Presentation by interns 2023
Jibebe

10th May 2023
iPIC exhibition room, JKUAT

Who we are

About 15 students and supervisors

e-Tricycle

e-Tractor

Demand for Electric Vehicle (EV) is Rising

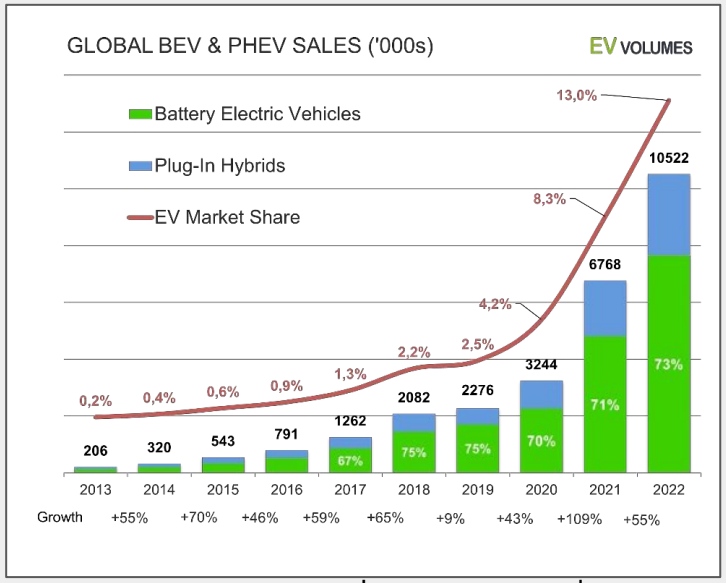


Image: www.ev-volumes.com

Establish EV research capability to assist Kenyan industry

Collaboration with

Association for the Physically Disabled of Kenya (APDK)

Garage visit

1st prototype

2nd prototype

Internship 2023
e-Tractor development

1. Electrify

2. Autonomous driving

Mechanical

Agricultural Engineering

Electrical

Electrical & Electronic Engineering

Navigation

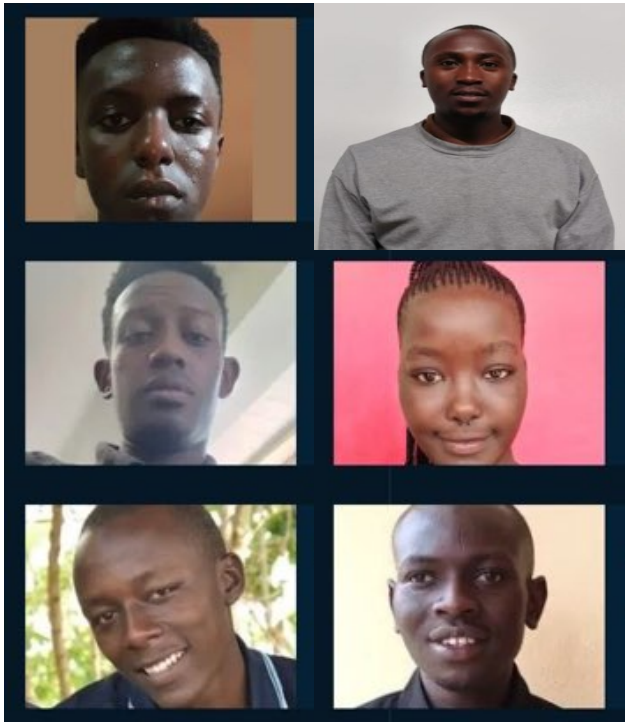
Electrical & Electronic Engineering

14 JKUAT students

JIBEBE SHUJAA E-TRACTOR
Mechanical team

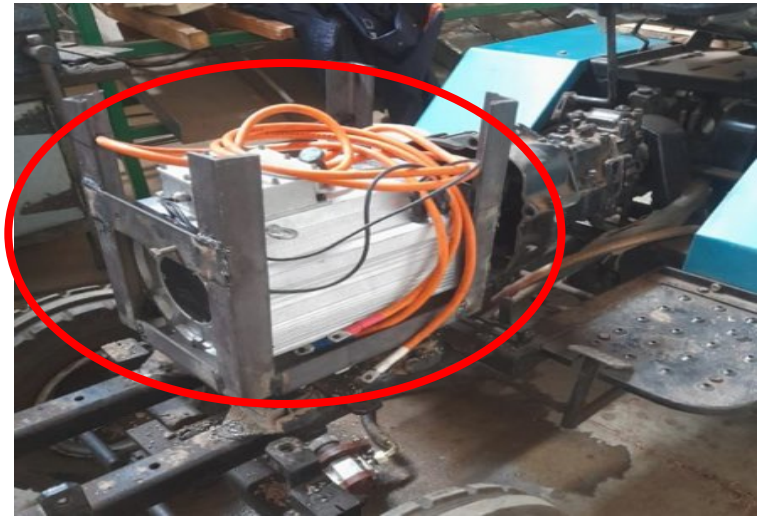
Supervisors;
- Dr. Shohei Aoki
- Mr. Kipkorir Rono

TEAM MEMBERS
- Isaac Ngugi
- Ian Mutisya
- Clinton Otieno
- Catherine Kipkazi
- Kennedy Ouma
- Peter Nzioki



