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Design and Fabrication of Electric Go-Kart

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***Abstract:-* The report aims at discussing the design procedure of the Go-Kart vehicle. The report is an account of application of extensive engineering concepts, production engineering, project management and team work. The report is a submission proof that these ideas have been efficiently and viably converted into a high performance vehicle.**
With the vision to eliminate the harmful gases in the air caused due to smouldering of fuel and to form a pollution-free environment, we have designed an electric go-kart.
This report is aimed at designing and developing a working model of an electric go-kart. The design and fabrication of the go-kart are made simple so that it could be operated even by non-professional drivers. The design is made keeping in mind the high strength of vehicle which can sustain more weight and provide the best facilities at a low cost.

Keywords Go-Kart, Electric vehicle, Lithium ion Battery, High performance vehicle.

I. INTRODUCTION

The design has been approached by considering all possible alternatives for a system by modelling them in CAD software like CREO Parametric 3.0 and analysed it on ANSYS 16.0 FEA software.

The design is mainly focused on the following objectives: Safety, Serviceability, Strength, Ruggedness, cost, durable, lightweight, high performance, ergonomics, and aesthetics.

Sub-Departments for Design:

- Chassis Department
- Steering Department
- Brakes and Tyres Department
- Transmissions Department

II. DESIGN METHODOLOGY

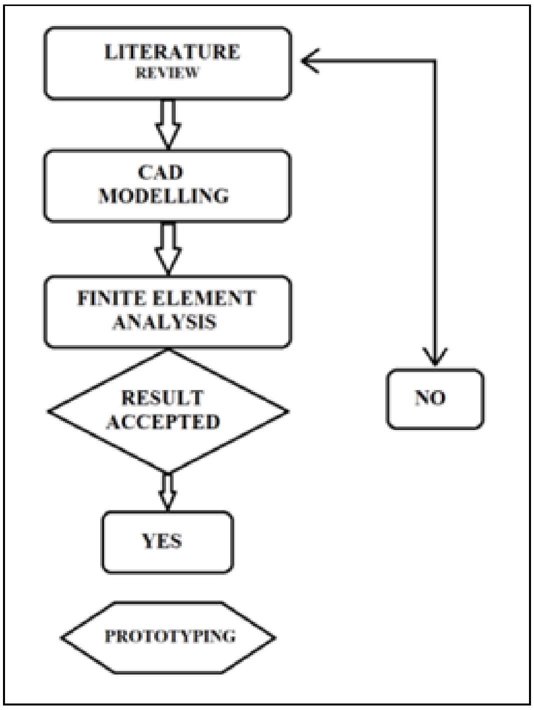

Fig.1. Design Methodology

TABLE I: COMPLETE VEHICLE SPECIFICATION

Parameters	**Specifications**
Overall Length	1.90691m (75.1”)
Overall Width	1.1938m (47")
Overall Height	1.088m (42.82”)
Wheelbase	1.1684m (46”)
Track Width	0.9652m (38”)
Ground Clearance	0.06326m (2.5”)
Max Speed	21.37 m/s
Max Acceleration	3.16 m/s^2
C.G Height	0.1397m (5.5”)
Stopping Distance	1.240 m (48.8”)
Overall Weight	190 Kg
Steering Ratio	1:1
Weight Distribution	35:65
Motor	48 V, 4.5KW BLDC
Battery	48 V, 50Ah Li-ion
Brake Disc	0.190m
Turning Radius	3.0214m
Ackermann Angle	21.8°

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III. MATERIAL SELECTION

The material with low cost high strength and good weld ability must be used for the roll cage. After the extensive paper study of different material, we concluded to decide between SAE 1018 and SAE 4130.

Alter discussion and analysis considering the physical strength, weight, availability and cost of the material we decided to use AISI 4130 as a roll cage material.

