ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Website: www.ijareeie.com

Vol. 7, Issue 6, June 2018

Impact of Electric Vehicles on Indian Distribution Systems

Pallavi Rodge[1], Kantilal Joshi[2]

M. Tech Student, Dept. of Electrical Engineering, G. H. Raisoni College of Engineering, Nagpur, India[1]

Associate Professor, Dept. of Electrical Engineering, G. H. Raisoni College of Engineering, Nagpur, India[2]

ABSTRACT: Fuel driven vehicles contribute to the drastic increase in the air pollution. For this, government is trying to promote the electric vehicles which may help to reduce the effluents emitted by the fuel driven vehicles in the environment. This paper determines the mathematical calculations and simulations of electric vehicles. This paper shows the load profile of uncoordinated as well as coordinate charging. It also develops the reference model to design a complete electric vehicle.

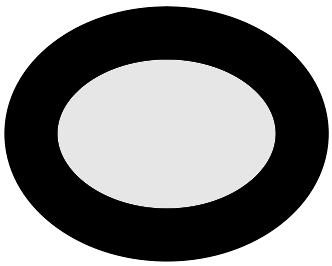
KEYWORDS: Electric vehicles; MATLAB/Simulink; Mathematical modelling; Load profile

I. INTRODUCTION

The electric vehicles are powered by rechargeable battery. They have both good as well as bad impact on the distribution system.In all the vehicles, range and performance is important. Some feature of electric vehicles make the mathematical modelling performance easier than the other vehicles. First model vehicle performance means its top speed and the acceleration. If achieved better target of electric vehicle, the performance of electric vehicles should be better than the fuel vehicles. The another feature of electric vehicle is range. Range can also be demonstrated.

In this paper, electric vehicle 'Mahindra e2o' has been simulated. Its performance and range has been analysed by the simulation results. The mathematical calculation and simulation modelling is developed. And the results are shown in the form of graph.

Wheel diameter is calculated from the data of spare wheel.



Tyre dimension=$155/70\ /\ R13\ inch$

The total diameter of the wheel=$2 \times \left(tyre\ width \times side\ wall\ \frac{height}{100}\right) + (diameter\ of\ the\ rim\ in\ mm)$ $=2 \times \frac{155\times70}{100} + (13 \times 25.4) = 0.5472m$

Radius= 0.2736 m

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Website: www.ijareeie.com

Vol. 7, Issue 6, June 2018

II.MATHEMATICAL CALCULATION OF PERFORMANCE OF VEHICLE

In order to perform the mathematical model of electric vehicle, its performance and range is importatnt. To move a vehicle, various forces are required and its total force is considered as total tractive force. This force is accomplished with rolling resistive force (F_{rr}), aerodynamic drag force (F_{ad}), hill climbing force (F_{hc}) and acceleration force.

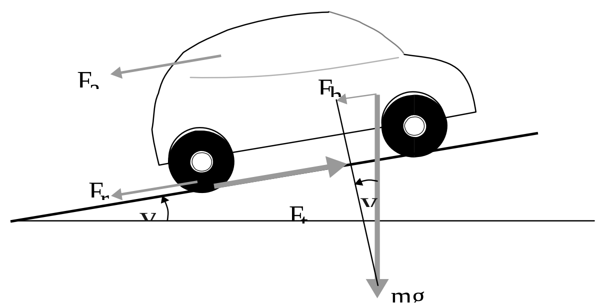


Fig1The Forces Acting on vehicle Moving Along a Slope [1]

The velocity of vehicle is 40kmph as considered for the further calculations. The electric vehicle, velocity in meter per second is shown as,

$v = 40 \times (0.2778 m/s) = 11.112 m/s$

A. ROLLING RESISTIVE FORCE

This force is due to the friction of moving tyre on the road.