Upgrade of ***Shujaa Tractor***

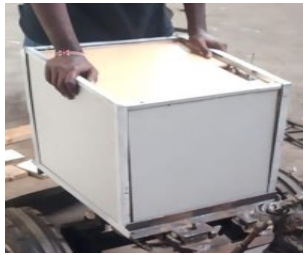
Internal combustion engine



Electric motor

Objective: Electrification of Shujaa tractor

Motor



Battery box

Specific objectives

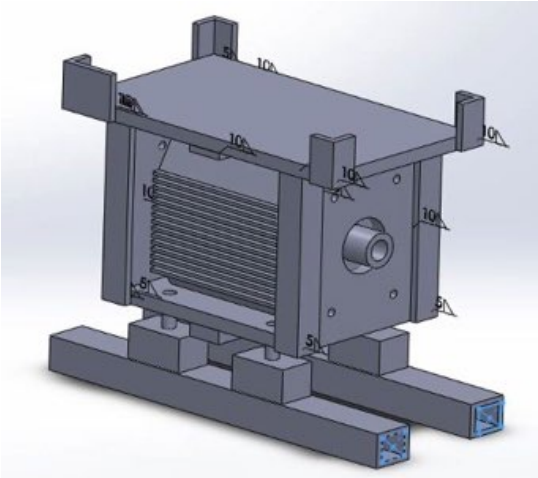
1. Disassembly of IC engine and its components
2. Design of motor and battery mountings
3. Design of a new steering system
4. Adjustments to increase **stability**
5. Fabrication and assembly of the EV

Tractor

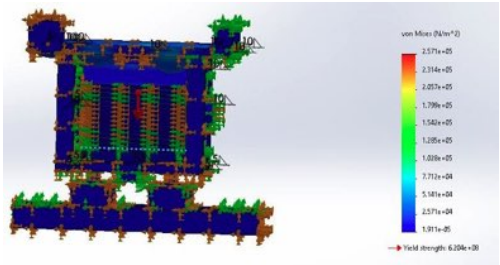
TIMELINE

- WEEK 1-3- Design
- WEEK 2-11- Fabrication work
- WEEK 13-14- Testing

- **POWERTRAIN**
  - **Retained** to shorten development time
- **MOTOR MOUNTING**
  - Fabricated with focus on **cooling** capabilities and **weights reduction**



CAD design



Simulation

Fabricated mounter

Fabricated and upgraded components

Couplings

Battery mount

Rubber mounts

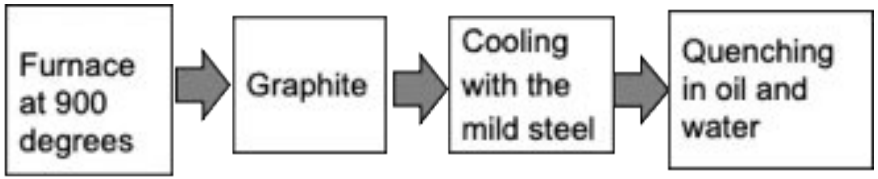
Machining

Grinding

Welding

Heat treatment of the mechanical parts

- Coupling for power transmission
  - **Mild steel** used
  - **Heat treated** to enhance the strength with assistance from Mr. Mwai



MILD STEEL HARDENING PROCESS

Furnace

Part (red-hot)

BATTERY MOUNTING

- Integrated into the chassis to **reduce weight and complexity**
- Chassis was extended to **improve weight distribution**

DESIGN OF A NEW STEERING SYSTEM

Steering angle using the **Ackerman geometry**

$$R = \frac{b}{\sin\phi} + \frac{a-c}{2}$$

R: Turning radius
Θ: Inner steering angle
Φ: Outer steering angle

$$\theta = \cot^{(-1)} \cot\left(\frac{\phi - c}{b}\right) = 11.5$$

$$\phi = \left[\sin^{(-1)}\right]\left[\frac{b}{\left(R + \left(\frac{c-a}{2}\right)\right)}\right] = 10.5$$

Total steering angle $\phi + \theta = 22$

Steering ratio $\frac{364}{22} = 16:1$

Total angle turned by steering wheel

$$= \frac{Lock\ to\ lock\ rack\ distance}{2 \times 3.14 \times \text{pinion}\ radius}$$

