iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 Issue: IV Month of publication: April 2023

DOI: https://doi.org/10.22214/ijraset.2023.50167

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue IV Apr 2023- Available at www.ijraset.com

Design and Implementation of Electrical Car with Manual Gear System

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Abstract: This essay's main goal is to explain how to turn an outdated car with a petrol or diesel engine into an electric vehicle. An automobile is electric if its whole driving mechanism is an electric motor that is entirely powered by a battery pack. This car's unique characteristic is that it can be operated using the manual gearing system that the car already has.

Our goal is to demonstrate a low-cost method for converting ageing vehicles to electric vehicles. The primary obstacles in developing an electric car are selecting a motor that is rated appropriately for the vehicle, considering the passengers, battery pack, chassis, and motor weights. Another task is selecting a battery that meet our project's financial objectives.

The use of several gear ratios provides several possible advantages, such as enhancing vehicle acceleration, gradeability, and top speed, and reducing the overall mass and space of the traction system. Due to their high torque and power requirements, performance vehicles, light to heavy duty trucks, and buses may particularly profit from multi-speed gearboxes.

Keywords: Permanent Magnet synchronous motor, Brush Less DC motor, manual gear box, rolling resistance, gradient resistance, aerodynamic resistance

I. INTRODUCTION

One of the best technologies for the future is the electric vehicle, which uses less fossil fuel and is more environmentally beneficial because it emits less dangerous pollutants. The charging module, converters, controllers, batteries, and electric motor are only a few of the numerous parts that make up an electric vehicle.

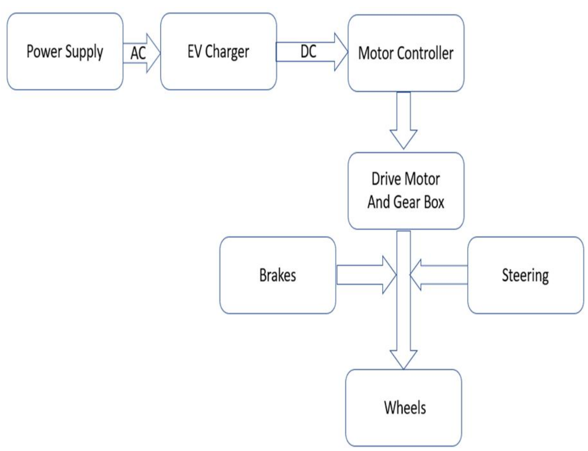

Figure 1. Block diagram of an electric car

Figure 1 shows the block diagram of how power is distributed in an electric vehicle. The power supply can be obtained from domestic sources or from any charging stations, as shown in Figure 1. The battery is then given access to this power via an EV charger after it has been rectified using a converter. A motor controller aids in regulating the input and output characteristics of the motor, transfers electric power from the battery to the motor. With a drive shaft, the wheel receives the mechanical power the motor produces. In an electric car, mechanical power is created as a result of the electric current passing through various parts. As a result, the output parameters of a vehicle, such as its power, torque, speed, etc., are determined by an electric motor. In order to counteract the force caused by the load and other opposing forces operating on the vehicle, the electric motor chosen to drive it must be capable of producing enough power and torque. This paper deals with calculating the power rating required to drive an electric vehicle, and charging time of battery through an EV charger, along with its operation.

II. SELECTION OF MOTOR OF SUITABLE RATING

The force required for driving a vehicle is calculated below [1] – [4].

$F_T= F_r+ F_g+ F_a$……………………………………………………..(i)

Where, F_T =Total force

F_r= force due to Rolling Resistance

F_g= force due to Gradient Resistance

F_a= force due to aerodynamic drag

F_T is the total force that the output of motor must overcome, in order to move the vehicle.

A. Rolling Resistance

Rolling resistance is the resistance offered to the vehicle due to the contact of tires with road. The formula for calculating force due to rolling resistance is given by equation (ii):

$F_r = C_{rr}*M*g$ ……………………………………………..………(ii)

Where, C_{rr} = coefficient of rolling resistance

M= mass in kg

g= acceleration due to gravity = 9.81 m/s^2

For the application considered, C_{rr} =0.01

M= 800 kg

Then, F_r= 0.01*800*9.81=78.48 N

B. Gradient Resistance

Gradient resistance of the vehicle is the resistance offered to the vehicle while climbing a hill or flyover or while travelling in a downward slope. The angle between the ground and slope of the path is represented as α, which is shown in Figure 2.

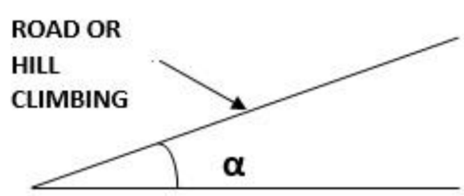

Figure 2. Angle between the ground and slope of a path

The formula for calculating the gradient resistance is given by equation (iv):

$F_g=M*g*\sin\alpha$ …………………………………………………………..(iv)

In this illustration, let us consider the electric car runs on a flat road. Therefore, the angle α =0º

F_g= 800*9.81*sin 0º = 0 N……………………………………………….(v)

In this case, the power required to overcome gradient resistance is also zero.

