

Master Docs

| | |
|----------------|---|
| ESP-12F Module | https://docs.google.com/document/d/1wUoiSMeibSNl0F_NMlV0ddZ1Dg242i610YBaoCVExxE/edit?usp=sharing |
| SIM800L GSM | https://docs.google.com/document/d/193Vo6pp46X-qUxQjWdD49m0Nta9paT70XTscvb2IJo0/edit?usp=sharing |
| NEO6M GPS | |
| Power supply | https://docs.google.com/document/d/1AFsmDC6KirVL0si4HC1F0pKSI1V_GLirmRBHtlKEOy8/edit?usp=sharing |
| PCB Design | https://docs.google.com/document/d/1qXwdmjExT49aWkSRiuPopTqJxmYwTDL7wfH6zcppezEY/edit?usp=sharing |
| Code | https://docs.google.com/document/d/1HPfyNyNh___vK64s4vKLNnPDrwxC7lyQ8gt_aOBQO0-g/edit?usp=sharing |

Spendings

Ref :

Colour codes

| | | |
|-----------------------------|---------|---------|
| Doubts or Questions | Pending | Cleared |
| Ideas to add in our project | Pending | Added |

Date : 04/12/2023

NMEA Data : NMEA (National Marine Electronics Association) is a standard data format supported by all GPS manufacturers, much like ASCII is the standard for digital computer characters in the computer world.

Link : <https://www.gpsworld.com/what-exactly-is-gps-nmea-data/>

Components available

- GPS Module : NEO-6M-0-001 (GY-GPS6MV2) → Datasheet :
<https://www.openimpulse.com/blog/wp-content/uploads/wpsc/downloadables/GY-NEO6MV2-GPS-Module-Datasheet.pdf>
- Microcontroller : NodeMCU ESP8266

GPS Module with NodeMCU

Connecting :

<https://microcontrollerslab.com/neo-6m-gps-module-esp8266-nodemcu-track-location-google-maps/>

GPS module with Arduino

Connecting : <https://randomnerdtutorials.com/guide-to-neo-6m-gps-module-with-arduino/>

SoftwareSerial Library : <https://docs.arduino.cc/learn/built-in-libraries/software-serial>

Pins in NodeMCU : <https://randomnerdtutorials.com/esp8266-pinout-reference-pios/>

UART GPS NEO-6M :

[https://www.waveshare.com/wiki/UART_GPS_NEO-6M#:~:text=Click%20Receiver%20menu%2C%20and%20select%3A%209600\(default\).](https://www.waveshare.com/wiki/UART_GPS_NEO-6M#:~:text=Click%20Receiver%20menu%2C%20and%20select%3A%209600(default).)

Libraries for parsing NEMA string

NMEA 0183 standard : <https://www.waveshare.com/w/upload/5/57/NMEA0183.pdf>

TinyGPS : <https://www.arduino.cc/reference/en/libraries/tinygps/>

TinyGPS++ : <https://github.com/mikalhart/TinyGPSPlus/tree/master/>

Arduino with 1.8 TFT Display

Connecting : <https://randomnerdtutorials.com/guide-to-1-8-tft-display-with-arduino/>

Date : 05/12/2023

Why are GPS signals bad indoors ?

[https://ascelibrary.org/doi/pdf/10.1061/9780784411506.ap02#:~:text=The%20L1%20frequency%20is%201%20C575.42,MHz%20\(wavelength%2025.48%20cm\).&text=The%20GPS%20](https://ascelibrary.org/doi/pdf/10.1061/9780784411506.ap02#:~:text=The%20L1%20frequency%20is%201%20C575.42,MHz%20(wavelength%2025.48%20cm).&text=The%20GPS%20)

Using TinyGPS++ library for NMEA data parsing

GPS Module datasheet

<https://www.mantech.co.za/datasheets/products/GY-NEO6MV2.pdf>

Bubbling doubts

Ref :

1.<https://www.engineersgarage.com/gps-receivers-and-nmea-standards/#:~:text=A%20GPGSV%20sentence%20can%20show,being%20viewed%20but%20not%20tracked.>

1. Why are the number of satellites in view for GPGGA and GPGSV NMEA sentences different ?
A GPGSV sentence can show more number of satellites than GPGGA sentence as it also shows the satellites which are not in solution. The SNR (Signal to Noise Ratio) can be used as raw signal strength and lies between 0 and 99.
2. Where is SNR present in NMEA ? GPGSV log

3. When and how does a GPS fix happen?
4. Cold start vs Hot start in a GPS module?
5. How often does a GPS module output location data?

Note

There is an LED on the NEO-6M GPS Module which indicates the status of Position Fix. It'll blink at various states depending on what state it's in:

No Blinking – It's searching for satellites.

Blink every 1s – Position Fix is found(The module can see enough satellites)

Tasks to do

Create my own library for Arduino that helps in parsing NMEA sentences → Because I am not able to use TinyGPS++ for extracting SNR values from GPS NMEA data. It will also be useful for us in the future if we want to extract particulars from data. But we could refer and use code from TinyGPS++ library to understand string extraction and other particulars. Also read the zip file that you have downloaded.

Date : 06/12/2023

Reading bytes and storing in a char array : <https://forum.arduino.cc/t/serial-input-basics-updated/382007>

Convert char array to string : <https://www.geeksforgeeks.org/convert-character-array-to-string-in-c/>

Parsing strings

- Split string :

[https://sentry.io/answers/split-string-in-cpp/#:~:text=Unlike%20getline\(\)%20%2C%20strtok\(\),character%20in%20the%20delimiter%20string%E2%80%9C](https://sentry.io/answers/split-string-in-cpp/#:~:text=Unlike%20getline()%20%2C%20strtok(),character%20in%20the%20delimiter%20string%E2%80%9C).

- Arduino String documentation (know methods of String class) :

<https://www.arduino.cc/reference/en/language/variables/data-types/stringobject/>

Date : 11/12/2023

PCB Design : https://www.youtube.com/watch?v=hr1qUTix3_M

SMD : Surface Mounted Devices

Designing a Power Supply system

1. Determine Power Requirements : Voltage/current needed for each component; Consider Peak power consumption for diff. Operating modes
2. Select Power source : Factors like capacity, voltage, size
3. Voltage regulation : Ensure stable voltage supply to device
4. Efficiency : Maximize battery life by optimizing power efficiency
5. Low-power modes : Reduce power consumption during idle/standby periods
6. Current limiting and protection : To prevent damage to device incase of short circuit or overload

Power requirements

(Check

NodeMCU esp8266 12-E

- Recommended : +5V Vin (see on board itself)
- Max allowed : +10V

NEO-6MV2 GPS Module

- Input voltage : 2.7V - 3.6V

OLED Display (NFP1315-51A)

- Driving voltage : 3.3V - 5V ([Ref](#))
- Max power consumption : ~20mA ([Ref](#))

Why are only Driving voltage specifications given for devices. What about current, why is it not discussed ?

Voltage Regulators

Maintain a constant voltage level in the output regardless of variations in the input voltage or changes in load.

Ref : <https://www.youtube.com/watch?v=lHK--OKijkQ>

Linear Regulators

- Take in a Logic level and drop it down to another logic level. So, $V_{out} > V_{in}$
- $V_{drop} = V_{out} - V_{in}$ in a voltage regulator. Power from voltage differential is then dissipated as heat from LDO, which means more is the dropped voltage V_{drop} , more hot the LDO becomes.
- DropOut voltage : Min. voltage diff b/w V_{in} and V_{out} for regulation $\rightarrow V_{in} \geq V_{out(nominal)} + \text{Dropout}$
- LDO (Low DropOut voltage) : Linear voltage regulator that can regulate even when supply voltage is close to output
- Works like a Comparator circuit \rightarrow Compares desired output with your input and regulates the output.

- Decoupling capacitors (check Datasheet)
- Advantages
 - Ease of use
 - Low output noise : as they contain no switching elements
 - Low cost
- Disadvantages
 - Inefficient, if my Vin >> Vout

Switching Regulator

Buck Regulator : Takes in DC output and drops it out to low value

Boost Regulator : Takes in DC output and bumps it up to high value

Buck-Boost Regulator : Allows to move b/w Buck and Boost mode

- Advantages
 - Higher efficiency
- Disadvantages
 - Very noisy

LDO Working

- Works using an Error Amplifier circuit (OpAmp that works with a Vref)

OctoPart : <https://octopart.com/search?q=NEO-6M¤cy=USD&specs=0>

Find most of the components and their datasheets here.

Date : 12/12/2023

Link : <https://www.youtube.com/watch?v=lT19dg73nKU&t=291s>

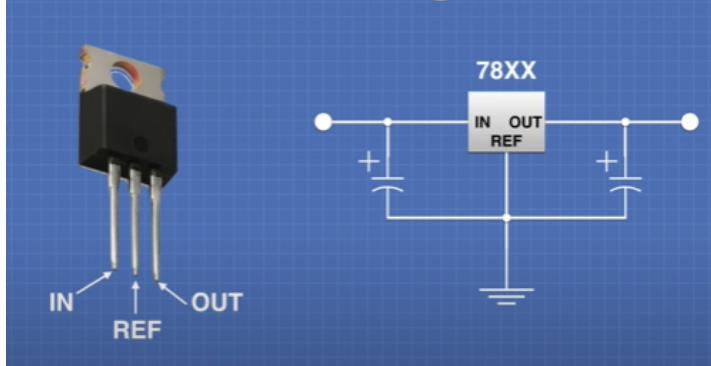
- 3.3V, 5V are normally used for microcontrollers and have stringent standards. For eg; for 5V devices voltage should be between 4.75V to 5.25V for proper operation. 6V, 12V are used for motors.

Linear Regulator

78XX Linear Regulator

- Popular 3-pin Voltage Regulator family
- “XX” indicates output voltage (eg; 7805, 7812)
- Output current : Upto 1.5 A
- What capacitances should we use ?

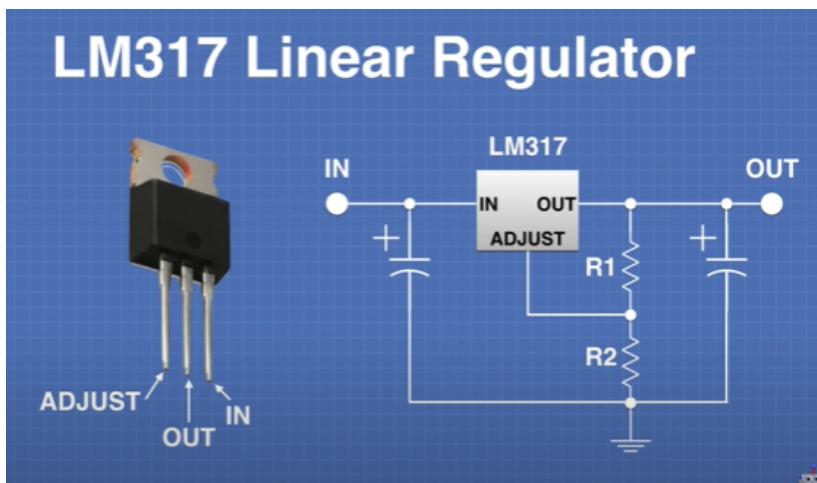
78XX Linear Regulator



LM317

- 3-Pin variable voltage regulator
- Output voltage from 1.25 V to 37 V DC
- Uses 2 external resistors to set output voltage
- Output current : Upto 1.5 A
- What capacitances and resistors should we use ?
- $V_{out} = 1.25 \times (1 + (R_2/R_1))$
- Value for R1 is generally 240-270 ohms and using a variable R2 we can control variable output
- Good device to use when we require an oddball output voltage (one that is not generally used)

LM317 Linear Regulator



PSM-165 Linear Module

- Breakout board with 3.3 V linear regulator
- Takes input from 4.5 V to 12 V
- Output current : Upto 800 mA
- Used on Arduino UNO to supply 3.3 V

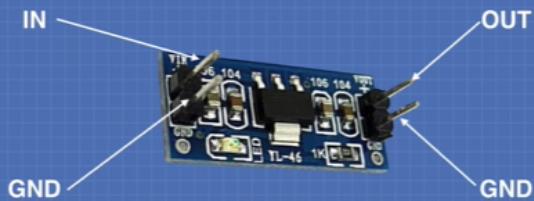
PSM-165 Linear Module



AMS1117-5 Linear Module

- Voltage drop = 1V. Lower than 78XX series
- Output current : Upto 1 A

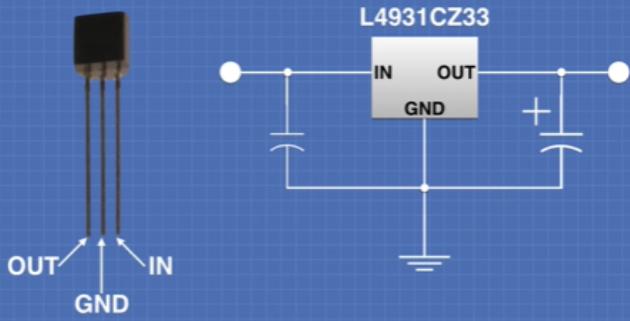
AMS1117-5 Linear Module



L4931CZ33 Regulator

- 3.3V Linear regulator
- Voltage Drop : 0.4V → Extermely low
- Also, available as 5V regulator
- Output current : Upto 250 mA
- Notice that the Input capacitor can be ceramic as well. However, the output is an electrolytic capacitor.

L4931CZ33 Regulator

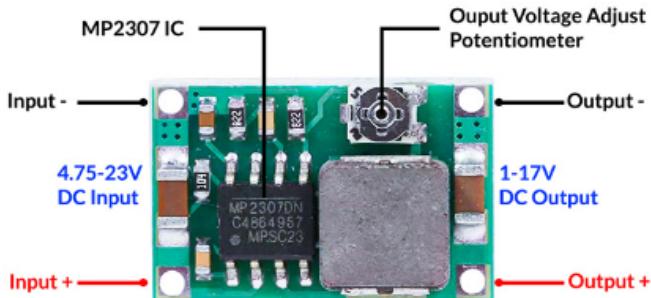


Buck Converters

- Takes higher input voltage and provides steady output voltage at lower level
- Provides output voltage using expanding and collapsing magnetic energy in a coil
- Very efficient (>95%) → Ideal for battery powered devices.

MINI-360

- 95% efficiency
- Input : 4.75-23 V DC
- Variable output : 1-17 V (Potentiometer on module)
- Output current : 1.8 A continuous, 3 A peak

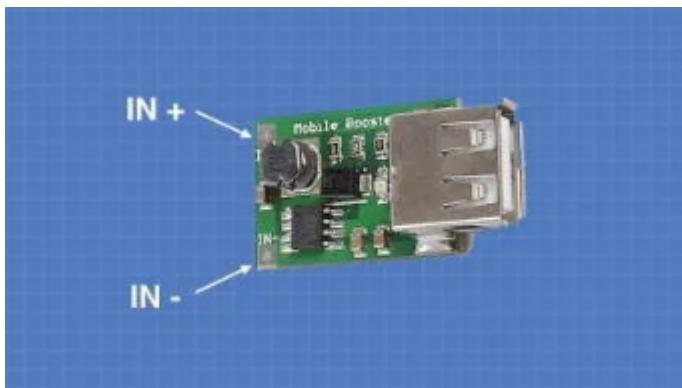


Boost Converters

- Output voltage is greater than Input voltage
- Same principle as Buck converter, just a diff way in wiring capacitor, coil and transistor.

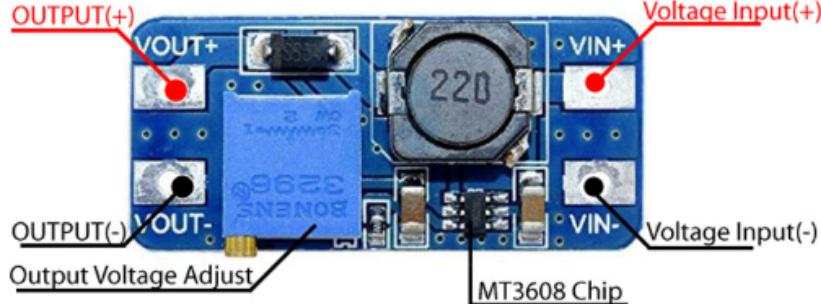
PSM-205 USB Boost Converter

- Input voltage : 0.9-5 V
- Output : 5 V, Upto 600 mA (comes from USB port)
- Operates at upto 96% efficiency



MT3608 Boost converter

- Adjustable output
- Input = 2-24 V
- Output = Upto 28 V at 2 A
- Efficiency = Upto 97%
- Note : While working with variable regulators first regulate the output voltage using potentiometer and then attach the load (To avoid burning out the load)

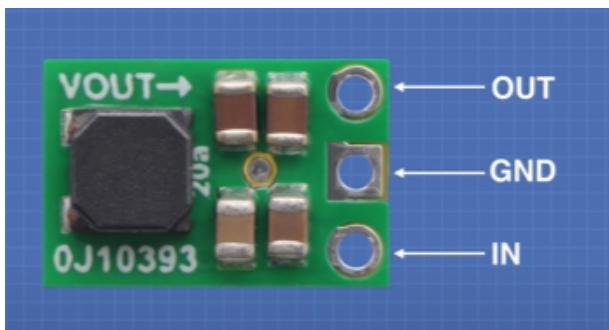


Buck-Boost Converter

- Where will it be used (just amazingggg to hear) ? Suppose, I have a device which works on 5 V and the battery that powers up is rated 7.5 V. So, I will use a Linear regulator or a Buck converter. But as days go, the battery's voltage falls down to 4.5 V or less. Now, I would prefer to use a Boost converter so that I could still use the same battery. Here, comes our hero "Buck-Boost Converter".

S9V11F5 Buck-Boost converter

- Output : 5 V
- Input voltage : 2-16 V (but atleast 3 V is required for startup of the converter)
- Output Current : 1.5 A with 2 A peak
- Very tiny with only 3 pins
- Capacitors are already integrated on the circuit board
- Note : This device gets very hot (consider this while laying out your circuit board)



Battery

Link : <https://www.youtube.com/watch?v=PXNKkcB0pI4>

Battery life depends on storage capacity and demand by load

- Positive and Negative terminals are electrically isolated from each other
- Electricity : Flow of electrons in circuit
- Electron flows from -ve to +ve. Conventional current flows from +ve to -ve.

How battery works ?

Link : <https://www.youtube.com/watch?v=9OVtk6G2TnQ>

- A metal oxidizes sending out electrons which is taken by another metal that gets reduced
- When these electrons are sent through light bulbs or motors they perform some work there.
- When all metal atoms are oxidized the battery runs out (producing no more electrons).
- In rechargeable batteries, this oxidation-reduction process is made reversible and the metal is oxidized again by using an external power supply
- However, after continuous recharging cycles, the process causes imperfections and irregularities in the metal's surface that prevents it from oxidizing properly. This means that electrons are no longer available to flow and hence the battery dies.

Link : <https://www.science.org.au/curious/technology-future/batteries>

- At the anode (Negative electrode), the electrode reacts with electrolyte in a reaction that produces electrons. These electrons accumulate at anode. Meanwhile, at cathode another chemical reaction happens simultaneously that enables that electrode to accept electrons.
- This exchange of electrons is called a redox or reduction-oxidation reaction
 - Oxidation : Loss of electrons (anode gets oxidized)
 - Reduction : Gain of electrons (cathode is reduced)
- While external wire provides a pathway for flow of -vely charged electrons, electrolyte provides the pathway for transfer of +vely charged ions to balance -ve flow.

Voltage, Current, Power, Capacity

- Voltage = Force at which the reaction driving the battery pushes electrons through the cell
 - Diff in potential b/w reactions that occur at each electrode
 - How strongly the cathode pull the electrons from anode
- Current = No. of electrons that happen to be passing through any one point of a circuit at a given time.
 - Higher the current, more work it can do at same voltage
- Power = Voltage x Current
 - Higher the power, quicker the rate at which battery can do work
- Capacity = Power of battery as a function of time
 - Describe length of time a battery will be able to power a device for
- Energy Density = Amount of energy a device can hold per unit volume

How long does a battery last ?

- Suppose if a battery is rated at 2500 mAh, it could provide;
 - 2500 mA for 1 hour
 - 1250 mA for 2 hrs ($1250 \times 2 = 2500$ mAh)
 - 20 mA for 125 hrs
- But in real life, battery wouldn't last as long because chemical reaction slows and other things like age and temperature also affects this
- If we have a battery of capacity 3000 mAh and the circuit consumes current of 19 mA, then the Battery life is calculated as Capacity (mAh) / Circuit current (mA) → $3000\text{mAh}/19\text{mA} = 157.9$ hrs max

How do we keep track of battery left in a phone ?

Link : https://www.quora.com/How-do-electronic-devices-measure-how-charged-a-battery-is?no_redirect=1

- Voltage and Current Curves : Voltage-to-charge ratio of a Lithium battery falls on a curve, so if a CPU is available we can predict the remaining % of charge available
- Coulomb counters (BMS- Battery Management System) : Very tiny resistive load in series with battery to measure how much current is flowing through it (by measuring voltage and resistance of load, it knows the current flow). From this, they can report exactly how much has come out of the battery since it was last charged and therefore how much is left.
- Learning Coulomb counters

We learned that all batteries outputs low voltage over time. How does a smartphone manage it ?

What happens when we plug-in a 7.4 V battery pack in a Linear Voltage Regulator vs a Buck Converter to give output of 5 V ? What happens to remaining power in both cases ?

Lithium-Ion Batteries

Li-ion 18650 batteries

Link : <https://www.fogstar.co.uk/blogs/fogstar-blog/what-are-18650-batteries>

- N18650CNP-2500mAh batteries (we have with us) → 18650 battery is a rechargeable lithium-ion battery
- Nominal voltage = 3.6 V, Capacity range = 1800mAh - 3600mAh
- 18650 → “18” refers to 18mm diameter and “65” refers to 65mm length
- Protected vs Unprotected 18650 batteries
 - Protected : Includes a small electronic circuit integrated into the cell packaging; Protects the battery against overheating, overcharging and over-discharging; Less likely to blow up and cause injury as compared to unprotected counterparts
- Charging
 - On avg, a 2600 mAh battery takes 4 hours and 3500 mAh takes around 5-6 hours; But it is more dependent on battery brand, charger and output of power source

How long does 18650 batteries last ?

Link : <https://www.fogstar.co.uk/blogs/fogstar-blog/how-long-does-an-18650-battery-last>

- Key features that impact life duration of 18650 battery : age, capacity, charge cycles

Batteries with us (18650) :

https://robu.in/product/bak-nmc-18650-2500mah-8c-lithium-ion-battery/?gad_source=1&gclid=CjwKCAiApuCrBhAuEiwA8VJ6JuHLFktRSeEhSGbGOQLehx2bxmFoSCPY6g07yNvWpBJPk8gdKiEKhoCObUQAvD_BwE

Power consumption/requirements

NodeMCU

- <https://tinker.yeoman.digital/2016/05/29/running-nodemcu-on-a-battery-esp8266-low-power-consumption-revisited/>
-

Date : 13/12/2023

Creating soundboxes for bus stops

- Doing API calls using ESP32 : <https://www.youtube.com/watch?v=cgoCmYLeaSI>
- Implementing Text-To-Speech on ESP32 : <https://www.youtube.com/watch?v=R-CZLimCcW8>

Creating PCB from Schematics

- EasyEDA : <https://www.youtube.com/watch?v=utBQqcuOt9U>

PCB

- Design files : Gerber files (contains detailed model of PCB)
- Drilling machine drills different holes on copper sheet based on Gerber file

Component Placement

Link : <https://www.protoexpress.com/kb/pcb-component-placement-rules/>

1. Order of Arrangement : All connectors should be placed first, on edge of circuit board
2. Component orientation : All similar components should be placed in same orientation. This will help in easy routing and faster soldering.
3. Part-to-part spacing : If you place components too close to each other on a circuit board, it will create many problems that will lead to redesign and refabrication

6 Basic Design Rules

Link : <https://www.youtube.com/watch?v=TDXu3TmPE8Q>

Selecting trace width

Trace geometry (Thickness and width) - Traces carry electric signals and must have a width compatible with the current passing through them. The designer must determine the minimum width of each trace in order to avoid dangerous overheating of the board; this parameter directly affects the routing process, as it reduces the space available on the PCB.

Ground planes : What are they ?

Avoid 90 degree angles : Why ?

Date : 14/12/2023

Link : <https://www.mclpcb.com/blog/pcb-layout-considerations/>

Component Placement order

Orientation

Power, Ground and Signal Trace considerations

1. Power and Ground planes : Why are they needed ? Can't we include them like other traces on the board ?
2. Track Design : Thin tracks can only carry so much current. Tracks that are 0.010" inches or 10 mils thick can only take a current of around one amp, while a track that is 250 mils thick can carry as much 15 amps with a 30 degree Celsius temperature rise. How are track widths calculated ?
3. Pad and Hole dimension : What are pads vs holes ? As the size of the pads and holes decreases, getting the right pad-to-hole size ratio becomes more crucial. It's especially critical when working with via holes.
4. Signal Integrity and RF issues : PCB layout design plays a crucial role in ensuring signal integrity and preventing electrical problems such as interference, often referred to as radio-frequency interference or electromagnetic interference.

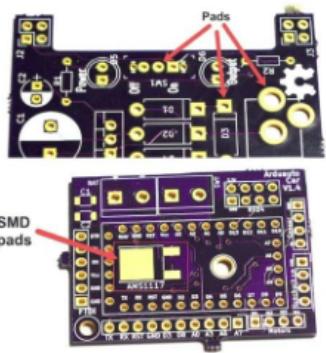
Avoiding these problems has a lot to do with how you route your traces.

- a. To prevent signal issues, avoid running tracks parallel to each other as they will have more crosstalk
 - b. If tracks need to cross over each other, make sure they do so at right angles. This will reduce capacitance and mutual inductance between the lines, decreasing crosstalk in turn.
 - c. Using semiconductor components that generate low electromagnetic radiation can also help with signal integrity. Sometimes, other needs may require parts that have higher electromagnetic generation, though.
 - d. When designing a PCB, eliminate antennas, which can radiate electromagnetic energy, as well as large loops of signal and ground-return lines that carry high frequencies. You must position integrated circuits carefully to achieve short interconnect lines. What does this mean ?
 - e. Placing a close ground grid over the PCB is another essential RF PCB layout design guideline that helps to ensure that return lines are close to the signal lines. This keeps the effective antenna area relatively small. In a multilayer board, you can achieve this with a ground plane. What does this mean ?
5. Thermal issues : Larger boards and those with higher component density and higher processing speeds tend to have more heat-related problems.

Pads and holes

A pad is the exposed region of metal on a circuit board that the component lead is soldered to. Multiple pads in conjunction are used to generate the component footprint or land pattern on the PCB. The two types of pads

available are through-hole and surface mount pads. Pads are the connection points between the electronic components and the PCB's traces.



Power and Ground Planes

- Power plane is a conductive layer in PCB that carries electrical power to various components on board
- Ground plane is a conductive layer in a PCB that serves as a reference point for the circuit's voltage levels.
- The ground plane helps in minimizing ground loops, reducing electromagnetic interference (EMI), and providing a stable reference voltage for signal integrity.

Link : <https://www.pcbnet.com/blog/how-to-reduce-emi-in-printed-circuit-boards>

Trace Layout for minimizing unwanted EMI

- Avoid right angles
- Shorten return paths → Return path is the path the current takes to return to the source. Mostly in multi-layer PCBs return paths are connected to ground plane through VIAs.
- Traces that are too close together can create crosstalk. Maintain a space of atleast twice trace width to prevent capacitive coupling

Ten circuit design tips

Link : <https://www.gadgetronicx.com/10-circuit-design-tips/>

1. Decoupling and Coupling capacitors : Power supplies are unstable and output voltage is fluctuating. Voltage fluctuations may make the circuit to misbehave and there is even a risk of Microcontroller skipping a instruction which can result in devastating results. In order to overcome this designers will add a capacitor in parallel and close to the power supply while designing circuit. If you know how capacitor works you will know, by doing this capacitor will start charging from the power supply until it reaches the level of VCC. Once the Vcc level is reached current will no more pass through the cap and stops charging. The capacitor will hold this charge until there is a drop in voltage from the power supply. When voltage from the supply, voltage across the plates of a capacitor will not change instantaneously. At this instant Capacitor will immediately compensate for the voltage drop from the supply by providing current from itself. Similarly when the voltage fluctuates otherwise creating a voltage spike in the output. Capacitor will start to charge with respect to the spike and then discharge while keeping the voltage across it steady thereby the spike will not reach the digital chip thus ensures steady working.

2. Discharge time of batteries : Batteries are susceptible to drop their output voltage when their current capacity decreases. Always use the battery that has 1.5 times capacity of the current you actually need to run your circuit for a given period of time. Why ?

Suppose, we want to run a 12V motor with a driver circuit for about 4 hours. The motor consumes 150mA and driver circuit consumes 50mA. If above circuit should run for 4 hours, current req. Is $(150+50) \text{ mA} \times 4 = 800 \text{ mA}$. For this case, we should choose a battery of capacity of 1200mAh. This is because Lithium ion batteries tend to drop their voltages when the current capacity drops to 20% of their total capacity. This means voltage will drop from 12v to somewhere around 9v when the current capacity drops to 240mA in Lithium battery. Here our circuit consumes 800mA for four hours as denoted above which leaves 400mA or 27% current capacity in the battery. Considering the losses this wiggle room should keep our circuit up and running and prevent damage of batteries as well.

3. Building blocks in circuit design : Circuit designing by itself can be pretty daunting but its is something very similar to building a house. Take any circuit you could probably find two or three building blocks in it which are put together to function as unit to perform the intended task. To design circuits you need to have understanding on these basic building blocks on how it works and methods to build them. Once you possess fair knowledge on these blocks you will find yourself in a good position to design circuits for the intended purposes. But remember putting these elements together may not be straightforward and take practice to do so but this will give you a head start in making your circuit design.
4. Resistor wattage : Wattage rating or power rating of a resistor indicate the amount of power it can safely dissipate in the form of heat. When power dissipated exceeds the rated wattage it will result in smoking of resistor and potentially can damage the entire circuit. So Wattage rating of a resistor is equally important as their resistance values.

Let's say you want to use a resistor in a circuit where it allows 50mA of current at 9V, so the total power here will be $P=VI$ or $P = 50\text{mA} * 9\text{V} = 0.45\text{Watts}$. In this case we should choose a resistor with wattage rating of at least $\frac{1}{2}$ or 0.5 Watt resistor.

5. Choosing the right component : Many designers will stick to the parts they have used in the past in their designs or use components from the circuits they find in the internet. This might sound like a workable approach but it will be definitely not optimum, you must choose your parts as per your requirements.

Date : 15/12/2023

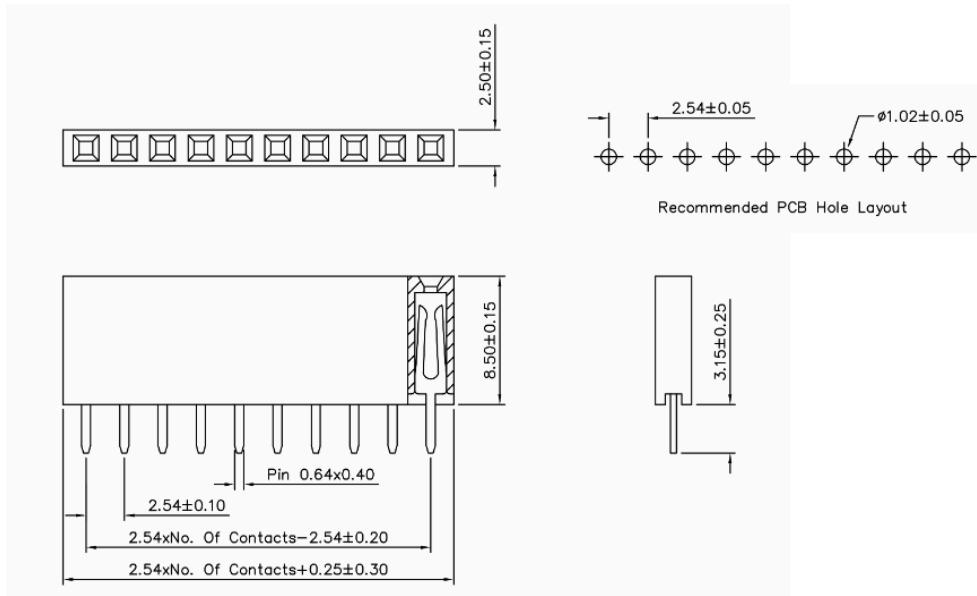
Trace

- Width : of the trace
- Clearance : Gap b/w trace and other conductive parts in a circuit

PCB Pad and Hole sizes

- Idea is to install female headers on PCB and attach the modules to it for testing purposes

Female header (on PCB)



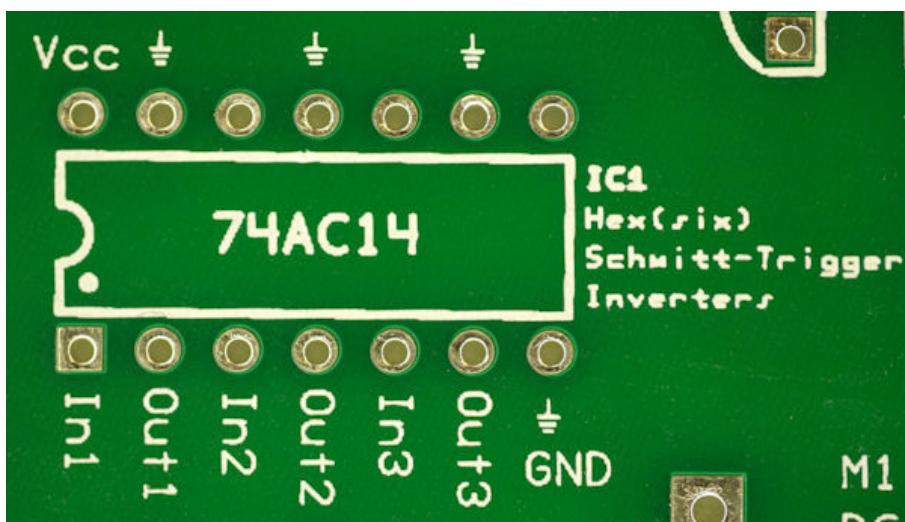
PCB

Substrate

Solder Mask

Silk Screen

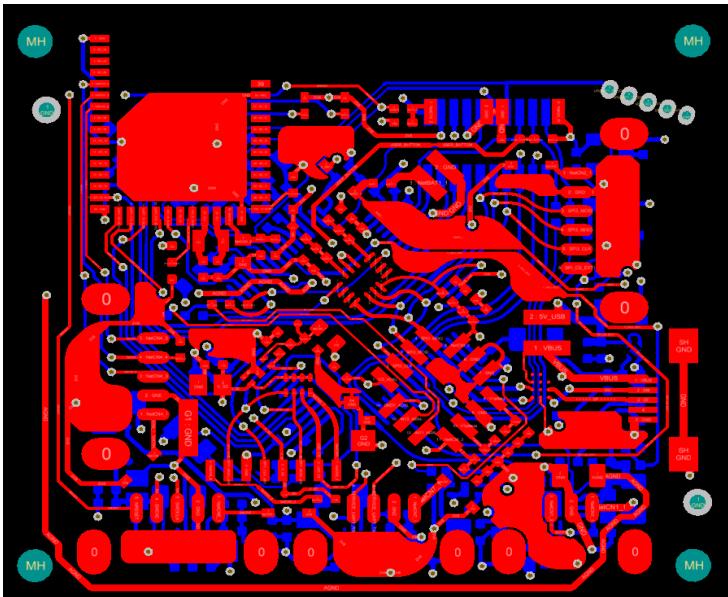
- White Ink over solder mask
- Identification of component names
- Symbols/ Pin nos/ Manufacturer data



Common terms

- DRC (Design Rule Check) : To check PCB design for any errors
- Hole : to insert components
- Pad : to solder components
- Via : Hole to connect 2 layers of PCB
- Track : Wire in a PCB

- Plane : Excess copper area (applied on both top/bottom side of pcb); Usually given to VCC/GND



- Footprint : PCB footprint of a component

PCB Design process

Steps 1-3 are reiterated again and again...

