakeup from Stop mode	X	-	-
Receiver timeout interrupt	X	-	-
Modbus communication	X	-	-
Auto baud rate detection	X	-	-
Driver Enable	X	X	X

1. X = supported.

3.19 Serial peripheral interfaces (SPI)/Inter-integrated sound interfaces (I2S)

Two SPI interfaces (SPI2 and SPI3) allow communication up to 18 Mbit/s in slave and master modes in full-duplex and simplex modes. The 3-bit prescaler gives 8 master mode frequencies and the frame size is configurable from 4 bits to 16 bits.

Two standard I2S interfaces (multiplexed with SPI2 and SPI3) are available, that can be operated in master or slave mode. These interfaces can be configured to operate with 16/32 bit resolution, as input or output channels. Audio sampling frequencies from 8 kHz up to 192 kHz are supported. When either or both of the I2S interfaces is/are configured in master mode, the master clock can be output to the external DAC/CODEC at 256 times the sampling frequency.

Refer to *Table 9* for the features available in SPI2 and SPI3.

Table 9. STM32F302x6/8 SPI/I2S implementation

SPI features(1)	SPI2	SPI3
Hardware CRC calculation	X	X
Rx/Tx FIFO	X	X
NSS pulse mode	X	X
I2S mode	X	X
TI mode	X	X

1. X = supported.

3.20 Controller area network (CAN)

The CAN is compliant with specifications 2.0A and B (active) with a bit rate up to 1 Mbit/s. It can receive and transmit standard frames with 11-bit identifiers as well as extended frames with 29-bit identifiers. It has three transmit mailboxes, two receive FIFOs with 3 stages and 14 scalable filter banks.

3.21 Universal serial bus (USB)

The STM32F302x6 STM32F302x8 embeds a full-speed USB device peripheral compliant with the USB specification version 2.0. The USB interface implements a full-speed (12 Mbit/s) function interface with added support for USB 2.0 Link Power Management. It has software-configurable endpoint setting with packet memory up-to 1 Kbyte (the last 256 bytes are used for CAN peripheral if enabled) and suspend/resume support. It requires a precise 48 MHz clock which is generated from the internal main PLL (the clock source must use an HSE crystal oscillator).

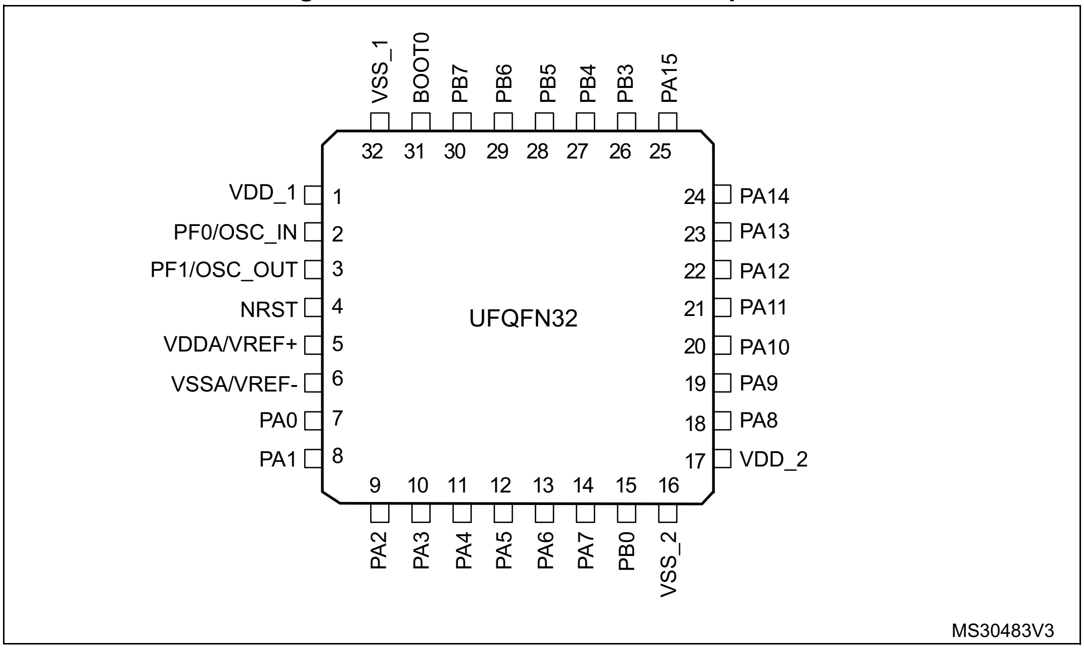
3.22 Touch sensing controller (TSC)

The STM32F302x6/8 devices provide a simple solution for adding capacitive sensing functionality to any application. These devices offer up to 18 capacitive sensing channels distributed over 6 analog I/O groups.

Capacitive sensing technology is able to detect the presence of a finger near a sensor which is protected from direct touch by a dielectric (for example glass, plastic). The capacitive variation introduced by the finger (or any conductive object) is measured using a proven implementation based on a surface charge transfer acquisition principle. It consists of charging the sensor capacitance and then transferring a part of the accumulated charges into a sampling capacitor until the voltage across this capacitor has reached a specific threshold. To limit the CPU bandwidth usage this acquisition is directly managed by the hardware touch sensing controller and only requires few external components to operate.

