IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 2 Issue 5, May 2015.
www.ijiset.com
ISSN 2348 – 7968

# Road Test of Light Duty Vehicle Using Electric Vehicle Drive System through MATLAB

**Alok Pandey**
Assistant Professor
M.I.T. Moradabad
alok.pandey.eei@gmail.com

**Priyal Rani**
student
M.I.T. Moradabad
priyal.mit.ee@gmail.com

**Vinod**
Student
M.I.T Moradabad
vinodkumar3684@gmail.com

**Susil Kumar**
student
M.I.T. Moradabad
susilraj60@gmail.com

## ABSTRACT

In this paper we present the simulation of electric vehicle motor-drive system. We were going to investigate on the condition monitoring of vehicle drive i.e. the vehicle flows the power in both the motoring and regeneration. We were simulating the drive to reduce the cost of on road test. In this model we were simulating the permanent magnet motor, an ideal motor controller combined with a proportional-integral controller. We validate and developed a stable MATLAB/Simulink model. This model was used to evaluate the flow of energy and the efficiency of electric drive for some value of speed torque condition. In this model some parameter were specified and some were modeled as Ideal.

## INTRODUCTION

In the past few years the electric vehicle were produced in the bulk so it is considered as the upcoming tipping point for the transition from the Internal Combustion Engine (ICE) as the prime mover of vehicles to electric propulsion systems.

For the growth in technology there must be some step taken for significant change in coming years or recent years. A sequential path that involves in traditional design workflow are:

- Requirements
- Design
- Implementation ,and
- Test and validation.

Simulation is the tool that reduces the cost of production for facilitates design. This process involve hardware in loop ,model in loop & hardware in loop testing so by simulation design process engineers can decrease both design cost and design time which is quite beneficial to the company.

In D.C. motor the torque is inversely proportional to the speed of the output shaft. In the other words there is a tradeoff between the torque produced by a motor and how frequently the output shaft spins [2].

## DRIVE CYCLE

Drive cycles is a set of velocity of vehicle that is to be attained at during the simulation. To reduce the cost of on road test, time of test and fatigue of engineer is the basic need of drive cycle. This process is done on the computer simulation or drive cycle process brings the road to the dynamometer.

It is the process that was used in vehicle simulation to model the drive system and predict the performance of it. There are much standard driving cycle used for testing road vehicles for fuel economy and other purposes. At constant speed extended periods and speed changes can be done frequently in driving cycles.

## SPEED AND TORQUE VALUES

It is assumed that the simulation is done on known values of speed and torque. If we have or assume some value of speed then we can calculate torque value if we have the dimension of wheels and other encountered values are known.

## PERMANENT MAGNET DC MOTOR

A permanent magnet dc motor is a dc motor whose poles are made up of permanent magnet. We are using a dc permanent magnet motor in simulation motor as this motor is not appropriate for BEV or HEV application due to weight and efficiency. We were using this motor in simulation purpose only instead of

permanent magnet synchronous motor (PMSM).

The permanent magnets of PMDC motor are readily magnetized and mounted on inner periphery of a cylindrical steal stator. The stator also serves as a return path for magnetic flux. The rotor has a conventional dc armature, commutator segments and brushes.

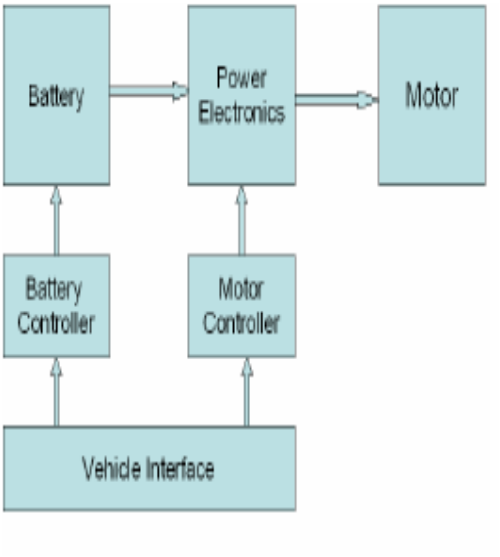


Figure 1: Electric Vehicle Drive Train

Some of key equations are:

$$E = K\emptyset N \quad (1)$$

$$T = K\emptyset Ia \quad (2)$$

$$N = V - {}^{IaRa}/_{K} \quad (3)$$

**Operation of Electric Vehicle Drive Train:**

In electric vehicle battery is used as a part of drive train. During motoring mode the drive consumes energy from the battery. If the same motor operates as a generator in the regeneration mode then it can also add charge to the battery. If we give the power to vehicle through internal combustion engine or the braking occur then the vehicle works in regenerating mode. We are using PMDC motor and a vehicle interface which communicates between battery controller and moor controller, and also gives interfacing between vehicle-level controls and sensors.