1. Schematic Capture (ISIS - Proteus)
 - a. Process of creating Circuit diagram on computer
 - b. Symbols and Interconnection wires are shown
 - c. Terminals and nets are used (when we can't use long wires)
2. Place components
3. Route traces
 - a. Copper traces are formed on PCB
 - b. Width is specified in mils/thou
 - c. Width of trace depends on current flowing through it
4. Generate Gerber files
 - a. Manufacturing data understandable by machines for drilling the PCB
5. Fabrication

Measurement units on PCB

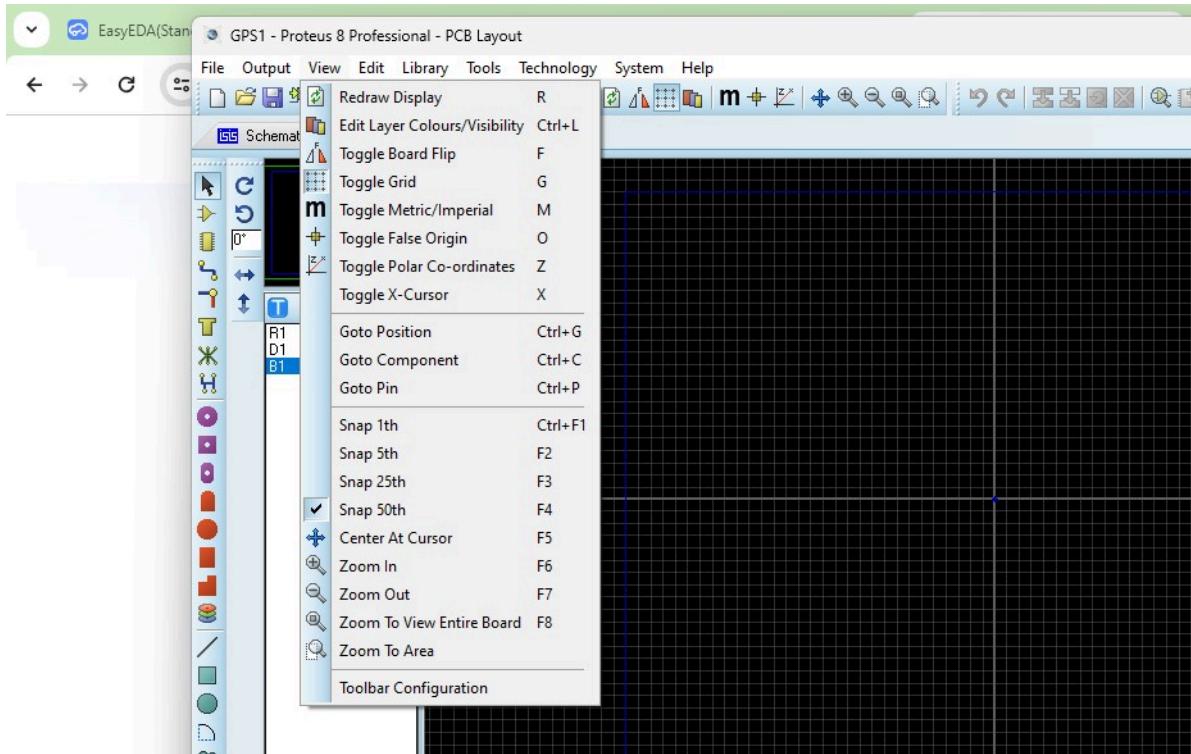
- 1 mil = 1 thou = 0.001 inch = 0.0254 mm

ISIS (Schematic Capture - Proteus)

- Press "G" - select grid/ dots/ etc on schematic canvas

ARES (PCB Design)

- Snap : In PCB design, a snap grid is the basis for the drag-and-drop functionality of the PCB editor. When a component is selected and moved around the screen, it "snaps" according to the resolution of the snap grid. For example, if the snap grid is set to 10 mils, the component will move in 10 mil spaces. ("th" stands for "thou" and is equal to "mils" or "1/1000s of an inch")



- Place the components such that the trace lengths are minimized in the PCB

Date : 18/12/2023 (Monday)

- Why don't we use capacitors as voltage regulators ?
 - Voltage Droop: Capacitors discharge over time, leading to a gradual decrease in voltage across the capacitor. This is known as voltage droop. As a result, capacitors alone cannot provide a stable and constant output voltage over an extended period.
- MT3608 booster : <https://embedblog.eu/?p=712>. How to adjust the Potentiometer on it to support output of 5 V ?

Date : 19/12/2023 (Tuesday)

- Why do PCB ceramic antenna have a metal casing on one side ? Chip antenna

- Using chip antennas in pcb design ?
 - Antenna position on PCB
 - Length of ground plane
 - Other components in proximity
 - Outer casing and material
 - Layout of PCB (power/noise)
 - Position within device
 - GPS frequency : 1575.42 MHz
 - Understanding antennas
 - Video : <https://www.youtube.com/watch?v=ZaXm6wau-jc>,
 - Text : <https://www.lesics.com/how-does-an-antenna-work.html>
 - GPS Patch antenna : <https://www.youtube.com/watch?v=s-jFprdDcM4>
 - GPS antenna datasheet :
https://datasheets.kyocera-avx.com/ethertronics/AVX-E_1004259.pdf
 - GPS antenna's Low Noise Amplifier circuitry :
<https://www.analog.com/media/en/technical-documentation/data-sheets/max2659.pdf>
 - Mobile phone GPS antennas :
<https://www.gpsworld.com/professional-oemcomponent-technologiesinnovation-mobile-phone-gps-antennas-9457/>
 - Antennas : <https://hb.diva-portal.org/smash/get/diva2:1312395/FULLTEXT01>
-

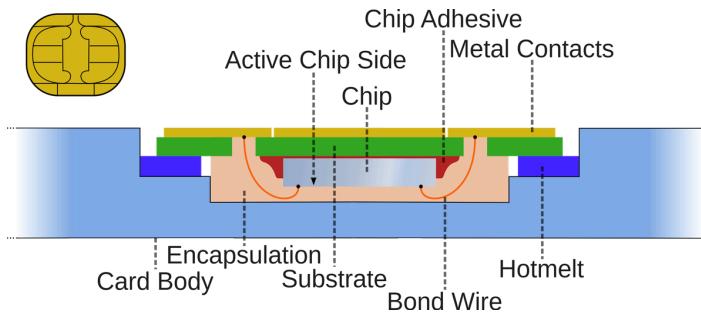
Date : 22/12/2023 (Friday)

- MT3608 module
 - Datasheet :
<https://www.olimex.com/Products/Breadboarding/BB-PWR-3608/resources/MT3608.pdf>
 - Doc 1 : https://oshwlab.com/Little_Arc/MT3608
 - PCB layout : <https://easyeda.com/editor?id=f5993e72640343db8f215d259a995500>
 - Schematic : <https://easyeda.com/editor?id=1e0ffd31e583452cb9b2fc5893aff53e>
- Learn more about Buck and Boost converters, Inductors
- Boost Converter Circuit
 - <https://components101.com/articles/boost-converter-basics-working-design>
 - Why do we need input capacitors :
<https://resourcespcb.cadence.com/blog/prevent-dc-dc-converter-oscillations-with-input-capacitance>

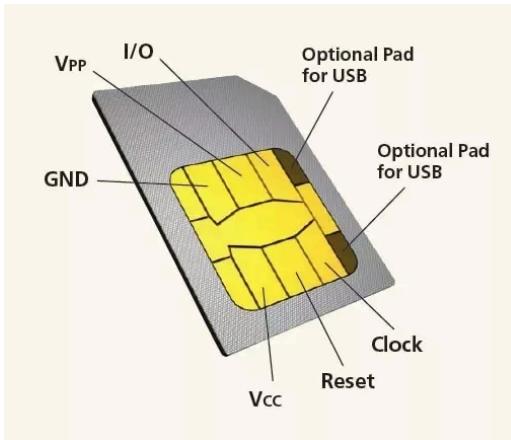
- Learn about MT3608 chip
 - Astable multivibrators
-

Date : 27/12/2023 (Wednesday)

- GSM Module (SIM800L)
 - <https://lastminuteengineers.com/sim800l-gsm-module-arduino-tutorial/>
 - <https://circuitdigest.com/microcontroller-projects/interfacing-sim800l-module-with-esp32>
- Some doubts;
 - What kind/model of GSM and GPS Modules are used inside a smartphone ?
 - Can I use just GSM for approx location tracking (removing GPS would mean less cost and less power consumption) since we don't have to track the vehicles in our use-case very precisely ? Location accuracy will be around 100-300 metres in cities and around a few kms in rural areas (poor network areas). Basically we could only get the location of the cell tower, which means that wherever the device is inside that cell of the cell tower, it will show the location of the cell tower only. This will be problematic while putting the location of shareauto on map. **But still could experiment with it.**
 - Why is a SIM card needed ? What and Why do we have 6 metallic contacts on one side ?
- SIM808 Chip has GPS/GSM/GPRS integrated, meaning that a single chip would be needed with 2 antennas, instead of mounting 2 chips separately.
- Nice blog on Hardware teardowns and other electronics stuff :
<https://pallavaggarwal.in/2023/12/19/valtrack-v4-vehicle-tracking-system/>
- SIM (Subscriber Identity Module)
 - Necessary for establishing connection to a network
 - Identifies what mobile phone subscriber is using a particular device
 - Stores a 64-bit number → unique identifier
 - When turn on the phone and connect to network → Sim passes its "ID number" and "Authentication key" found on SIM card to Cell provider (Authentication process happens and cell connects to the network)
 - Extra space could be used for saving phone numbers
 - Sim card Cross-section



- Sim card Top-view
 - GND and Vcc : Power supply
 - Reset : Reinitialize settings
 - CLK (Clock Contact): The clock contact provides the timing signal for communication between the SIM card and the mobile device. It ensures synchronized data transfer.
 - I/O : Transfer of data between the SIM card and the mobile device
 - Vpp (Programming Voltage) : The programming voltage is applied to enable write operations, and once the personalization process is complete, the SIM card operates using the standard operating voltage (Vcc) supplied by the mobile device. When programming or updating data on a SIM card, a higher voltage (Vpp) is applied to allow for the modification of specific memory locations



Date : 30/12/2023 (Saturday)

- SIM800L not working... LED is blinking then it stops working : Connecting it to a higher voltage made it work continuously
- LED is blinking every 1 sec meaning module is active... But not connecting to network ?

SIM800L module

Ref : <https://www.electroduino.com/sim800l-gsm-module/>

Datasheet : https://components101.com/sites/default/files/component_datasheet/SIM800L-Datasheet.pdf



- Operating voltage of chip : 3.4 V - 4.4 V
- LED status indicators
 - Blink every 1 sec : GSM module running but no connection with cellular network yet
 - Blink every 2 secs : GPRS connection that you requested is active
 - Blink every 3 secs : Module made contact with cellular network; Ready to transmit/receive voice/SMS
- Connecting a PCB antenna to a U.FL male connector will provide better performance than Helical antenna. Why ?



- Pinouts
 - NET : Attach Helical Antenna here
 - VCC : Power supply of 3.4V-4.4V with min 2 Amp req. Remember, never connect to 5V power supply, which can destroy module. It doesn't work on 3.3V power supply. How are these specs defined ? If I have a new module how could I get to know about these kind of specs ? Check their datasheet (page 21) :

https://components101.com/sites/default/files/component_datasheet/SIM800L-Datasheet.pdf

| Feature | Implementation |
|--------------|--------------------|
| Power supply | 3.4V ~4.4V |
| Power saving | typical power cons |

- RST : Pulling pin LOW for 100ms performs hard reset of module. **What happens ?**
- SPK+, SPK- : Speaker pins
- MIC+, MIC- : Microphone inputs
- DTR : Pulling pin HIGH activates sleep mode (Serial communication disabled). Pulling LOW deactivates sleep mode
- RING : “Interrupt” out pin from module; Used to detect calls and SMS. By default HIGH, but when a call is received it gives a LOW pulse for 120 ms.
- Power (Check Datasheet for better understanding)
 - Operating voltage : 3.4 V - 4.4 V
 - Recommended supply voltage : 4 V
 - Peak current : 2 A
 - Doesn't have an internal voltage regulator, so we need an external regulated power supply.
 - Module is a bit power hungry → Power supply must be able to source 2 A
 - Consumption
 - Sleep mode < 2 mA
 - Idle mode < 7 mA
 - GSM transmission (avg) = 350 mA
 - GSM transmission (peak) = 2000 mA
 - **Why is there a diff in avg and peak during GSM transmission ?**
 - Datasheet : “When designing the power supply in user’s application, pay special attention to power losses. Ensure that the **input voltage never drops below 3.0V even when current consumption rises to 2A in the transmit burst. If the power voltage drops below 3.0V, the module may be shut down automatically.** The PCB traces from the VBAT pins to the power supply must be wide enough (at least 60mil) to decrease voltage drops in the transmit burst. The power IC and the bypass capacitor should be placed to the module as close as possible.” → **This could be observed when you see the SIM800L module in which PCB traces are much wider from Vcc.**

Interfaces

- UART and **AT commands**

Doubts / Terms to explore

- Pitch (PCB) : the distance between the centers of adjacent features or traces on any layer
- Bypass Capacitor (Low ESR) = 100 uF : Usually, placed between Vcc and GND pins of a IC which leads to shorting AC signals to GND. Thus, AC noise on DC signal is removed, producing a clean DC signal

- Eliminating high frequency interference = 33pF and 10pF
 - Coupling vs Decoupling (Bypass) capacitors :
<https://www.etechnoq.com/2019/12/exact-difference-between-coupling.html>
 - Why do we need Bypass caps in Voltage Regulator ICs ? (Wires connecting voltage source and ICs can act as antennas generating noise. Need caps to remove these high freq. ripples)
<https://www.etechnoq.com/2019/10/why-capacitor-need-to-use-with-ic-78xx.html>
 - How do we select Capacitor values for Coupling and Decoupling purposes ?
-

Date : 31/12/2023 (Sunday)

Vehicle Tracker

- Valtrack V4 :
<https://www.youtube.com/watch?v=Cyq3swUJKL8&list=RDCMUC7raRsx4ojx3cyXT3x9-PuQ&index=8>
-

GPS module

GSM module

GPS+GSM module

- A9G module :
<https://www.youtube.com/watch?v=Yi5dgZBiq7g&list=RDCMUC7raRsx4ojx3cyXT3x9-PuQ&index=2>

Troubleshooting SIM800 module

- <https://www.youtube.com/watch?v=qI8vdiQdXtA>
- Whattttt aaaaaaaaaa guyyy, changed my life today... Finally GSM worked (I am on world tops now) :
<https://www.youtube.com/watch?v=RFCr25Yvix0>
 - Basically, connected a 470uF cap across the voltage supply. So, it must have acted as decoupling capacitor and removed voltage fluctuations. But I could not observe this using multimeter (maybe because my multimeter is cheap and not accurate)
- <https://www.youtube.com/watch?v=t6XMdWimv2A> → Shorten length of wire (lower resistance). When GSM model searches for network in the beginning (Transmission burst phenomenon), it consumes 2A current.

Date : 01/01/2024 (Monday)

Importance of common GND

SIM800L Module was not working for a long time... The connection was as follows;
Ckt 1 : Power supply through 5 V voltage regulator module - 5V(Voltage Regulator)-Vcc(SIM800L) and GND(Voltage Regulator)-GND(SIM800L). Rx(NodeMCU)-TX(SIM800L) and Tx(NodeMCU)-Rx(SIM800L)

Later, I just tried creating a common GND between NodeMCU and SIM800L module. Then everything worked. Why do we need a common GND ?

Ckt 2 : Ckt1 + Connected GND of NodeMCU, SIM800L and Power Supply together (created common GND)

<https://quora.com/Why-it-is-necessary-to-common-all-the-ground-in-circuit>

AT commands

Ref : <https://lastminuteengineers.com/sim800l-gsm-module-arduino-tutorial/>

- Modem instructions
- “AT” stands for “ATtention”
- Commands
 - **AT** : This is the most basic AT command. It also initializes the Auto-bauder. If all is well, it sends the OK message, telling you that it is understanding you correctly.
 - **AT+CSQ** : It checks ‘Signal Strength’. The first number in the output response is the signal strength in dB. It should be more than about 5. Higher is better. Note that this signal strength depends on your antenna and location!
 - **AT+CCID** : It checks whether the SIM card is valid or not and sends the SIM card number.
 - **AT+CREG?** : It checks whether you are registered to the network or not. The second number in the output response should be 1 or 5. 1 indicates that you are registered to a home network and 5 indicates a roaming network. Any number other than these two indicates that you are not registered to any network.
 - **ATI** : Returns the module name and revision.
 - **AT+COPS?** : Checks which network you are connected to.
 - **AT+COPS=?** : Returns the list of operators present in the network.
 - **AT+CBC** : Returns Li-Po battery status. The second number is the battery level (in our case it is 93%) and the third number is the actual voltage in mV (in our case 3.877 V)
 - **Sending SMS**

GSM to arduino : Connections + Code

Ref : <https://lastminuteengineers.com/sim800l-gsm-module-arduino-tutorial/>

Going through Datasheets

How to read a datasheet ? <https://www.sparkfun.com/tutorials/223>

- **SIM800L GSM module**

Datasheet : https://components101.com/sites/default/files/component_datasheet/SIM800L-Datasheet.pdf

(Note : Amazing datasheet with clearly explained practices to use while designing power supply and such)

- Voltage : 3.4 V - 4.4 V
- Current : Max = 2 A (during transmission burst, especially when GSM module is connecting to a cellular network)

- **NEO6M GPS module**

Datasheet :

https://content.u-blox.com/sites/default/files/products/documents/NEO-6_DataSheet_%28GPS.G6-HW-09005%29.pdf

- NEO6MV2 Arduino/NodeMCU compatible GPS module (NEO6M integrated on the module) :

<https://www.epitran.it/ebayDrive/datasheet/NEO6MV2.pdf>

- Voltage : 2.7 V - 3.6 V

| Parameter | Symbol | Module | Min | Typ | Max | Units |
|----------------------|--------|------------------------|------|-----|------|-------|
| Power supply voltage | VCC | NEO-6G | 1.75 | 1.8 | 1.95 | V |
| | | NEO-6Q/M NEO-6P/V/T | 2.7 | 3.0 | 3.6 | V |
| Supply voltage USB | VDDUSB | All | 3.0 | 3.3 | 3.6 | V |

- Current : Max = 67mA, Avg = ~40mA

| Parameter | Symbol | Module | Min | Typ | Max | Units | Condition |
|-----------------------------------|--|--------------------------|-----|--------------------------------------|-----|-------|--|
| Max. supply current ¹⁵ | I _{CCP} | All | | | 67 | mA | V _{CC} = 3.6 V ¹⁶ / 1.95 V ¹⁷ |
| | I _{CC} Acquisition | All | | 47 ¹⁹ | | mA | |
| | I _{CC} Tracking (Max Performance mode) | NEO-6G/Q/T NEO-6M/P/V | | 40 ²⁰ 39 ²⁰ | | mA | |
| | I _{CC} Tracking (Eco mode) | NEO-6G/Q/T NEO-6M/P/V | | 38 ²⁰ 37 ²⁰ | | mA | V _{CC} = 3.0 V ¹⁶ / 1.8 V ¹⁷ |
| | I _{CC} Tracking (Power Save mode / 1 Hz) | NEO-6G/Q NEO-6M | | 12 ²⁰ 11 ²⁰ | | mA | |
| | | | | | | | |

- **OLED**

Datasheet : <https://www.vishay.com/docs/37902/oled128o064dbpp3n00000.pdf>

Other amazing ref (reg power consumption) :

<https://bitbanksoftware.blogspot.com/2019/06/how-much-current-do-oled-displays-use.html>

- Voltage

| Item | Symbol | Condition | Min | Typ | Max | Unit |
|----------------------------|--------|-----------|-----|-----|-----|------|
| Supply Voltage for Logic | VDD | — | 2.8 | 3.0 | 3.3 | V |
| Supply Voltage for Display | VCC | — | 10 | 12 | 15 | V |

But in our module (with OLED and PCB), we just have one Vcc pin. And as we connect Vcc to 3.3V out from NodeMCU Logic is powered up. But, how is the 10-15V power supply given for the Display ??? The answer is below... Because the SSD1306 has an internal charge pump that can generate required voltage from logic supply.

<https://electronics.stackexchange.com/questions/379031/128x64-oled-not-working-on-3-3v>

- Current : Max = around 10 mA, Avg = ~5mA

The ubiquitous 128x64 0.96" OLEDs can potentially display a screen full of useful information on less than 5mA

| Type | Display Off | On, but Black | Contrast 31, 50% pixels lit | Contrast 127, 50% pixels lit | Contrast 255, 50% pixels lit | Contrast 31, 100% pixels lit | Contrast 127, 100% pixels lit | Contrast 255, 100% pixels lit |
|---------------|-------------|---------------|-----------------------------|------------------------------|------------------------------|------------------------------|-------------------------------|-------------------------------|
| 128x128 1.12" | 5mA | 7.1mA | 49.5mA | 104.0mA | 108.0mA | 89.9mA | 104.0mA | 104.0mA |
| 128x64 1.3" | 490uA | 490uA | 15.4mA | 26.1mA | 31.4mA | 20.6mA | 33.7mA | 39.1mA |
| 128x64 0.96" | 26uA | 469uA | 5.6mA | 8.1mA | 11.0mA | 10.3mA | 15.1mA | 20.7mA |

Date : 02/01/2024 (Tuesday)

Issue

- Got stuck with the output voltage at 27 V → Need to understand the circuit to identify issue
- GSM module not working (AGAINNNNN)

MT3608 module

Datasheet : <https://www.olimex.com/Products/Breadboarding/BB-PWR-3608/resources/MT3608.pdf>

Working : <https://components101.com/modules/mt3608-2a-dc-dc-step-up-power-module>

(Take printout to study later)

1) SS34 diode :

- Min voltage drop = 0.2 volts when 0.1 amps is flowing through it
- Max current through the diode = 3 A when the voltage drop is 0.5 V
- Max reverse voltage = 40 volts.

Using Multimeter to check components

- Diode

Put Multimeter in Diode/Continuity mode : When you touch the multimeter probes on diode in forward bias, it shows a reading (which is forward bias voltage drop in mV); When diode is touched in reverse bias orientation, doesn't show any reading (because diode doesn't conduct in reverse bias)

- Potentiometer

It just another resistor

- Current

Reason for Issue (Possible)

- Potentiometer is not able to change its resistance (Must be damaged internally)

Original Reason

- Potentiometer is a multiple turn pot and control are not precise

See cross-section for understanding (Page : 13) :

<https://www.bourns.com/docs/technical-documents/technical-library/trimmers/technical-articles/trmrpmr.pdf?sfvrsn=0>

Go through this later

Date : 03/01/2024 (Wednesday)

Issue (since yesterday afternoon)

- In Perfboard prototype, GSM model was ON indicated by blinking of LED every 1 sec, but was not connecting to network, which is indicated by blink every 3 secs (even after placing the Cap across Vcc and GND, to ensure ample current for load - 2 A during Transmission burst initially)

Reason

- After multiple attempts, finally tested on breadboard again from scratch → Issue was thickness of wires used : Why ? Thin wires, bigger resistance → GSM module was not getting 2 A current (as the wire itself acts as a load here)

Solution → Decrease resistance as much as possible

- Thicker wires
- Shorter supply paths from power supply to module

Design Corrections to do

- 1) Thicker wires for Power supply lines
- 2) Connect diodes on power supply lines : Why ? When connecting on Power supply, if I need to connect with NodeMCU (for programming or reading serial monitor data), 3.3/5V DC regulator on top of battery is powering up too from Computer's current through USB

Understand these

- Why is my board not working properly ??? GSM not getting connected to the network - Randomly gets connected once a while ? **Have to learn more on SIM800L module. Rectify this issue by tomorrow.**

How does a GSM module connect with the Internet ?

References

- Connecting GSM module with Firebase : <https://www.youtube.com/watch?v=gLYalgAKhjo>
- Sending GPS Data to Firebase using GSM module : <https://www.youtube.com/watch?v=i1yBv1CM7mY>

Access Point Name (APN)

- Gateway between a GSM, GPRS, 3G or 4G mobile network and another computer network, frequently the public Internet. A mobile device making a data connection must be configured with an APN to present to the carrier.

Date : 04/01/2024 (Thursday)

Connecting GSM module with Firebase DB

- Ref : <https://how2electronics.com/gsm-arduino-communication-with-firebase-or-thingspeak/>
- Issue 1 : HTTP Client not getting connected when using “ArduinoHttpClient” library
- Let's break down things;
 - Firebase Realtime DB is a normal DB. How do you generally put data in it ?
 - How to connect with Firebase DB from Arduino ?
 - How can I use that same method in Arduino to raise HTTP request for putting data into that DB ?

Finally, Something that works

Firebase Realtime DB :

<https://console.firebaseio.google.com/project/gps-tracker2-13e30/database/gps-tracker2-13e30-default-rtdb/data>

Arduino Codes :

- 1) Putting data into Firebase (using GSM)
 - Code : https://github.com/Raghul-PK/GPS_Receiver/blob/main/Firebase_To_GSM
- 2) Getting data from Firebase (using GSM)
 - Ref : <https://www.youtube.com/watch?v=uudJ-tiigmw>
 - Code : https://github.com/Raghul-PK/GPS_Receiver/blob/main/GSM_To_Firebase

Make sure to update pin numbers of GSM module, APN name/username/password and Firebase Host/Auth/Path in code.

Understanding the code

TinyGSM library : <https://github.com/vshymanskyy/TinyGSM>

- Initialize the modem
 - `modem.init()` or `modem.restart()`
 - restart generally takes longer than init but ensures the module doesn't have lingering connections

I feel GSM is performing so much better after the inclusion of this in the code, it is taking time for the initial start, but after that it starts performing good. If possible, need to find something similar for GPS as well.

Date : 05/01/2024 (Friday)

Arduino Code

Extracting the necessary info from NMEA using TinyGPS+

Code : https://github.com/Raghul-PK/GPS_Receiver/blob/main/GPS/TinyGPSPlus_ExtractingEssentials

- Let's use TinyGPS++ library to get GPS data including Time, Lat and Long data (leave out SNR for now). Then, send these details to Firebase using TinyGSM library. (Note : Check “UsingCustomFields.ino” in

Github documentation of TinyGPS++ → Could be utilized for extracting SNR :
<https://github.com/mikalhart/TinyGPSPlus/blob/master/examples/UsingCustomFields/>

- Single output :

```
Date : 050124
Time : 074006.00
Lat : 2832.63403
Long : 07716.27368
SNR : 37
Lat : 28.54
Long : 77.27
```

- Here, when I use inbuilt methods for getting Lat and Long, outputs are 28.54 and 77.27;

```
Serial.println("Lat : " + String(gps.location.lat()));
Serial.println("Long : " + String(gps.location.lng()));
```

But when I use NMEA sentence extraction (see doc : <https://www.tronico.fi/OH6NT/docs/NMEA0183.pdf> for understanding which NMEA-0183 strings to use), I get diff outputs → 2832.63403 and 07716.27638 (angles are same 28 and 77, but minutes are diff in lat/long);

```
TinyGPSCustom gps_lat(gps, "GPRMC", 3); //
TinyGPSCustom gps_long(gps, "GPRMC", 5); //

Serial.println("Lat : " + String(gps_lat.value()));
Serial.println("Long : " + String(gps_long.value()));
```

I am proceeding with custom NMEA extraction, since we can extract data directly from NMEA-0183 format without preprocessing and this is much easier and readable than creating custom methods from scratch like we did initially for getting Lat, Long and SNR.

Integrating GPS and GSM Code (TinyGPS + TinyGSM)

Code : https://github.com/Raghul-PK/GPS_Receiver/blob/main/Tracker/V1_LibrariesSupport

- Getting HTTP ERROR response (JSON could not be parsed, since Lat/Long values are sometimes returned NULL). So, we have to send something else ("0") when we are not getting GPS data. Now, issue has been resolved.

```
lat_data = String(gps_lat.value()) != "" ? String(gps_lat.value()):"0";
long_data = String(gps_long.value()) != "" ? String(gps_long.value()):"0";
SNR_data = String(snr.value()) != "" ? String(snr.value()):"0";
```

- We will create the following Key-value architecture in Firebase;

Realtime DB's Root → Date → Time → {"Lat": lat, "Long": long, "SNR": snr}

Code

```
String FIREBASE_PATH = "/" + cur_date + "/" + cur_time + "/";
PostToFirebase(FIREBASE_PATH, Data, &http_client);
```

- Error 1 : Got the error → Issue was because of the presence of “.” in hour field in path, so get a substr of it to rectify it.

```
Lat = 0Long = 0SNR = 0POST:/050124/092518.00/.json?
Data:{"Lat":0,"Long":0,"SNR":0}
Status code: 400
Response: {
    "error" : "Invalid path: Invalid token in path"
}
```

- Error 2 : Getting following error

```
Fix status : 1
Lat = 2832.63080Long = 07716.27624SNR = 34POST:/050124/111131/.json?auth=zhw6Zkn3C
Data:{"Lat":2832.63080,"Long":07716.27624,"SNR":34}
Status code: 400
Response: {
    "error" : "Invalid data; couldn't parse JSON object, array, or value."
}
```

Why ?

- Invalid Key names :

<https://help.zapier.com/hc/en-us/articles/8496008666509-Common-Problems-with-Firebase#creating-a-firebase-structured-query-for-a-search-0-1>
- This error might be only because of the values of Lat/Long being in decimals, because earlier whole nos were going fine → Issue was rectified by enclosing values in double quotes (single quotes didn't work)

```
String Data = "{";
Data += "\"Lat\":\"" + String("\"\") + lat_data + String("\"\") + ",";
Data += "\"Long\":\"" + String("\"\") + long_data + String("\"\") + ",";
Data += "\"SNR\":\"" + String("\"\") + SNR_data + String("\"\") + "";
Data += "}";
Data += "};
```

Output JSON format

```
Fix status : 1
Lat = 2832.62954Long = 07716.27449SNR = 34POST:/050124/114807/.json?
Data:{"Lat":"2832.62954","Long":"07716.27449","SNR":"34"}
Status code: 200
Response: {"Lat":"2832.62954","Long":"07716.27449","SNR":"34"}
```

Assigning external indicators

- GPS “Connected” Indicator : After GPS fix is achieved and GPS module start receiving Lat/Long data
 - NMEA “GPGGA” sentence 6th term → GPS Quality Indicator. 1, if GPS fix available
 - Update on OLED screen with “GPS Connected” or “GPS Lost”
- GPRS “Connected” Indicator : After network connectivity is achieved
 - Use modem.gprsConnect() method in Integrated GPS+GSM code above
 - Update on OLED screen with “GPRS Connected” or “GPRS Lost”

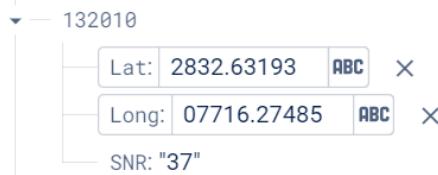
If above both are achieved, only then display the below one.

- Firebase “last update” Indicator : Only if we transfer GPS data after GPS fix and get a Response Status code = 200.
 - Update on OLED screen with last update date and time.

Putting coordinates on Maps : Python (for Demo purposes only) [9:45 pm]

- Retrieving latest stored Lat/Long values from Firebase DB

Connecting Python and Firebase Ref :



- Conversion of NMEA Lat/Long format (degrees and decimal minutes) to decimal degrees



You

Convert lat = 2832.63193 and long = 07716.27485 into decimels



ChatGPT

To convert latitude and longitude values from the format used in NMEA sentences (degrees and decimal minutes) to decimal degrees, you can use the following formula:

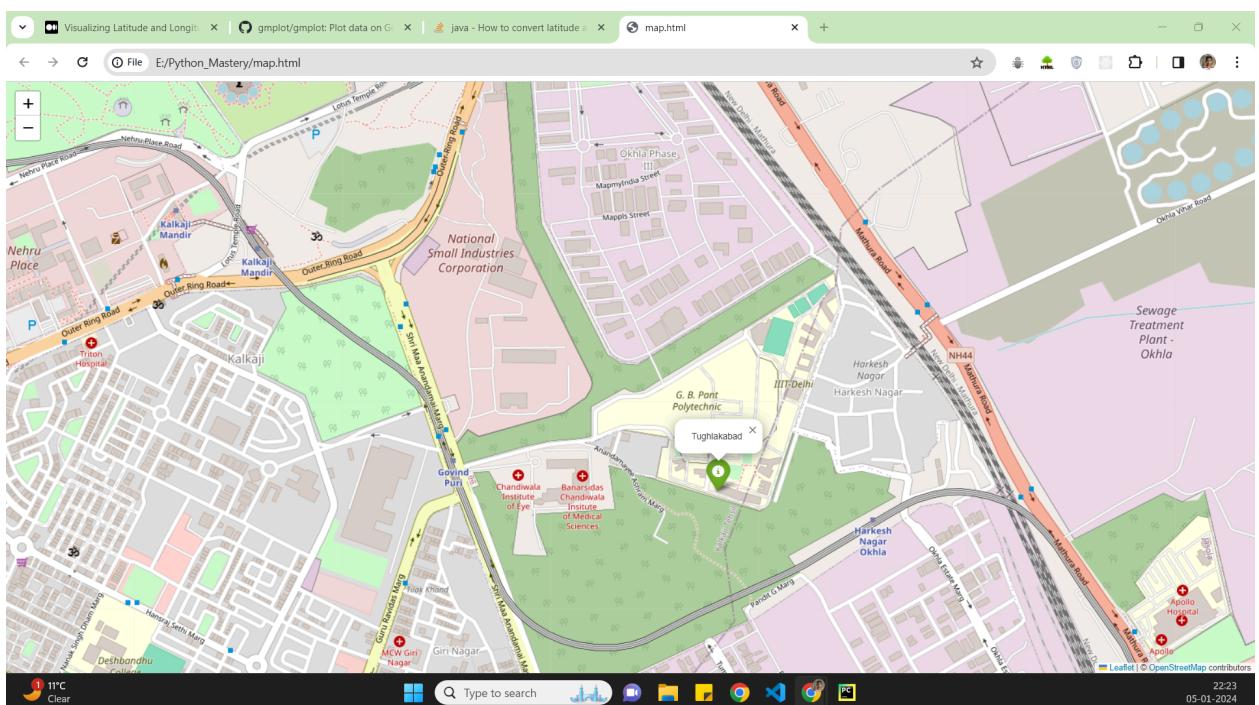
Decimal Degrees = Degrees + (Minutes / 60)

For the provided values:

- Latitude: $28 \text{ degrees} + (32.63193 \text{ minutes} / 60) = 28.5438655 \text{ degrees}$
- Longitude: $77 \text{ degrees} + (16.27485 \text{ minutes} / 60) = 77.2712475 \text{ degrees}$

- Using Folium to display locations on Map

Ref : <https://www.fusebulbs.com/how-to-plot-coordinates-on-the-map-python/>



Date : 06/01/2024 (Saturday)

Retrieving data from Firebase

- Ref : <https://medium.com/@drkaojha/using-firebase-with-python-8bb01d04815e>
- Got issue while installing Pyrebase using pip (Ref : <https://github.com/thisbejim/Pyrebase/issues/299>) → Issue resolved by installing Pyrebase4

Error : Getting Status code = -3 while putting data to Firebase

- Ref : <https://github.com/arduino-libraries/ArduinoHttpClient/issues/29>

Error : HTTP Client not getting connected sometimes. Why ?

