Data Acquisition System of an All-Terrain Vehicle

A MINOR PROJECT REPORT

Submitted by

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in partial fulfilment for the award of the degree

of

BACHELOR OF TECHNOLOGY

IN

ELECTRONICS & COMMUNICATION ENGINEERING

Maharaja Agrasen Institute of Technology

To Whom It May Concern

We, **Vikas Vivek** Enrollment No. **40714802818**, **Nishant Sharma** Enrollment No. **20814802818, Shashank Pundeer** Enrollment No. **40414802818 and Sumit Kumar** Enrollment No. **75314802818** students of **Bachelors of Technology (ECE), class of 2018-2022, Maharaja Agrasen Institute of Technology, Delhi** hereby declare that the MINOR PROJECT report entitled "***Data Acquisition System of an All-terrain Vehicle***" is an original work and the same has not been submitted to any other Institute for the award of any other degree.

Date: 6 June, 2022

Electronics and Communication Engineering

8-E-456

ACKNOWLEDGEMENT

First and foremost, we wish to express our profound gratitude to Maharaja Agrasen Institute of Technology, which allowed us to gather such a helpful and learning experience essentially important for the electronics branch. Secondly, we would like to thank SAE collegiate Club of MAIT and Team Jatayu for helping us experiment with their vehicle. This minor project is of an immense academic record. We would further like to extend our heartiest thanks to **Dr. Divya Goel** ma'am who encouraged us to cope up with the problems that we faced during this time.

Our heartfelt thanks for her immense help and support, useful discussions and valuable recommendations throughout the course of our project work. We wish to thank our respected faculties for their support.

Last but not the least we thank the almighty for enlightening me with their blessings.

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Abstract

The project is aimed to get data from the Society of Automotive Engineers (SAE) 4WD m-Baja vehicle which is a single-seated all-terrain vehicle and is used for off road usage and endurance on a rocky and rough terrain. In many aspects it is similar to an All-Terrain Vehicle (ATV) except that it is much smaller in size and has safer rollover capabilities. The values assumed for designing are then validated using Data Acquisition System, which includes various testing's', modifications and iterations. Thorough testing is done after implementation to get the best possible iteration of the design/part.

Keywords: embedded systems, off-road, data acquisition

Introduction

ALL-TERRAIN VEHICLE (ATV)

As the name implies, it is designed to handle a wider variety of terrain than most other vehicles. An all-terrain vehicle (ATV) is defined as a motorized off-highway vehicle designed to travel on four low-pressure or non-pneumatic tires, having a seat designed to be straddled by the operator and handlebars for steering control. ATVs are subdivided into two types as designated by the manufacturer. Type I ATVs are intended by the manufacturer for use by a single operator and no passenger. Type II ATVs are intended by the manufacturer for use by an operator and a passenger, and are equipped with a designated seating position behind the operator. Some famous ATV manufacturers include Polaris, Honda, Kawasaki etc.

Development of these vehicles take immense amount of time. Testing alone is the most tedious part of development of these vehicles. During the designing phase of these vehicles, some values of forces are assumed and other measurements need to be taken. First iteration is done via simulation only with highly assumed values, but after some initial iteration, physical tests are done, and this is where Data Acquisition comes into play.

Literature Review

The purpose of the roll cage is to provide a minimal three-dimensional space surrounding the driver. The cage must be designed and fabricated to prevent any failure of the cage's integrity. The goal is to design a chassis which is optimized in terms of size in such a way that it does not affect the driver's comfort. Ergonomics is the scientific and analytical discipline concerned with the design or understanding of interactions among humans and other elements of a system.

There has been a lot of improvement in the designing methodology of a vehicle these days. The aim these days is to provide maximum comfort to the driver. Companies like Rolls-Royce, Mercedes spent a lot on R&D for better driver comfort and performance of the vehicle. Modern sensors open the possibility of designing with exact values instead of assumed values. Data Acquisition would really help in acquiring values and giving refined designing procedures.