In this block diagram we are using a battery which gives supply to the motor. A power electronics device is also used which converts D.C. into three phase A.C. as in this block diagram we are using a Permanent Magnet Synchronous Motor (PMSM) motor or high efficiency A.C. INDUCTION MOTOR [1].

## KEY EQUATION

Developed Motor Torque

$$Td(Nm) = Km * Ia(Amp) \quad (4)$$

Developed Motor Voltage

$$VD(Volt) = WD(rad/sec)/Km \quad (5)$$

Motor Voltage

$$VH = IH * RA + LH * \frac{dI}{dt} + VD \quad (6)$$

Controller high side voltage

$$VH = K * VL \quad (7)$$

Controller high side current

$$IH = {}^{1}/_{K} * IL \quad (8)$$

Battery model calculation

$$VB = Ia * Ra + EB \quad (9)$$

Error Voltage Calculation

$$BERR = EB(Actual) - EB(Calculated) \quad (10)$$

PI Calculation

$$K = (KP + s * Ki) * BERR \quad (11)$$

## SIMULATION MODEL BLOCKS

### Motor Model

ISSN 2348 – 7968

This model satisfies equations 1, 2 &3 as shown in figure-2

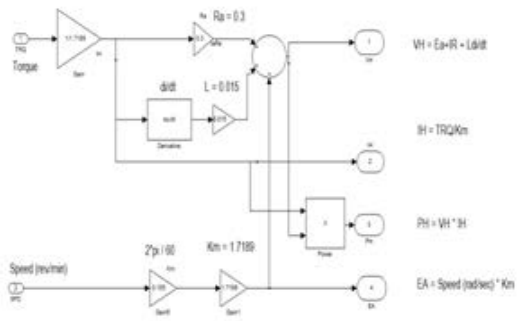


Figure-2 Motor Model

## Battery Model

This model satisfied equations 6, 7& 8. By this simulated model we get battery voltage battery power and battery current. This help us to know that the motor is working in which mode whether it is a regenerating or

Motoring mode. The block is shown in figure - 3

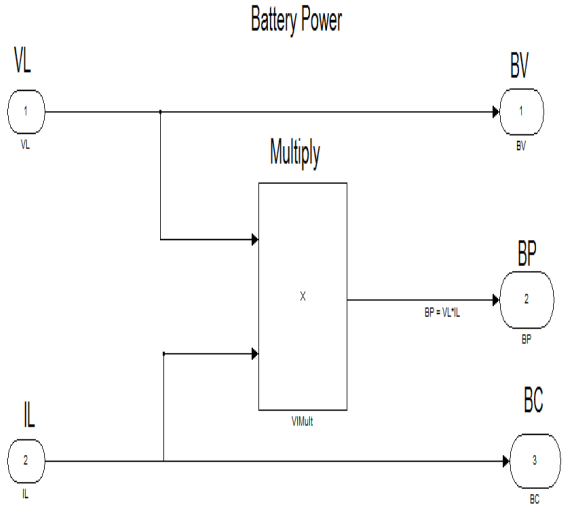


Figure-3 Battery Model

## Motor Drive Model

We are taking the values of speed and torque in MATLAB Workspace and which is then read by the model lookup tables. The clock input were setup in model parameter are as Tmin=0, Tstep=0.01 &Tstop=100 seconds.

The complete drive cycle is shown in figure-4 as given below.

## VALUES OF ROAD TORQUE AND SPEED

The given data is the data processed in simulation of model for evaluation of its performance and efficiency of drive cycle. These values of speed & torque data are given in MATLAB Workspace using MATLAB coding.