TABLE II. MATERIAL COMPARISON

Properties	**AISI 1018**	**AISI 4130**
% carbon	0.14-0.20	0.28-0.33
Density (g/cc)	7.87	7.85
Modulus of Elasticity (GPa)	200	205
Yield Strength (MPa)	365	435
Ultimate Strength (MPa)	450	670
Bulk Modulus	140	140
Poisson's Ratio	0.29	0.29
Elongation at Break	15%	25.50%

[1] ROLL CAGE

Calculation of Impact force:

The estimation of impact force was done by using "**Impulse-Change in momentum theorem**."

Impulse = F. Δt

Overall Weight (m) = 190 Kg (max.)

Δt = Impact time

F. Δt = ΔP

$$F = \frac{m * v}{\Delta t}$$

Impulse Time = Weight*(velocity/load)

Δt= 0.4 sec

A. Worst collision case

B. General Case (Real world scenario)

Front Impact Tests:

Impact load calculations regarding front impact test are as follows:

M (mass of the vehicle = 190kg Driver included)

Velocity (v) = 90Km/hr = 25m/sec

$$F = \frac{m * v}{\Delta t}$$

F = 11875 N

Conclusion:-

Deformation = 0.52997mm

Stress generated = 334.65MPa

Thus in frontal collision, if the load reaches to the front most member the chassis and driver would be safe with

F.O.S = 1.148 (considering yield point as material strength)

Rear Impact Test:

In rear collision, the vehicle is assumed to be stationary, fixed and another vehicle with same mass and collides with the former vehicle. Force is applied on rear portion of vehicle and all DOF'S of front were constrained.