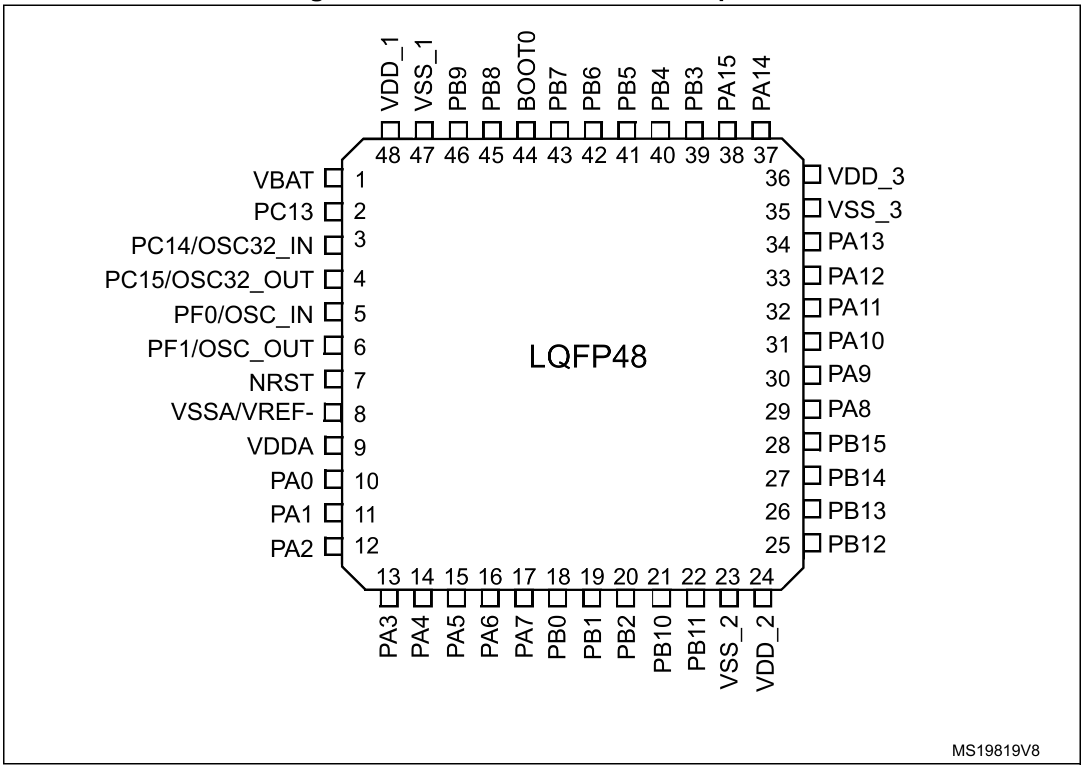
4 Pinouts and pin description

Figure 4. STM32F302x6/8 UFQFN32 pinout



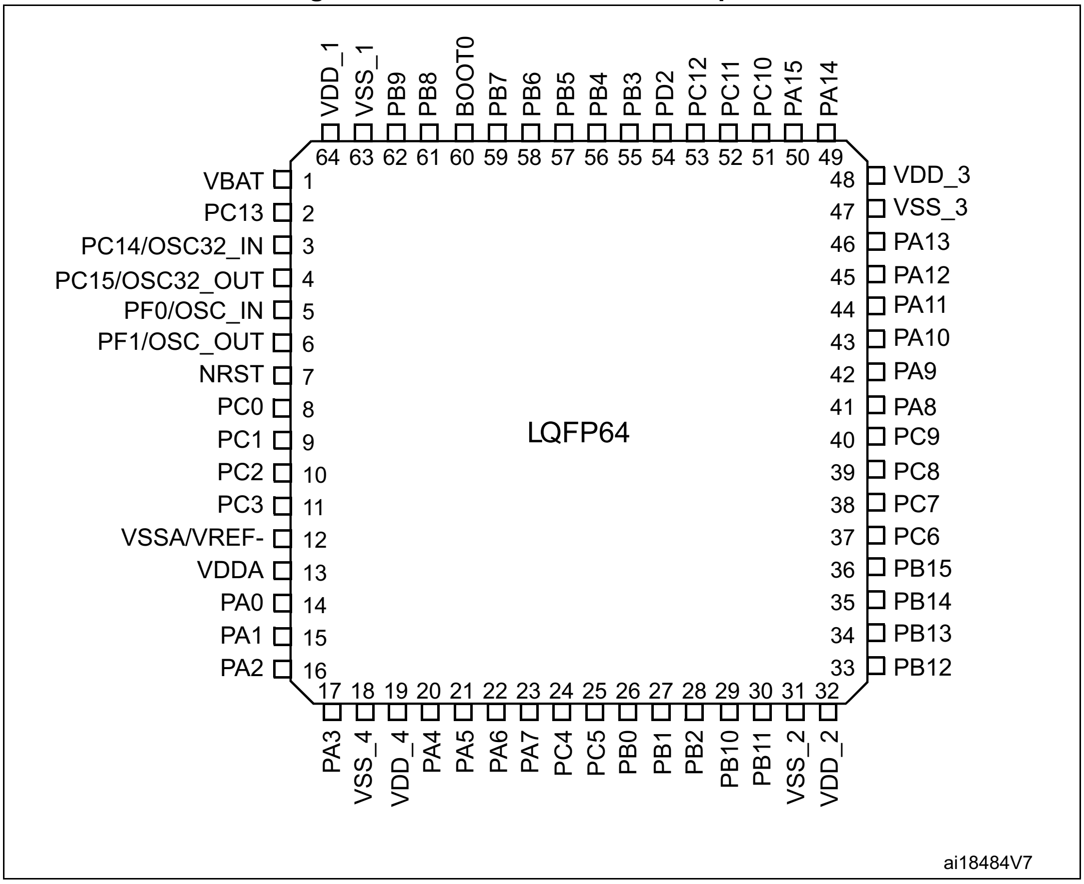
1. The above figure shows the package top view.