$$= 1.01 turns \times 360 = 364$$

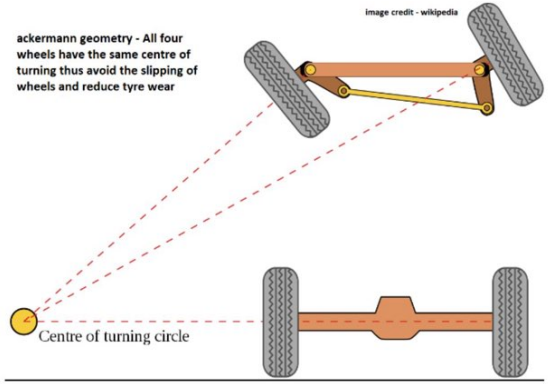


Figure -: 1 Ackerman geometry

Fabrication of new steering system

Designed steering system

Steering column and steering rack installed on the tractor

Checking the steering

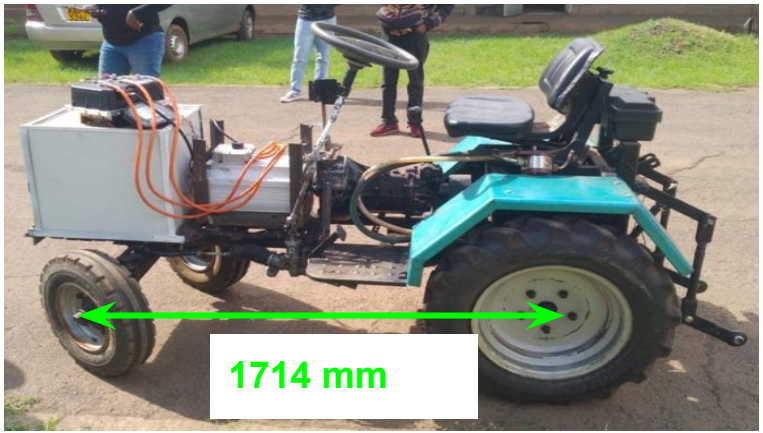
ADJUSTMENTS ON STABILITY

Wheelbase was increased by 200mm

Yawing and **pitching** of the tractor was **reduced**

Before modification

After modification



Tractor demo

Tractor on road during testing

Challenges

- Inexperience in the field of advanced testing and simulation
- Lack of technical knowledge in some research areas

Remaining issues

In the next prototype, there are a few changes to be made to make it ready for production. These are such as;

- Incorporation of a **suspension** to improve ride quality
- Implementation of **traction control** to improve stability
- Upgrading braking from **2 wheel drum brake** to **hybrid disc** and **drum brake**.
- Incorporation of **power steering**
- Incorporation of **all wheel drive** with torque vectoring

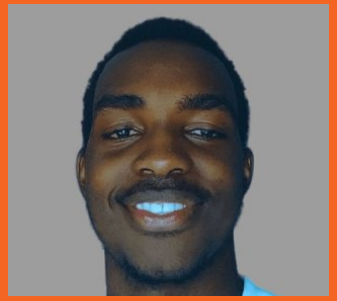
CLOSING REMARKS

As the mechanical team, we would like to appreciate the support we have received from our supervisors with special focus on Dr. Shohei Aoki. The encouragement and willingness to assist has propelled us to push the development of the Shujaa E-tractor. We would like to challenge the next mechanical team to push harder and optimize the Shujaa tractor further.

THANK YOU

どうもありがとうございます

Electrical Team -
Jibebe E-tractor project



Stephen Kinuthia

Laban Mwangi

Victor Ngatia

Eunice Orenge

Introduction

- The main objective was to convert an IC engine tractor into an **electric tractor**, thus design and fabricate the **electrical system**
  - Zero emissions
  - Less maintenance
  - Cheaper to maintain
- The main electrical components include:
  - Electric motor, battery, and control system

Objectives

1. **Design of the electrical system**
    a. Design the HV and LV circuits
    b. Design and fabricate power ports
    c. Design of buck converters
    d. Dashboard

Objectives

2. Testing of components

a. Motor tests: Speed,Braking,Output Voltage,Navigation modes tests.

b. Battery tests: Charging, Discharging rate,Output voltage

3. Mounting on tractor.

SPECIFICATIONS OF THE MAJOR ELECTRICAL SYSTEM COMPONENTS

The motor

-Output power 15kW
-Voltage Input 96V (AC)
-Current Max 174 A (AC)
-Rated speed 3000 rpm
-Peak speed 6000 rpm
-Rated torque 47.75 Nm