Load speed and Torque values are

Svals = {0 500 1000 750 750}

Stime = {0 2 30 55 70}

Tvals = {0 160 160 75 75 -130 -130 0 0}

Ttime = {0 2 4 6 20 55 60 70}

## VALUES OF ROAD TORQUE AND SPEED

The given data is the data processed in simulation of model for evaluation of its performance and efficiency of drive cycle. These values of speed & torque data are given in MATLAB Workspace using MATLAB coding.

Load speed values are

Svals = {0 500 1000 750 750}

Stime = {0 2 30 55 70}

Road torque values are

Tvals = {0 160 160 75 75 -130 -130 0 0}

Ttime = {0 2 4 6 20 30 55 60 70}

ISSN 2348 – 7968

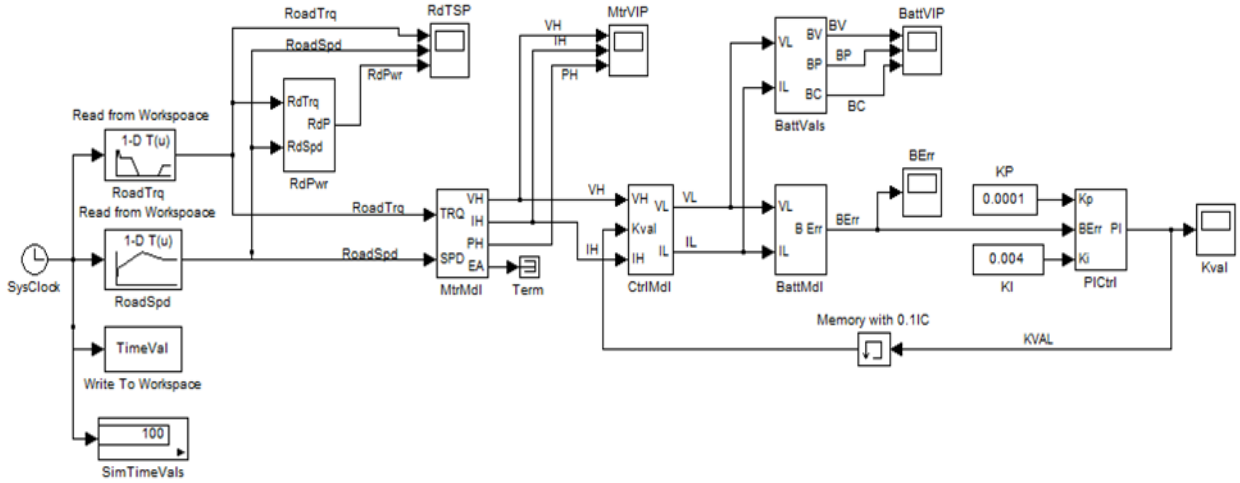


Figure 4: DC Permanent Magnet Motor, Controller, Battery Drive System Model

## Results through MATLAB

### Road Speed, Torque & Power

From the graph given in figure 6 we can calculate the value of road torque, speed and power. By this we find the condition on which the motor is working as when the motor torque is in opposite direction to the speed then the motor is working as a generator or in regeneration mode.

### Motor Voltage, Current and Power

Figure 7 gives the value of Motor Voltage, Current and Power. The Motor Power is plotted in both the Regenerating and Motoring mode. When the current is in opposite polarity to the voltage then the motor is working as a generator or the motor is working in Regenerating mode.

### Battery Voltage, Current& Power

The Power is supplied to the motor by battery. Since the torque is directly proportional to the current so the motor current, motor torque & battery current follow each other. When the both current and voltage are of same polarity then the motor is working normally in motoring mode if one of the current and voltage is negative or of opposite polarity then the motor is in regenerating mode.the graph is shown in Figure 8.

### Battery Voltage Error

It is the difference between the nominal battery internal voltage and the calculated motor voltage and current. At starting the maximum error occurs then it quickly recover to some positive value. The battery error becomes negative in regenerating mode as shown in Figure 9

### Controller Gain (K)

The value of controller gain is influenced with motor speed it increases when the speed of motor increases and decreases when the motor speed decreases. Its initial value is 0.1 as given in Figure 5.