- gprsConnect() not able to connect (Ref : [TinyGSM Github Documentation](#))

This library is "blocking" in all of its communication. Depending on the function, your code may be blocked for a long time waiting for the module responses. Apart from the obvious (ie, `waitForNetwork()`) several other functions may block your code for up to several *minutes*. The `gprsConnect()` and `client.connect()` functions commonly block the longest, especially in poorer service regions. The module shutdown and restart may also be quite slow.

The same issue can be seen here (`modem.gprsConnect()` was not able to connect to network) initially - “Connecting to airtelgprs.com fail” when I was trying experimenting with this in balcony of R&D 6th floor. But when I come inside of the lab, got “Connecting to airtelgprs.com OK”. So, it is all about network connectivity.

```
Connecting to airtelgprs.com ` ` ` ` ` SIM800L serial initialize
` ` ` ` ` Initializing modem...
Modem:
` ` ` ` Connecting to airtelgprs.com fail
` ` ` ` Connecting to airtelgprs.com OK
` ` ` ` Fix status : 0
` ` ` ` Lat = 0 Long = 0 SNR = 0 POST:/060124/091638/.json?auth=zhw6Zkn3OQ
` ` ` ` Data:{"Lat":"0","Long":"0","SNR":"0"}
` ` ` ` Status code: 200
` ` ` ` Response: {"Lat":"0","Long":"0","SNR":"0"}
` ` ` ` Fix status : 0
` ` ` ` Lat = 0 Long = 0 SNR = 0 POST:/060124/091645/.json?auth=zhw6Zkn3OQ
```

But why is the network poor outside and good inside the building ? Not sure why. But ideally it has to be the opposite.

Let's deviate a bit and look at the prices of individual Pieces of the built project so far; (sing IndiaMart)

- NEO6M GPS Module : Rs.400-500

- SIM800L GSM module : Rs.200-300
 - NodeMCU :
 - MT3608 DC-DC Boost converter
 - Lithium Ion Battery
 - OLED
 - 220uF Capacitor
-

Date : 08/01/2024 (Monday)

Code for plotting a day's entire location data

Github : https://github.com/Raghul-PK/GPS_Receiver/tree/main/PlottingMaps

Prof's Feedbacks

| | |
|--|---|
| Pravesh sir | |
| Reduce power consumption of the system | |
| Need updates every 1 min or so | At present we are updating every 5-7 secs or so. 1 minute updates are enough. |

| | |
|--|---|
| Sanat sir | |
| Power supply 1) Reduce DC-DC Voltage conversions 2) Choose the right battery | We have 3 voltage conversions now; 1) At the battery source 2) At boost converter (for up-ing voltage to 4 V for SIM800L) 3) NodeMCU voltage drop to 3.3 V to GPS module |
| Optimize location updates based on vehicle's velocity | When a vehicle is static, there is no need to update the server (GSM idle). When a vehicle is fast, faster updates are necessary. |
| Choose the right microcontroller and design it's external circuitry | Reduce power consumption and cost |

Optimizing location updates (Decreasing GSM usage)

- Parameters
 - Velocity : The faster the vehicle, faster the frequency of updates
 - Distance from last updated location : If vehicle has moved a fixed distance (50m or 100m) from previous location, then DB is updated with location and timestamp.

Existing products (GPS Vehicle trackers)

Bike Trackers

All designs have a common pattern. Had 4 wires : orange (Ignition wire), red (12 V battery in bike), black (Ground), yellow (12 V relay : for turning On/Off bike remotely using phone)

- Qubo : <https://www.youtube.com/watch?v=y2sjiy2gLRo>
- One-Lap GPS Tracker : <https://www.youtube.com/watch?v=a8J-y7yf86k>
 - Had 3 wires : orange (Ignition wire), red (12 V battery in bike), black (Ground)
 - It is updating every few secs or so (not continuously)
- Ajaas GPS Tracker

Optimizing for Power

GSM

- Reduce Transmission bursts : Reduce no. of updates to server
- Switch off device/Reduce functionality when not in use

GPS

- Switch off device when not in use

GSM : SIM800L Power requirements

Note : When battery is used total impedance b/w battery and VBAT pins should be less than 150m Ohms

- Power supply : 3.4 V - 4.4 V
- Power consumption in Sleep mode = 0.7 mA (AT command to activate sleep mode → AT+CFUN=0)
- Transmitting burst current = 2 A peak [pg:21]
- Power saving modes (current consumption is at lowest) [pg:27]
 - Min. functionality mode : “AT+CFUN=<fun>”

There are three functionality modes, which could be set by AT command “AT+CFUN=<fun>”. The command provides the choice of the functionality levels <fun>=0,1,4.

- AT+CFUN=0: Minimum functionality.
- AT+CFUN=1: Full functionality (default).
- AT+CFUN=4: Flight mode (disable RF function).

Table 7: The current consumption of Minimum Functionality Mode (BS-PA-MFRMS=9)

| <fun> | Current consumption(mA) (sleep mode) |
|-------|--------------------------------------|
| 0 | 0.796 |
| 1 | 1.02 |
| 4 | 0.892 |

- Sleep mode : “AT+CSCLK=1”
- Current consumption (Vbat = 3.8V) [pg:60]

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|-------------------|-----------------|--|--------------------------------------|-----------------|---------|----------------|
| VBAT | Voltage | | 3.4 | 4.0 | 4.4 | V |
| | Power drop | PCL=5 | | | 350 | mV |
| | Voltage ripple | PCL=5 @ f<200kHz @ f>200kHz | | | 50 2 | mV mV |
| I _{VBAT} | Average current | Power down mode | 50 | 60 | uA | |
| | | Sleep mode (at+cfun=1): (BS-PA-MFRMS=9) (BS-PA-MFRMS=5) (BS-PA-MFRMS=2) | 1.02 1.11 1.88 | | | mA mA mA |
| | | Idle mode (at+cfun=1): GSM850 EGSM900 DCS1800 PCS1900 | 18.7 18.7 18.7 18.7 | | | mA |
| | | Voice call (PCL=5): GSM850 EGSM900 DCS1800 PCS1900 | 199.48 216.12 146.48 131.77 | | | mA mA |
| | | Data mode GPRS (1Rx,4Tx): GSM850 EGSM900 DCS1800 PCS1900 | 453.57 344.74 216.20 274.04 | | | mA mA |
| | | Data mode GPRS (3Rx,2Tx): GSM850 EGSM900 DCS1800 PCS1900 | 386.09 345.02 216.79 239.12 | | | mA mA |
| | | Data mode GPRS (4Rx,1Tx): GSM850 EGSM900 DCS1800 PCS1900 | 212.69 227.95 158.19 148.49 | | | mA mA |
| | | I _{MAX} | Peak current | During Tx burst | 2.0 | A |

- How to switch to other GSM modes ?

GPS : NEO-6M module Power Requirements

Ref : [Datasheet](#) [Pg:15]

| Parameter | Symbol | Module | Min | Typ | Max | Units | Condition |
|-----------------------------------|--|--------------------------|-----|--------------------------------------|-----|-------|--|
| Max. supply current ¹⁵ | I _{CCP} | All | | | 67 | mA | VCC = 3.6 V ¹⁶ / 1.95 V ¹⁷ |
| | I _{CC} Acquisition | All | | 47 ¹⁹ | | mA | |
| | I _{CC} Tracking (Max Performance mode) | NEO-6G/Q/T NEO-6M/P/V | | 40 ²⁰ 39 ²⁰ | | mA | |
| | I _{CC} Tracking (Eco mode) | NEO-6G/Q/T NEO-6M/P/V | | 38 ²⁰ 37 ²⁰ | | mA | VCC = 3.0 V ¹⁶ / 1.8 V ¹⁷ |
| | I _{CC} Tracking (Power Save mode / 1 Hz) | NEO-6G/Q NEO-6M | | 12 ²⁰ 11 ²⁰ | | mA | |
| | | | | | | mA | |

¹⁵ Use this figure to dimension maximum current capability of power supply. Measurement of this parameter with 1 Hz bandwidth.

¹⁶ NEO-6Q, NEO-6M, NEO-6P, NEO-6V, NEO-6T

¹⁷ NEO-6G

¹⁸ Use this figure to determine required battery capacity.

¹⁹ >8 SVs in view, CNo >40 dBHz, current average of 30 sec after cold start.

²⁰ With strong signals, all orbits available. For Cold Starts typical 12 min after first fix. For Hot Starts typical 15 s after first fix.

- How to switch to other GPS modes ?

- How much time does the GPS module's on-chip memory hold almanac/ephemeris data ?

Date : 09/01/2024 (Tuesday)

Main Goal for the day

- Understanding different modes and their power consumptions in GSM module

SIM800L

- Frequency bands : Quad-band - supports 850MHz, 900Hz, 1800MHz, 1900MHz. Freq. bands can be set by AT Command "AT+CBAND"
- GPRS Multi-slot classes from 1-12
 - More the class number, faster is the upload and download rates
- Coding schemes and max. Data transfer rates

| 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 |

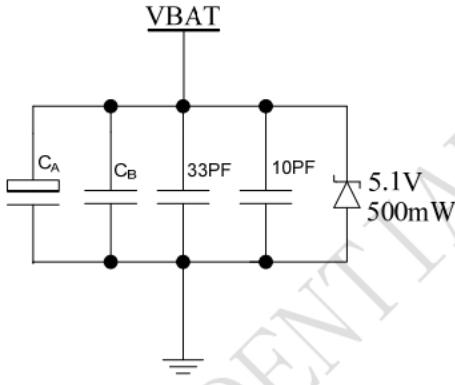
- Operating modes

| Mode | Function |
|----------------------------|---|
| Normal operation | GSM/GPRS SLEEP Module will automatically go into sleep mode if the conditions of sleep mode are enabling and there is no on air and no hardware interrupt (such as GPIO interrupt or data on serial port). In this case, the current consumption of module will reduce to the minimal level. In sleep mode, the module can still receive paging message and SMS. |
| | GSM IDLE Software is active. Module is registered to the GSM network, and the module is ready to communicate. |
| | GSM TALK Connection between two subscribers is in progress. In this case, the power consumption depends on network settings such as DTX off/on, FR/EFR/HR, hopping sequences, antenna. |
| | GPRS STANDBY Module is ready for GPRS data transfer, but no data is currently sent or received. In this case, power consumption depends on network settings and GPRS configuration. |
| | GPRS DATA There is GPRS data transfer (PPP or TCP or UDP) in progress. In this case, power consumption is related with network settings (e.g. power control level); uplink/downlink data rates and GPRS configuration (e.g. used multi-slot settings). |
| Power down | Normal power down by sending AT command "AT+CPOWD=1" or using the PWRKEY. The power management unit shuts down the power supply for the baseband part of the module, and only the power supply for the RTC is remained. Software is not active. The serial port is not accessible. Power supply (connected to VBAT) remains applied. |
| Minimum functionality mode | AT command "AT+CFUN" can be used to set the module to a minimum functionality mode without removing the power supply. In this mode, the RF part of the module will not work or the SIM card will not be accessible, or both RF part and SIM card will be closed, and the serial port is still accessible. The power consumption in this mode is lower than normal mode. |

- Power supply

- Range = 3.4 V - 4.4 V → Recommended = 4 V

- Peak current = 2 A (power supply must be able to provide this current during transmission burst) - whenever it tries to send SMS or register to a cell tower
- For VBAT input, a bypass capacitor with low ESR ("Effective Series Resistance") like a 100uF is strongly recommended.
- Additionally, we have to eliminate high frequency interference with our power supply, and hence we are using 33pF and 10pF caps. **Why this vals of caps ?** 5.1V/500mW Zener diode is to prevent the chip from damaging by voltage surge.

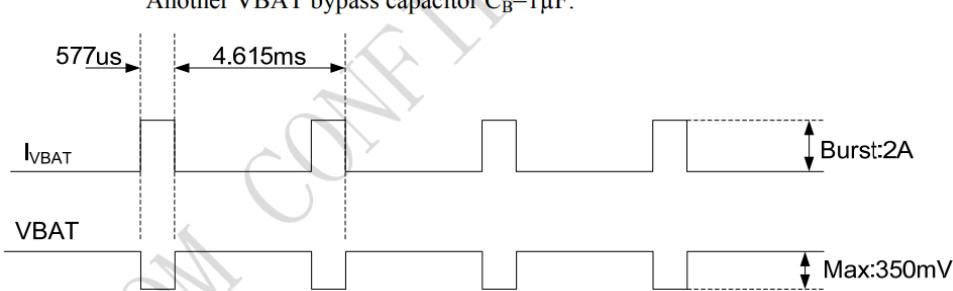


- Also as directly quoted from the datasheet, "a single 3.7 V Li-ion cell battery can be connected to the SIM800L VBAT pins directly. But the Ni-Cd or Ni-MH battery must be used carefully, since their maximum voltage can rise over the absolute maximum voltage of the module and damage it." **Could I actually reduce usage of DC-DC level converters; What about using two 3.7V batteries in series (so as to get 3.7V, 5000mAh) battery pack ?** and **Why can't we have Ni-Cd and Ni-MH batteries ?**
- When battery is used, the total impedance between battery and VBAT pins should be less than 150mΩ
- **Power story during transmission bursts**
 - VBAT voltage drop during transmission burst. **Why is this voltage drop happening ?**

VBAT=4.0V,

A VBAT bypass capacitor $C_A=100\mu F$ tantalum capacitor (ESR=0.7Ω),

Another VBAT bypass capacitor $C_B=1\mu F$.



- In Datasheet : "Ensure that the input voltage never drops below 3.0V even when current consumption rises to 2A in the transmit burst. If the power voltage drops below 3.0V, the module may be shut down automatically." "Hardware powerdown voltage is 3 V"
- In Datasheet : "The PCB traces from the VBAT pins to the power supply must be wide enough (at least 60mil) to decrease voltage drops in the transmit burst. The power IC and the bypass capacitor should be placed to the module as close as possible." **Why ?**

- Wider trace : reduces resistance, preventing significant voltage drops and ensuring stable power delivery to module
- Placing components nearby module : Minimizes len of traces, reducing parasitic inductance and resistance. This, in turn, enhances the effectiveness of the bypass capacitor in providing instantaneous current during transient loads.
- URC : Unsolicited Result Code → message that is not triggered as a response to a previous AT command and can be output at any time to inform a specific event or status change.

AT Commands

Table 1: Types of AT commands and responses

| | | |
|-------------------|--------------|---|
| Test Command | AT+<x>=? | The mobile equipment returns the list of parameters and value ranges set with the corresponding Write Command or by internal processes. |
| Read Command | AT+<x>? | This command returns the currently set value of the parameter or parameters. |
| Write Command | AT+<x>=<...> | This command sets the user-definable parameter values. |
| Execution Command | AT+<x> | The execution command reads non-variable parameters affected by internal processes in the GSM engine. |

- AT+CPOWD : Power Down module
 - AT+CPOWD=0 → Power Off urgently
 - AT+CPOWD=1 → Normal Power off
- AT+IPR=x : Set a fixed baud rate and save config to non-volatile flash memory
- AT+CSCLK=1 : Set module into Sleep mode (power-saving)
- AT+CFUN=<fun> : Set module into min functionality
 - AT+CFUN=0 → Minimum functionality
 - AT+CFUN=1 → Full functionality (default)
 - AT+CFUN=4 → Flight mode (disable RF function).

Off-doubts (with ChatGPT)

- Why do mobile signals not interfere with each other ?
 - Frequency division : Allocating specific freq. bands to users
 - Time division : Same frequency. Time is divided into slots and each user is assigned a diff. Slot
 - CDMA (Code Div Multiple Access) : Each user is given a unique code; signals are distinguished by these codes
 - Cellular architecture and Power control within cells
- Why does GPRS consume power even when it is not transmitting ?
 - Standby mode : Device consumes power to maintain its registration with the network, monitor paging channels, and be ready to resume data transmission quickly.
 - Cell Reselection and Handovers : Continuously monitor the signal strength and quality of neighboring cells, so that they can switchover to a different cell if it offers better signal conditions

- In SIM800L datasheet “The isolations of the three antenna should be bigger than 30dB”. What does this mean ?
- Also look at this “NOTE: About the RF trace layout please refer to“AN_SMT Module_RF_Reference Design_Guide”.

Li-Ion battery

- Ref : <https://evreporter.com/know-your-lithium-ion-cells/>
- The Voltage-Current Battery Capacity of a Lithium-ion battery is almost linear for a majority of its working duration in a cycle - Hence, I could use a 3.7V Li-ion battery itself for powering up the SIM800L module directly.

Date : 10/01/2024 (Wednesday)

GPS Module

Ref

- 1) Product Summary :
https://content.u-blox.com/sites/default/files/products/documents/NEO-6_ProductSummary_%28GPS.G6-HW-09003%29.pdf
- 2) Datasheet :
https://content.u-blox.com/sites/default/files/products/documents/NEO-6_DataSheet_%28GPS.G6-HW-09005%29.pdf
- 3) Hardware Integration Manual :
https://content.u-blox.com/sites/default/files/products/documents/LEA-NEO-MAX-6_HIM_%28UBX-14054794%29_1.pdf
- 4) Power Management - Application notes :
https://content.u-blox.com/sites/default/files/products/documents/u6-PowerMgt_AppNote_%28GPS.G6-X-10014%29.pdf
- 5) Receiver Description including Protocol Specification :
https://content.u-blox.com/sites/default/files/products/documents/u-blox6_ReceiverDescrProtSpec_%28GPS.G6-SW-10018%29_Public.pdf

Assisted GPS

- Assisted GPS (A-GPS) : Supply of aiding information like ephemeris, almanac, rough last position and time and satellite status and an optional time synchronization signal will reduce time to first fix significantly and improve the acquisition sensitivity.
- AssistNow Autonomous : Provides functionality similar to Assisted-GPS without the need for a host or external network connection. Based on previously broadcast satellite ephemeris data downloaded to and stored by the GPS receiver, AssistNow Autonomous automatically generates accurate satellite orbital data (“AssistNow Autonomous data”) that is usable for future GPS position fixes. AssistNow Autonomous data is reliable for up to 3 days after initial capture.

Power Management

- **Max Performance Mode :** During cold start, the receiver continuously uses an acquisition engine to search for all satellites. Once the receiver has a position fix, the acquisition engine continues to be used to search for all visible satellites that are not being tracked.
- **Eco mode :** Receiver continuously uses an acquisition engine to search for all satellites. Once position fix is done and sufficient number of satellites are being tracked, the acquisition engine is powered off resulting in significant power savings. The tracking engine continuously tracks acquired satellites and acquires other available or emerging satellites.
- **Power Save Mode :** Reduction in system power consumption by selectively switching parts of the receiver on and off.
- **Acquisition vs Tracking engines ???**
 - Acquisition engine : GPS module searches for satellite signals by scanning different frequency and code combinations. The acquisition engine identifies the satellites in view and estimates their Doppler frequencies, helping the module lock onto the signals.
 - Tracking engine : In the tracking phase, the module precisely follows the received satellite signals, adjusting for changes in Doppler frequency due to relative motion between the satellite and the GPS receiver

Power requirements

- Power supply = 2.7 V - 3.6 V
- Power consumption
 - 111 mW @ 3 V (continuous mode)
 - 33 mW @ 3 V (Power Save Mode - 1 Hz)
- Backup power (on pin V_BCKP) = 1.4 V - 3.6 V, 22uA

Why and What is this ? Used to power Real-Time Clock and backup RAM incase of power failure on Vcc. This helps GPS receiver to recover from power failure with a Hostart or Warmstart and to maintain config settings saved in backup RAM.

Can we switch off modules for sometime to reduce power consumption ? When switching from backup mode to normal operation or at start-up u-blox 6 modules must charge the internal capacitors in the core domain. In certain situations this can result in a significant current draw. For low power applications using Power Save and backup modes it is important that the power supply or low ESR capacitors at the module input can deliver this current/charge.

Table 11 lists examples of the total system supply current for a possible application.

| Parameter | Symbol | Module | Min | Typ | Max | Units | Condition |
|-----------------------------------|--|------------|------------------|-----|-----|-------|--|
| Max. supply current ¹⁵ | Iccp | All | | | 67 | mA | VCC = 3.6 V ¹⁶ / 1.95 V ¹⁷ |
| | Icc Acquisition | All | 47 ¹⁹ | | | mA | |
| | Icc Tracking (Max Performance mode) | NEO-6G/Q/T | 40 ²⁰ | | | mA | |
| | | NEO-6M/P/V | 39 ²⁰ | | | mA | |
| | Icc Tracking (Eco mode) | NEO-6G/Q/T | 38 ²⁰ | | | mA | VCC = 3.0 V ¹⁶ / 1.8 V ¹⁷ |
| | Icc Tracking (Power Save mode / 1 Hz) | NEO-6G/Q | 12 ²⁰ | | | mA | |
| | | NEO-6M | 11 ²⁰ | | | mA | |



Values in Table 11 are provided for customer information only as an example of typical power requirements. Values are characterized on samples, actual power requirements can vary depending on FW version used, external circuitry, number of SVs tracked, signal strength, type of start as well as time, duration and conditions of test.

¹⁵ Use this figure to dimension maximum current capability of power supply. Measurement of this parameter with 1 Hz bandwidth.

¹⁶ NEO-6Q, NEO-6M, NEO-6P, NEO-6V, NEO-6T

¹⁷ NEO-6G

¹⁸ Use this figure to determine required battery capacity.

¹⁹ >8 SVs in view, CNo >40 dBHz, current average of 30 sec after cold start.

²⁰ With strong signals, all orbits available. For Cold Starts typical 12 min after first fix. For Hot Starts typical 15 s after first fix.

- For low power applications using Power Save and backup modes, ensure that the power supply or low ESR capacitors at the module input can deliver the required current/charge for switching from backup mode to normal operation. In certain situations charging the internal capacitors in the core domain can result in a significant instantaneous current draw. (Ref-3)

Default settings

- Power mode : Max Performance Mode
- AssistNow Autonomous : Disabled
- Time pulse (configurable from 0.25Hz - 1 kHz) : 1Hz Nav; 1 pulse/sec synchronized at rising edge, pulse length of 100ms. What is this Timepulse ? They can't be related with baud rates since baudrates are fixed at 9600Hz or so. Maybe, if I observe connecting a GPS module to Arduino, it sends location data every 1 sec or so (because it might be configured with time pulse of 1Hz).

Placement (Ref-3 pg:39)

- Interference : Connection to the antenna must be as short as possible to avoid jamming into the very sensitive RF section
- Heat : The RF part of the receiver is very sensitive to temperature and sudden changes can have an adverse impact on performance.

Software options - modes (Ref-4 pg:6)

“Max Performance Mode” vs “Eco Mode” - Current consumptions of module

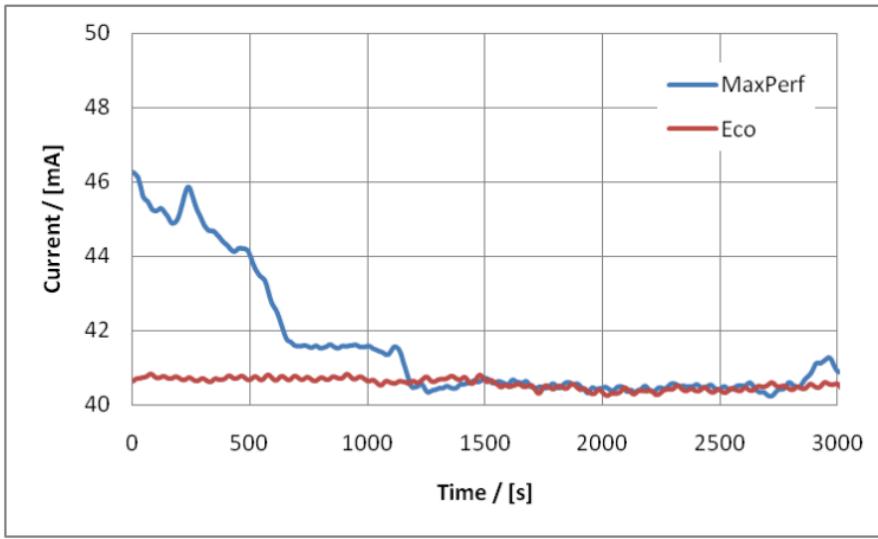
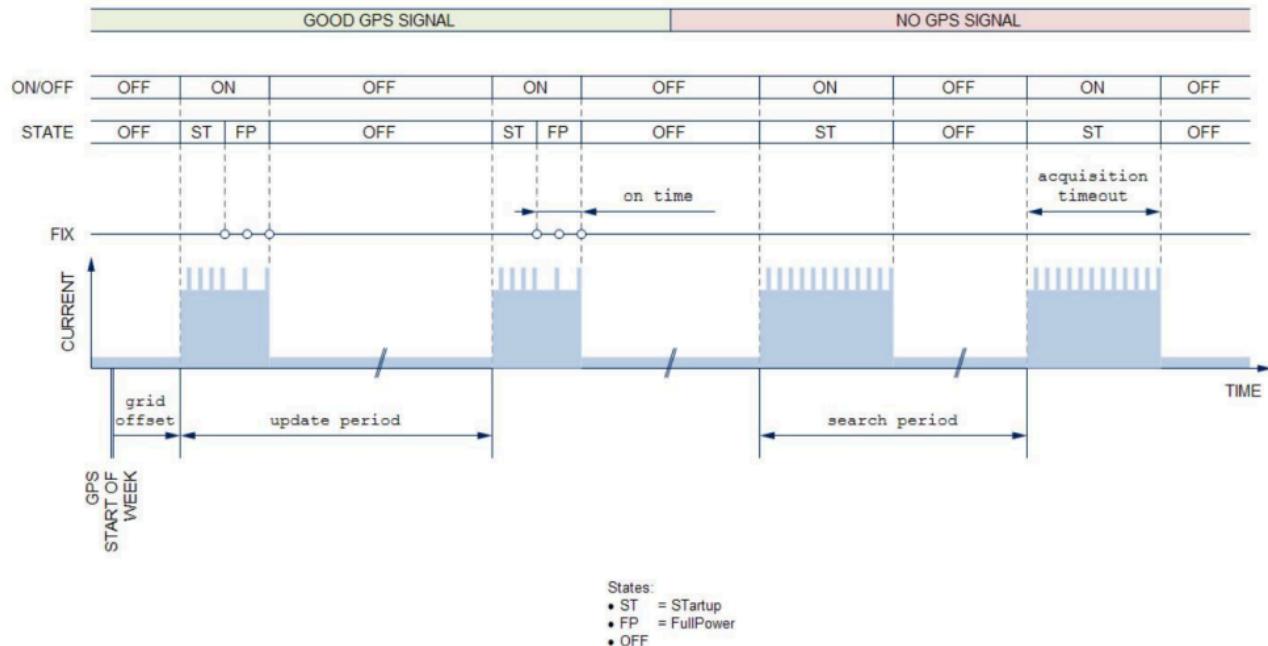


Figure 7: Current consumption during cold start with good sky visibility (acquisition: 0s...1200s, tracking: 1200s...2700s)

Power Save Mode (Ref-4 pg:8)

- **ON/OFF operation for long update periods**

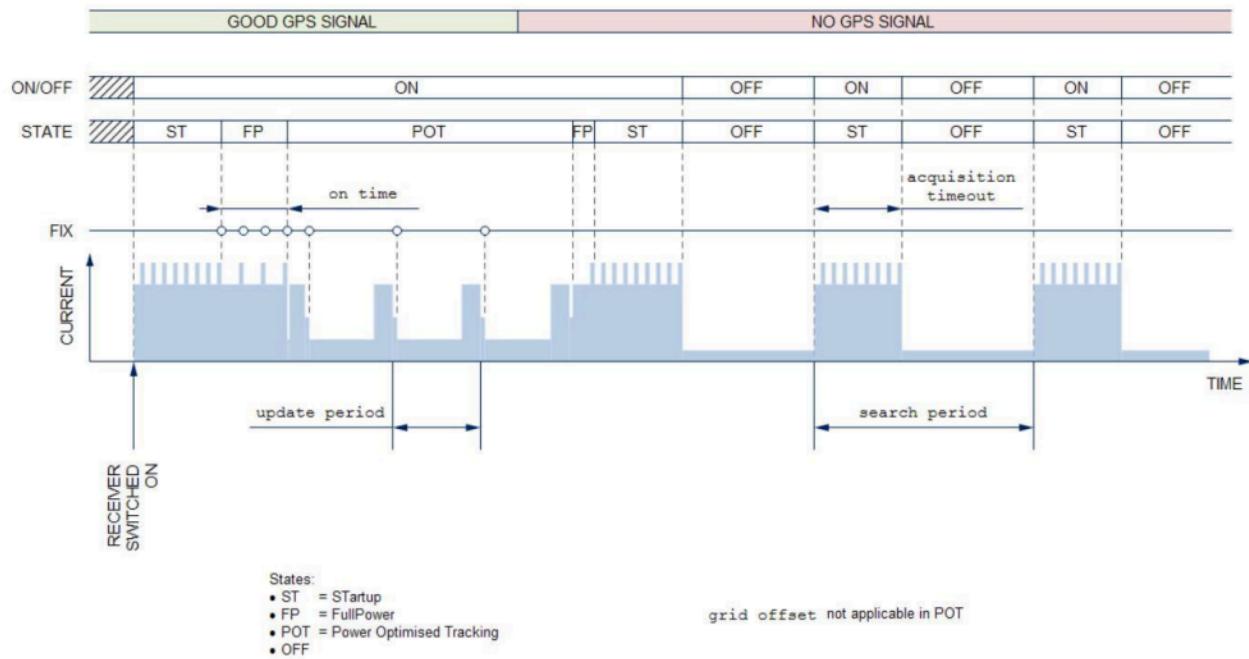
When the receiver is switched on, it enters **acquisition state** to get a position fix within a given time, which is called acquisition timeout. When there is a position fix before timeout, it switches to **tracking state**. It remains in this state until the on time is over. In this case the receiver enters the inactive for **update state**. Once the update period is over the sequence starts again. If signal is lost, while in tracking state, the receiver enters acquisition state. If there are no position fixes before acquisition timeout, the receiver switches to inactive for search state. This sequence will repeat according to the search period until the receiver again gets a position fix.



- **Cyclic tracking operation for short update periods**

When the receiver is switched on, it enters **acquisition state**. If it gets a position fix before acquisition timeout, the receiver enters **tracking state** until on time is over. Now the receiver enters the **power optimized tracking state**, which is designed to reduce power consumption while continuously calculating position fixes. The receiver stays in power optimized tracking state as long as the GPS signal is

strong enough. If it is not, the receiver returns to tracking state or even to acquisition state. If the receiver has lost the position fix or cannot get a position fix before acquisition timeout, it will behave like in ON/OFF operation with no GPS signal.



Considerations for low-power designs (Ref-4 pg:10)

- Supply voltage

Good performance requires a clean and stable power supply with minimal ripple.

- Wide power lines or even power planes are preferred.
- Place LDO near the module.
- Avoid resistive components in the power line (e.g. narrow power lines, coils, resistors, etc.) → Placing a filter/resistance at Vcc may result in significantly longer acquisition times
- Recommendation : For low power applications, 1.8V solutions are best as current will remain lower than in 3 V solutions.

- Configuring Power Save Mode

- Note : Poor signal conditions can degrade the performance of PSM and lead to power consumption (comparable to Max Performance mode with worse GPS performance)

Configuring Power Save Mode in NEO-6M

- Put a GPS NEO-6M in Power Save Mode :

<https://forum.arduino.cc/t/put-a-gps-neo-6m-in-power-save-mode/858488/8>

- GPS module Power management : Used

<https://forum.arduino.cc/t/gps-module-power-management/477859/38>

- Disable GPS Module to reduce energy consumption :

<https://forum.arduino.cc/t/disable-gps-module-to-reduce-energy-consumption/486868>

NeoGPS (Arduino Library)

Doubts to clear

- Power consumption ?
 - Diff modes ?
 - Time-To-First-Fix ?
 - Hot/Warm/Cold starts and time taken ?
 - How long can a GPS module switch off to be able to do a hot-start quickly ?
-

Date : 11/01/2024 (Thursday)

Connecting UBLOX-GPS with U-center

Ref : <https://bigdanzblog.wordpress.com/2015/01/15/connecting-u-blox-neo-6m-gps-to-arduino/>

- I tried with GPS-Arduino-Ucenter(computer) → Working fine, as I could see NMEA commands. But I was unable to read firmware versions and do configurations on the GPS module → So, we need to try the same using a USB-SerialTTL connector cable. **What actually happens and why can't I directly connect some jumpers to the wires from the USB ?**

Microcontroller

- How to choose one for our project ? (Req : 2 UARTs, Low-power consumption)
 - How are SMD microcontrollers programmed ?
-

Date : 12/01/2024 (Friday)

Microcontrollers Terms

- Memory
 - Program memory (Flash/ROM) : Stores firmware/program code; Non-volatile
 - Data memory (RAM) : Stores temporary data during program execution; Volatile
- Clock speed : Rate at which a microcontroller's CPU operates, measured in Hertz (Hz) or MHz. Higher clock speeds means faster processing
- Clock source : External oscillator or internal circuit that provides the clock signal, determining the operating speed of a microcontroller
- Compiler : Software tool for translating high-level programming languages into machine code/assembly language for a specific microcontroller architecture
- Firmware
 - Any program that resides in a microcontroller based system, usually stored in flash memory.
 - It tells the microcontroller what to do
 - It is loaded using a Dedicated programming device
- Bootloader

- Small program that facilitates the programming of flash memory
- Allows the firmware to be loaded into the micro without the use of a dedicated programming device
- It loads a larger program from a peripheral device and then executes it.
- Bootloader is loaded only once, but the Firmware can be loaded over and over again as the needs change.
- Devices like Arduino have a bootloader so that you can easily program them via a USB cable instead of having to buy a Dedicated programming device

- How to know the memory requirements for a code/project ?
- How to select the right microcontroller ?
- If we are using libraries in Arduino, how is memory occupancy post compilation and uploading to microcontroller ?
- How are program stored in memory in physical form ?
- What are the main components in a microcontroller ?
- Let's take some datasheets of microcontrollers and microcontroller development boards and look into them

Microcontroller Requirements

| | | |
|-------------------------------------|--|--|
| | | |
| Functionality | Define tasks that your project needs to perform | Using 2 Arduino libraries; TinyGPS+ and TinyGSM. |
| Memory requirements | Estimation of Program memory (Flash/ROM) and Data memory (RAM) | |
| Power consumption/efficiency | As low as possible | |
| I/O requirements | GPIO pins, Analog pins and Communication interfaces used | 2 UART interfaces |
| Cost | As low as possible | |

Software vs Hardware UARTs

Date : 13/01/2024 (Saturday)

Which microcontroller is best for you ?

Ref : <https://www.youtube.com/watch?v=wXtIVnwHUmE>

1. PIC (MicroChip)

- Direct access to registers via their address (Clearly defined in their datasheets)
- Lots of Peripherals - removes CPU from doing bit-banging
- Low-cost : Good for production line products

2. AVR

Advantages

- Support Arduino IDE, through a bootloader that you can load onto them
- Makes coding more simpler because of the amount of software support (Arduino libraries, etc)

3. STM

STM8

- Smaller and efficient
- No DIP packages

STM32

- Arduino support

4. RP2040

- Uses ARM core and 32-bit
- No internal program memory; Loads it program memory from an external flash chip internally to itself in its static RAM and then runs from there
- When connected to a computer, it appears as a flash drive

Microcontroller Showdown: Which one wins for your project ?