$F_{rr} = u_{rr} * m * g = 0.005 * 1257 * 9.8$

$= 61.59 N$ (1)

Where, F_{rr} is the rolling resistive force

u_{rr} is thecoefficient of rolling resistance. The typical value of u_{rr} is 0.005

m is the mass of the vehicle

g is acceleration due to gravity= $9.8 m/s^2$

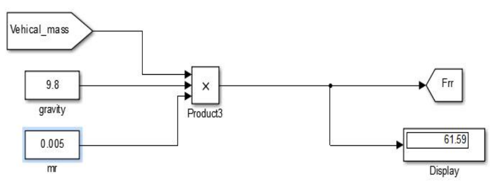


Fig 2 The Rolling Resistive Force

B. AERODYNAMIC DRAG FORCE

This force is due to the friction between moving vehicle and air.

$F_{ad} = \frac{1}{2} \rho A C_d V^2 = 0.5 * 1.25 * 2.4 * 0.3 * 11.11^2$

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Website: www.ijareeie.com

Vol. 7, Issue 6, June 2018

$= 54.63N$ (2)

F_{ad} is the aerodynamic drag force

$\rho$is the density of air, humidity. The value of density is 1.25

A is the frontal area of vehicle. It assume to be $2.4m^2$

V is the velocity in m/s

$C_d$is the drag coefficient called as constant. The typical value of a drag coefficient is 0.3

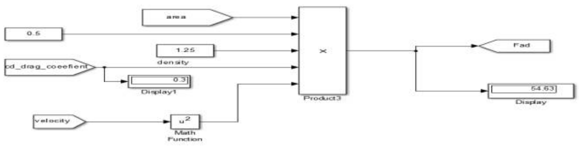


Fig 3Aerodynamic Drag Force

C. HILL CLIMBING FORCE

This force is depends upon the slope of the road. Consider vehicle moving on the flat road.

$F_{hc} = mgsin(\psi) = 0N$ (3)

Here, m is the mass of the vehicle in kg

g is the acceleration due to gravity

ψ is slope of angle

D. ACCELERATION FORCE

This force increases with the speed of the vehicle.According to Newtons second law. For the calculation of acceleration motor parameter is to be considered. Assume gear efficiency as 0.98 and gear ratio, torque is given as 10.83 and 70 Nm

$Wheel\,Torque = torque \times gear \times \eta = 70 \times 10.83 \times 0.98 = 742.938Nm$

Force on wheel is given as, $F_{wheel} = \frac{T_{wheel}}{R_{wheel}} = \frac{742.938}{0.2768} = 2684N$

Then, $Acceleration = \frac{F_{wheel}}{mass \times \lambda} = \frac{2684}{1257 \times 1.1} = 1.8m / s$

$F_{la} = ma$ (4)

The angular acceleration force is required to move a vehicle in angular speed, then the angular acceleration force is

$F_{wa} = I \frac{G^2}{\eta_g r^2} a = 74.29Nm$ (5)

I is the moment of inertia = 0.025kg.m^2

$G$is the gear ratio = 10.38

r is the radius of the wheel = 0.2736

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Website: www.ijareeie.com

Vol. 7, Issue 6, June 2018

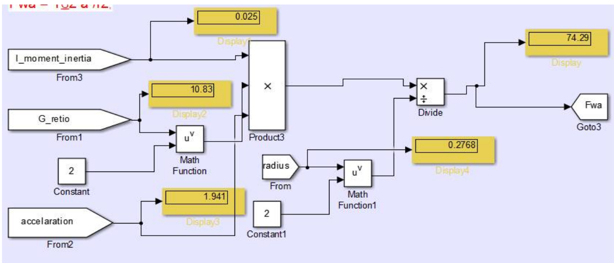


Fig 4 Acceleration Force

E. TOTAL TRACTIVE EFFORT

The total tractive effort is the sum of all these forces required to move a prototype of electric vehicle in newton

$F_{te} = F_{rr} + F_{ad} + F_{hc} + F_{la} + F_{wa}$

$= 190.6N$ (6)