The controller

-Working voltage (DC) 96 - 144V
-Current Output Max 500 - 600A

The battery

-Capacity 16 kWh
-Voltage Output 106 V
-Current Output 3 A

Power flow

BATTERY

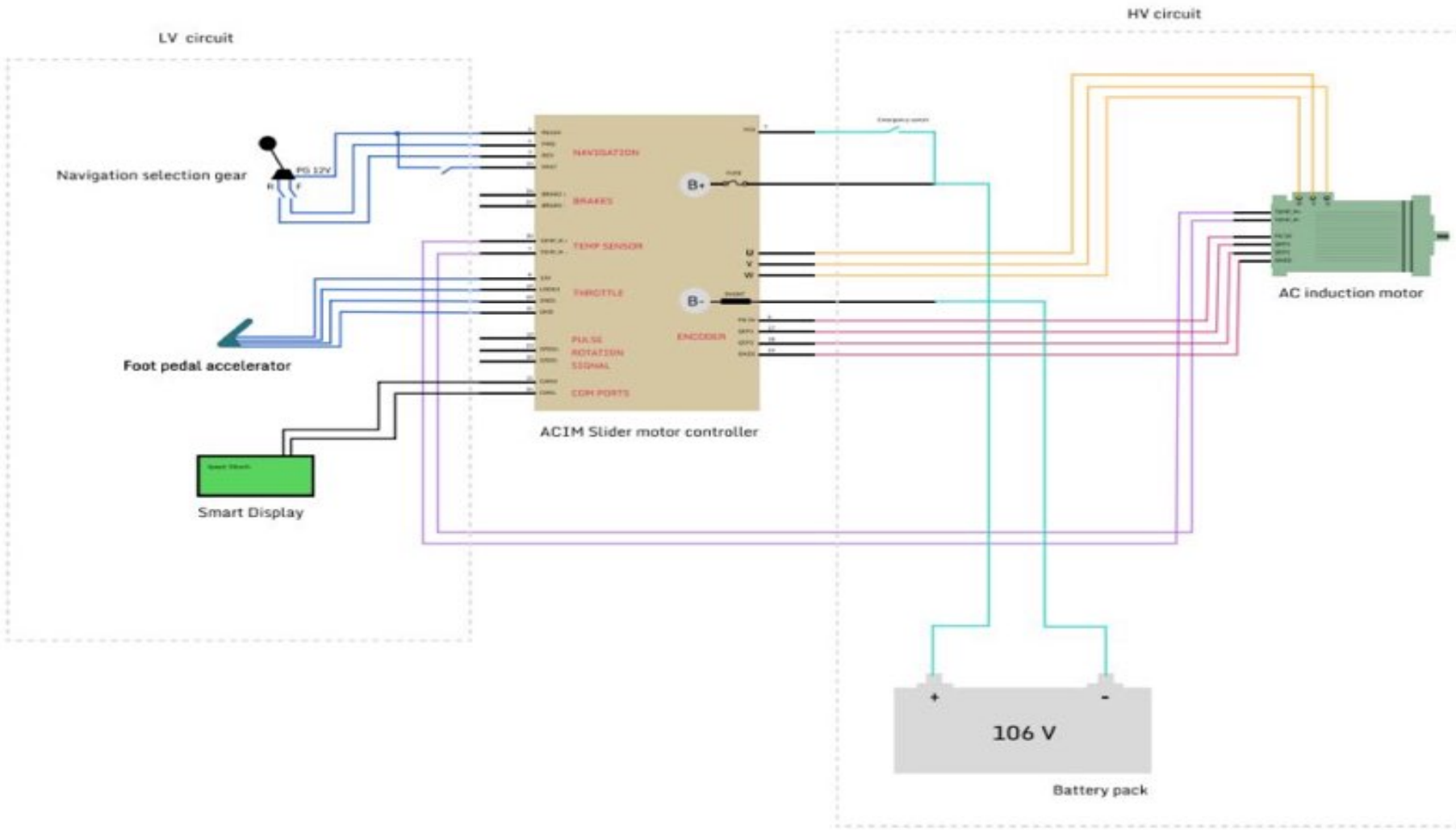
MOTOR CONTROLLER

MOTOR

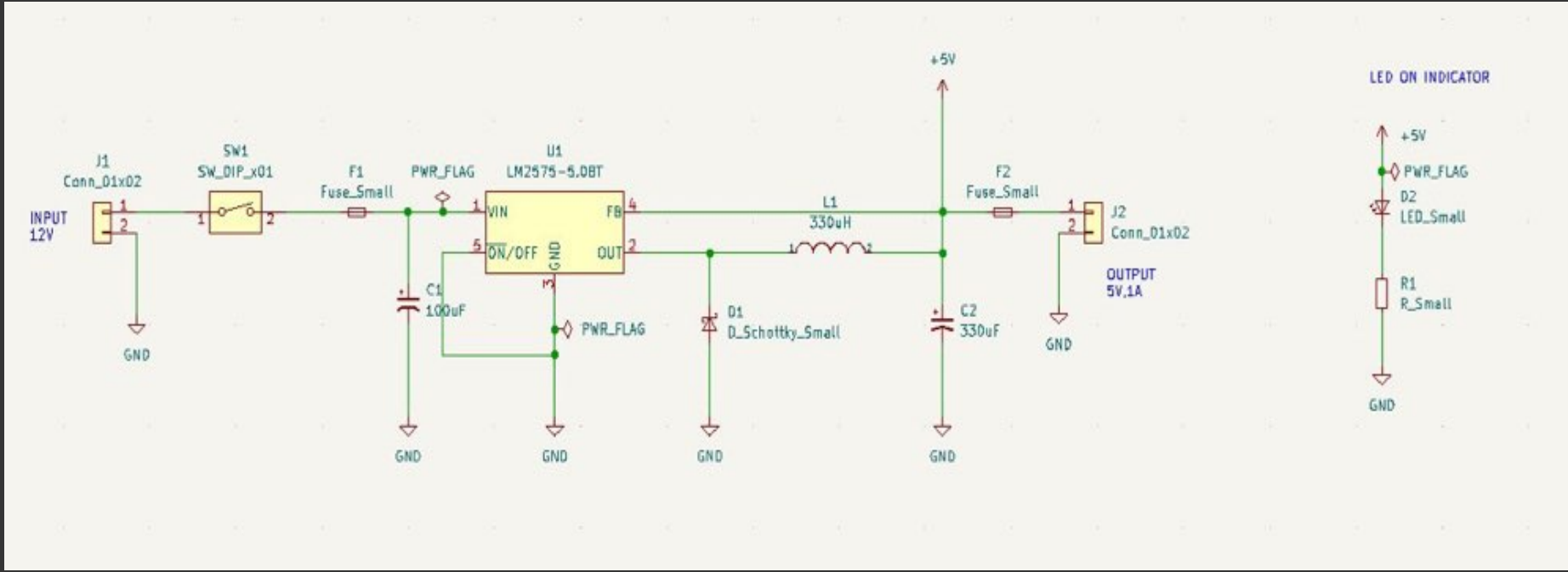
LOW VOLTAGE DC CONVERTER

LIGHTS AND INDICATORS OF THE TRACTOR