Figure 5. STM32F302x6/8 LQFP48 pinout



1. The above figure shows the package top view.

Figure 6. STM32F302x6/8 LQFP64 pinout



1. The above figure shows the package top view.

2.2. Key Features

Table 1: Key Features

Features	Implementation
Power Supply	● Supply voltage: 3.0V~4.3V Typical: 3.3V
Power Consumption	● Acquisition: 25mA @VCC=V_BCKP=3.3V ● Tracking: 20mA @VCC=V_BCKP=3.3V ● Standby: 1.0mA @VCC=V_BCKP=3.3V ● Backup: 7uA @V_BCKP=3.3V
Receiver Type	● GPS L1 1575.42MHz C/A Code ● 66 search channels, 22 simultaneous tracking channels
Sensitivity	● Acquisition: -148dBm ● Re-acquisition: -160dBm ● Tracking: -165dBm
TTFF (EASY enabled)	● Cold start: 15s typ. @-130dBm ● Warm start: 5s typ. @-130dBm ● Hot start: 1s typ. @-130dBm
TTFF (EASY disabled)	● Cold start (Autonomous): 35s typ. @-130dBm ● Warm start (Autonomous): 30s typ. @-130dBm ● Hot start (Autonomous): 1s typ. @-130dBm
Horizontal Position Accuracy (Autonomous)	● <2.5m CEP @-130dBm
Max Update Rate	● Up to 10Hz,1Hz by default
Accuracy of 1PPS Signal	● Typical accuracy: ±10ns ● Time pulse width 100ms
Velocity Accuracy	● Without aid: 0.1m/s
Acceleration Accuracy	● Without aid: 0.1m/s²
Dynamic Performance	● Maximum altitude: 18,000m ● Maximum velocity: 515m/s ● Acceleration: 4G
UART Port	● UART Port: TXD1 and RXD1 ● Supports baud rate from 4800bps to 115200bps, 9600bps by default ● UART port is used for NMEA output, MTK proprietary commands input and firmware upgrade
Temperature Range	● Normal operation: -40°C ~ +85°C ● Storage temperature: -45°C ~ +125°C
Physical Characteristics	● Size: 16±0.15 × 16±0.15 × 6.45±0.1mm ● Weight: Approx. 6.0g

NOTES

1. The power consumption is measured in the open sky with internal patch antenna. Meanwhile, EASY, AIC and SBAS are enabled.
2. If the external active antenna is used, VCC pin will supply power for external active antenna. The typical additional current consumption is about 11mA @3.3V.
3. The performance of external active antenna is similar to that of internal patch antenna expect for power consumption.

2.3. Block Diagram

The following figure shows a block diagram of L80 module. It consists of a single chip GPS IC which includes the RF part and Baseband part, a SPDT, a patch antenna, a LNA, a SAW filter, a TCXO, a crystal oscillator, short protection and antenna detection circuit for active antenna.

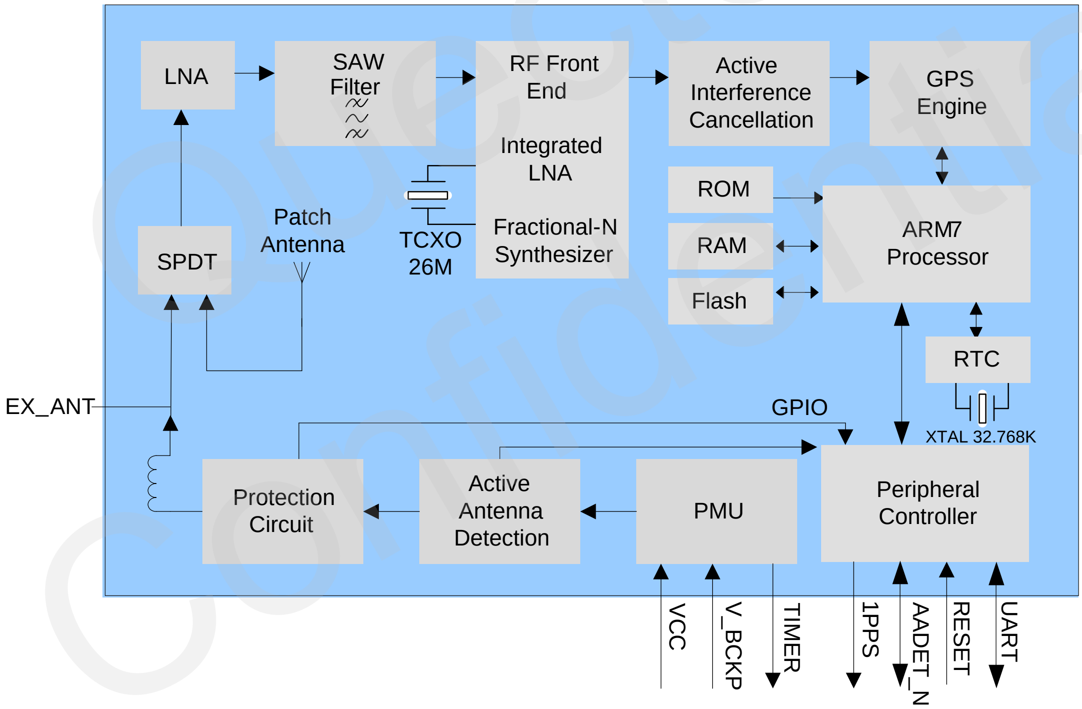


Figure 1: Block Diagram

3 Application

The module is equipped with a 12-pin 2.54mm pitch SMT pad that connects to your application platform. Sub-interfaces included in the pad are described in details in the following chapters.