Objective

The project is aimed to get data from the Society of Automotive Engineers (SAE) 4WD m-Baja vehicle which is a single-seated all-terrain vehicle and is used for off road usage and endurance on a rough terrain. In many aspects it is similar to an All-Terrain Vehicle (ATV) except that it is much smaller in size and has safer rollover capabilities. The values assumed for designing are then validated using Data Acquisition System.

This project is divided into subdivisions-

1.1 RPM measurement and Speedometer

1.2 Damper Tuning using Laser Sensor

1.3 Using Cantilevered Load Cell

1.4 Strain Gauge

1.5 Lora & HC12

1.6 Flow Meter

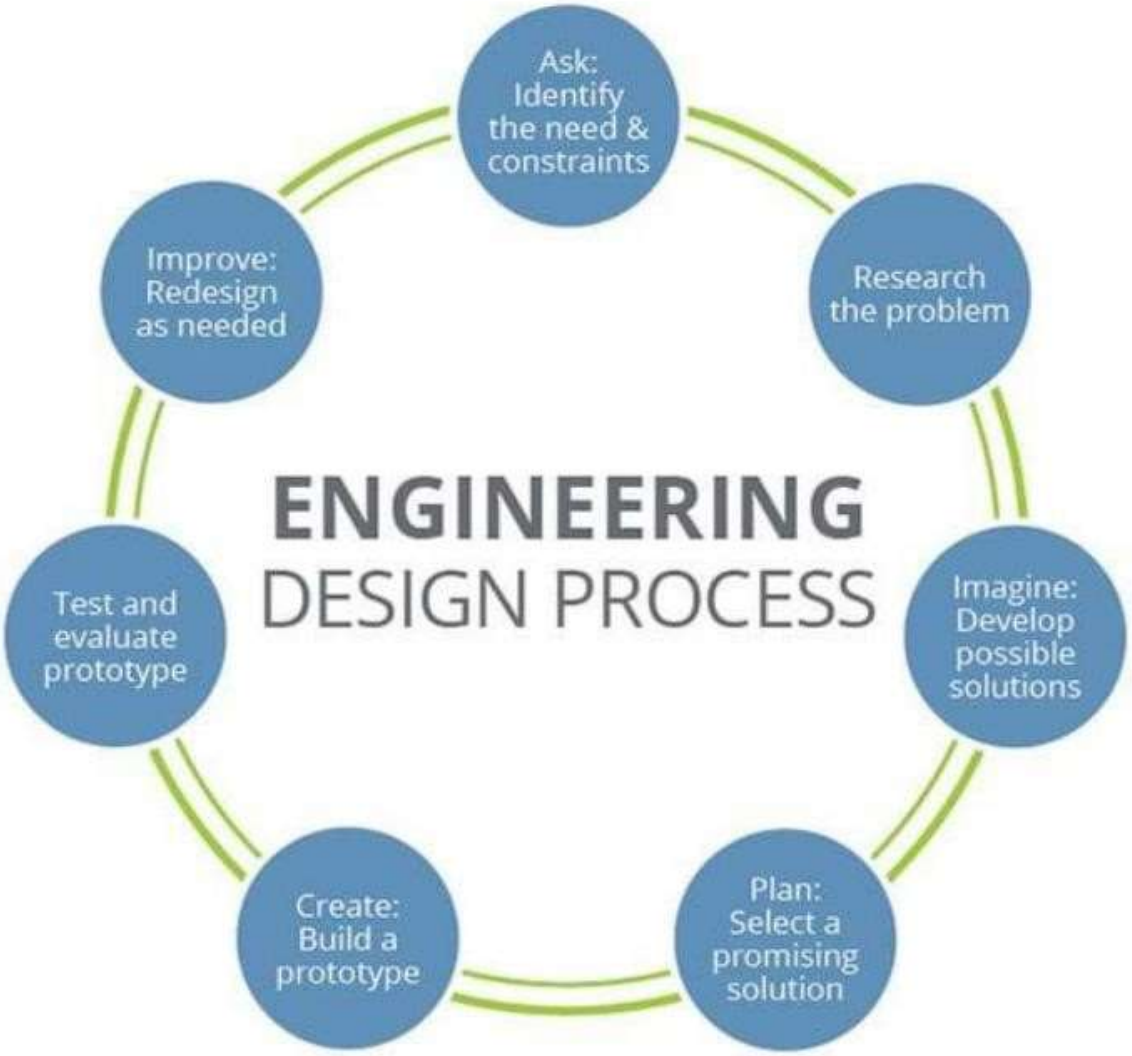
1.7 OLED

1.8 PCBs

1.9 Dashboard

2.0 DAQ Box

Design Ideology



1.1 RPM Measurement and Speedometer

Measuring rotation of a rotating shaft sounds simple, but it's the very basic step to tackle. And building the brains of such a device is no joke. So, to start with, we gathered

- Arduino Mega, a commonly available hobbyist microcontroller which provides multiple interrupts
- A3144 Hall Effect Module, which has high precision and high frequency device which detects magnetic field
- A strong neodymium magnet for high intensity and focus magnetic field