Velocity (v) = 70Km/hr = 19.44m/sec

F = 9237 N

Conclusion:-

Deformation= 0.0035142m

Stress generated= 490.23MPa

IV. CAD MODEL

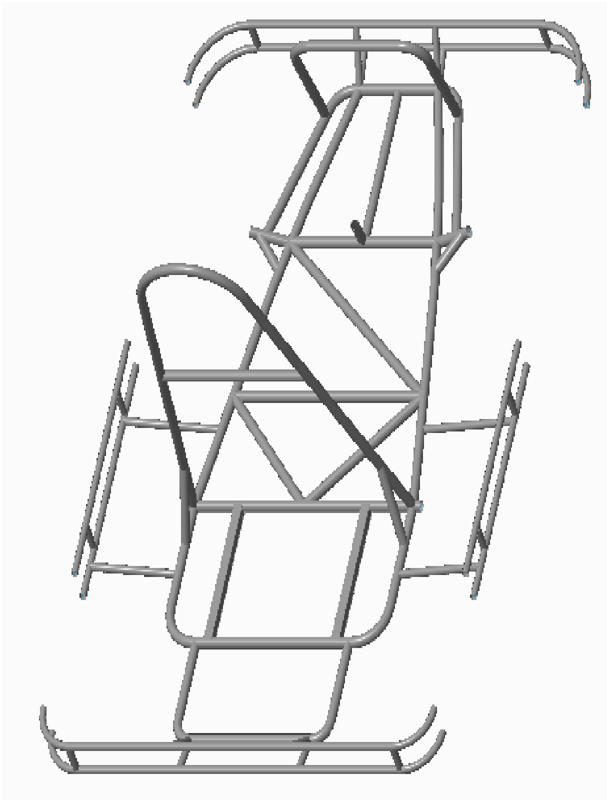

Fig.2. Isometric View Roll cage

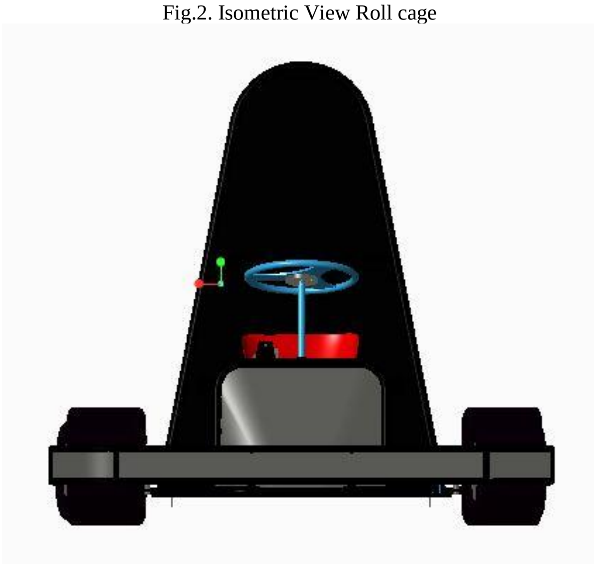

Fig.3. Front View

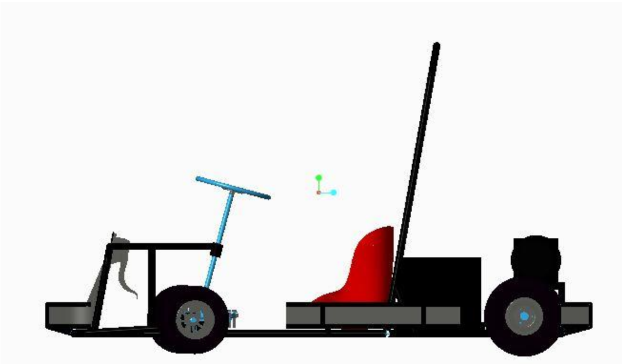

Fig.4. Left View

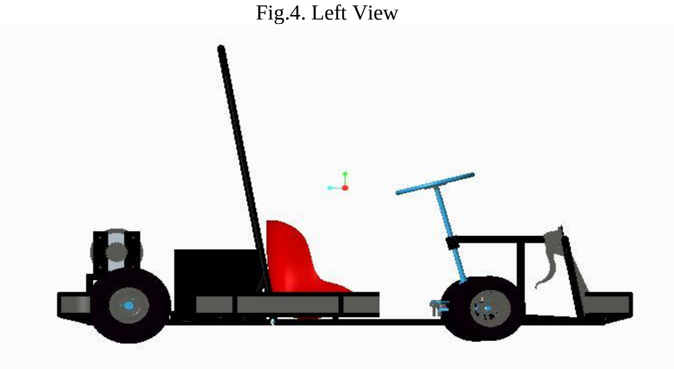

Fig.5. Right View

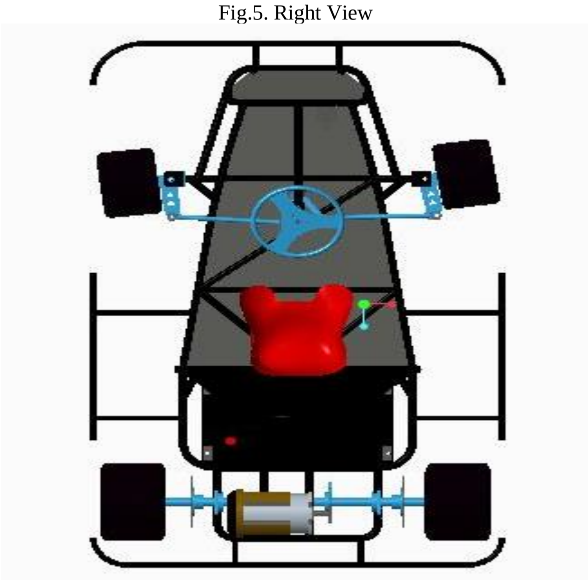

Fig.6. Top View

V. CAE ANALYSIS

A. Front Impact

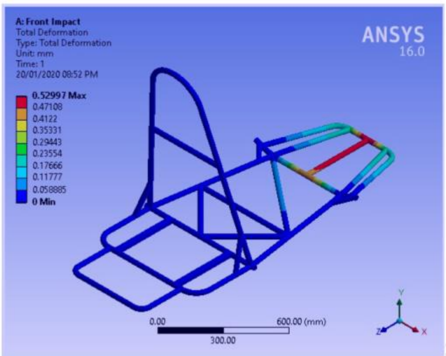

Fig.7. Total Deformation

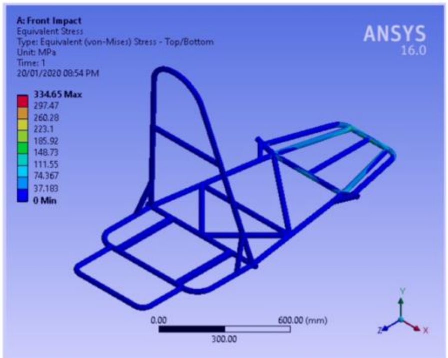

Fig.8. Equivalent Stresses

B. Rear Impact

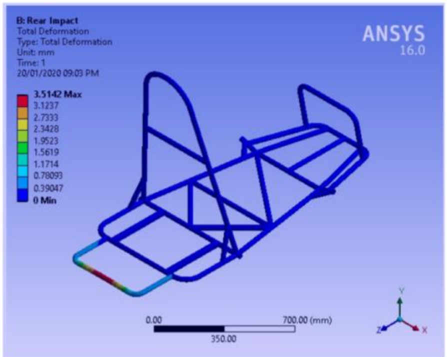

Fig. 9. Total Deformation

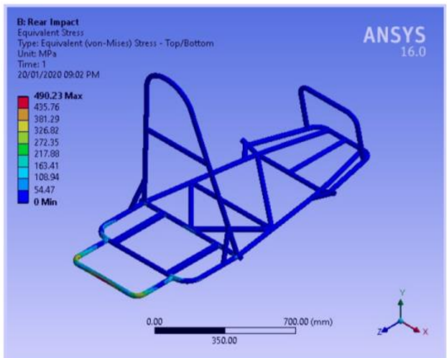

Fig.10. Equivalent Stresses

[2] STEERING

Steering system is one of the crucial mechanisms, which are responsible for a smooth maneuver controlling of the vehicle. Apart from the controlling of the vehicle, steering system is expected to display its Good Ergonomics as well as the ease of use. The primary objective of the any steering mechanism is to reduce the steering effort as possible and for that, decreasing the steering wheel travel which results in a quick responsiveness of the steering wheel. The steering geometry is Ackermann-type steering mechanisms which uses four-bar linkages.

TABLE III.

Description	Values
Wheelbase	1.1684 m
Track Width	0.9652 m
Inner Wheel Angle	32.6°
Outer Wheel Angle	22.2°
Turning Radius	3.0214 m

Ackermann Angle	21.8°
Length of Tie Rod	0.341m
Length of Stub Axle	0.132 m
Ackermann Error	0.4
Steering Ratio	01:01
Normal Force	686 N
Lateral Force	8750 N
Tractive Force	411 N
Moment of NF	4.05Nm
Moment of LF	38.7Nm
Moment of TF	53.4Nm
Torque on Kingpin	107.3Nm
Pivot Distance	0.3579 m
Camber Angle	2°
Caster Angle	2°
King Pin Inclination	2°
Scrub Radius	0.1317 m
Caster Trail	0.00433 m