- Pick one that gives you more room to grow (meaning if you need 8 GPIO pins, take one with 10 GPIO pins → will be useful if you want to add a button down the line)
- Don't select a microcontroller with more performance/features than you need (Suppose for a simple temperature monitoring system, you don't need to use a 32-bit microcontroller running at 100MHz → unnecessary cost/design complexities)
- Flash Memory
- SRAM
- EEPROM
- Internal RC oscillator
- External crystal
- Speed is not just dependent on clock speed, but also Data width of processor and hardware accelerations

Categories based on width of data buses

- 8 bit : Less demands on processing speeds; Limited data processing; Limited user interface
 - Flash memory : 512 B - 256 KB
 - SRAM : 32 B - 8 KB

- EEPROM : 0 - 4 KB
 - Popular lines
 - 8051 series (Intel)
 - PIC series (Microchip)
 - AVR series (Microchip)
 - 16 bit
 - 32 bit
-

ESP32

Making Commercial products with ESP32

Ref : <https://www.youtube.com/watch?v=2vHB8AUQKWM>

- ESP32 Development boards
- SMD modules that can be mounted on main PCB

ESP8266

Soldering SMD ESP8266 module on NodeMCU : <https://www.youtube.com/watch?v=cbUHIXOZiIM>

3 layers : Microchip → Module → Development boards

1) Microchip

- Uses a Tensilica L106 **32-bit RISC** processor
- Runs on 3.3 V
- 17 GPIO pins
- Comm Interfaces : UART, SPI bus, Software I2C
- PWM, I2S with 1 DMA, 1 ADC
- Wifi : 2.4 GHz
- Flash memory : External (doesn't have built-in storage); Connects over SPI with 6 IO pins; i/2 MB to 4 MBs and more
- For the ADC pin, you can provide only a voltage b/w 0-1 V. Hence, an external voltage regulator circuit must be added for using it.

2) Modules

- Added a Flash memory along with ESP8266 chip; Some also includes Antenna (some doesn't)
- Models : ESP-01 to ESP-14 → ESP-01 and ESP-12 are most popular
- Code is loaded using a Serial port : So we need an external USB - Serial TTL converter

3) Development boards

Wemos D1 Mini

- USB to Serial programmer
- 3.3V regulator

- Voltage divider for ADC
- LEDs, Buttons, RESET
- Breadboard friendly

Programming ESP-12 modules : https://www.youtube.com/watch?v=_iX67plFeLs

- If your programmer has CH340G chip, you may have to install windows driver for it

ESP-12F

How to turn off Wifi circuitry in ESP-12F ?

Power Consumption in diff. Modes

- Modem sleep

Best power saving mode - Much Deeper Deep Sleep ESP8266

Ref : https://www.youtube.com/watch?v=n_A_8Y4xNx8

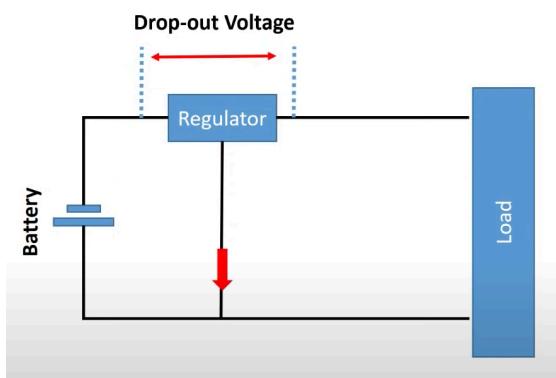
- Deep sleep : Consumes around 20 uA (which in itself is awesome)
- Normally, Clock enable is pulled high with a pullup resistor of 10K and this is added outside the module. But most times this pullup is implemented inside the module itself (check it by placing multimeter probes across the Clock enable and Vcc) and hence not required to be placed externally. When you remove this, you find that power consumption now drops to 3uA

Date : 16/01/2024 (Tuesday)

#58 ESP8266 Sensor runs 17 days on a coin cell/transmits data (deep-sleep)

Ref : <https://www.youtube.com/watch?v=lYuYTfO6iOs>, <https://www.esp8266.com/viewtopic.php?p=41638>

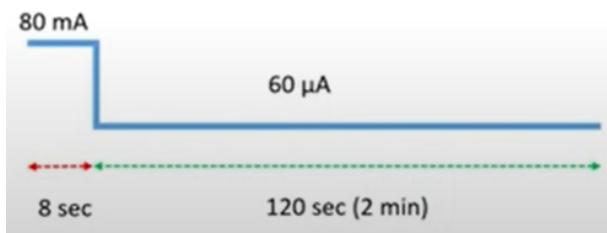
- aFrom datasheet : ESP8266 needs 3- 3.6 V with avg current = 80 mA
- Selection of Voltage regulator : He chose HT7333 instead of LM1117 and L78L33C. Why ?



- Dropout voltage : minimum voltage difference/drop between the input and output of a voltage regulator required for the regulator to maintain a stable and specified output voltage
- Quiescent current : Small current req for the stabilization of LDO even when no load is connected across it

| LDO | Dropout Voltage | Quiescent current |
|---------|-----------------|-------------------|
| LM1117 | 1.2 V | 5 mA |
| L78L33C | 1.7 V | 6 mA |
| HT7333 | 150 mV | 4 uA |

- ESP8266 takes in around peak current of 350 mA → Leads to voltage drop due to current spikes → So, place a Tantalum cap across supply pins of ESP8266 module
- Project : ESP module senses the Vcc (using inbuilt ADC), uploads it to 2 IOT DBs (First 8 secs) and Deep-sleeps (for next 2 mins - 120 secs)
 - ESP module consumes ~80mA in normal mode and ~20 uA in DeepSleep mode
 - LDO consumes around ~40-50 uA



$$= 80 \text{ mA} \times 8 \text{ secs} = 640 \text{ mA sec}$$

$$= 60 \mu\text{A} \times 120 \text{ secs} = 7.2 \text{ mA sec}$$

$$\text{One cycle} = 640 + 7.2 \text{ mA sec} = 647.2 \text{ mA sec}$$

- Took current readings of NodeMCU using a Multimeter → The values seem higher because we are not using ESP-12F module directly, but instead using NodeMCU (which has voltage regulators, USB-UART, etc) and hence more current is consumed.
 - Without any code execution = 82.7 mA (Why?)
 - Blink example = 26 mA
 - LED On always = 84.4 mA
 - Deep Sleep = 10 mA

Power consumption of ESP-12F module

- Datasheet (ESP-12F) :
 - https://docs.ai-thinker.com/_media/esp8266/docs/esp-12f_product_specification_en.pdf
- Power supply = 3.3 V
- See documentation (ESP-12F) :
 - https://docs.google.com/document/d/1wUoiSMeibSNl0F_NMlV0ddZ1Dg242i610YBaoCVExxE/edit?usp=s_haring

Electrostatic Sensitive Devices

- Why are some devices electrostatic sensitive, what happens and how to handle them ?
- How to package them to protect them from damage ?
- Why is ESP-12F electrostatic sensitive ?
 - Contains various ICs that are susceptible to ESD
 - Small form factor → Limited space for protective measures against ESD
 - Module has exposed pins and components that can come into contact with external surfaces or be handled during installation or maintenance

Building prototype with ESP-12F

Reading more on **ESP-12F** (Check out **ESP-12F Master Docs**)

Date : 19/01/2024 (Friday)

Programming esp8266 using NodeMCU (Check **ESP-12F Master docs**)

- Ref : <https://circuitjournal.com/esp8266-with-arduino-ide>
- Why do we use resistors when we pull pins low or high ?

Common scenarios,

- Pull-Up Resistors: When a pin is configured as a pull-up, the resistor pulls the pin HIGH by default. This is commonly used with buttons or switches. When the button is not pressed, the resistor pulls the pin HIGH, and when the button is pressed, it connects the pin to GND, pulling it LOW.
- Pull-Down Resistors: When a pin is configured as a pull-down, the resistor pulls the pin LOW by default. This is also used in similar scenarios where you want a known state when no external influence is present.

Bare minimum needed on an ESP-12F chip after programming

Problem

- I am unable to use Hardware UART pins for SoftwareSerial → Not able to configure them as Software UART pins

SoftwareSerial (**Software-based implementation of Serial communication on normal GPIO pins**) limitations

- Baud Rate limitations : High baud rates can lead to timing issues and data errors
- Blocking : Communication is blocking in Software serial; Program has to wait for entire byte to be transmitted or received before proceeding to next operation
- Pin options : Not all GPIO pins are suitable for SoftwareSerial, and certain pin combinations might have better performance than others.
- Timing sensitivity : Relies on Software interrupts and busy-wait loops for timing, which can be sensitive to other tasks running in the background
- Resource consumption : Consumes more CPU cycles compared to Hardware serial
- No Full-Duplex support

Creating circuit and schematic in EasyEDA

- Diff. b/w Net labels and Net Ports

Ref : <https://www.eevblog.com/forum/altium/netlabels-vs-ports/>

"Net labels are useful for power nets when you want a schematic to maintain some sort of signal flow (easy to follow) and then just place power net labels where and when you need to supply a part of the circuit or a device. Makes for a much tidier and easier to follow schematic." - from forum above

Do we really need a boost converter for connecting b/w Li-ion and GSM module ?

- Ref : Read first comment and its replies →

<https://electronics.stackexchange.com/questions/31083/how-to-power-a-gsm-modem-from-a-li-po-battery>

Date : 20/01/2024 (Saturday)

- TP4056 Li-ion charging module → Ref Power Supply - Master Docs

Date : 22/01/2024 (Monday)

Ref : Power Supply - Master Docs

- Li-ion battery charging procedure
- TP4056 Li-ion charging module - going through each component

Ref : PCB Design - Master Docs

- Creating PCB designs with ESP8266 modules (ESP-12F)

Date : 23/01/2024 (Tuesday)

Ref : PCB Design - Master Docs

- Created the PCB DEsign according to the guidelines learnt
- Added ground plane using Copper area tool in EasyEDA
- EasyEDA Schematic/PCB link :

<https://easyeda.com/editor?id=a5a491d4b6504714b39bb4b1d720c66d1766969999e44f629f7df83047eb0c28>

Date : 24/01/2024 (Wednesday)

Ref : **Code - Master Docs**

- Understanding existing code

Getting garbage values when connected to ESP-12F's GPIO 0 and 2 pins

GPIO 0 and 2 pins are used during the boot process and must be pulled LOW/HIGH depending on the modes needed. Using UART on these pins means that we have to be very careful about their states (LOW/HIGH) during power-up or reset.

How to select baud rates for a specific application ?

- Ensures efficient and error-free data transmission
- Rate at which info is transferred in a communication channel
- Device compatibility : Both devices in comm. channel must support the chosen baud rate.
- Req. data rate : If application needs to transfer large amounts of data quickly, high baud rate is preferred. For applications with less frequent or smaller data packets, a lower baud rate may be sufficient.
- Dist. of communication : Longer the distance, lower the baud rate must be
- Noise/Interference : High baud rates are more susceptible to errors in noisy environments/ environments with high EMI.

Date : 25/01/2024 (Thursday)

Tasks to do

- Code
 - Complete the code according to (Add Idea) updates in "GPS Tracker Code - Master Docs"
 - Get the time duration b/w each code block execution by inserting millis() and putting time on Serial monitor
 - Restarting modem
 - Connecting HTTP client with DB
 - Typical Response time from server (timeout is currently 10 secs, see if we could change it. Reducing it would mean that we could make more requests in same time)
- PCB
 - Redesign PCB on EasyEDA and change the pinouts to support new code
 - Create PCB without Li-ion battery mount
 - Submit it to Abhijeet sir - DI Lab
- Order
 - TP4056 charger module
 - 3.3V regulators (atleast something for PCB prototype now)
 - Caps and resistors
 - Lithium battery and battery holder

Work

- Why are pointers needed ? Concept of referencing-dereferencing → Check Code- docs
- Add code for enabling sleep on ESP-12F → If modem is restart

Issue : We get “-3” status code in HTTP response

Indicates a problem with GSM module’s communication or network connection. Let’s see how to resolve...

- Check SIM card and network signal : Ensure SIM card is inserted properly and verify that the area has good network signal strength
- Ensure **proper power supply** during transmission
- Ensure that your NodeMCU board has **enough available memory and resources** to handle the GSM communication and HTTP requests. Avoid excessive memory usage or resource-intensive operations in your code.

When should we do modem.restart() ? → Initialize the modem

- We will check at the setup() stage whether the SIM800L is connected to the network or not. If not, we will restart.
- Also, maybe we could restart if we find that we are getting response status as “-3”.

Using DeepSleep modes in our project

- If we have successfully updated location data on DB (if we get positive response status from DB), we will put ESP12F to sleep for some duration based on current vehicle speed
- If not, we wi

PCB Design

- We will create a PCB design that supports the sleep of ESP-12F (connector that connects GPIO16 and RST pins) → Why ? Because we can’t create a trace directly as during programming of ESP-12F, uploading of code gets affected as we have connected GPIO16 and RST. We should disconnect the connector during code upload.

Date : 26/01/2024 (Friday)

GSM (Global System for Mobile communications)

Connecting to network

- Establishing connection b/w device and mobile network. Fundamental step before any specific data communication protocols can be used
- Involves registration of device with cellular network, obtaining necessary network parameters and being assigned an unique identifier with the network

Connecting with GPRS (General Packet Radio Service)

- GPRS is a packet-switched mobile data service available on GSM networks.
- After connecting to the network, the device can establish a GPRS connection to send/receive data over cellular networks.

Logic for setting ESP-12F sleep duration in deep-sleep

1) Based on vehicle speed from GPS

Idea

- Based on vehicle speed, change the frequency of location updates
- However, if vehicle is at rest or speed is below a cutoff speed, have a default frequency → Make a lower and upper boundary within which frequency of updates is set based on vehicle speed

Implementation

- Getting vehicle speed ("v" knots)
 - GPRMC (7th term) : Speed in knots → Convert to m/s
 - 1 knot = 0.51444 m/s → Speed(m/s) = v * 0.51444
- Determining Sleep duration (Logic) : Let us assume that we want to track vehicle every 200 ms. So, we will multiply a weighted factor with current speed, so that we will track the next vehicle location when it reaches 200 metres by calculating with the current speed.
- Put board to deepsleep for that duration

2) Based on vehicle speed and its current location

Idea

- Same logic as above + closer the vehicle gets to a stop, the more faster the updates will be

Note

- In any of these ideas, if the GSM module is not successful in pushing the location data to DB, don't let the ESP-12F go into sleep. Raise a fresh HTTP request again.
- If GPS module didn't get fix yet, don't do the update. Wait till you get the GPS fix and straightway start raising HTTP Put requests again for sending location data to DB.

Understand the nitty-gritties in sending HTTP requests through GPRS network

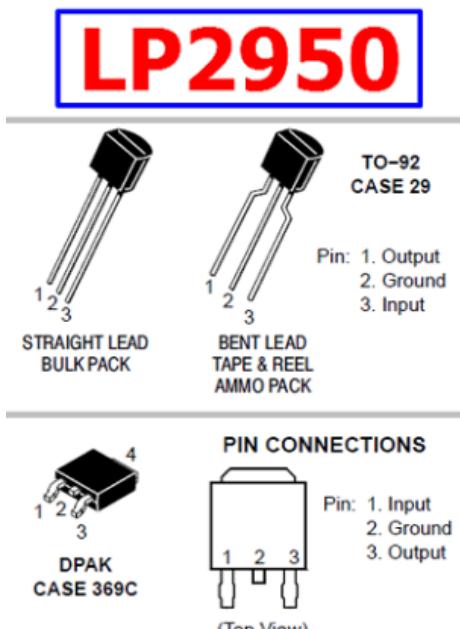
- How much time does each part of code take ? Restarting modem, Establishing GPRS, Connecting with server, Raising HTTP request, Waiting for Response, etc.
- How can I cut-off time in each of these parts ? Need to balance between power consumption and tracking efficiency → Because if I switch off and start GPS/GSM module each time, it takes too much time to get working; On other hand, if I keep all modules always ON, they consume too much power.

Date : 28/01/2024 (Sunday)

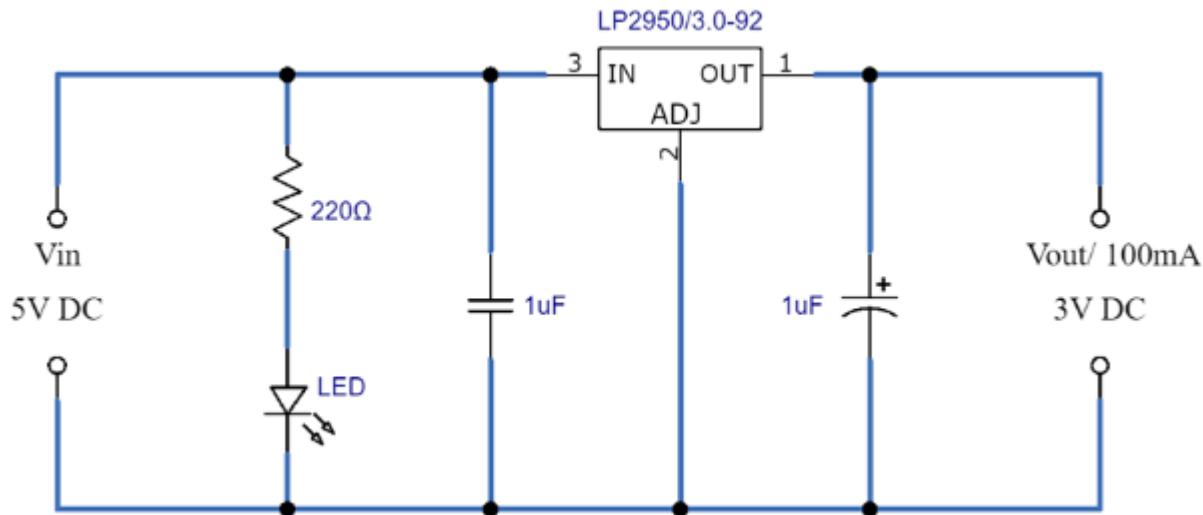
3.3 V Voltage regulation

- using LM2950G voltage regulator
- Specifications
 - Dropout voltage
 - Max 450 mV at 100 mA
 - Typ 380 mV at 100 mA

- Datasheet : [http://www.htckorea.co.kr/Datasheet/LDOLM2950G.pdf](http://www.htckorea.co.kr/Datasheet/LDO/LM2950G.pdf)
- Ref : <https://www.circuits-diy.com/lp2950-adjustable-micropower-voltage-regulator-circuit-2/>
- Pinout diagram



- Application



- Updated the entire setup on prototype
- Issue : Getting 1.37 V at output of voltage regulator. But this works fine on breadboard. How ?

Date : 29/01/2024 (Monday)

Issue : Both yesterday and today I tried using 2 different pieces of LM2950 for obtaining 3.3V regulated output. The model worked well on a breadboard, but when I connected it with the circuit prototype, it was only giving an output of 1.85 V. The reason might be;

- Voltage regulator got destroyed in the circuit

Electrical characteristics of LM2950

| Parameters | Condition | Min. | Typ. | Max. | Unit |
|--|--|-----------|------|-----------|--------|
| Output Voltage | T _J =25°C | 0.990 VO | VO | 1.010 VO | V |
| | -25°C ≤ T _J ≤ 85°C | 0.985 VO | | 1.015 VO | V |
| | Full Operating Temperature | 0.980 VO | | 1.020 VO | V |
| Output Voltage | 100uA ≤ I _{OUT} ≤ 100mA, T _J ≤ T _{JMAX} | 0.976 VO | VO | 1.024 VO | V |
| Output Voltage Temperature Coefficient | (Note 1) | | 50 | 150 | ppm/°C |
| Line Regulation | (V _{OUT} +1V) ≤ V _{IN} ≤ 30V | | 0.04 | 0.2 | % |
| Load Regulation (Note 2) | 100uA ≤ I _{OUT} ≤ 100mA | | 0.1 | 0.3 | % |
| Dropout Voltage (Note 3) | I _{OUT} =100uA | | 50 | 80 | mV |
| | I _{OUT} =100mA | | 380 | 450 | mV |
| Ground Current | I _{OUT} =100uA | | 75 | 120 | µA |
| | I _{OUT} =100mA | | 3 | 12 | mA |
| Dropout Ground Current | V _{IN} =V _{OUT} -0.5V, I _{OUT} =100uA | | 110 | 170 | µA |
| Current Limit | V _{OUT} =0V | | 160 | | mA |
| Thermal Regulation | | | 0.05 | 0.2 | %/W |
| Output Noise, (10Hz to 100KHz) | C _{OUT} =1uF | | 430 | | µVrms |
| | C _{OUT} =200uF | | 160 | | |
| Over Temperature Protection | | | 165 | | °C |

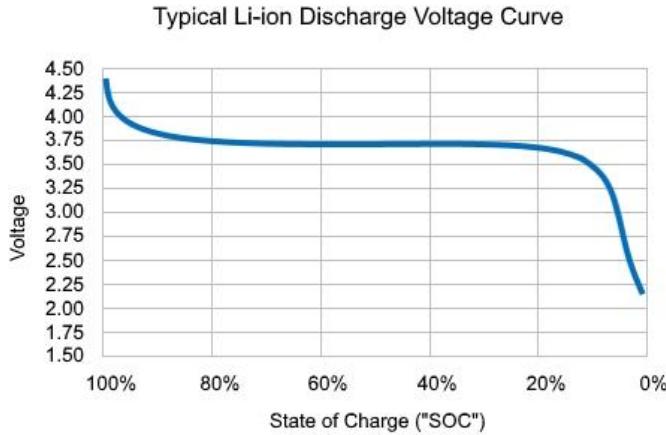
Using diode to lower voltage supply to power ESP12F, NEO-6M GPS

Ref :

<https://www.eevblog.com/forum/beginners/almost-too-afraid-to-ask-why-not-use-a-diode-to-lower-voltage-supply/>

- Output voltage follows the battery voltage. However, circuit's power requirements matter.
- The point of regulation is, when you have a load that can't handle a wide range of supply voltage, but your source spans a wider range than that. Say you have an MCU that needs 2.5-3.6V. But a battery that does 3.3-4.2V or something. Well, in this case, it might be adequate to simply drop the 0.6V or so.
- Just be aware that the voltage drop over diode is not a constant; it's a logarithm of current. If the load current varies over many orders of magnitude, drop over the diode is far from constant. So if you add a

diode to prevent parts from failing because of overvoltage, then if the load goes into very low consumption, the drop over the diode can be just like 0.2V even if it's 0.7V during active period.



Based on the Li-ion battery discharge profile, our battery will have an output of 3.5V to 4.2V. So if we are using a diode with a smaller voltage drop (say 0.6V), we could provide a voltage of 2.9V to 3.6V to ESP-12F and GPS module. We have to verify whether these work in those voltage levels.

Working voltages

- ESP-12F : 2.7V to 3.6V (Typ 3.3V)
- NEO-6M GPS module : till 3.6V

So, this approach would work.

But how efficient or how damaging this power setup is to the modules over period of time (because generally these work at typical voltage level of 3.3V) ?

Date : 30/01/2024 (Tuesday)

Things to learn

- Norton-Thevenin equivalent circuits
- Current limiting
- Isolation in circuits

Issue : When I placed a 3.3V voltage regulator across the power supply to provide a regulated voltage of 3.3V to ESP12F and GPS module, the voltage regulators got damaged.

- Issue is rectified by placing large capacitors to reduce the effect of current surges

Date : 31/01/2024 (Wednesday)

- ESP12F board doing auto restart. Problem might be due to power supply issues.
Ref : <https://stackoverflow.com/questions/31083757/esp8266-constantly-restarting>

- Got PCB from DI lab. Abhijeet sir gave me the design with only 1 side (Top). The bottom side with Ground plane was not done → So, I scratched away all the copper around the component solder holes, so that short circuits won't happen.
-

Date : 01/02/2024 (Thursday)

Prototyping

PCB design

- I wanted to have SMD on one side and through hole components on other side. But now I am stuck with the problem of wrong pcb design leading to both placing of components on one side.

Short-circuits and Magic smoke

- Battery started smoking and negative terminal of battery holder containing a spring melted away making battery holder un-useable.
- Issue was that I soldered VCC of GSM to GND (back again to PCB Design Issue)

Learning

- **Voltage Regulator Protection**
- Remember, the problem of protecting voltage regulator occurs due to the peak currents of 2A required by GSM. Atleast, I think so. It would be better if I approximate those currents with some loads and continue working on it. How to go on with it ?
 - Install a circuit simulation software and check how transient currents/voltages work and affect the other components
 - Use oscilloscope and check currents and voltages at different points
- I made the pcb circuit with 200uF Caps on input and output of Voltage regulator. Its giving 2.45 V as regulated output instead of 3.3V. **Why ? Does capacitances influence ???**
- Circuit seems to be working fine;
 - GSM blinking every 3 secs
 - I think when GPS turns off after scanning for satellites, ESP12F gets enough power and gets turned on → So, maybe I could either give power to ESP12F or GPS at a particular time

Date : 02/02/2024 (Friday)

- **Serial.write() vs Serial.print()**

<https://arduino.stackexchange.com/questions/10088/what-is-the-difference-between-serial-write-and-serial-print-and-when-are-they>

Understand AT commands more properly

Ref : SIM800L Master Docs

- Is it better to configure SIM800L module to operate exclusively in class “CG” mode (GPRS only) ?
-

Date : 03/02/2024 (Saturday)

- I played around with AT commands yesterday. This might have changed some configurations in SIM800L module.
- The point of this “Daily Logs” is not just to capture our learnings, but also our experimentations so that it will be more easier for us to proceed/debug further. Remember !!!*
- I have changed the configurations most probably. I bought new SIM800L modules and connected them up on the board. They worked fine. So, it is always better to keep track of changes done (even those done on serial monitor of IDE)
-

Date : 05/02/2024 (Monday)

- At present, the current PCB design works fine with both GSM and GPS modules. But I am not sure whether it works together properly. Need to verify it first.
 - I have to understand AT commands and GSM modules more properly. Especially how to make a HTTP request to DB and stuff like that without TinyGSM.
-

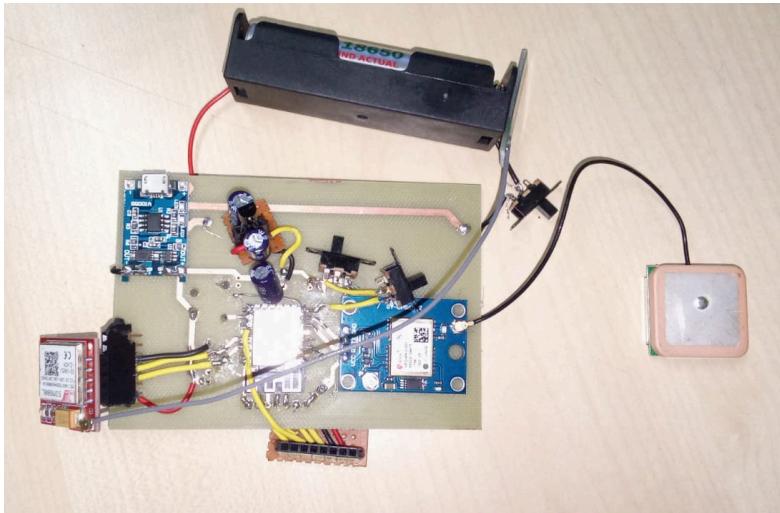
Date : 06/02/2024 (Tuesday)

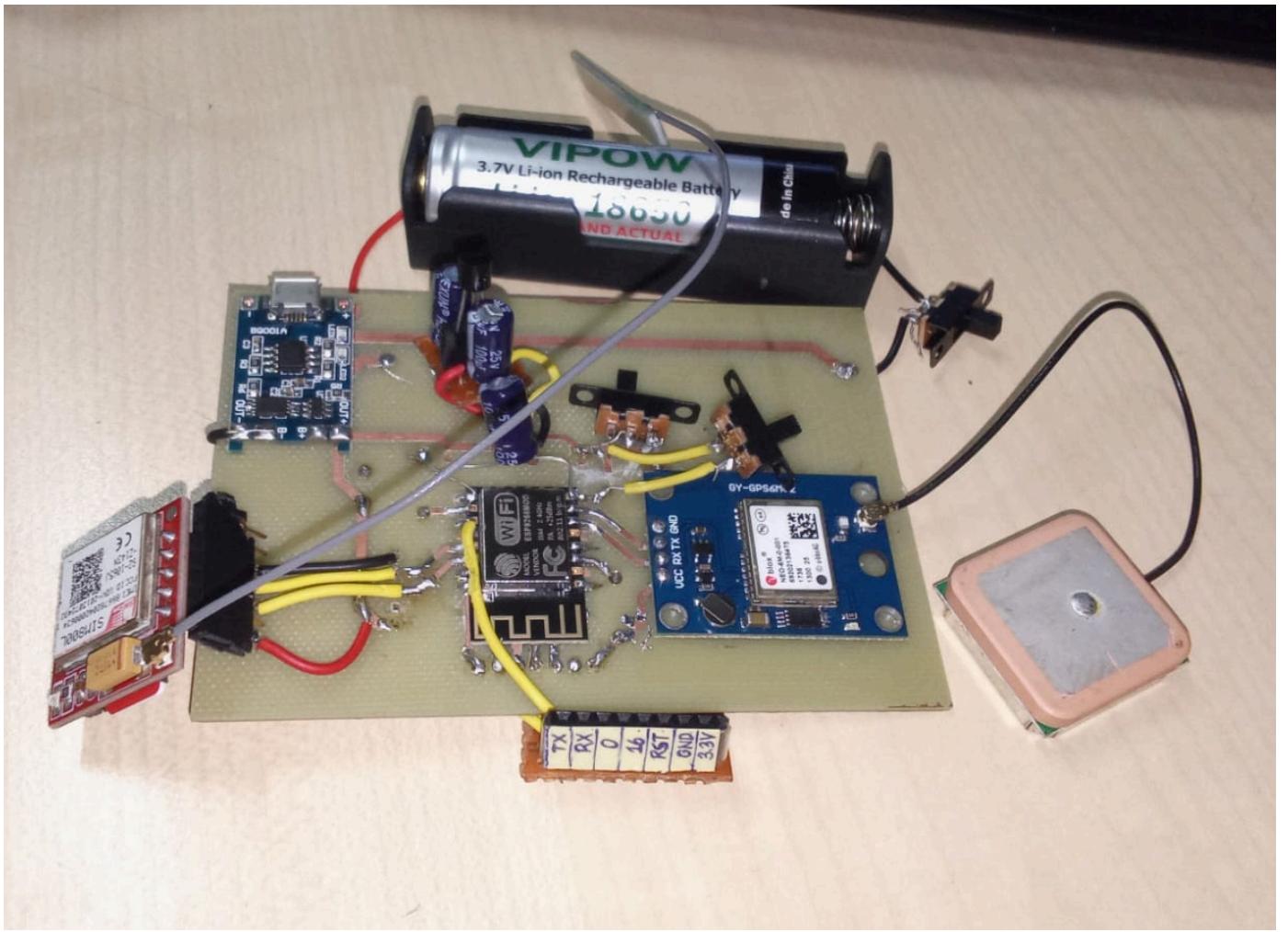
- I am getting stuck with the same problem for quite a long time now. Maybe, I could structure the GPS tracker’s process flow as follows;
 - Step 1 : Switch ON GPS
 - Step 2 : Wait till we get GPS location fix
 - Step 2 : Get the GPS coordinates
 - Step 3 : If GPRS is disabled, Switch ON GSM and start GPRS service.
 - Step 4 : Initialize HTTP service, Connect with DB and push location data
 - If GPRS is connected, then switch ON GPS and get location data again. Do Step 4.
- Disabling GPS module
 - <https://forum.arduino.cc/t/disable-gps-module-to-reduce-energy-consumption/486868>
 - <https://forum.arduino.cc/t/gps-module-power-management/477859/23>

- ESP12F power issue
 - <https://www.esp8266.com/viewtopic.php?f=160&t=16168&start=20>
 - <https://stackoverflow.com/questions/31083757/esp8266-constantly-restarting>
 - Suggested to add Capacitors b/w Vcc and GND

Experimentation - 1

Place 2 switches; One switch b/w GPS and 3.3V regulated output; Other switch b/w ESP12F and 3.3V regulated output. Calculate voltages in different scenarios - check whether all modules are receiving proper voltages as expected.





- **Observations** (Independent of whether GSM module is connected to Power supply or not)... GSM was not influencing atleast based on observations

| Power to GPS only | Power to ESP12F only | Power to both GPS + ESP12F |
|-------------------|----------------------|----------------------------|
| 3.3 V | 3.3 V | 2.45 V |

- **Possible reasons**

- **Voltage drop across regulator** : If input voltage to regulator is close to this dropout voltage and load increases, the output voltage may decrease due to inability of regulator to maintain desired voltage level
- **Limited output current capability** : As load increases, regulator may struggle to provide sufficient current, resulting in voltage drop
- **Voltage drops** due to resistance in connecting wires
- **Inaccurate Voltage Reference** used by regulator

- **Personal notes :**

- I feel that the issue arises mostly because of the first and second reasons. Input voltage is around 3.8V and we need output of around 3.3V (around 500mV reduction). Dropout voltage of LM2950G

voltage regulator is around 450 mV (very close to 500 mV). Also, this would affect the operating range of my device. So, let's look at switching regulators.

- Output current capability of LM2950 is 160mA which is quite decent for our purpose, since ESP12F takes about 20-25 mA (without WiFi) and GPS takes around 67 mA max, totalling less than 100mA.

Experimentation - 2.1

Try adding a 3.3V buck converter and check whether it performs any better than the LDO being used currently.

- **Observations** (Independent of whether GSM module is connected to Power supply or not)... GSM was not influencing atleast based on observations

| Power to GPS only | Power to ESP12F only | Power to both GPS + ESP12F |
|-------------------|----------------------|----------------------------|
| 3.1 V | 3.3 V | 3.1 V |

So, the output was getting determined due to the Voltage drop of GPS. But why ??? Shouldn't the voltage regulator be giving the same regulated output of 3.3V under various circumstances. Also, the upper limit of regulated voltage is set to 3.3V. I can't increase any further.

Experimentation - 2.2

Connect output of Buck converter to a potentiometer. Vary resistance (Load) which will vary current flowing thus simulating a GPS or any such load. Check performance (Regulated output voltage) across multiple such resistances.

- **Observations**

| Input voltage | Load Resistance | Output Current | Regulated voltage output |
|---------------|-----------------|----------------|--------------------------|
| 3.77 V | 34.4 ohms | 88 mA | 3.02 V |
| 3.78 V | 57.6 ohms | 53 mA | 3.05 V |
| 3.78 V | 149 ohms | 20.9 mA | 3.10 V |
| 3.8 V | 385 ohms | 8.3 mA | 3.15 V |
| 3.79 V | 831 ohms | 3.79 mA | 3.15 V |
| 3.8 V | 1.179 Kohms | 2.7 mA | 3.20 V |
| 3.8 V | 7.3 Kohms | 0.45 mA | 3.25 V |
| 3.8 V | 8.5 Kohms | 0.39 mA | 3.27 V |
| 3.8 V | 14.64 Kohms | 0.23 mA | 3.3 V |
| 3.8 V | 32.4 Kohms | 0.101 mA | 3.3 V |

| | | | |
|-------|--------------|---|--------|
| 3.8 V | Open-circuit | - | 3.33 V |
|-------|--------------|---|--------|

From above study conducted with aid of multimeter, we can infer that performance (regulated output voltage of 3.3V) drops when load current above ~0.3 mA. But why ?

Date : 07/02/2024 (Wednesday)

Experimentation - 3

Connect with MT3608 Step-Up converter. Set MT3608 Output voltage at ~4 V. Connect thi with LM2950 3.3V LDO Voltage regulator. Add loads across LM2950 and check performance.