- HC-05 Bluetooth module to record and store data even on a moving vehicle

To measure the rpm, neodymium magnet was stuck with the steel shaft, then mounted securely with the help of feviquick and electrician's tape.

Hall effect module only work on close proximity with the magnet, thus mounting it was a challenge. Thus, it was mounted on the gearbox with the help of quickhardening m-seal. Now, when the shaft will rotate, magnet will rotate with it, coming in close proximity with the sensor on every turn. The hall effect module will register a pulse on every revolution of the magnet, thus noting down the RPM of the gearbox shaft.

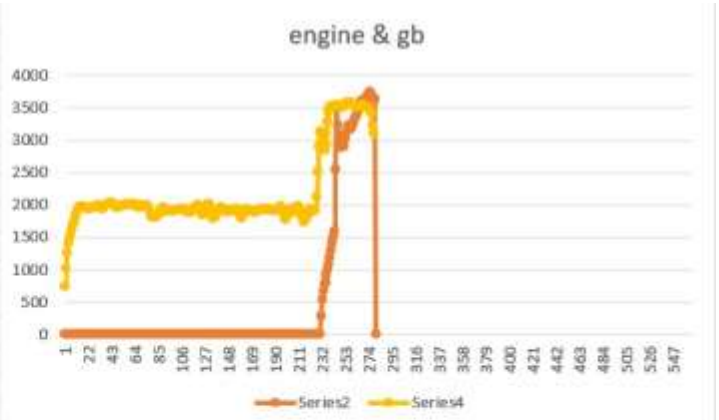
Now that we have the RPM of the gearbox shaft, we can do a similar approach on for the engine RPM. But an internal combustion engine already has a magnet mounted on the flywheel to generate current for the spark plug which will then ignite fuel in the piston chamber. So, making further use of inbuilt magnet, Hall Effect Module was mounted in such a way that on every rotation of the flywheel, its magnet would be in close proximity. Thus, again, module will register a pulse on every revolution, thus noting the engine RPM.