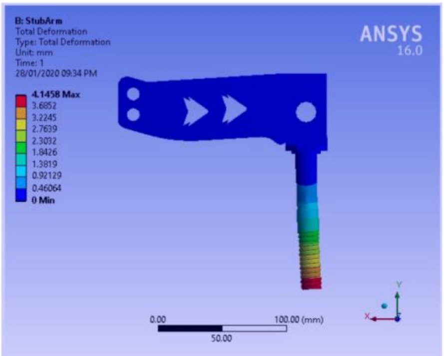

Fig.11. Stub arm Total Deformation

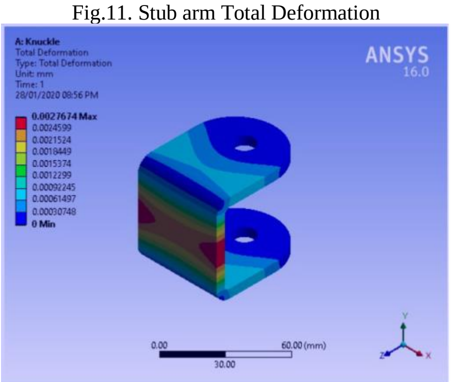

Fig.12. Knuckle Total Deformation

[3] TRANSMISSION

Electric Powertrain - EVs have a single-speed transmission which sends power from the motor to the wheels.

The motor is powered by a battery or by multiple batteries which store the electricity required to run an EV. The higher the kW of the battery, the higher the range.

We have used chain drive type Transmission Between motor and drive shaft. The main advantage being its lightweight, highly efficient, low maintenance characteristics.

TABLE IV. TRANSMISSION SPECIFICATION

Description	Values
Transmission Type	Chain drive
Motor Sprocket teeth	13
Shaft Sprocket teeth	40
Gear Ratio	3.08:1
Motor Peak Torque	38 Nm
Motor Maximum Power	4.5 KW
Motor Type	BLDC
Motor Voltage	48V
Motor Maximum rpm	4500
Maximum Velocity	21.4 m/s
Maximum Acceleration	3.16 m/s^2
Torque on Wheel	104.2 Nm
Transmission Efficiency	90%
Tyre radius	0.14m
Total tractive effort	143.2 N
Rolling Resistance	93.2 N
Air Drag	50 N
Force at Wheels	601.09 N

[4] BRAKING SYSTEM

The hydraulic disc brakes are used in motor vehicles to slow down its rotational motion by the help of frictional force. It is caused by pushing the brake pads against the disk rotor. It converts kinetic energy into heat energy that dissipates through the rotor vents and slows down the vehicle. Disc brake offers much better stopping performance.

Advantages of Disc brake system:-

- Ability to provide more consistent frictional behaviour.
- Better braking performance at high speed.
- Ability to lose heat developed due to friction quickly.

Selection of brakes:

These are considerations and certain selections that are selected for the better and safe braking. For the vary purpose master cylinder bore diameter was taken under consideration and calculation was done. Two discs have been used at the shaft for multiplying braking force. Some selected parameters are:-

TABLE VII. BRAKE SPECIFICATION

Parts	Specification
Overall Weight	190 kg
Deceleration	0.7g
Weight ratio	35:65
Tire Diameter Rear	11”
Tire Diameter front	10”
Static Rear Weight	123.5 Kg
Static Front Weight	66.5 Kg
COF Between Tire & Road	0.7
COF Between Pad & Rotor	0.45
Wheel Base	46”
Height of Gravity	0.1397m
Dynamic Front Weight	811.365 N
Dynamic Rear Weight	1052.535 N
Master cylinder (bore diameter)	0.014m
Caliper (piston diameter)	0.028 m
Number of caliper piston	2
Load Applied on Brake pedal	20 Kg
Pedal Ratio	5:1
Force on Push Road	1000 N
Clamping Force	7193.1915 N
Braking Torque	1009722.56 Nm
Braking Force	722779 N
Deceleration	38.04m/s^2
Stopping Distance	1.240 m
Stopping Time	0.255 sec
Brake fluid	DOT 3

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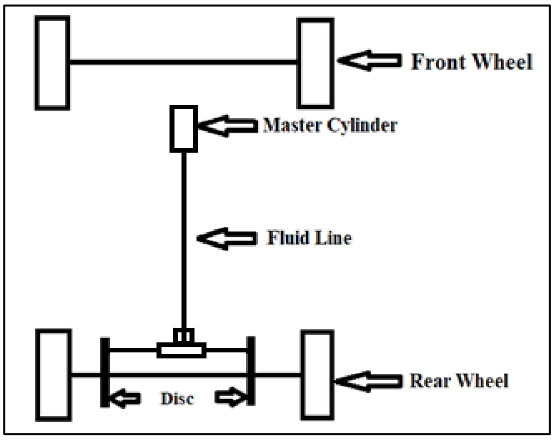