NAVIGATION SYSTEMS

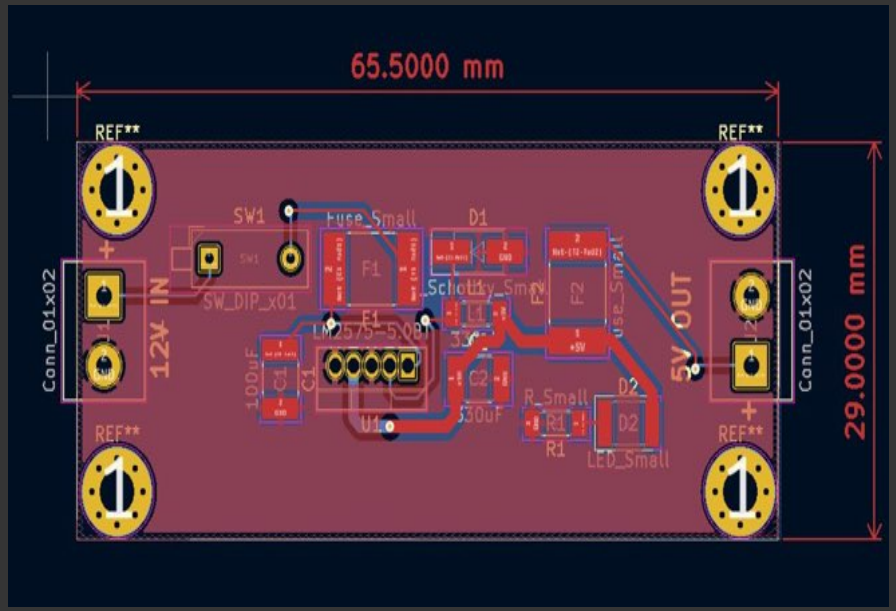

LV circuit
HV circuit
Navigation selection gear
PG 12V
R
F
Foot pedal accelerator
Smart Display
NAVIGATION
BRAKES
TEMP SENSOR
THROTTLE
PULSE ROTATION SIGNAL
COM PORTS
B+
B-
ENCODER
U
V
W
ACIM Slider motor controller
AC induction motor
+
-
106 V
Battery pack