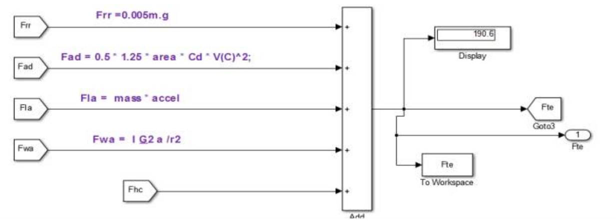


Fig 5Total Tractive Effort

III. RANGE MODELLING OF BATTERY ELECTRIC VEHICLES

To expect the value of range, the energy required to move the vehicle in one second is calculated. This process is repeated until battery is null. Consider one-minute time intervals that means energy and the power both are equal. Using various efficiencies, the energy required to move the vehicle for one second is same as the power.

$Energy\ required\ in\ one\ second = Pte$

$P_{te} = F_{te} \times V = 2118Nm/sec$ (7)

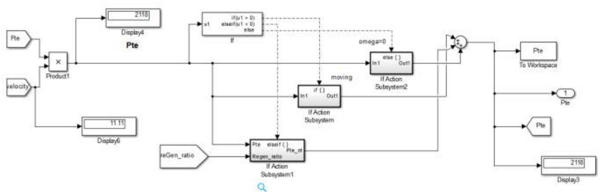


Fig 6Energy Required in Moving the Vehicle in One Second

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Website: www.ijareeie.com

Vol. 7, Issue 6, June 2018

However, if the motor is being used to slow the vehicle, then the efficiencyworks in the opposite sense [1]. In other words, the electrical power from the motor is reduced, and the equation becomes,

$P_{min} = P_{mout} \times \eta_m = 2505 Watt$ (8)

$P_{mout} = P_{te} \times \eta_{gear} = 2161 Watt$ (9)

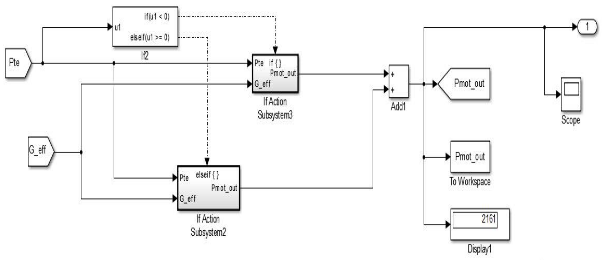


Fig 7 Motor Output Power

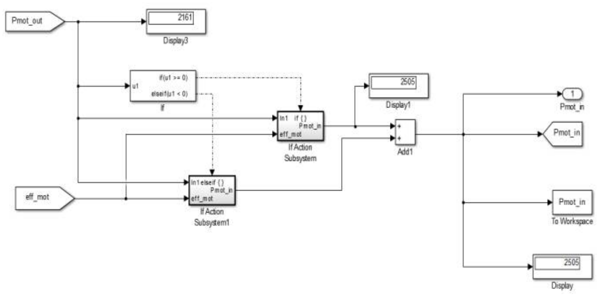


Fig 8 Motor Input Power

The P_{min} gives the electrical power to the motor and the P_{mout} gives the mechanical power from the motor.

The battery power is the sum of motor input power and accessories power. Consider constant value of P_{ac} is 350

$P_{battery} = P_{min} + P_{ac} = 2755.2 Watt$ (10)

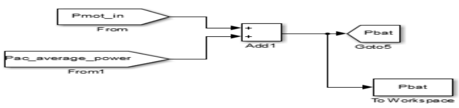


Fig 9The Battery Power

If the battery power is greater than zero, the current is calculated as

$$I = \frac{E - \sqrt{(E \times E) - (4 \times Rin \times P_{battery})}}{2 \times R_{in}} = 52.92 Amp$$