3.1. Pin Assignment

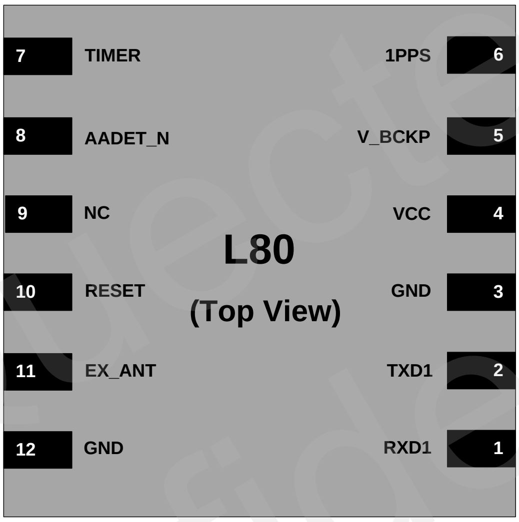


Figure 2: Pin Assignment

3.2. Pin Definition

Table 3: Pin Description

Power Supply					
Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
VCC	4	I	Main power supply	Vmax=4.3V Vmin=3.0V Vnom=3.3V	Supply current not less than 100mA.
V_BCKP	5	I	Backup power	Vmax=4.3V	Supply power for RTC

			supply	Vmin=1.5V Vnom=3.3V	domain. The V_BCKP pin can be directly supplied power by battery or connect it to VCC.
Reset					
Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
RESET	10	I	System reset	VILmin=-0.3V VILmax=0.8V VIHmin=2.0V VIHmax=3.6V	Low level active. If unused, keep this pin open or connect it to VCC.
UART Port					
Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
RXD1	1	I	Receive data	VILmin=-0.3V VILmax=0.8V VIHmin=2.0V VIHmax=3.6V	
TXD1	2	O	Transmit data	VOLmin=-0.3V VOLmax=0.4V VOHmin=2.4V VOHmax=3.1V	
RF Interface					
Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
EX_ANT	11	I	External active antenna RF input	Characteristic impedance of 50Ω	If unused, keep this pin open.
Other Interfaces					
Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
1PPS	6	O	One pulse per second	VOLmin=-0.3V VOLmax=0.4V VOHmin=2.4V VOHmax=3.1V	Synchronized at rising edge, the pulse width is100ms. If unused, keep this pin open.
TIMER	7	O	An open drain output signal can be used to control GPS module main power on/off	VOLmin=-0.3V VOLmax=0.4V VOHmin=1.1V VOHmax=3.1V	It belongs to RTC domain. If unused, keep this pin open or connect to Ground externally.

2.2. Key Features

The following table describes the detailed features of M66 module.

Table 1: Module Key Features

Feature	Implementation
Power Supply	Single supply voltage: 3.3V ~ 4.6V Typical supply voltage: 4V
Power Saving	Typical power consumption in SLEEP mode: 1.3 mA @DRX=5 1.2 mA @DRX=9
Frequency Bands	● Quad-band: GSM850, EGSM900, DCS1800, PCS1900. ● The module can search these frequency bands automatically ● The frequency bands can be set by AT command ● Compliant to GSM Phase 2/2+
GSM Class	Small MS
Transmitting Power	● Class 4 (2W) at GSM850 and EGSM900 ● Class 1 (1W) at DCS1800 and PCS1900
GPRS Connectivity	● GPRS multi-slot class 12 (default) ● GPRS multi-slot class 1~12 (configurable) ● GPRS mobile station class B
DATA GPRS	● GPRS data downlink transfer: max. 85.6kbps ● GPRS data uplink transfer: max. 85.6kbps ● Coding scheme: CS-1, CS-2, CS-3 and CS-4 ● Support the protocols PAP (Password Authentication Protocol) usually used for PPP connections ● Internet service protocols TCP/UDP, FTP, PPP, HTTP, NTP, PING ● Support Packet Broadcast Control Channel (PBCCH) ● Support Unstructured Supplementary Service Data (USSD)
Temperature Range	● Normal operation: -35°C ~ +80°C ● Restricted operation: -40°C ~ -35°C and +80°C ~ +85°C 1) ● Storage temperature: -45°C ~ +90°C
Bluetooth	● Support Bluetooth specification 3.0 ● Output Power: Class 1 (Typical 7.5dBm)
SMS	● Text and PDU mode ● SMS storage: SIM card
SIM Interface	Support SIM card: 1.8V, 3.0V
Audio Features	Speech codec modes: ● Half Rate (ETS 06.20) ● Full Rate (ETS 06.10)

	● Enhanced Full Rate (ETS 06.50/06.60/06.80) ● Adaptive Multi-Rate (AMR) ● Echo Suppression ● Noise Reduction
UART Interfaces	UART Port: ● Seven lines on UART port interface ● Used for AT command, GPRS data ● Multiplexing function ● Support autobauding from 4800bps to 115200bps Debug Port: ● Two lines on debug port interface DBG_TXD and DBG_RXD ● Debug Port only used for firmware debugging Auxiliary Port: ● Used for AT command
Phonebook Management	Support phonebook types: SM, ME, ON, MC, RC, DC, LD, LA
SIM Application Toolkit	Support SAT class 3, GSM 11.14 Release 99
Real Time Clock	Supported
Physical Characteristics	Size: 15.8±0.15 × 17.7±0.15 × 2.3±0.2mm Weight: Approx. 1.3g
Firmware Upgrade	Firmware upgrade via UART Port
Antenna Interface	Connected to antenna pad with 50 Ohm impedance control

NOTE

1) When the module works within this temperature range, the deviations from the GSM specification may occur. For example, the frequency error or the phase error will be increased.