Design of Buck Converter

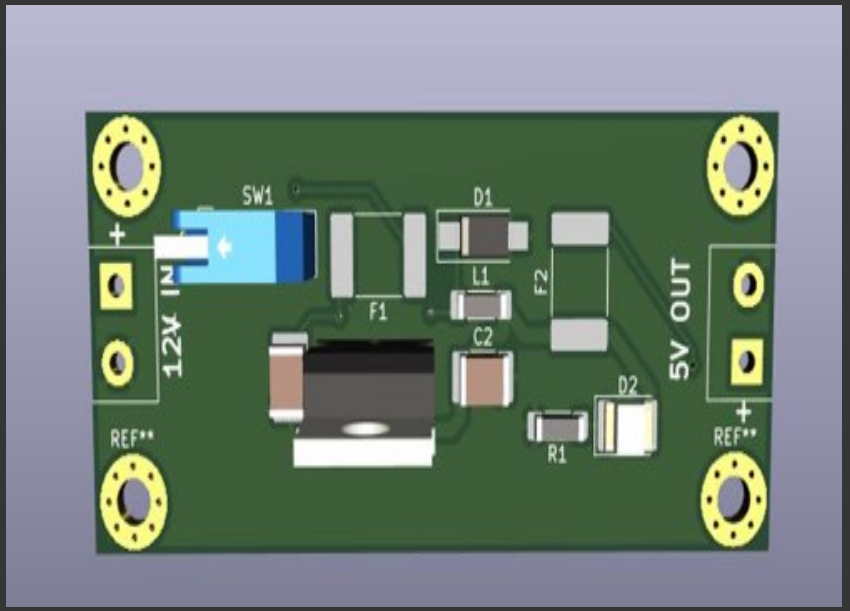


Schematic diagram of the converter

PCB Design of Buck Converter

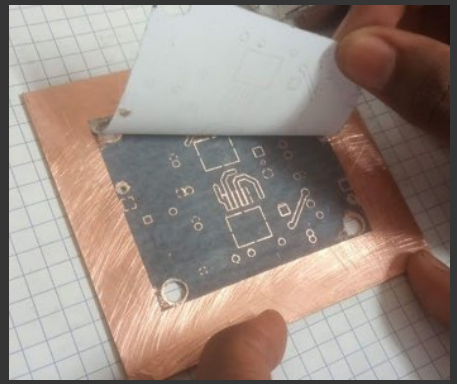


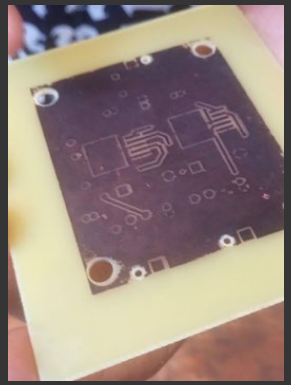
Design on KiCAD

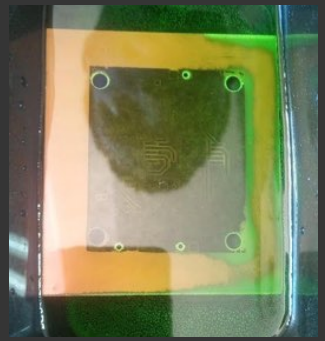


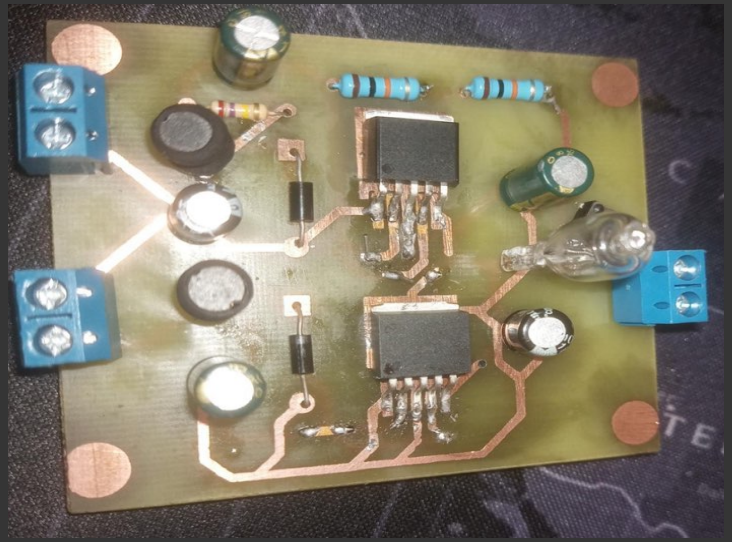
3-D Model

PCB Fabrication of Buck Converter









After etching and soldering the components on the PCB

Outcome of Tests

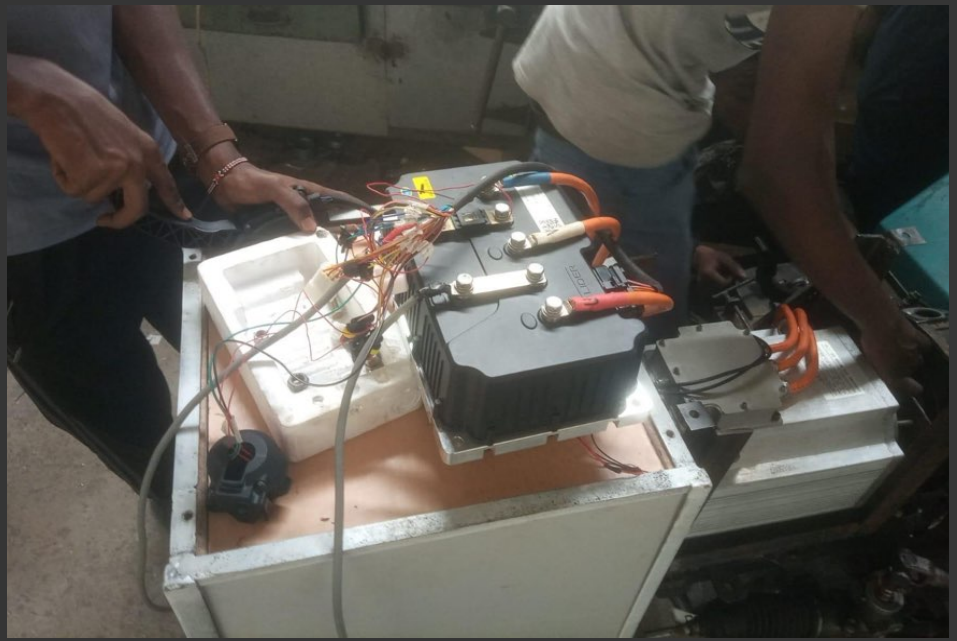
Motor Tests

- Speed Test : 3000 rpm
- Brake Test : Manually done on tractor.
- Controller output voltage : 60V Line to Line
- Navigation Modes i.e Reverse, Forward and Half Rev work perfectly

Battery Tests

- Output Voltage: 106V DC

Mounting components on the tractor



All electrical components on tractor

Display of Tractor

Challenges and remaining tasks

Challenges

- The first controller were disabled after experiencing an error
  - Under voltage and acceleration error
- A lot of time was spent in trouble shooting and purchasing another
  - The delay was felt across all the teams

Remaining Tasks

1. Connection of the DC-DC converters
2. Charging and Discharging Tests

Skills learned and developed

- PCB Designing
- Troubleshooting Electrical components
- PCB etching
- Soldering
- Presentation skills ; shaped by our weekly reporting sessions

Navigation Group.

DENNIS BUNDI

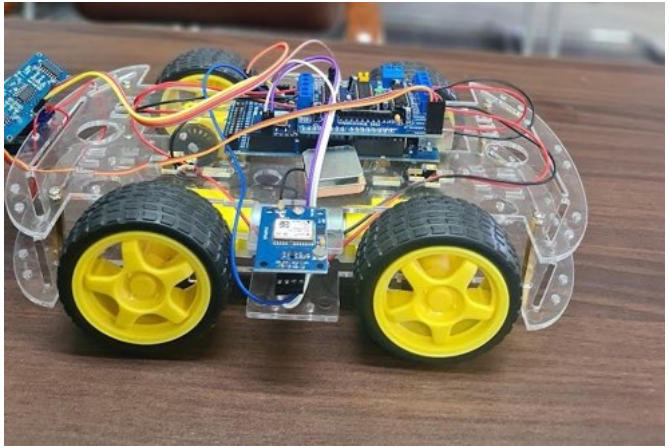
OMAR WAKA

KIRAGU MAINA

CHARLES OTIENO

Objective 1: Construction of a test robot

- Test robot was developed to test the following functions:
  - Obstacle Avoidance
  - Navigation system using GPS
  - Automation (unmanned system with functional sensors).
- Robot was actually developed in a period of three weeks