And, $CR = CR + \frac{I^K}{3600}$

If this condition is not satisfied, the battery power is given as

$$P_{battery=} - 1 \times P_{battery}$$

Then, the current is calculated by below formula

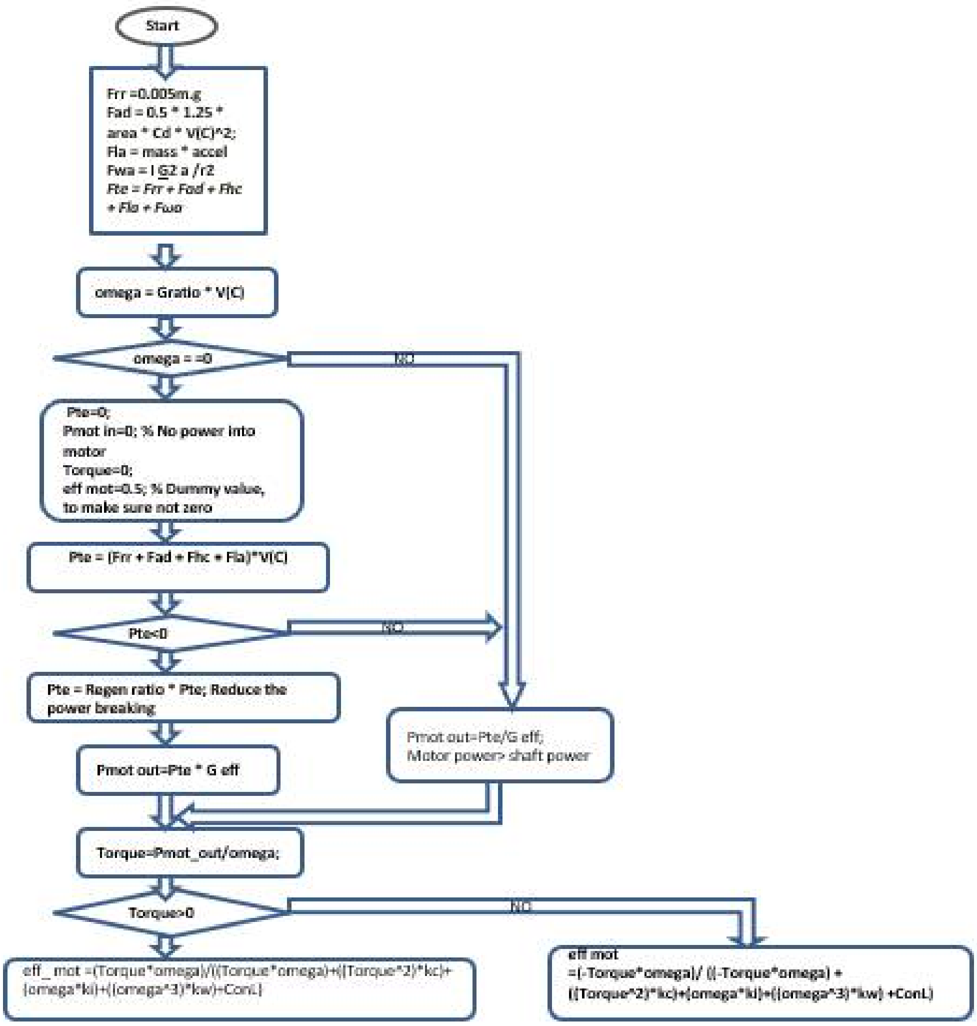
$$I = \frac{-E + (E \times E + \sqrt{(4 \times 2 \times R_{in} \times P_{battery})})}{2 \times 2 \times R_{in}}$$

And, $CR = CR - \frac{I}{3600}$

The depth of discharge is the ratio of charge remaining to peukert capacity. which is given as $DOD = \frac{CR}{Peucap}$
Battery is completely discharged when depth of discharge shows 0.99 i.e 1. And distance is given as