- Observations

| Input voltage | Load Resistance | Load Current | LM2950 Output (V) Load connected | MT3608 Output (V) LDO + Load connected |
|---------------|-----------------|--------------|-------------------------------------|---|
| 3.78 V | 17.5 ohms | ~151 mA | 2.45 V | 3.96 V |
| 3.78 V | 21.6 ohms | ~146 mA | 2.93 V | 3.99 V |
| 3.73 V | 28.8 ohms | ~111.5 mA | 3.28 V | 4.00 V |
| 3.78 V | 34.4 ohms | 96 mA | 3.27 V | 4.00 V |
| 3.77 V | 57.6 ohms | 57 mA | 3.27 V | 3.99 V |
| 3.78 V | 148 ohms | 22 mA | 3.28 V | 3.99 V |
| 3.78 V | 385 ohms | 8.5 mA | 3.27 V | 3.99 V |
| 3.78 V | 831 ohms | 4 mA | 3.26 V | 3.99 V |
| 3.78 V | 1.179 Kohms | 2.8 mA | 3.27 V | 3.99 V |
| 3.78 V | 14.64 Kohms | 0.23 mA | 3.27 V | 3.99 V |
| 3.78 V | 32.4 Kohms | 0.1 mA | 3.27 V | 3.99 V |
| 3.79 V | Open-circuit | - | 3.27 V | 4.00 V |

Finally, got a configuration that seems to be delivering a constant of ~3.27 V consistently over multiple loads.

The highlighted part in yellow observed above is because of the electrical characteristics of LM2950 LDO being used.

| Parameters | Condition | Min. | Typ. | Max. | Unit |
|----------------|------------|------|------|------|------|
| Ground Current | IOUT=100uA | | 75 | 120 | µA |
| | IOUT=100mA | | 3 | 12 | mA |

| | | | | | |
|--------------------------|--|--|------|-----|----|
| Current Limit | V _{OUT} =0V | | 160 | | mA |
| Dropout Voltage (Note 3) | I _{OUT} =100uA | | 50 | 80 | mV |
| | I _{OUT} =100mA | | 380 | 450 | mV |
| Line Regulation | (V _{OUT} +1V) ≤ V _{IN} ≤ 30V | | 0.04 | 0.2 | % |
| Load Regulation (Note 2) | 100uA ≤ I _{OUT} ≤ 100mA | | 0.1 | 0.3 | % |

- Ground current : Quiescent current (I_Q) → Current consumed by LDO when it's in Idle state, not supplying any load current
- Current Limit : Max. output current that LDO can deliver while still maintaining regulation
- Line regulation : Change in O/P voltage to Change in I/P voltage = (dV_{out} / dV_{in})

$$\text{Line Regulation (\%)} = \left(\frac{\Delta V_{\text{out}}}{V_{\text{out}}} \right) \times 100 \times \left(\frac{1}{\Delta V_{\text{in}}} \right)$$

- Load regulation :

Change in O/P voltage from No load to Full load condition = (V_{no load} - V_{full load}) / dI_{load}

- Ability of a voltage regulator to maintain a constant output voltage despite changes in the load current. In Electrical characteristics table, 0.1% and 0.3% means that if load current varies b/w 100 uA and 100 mA

$$\text{Load Regulation (\%)} = \left(\frac{\Delta V_{\text{out}}}{V_{\text{out}}} \right) \times 100 \times \left(\frac{1}{\Delta I_{\text{load}}} \right)$$

Experimentation - 4

Connect battery with LM2950 3.3V LDO Voltage regulator. Add loads across LM2950 and check performance.

- Observations

| Input voltage | Load Resistance | Load Current | LM2950 Output (V) Load connected |
|---------------|-----------------|--------------|-------------------------------------|
| 3.78 V | 17.5 ohms | ~151 mA | 2.45 V |
| 3.78 V | 21.6 ohms | ~146 mA | 2.93 V |
| 3.73 V | 29 ohms | ~110 mA | 3.26 V |
| 3.78 V | 34.4 ohms | | |
| 3.77 V | 57.6 ohms | 57 mA | 3.27 V |
| 3.78 V | 148 ohms | | |

Almost the same results as the previous table. So, the problem is with the choice of LDO. Or maybe the circuit was not working as expected because it was consuming more than 110 mA and hence there is a big voltage drop when we connect the GPS. Let's check the GPS datasheet now for more clarity.

Checking GPS datasheet;

Reqs max of 67 mA

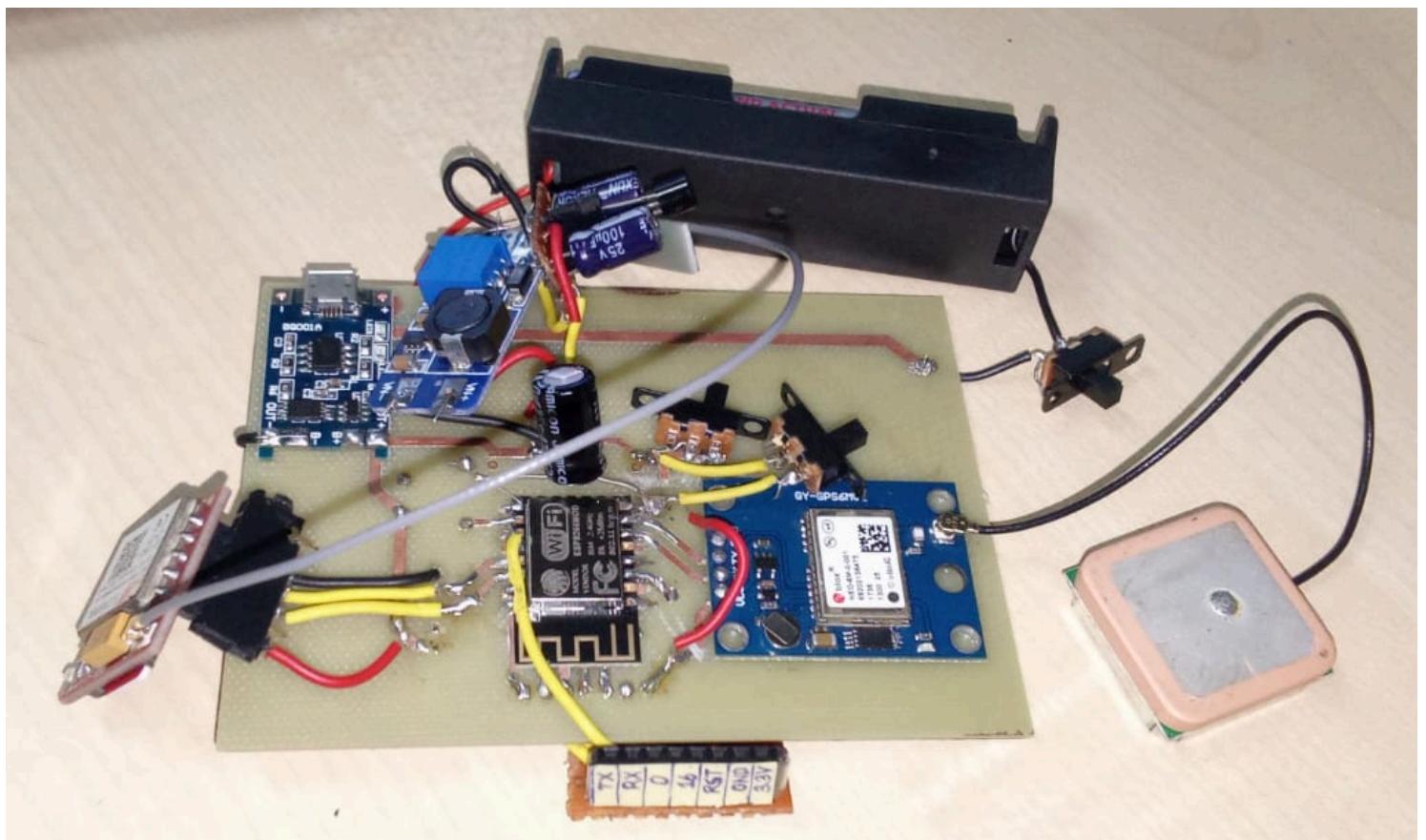
Seems that the culprit was ESP12F after all...

- ESP12F consuming too much power during startup.
Ref : <https://github.com/esp8266/Arduino/issues/2111>
<https://github.com/esp8266/Arduino/issues/2462>
<https://github.com/esp8266/Arduino/pull/5395>

Change : Capacitor across GND and VCC was increased from 100uF to 470 uF. Current seems to be managed good as well, not exceeding above 80mA in total.

Current Circuit

- Battery - TP4056 (~3.7 V)
 - 470uF cap - GSM module
 - MT3608 Boost converter (4 V) - LM2950 LDO (3.3 V) with decoupling caps
 - GPS
 - 470uF cap - ESP12F



- Take this to lab and test using oscilloscope;;

- Power consumptions of modules
 - Effect of placing caps on GSM module and ESP12F
- Observed that my NMEA data contains GNRMC and GNGGA sentences, instead of GPRMC and GPGGA sentences.
- The only diff is that GNSxx sentences refer to generic GNSS sentences and GPSxx sentences refer to particularly sentences from GPS satellites. The NMEA sentence format of both sentences are the same
-

Date : 08/02/2024 (Thursday)

PCB Design updates/changes

- Place cap across Vcc and Gnd of ESP12F
- Boost converter inclusion
- Avoid last time's mistakes;
 - Get proper Double-sided design instead of Single-sided design (Inform Abijeet sir properly)
 - If placing SMD on one side and THT components on other side, design accordingly taking mirror image of footprints

Make existing prototype clean

- Wires shouldn't touch each other
- Organize Boost converter, LDO, GSM module, Battery properly
- Now things are not working properly again. ESP12F getting reset every now and then. Have to check using Oscilloscope no matter what, tomorrow.

WatchDog timers

- A watchdog timer (WDT) is a piece of hardware that can be used to automatically detect software anomalies and reset the processor if any occur.
- Normally, it's based on a counter that counts down from some initial value to zero. The embedded software selects the counter's initial value and periodically restarts it. If the counter ever reaches zero before the software restarts it, the software is presumed to be malfunctioning and the processor's reset signal is asserted .

Is my ESP12F getting resetted because of WatchDog Timer ?

Date : 13/02/2024 (Tuesday)

- HY1803D Bench Power supply
- Ref : IMSAI Guy Youtube channel  #733 Deciphering a Schematic (part 1 of 2)
- Schematic Link : <https://github.com/imsaiqu/HY1803d/blob/main/HY1803D%20Power%20Supply.pdf>
- Op-Amp based adjustable voltage regulators ???

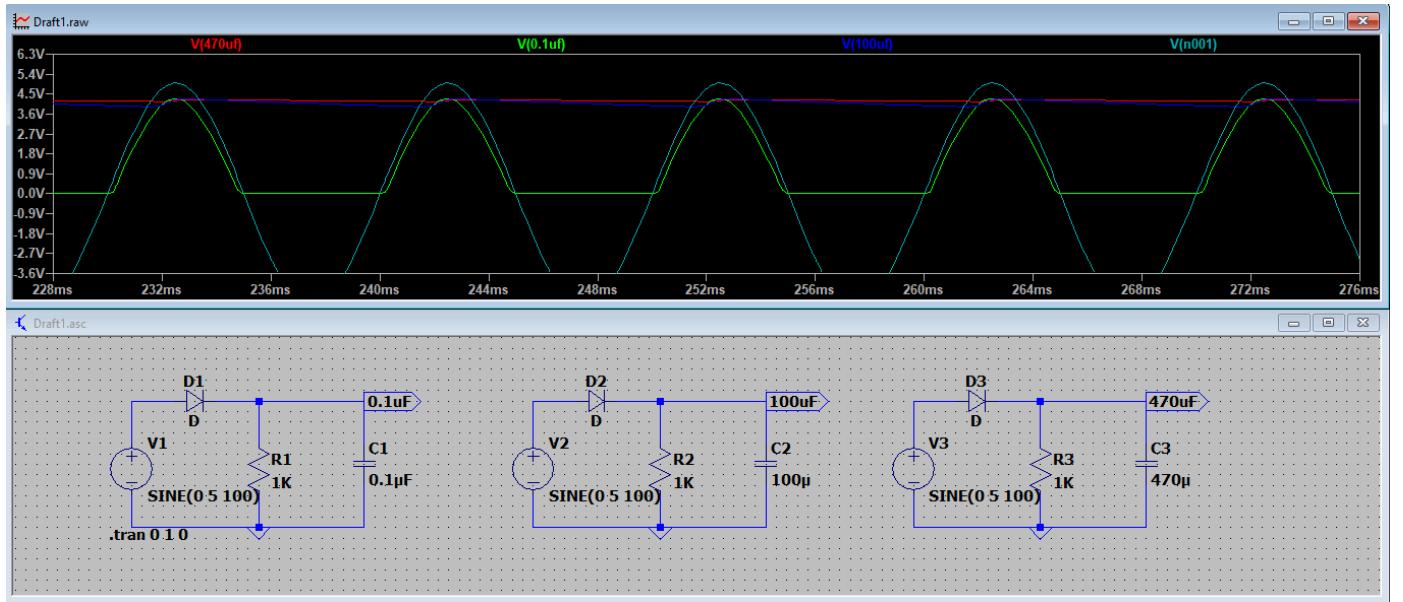
- Op-Amp based current limiting circuits ???
- Why do we use 2 caps one very high capacitance ($470\mu F$) and one with low capacitance ($0.1\mu F$) in parallel with protection diode ?
- Darlington pair ??? Revisit again ?
- Configuring transistors ??? Resistor at base, etc
- Why place a cap across the Bridge rectifier ?

- Op-amp based voltage regulator :
<https://www.allaboutcircuits.com/technical-articles/how-to-design-a-precision-current-pump-with-op-amps/>
- Op-amp based adjustable current source :
<https://www.merghart.com/p/28/opamp-adjustable-current-source>

- How do they choose the right capacitance values to place across devices in a circuit ?

LTSpice

- Placing diff Caps across a load connected to a voltage source ($0.1\mu F$, $100\mu F$, $470\mu F$)



- Pulse source : <https://www.youtube.com/watch?v=5sYnePkanfU>
 - PULSE(Vinitial Von Tdelay Trise Tfall Ton Tperiod Ncycles)
 PULSE(StartingVoltage HighVoltage TimeAfterWhichPulseStarts RiseTime FallTime
 HighVoltageDuration TimePeriodOfPulse NoOfCycles/Pulses)



- Get the voltage and current graphs during GSM operation ? → Simulate it using pulsed Voltage source

Date : 14/02/2024 (Wednesday)

Capacitors

- Why do we use multiple value of decoupling capacitors ?
- If I am using a 470uF Cap across GSM module, where is the 2A peak current taken from ? Is it taken from the 470uF Cap or from the power source directly ?

Output Caps in Power supply

- Power supply attempts to deliver a constant current to the load, but when load current changes, the voltage delivered to load also changes
- Why ?
- Bandwidth of Power supply
 - Parasitic impedances of conductors b/w power supply and load
- Caps placed at load can act as charge reservoirs to buffer the difference b/w load current transient and current being supplied by voltage source. The value of Caps can be chosen considering the following equation;
- $$I = C * (dV/dt)$$

High-Frequency Decoupling

Suppose we have a digital circuit with fast switching components generating noise in the range of 10 MHz. To effectively filter out this noise, we can use a decoupling capacitor with a time constant smaller than the period of the noise signal.

Given,

$$f = 10 \text{ MHz} = 10 \times 10^6 \text{ Hz}$$

$$\text{Time period} = 1/(2\pi f) = 1/(2\pi 3.14 \times 10^6) = 15.9 \text{ ns}$$

Load Transient Response

Consider a microcontroller powering a load that experiences rapid current spikes during its operation. We want to select a decoupling capacitor that can provide sufficient charge to meet these transient current demands while maintaining stable voltage.

Given,

$$\text{Max transient current (I)} = 100 \text{ mA}$$

$$\text{Max acceptable voltage drop (dV)} = 100 \text{ mV}$$

$$\text{Max acceptable time for voltage recovery (dt)} = 10 \mu\text{s}$$

$$I = C * (dV/dt) \rightarrow C = I * (dt/dV)$$

$$C = (100 \times 10^{-3}) \times ((10 \times 10^{-6}) / (100 \times 10^{-3}))$$

$$= 10 \mu\text{F}$$

Voltage Droop and Jump

When load current increases suddenly, voltage drops can occur due to properties of power supply and load.

- Internal resistance of Power source : As load current increases, voltage drop across internal resistor also increases, leading to decrease in voltage across load
- Conductor Resistance : Voltage drop in conductors b/w power supply and load

Why transient load currents in GSM/GPS modules ?

Occurs during specific phases of operation such as data transmission, reception, signal acquisition and processing. During each operation different circuitry is used and hence power is consumed.

Capacitors to handle transient load currents

Provides a source of instantaneous energy to supplement power supply and stabilize voltage during these transient events.

Factors to consider

- Choose caps with **sufficient capacitance** to store an adequate amount of energy to meet transient power demands of the load
- **Low ESR (Eq. series resistance) and ESL (Eq. series inductance)** for minimizing energy losses and maximizing effectiveness of transient response
- **Place caps as close to load as possible** to minimize parasitic effects and impedance mismatches
- Ensure that capacitors can **withstand the temperature and environmental conditions** of the application and have a **sufficient lifetime to meet reliability requirements**.

Date : 15/02/2024 (Thursday)

Applications of Capacitors

Ref :  10 awesome application of capacitors in circuits

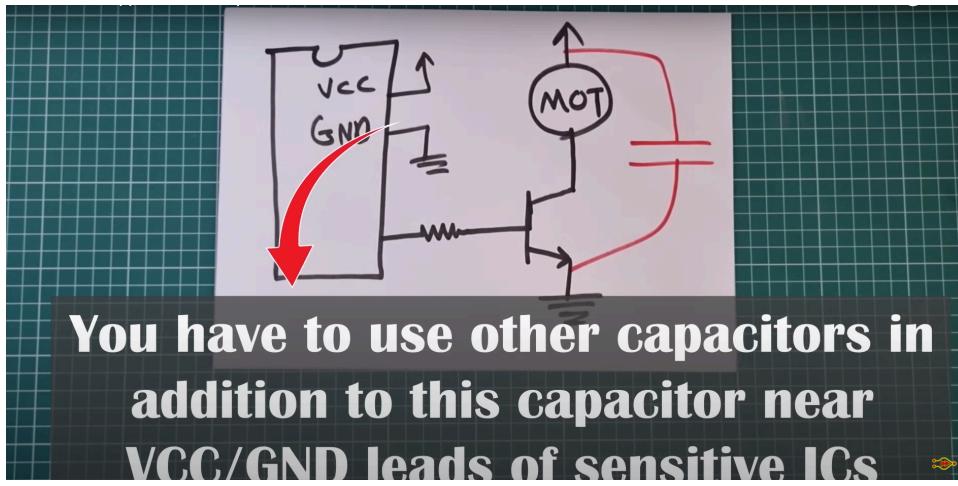
Differences b/w Caps

- Speed
- Freq
- ESR
- ESL
- Stability : Changes in environmental conditions
- Polarity
- Capacity
- Price
- Shape and Size

1) Remove Ripples from Rectifiers

- Voltage of cap should be more than waveforms peak voltage to prevent risk of Cap damage

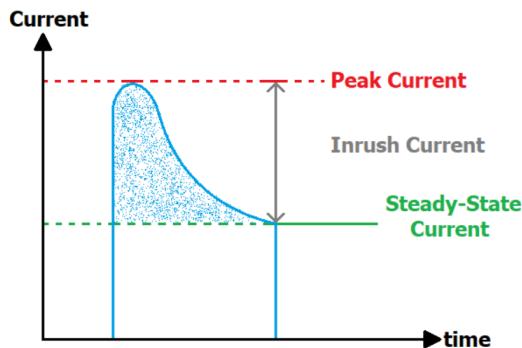
2) Dealing with Inrush current



- When DC motor turns ON, it has an inrush current. This will cause serious voltage drop at Vcc. This could be solved using “Inrush current limiter circuit” which is costly and complex. A cheaper alternative is to use Caps.

Ref : <https://circuitdigest.com/tutorial/what-is-inrush-current-and-how-to-limit-it>

- Inrush current is the maximum current drawn by an electrical circuit at the time it's turned ON



3) DC motor noise elimination

- 100nF (to filter the noise)

4) Debouncing Push buttons

- 220nF → Calculate cap value by using max duration of bounce pulses.
- Usually a 100nF - 470nF cap is used to debounce a button

5) To eliminate general noise

- Parallel to load

6) Coupling Caps

- Series with load - blocks DC, but allows AC
- Mostly used with amplifiers to allow signals enter the amplifier, but removing the DC signal

7) To make delays

- Using RC combo

- 8) Capacitors as sensors
- 9) To build capacitive power supplies

Improving Load Transient Response for Controlled Loads

Ref : <https://www.ti.com/lit/an/slvaee0/slvaee0.pdf>

- Large load transients are present in a number of applications containing heavy loads like
 - RF transmitters in wireless sensors
 - High-brightness LEDs in lighting
 - Laser diodes in time-of-flight cameras
 - Motors and actuators in mechanical systems

Understanding Load-transient response of LDOs

Ref : <https://www.ti.com/lit/an/slyt151/slyt151.pdf?ts=1707986336054>

- Why are caps with same voltage and capacitance values have different sizes ?

PK-GNSS Device Updates

- Added a Buck converter after battery directly
- Need to take it out and test

Date : 16/02/2024 (Friday)

- Went to ECE lab and used oscilloscope (add experimentation and reading here)
- Issue of restarting might be because of the Watchdog Timer

Date : 17/02/2024 (Saturday)

- Explore on reasons of ESP12F resetting
(https://docs.google.com/document/d/1wKiX9QNAf3P_4bWz79852Rq9RdTs11-6PH_uabLGmQc/edit?usp=sharing)
- WatchDog Timers
Best reference : https://www.sigmdel.ca/michel/program/esp8266/arduino/watchdogs_en.html
- Seems that the issue of ESP resetting was because of Hardware WDT after all. Debugged using `esp.getResetReason()`
 - Initial “ESP Reset External System” was when I pressed Reset button
 - The next “ESP Reset Hardware WatchDog” is printed when ESP auto-restarts (The issue we have been observing so far)

Started running from 01:36 pm

- What a normal putting data operation looks like...

```
SIM800L serial initialize
Device is registered on the network.
Modem: SIM800 R14.18
140
Connecting to airtelgprs.com OK
5968

5968
Connecting to DB 11700

Reading GPS data :
$GNRMC,,V,,,,,,,,N,V*37
$GNGGA,,,0,00,99.9,,,,,*6F
$GNGS$GNRMC,,V,,,,,,,,N,V*37
$GNGGA,,,0,00,99.9,,,,,*6F
$GNGSA,A,1,,,,,,,,99.9,99.9,99.9,1*0A
$GNGSA,A,1,,,,,,,,99.9,99.9,99.9,4*0F
$GPGSV,1,1,00,0*65
$BDGSV,1,1,00,0*74
$GNTXT,1,1,01,ANTENNA OPEN*3B
Fix status : 0
Lat = 0.00Long = 0.00SNR = 0Speed = 0Posting to DB 12843
POST:/0/0/.json?auth=zhw6zkn3OQXjojhr8dDPn3OTJFdzhNk27c828puQ
Data:{ "Lat": "0.00", "Long": "0.00", "SNR": "0" }
12898
HTTP Put request
14759

14759
Response
Status code: 200
Response: { "Lat": "0.00", "Long": "0.00", "SNR": "0" }
16423
```

- Instances when ESP resets

Initialization of modem

```
SIM800L serial initialize
Device is not registered on the network. Let's connect...
1077
Initializing modem...
□????zH??hESP Reset Hardware Watchdog
```

Connecting to airtelgprs.com

```
SIM800L serial initialize
Device is not registered on the network. Let's connect...
1079
Initializing modem...
5940

Modem: SIM800 R14.18
5975
Connecting to airtelgprs.com????P8?□4?ESP Reset Hardware Watchdog
```

Connecting to DB

```
SIM800L serial initialize
Device is not registered on the network. Let's connect...
1079
Initializing modem...
11111

Modem:
12116
Connecting to airtelgprs.com OK
17775

17775
Connecting to DB 888P8904909ESP Reset Hardware Watchdog
```

- Other issues

```
POST:/0/0/.json?auth=zhw6Zkn3OQXjojhr8dDPn3OTJFdzhNk27c828puQ
Data:{ "Lat":"0.00", "Long":"0.00", "SNR":"0" }
35202
HTTP Put request
37574

37574
Response
Status code: -3
Response:
100004
```

- 60 secs delay b/w Request and Response. Why is the system waiting sooo long ???
- This issue also mostly arises with status code = -3

Observations

- If I get stuck with the system not crossing the initial stages (Modem Initialization, Connecting to GPRS, Connecting to DB) for a long time, then switching OFF and then switching back the module ON helps in resolving the issue. Now, I can send updates to DB as before.
- If GPS is also active (meaning that I take this device to the balcony of 6th floor, RnD), system is not passing “Connecting to GPRS” stage → I really have to learn how to use AT commands to get things working. This will let me have more control over what my system does than blackbox methods from a

library.

```
SIM800L serial initialize
Device is not registered on the network. Let's connect...
1079
Initializing modem...
11111

Modem:
12116
Connecting to airtelgprs.com 2 9$] 9ESP Reset Hardware Watchdog
```

PK-GNSS Device Updates

- Added a 100nF (104) ceramic capacitor on RST and EN pins of ESP12F (to prevent chip from resetting randomly when RF spikes are present)
 - Post : But didn't had any noticeable change → actually, it changed. But why ??? Initially connecting to the network takes multiple attempts (I mean ESP12F restarts multiple times). But once connected everything seems to work fine.
 - Also, noticed one observation : Even after posting to DB through a HTTP request, it seems that sometimes we get a status code of “-3” after a very long time (time in which our system does almost nothing... Sits not doing anything for a minute or so). So, let us just focus on pushing updates to server and not wait till we get the response.

Date : 19/02/2024 (Monday)

- When do hardware Watchdogs normally reset the microcontrollers ?
 - Did Data Analysis work (Transit dataset)

Date : 21/02/2024 (Wednesday)

Pre-processor directives

- Used to affect compile time settings of the program.

| Pre-Processor | Description |
|---------------|--|
| #include | It is used to include a file in the C program |
| #define | It is used to define a macro or constant |
| #ifdef | It checks if a macro is defined or not |
| #ifndef | It checks if a macro is not defined |
| #if | It checks for a condition at compile time |
| #else | It specifies the alternative statement if the condition is false |
| #elif | It specifies the next condition if the previous #if statement is false |
| #endif | It denotes the end of the conditional statements |
| #pragma | It is used to provide additional information to the compiler |

- #define : Used to define macros, which are symbolic names representing a constant value or a code snippet that gets replaced during preprocessing.
- #include : Used to include header files (contain a set of predefined standard library functions) into the source code, allowing access to pre-defined functions, constants, and data types.

typedef

- Eg; **typedef TinyGsmESP8266 TinyGsm;**
- Lets you define your own identifiers that can be used in place of type specifiers such as int , float , and double
- Used to create a new name for a data type, but it doesn't create a new type.

```
typedef int myint;
```

The diagram shows the `typedef int myint;` statement with three boxes below it. The first box is labeled "keyword" with an arrow pointing to the `typedef` keyword. The second box is labeled "datatype" with an arrow pointing to the `int` keyword. The third box is labeled "new name" with an arrow pointing to the identifier `myint`.

- \r = CR (Carriage Return) → Used as a new line character in Mac OS before X
- \n = LF (Line Feed) → Used as a new line character in Unix/Mac OS X
- \r\n = CR + LF → Used as a new line character in Windows

GPRS connection flow

Restarting the modem

- restart [TinyGsmModem.tpp]

```

/*
 * Power functions
 */
bool restart(const char* pin = NULL) {
    return thisModem().restartImpl(pin);
}

- restartImpl(pin) [TinyGsmClientSIM800.h]

/*
 * Power functions
*/
protected:
    bool restartImpl(const char* pin = NULL) {
        if (!testAT()) { return false; }
        sendAT(GF("&W"));
        waitResponse();
        if (!setPhoneFunctionality(0)) { return false; }
        if (!setPhoneFunctionality(1, true)) { return false; }
        delay(3000);
        return init(pin);
    }

- testAT() [TinyGsmModem.tpp]
// Test response to AT commands
bool testAT(uint32_t timeout_ms = 10000L) {
    return thisModem().testATImpl(timeout_ms);
}

- testATImpl(timeout_ms) [TinyGsmModem.tpp]
bool testATImpl(uint32_t timeout_ms = 10000L) {
    for (uint32_t start = millis(); millis() - start < timeout_ms;) {
        thisModem().sendAT(GF(""));
        if (thisModem().waitResponse(200) == 1) { return true; }
        delay(100);
    }
    return false;
}

- setPhoneFunctionality()
bool setPhoneFunctionality(uint8_t fun, bool reset = false) {
    return thisModem().setPhoneFunctionalityImpl(fun, reset);
}

- setPhoneFunctionalityImpl()

```

```
// <fun> 0 Minimum functionality
// <fun> 1 Full functionality (Default)
// <fun> 4 Disable phone both transmit and receive RF circuits.
// <rst> Reset the MT before setting it to <fun> power level.
bool setPhoneFunctionalityImpl(uint8_t fun, bool reset = false) {
    sendAT(GF("+CFUN="), fun, reset ? ",1" : "");
    return waitResponse(10000L) == 1;
}
```

- init() [TinyGSModem.tpp]

```
bool init(const char* pin = NULL) {
    return thisModem().initImpl(pin);
}
```

- initImpl()

```

class GsmClientSecureSim800 : public GsmClientSim800 {
    bool initImpl(const char* pin = NULL) {
        DBG(GF("### TinyGSM Version:"), TINYGSM_VERSION);
        DBG(GF("### TinyGSM Compiled Module: TinyGsmClientSIM800"));

        if (!testAT()) { return false; }

        // sendAT(GF("&FZ")); // Factory + Reset
        // waitResponse();

        sendAT(GF("E0")); // Echo Off
        if (waitResponse() != 1) { return false; }

#define TINY_GSM_DEBUG
        sendAT(GF("+CMEE=2")); // turn on verbose error codes
#else
        sendAT(GF("+CMEE=0")); // turn off error codes
#endif
        waitResponse();|}

        DBG(GF("### Modem:"), getModemName());

        // Enable Local Time Stamp for getting network time
        sendAT(GF("+CLTS=1"));
        if (waitResponse(10000L) != 1) { return false; }

        // Enable battery checks
        sendAT(GF("+CBATCHK=1"));
        waitResponse();

        SimStatus ret = getSimStatus();
        // if the sim isn't ready and a pin has been provided, try to unlock the sim
        if (ret != SIM_READY && pin != NULL && strlen(pin) > 0) {
            simUnlock(pin);
            return (getSimStatus() == SIM_READY);
        } else {
            // if the sim is ready, or it's locked but no pin has been provided,
            // return true
            return (ret == SIM_READY || ret == SIM_LOCKED);
        }
    }
}

```

PK-GNSS Updates : Code

- Updated the code to Github : V2 version
 - Removed Hardware and Software WatchDogs
 - Changed process flow of establishing connection to network and updating DB

```

Time passed since start = 236 secs
Connecting to DB
Reading GPS data :
$GNRMC,181156.00,V,,,,,,,,,N,V*13
$GNGGA,181156.00,,,,0,00,99$GNRMC,181215.00,V,,,,,,,,,N,V*17
$GNGGA,181215.00,,,,0,00,99.9,,,*4F
$GNGSA,A,1,,,,,,,,,99.9,99.9,99.9,1*0A
$GNGSA,A,1,,,,,,,,,99.9,99.9,99.9,4*0F
$GPGSV,1,1,00,0*65
$BDGSV,1,1,00,0*74
$GNTXT,1,1,01,ANTENNA OK*2B
Fix status : 0
Lat = 0, Long = 0, SNR = 08, Speed = 0
Posting to DB
POST:/0/181215/.json?auth=zhw6Zkn3OQXjojhr8dDPn3OTJFdzhNk27c828puQ
Data:{ "Lat": "0", "Long": "0", "SNR": "08" }
HTTP Put request
Response
Status code: 200
Time passed since start = 247 secs

Time pa??since start = 258 secs
Connecting to DB
Reading GPS data :
$GNRMC,181216.00,V,,,,,,,,,N,V*14
$GNGGA,181216.00,,,,0,00,99$GNRMC,181237.00,V,,,,,,,,,N,V*17
$GNGGA,181237.00,,,,0,00,99.9,,,*4F
$GNGSA,A,1,,,,,,,,,99.9,99.9,99.9,1*0A
$GNGSA,A,1,,,,,,,,,99.9,99.9,99.9,4*0F
$GPGSV,1,1,00,0*65
$BDGSV,1,1,00,0*74
$GNTXT,1,1,01,ANTENNA OK*2B

```

- Avg. time taken for connecting with DB and updating = ~10 secs
- Gap b/w initiating the next DB update after current DB update is over = 10 secs

- Restarting DB, if we have no success response after DB update for a long time

```

Time passed since start = 320 secs
Connecting to DB
Reading GPS data :
$GNRMC,181323.00,V,,,,,,,,,N,V*13
$GNGGA,181323.00,,,,,0,00,99$GNRMC,181453.00,V,,,,,,,,,N,V*13
$GNGGA,181453.00,,,,,0,00,99.9,,,,,*4B
$GNGSA,A,1,,,,,,,,,,99.9,99.9,99.9,1*0A
$GNGSA,A,1,,,,,,,,,,99.9,99.9,99.9,4*0F
$GPGSV,1,1,04,05,,,33,17,,,09,21,,,16,33,,,26,0*6B
$BDGSV,1,1,00,0*74
$GNTXT,1,1,01,ANTENNA OK*2B
Fix status : 0
Lat = 0, Long = 0, SNR = 33, Speed = 0
Posting to DB
POST:/0/181453/.json?auth=zhw6Zkn3OQXjojhr8dDPn3OTJFdzhNk27c828puQ
Data:{ "Lat": "0", "Long": "0", "SNR": "33" }
HTTP Put request
Response
Status code: -2
Time passed since start = 410 secs

ESP not updating to DB for a long time --> 100677
Restarting the board^?      !8!!RT!!!!ESP Reset : Software/System restart
Starting SIM800L modem
Modem: SIM800 R14.18
Connecting to airtelgprs.com OK
Time passed since start = 67 secs
Connecting to DB
Reading GPS data :
b!b!b9QOK*2B

```

- Changes to incorporate
 - Dynamic timing of updating location data to DB (based on current vehicle speed)
 - Handling issues that might cause device not to work properly
- Restarting ESP12F;
 - `ESP.reset()` : Performs a soft reset of microcontroller. Restarts the CPU but does not reset the peripherals or clear the RAM contents.
 - `ESP.restart()` : Performs a full system reset of the microcontroller. Restarts the entire system, including resetting the CPU, peripherals, and clearing the RAM contents.
- Signed vs unsigned long ???
 - “Signed” long represents integers that can hold both +ve and -ve values
 - “Unsigned” long represents integers than can hold only +ve values

Date : 22/02/2024 (Thursday)

Buck converters

- How they work ? PWM signal is sent through LC filter which gives out a cleaner DC output.
- How to design one ?

PCB Design : Changes to keep note of

- Place cap across Vcc and Gnd of ESP12F
- Place ceramic caps (decoupling caps - 100nF) across RESET and CH_EN pins of ESP8266
- Boost converter inclusion
- Add ON/OFF switch b/w TP4056 out and Power line
- Add programming headers properly
- Reduce PCB size
- Avoid last time's mistakes;
 - Get proper Double-sided design instead of Single-sided design (Inform Abijeet sir properly)
 - If placing SMD on one side and THT components on other side, design accordingly taking mirror image of footprints

Think...