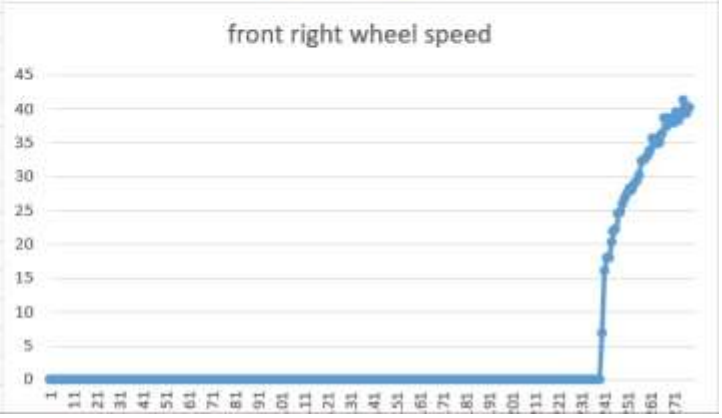
Speedometer – It is essentially a device which measures speed of a moving object, such as a vehicle. So, to measure speed of our ATV, we mounted the module near front left wheel, as RPM of the wheel will output the actual speed of the moving vehicle. But, during slow speed, wheel doesn't rotate much. And thus, even though wheel will rotate, pulse will not be registered due to magnet not being near the module. Hence, for this problem, we simply used four equally spaced magnets so that even on slow rotations, there's at least one pulse generated, which will be registered as an actual RPM.

Four magnets can be seen mounted near the Hall Effect module.

Data was obtained and stored via Bluetooth module, and thus we obtained RPMs of gearbox, engine and vehicle speed and the graph so plotted can be seen below.

(shaft)	0 (engine)	739	Speed	0
(shaft)	0 (engine)	1014	Speed	0
(shaft)	0 (engine)	1263	Speed	0
(shaft)	0 (engine)	1399	Speed	0
(shaft)	0 (engine)	1487	Speed	0
(shaft)	0 (engine)	1555	Speed	0
(shaft)	0 (engine)	1634	Speed	0
(shaft)	0 (engine)	1708	Speed	0
(shaft)	0 (engine)	1744	Speed	0
(shaft)	0 (engine)	1809	Speed	0
(shaft)	0 (engine)	1832	Speed	0
(shaft)	0 (engine)	1877	Speed	0
(shaft)	0 (engine)	1920	Speed	0
(shaft)	0 (engine)	1955	Speed	0
(shaft)	0 (engine)	1980	Speed	0
(shaft)	0 (engine)	1982	Speed	0
(shaft)	0 (engine)	1980	Speed	0
(shaft)	0 (engine)	1974	Speed	0
(shaft)	0 (engine)	1957	Speed	0
(shaft)	0 (engine)	1943	Speed	0
(shaft)	0 (engine)	1941	Speed	0
(shaft)	0 (engine)	1940	Speed	0
(shaft)	0 (engine)	1940	Speed	0
(shaft)	0 (engine)	1950	Speed	0
(shaft)	0 (engine)	1954	Speed	0
(shaft)	0 (engine)	1958	Speed	0
(shaft)	0 (engine)	1964	Speed	0
(shaft)	0 (engine)	1968	Speed	0
(shaft)	0 (engine)	1982	Speed	0





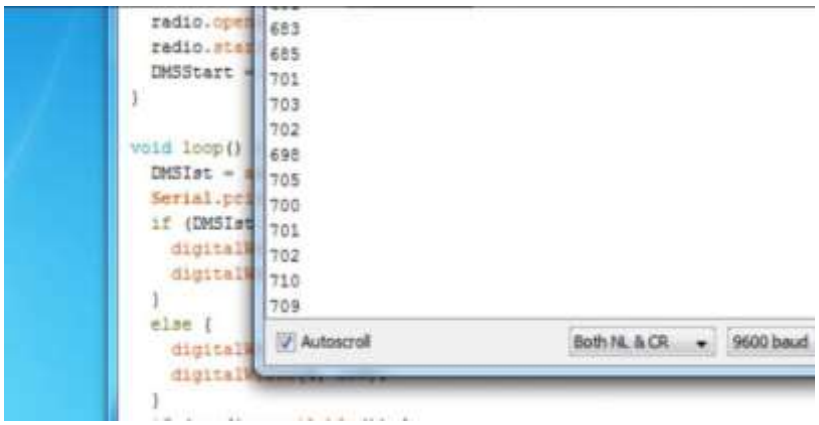
1.2 Cantilevered Load Cell

A strain gauge is a device which can measure strain in a part of metal piece. A load cell is nothing but strain gauge attached to an aluminum piece. Whenever this aluminum piece would be in stress, it would bend ever so slightly, and the amount by which it bends will be recorded by the attached strain gauge. Load cells are used in almost every weighing scale, and are commonly available in the correct markets.