$$Distance = D + \frac{V}{1000}$$

A. FLOW CHART



ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Website: www.ijareeie.com

Vol. 7, Issue 6, June 2018

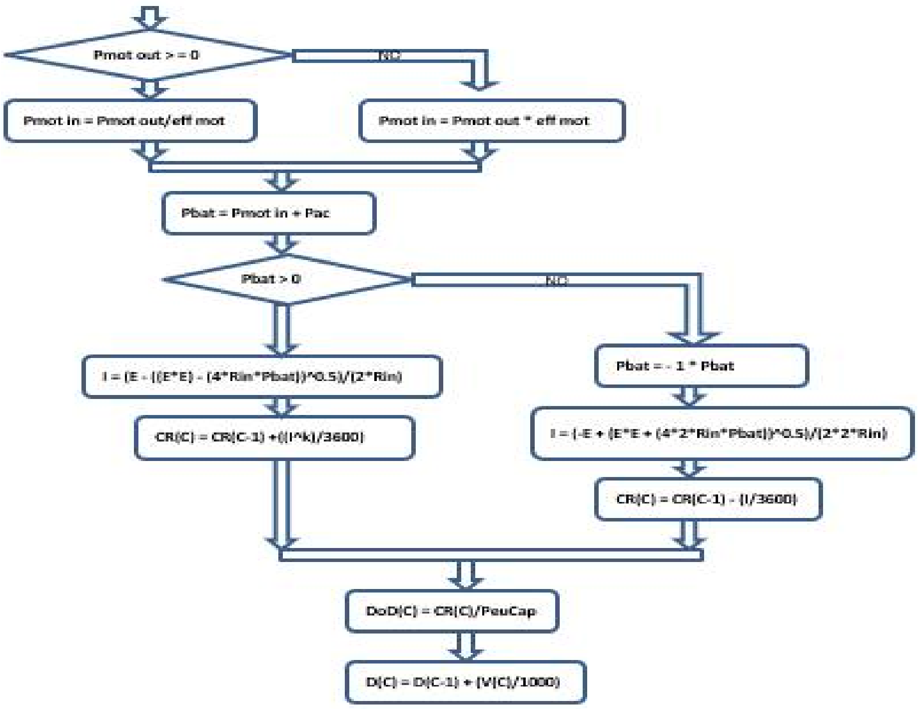


Fig10Flow Chart of Modelling of Electric Vehicle

B. PARAMETERS

Battery Parameters		
	Capacity	280Ah
	No. of modules	16
	No. of cells	64
	On board power	15Kwhr
Motor Parameters (3phase IM)		
	Torque	70Nm
	Controller	600Amp
	Mass(gross wt.)	1257Kg
	Top speed	80Kmph
	Range	140km
	Spare wheel	155/70/R13

Table1 Parameters Consider for Electric Vehicle Simulation

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Website: www.ijareeie.com

Vol. 7, Issue 6, June 2018

IV. SIMULATIONS RESULT

The input is needed from slope, acceleration and speed of a road while the output is shown in the form of total tractive effort, power and depth of discharge and distance covered by the electric vehicle in full charge.

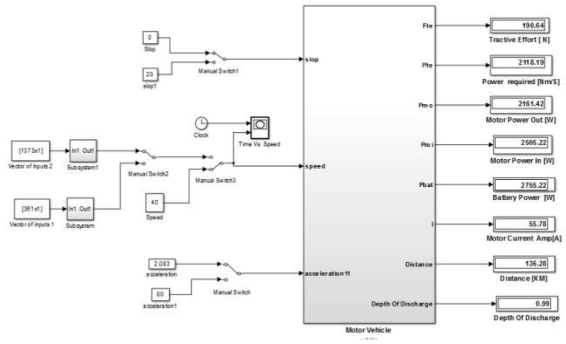


Fig 11Simulation Model of Electric Vehicle

The above figure shows simulation model of electric vehicle. For testing the electric vehicle, consider speed at 40kmph, with the total mass 1257kg, gear ratio 10.38, it requires motor output power 2161.42watt, motor input power 2505.22watt, battery power 2755.22 watt and distance covered in complete charge is 136.28Km.

A. FOR VELOCITY 40KMPH

The various graph shows energy required in one second, efficiency of motor and total distance covered by a vehicle till battery is completely discharged.