- VCCs should be brought on same side to reduce trace lengths from power source
- SIM card slot must be accessible from side

3-D Enclosure design

Date : 23/02/2024 (Friday)

Tasks for today

- Place device in balcony and check if DB updates are happening as expected
- Complete PCB design
- Make a list of parts that needs to be bought
- Look for other buck converter alternatives with smaller footprint

ArduinoHttpClient.h library status codes

```
static const int HTTP_SUCCESS =0;
// The end of the headers has been reached. This consumes the '\n'
// Could not connect to the server
static const int HTTP_ERROR_CONNECTION_FAILED =-1;
// This call was made when the HttpClient class wasn't expecting it
// to be called. Usually indicates your code is using the class
// incorrectly
static const int HTTP_ERROR_API =-2;
// Spent too long waiting for a reply
static const int HTTP_ERROR_TIMED_OUT =-3;
// The response from the server is invalid, is it definitely an HTTP
// server?
static const int HTTP_ERROR_INVALID_RESPONSE =-4;
```

- http->connectionKeepAlive(); // Currently, this is needed for HTTPS

This line is essential. Otherwise I am getting -3 status code. Investigate why ???

Exploring ArduinoHttpClient.h library

1) Creating a HttpClient object

```
TinyGsm modem(sim800);  
TinyGsmClientSecure gsm_client_secure_modem(modem, 0);  
  
const char FIREBASE_HOST[] = "gps-tracker2-13e30-default.firebaseio.com";  
const int SSL_PORT      = 443;  
HttpClient http_client = HttpClient(gsm_client_secure_modem, FIREBASE_HOST, SSL_PORT);
```

```
HttpClient::HttpClient(Client& aClient, const char* aServerName, uint16_t aServerPort)  
    : iClient(&aClient), iServerName(aServerName), iServerAddress(), iServerPort(aServerPort),  
    iConnectionClose(true), iSendDefaultRequestHeaders(true)  
{  
    resetState();  
}
```

2) Setting timeout for getting HTTP response

```
http_client.setHTTPResponseTimeout(10*1000);
```

3) Connecting to DB

```
http_client.connect(FIREBASE_HOST, SSL_PORT);
```

Where is “connect” method present ? [Src : HttpClient.h]

```
// Inherited from Client  
virtual int connect(IPAddress ip, uint16_t port) { return iClient->connect(ip, port); };  
virtual int connect(const char *host, uint16_t port) { return iClient->connect(host, port); };
```

What is iClient object ? [Src : HttpClient.h]

```
// Client we're using  
Client* iClient;
```

What is Client class ? [Src : HttpClient.h]

```
#include "Client.h"
```

- Generic class that's typically used as a base class for specific network communication classes, such as EthernetClient, WiFiClient, or GSMClient, depending on the network interface you're using (Ethernet, WiFi, GSM, etc.).
- Used to create network clients to connect to specified internet servers using protocols like TCP or UDP. This header file provides the necessary definitions and functions for working with network clients in Arduino sketches.

4) Connection keep alive

```
http->connectionKeepAlive();
```

[Src : HttpClient.h]

```
/** Enables connection keep-alive mode
 */
void connectionKeepAlive();
```

[Src : HttpClient.cpp]

```
void HttpClient::connectionKeepAlive()
{
    iConnectionClose = false;
}
```

What is iConnectionClose ?

[Src : HttpClient.h]

```
bool iConnectionClose;
```

[Src : HttpClient.cpp]

Default state of iConnectionClose = true (meaning close HTTP connection once done)

```
HttpClient::HttpClient(Client& aClient, const char* aServerName, uint16_t aServerPort)
    : iClient(&aClient), iServerName(aServerName), iServerAddress(), iServerPort(aServerPort),
      iConnectionClose(true), iSendDefaultRequestHeaders(true)
{
    resetState();
}

if (iConnectionClose)
{
    // Tell the server to
    // close this connection after we're done
    sendHeader(HTTP_HEADER_CONNECTION, "close");
}
```

5) Send a PUT request

```
http->put(url, contentType, data);
```

[Src : HttpClient.h]

```

/** Connect to the server and send a PUT request
 * with body and content type
 * @param aURLPath      Url to request
 * @param aContentType Content type of request body
 * @param aBody          Body of the request
 * @return 0 if successful, else error
 */
int put(const char* aURLPath, const char* aContentType, const char* aBody);
int put(const String& aURLPath, const String& aContentType, const String& aBody);
int put(const char* aURLPath, const char* aContentType, int aContentLength, const byte aBody[]);

```

[Src : HttpClient.cpp]

```

int HttpClient::put(const String& aURLPath, const String& aContentType, const String& aBody)
{
    return put(aURLPath.c_str(), aContentType.c_str(), aBody.length(), (const byte*)aBody.c_str());
}

```

6) Closing HTTP Connection

`http_client.stop();`

Where is “stop” method ?

[Src : HttpClient.h]

```

virtual void stop();

```

[Src : HttpClient.cpp]

```

void HttpClient::stop()
{
    iClient->stop();
    resetState();
}

```

PK-GNSS Updates : Design

- Try adding an external watchdog to take care of the system
- This would restart the microcontroller if it is not updating the DB for a long time (~100s)

Issues

- GPRS taking too long to connect sometimes

```

Connecting to airtelgprs.com fail
Connecting to airtelgprs.com fail
Connecting to airtelgprs.com fail
Connecting to airtelgprs.com fail
Connecting to airtelgprs.com OK
Time passed since start = 147 secs

```

```
Connecting to airtelgprs.com fail
Connecting to airtelgprs.com fail
Connecting to airtelgprs.com fail
Connecting to airtelgprs.com fail
Connecting to airtelgprs.com OK
Time passed since start = 353 secs

|Connecting to airtelgprs.com fail
|Connecting to airtelgprs.com fail
|Connecting to airtelgprs.com fail
|Connecting to airtelgprs.com fail
|Connecting to airtelgprs.com OK
|Time passed since start = 314 secs
```

Date : 26/02/2024 (Monday)

Firebase DB url :

"[https://"+firebaseProjectId+".firebaseio.com/](https://)" + your-data-node + ".json?auth=" + firebaseAuthToken

For our GNS tracker;

URL =

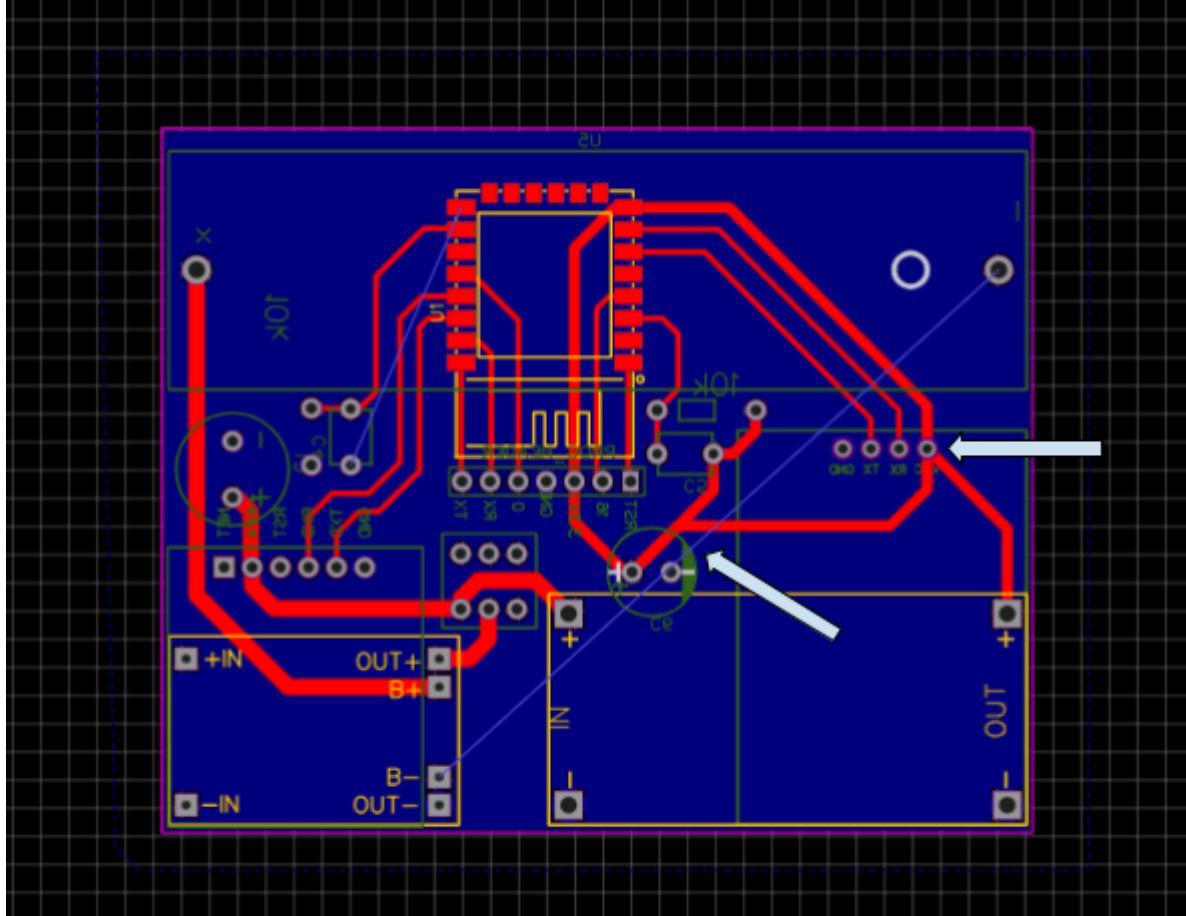
<https://gps-tracker2-13e30-default-rtdb.firebaseio.com/.json?auth=zhw6Zkn3OQXjojhr8dDPn3OTJFdzhNk27c828puQ>

- https://: This is the protocol used for communication, indicating that the connection will be made over HTTPS, which ensures secure communication.
- gps-tracker2-13e30-default-rtdb: This is your Firebase project ID followed by -default-rtdb, indicating the default Realtime Database instance associated with your project.
- .firebaseio.com: This is the domain for Firebase Realtime Database.
- /.json: This part of the URL specifies that you want to access the root node of the database in JSON format.
 - Accessing the root node of the database (/json) allows you to interact with the entire database tree. From here, you can read, write, or modify data stored in your Firebase Realtime Database.
 - If you intend to interact with a specific node within your database, you'll need to append the path to that node to the base URL. For example, if you have a node named "users" containing user data, you would access it using the URL <https://gps-tracker2-13e30-default-rtdb.firebaseio.com/users.json>.

- Pushbutton (6-Pin)

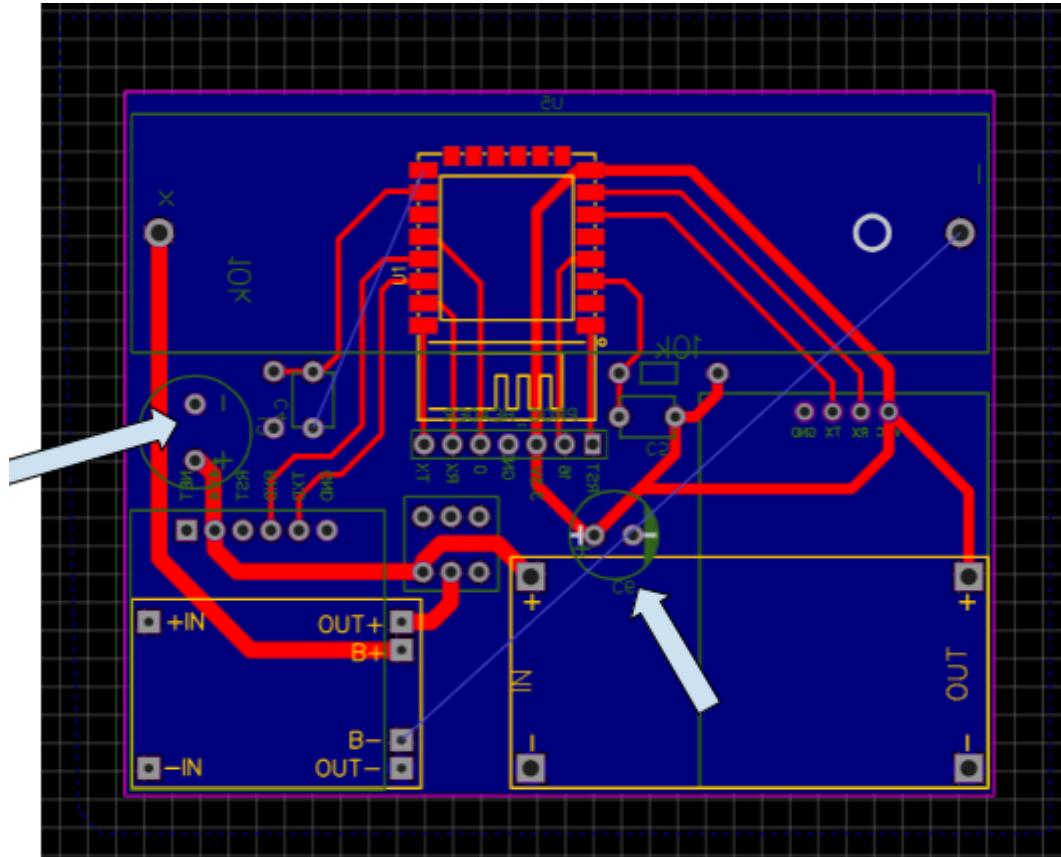
Date : 27/02/2024 (Tuesday)

- Yesterday created a new pcb design. Verify with somebody or online whether these routing affects EMI or cause any other issues. (Highlighted with arrows pointing at the possible issues)



- Also, check how I could select trace widths properly ? (UART lines, Power lines, etc)

- I am adding all capacitors to common ground, maybe not providing proper return paths. For eg; incase of GSM module I am placing the ground of 470uF cap away from the module. Does it affect the performance significantly ??? (Highlighted with arrow)



Date : 28/02/2024 (Wednesday)

Dimensions

- Pushbutton : 1.3 cms (on → when pressed) to 1.5 cms (off)
- Battery : 2 cms
- Buck converter : 1.2 cms

Creating APIs for retrieving latest (or live) location on vehicle

Docs (learning about creation and consumption of APIs) :

<https://docs.google.com/document/d/1WEZCqofVPt-BldM1csqnfFxwFtcmHFRw3Krc9DjqOeE/edit?usp=sharing>

Ref : <https://sentry.io/answers/redirect-to-a-url-in-flask/>

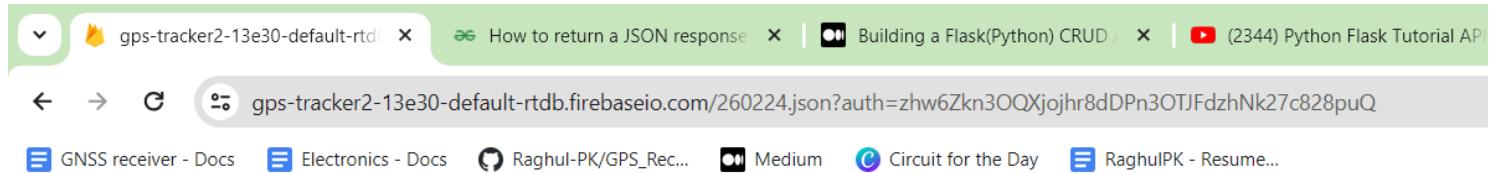
```
from flask import Flask, redirect
app = Flask(__name__)

# vehicle number is in URL
@app.route("/latestLoc/<string:gps_id>/", methods=['GET'])
def getLatestLocation(gps_id):
    url = "https://gps-tracker2-13e30-default-rtdb.firebaseio.com/" + gps_id + ".json?auth=zhw6Zkn3Q0Xjojhr8dDPn30TJFdzhNk27c828puQ"
    # Extract latest location data API endpoint
    return redirect(url, code=302)

app.run()
```

Typing this URL 127.0.0.1:5000/latestLoc/260224/

will redirect to the below url;



Get data from an API in flask

Ref : https://www.youtube.com/watch?v=F_SBxcV335k

```

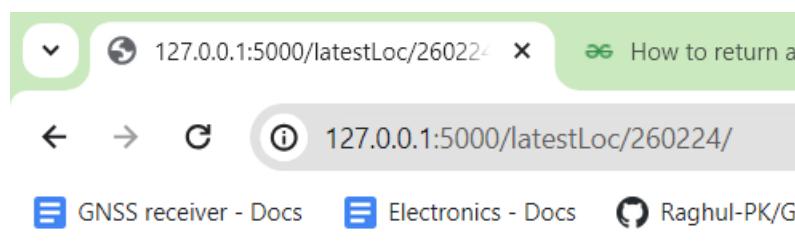
gps_tracker.py app.py
1 from flask import Flask
2 import requests, json
3 app = Flask(__name__)
4
5 # Get last known location of a specific vehicle
6 # Identified by its GPS_id
7 @app.route("/latestLoc/<string:gps_id>", methods=['GET'])
8 def getLatestLocation(gps_id):
9     url = "https://gps-tracker2-13e30-default.firebaseio.com/" + gps_id + ".json?auth=zhw6Zkn3OQXjojhr8dDPn3OTJFdzhNk27c828puQ"
10    # Extract latest location data API endpoint
11    req = requests.get(url)
12    json_data = json.loads(req.content) # This is a dictionary
13
14    # Retrieve last key-value pair in dict
15    # Originally, {'Lat': '0', 'Long': '0', 'SNR': '0'} will not be saved in final version
16    latest_time = list(json_data)[-1]
17    latest_loc = json_data[latest_time]
18    print("Last tracked time : " + str(latest_time))
19    print("Last recorded location data : " + str(latest_loc))
20    return str(latest_time) + str(latest_loc)
21
22 app.run()

```

```

E:\Python\FlaskProjects\venv\Scripts\python.exe E:/Python/FlaskProjects/gps_tracker.py
 * Serving Flask app 'gps_tracker'
 * Debug mode: off
WARNING: This is a development server. Do not use it in a production deployment. Use a production WSGI server instead.
 * Running on http://127.0.0.1:5000
Press CTRL+C to quit
127.0.0.1 - - [29/Feb/2024 01:09:48] "GET /latestLoc/260224/ HTTP/1.1" 200 -
Last tracked time : 064623
Last recorded location data : {'Lat': '0', 'Long': '0', 'SNR': '0'}

```



Date : 29/02/2024 (Thursday)

Firestore URLs and how to access particular data

- URL :
<https://gps-tracker2-13e30-default.firebaseio.com/json?auth=zhw6Zkn3OQXjojhr8dDPn3OTJFdzhNk27c828puQ>

```

{
  "0": {
    "0": {
      "Lat": "0", "Long": "0", "SNR": "15"}, "045500": {
      "Lat": "0", "Long": "0", "SNR": "0"}, "045604": {
      "Lat": "0", "Long": "0", "SNR": "0"}, "045624": {
      "Lat": "0", "Long": "0", "SNR": "22"}, "045643": {
      "Lat": "0", "Long": "0", "SNR": "33"}, "045659": {
      "Lat": "0", "Long": "0", "SNR": "31"}, "045811": {
      "Lat": "0", "Long": "0", "SNR": "18"}, "045815": {
      "Lat": "0", "Long": "0", "SNR": "21"}, "045856": {
      "Lat": "0", "Long": "0", "SNR": "46"}, "045916": {
      "Lat": "0", "Long": "0", "SNR": "17"}, "050000": {
      "Lat": "0", "Long": "0", "SNR": "34"}, "050021": {
      "Lat": "0", "Long": "0", "SNR": "27"}, "050041": {
      "Lat": "0", "Long": "0", "SNR": "37"}, "050125": {
      "Lat": "0", "Long": "0", "SNR": "21"}, "050145": {
      "Lat": "0", "Long": "0", "SNR": "27"}, "050228": {
      "Lat": "0", "Long": "0", "SNR": "38"}, "050244": {
      "Lat": "0", "Long": "0", "SNR": "27"}, "050322": {
      "Lat": "0", "Long": "0", "SNR": "38"}, "050342": {
      "Lat": "0", "Long": "0", "SNR": "27"}, "050418": {
      "Lat": "0", "Long": "0", "SNR": "35"}, "050457": {
      "Lat": "0", "Long": "0", "SNR": "41"}, "050534": {
      "Lat": "0", "Long": "0", "SNR": "47"}, "050618": {
      "Lat": "0", "Long": "0", "SNR": "47"}, "050657": {
      "Lat": "0", "Long": "0", "SNR": "45"}, "050716": {
      "Lat": "0", "Long": "0", "SNR": "27"}, "050753": {
      "Lat": "0", "Long": "0", "SNR": "44"}, "050813": {
      "Lat": "0", "Long": "0", "SNR": "29"}
    }
  }
}

```

- URL (**Date**) :

[https://gps-tracker2-13e30-default.firebaseio.com/260224.json?auth=.../260224](https://gps-tracker2-13e30-default.firebaseio.com/260224.json?auth=...)

```

{
  "045624": {
    "Lat": "0", "Long": "0", "SNR": "22"}, "045643": {
    "Lat": "0", "Long": "0", "SNR": "33"}, "045659": {
    "Lat": "0", "Long": "0", "SNR": "31"}, "045811": {
    "Lat": "0", "Long": "0", "SNR": "18"}, "045815": {
    "Lat": "0", "Long": "0", "SNR": "21"}, "045856": {
    "Lat": "0", "Long": "0", "SNR": "46"}, "045916": {
    "Lat": "0", "Long": "0", "SNR": "17"}, "050000": {
    "Lat": "0", "Long": "0", "SNR": "34"}, "050021": {
    "Lat": "0", "Long": "0", "SNR": "27"}, "050041": {
    "Lat": "0", "Long": "0", "SNR": "37"}, "050125": {
    "Lat": "0", "Long": "0", "SNR": "21"}, "050145": {
    "Lat": "0", "Long": "0", "SNR": "27"}, "050228": {
    "Lat": "0", "Long": "0", "SNR": "38"}, "050244": {
    "Lat": "0", "Long": "0", "SNR": "27"}, "050322": {
    "Lat": "0", "Long": "0", "SNR": "38"}, "050342": {
    "Lat": "0", "Long": "0", "SNR": "27"}, "050418": {
    "Lat": "0", "Long": "0", "SNR": "35"}, "050457": {
    "Lat": "0", "Long": "0", "SNR": "41"}, "050534": {
    "Lat": "0", "Long": "0", "SNR": "47"}, "050618": {
    "Lat": "0", "Long": "0", "SNR": "47"}, "050657": {
    "Lat": "0", "Long": "0", "SNR": "45"}, "050716": {
    "Lat": "0", "Long": "0", "SNR": "27"}, "050753": {
    "Lat": "0", "Long": "0", "SNR": "44"}, "050813": {
    "Lat": "0", "Long": "0", "SNR": "29"}
  }
}

```

- URL (**Date/Time**) :

[https://gps-tracker2-13e30-default.firebaseio.com/260224/045624](https://gps-tracker2-13e30-default.firebaseio.com/260224/045624.json?auth=...)

```

{
  "Lat": "0", "Long": "0", "SNR": "22"
}

```

- URL (**Date/Time/GPS_data**) :

[https://gps-tracker2-13e30-default.firebaseio.com/260224/045624/SNR](https://gps-tracker2-13e30-default.firebaseio.com/260224/045624/SNR.json?auth=...)

"22"

Created 2 API endpoints for retrieving location data

- 1) To get the entire journey of a vehicle on a particular day**

Code

```
# Get journey of a specific vehicle on a specific date
# Identified by its GPS_id
@app.route("/<string:gps_id>/journey/<string:date>", methods=['GET'])
def getDateJourney(gps_id, date):
    gps_id = "" # For time being, as we don't have gps-id still in db
    url = "https://gps-tracker2-13e30-default-rtbd.firebaseio.com/" + gps_id + (date + "/") + ".json?auth=zhw6Zkn3OQXjojhr8dDPn3OTJFdzhNk27c828puQ"
    req = requests.get(url)
    json_data = json.loads(req.content) # This is a dictionary

    return json_data
```

Entire URL : "Base_URL/<GPS_id>/journey/<date:ddmmyy(GMT)>"

```
{"074514": [{"Lat": "2832.63841", "Long": "07716.27131", "SNR": "49"}, {"080339": {"Lat": "0", "Long": "0", "SNR": "0"}, {"080619": {"Lat": "0", "Long": "0", "SNR": "0"}, {"080702": {"Lat": "0", "Long": "0", "SNR": "0"}, {"080853": {"Lat": "0", "Long": "0", "SNR": "0"}, {"080935": {"Lat": "0", "Long": "0", "SNR": "0"}, {"085521": {"Lat": "0", "Long": "0", "SNR": "15"}, {"085521": {"Lat": "0", "Long": "0", "SNR": "33"}, {"085545": {"Lat": "0", "Long": "0", "SNR": "33"}, {"085701": {"Lat": "2832.66529", "Long": "07716.37793", "SNR": "31"}, {"085701": {"Lat": "2832.65415", "Long": "07716.3728"}, {"085806": {"Lat": "2832.63792", "Long": "07716.36567", "SNR": "38"}, {"085806": {"Lat": "2832.62950", "Long": "07716.3627"}, {"085904": {"Lat": "2832.62897", "Long": "07716.36005", "SNR": "27"}, {"085904": {"Lat": "2832.62985", "Long": "07716.3583"}, {"085957": {"Lat": "2832.63032", "Long": "07716.35625", "SNR": "27"}, {"085957": {"Lat": "2832.63044", "Long": "07716.3553"}, {"090056": {"Lat": "2832.63157", "Long": "07716.35430", "SNR": "29"}, {"090056": {"Lat": "2832.63120", "Long": "07716.3540"}, {"090156": {"Lat": "2832.62633", "Long": "07716.36826", "SNR": "23"}, {"090156": {"Lat": "2832.63059", "Long": "07716.3578"}]}
```

Issues : If date is not there in DB, then will get a HTTP status code 500 → server encountered an unexpected condition that prevented it from fulfilling the request (Google)

500 Internal Server Error

Internal Server Error

The server encountered an internal error and was unable to complete your request. Either the server is overloaded or there is an error in the application.

- 2) To get the last known location of a vehicle**

Code

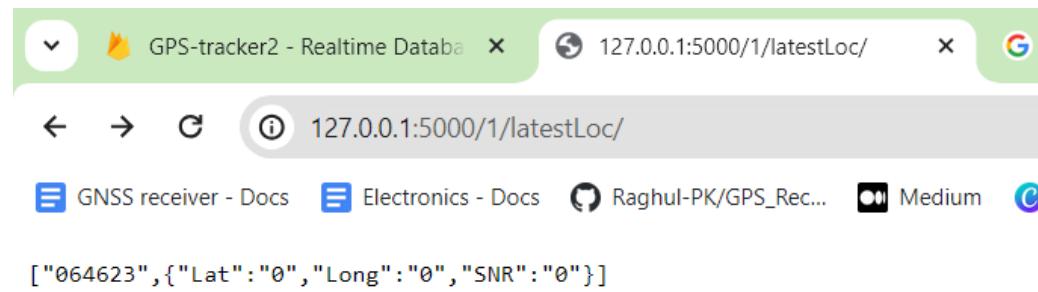
```
# Get last known location of a specific vehicle
# Identified by its GPS_id
@app.route("/<string:gps_id>/latestLoc/", methods=['GET'])
def getLatestLocation(gps_id):
    gps_id = "" # For time being, as we don't have gps-id still in db
    url = "https://gps-tracker2-13e30-default-firebase.com/" + gps_id + ".json?auth=zhw6Zkn300Xjojh
    req = requests.get(url)
    json_data = json.loads(req.content) # This is a dictionary

    # Go to the last date for that particular gps_id
    latestDate = list(json_data)[-1]
    latestDate_data = json_data[latestDate]
    print(type(latestDate_data))

    # Go to the last timestamp for that particular date
    latestTime = list(latestDate_data)[-1]
    latestTime_data = latestDate_data[latestTime]

    return [latestTime, latestTime_data]
```

Entire URL : “Base_URL/<GPS_id>/latestLoc”



Updated code-1 (to check if data is present in DB before data retrieval)

```
# Get journey of a specific vehicle on a specific date
# Identified by its GPS_id
@app.route("/<string:gps_id>/journey/<string:date>/", methods=['GET'])
def getDateJourney(gps_id, date):
    gps_id = "" # For time being, as we don't have gps-id still in db
    url = "https://gps-tracker2-13e30-default-firebase.com/" + gps_id + ".json?auth=zhw6Zkn300Xjojh
    req = requests.get(url)
    json_data = json.loads(req.content) # This is a dictionary

    if date in json_data:
        # Go to the specified date
        Date_data = json_data[date]
        print(Date_data)
        print(type(Date_data))
        return Date_data
    else:
        return ("Date doesn't exist")
```

Discussions with Pravesh sir

- Updated about the API endpoints
- I will get the PCB design from Abhijeet sir tomorrow
- Host it in their domain

Kshitij bro

- Created key file using “ssh-keygen” and shared with Kshitij bro
- He placed the “.pub” (public key file) on server
- Told me to use tmux for creating sessions and running apps (so that app runs even after we disconnect the SSH connection from the remote server)



Kshitij Srivastava

to me ▾

You can follow these instructions to host the app:

1. Login to the server using the following command - `ssh ubuntu@3.110.166.117`
2. Make the project directory in the `app/` folder
3. Run the flask application on host `0.0.0.0` and port number `8000`
4. The app will be accessible at - <https://dev-gps-tracker.chartr.in>

Please use virtualenv for install your application's libraries.

- You can make one using `virtualenv venv`
- Activate it - `source venv/bin/activate`

Let me know if you have any issues.

Regards,
Kshitij

- Above command “`ssh ubuntu@3.110.166.117`” will work fine if the keys are created from .ssh folder inside the parent directory (administrator / System32). But as I created the keys in a different directory I have to specify “`ssh -i <key_path> <username@ip-remote_server>`”. (Helped by Rasheed bro)

Deployment of API

Using SSH to connect to server

- `ssh -i C:\Users\Raghul.P.K\gps_tracker_key ubuntu@3.110.166.117`

```
C:\Windows\System32>ssh -i C:\Users\Raghul.P.K\gps_tracker_key ubuntu@3.110.166.117
Welcome to Ubuntu 22.04.3 LTS (GNU/Linux 6.2.0-1017-aws aarch64)

 * Documentation:  https://help.ubuntu.com
 * Management:     https://landscape.canonical.com
```

Move to the right directory → `cd apps/gps_tracker`

Add the Python file in directory

Open Nano text editor and create a python script

```
nano example.py
```

```

ubuntu@ip-172-31-15-36: ~/apps/gps_tracker
GNU nano 6.2                               app.py

from flask import Flask
import requests, json
app = Flask(__name__)

# Get last known location of a specific vehicle
# Identified by its GPS_id
@app.route("/<string:gps_id>/latestLoc/", methods=['GET'])
def getLatestLocation(gps_id):
    gps_id = "" # For time being, as we don't have gps_id still in db
    url = "https://gps-tracker2-13e30-default-firebase.com/" + gps_id + ".json?auth=zhw6Zkn30QXj"
    req = requests.get(url)
    json_data = json.loads(req.content) # This is a dictionary

    # Go to the last date for that particular gps_id
    latestDate = list(json_data)[-1]
    latestDate_data = json_data[latestDate]

^G Help      ^O Write Out   ^W Where Is   ^K Cut          ^T Execute   ^C Location M-U Undo
^X Exit      ^R Read File   ^\ Replace    ^U Paste        ^J Justify   ^/ Go To Line M-E Redo

```

Running the app on Ubuntu server

Tmux sessions are created so that our apps will be running even after the SSH connection is logged out

1. Start a new “tmux” session → export : Creates a new session

```

ubuntu@ip-172-31-15-36:~/apps/gps_tracker$ tmux list-sessions
no server running on /tmp/tmux-1000/default
ubuntu@ip-172-31-15-36:~/apps/gps_tracker$ tmux new-session -s gps-tracker
[session_name] [session_id]

```

- Allows you to create multiple terminal sessions within a single window/session
- Session management : You can detach from a session (keeping it running in the background) and reattach to it later, even from a different location or after logging out and back in.