C. Aerodynamic Drag

Aerodynamic drag is the resistive force offered due to viscous force acting on the vehicle. It is largely determined by the shape of the vehicle. The formula for calculating the aerodynamic drag is given by equation (vi):

$F_a= 0.5*C_A*A_f*\rho*(V+Vo)^2$ ……………………………………….…(vi)

$F_a= [(0.5)*4.5*1.475*1.515*1.23*(13.888+0)^2]$

= 92.66 N

These are the three main forces which act on the vehicle when it travels at constant speed.

Therefore, the total tractive power required to move the vehicle is

F_T= 78.48 N+ 0 N+92.66 N=171.14 N…………………………………..(vii)

P_T= 171.14*(50) *(1000/3600) = 2376.94 W

But electric motor with output power rating of 2376. 94 W should not be selected. The losses due transmission of power to the wheel must be included. Therefore, the mechanical power output ($M_{tractive}$) required to drive the vehicle is given by equation (viii):

$M_{tractive} = P_T / \eta$ ……………………………………………………..…(viii)

Where, η= efficiency of the transmission gear system.

Let us consider the efficiency of the transmission system to be 0.85. Therefore, the mechanical power output required is:

$M_{tractive} = P_T / \eta$= 2376.94/0.85 = 2796.22= 3 kW (approximately).

For an electric car of 800 kg, a motor with output power rating of 3 kW has to be selected.

Brush less DC motor and Permanent magnet synchronous motor are two most widely used motors in Electric Vehicles. PMSM is superior in some aspects with respect to BLDC motor as mentioned in Table 1.

Table 1
Difference Between BLDC And Pmsm Motors

Parameter	BLDC Motor	PMSM Motor
Definition	An electronically commutated DC motor which does not have carbon brushes and commutator assembly.	An AC synchronous motor that uses permanent magnets to provide the necessary field excitation.
Supply	DC Supply	AC Supply
Torque	Comparatively less torque	Higher Torque
Efficiency	85%-90%	92%-97%
Waveform of back emf	The waveform of back emf of a BLDC motor is trapezoidal shaped.	The waveform of back emf of a PMSM motor is sinusoidal shaped.
Vibrations	Comparatively more vibrations	Less vibrations

Here we have chosen a 3KW Permanent magnet synchronous motor.

III. BATTERY CHARGING TIME CALCULATIONS

In general, a 75Ah battery yields approximately 900 W. So, for a 3 KW permanent magnet synchronous motor, its requisites 4 batteries of 75 Ah. In order to increase the discharge time of the battery or running time of the car, we have chosen 5 batteries of each 100Ah current rating. [6]

In order to meet the Voltage requirement of the permanent magnet synchronous motor 60 V, we need each battery of 12 V.

When battery is charged through a charger,

Battery capacity = 100Ah

Charge current rating = 15A

Charger voltage = 60 V

Lead Acid battery efficiency = 80 to 85 %

Charge time = (Battery capacity x Depth of Discharge) / (Charge current x Charge efficiency)

= (100 x 50%) / (15 x 85%)

= 3.92 hours

IV. SPECIFICATIONS OF EQUIPMENT

A. Motor Specifications

The motor specifications are as follows:

Type: Permanent Magnet Synchronous Motor

Voltage (V): 60

No Load Current (A): 6

Rated Current (A): 60

Rated Speed (RPM): 3700±100

Rated Torque (Nm): 13.2

Max. Output Torque (Nm): 46.3
Rated Power (W): 3000
Max. Power Output (W): 4000
Efficiency(η): >88%
Number of poles: 8
Insulation class: B

B. Motor Controller Specifications

The controller specifications are as follows:
Rated voltage: 60 V
Peak protection current: 110A
Rated power: 6600 W
Under Voltage Protection: 53 V
Throttle voltage: 1V to 4.5V
Phase commutation angle: 120 degrees
Brake De-energize: High
Heat dissipation: Natural cooling
Ambient temperature: 20º C to 60º C

C. EV Charger Specifications

Input Voltage: 220-240V, 50-60 HZ AC
Output Voltage: 48v or 60v
Current rating: 15A

D. Battery Specifications

No. of Batteries: 5
Make: GOWELL
Voltage: 12 V(each)
Weight: 30 kg
Warranty: 18 Months
Battery Type: Lead Acid Battery
Capacity: 100 Ah

V. ELECTRIC CAR WITH MANUAL GEAR SYSTEM

Advantages of using manual gear system in electrical vehicle are as follows:

1) Higher speed
2) Good torque
3) Good efficiency
4) Smoothness

VI. PROCEDURES

As we are merely using the car's current gear box, the design is not overly complicated.

Figure 2. Motor and Gear Box Arrangement

After removing any unnecessary components from the car, such as the fuel tank and the silencer, attach the engine to a 4-speed gearbox coupler and fit it to the gearbox using the pressure plate, clutch plate, and flywheel as shown Figure 2.