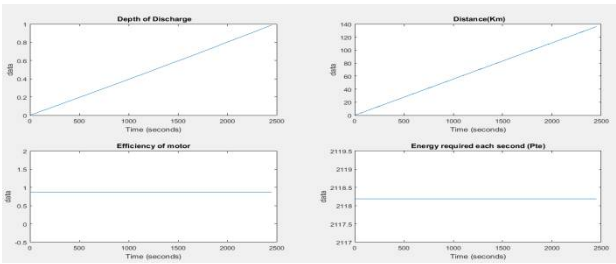


Fig 12 Simulation of Energy Required in One Second, Efficiency of Motor, Depth of Discharge and Distance

The output of a current and various power i.e. electrical power, mechanical power and battery power is as shown in graph below.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Website: www.ijareeie.com

Vol. 7, Issue 6, June 2018

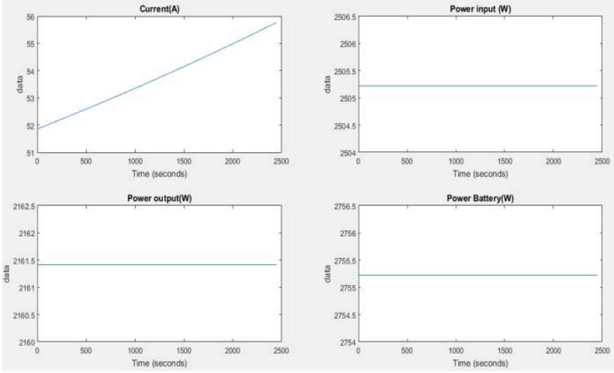


Fig 13Current and Power Output Waveform

B. FOR VECTOR RESULTS

The results vary with the number of vectors put in the input.

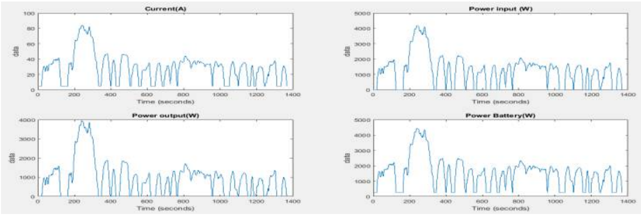


Fig 14 Vector 1373, Current and Power Output Waveform

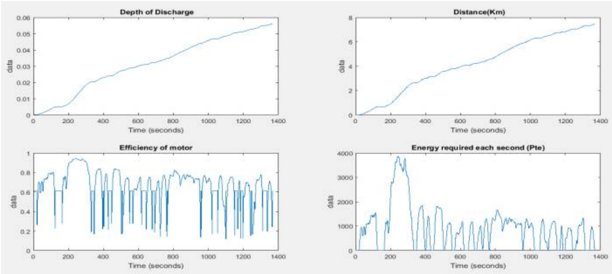


Fig 15 Vector 1373, Energy Required in One Second, Efficiency of Motor, Depth of discharge and Distance

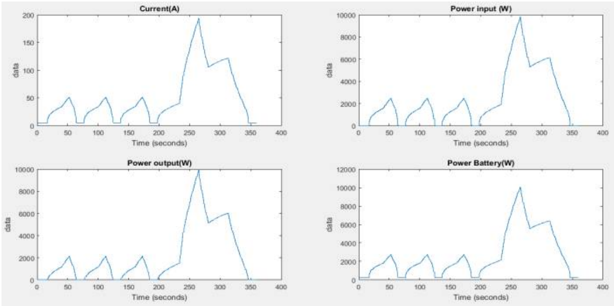


Fig 16 Vector 361, Current and Various Power Waveform

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Website: www.ijareeie.com

Vol. 7, Issue 6, June 2018

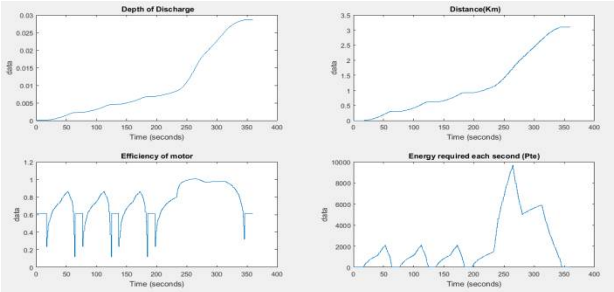


Fig 17 Vector 361, Energy Required in One Second, Efficiency of Motor, Depth of Discharge and Distance

VELOCITY	DOD 100%
	Range[km]
40Kmph	136.28
60Kmph	107.32
80Kmph	77.71

Table II. Simulation Results for Different Inputs

Mahindra e2o gives a range of 140 km for complete depth of discharge under ideal condition. The mathematical calculation and simulation result matches nearly to the specified data of electric vehicle.