Test robot assembly

- Assembled the test robot
- Performed tests on the obstacle avoidance course
- Uploading of code
- Sensor calibration
- Motor driver speed control

Objectives 2: GPS navigation

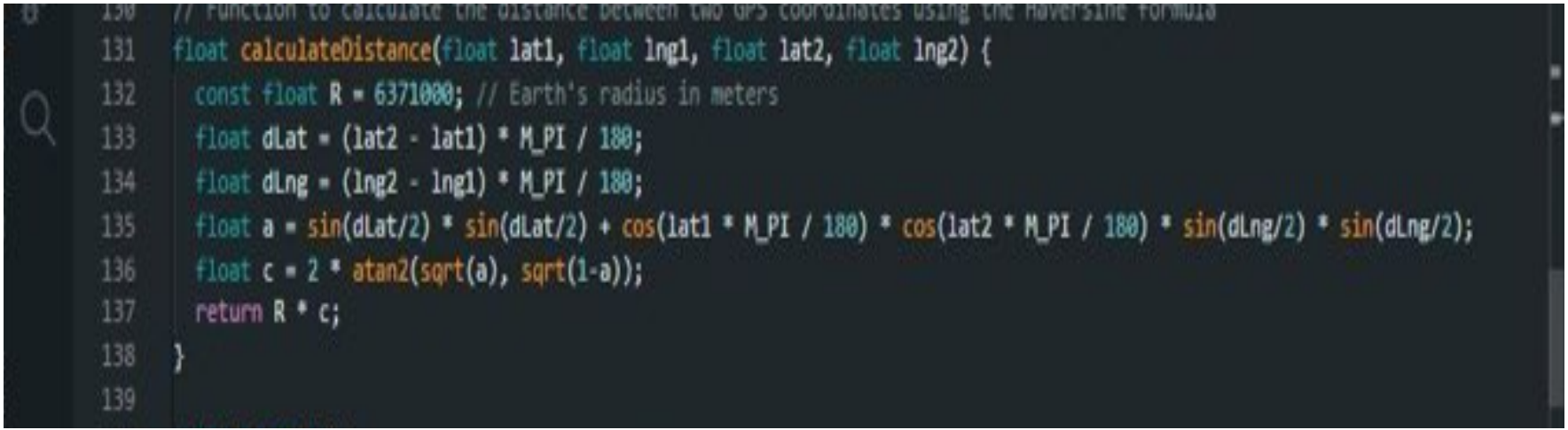
Research on available GPS modules

- **First module**
  - Neo 6m GPS module: Failure
  - Instability at first and later on total malfunctioning
- **Second module**
  - **Neo 7m GPS** module: Success
  - Needed some more calibration using the **haversine formula**
    - use the radius of the earth as the focal point
    - target point to the starting locations

Neo 7m GPS

HAVERSINE formula of the GPS module.

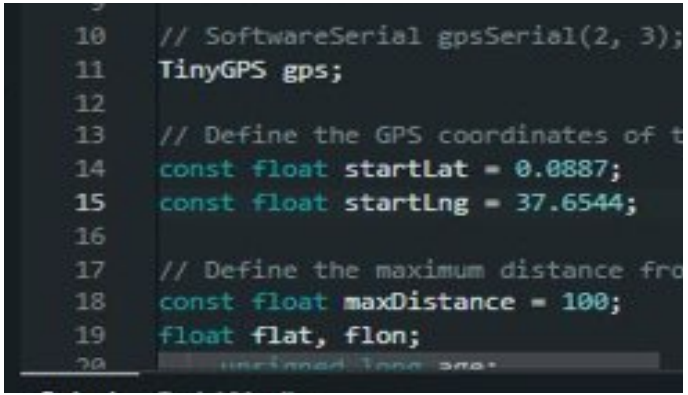
- Haversine formula is used to calculate the position
    - Longitude and latitude in meters



```
130  // Function to calculate the distance between two GPS coordinates using the Haversine formula
131  float calculateDistance(float lat1, float lng1, float lat2, float lng2) {
132    const float R = 6371000; // Earth's radius in meters
133    float dLat = (lat2 - lat1) * M_PI / 180;
134    float dLng = (lng2 - lng1) * M_PI / 180;
135    float a = sin(dLat/2) * sin(dLat/2) + cos(lat1 * M_PI / 180) * cos(lat2 * M_PI / 180) * sin(dLng/2) * sin(dLng/2);
136    float c = 2 * atan2(sqrt(a), sqrt(1-a));
137    return R * c;
138  }
139
```