[5] By doing this, we can turn our combustion engine into an electrical one that runs faster and more efficiently while consuming less motor power. This vehicle has a 100ah controller, a 3000w PMSM motor, and series-connected lead-acid batteries with a 12V and 100ah capacity. The outcomes of our road testing of this car are excellent. The car has a gross weight of 800 kg, a motor that can lift up to 1100 kg of weight, a top speed of 60 km/h with 4 passengers, and a range of 50 to 60 kilometres due to the usage of lead acid batteries. [7] The manual gear mechanism raises the motor's rpm from 3000 to 6000 while also providing the fundamental torque required for movement. the movement of electricity produced by a solar panel array into a battery pack. A PMSM motor will thereafter be driven by the energy that was previously stored.

VII. CONCLUSION

Here, the future is occupied by electric vehicles. They encourage further generations towards eco-friendly transport. As we have seen number of old cars becoming iron trash due to various internal faults. These types of cars can be renovated to the electric vehicle mentioned in this paper. They can be very useful in Urban transport of shorter distance and ca even reduce sound pollution to some extent.

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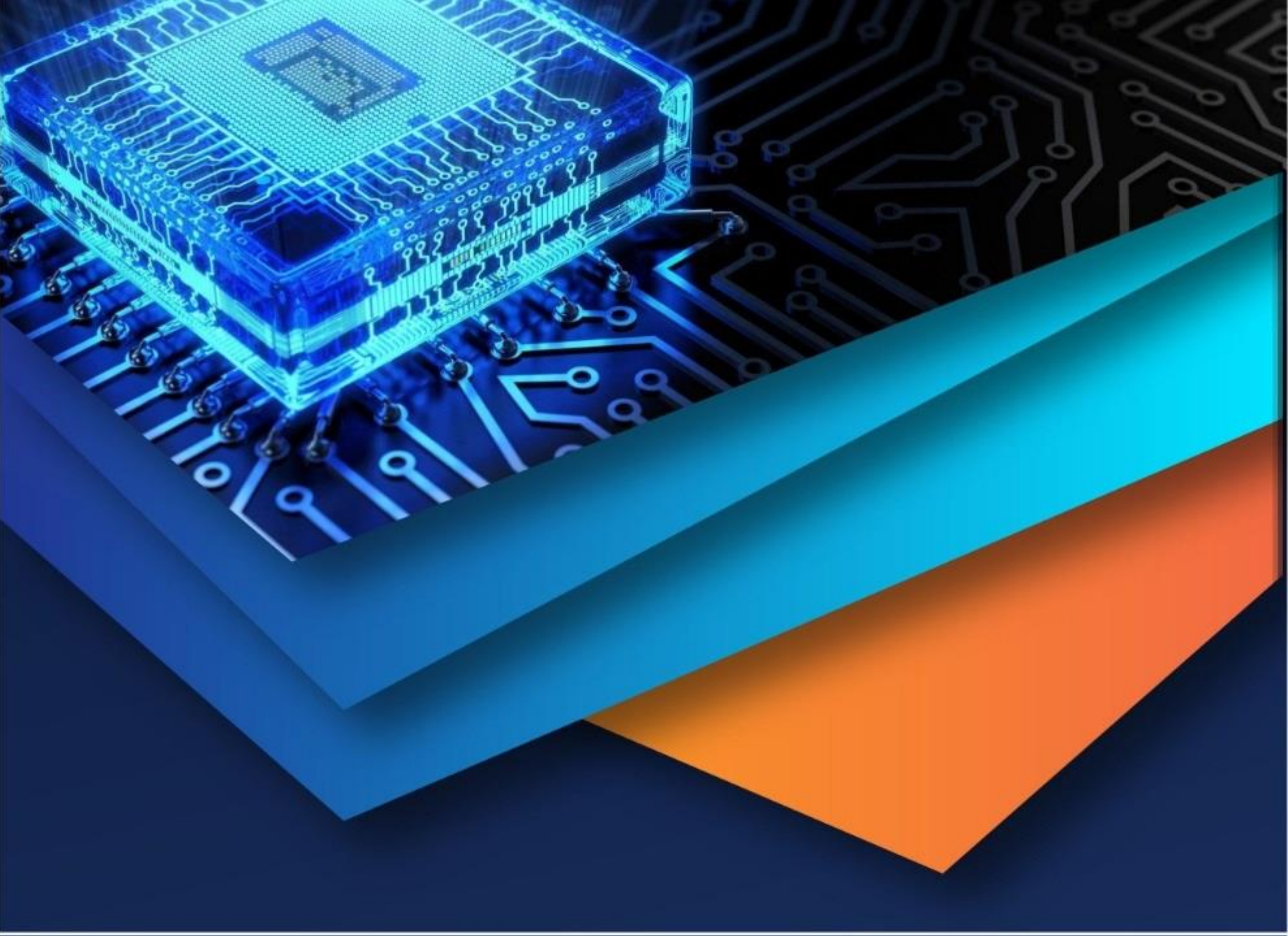

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