Fig.13. Layout of braking circuit

[5] ELECTRICAL SYSTEM

Objective:

The E-power train system has the following objectives are:

- To have a combustion free vehicle.
- To have agility in the performance.
- To achieve flexibility on the road.

1) BLDC Motor:

Brushless DC motors work on the same principle as that of a conventional DC motor. Due to its low noise and lightweight, it is being used for a vehicle. It requires low maintenance as well.

TABLE VIII. MOTOR SPECIFICATION

Criteria	**Specification**
Max power	4.5KW
Peak torque	38N-m
Max. RPM	4500
Rated Current DC	94 Amp
Weight	12 Kg
Continues Torque	10.8 N-m
Efficiency (n)	89%
Supply voltage	48V
Operating Temperature	50^{0}C
Protection	IP55

2) Battery (Li-ion):-

Lithium-ion batteries have a high energy density and are rechargeable. They are commonly used in consumer electronics. The life cycle and efficiency of Li-ion batteries are more as compared to the other rechargeable batteries.

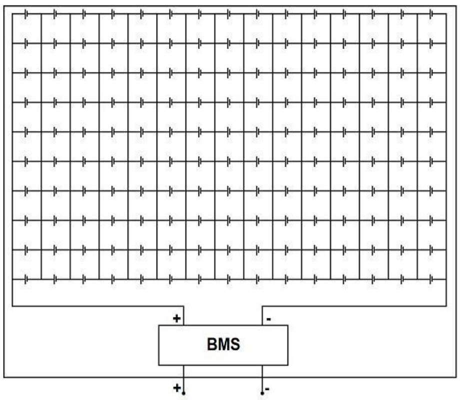

Fig 14: Battery BMS System

TABLE IX. BATTERY SPECIFICATION

Supply voltage	48v
Battery capacity	50 Ah
Cell voltage	3.6v
Efficiency(n)	90%
Weight	34kg
Cooling system	Natural cooling
BMS	Integrated
Charging Time (15Amp)	7200 Sec

3) Controller:

A motor controller is a device used for operating an electric motor and is coordinated in some predetermined manner. A controller can have a manual or automatic system in order to start and stop the motor, for changing the direction of rotation from forward to reverse, for selection and regulation of speed and for limiting the torque. It is also used to protect the motor from overloads and faults.

Other components:

Fuse, Kill Switch, Contactor, FNR, Relay.