CASE1: IMPACT ON THE LOAD PROFILE WITH EVS UNCOORDINATED CHARGING

As per the peak load of Ola charging station, we divided 200 electric vehicles with the height of per hour peak with different times. According to the peak load of Ola, we assumed vehicles distributed through it, having maximum peak time of 11 am to 7 pm in the charging station. The electric vehicles are simulated to calculate range, distance and speed of the vehicle. As per the simulation, vehicles have range of 137km with speed 40kmph. At full charge. Say, if one vehicle completes four trips in a day, it means that the battery of the vehicle needs to be charged four times. An electric vehicle consumes 37 units to charge completely [4]. So, load on electricity increases. As per the graph mention below, the maximum load occurs at 1pm which is 3108kwatt. If a vehicle runs at speed of 40kmph, it covers a distance of 136.28 km. Similarly, if vehicles run at a speed of 60Kmph and 80Kmph respectively, it covers a distance of 107.32km and 77.72Km respectively. Due to various losses that occur in the system, the range and depth of discharge gets affected. Battery gets easily discharged. Total distance covered by the vehicle is the product of range and per day trip of the vehicle. Hence, at the four trips of range 136.28km, vehicle covers a distance of 545.12Km. For the load profile 200 vehicle is to be considered. These 200 vehicles vary with time. At different time, various numbers of vehicles come at charging station. Maximum numbers of vehicles charge their vehicles in the charging station between 11am to 7pm. In this scenario, the impact of electric vehicles on the load profile with uncoordinated charging is seen.In this case, it is assumed that most of the vehicles are charged between 11am to 7pm in different charging stations as per the vehicle owner's suitability. Hence, due to the charging of electric vehicle between 11am and 7pm, the loadincreases and load profile is at the peak. Therefore, this case is considered as uncoordinated charging of electric vehicle. The uncoordinated charging substantially increases the voltage unbalance of the distribution system.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Website: www.ijareeie.com

Vol. 7, Issue 6, June 2018

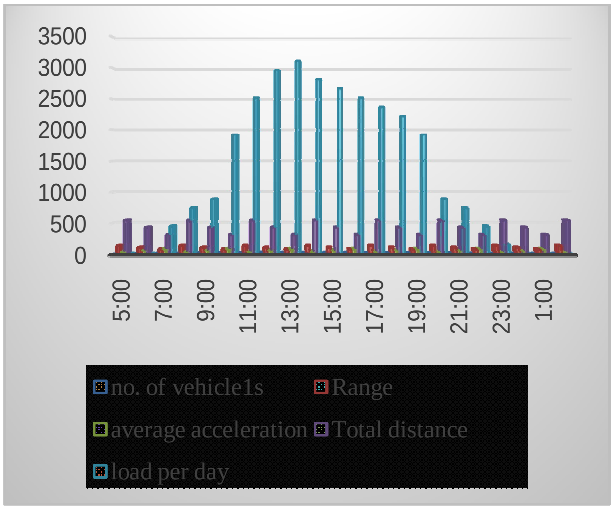


Fig 18 Load Profile of Uncoordinated Charging of EV

From the above graph it is clear that, the peak load is at3108kw due to uncoordinated charging.

CASE II: IMPACT OF COORDINATED CHARGING OF ELECTRIC VEHICLE

To reduce the problems of uncoordinated charging system, coordinated charging is used. In the second scenario, the load on the distribution system is distributed with respect totime. In this case, it is assumed that the electric vehicle owner charges their vehicle during base load period. Means from 6am to 6pm instead of 11pm to 7pm. Due to this load of uncoordinated charging, it is distributed with time. And the peak load gets flatter.