2. Run your flask application : Starts the Flask development server with host(0.0.0.0) and port(8000)

```

export FLASK_APP=app.py
flask run --host=0.0.0.0 --port=8000

```

- export FLASK_APP=app.py
- flask run --host=0.0.0.0 --port=8000

```

ubuntu@ip-172-31-15-36: ~/apps/gps_tracker
ubuntu@ip-172-31-15-36:~/apps/gps_tracker$ export FLASK_APP=app.py
ubuntu@ip-172-31-15-36:~/apps/gps_tracker$ flask run --host=0.0.0.0 --port=8000
 * Serving Flask app 'app.py' (lazy loading)
 * Environment: production
   WARNING: This is a development server. Do not use it in a production deployment.
   Use a production WSGI server instead.
 * Debug mode: off
/home/ubuntu/apps/gps_tracker/app.py:48: Warning: Silently ignoring app.run() because the application is being run from a command line executable. Consider putting app.run() behind an if __name__ == "__main__":
g.
  app.run()
 * Running on all addresses.
   WARNING: This is a development server. Do not use it in a production deployment.
 * Running on http://172.31.15.36:8000/ (Press CTRL+C to quit)
172.31.43.46 - - [29/Feb/2024 14:26:42] "GET / HTTP/1.1" 404 -
172.31.16.198 - - [29/Feb/2024 14:26:43] "GET / HTTP/1.1" 404 -
172.31.14.130 - - [29/Feb/2024 14:26:43] "GET / HTTP/1.1" 404 -

```

```

ubuntu@ip-172-31-15-36:~/apps/gps_tracker
ubuntu@ip-172-31-15-36:~/apps/gps_tracker$ export FLASK_APP=app.py
ubuntu@ip-172-31-15-36:~/apps/gps_tracker$ flask run --host=0.0.0.0 --port=800
 * Serving Flask app 'app.py' (lazy loading)
 * Environment: production
WARNING: This is a development server. Do not use it in a production deploy
Use a production WSGI server instead.
 * Debug mode: off
/home/ubuntu/apps/gps_tracker/app.py:48: Warning: Silently ignoring app.run()
so the application is run from the flask command line executable. Consider put
app.run() behind an if __name__ == "__main__" guard to silence this warning.
app.run()
 * Running on all addresses.
WARNING: This is a development server. Do not use it in a production deploy
 * Running on http://172.31.15.36:8000/ (Press CTRL+C to quit)
172.31.43.46 - - [29/Feb/2024 14:26:42] "GET / HTTP/1.1" 404 -
172.31.16.198 - - [29/Feb/2024 14:26:43] "GET / HTTP/1.1" 404 -
172.31.14.130 - - [29/Feb/2024 14:26:43] "GET / HTTP/1.1" 404 -
172.31.43.46 - - [29/Feb/2024 14:27:12] "GET / HTTP/1.1" 404 -
172.31.16.198 - - [29/Feb/2024 14:27:13] "GET / HTTP/1.1" 404 -
172.31.14.130 - - [29/Feb/2024 14:27:13] "GET / HTTP/1.1" 404 -
<class 'dict'>
172.31.16.198 - - [29/Feb/2024 14:27:26] "GET /latestLoc/ HTTP/1.1" 200 -
<class 'dict'>
172.31.16.198 - - [29/Feb/2024 14:27:31] "GET /latestLoc/ HTTP/1.1" 200 -
172.31.43.46 - - [29/Feb/2024 14:27:42] "GET / HTTP/1.1" 404 -
172.31.16.198 - - [29/Feb/2024 14:27:43] "GET / HTTP/1.1" 404 -
172.31.14.130 - - [29/Feb/2024 14:27:43] "GET / HTTP/1.1" 404 -
172.31.43.46 - - [29/Feb/2024 14:28:12] "GET / HTTP/1.1" 404 -
172.31.16.198 - - [29/Feb/2024 14:28:13] "GET / HTTP/1.1" 404 -
172.31.14.130 - - [29/Feb/2024 14:28:13] "GET / HTTP/1.1" 404 -
172.31.16.198 - - [29/Feb/2024 14:28:18] "GET /latestLoc/ HTTP/1.1" 200 -

```

3. Detach from the session → “Ctrl+B” and “D” : The session runs as a background process

```

ubuntu@ip-172-31-15-36:~/apps/gps_tracker$ tmux new-session -s gps-tracker
[detached (from session gps-tracker)]
[detached (from session gps-tracker)]
ubuntu@ip-172-31-15-36:~/apps/gps_tracker$ tmux list-sessions
gps-tracker: 1 windows (created Thu Feb 29 14:25:54 2024)

```

4. Reattach to the session (keep “session_name” as “gps_tracker”)

- `tmux attach -t gps-tracker`

```
tmux attach -t session_name
```

5. Close the “tmux” session

```
exit
```

List all tmux sessions running on a server → `tmux list-sessions`

```

ubuntu@ip-172-31-15-36:~$ tmux list-sessions
gps-tracker: 1 windows (created Thu Feb 29 10:36:26 2024)
my_gps_tracker: 1 windows (created Thu Feb 29 13:50:52 2024)

```

Delete a tmux session → `tmux kill-session -t gps-tracker`

Hit API url and check (It works !!!)

```
1 // 20240229195818
2 // https://dev-gps-tracker.chartr.in/1/latestLoc/
3
4 {
5     "Lat": "0",
6     "Long": "0",
7     "SNR": "0",
8     "Time": "064623"
9 }
```

```
1 // 20240229201105
2 // https://dev-gps-tracker.chartr.in/1/journey/
3
4 {
5     "045624": {
6         "Lat": "0",
7         "Long": "0",
8         "SNR": "22"
9     },
10    "045643": {
11        "Lat": "0",
12        "Long": "0",
13        "SNR": "33"
14    },
15    "045659": {
16        "Lat": "0",
17        "Long": "0",
18        "SNR": "31"
19    },
20    "045720": {
21        "Lat": "0",
22        "Long": "0",
23        "SNR": "46"
```

Date : 05/03/2024 (Tuesday)

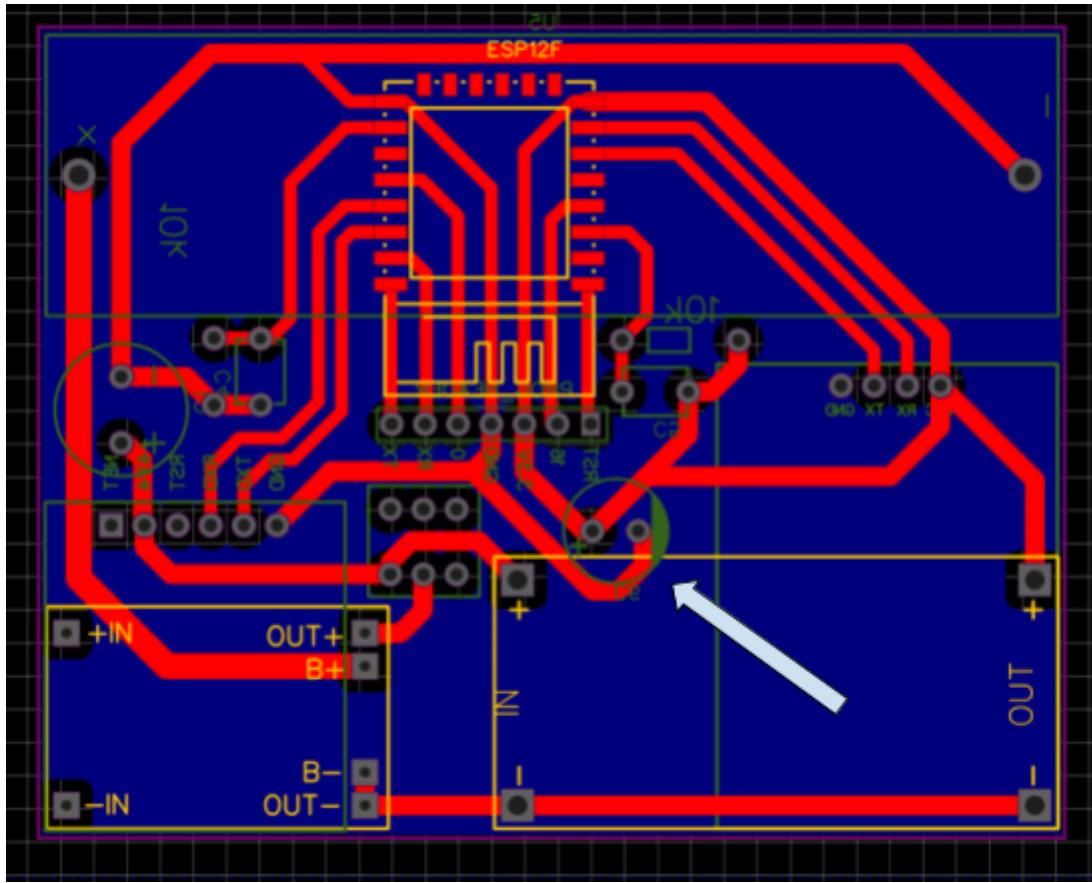
- Experiencing Power issue in new design

Getting ESP Reset Reason : “Power ON” in Serial monitor

Things to check

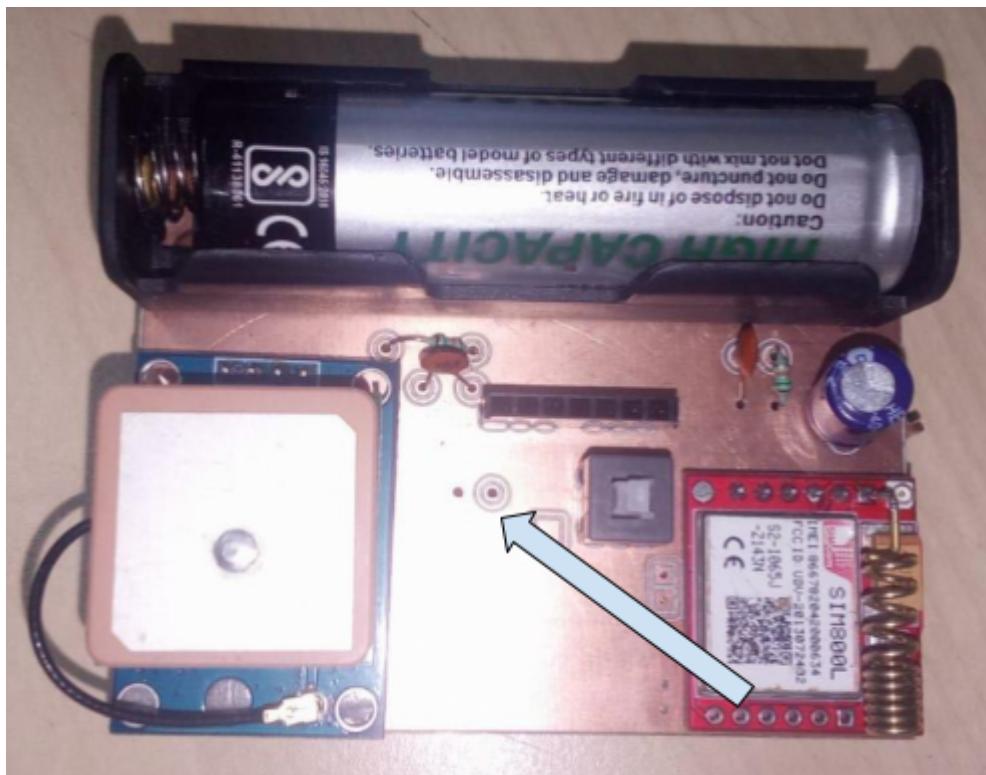
- Add Decoupling Cap directly on ESP12F

- Remove the Cap "C6" connected to ESP12F, which was originally meant to be used as Decoupling cap for ESP12F's Power supply



Updated on Prototype

- Top side
Arrow : Points the place where originally Cap was placed

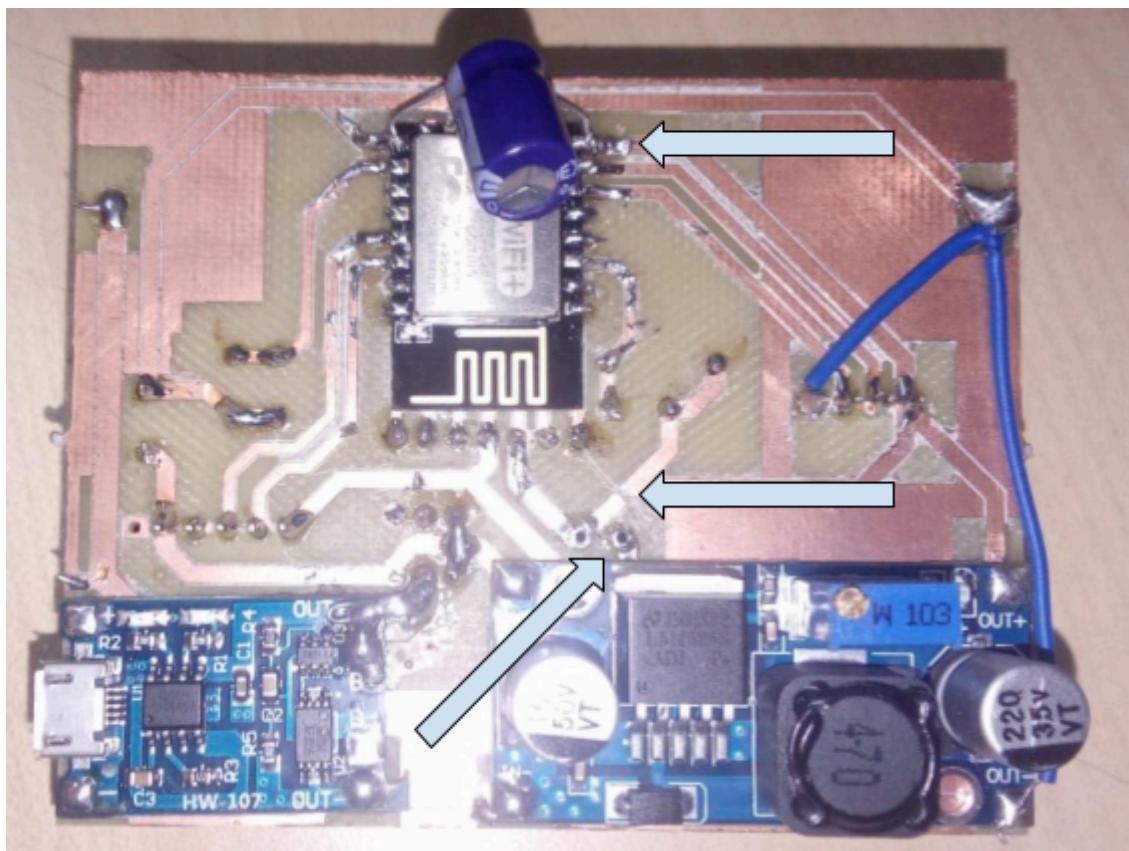


- Bottom side

Upper arrow : Cap (470uF, 25V) added across ESP12F directly

Middle arrow : Cut off the Copper trace

Bottom arrow : Remove Original placement of Cap

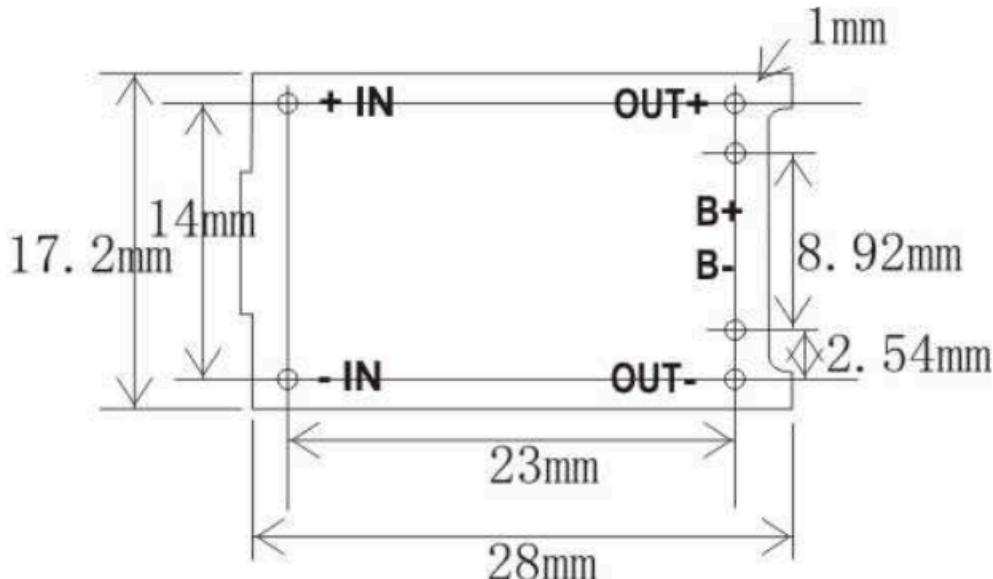


Date : 06/03/2024 (Wednesday)

- Building a 3D design of the prototype board on Fusion360, so that I could build the enclosure
- Installed Fusion360 (Personal) on Windows

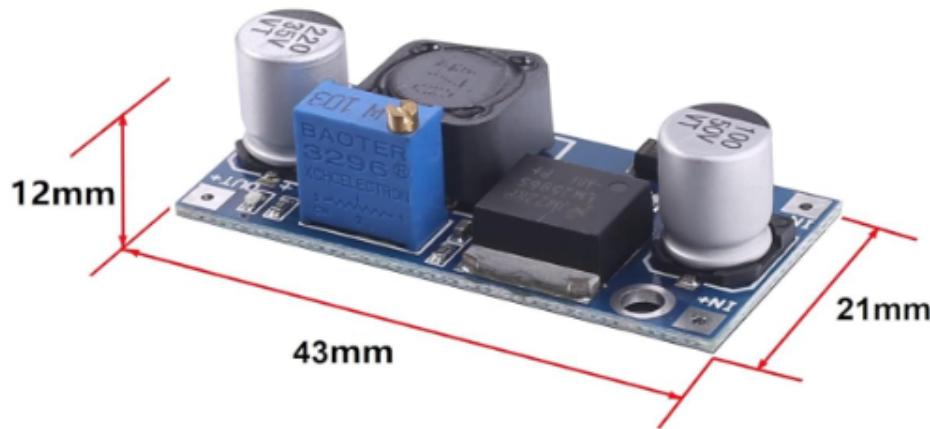
Parts

- TP4056 : <https://forum.fritzing.org/t/tp4056-charger-board/4795>



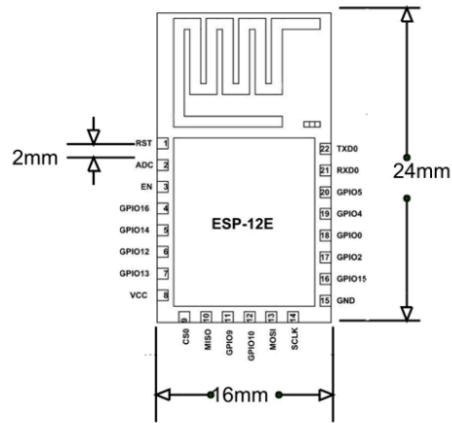
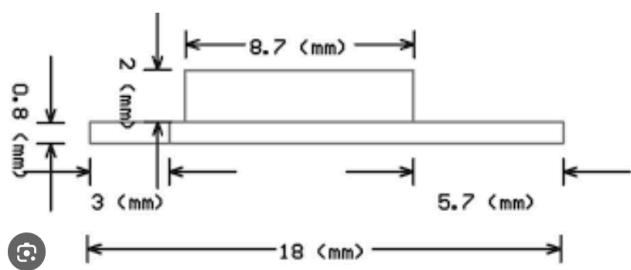
- Buck converter :

<https://www.amazon.com/PlusRoc-Converter-Efficiency-Regulator-Adjustable/dp/B0B2BXWRXL?th=1>



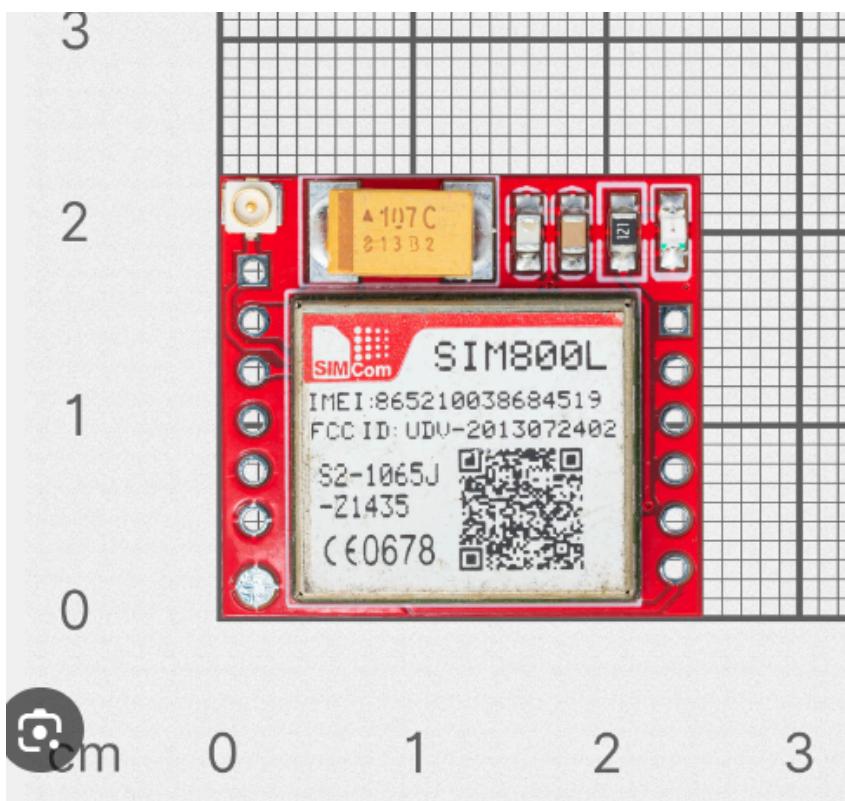
- ESP12F

Dim =

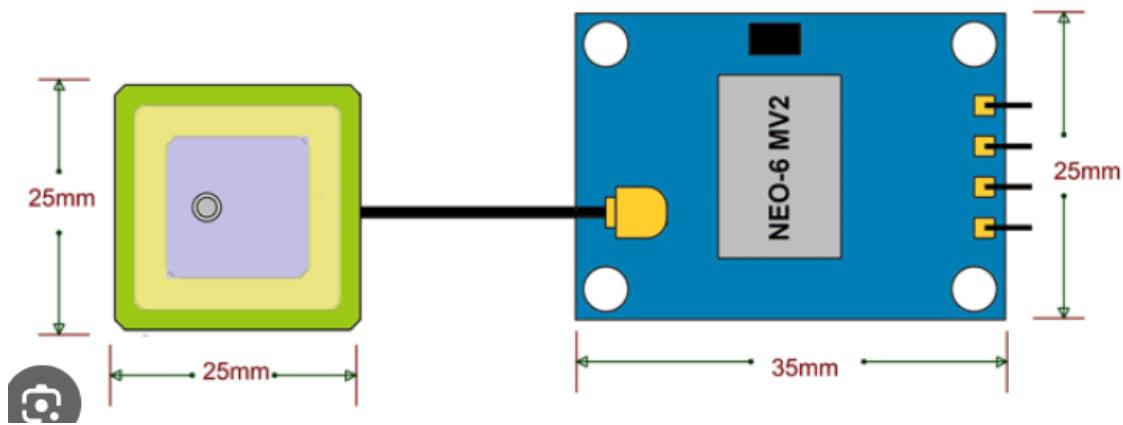


- GSM (SIM00L)

Dim = 25 x 23 x ~10 (including antenna)



- GPS (NEO-6M)



3D printing - Design tips

Ref :

- 1)[https://www.hubs.com/knowledge-base/enclosure-design-3d-printing-step-step-guide/?utm_source=reddit.co
m&utm_medium=social&utm_campaign=buffer](https://www.hubs.com/knowledge-base/enclosure-design-3d-printing-step-step-guide/?utm_source=reddit.com&utm_medium=social&utm_campaign=buffer)
 - 2)<https://facfox.com/news/basic-design-guidelines-for-3d-printed-enclosures/>
-

Date : 07/03/2024 (Thursday)

Choosing the Best fasteners for 3D printed parts

<https://www.fictiv.com/articles/how-to-choose-the-best-fasteners-for-3d-printed-parts>

- Threaded Inserts for 3D printed parts
 - Self-tapping screws
 - Designing threads into a 3D model
 - Cutting 3D printed part fastener threads with a Tap
 - Captured Hex nuts

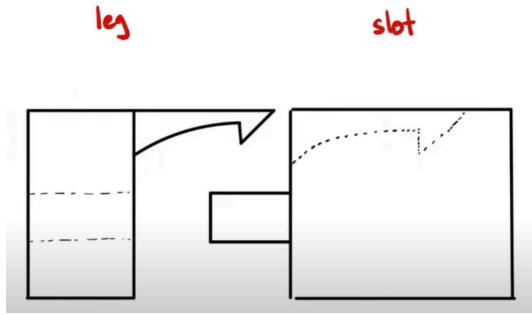
 - Clearance holes for bolts : <https://engineersbible.com/clearance-hole-metric/>
 - Nuts and bolts :

<https://www.essentracomponents.com/en-us/news/solutions/fastening-components/what-are-the-different-types-of-nuts-and-bolts>
-

Date : 09/03/2024 (Saturday)

- Guide to 3D printing snapfits and Maximizing layer strength :

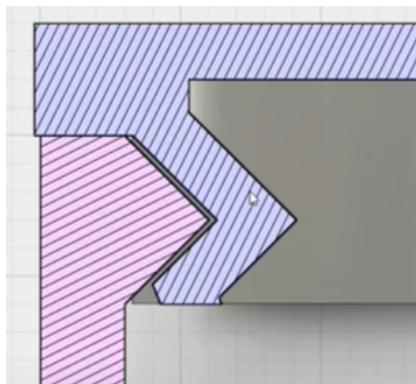
<https://www.youtube.com/watch?v=xULgfJfwuw&t=1s>



- Don't make arm too thick
- Don't make hook too deep
- Leave clearance space b/w snapfit and intended slot
- Orientation of 3D printing also matters. Why? Because in 3D printing, plastic layers are stacked one over the other and parts might break due to shear stress; Poor layer adhesion

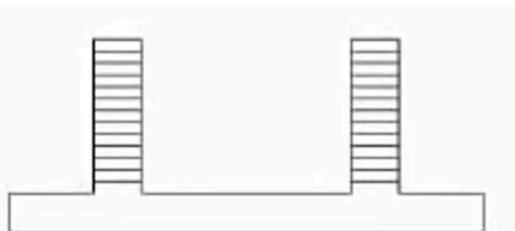
Ref : <https://www.youtube.com/watch?v=HcLT5Hz9-mk>

- Chamfer : Cut-away to make a sloping edge to ease assembling

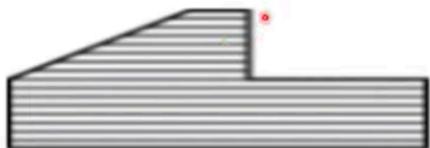


Ref : https://www.youtube.com/watch?v=m_-d8xcSDQs

- Stereolithography (SLA) is a 3D printing technology that builds parts by polymerizing a liquid photopolymer resin with a UV laser one layer at a time. Fused Deposition Modeling (FDM) is a 3D printing technology that builds parts by extruding a melted plastic onto the build plate one layer at a time.
- Injection molding is isotropic, but in 3D printing you have to deal with stacking plastic layers. In the photo, top design will break easily while the bottom can withstand shearing stress better based on how the plastic is stacked - So, it all depends on the orientation of printing a snap design using a 3D printer

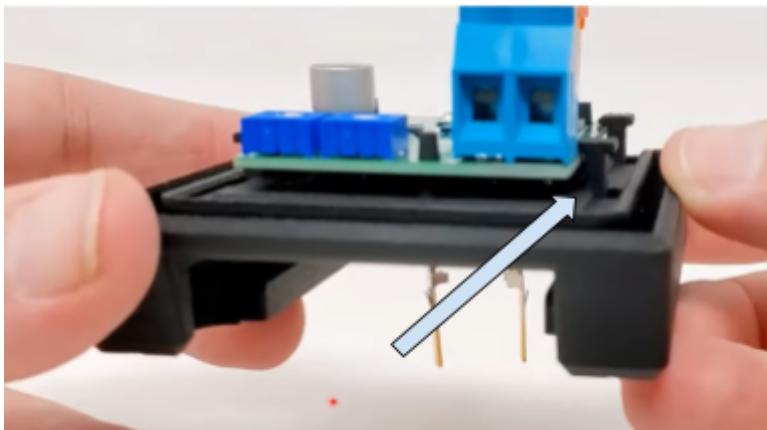


FDM / SLA snaps built like this will fail

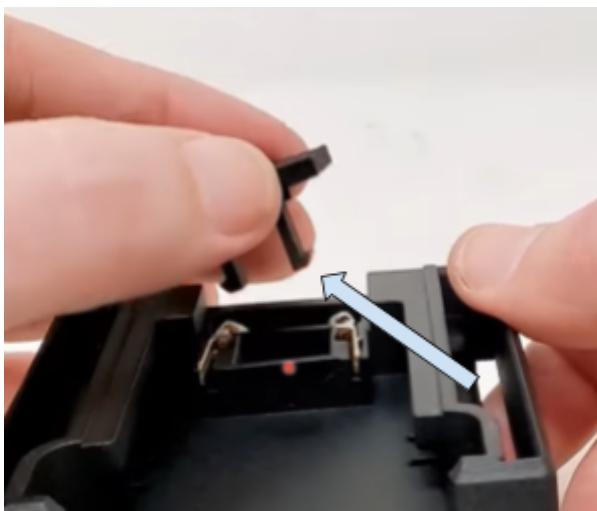


FDM / SLA snaps built like this will work

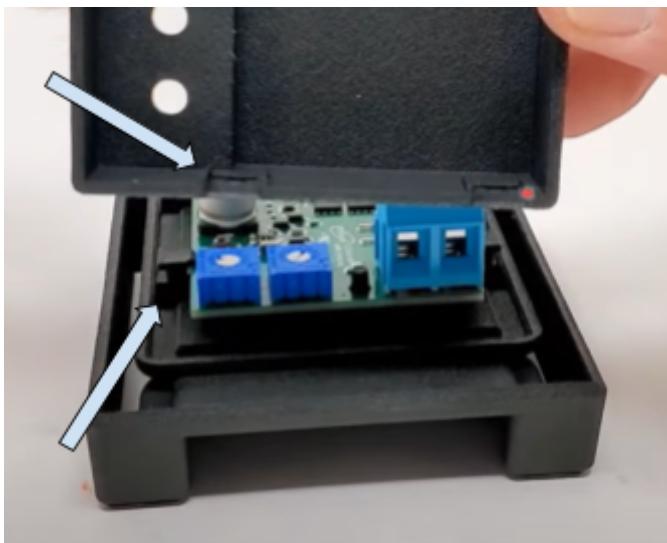
- Interesting design
 - PCB Holder



- Battery contacts holder (at bottom)

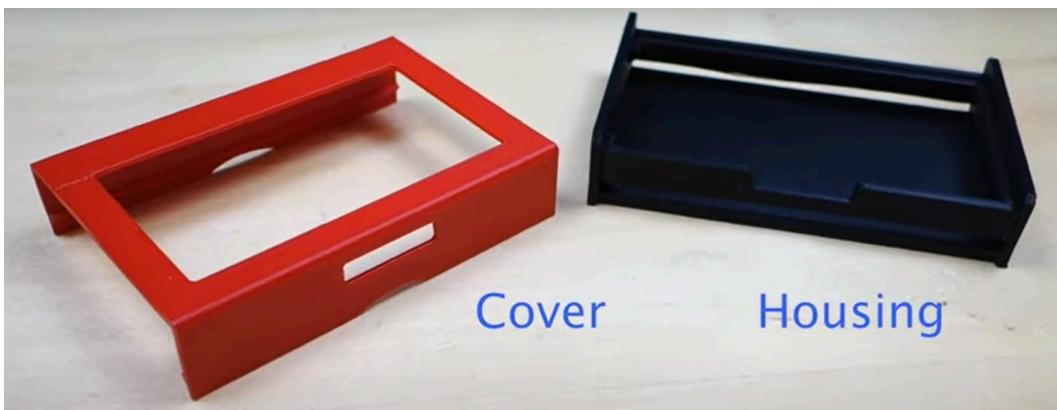


- Top casing (contains a ramp and ledge kind-of mechanism); Pushing it down makes the PCB supporters legs to move into the top casing's slots

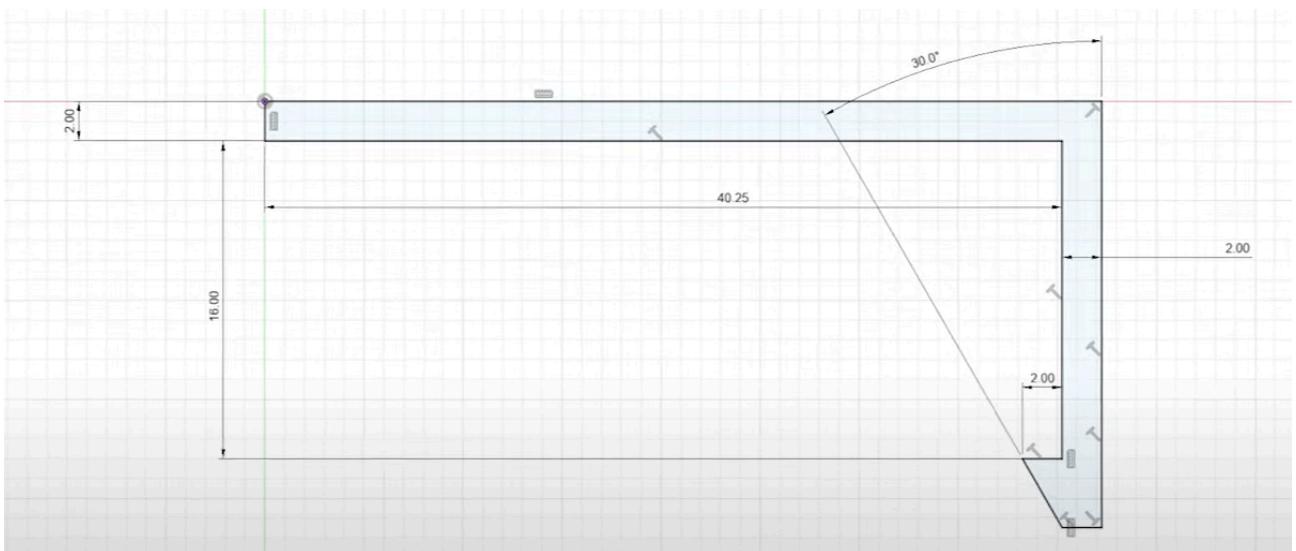


Ref : <https://www.youtube.com/watch?v=qKG3rbYH-gU>

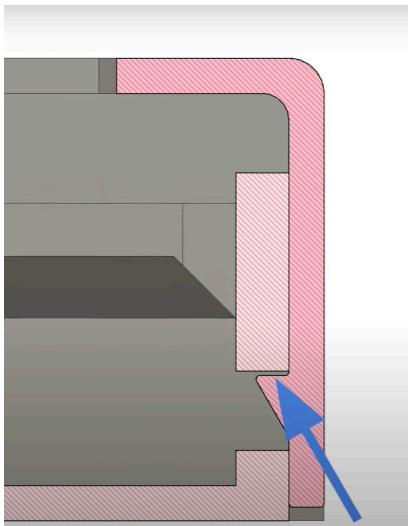
- Cover that snaps in place
- Decide whether the snap will be in housing or the cover



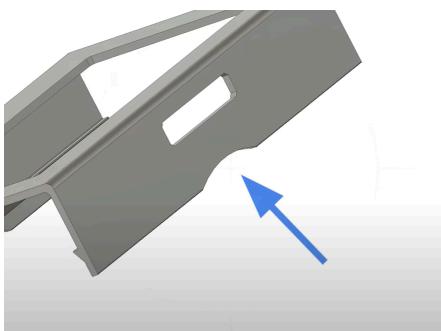
- Side view of snap



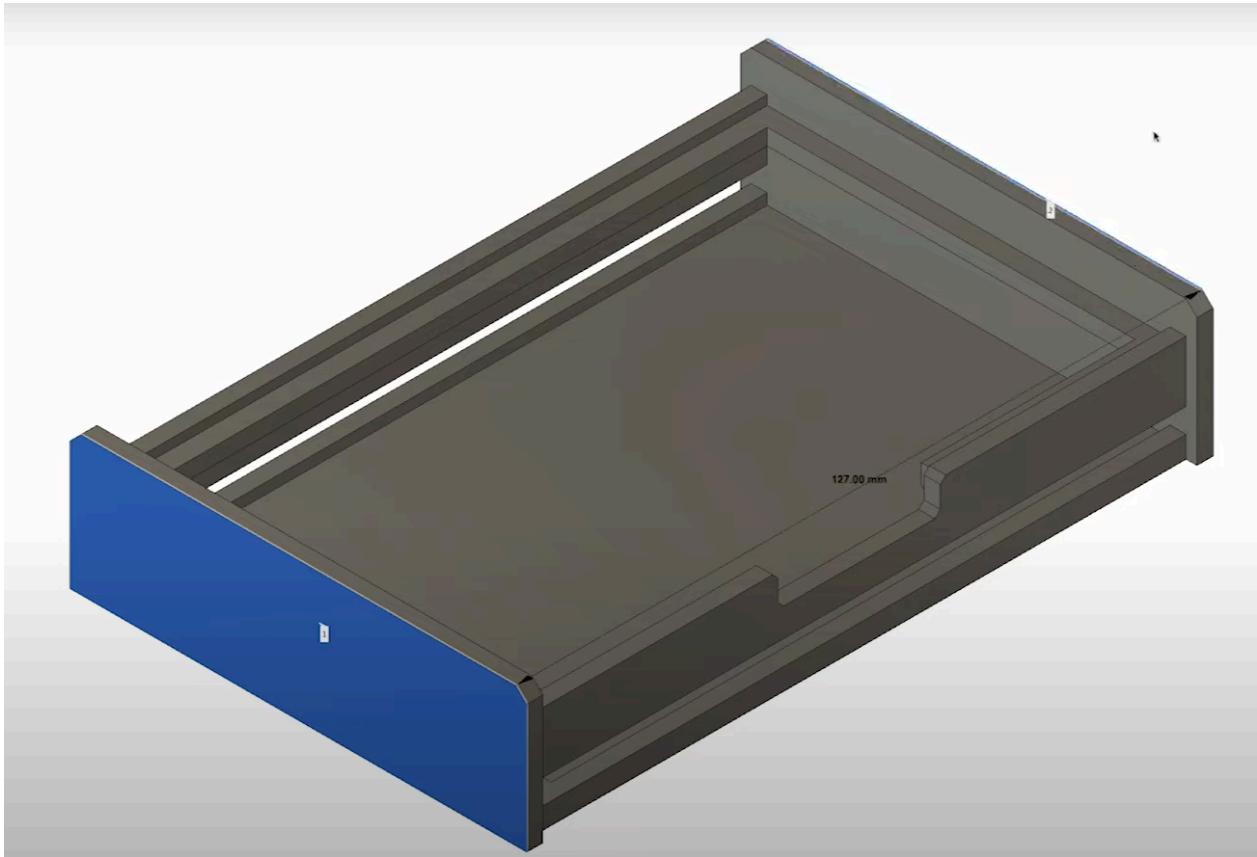
- Gap b/w snap and hole (undercut)