Strain Gauge is a very simple transducer, that is, they change their resistivity when any deflection in metal piece is measured.

We are using a load cell of upper limit of 200kgs which was enough for our required applications. The signal from load cell alone is very feeble, thus we use HX711 amplifier and an Arduino Uno to record the data

Now, in the ATV, some force needs to be assumed during designing of some braking components that the driver will apply on the brake pedal. To measure exactly how much that force is, we mounted this load cell on pedal itself after calibration and thus, actual driver force was measured which came out to be 680N.



Carrying over the same idea, we implemented the load cell as a damper, or shocker. Instead of installing a damper, we placed the modified load cell in the position hoping to measure dynamic forces that act on the damper. But, during this process, calibration wasn't done correctly, so the data acquired from this setup wasn't reliable. However, even though it was unsuccessful, we will try again after we gain access to our college.

1.3 Damper Tuning using Laser

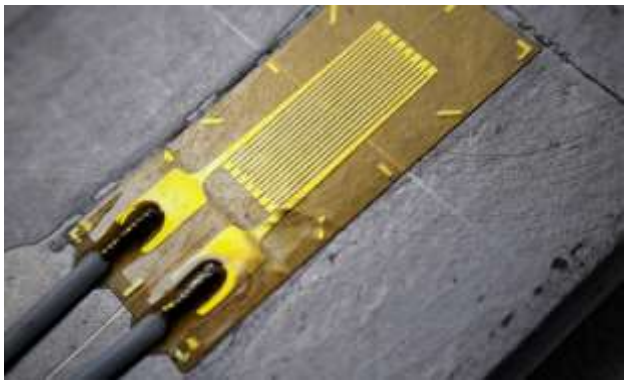
The spring and damper have a very important role to play in race car vehicle dynamics and performance. As a system, it controls the relative motion between the sprung and unsprung masses and is arguably the most important for its influence into tire performance. The VL53L0X is a new generation Time-of-Flight (ToF) laser ranging module housed in the smallest package. Providing accurate distance measurement whatever the target reflectance unlike conventional technologies. It can measure absolute distances up to 2m, setting a new benchmark in ranging performance levels, opening the door to various new applications.

A damper has two parts, one which moves according to the bumps and surface of road, and other being the stable one, mounted to the vehicle chassis. We mounted the laser sensor on the fixed part of front right damper, while mounting a reflective surface on the moving part. Thus, as the damper will compress and expand, it's every movement will be recorded accurately and precisely, which can be seen in the graph. This data was recorded when vehicle was making a left turn, thus, we can see deflection due to body roll and weight transfer.

1.4 Strain Gauge

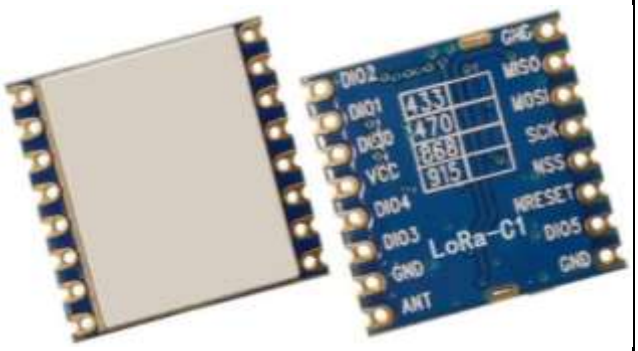
A Strain gauge (also spelled strain gage) is a device used to measure strain on an object. It takes advantage of the physical property of electrical conductance and its dependence on the conductor's geometry. When an electrical conductor is stretched within the limits of its elasticity it will become narrower and longer, which increases its electrical resistance end-to-end. Conversely, when a conductor is compressed such that it does not buckle, it will broaden and shorten which decreases its electrical resistance end-to-end. From the measured electrical resistance of the strain gauge, the amount of induced stress may be inferred.