Table 2: Coding Schemes and Maximum Net Data Rates over Air Interface

Coding Scheme	1 Timeslot	2 Timeslot	4 Timeslot
CS-1	9.05kbps	18.1kbps	36.2kbps
CS-2	13.4kbps	26.8kbps	53.6kbps
CS-3	15.6kbps	31.2kbps	62.4kbps
CS-4	21.4kbps	42.8kbps	85.6kbps

3.1. Pin of Module

3.1.1. Pin Assignment

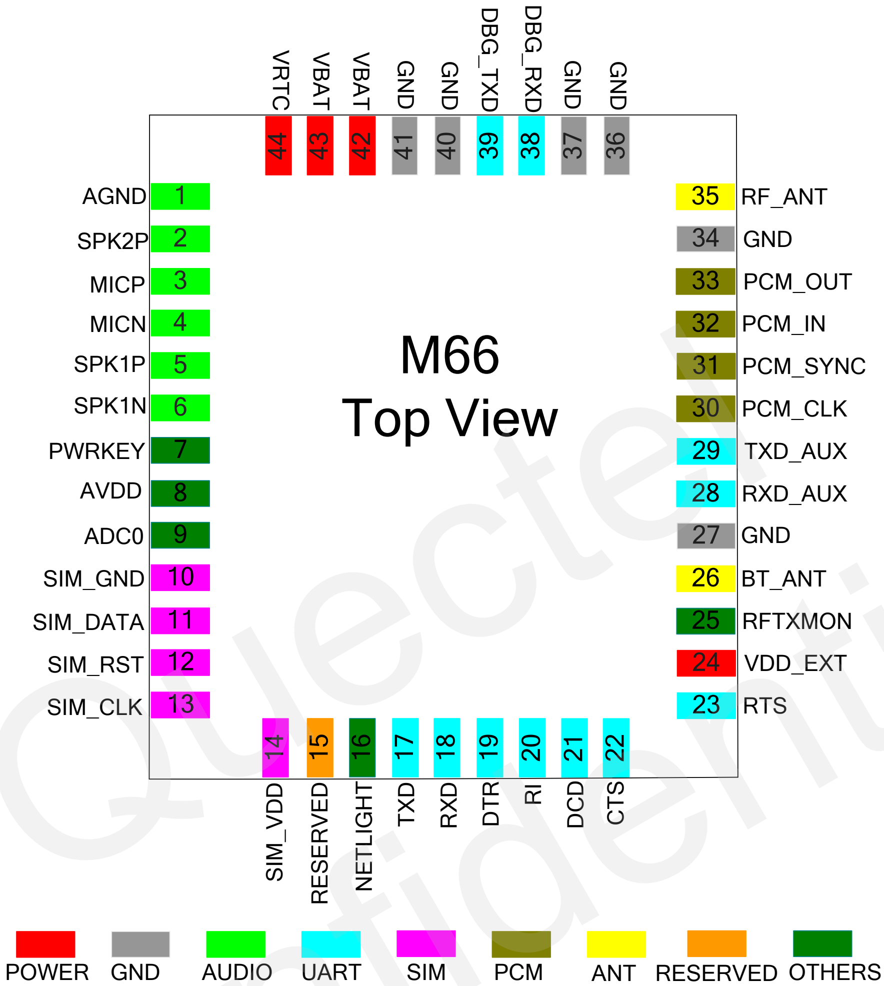


Figure 2: Pin Assignment

NOTE

Keep all reserved pins open.

Features

- **ATMega328P** Processor
    - **Memory**
        - AVR CPU at up to 16 MHz
        - 32KB Flash
        - 2KB SRAM
        - 1KB EEPROM
    - **Security**
        - Power On Reset (POR)
        - Brown Out Detection (BOD)
    - **Peripherals**
        - 2x 8-bit Timer/Counter with a dedicated period register and compare channels
        - 1x 16-bit Timer/Counter with a dedicated period register, input capture and compare channels
        - 1x USART with fractional baud rate generator and start-of-frame detection
        - 1x controller/peripheral Serial Peripheral Interface (SPI)
        - 1x Dual mode controller/peripheral I2C
        - 1x Analog Comparator (AC) with a scalable reference input
        - Watchdog Timer with separate on-chip oscillator
        - Six PWM channels
        - Interrupt and wake-up on pin change
    - **ATMega16U2 Processor**
        - 8-bit AVR® RISC-based microcontroller
    - **Memory**
        - 16 KB ISP Flash
        - 512B EEPROM
        - 512B SRAM
        - debugWIRE interface for on-chip debugging and programming
    - **Power**
        - 2.7-5.5 volts