- Easier to grab and remove cover



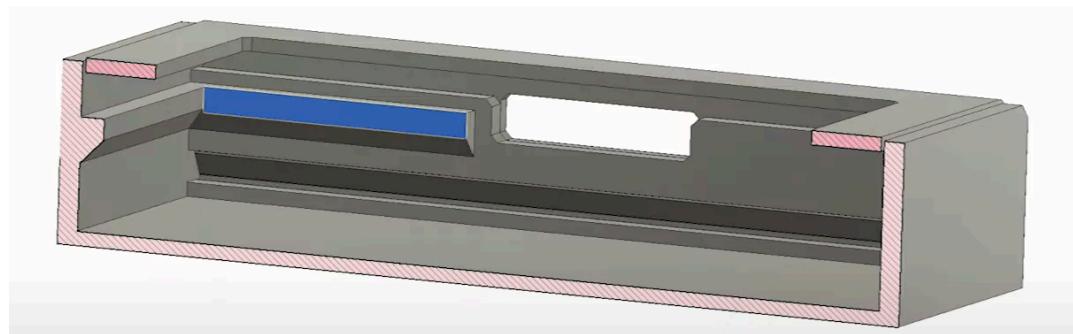
- Housing (walls are 3mm thick)



- Give a small clearance b/w cover and housing

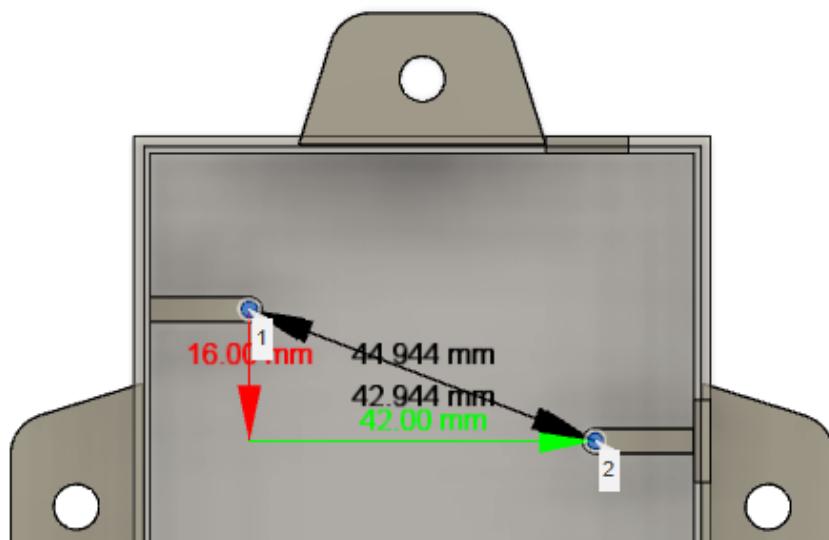


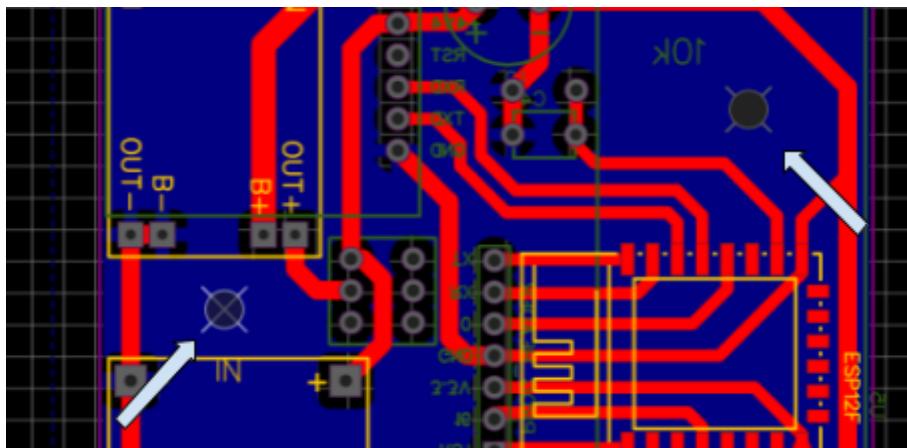
- For snap cover to properly work, housing needs to be stiff relative to the covering
 - If housing wall is not stiff enough, then wall will cave in and snap force will be significantly less
 - Added a beam along the walls for stiffening support



Date : 11/03/2024 (Monday)

- PCB has holes of width 3mm and gets fixed upon the extruded circle in the 3d design





(221.629, -158.463) and (237.629, -200.566)

- These are the coordinates of holes on PCB and their distances (considering we drew a right angled triangle over them) are 16, 42.08 and 44.98 units

Ref : <https://tutorials.probots.co.in/how-to-design-snap-fits-for-3d-printing-enclosures-part-c/>

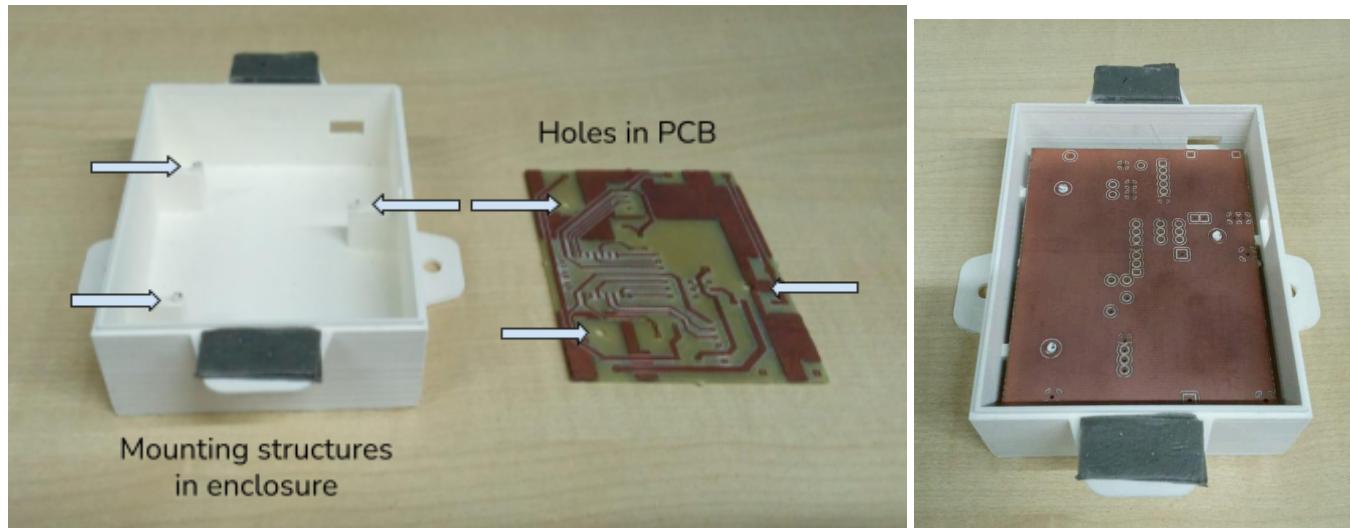
- Designing Snap fit for 3D-printing enclosures

Dates in b/w

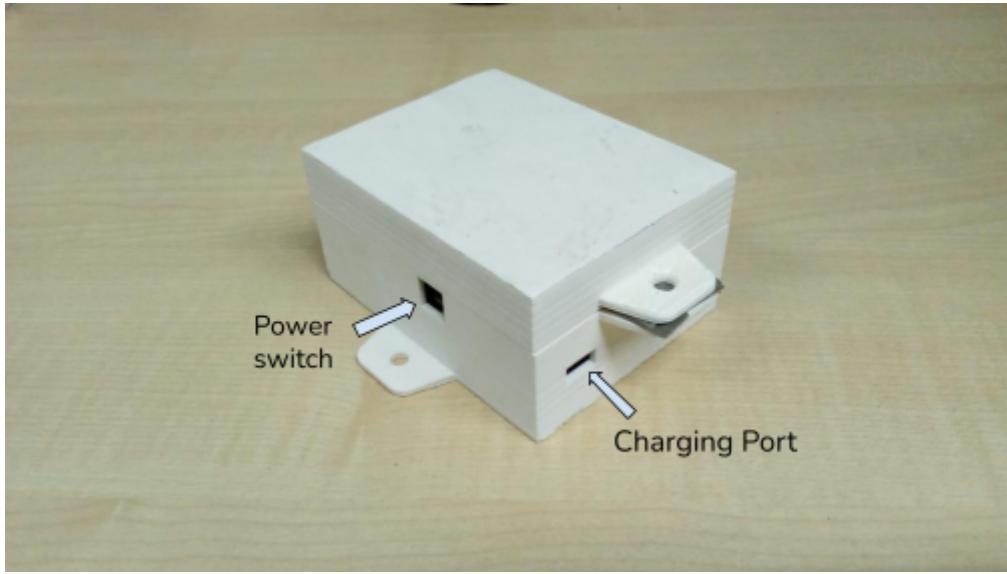
Worked on 3D printed Enclosure designs and updated PCB designs that allow mountable onto the 3D Enclosure.

- Displayed in RIISE

Here are some pictures of the almost finalized prototype;







Date : 18/03/2024 (Monday)

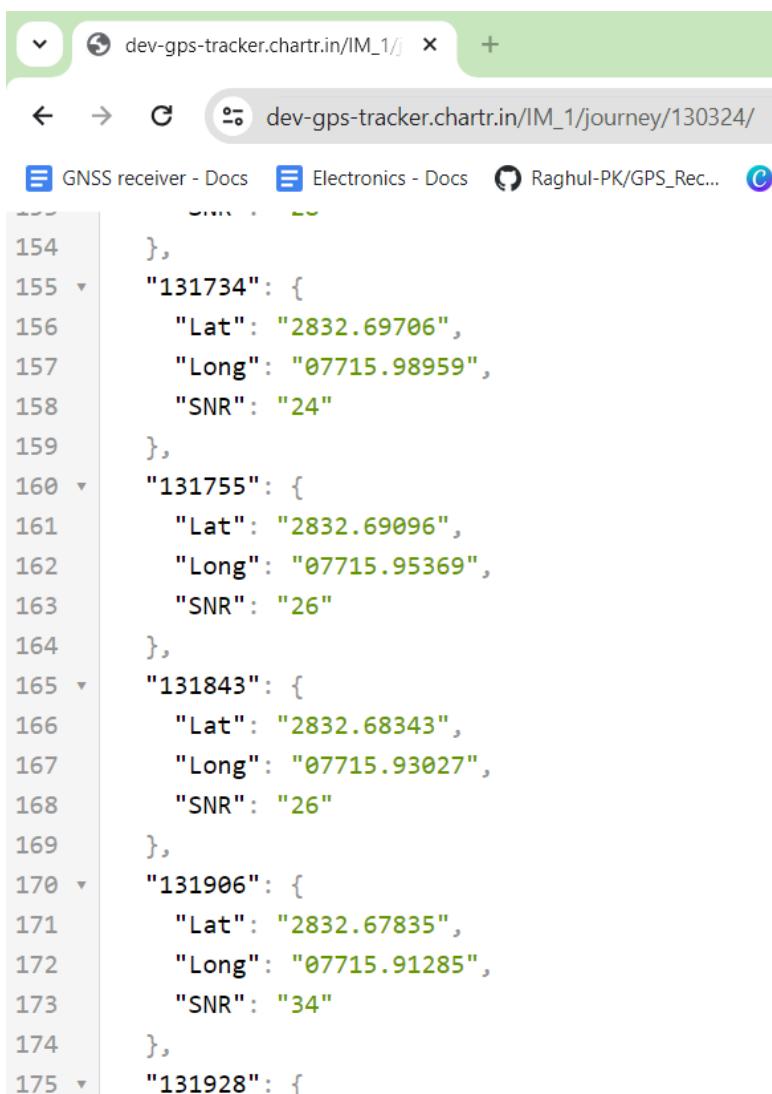
Power optimizing my existing GPS receiver

Where could we optimize it ?

- Power supply
- GSM
 - Send data only when necessary. Suppose, if vehicle is not moving for a long time then don't do update to server (or reduce frequency of updates)
- GPS
- Microcontroller

Dates in b/w

- Deploying updated backend APIs to Chartr's server. Available at:
 - Journey API : https://dev-gps-tracker.chartr.in/IM_1/journey/130324/
<base_url>/<gps_id>/journey/<ddmmmyy>



The screenshot shows a browser window with the URL https://dev-gps-tracker.chartr.in/IM_1/journey/130324/. The page content is a JSON array of GPS location data. The data is as follows:

```
[{"id": "131734", "Lat": "2832.69706", "Long": "07715.98959", "SNR": "24"}, {"id": "131755", "Lat": "2832.69096", "Long": "07715.95369", "SNR": "26"}, {"id": "131843", "Lat": "2832.68343", "Long": "07715.93027", "SNR": "26"}, {"id": "131906", "Lat": "2832.67835", "Long": "07715.91285", "SNR": "34"}, {"id": "131928"}]
```

- Latest Location API : https://dev-gps-tracker.chartr.in/IM_1/latestLoc/
<base_url>/<gps_id>/latestLoc

```

1 // 20240326122426
2 // https://dev-gps-tracker.chartr.in/IM_1/latestLoc/
3
4 {
5     "Date": "130324",
6     "Lat": "2837.27060",
7     "Long": "07718.49851",
8     "SNR": "-",
9     "Time": "142139"
10 }

```

Date : 26/03/2024 (Tuesday)

Power consumption

(Although we have discussed this in multiple places in the past, let us look at how each component consumes power, how much power and the reasons behind such power consumption → This will give us a better idea on the areas we could work for reducing power usage)

GPS (NEO-6M)

| Parameter | Symbol | Module | Min | Typ | Max | Units | Condition |
|--------------------------------------|--|------------|------------------|-----|-----|--|---|
| Max. supply current ¹⁵ | Iccp | All | | 67 | mA | VCC = 3.6 V ¹⁶ / 1.95 V ¹⁷ | |
| Average supply current ¹⁸ | Icc Acquisition | All | 47 ¹⁹ | | mA | | |
| | Icc Tracking (Max Performance mode) | NEO-6G/Q/T | 40 ²⁰ | | mA | | |
| | | NEO-6M/P/V | 39 ²⁰ | | mA | | |
| | Icc Tracking (Eco mode) | NEO-6G/Q/T | 38 ²⁰ | | mA | | VCC = 3.0 V ¹⁶ / 1.8 V ¹⁷ |
| | Icc Tracking (Power Save mode / 1 Hz) | NEO-6G/Q | 12 ²⁰ | | mA | | |
| | | NEO-6M | 11 ²⁰ | | mA | | |

Date : 27/03/2024 (Wednesday)

Connecting NEO-6M GPS module to u-center software for config

- Issue : Device drivers for PL2303 USB-TTL converter not working

Fix : <http://wp.brodzinski.net/2014/10/01/fake-pl2303-how-to-install/>

How is the issue resolved : By using old device drivers that also support fake PL2303 chips

- Not able to configure any settings of GPS module. Most probably these are clones and hence not programmable (read abt it in some forum) → Verify and Confirm this once
-

Date : 28/03/2024 (Thursday)

GPS Module

(Consuming around ~30mA)

- Switch it ON initially till you get GPS fix, then switch it off → Use hot starts when needed to get location data.
 - Use MOSFET/Transistor based switch to cut off power supply : Might not be practical as we have a voltage drop across FETs (PN-NP junctions), meaning that we have to provide a significantly higher voltage inorder to ensure that GPS receives ~3.3V.
 - Send NMEA commands from ESP to switch module off (But does this work in clones)
- Switch ON the Power Save Mode (however this might not be possible to configure in NEO-6M clones)

Resources to check

- <https://electronics.stackexchange.com/questions/235041/low-voltage-drop-transistor-mosfet-switch-3-3v-200ma>
(Learn about voltage drop in MOSFETs)

GSM Module

- Restarting modem - Establishing connection to network
- GPRS connection
- HTTP connection (with DB)

ESP12F

- Goto Deep Sleep mode once update to DB is done (and device gets a 200 http status code)
 - Switch off the RF circuitry
-

Date : 29/03/2024 (Friday)

Designing a MOSFET based switch for GPS module

- ESP12F I/O pin specs
(Ref : <https://www.quora.com/How-much-current-mA-can-each-pin-in-an-ESP8266-produce>)
 - Voltage : 3.3 V (or source voltage)
 - Current : max 12 mA
- Load - GPS module
 - Voltage : 3.3 V
 - Current : ~30-40 mA

Date : 30/03/2024 (Saturday)

References

1. <https://electronicsbeliever.com/how-to-select-a-mosfet-for-power-electronics/>
-

Date : 01/04/2024 (Monday)

Based on googling and considerations for a few days, best course of action to reduce power consumption are;

- Doing server updates based on current vehicle speed : Faster vehicle speeds, faster updates; Lower vehicle speeds, lower speed of updates
- Switch off GPS in b/w updates (hot starts take around 5-10 ms) using MOSFET (Switching to low-power modes is not an option for GPS clones)

Other possibilities

- Adding accelerometers, gyros and other sensors for filling in b/w data → Switch off GPS for longer time periods
 - Use more efficient GPS and GPRS modules : Less power consumption, Higher costs
 - Place a solar panel on top of the device to provide continuous supply
-

Date : 02/04/2024 - 04/04/2024

Power budget/estimate

- Analysis process performed on the power delivery network from input to electrical or electronic loads by identifying the power consumed by each electrical functional block and the power dissipated during the power delivery.

How to conduct a power budget analysis ?

- Identify components and subsystems
- Determine power requirements in terms of voltage and current for each component and subsystem (use datasheets)
- Estimate duration and frequency of each operating mode (active, standby, sleep, etc) and usage patterns
- Calculate power consumption of each component/ subsystem in each operating mode
- Sum up the power consumption of all components to obtain total power consumption of GPS device in each operation mode

NEO-6M GPS

Ref

- https://content.u-blox.com/sites/default/files/products/documents/NEO-6_DataSheet_%28GPS.G6-HW-09005%29.pdf : pg.15

| Parameter | Symbol | Module | Min | Typ | Max | Units | Condition |
|--------------------------------------|--|------------|------------------|-----|-----|-------|--|
| Max. supply current ¹⁵ | Iccp | All | | | 67 | mA | VCC = 3.6 V ¹⁶ / 1.95 V ¹⁷ |
| | Icc Acquisition | All | 47 ¹⁹ | | | mA | |
| | Icc Tracking (Max Performance mode) | NEO-6G/Q/T | 40 ²⁰ | | | mA | |
| | | NEO-6M/P/V | 39 ²⁰ | | | mA | |
| | Icc Tracking (Eco mode) | NEO-6G/Q/T | 38 ²⁰ | | | mA | VCC = 3.0 V ¹⁶ / 1.8 V ¹⁷ |
| | | NEO-6M/P/V | 37 ²⁰ | | | mA | |
| Average supply current ¹⁸ | Icc Tracking (Power Save mode / 1 Hz) | NEO-6G/Q | 12 ²⁰ | | | mA | |
| | | NEO-6M | 11 ²⁰ | | | mA | |

| Modes | Supply Voltage | Load Current | Power consumed |
|---|----------------|--------------|----------------|
| Acquisition mode [Cold start = 27 s, Hot start = 1 s] | 3.3 V | 47 mA | 155.1 mW |
| Tracking mode | 3.3 V | 40 mA | 132 mW |

SIM800L GSM

Ref : https://components101.com/sites/default/files/component_datasheet/SIM800L-Datasheet.pdf

| Modes | Supply Voltage | Load Current | Power consumed |
|---|----------------|--------------|----------------|
| GPRS Data Transmission (Tx burst = 2 A peak) | 3.3 V | ~250-350 mA | 825-1155 mW |
| Standby / Idle mode | 3.3 V | ~20-30 mA | 66-99 mW |

These values are approximate and may vary based on network conditions, antenna configurations, settings, etc.

ESP12F

| Mode | Supply Voltage | Load Current | Power consumed |
|--------------------------|----------------|--------------|----------------|
| Modem sleep + CPU active | 3.3 V | ~20 mA | 66 mW |
| Deep Sleep | 3.3 V | ~0.02 mA | 0.066 mW |

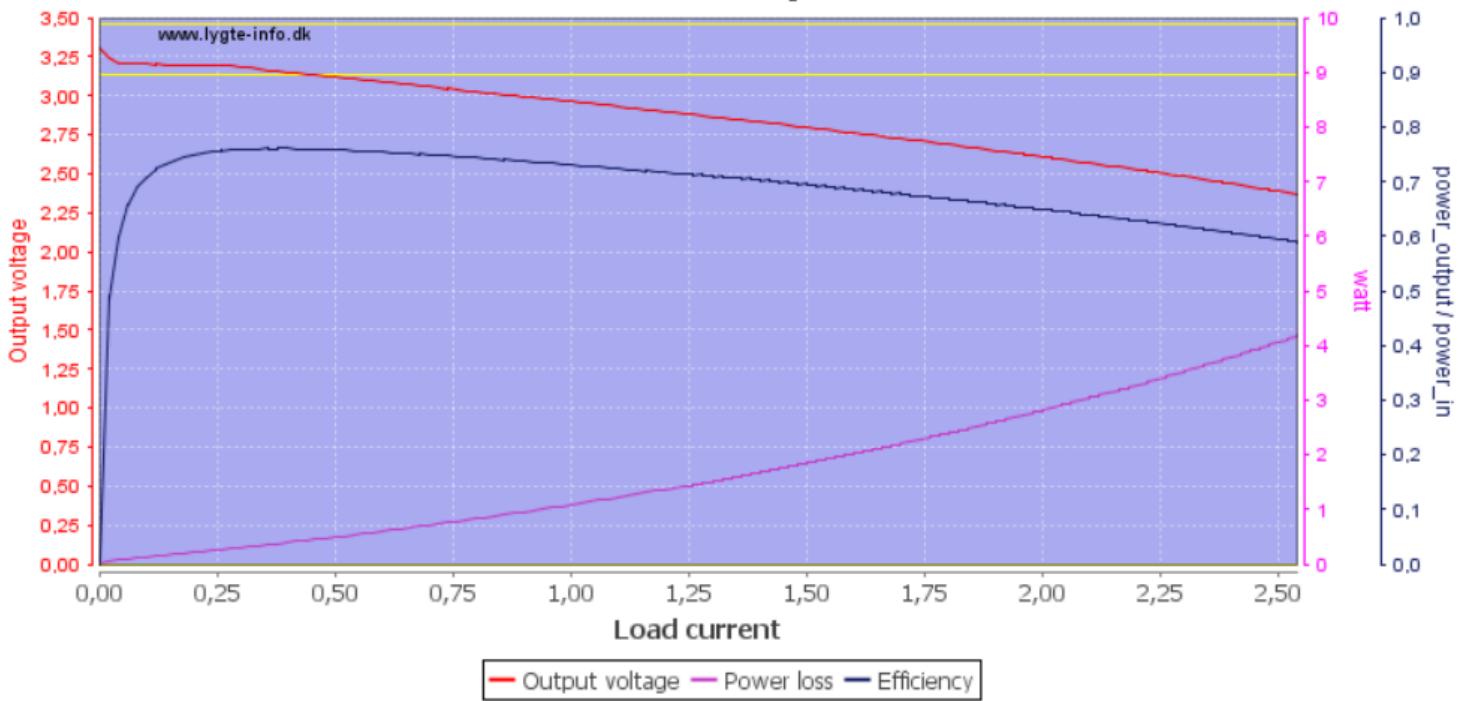
LM2956 buck converter module

Ref : <https://lygte-info.dk/review/Power%20Adjustable%20buck%20converter%20LM2596%20UK.html>

Input = 4 V

Output = 3.3 V

Load sweep 4V



Operating modes and power consumption of the system

Version 1

“Server updates” mode (table - “Power1”)

| Module | Current | Voltage | Power usage |
|-----------------|---|---------|---|
| NEO-6M GPS | 40 mA | 3.3 V | 132 mW |
| ESP12F | 20 mA | 3.3 V | 66 mW |
| Total (above 2) | 60 mA | | 198 mW |
| LM2956 | <ul style="list-style-type: none"> - Output = 60 mA, 3.3 V - From graph above → efficiency = ~70% - Hence, input current; $I = 86 \text{ mA } (60 * (100/70)) \text{ at } 3.7 \text{ V}$ | 3.7 V | 96 mW $((86-60 \text{ mA}) * 3.7 \text{ V})$ |
| SIM800L GSM | 300 mA (GPRS transmission) | 3.7 V | 1110 mW |
| Total device | | | 1404 mW |

* We are including 2A peak currents in SIM800L consumption

* Assuming, battery provides constant 3.7 V (as most of Li-ion discharge lifetime, it outputs 3.7V)

"In b/w Server updates" mode (table - "Power2")

| Module | Current | Voltage | Power usage |
|-----------------|--|---------|---|
| NEO-6M GPS | 40 mA | 3.3 V | 132 mW |
| ESP12F | 20 mA | 3.3 V | 66 mW |
| Total (above 2) | 60 mA | | 198 mW |
| | | | |
| LM2956 | <ul style="list-style-type: none"> - Output = 60 mA, 3.3 V - From graph above → efficiency = ~70% - Hence, input current; $I = 86 \text{ mA} (60 * (100/70)) \text{ at } 3.7 \text{ V}$ | 3.7 V | 96 mW $((86-60 \text{ mA}) * 3.7 \text{ V})$ |
| | | | |
| SIM800L GSM | ~30 mA (Standby) | 3.7 V | 111 mW |
| | | | |
| Total device | | | 405 mW |

Battery

- 2500 mAh Capacity battery
- Energy = Voltage * Capacity
 $= 3.7 \text{ V} * 2500 \text{ mAh} = 9250 \text{ mWh}$

Battery life approx calculation

Assumptions;

- We want to update the server every 30 secs → "Server updates" mode last for ~5-10 secs (based on observation) → Therefore, we will make "In b/w server updates" last for ~20-25 secs
- Avg. power consumption per cycle
 $= \text{"Server Update" mode power consumption} + \text{"In b/w server updates" mode}$
 $= [1404 \text{ mW} / (60 * 60)] * 10 + [405 \text{ mW} / (60 * 60)] * 20 = 3.9 \text{ mW} + 2.25 \text{ mW}$
 $= 6.15 \text{ mW is consumed in a single cycle (30 secs)}$
 $= 12.3 \text{ mW is consumed in a single minute (2 cycles / min)}$
- In an hour of operation, $12.3 \text{ mW} * 60 = 744 \text{ mW}$ is consumed
- Therefore, approx battery life in hours;
 $= 9250 \text{ mWh} / 744 \text{ mW} = \sim 12.5 \text{ hrs}$

Version 2

- ESP12F goes to deep sleep after updating to server

“Server updates” mode [Same as before]

“In b/w Server updates” mode - Updated (1) (table - “Power3”)

| Module | Current | Voltage | Power usage |
|-----------------|--|---------|---|
| NEO-6M GPS | 40 mA | 3.3 V | 132 mW |
| ESP12F | ~ 0.02 mA (Sleep) | 3.3 V | 0.066 mW |
| Total (above 2) | 40 mA | | ~132 mW |
| | | | |
| LM2956 | <ul style="list-style-type: none"> - Output = 40 mA, 3.3 V - From graph above → efficiency = ~70% - Hence, input current; $I = 57 \text{ mA} (40 * (100/70)) \text{ at } 3.7 \text{ V}$ | 3.7 V | 62.9 mW $((57-40 \text{ mA}) * 3.7 \text{ V})$ |
| | | | |
| SIM800L GSM | ~30 mA (Standby) | 3.7 V | 111 mW |
| | | | |
| Total device | | | ~305 mW |

Battery life approx calculation

Assumptions;

- We want to update the server every 30 secs → “Server updates” mode last for ~5-10 secs (based on observation) → Therefore, we will make “In b/w server updates” last for ~20-25 secs
- Avg. power consumption per cycle
= “Server Update” mode power consumption + “In b/w server updates” mode
 $= [1404 \text{ mW} / (60*60)] * 10 + [305 \text{ mW} / (60*60)] * 20 = 3.9 \text{ mW} + \sim 1.7 \text{ mW}$
= 5.6 mW is consumed in a single cycle (30 secs)
= 11.2 mW is consumed in a single minute (2 cycles / min)
- In an hour of operation, $11.2 \text{ mW} * 60 = 672 \text{ mW}$ is consumed
- Therefore, approx battery life in hours;
 $= 9250 \text{ mWh} / 672 \text{ mW} = \sim 13.7 \text{ hrs}$

Version 3

- ESP12F goes to deep sleep after updating to server
- MOSFET to switch ON/OFF GPS (supports hot-start, otherwise if we depend on cold-start it will take around 30 secs or even a few mins get GPS fix initially)

MOSFET selection

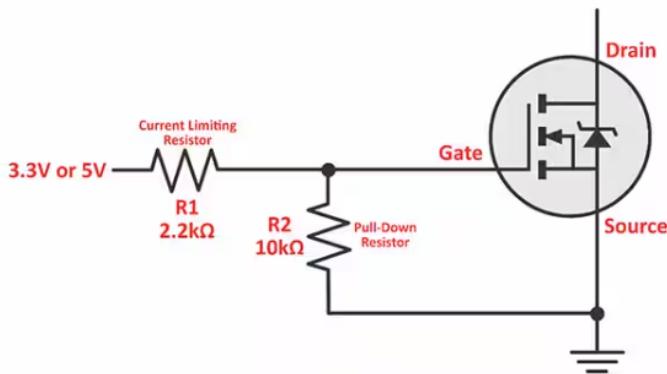


Figure 3

- A high signal from a specific pin on ESP12F will switch MOSFET ON. When ESP12F goes into deep sleep this pin is pulled low, switching the MOSFET OFF.
- Power loss = Conduction loss + Switching loss (We won't consider Switching loss as we don't use it that very frequently which includes turn-on loss and turn-off loss)
- Conduction loss = $I(\text{drain})^2 * R_{ds(\text{ON})}$ [(Drain current)² * On-resistance of MOSFET]
- I need a MOSFET that fills the following criteria : ***I want n-channel MOSFET for switching application to switch on a GPS module that consumes 47 mA at 3.3V. The gate of the MOSFET is connected to ESP12F that can provide a maximum of 12 mA at 3 V output. How to select a MOSFET such that the parameters are met and power consumption is reduced ?***
 - Gate-source voltage : $V_{gs(\text{th})} \leq 3\text{V}$
 - Gate drive current : $I_{gate} \leq 12\text{ mA}$ (this is the max load current that could be given by ESP12F)
 - Drain-Source voltage : $V_{ds} \geq 3.3\text{ V}$ (since GPS module needs ~3.3V for operation)
 - Drain current : $I_d \geq 47\text{ mA}$
 - On-resistance : $R_{ds(\text{on})}$ should be lower to minimize power dissipation and voltage drop across MOSFET when it is ON
 - I have to make sure that the $R_{ds(\text{on})}$ of MOSFET is such that $I_{gate} \leq 12\text{ mA}$, since it is the max current that ESP12F can possibly provide
 - Also, we want voltage drop should be as low as possible to ensure reduced power dissipation
- Based on above discussions, IRLZ44 MOSFET seems to be a good fit (Datasheet : <https://www.vishay.com/docs/91328/irlz44.pdf>). Check pg : 2
 - $R_{ds(\text{on})} = 0.039\ \Omega$ at $V_{gs} = 4\text{ V}$
 - $V_{gs(\text{th})} = 1-2\text{ V}$
 - Power loss (when MOSFET is in ON state) = $I(\text{drain})^2 * R = (47\text{ mA}^2) * 0.04 = 0.088\text{ mW}$

“Server updates” mode

When getting GPS fix (hot-start); (table - “Power4”)

- Note : Here we have the added power budget of a MOSFET also

| Module | Current | Voltage | Power usage |
|--------|---------|---------|-----------------------|
| MOSFET | | | 0.088 mW (see calc in |

| | | | |
|-----------------|---|-------|--|
| | | | begn. of Version 3) |
| NEO-6M GPS | 47 mA | 3.3 V | 155.1 mW |
| ESP12F | 20 mA | 3.3 V | 66 mW |
| Total (above 2) | 67 mA | | 221 mW |
| | | | |
| LM2956 | <ul style="list-style-type: none"> - Output = 67 mA, 3.3 V - From graph above → efficiency = ~70% - Hence, input current; $I = 95.7 \text{ mA } (67 * (100/70)) \text{ at } 3.7 \text{ V}$ | 3.7 V | 106 mW $((95.7 - 67 \text{ mA}) * 3.7 \text{ V})$ |
| | | | |
| SIM800L GSM | ~30 mA (Standby) | 3.7 V | 111 mW |
| | | | |
| Total device | | | ~438 mW |

Sending location data to DB (table - “Power5”)

- Note : Here we have the added power budget of a MOSFET also

| Module | Current | Voltage | Power usage |
|-----------------|---|---------|---|
| MOSFET | | | 0.088 mW (see calc in begn. of Version 3) |
| NEO-6M GPS | 40 mA | 3.3 V | 132 mW |
| ESP12F | 20 mA | 3.3 V | 66 mW |
| Total (above 2) | 60 mA | | 198 mW |
| | | | |
| LM2956 | <ul style="list-style-type: none"> - Output = 60 mA, 3.3 V - From graph above → efficiency = ~70% - Hence, input current; $I = 86 \text{ mA } (60 * (100/70)) \text{ at } 3.7 \text{ V}$ | 3.7 V | 96 mW $((86-60 \text{ mA}) * 3.7 \text{ V})$ |
| | | | |
| SIM800L GSM | 300 mA (GPRS transmission) | 3.7 V | 1110 mW |
| | | | |
| Total device | | | 1404 mW |

"In b/w Server updates" mode - Updated (2) (table - "Power6")

| Module | Current | Voltage | Power usage |
|-----------------|--|---------|-------------|
| MOSFET | ~0 mA (small leakage current) | 3.3 V | ~0 mW |
| NEO-6M GPS | 0 mA | 3.3 V | 0 mW |
| ESP12F | ~ 0.02 mA (Sleep) | 3.3 V | 0.066 mW |
| Total (above 2) | ~0 mA | | ~0. mW |
| LM2956 | - Output = ~0 mA, 3.3 V - From graph above → efficiency = ~70% - Hence, input current; $I = 57 \text{ mA } (40 * (100/70)) \text{ at } 3.7 \text{ V}$ | 3.7 V | ~ 0 mW |
| SIM800L GSM | ~30 mA (Standby) | 3.7 V | 111 mW |
| Total device | | | ~111 mW |

Battery life approx calculation

Assumptions;

- We want to update the server every 30 secs → "Server updates" mode last for ~15 secs (including GPS hot-start and sending location data to DB) → Therefore, we will make "In b/w server updates" last for ~15 secs
- Avg. power consumption per cycle
 = "Server Update" mode power consumption (when getting GPS fix hot-start)
 + "Server Update" mode power consumption (sending location data to DB)
 + "In b/w server updates" mode

$$= [438 \text{ mW} / (60*60)] * 5$$

$$+ [1404 \text{ mW} / (60*60)] * 10$$

$$+ [111 \text{ mW} / (60*60)] * 15$$

$$= 0.608 \text{ mW} + 3.9 \text{ mW} + 0.4625 \text{ mW}$$

$$= 4.97 \text{ mW is consumed in a single cycle (30 secs)}$$

$$= 9.94 \text{ mW is consumed in a single minute (2 cycles / min)}$$
- In an hour of operation, $9.94 \text{ mW} * 60 = 596.4 \text{ mW}$ is consumed
- Therefore, approx battery life in hours;

$$= 9250 \text{ mWh} / 597 \text{ mW} = \sim 15.5 \text{ hrs}$$