Here we have used linear patterns strain gauge which are used to measure strain in a single direction. Its application includes: Fatigue testing, concrete testing, Crack propagation, Dog Bone testing etc.



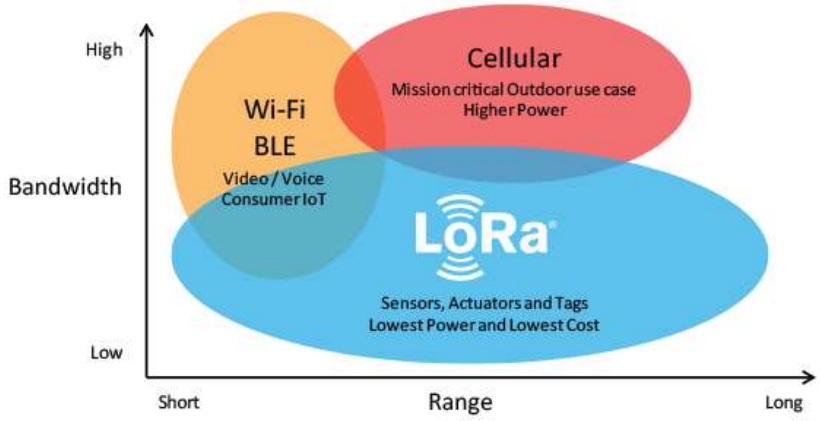
1.5 Lora & HC12

The term LoRa stands for Long Range. It is a wireless Radio frequency technology introduced by a company called Semtech. This LoRa technology can be used to transmit bi-directional information to long distance without consuming much power. This property can be used by remote sensors which have to transmit its data by just operating on a small battery.

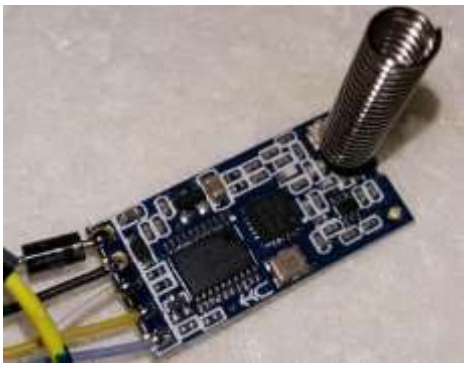


Typically Lora can achieve a distance of 15-20km (will talk more on this later) and can work on battery for years. Remember that LoRa, LoRaWAN and LPWAN are three different terminologies and should not be confused with one another. We will discuss them briefly later in this article.

Problem faces in LoRa – Range was not as high as advertised. Data received during testing in college was extremely reliable, but during the event, either due to extreme heat or vibrations or other noise, data was very noisy and choppy. Also, range was lost after almost 100-150 ft even during line-of-sight communication. Overall, it's a good transceiver, but didn't work quit as effectively as it should.



HC-12 is a wireless serial port communication module used in variety of applications like wireless sensor, building security, wireless robot control, PC wireless networking etc.The figure shows the image of wireless module HC-12. HC12 is a wireless serial port communication module used in variety of applications like wireless sensor, building security, wireless robot control, PC wireless networking etc. It features 1 KM open space wireless transmission at a baud-rate of 5000 bps. The maximum transmission power is 100 mW. It includes built-in MCU for serial communication with external device.



Problem faced in HC12 - Same problem as LoRa, but data was not as noisy as LoRa. Range was even shorter, with data disappearing at about 50ft.

1.6 Flow Meter

Flow meters are sophisticated measuring devices that employ a range of technologies designed to quantify the rate or volume of a moving fluid, either liquid or gas, in an open or closed conduit. For the measurement of the fuel level during the run time of the vehicle we have used a simple flow meter and Arduino Uno. We have used a Hall Effect, an electromagnetic-typed flow meter.