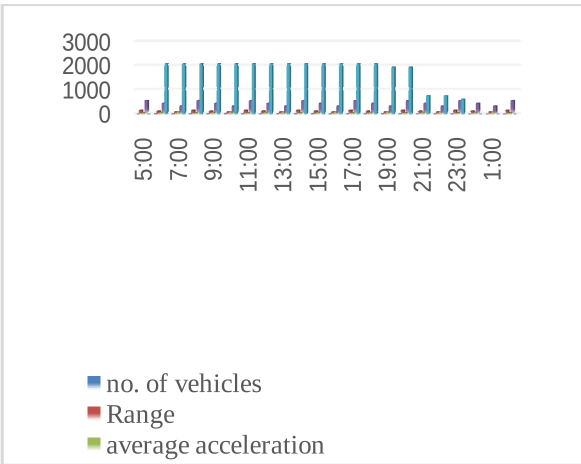


Fig 19 Load Profile of Coordinated Charging of EV

In the coordinated charging load from 3108kwatt shifts to 2072kwatt. Hence, 1036kwatt electricity is saved. Due to this, peak load period gets flatter. From the above graph it is seen that the load curve is flatter as compared to the uncoordinated charging system. For time period 6am-6pm, fourteen no. of vehicles is to be considered. After 6 pm number of vehicles reduces.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Website: www.ijareeie.com

Vol. 7, Issue 6, June 2018

V. CONCLUSION

In this paper analytical calculation of electric vehicles are presented. And simulation model of electric vehicle was developed in MATLAB/Simulink. To design a separate model of electric vehicle one has to spend time as well money. This paper gives ready design model of electric vehicle which will help the manufacturer to develop electric vehicles easily.

It can be assumed that the electric vehicles will increase in the next few years. Therefore, load on the distribution grid will increase tremendously with sudden demand of more electricity in order to charge these vehicles. This can be controlled through proper management of charging system with respect to time.

REFERENCES

[1] Anna, Ravi, D.K.Jain, “Impact of Plug-In Electric Vehicles on the Distribution Grid”International Electrical Engineering Journal (IEEJ) Vol. 5 (2014) No.7, pp. 1478-1483
[2] James Larminie,John Lowry, “Electric Vehicle Technology Explained” John Wiley & Sons Ltd.
[3] Www.mahindrae2oplus.com
[4] A Peek at India's First EV Charging Station - The Hans India
[5] Aalok Bhatt, “Planning and Application of Electric Vehicle with MATLAB®/Simulink®”, IEEE 2016
[6] Mr. Anurag M. Lulhe, Prof. Tanuja N. Date, “A Design & MATLAB Simulation ofMotor Drive used for Electric Vehicle” International Conference on Control, Instrumentation, Communication and Computational Technologies (lCCICCT), 2015
[7] Kristien Clement-Nyns, Edwin Haesen, Student Member, IEEE, and Johan Driesen, Member, IEEE, “The Impact of Charging Plug-In Hybrid Electric Vehicles on a Residential Distribution Grid”IEEE Transactions on Power Systems, Vol. 25, no. 1, Feb. 2010
[8] Xin Gong,Tao Lin, “Optimal Decisionmaking on Charging of Electric Vehicles” TELKOMNIKA Indonesian Journal of Electrical Engineering, Vol 12 No 4, 2014 pp. 2431-2438
[9] Michael Kuss, Tony Markel, and William Kramer, “Application of Distribution Transformer Thermal Life Models to Electrified Vehicle Charging Loads Using Monte-Carlo Method”, NREL, January 2011
[10] Md .Ruhul Amin,Rajib Baran Roy, “Determination of Electric Vehicle Power Consumption for Assorted Pavement Gradient Using Matlab/Simulink”TELKOMNIKA Indonesian Journal of Electrical Engineering,Vol 12 No 9, 2014, pp. 6602-6611