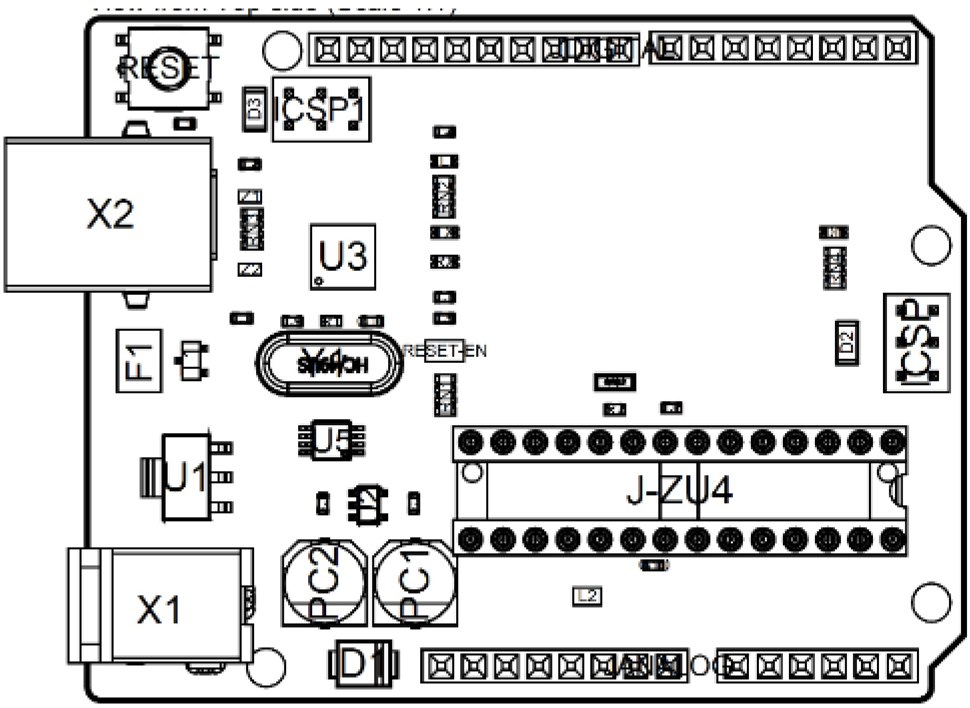
2.2 Power Consumption

Symbol	Description	Min	Typ	Max	Unit
VINMax	Maximum input voltage from VIN pad	6	-	20	V
VUSBMax	Maximum input voltage from USB connector		-	5.5	V
PMax	Maximum Power Consumption	-	-	xx	mA

3 Functional Overview

3.1 Board Topology

Top view



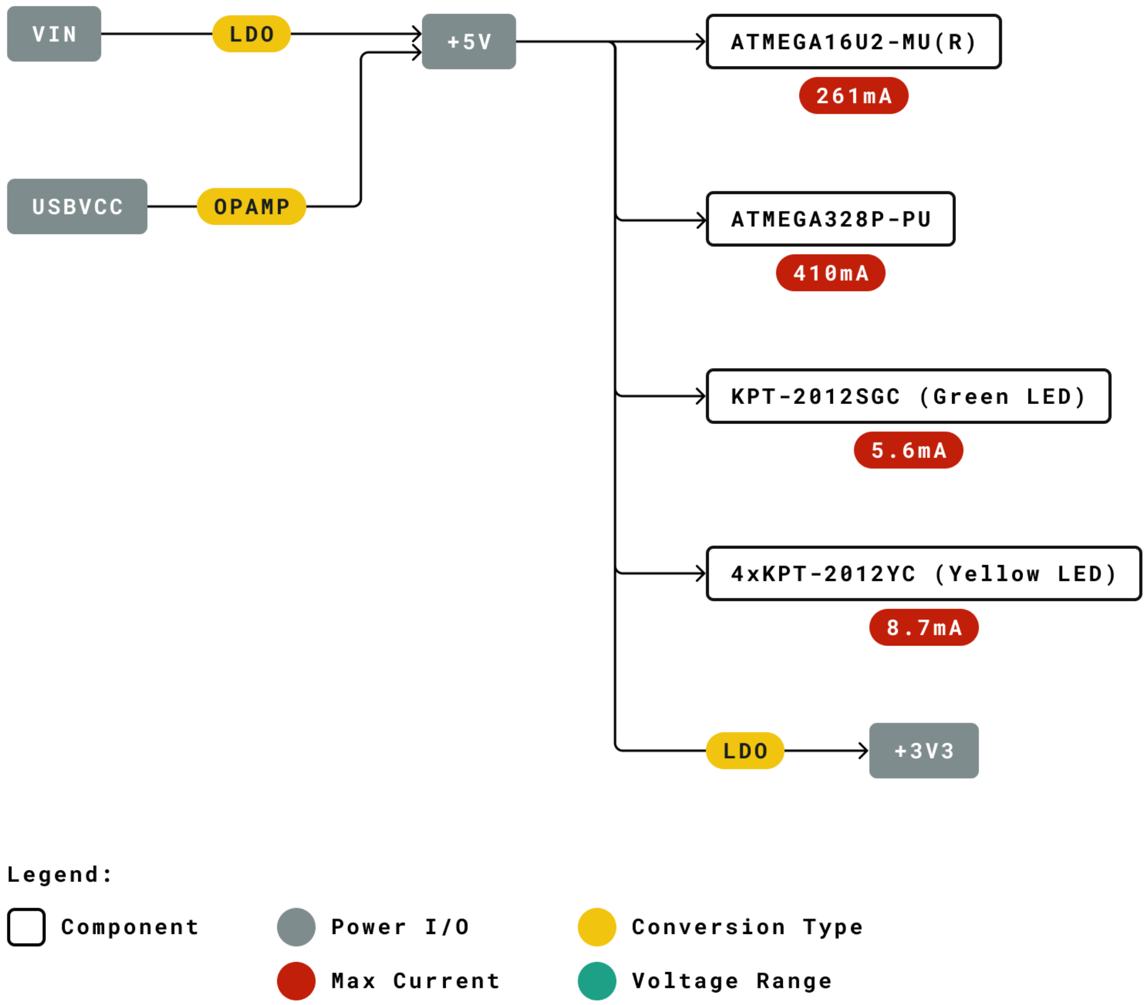
Board topology

Ref.	Description	Ref.	Description
X1	Power jack 2.1x5.5mm	U1	SPX1117M3-L-5 Regulator
X2	USB B Connector	U3	ATMEGA16U2 Module
PC1	EEE-1EA470WP 25V SMD Capacitor	U5	LMV358LIST-A.9 IC
PC2	EEE-1EA470WP 25V SMD Capacitor	F1	Chip Capacitor, High Density
D1	CGRA4007-G Rectifier	ICSP	Pin header connector (through hole 6)
J-ZU4	ATMEGA328P Module	ICSP1	Pin header connector (through hole 6)
Y1	ECS-160-20-4X-DU Oscillator		