Hall-effect, in general, is the presence of a transverse voltage on a current-carrying conductor with a nearby magnetic field. A voltage exists because the magnetic field tends to push or pull the charges (depending on the polarity of the magnetic field) to one side of the conductor. If one side of the conductor is more negative than the other, then a potential difference exists and thus voltage arises.

The flow meter is places in between the pipe that connects the fuel tank and the engine as the fuel flow from the fuel tank to the engine, the impeller that is present in the flow meter rotates horizontally and this rotation is traced by the hall effect sensor which generates an electric pulse during each rotation of the impeller and this data is processed by the Arduino Uno and then the data is displayed through the OLED.

During the event the seal around the fuel line was ruptured due to vibrations, thus fuel entered the circuitry. But this didn’t impact its performance, and was corrected by installing a clip around the seal. The flow meter worked efficiently all the event, and was very reliable during the 4-hour endurance race.

1.7 OLED

Displaying the data to the driver is very important so the brightness of display play a critical part as most of the event are during the day time. So we have used the OLED (Organic Light-Emitting Diode) display as it is the brightest display available. The OLED display is an alternative for an LCD display. It is super-light, almost paper-thin, flexible, and produce a brighter and crisper picture.

We have used has individual 128*64 white OLED pixels. It is 0.96'' (25mm* 14mm) in size and monochrome (only one color) but there are many color available. This OLED uses I2C protocol. Though the SPI is generally faster than the I2C but it requires more I/O pins. While I2C requires only 2 pins and can be shared with other I2C peripherals. It's a trade-off b/w pins and speed.

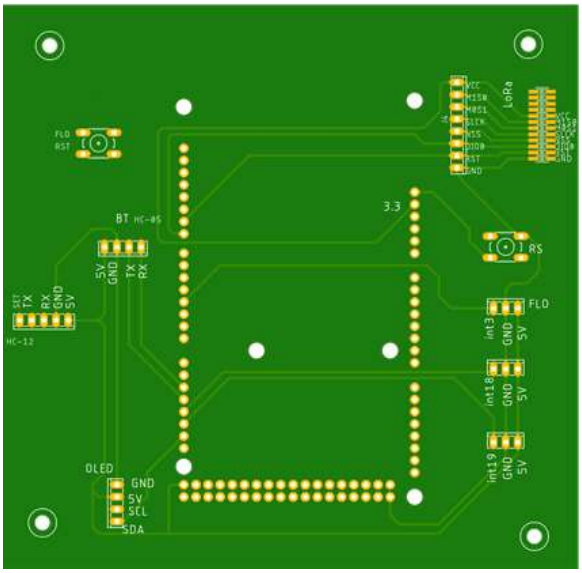
An OLED display works without a backlight because it makes its own light. This is why the display has such high contrast, extremely wide viewing angle and can display deep black levels. Absence of backlight significantly reduces the power required to run the OLED. On average the display uses about 20mA current, although it depends on how much of the display is lit.

During the event the OLED worked flawlessly under the daytime and was visible even in extreme light. Flow meter data was displayed on the screen

1.8 PCBs

The process of making a custom PCB is quite a tedious task as not only the designing of PCB is hard then choosing a suitable PCB manufacturer is quite an important process.