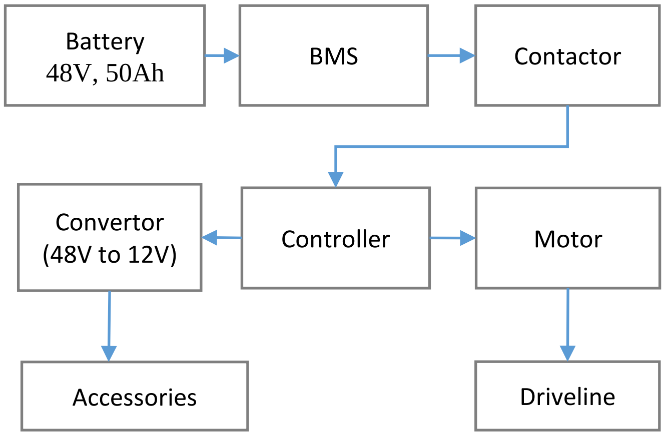

Fig 15: Circuit Diagram

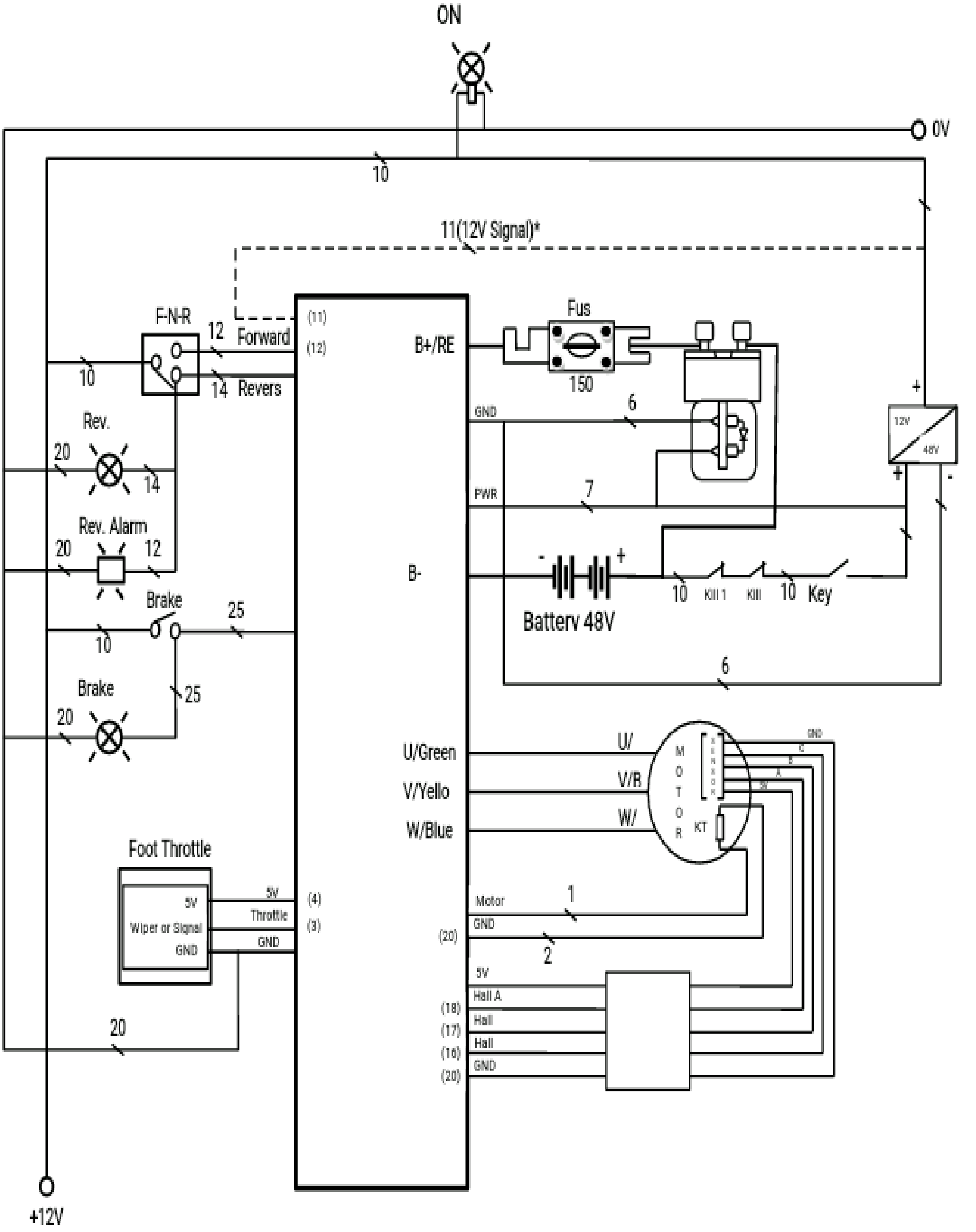

Fig. 16. Circuit Diagram

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VI. VEHICLE VIEWS

Fig.17

Fig.18

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