3.2 Processor

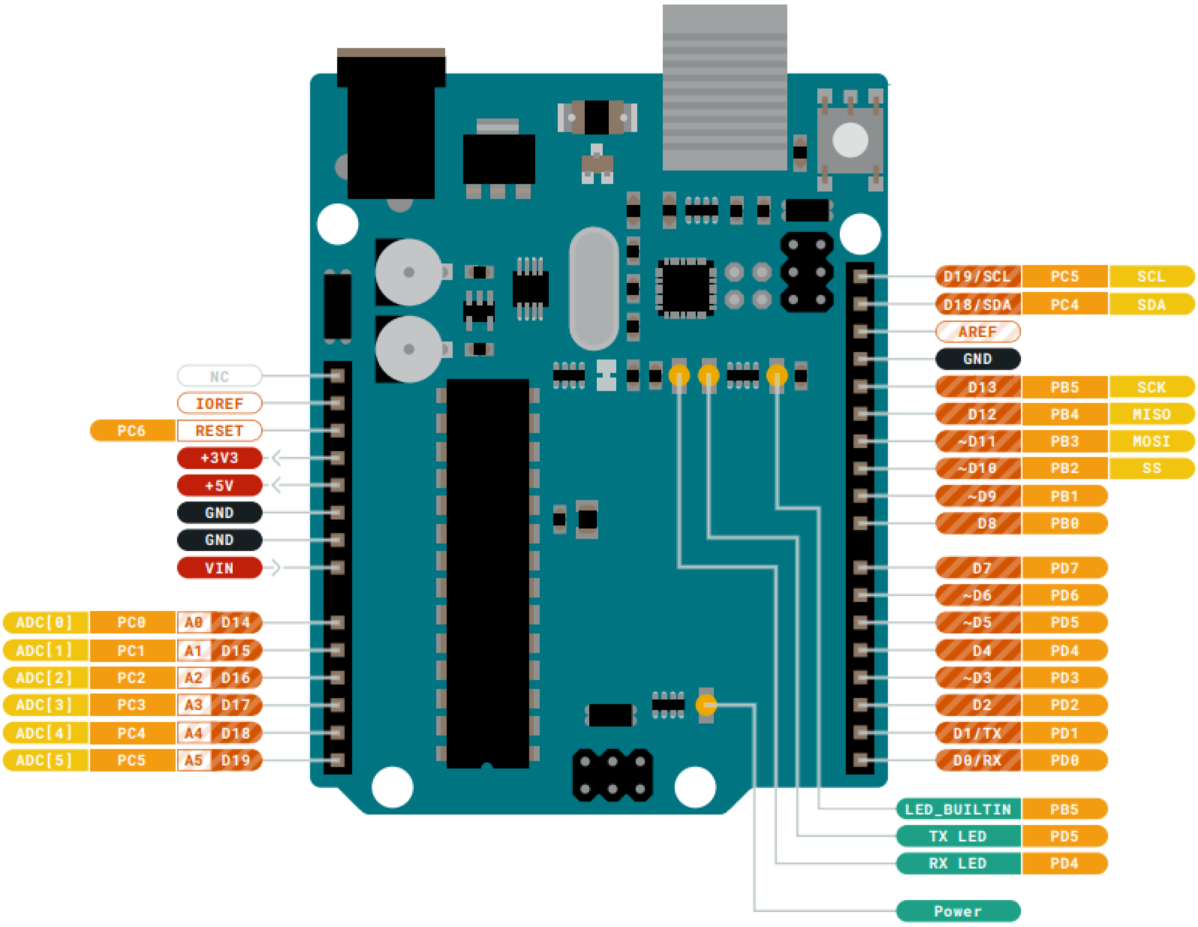
The Main Processor is a ATmega328P running at up tp 20 MHz. Most of its pins are connected to the external headers, however some are reserved for internal communication with the USB Bridge coprocessor.