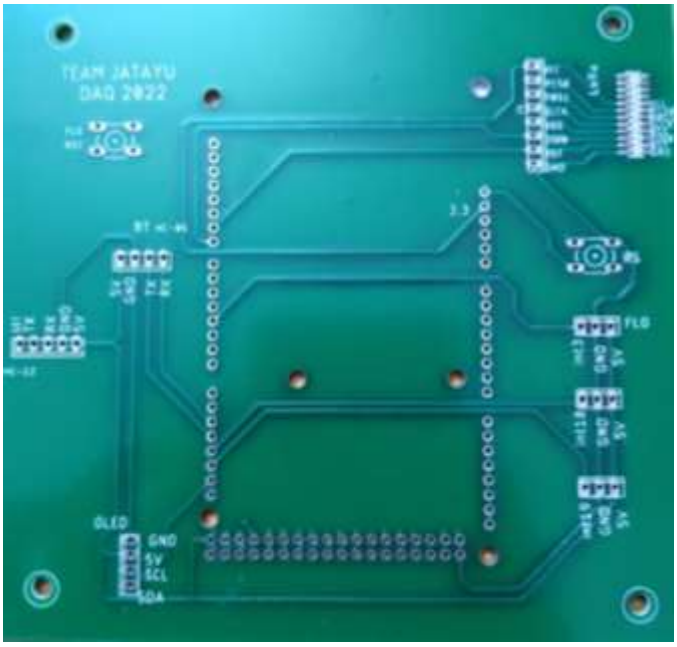
There are several necessary files needed to be shared directly to PCB manufacturer for them to process a custom PCB order. The following are the data



- All copper layers
- Share details about all paste, silkscreen, and solder mask layers.
- A valid silhouette, with slots and cutouts, indicates if possible
- Provide at least one fabrication drawing or suchlike document

There are factors that are to be considered such as mode of transportation for the delivery of the PCB, does the manufacture accept small orders, and the most important is that does the realization of the PCB guarantee function.

After foresing all these factors we have designed a custom PCB for better integration and packaging of the whole system. HC12, LoRa, HC05, OLED and other components.



We also made a PCB, designing components around basic AtMega328P chip. i.e., we've built a custom Arduino UNO, with much smaller footprint and better packaging.

1.9 Dashboard

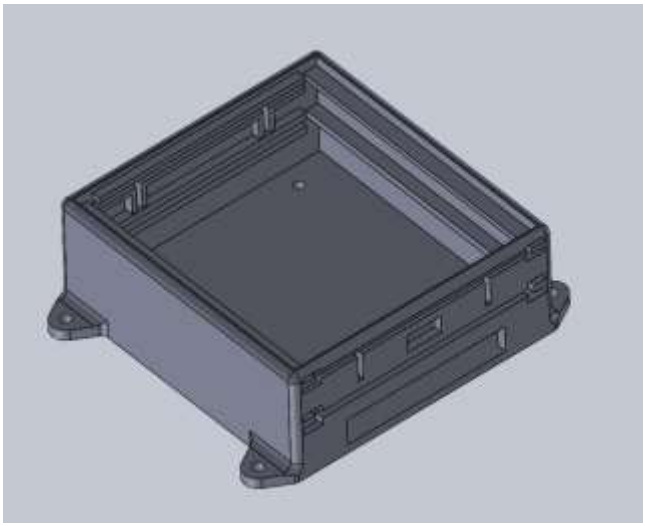
As we see on many cars, useful vehicle data is displayed on the dashboard. At minimum, a dashboard display has a speedometer and a fuel gauge. In addition to those gauges, the display will feature some combination of a tachometer, charging system gauge, oil pressure gauge and engine temperature gauge. But, in our ATV, as everything can be considered ‘raw’, no such data is displayed. To mitigate this problem, idea of driver-display came to fruition.

In this display, important information like Vehicle speed, fuel left and Engine RPM was displayed so that driver could take decisions easily.

2.0 DAQ Box

An enclosure was first design using the CAD software and then was 3-D printed for aforementioned PCB and for the safekeeping of the connectors and other connected modules.

As it contains all the main component or have the wiring of the component the structural strength is to be considered.



Results

- Engine, gearbox RPM was found out
- Vehicle speed was calculated and measured
- Force on brake pedal was found out
- Although unsuccessful, load as damper needs some more tuning and if data points do match, it’ll be highly beneficial.
- Damper as well as road frequency was found out
- Driver display is ready to be installed.