Code Explanation

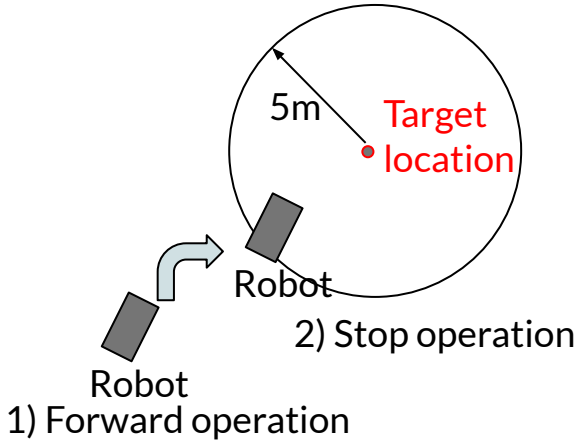
- Subtracting the two locations to achieve the distance to set TARGET
- Calculate both the **distance** and **cardinal orientation** from the current position to the set TARGET location



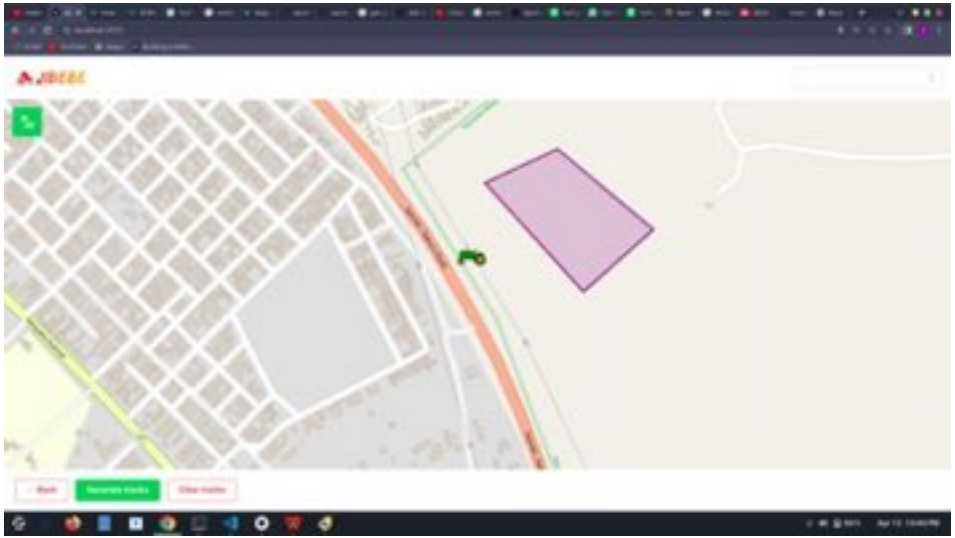
Code Explanation

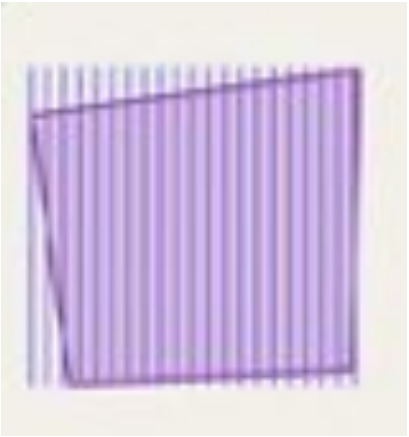
- Observe the reduction of distance and change in orientation from the serial monitor
- Upon further increase and maintaining the same coordinates, the distance and orientation remains constant showing the the GPS module is working and actively calculating the distance.

```
10:48:44.320 -> Jibebe Project by Navigation group
10:48:44.353 -> Automation using GPS coordinates
10:48:44.388 ->
10:48:58.726 ->  LAT      LON          Distance to target location
10:48:58.760 -> -1.095524  37.012279   5.01 meters
```



Tractor path generator





CONCLUSIONS.

From the navigation group, we have made successful steps from our group objectives and some objectives are yet to be fulfilled.

- **Achievements.**

1. Assembly of test robot.
2. Obstacle avoidance sensor implementation.
3. GPS module testing.
4. Path generating application.

CONCLUSIONS.

From the navigation group, we have made successful steps from our group objectives and some objectives are yet to be fulfilled.

- **Future endeavours.**

1. Application on the tractor.
2. Development of a website.

Way forward

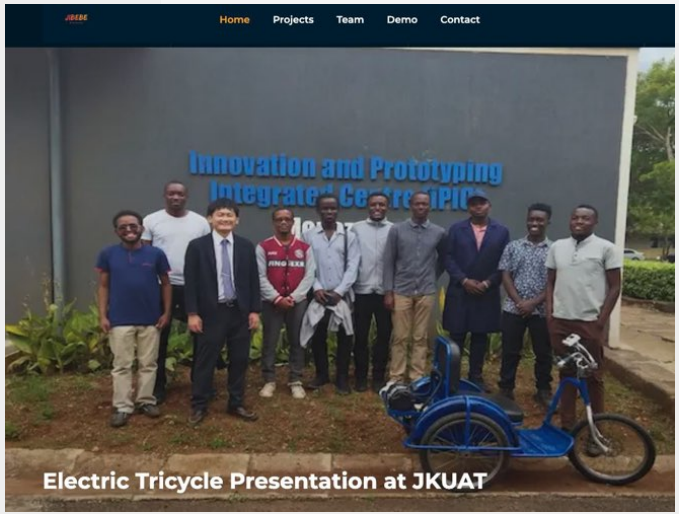
Final year students work with APDK to commercialize the tricycle

More JKUAT researchers are sought to establish EV research group

Tractor project seek industrial partner

Follow us

Jibebe JKUAT



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