3.3 Power Tree



Power tree

5 Connector Pinouts



Pinout

5.1 JANALOG

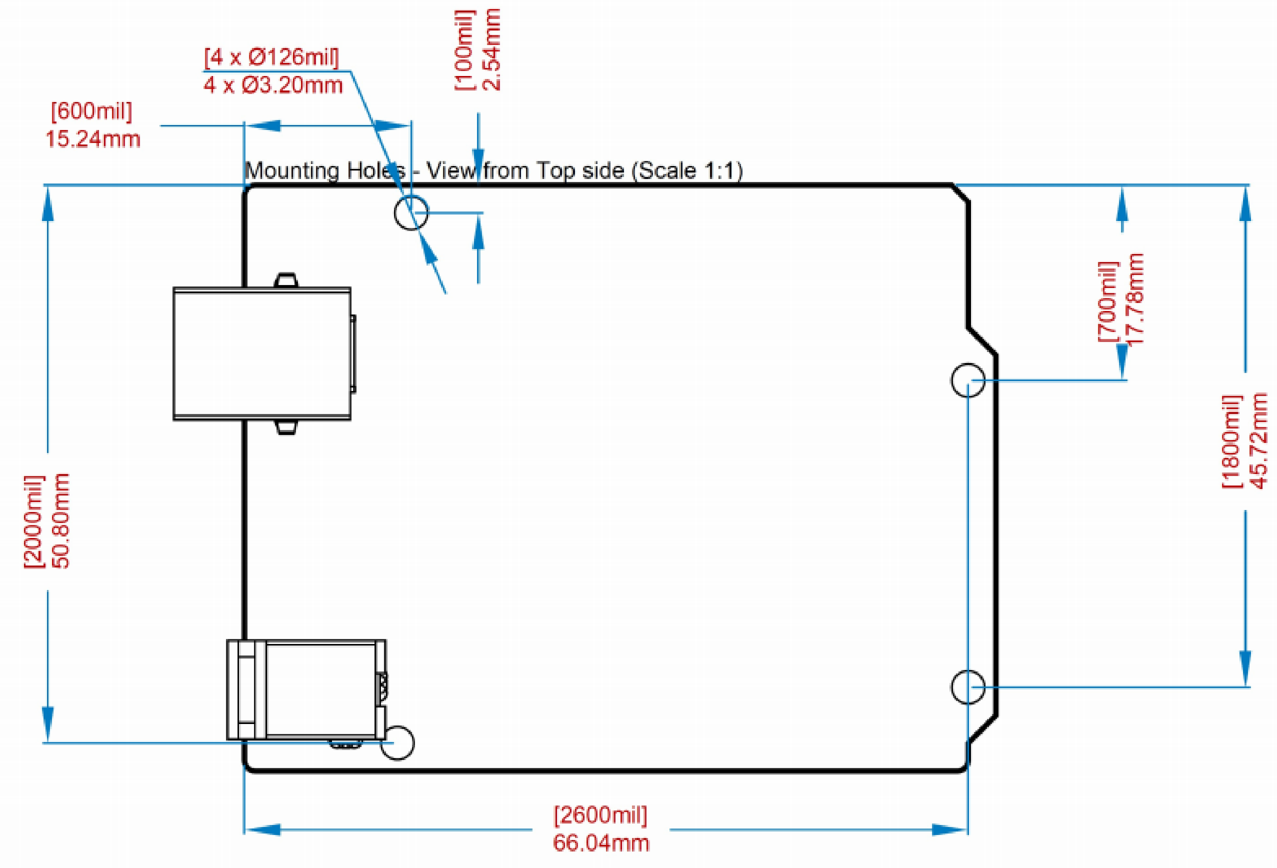
Pin	Function	Type	Description
1	NC	NC	Not connected
2	IOREF	IOREF	Reference for digital logic V - connected to 5V
3	Reset	Reset	Reset
4	+3V3	Power	+3V3 Power Rail
5	+5V	Power	+5V Power Rail
6	GND	Power	Ground
7	GND	Power	Ground
8	VIN	Power	Voltage Input
9	A0	Analog/GPIO	Analog input 0 /GPIO
10	A1	Analog/GPIO	Analog input 1 /GPIO
11	A2	Analog/GPIO	Analog input 2 /GPIO
12	A3	Analog/GPIO	Analog input 3 /GPIO
13	A4/SDA	Analog input/I2C	Analog input 4/I2C Data line
14	A5/SCL	Analog input/I2C	Analog input 5/I2C Clock line

5.2 JDIGITAL

Pin	Function	Type	Description
1	D0	Digital/GPIO	Digital pin 0/GPIO
2	D1	Digital/GPIO	Digital pin 1/GPIO
3	D2	Digital/GPIO	Digital pin 2/GPIO
4	D3	Digital/GPIO	Digital pin 3/GPIO
5	D4	Digital/GPIO	Digital pin 4/GPIO
6	D5	Digital/GPIO	Digital pin 5/GPIO
7	D6	Digital/GPIO	Digital pin 6/GPIO
8	D7	Digital/GPIO	Digital pin 7/GPIO
9	D8	Digital/GPIO	Digital pin 8/GPIO
10	D9	Digital/GPIO	Digital pin 9/GPIO
11	SS	Digital	SPI Chip Select
12	MOSI	Digital	SPI1 Main Out Secondary In
13	MISO	Digital	SPI Main In Secondary Out
14	SCK	Digital	SPI serial clock output
15	GND	Power	Ground
16	AREF	Digital	Analog reference voltage
17	A4/SD4	Digital	Analog input 4/I2C Data line (duplicated)
18	A5/SD5	Digital	Analog input 5/I2C Clock line (duplicated)

5.3 Mechanical Information

5.4 Board Outline & Mounting Holes



Board outline

Bibliography

[1] Wael El-Medany, Alauddin Al-Omary, Riyadh Al-Hakim, Sufyan Al-Irhayim, and Mustafa Nusaif. A cost effective real-time tracking system prototype using integrated gps/gprs module. In *2010 6th International Conference on Wireless and Mobile Communications*, pages 521–525. IEEE, 2010.

[2] Paul Benjamin Fleischer, Atso Yao Nelson, Robert Adjetey Sowah, and Appah Bremang. Design and development of gps/gsm based vehicle tracking and alert system for commercial inter-city buses. In *2012 IEEE 4th International Conference on Adaptive Science & Technology (ICAST)*, pages 1–6. IEEE, 2012.

[3] Kunal Maurya, Mandeep Singh, and Neelu Jain. Real time vehicle tracking system using gsm and gps technology-an anti-theft tracking system. *International Journal of Electronics and Computer Science Engineering*, 1(3):1103–1107, 2012.

[4] Hoang Dat Pham, Micheal Drieberg, and Chi Cuong Nguyen. Development of vehicle tracking system using gps and gsm modem. In *2013 IEEE conference on open systems (ICOS)*, pages 89–94. IEEE, 2013.

[5] Ni Ni San Hlaing, Ma Naing, and San San Naing. Gps and gsm based vehicle tracking system. *International Journal of Trend in Scientific Research and Development (IJTSRD)*, 3(4):271–275, 2019.