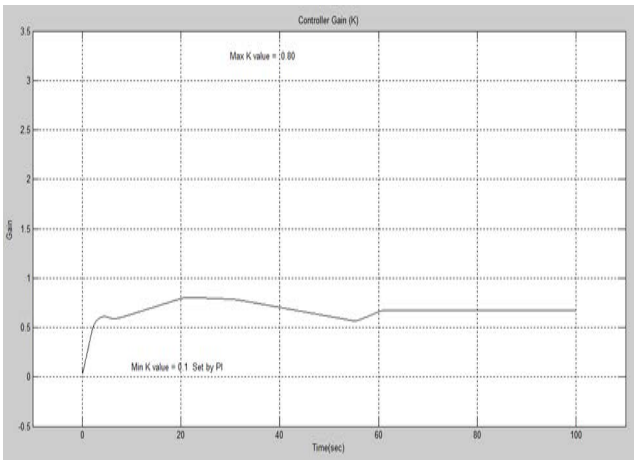


Figure 5: Controller Gain

ISSN 2348 – 7968

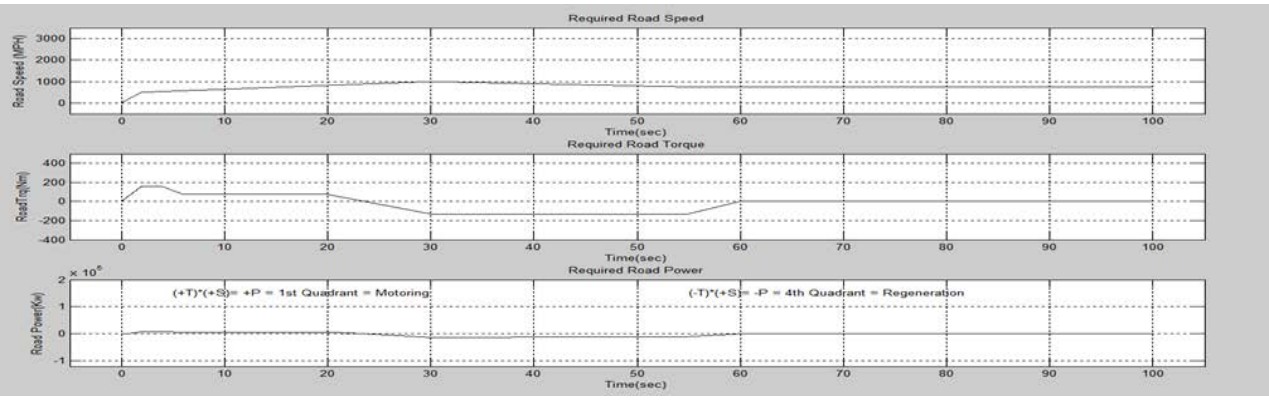


Figure 6: Road Speed, Torque & Power

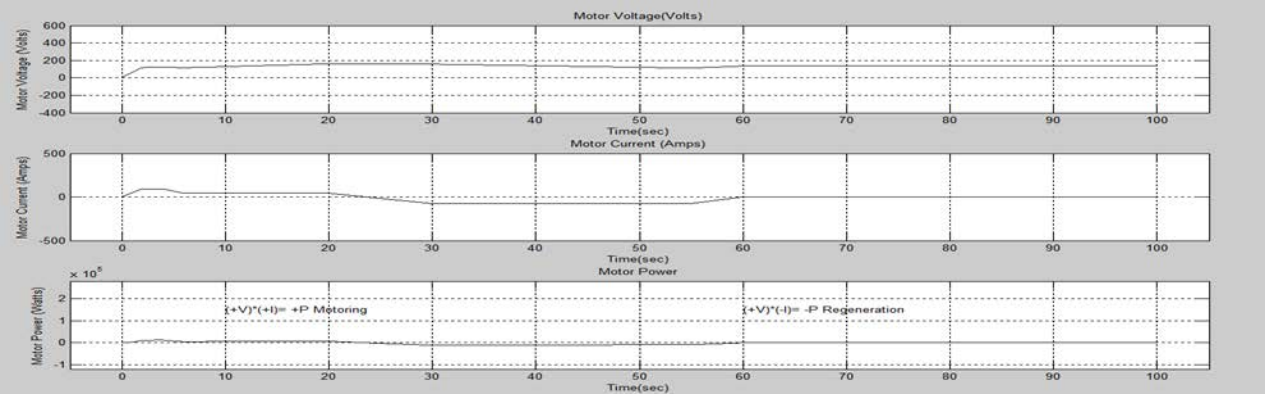


Figure 7: Motor Current, Voltage & Power

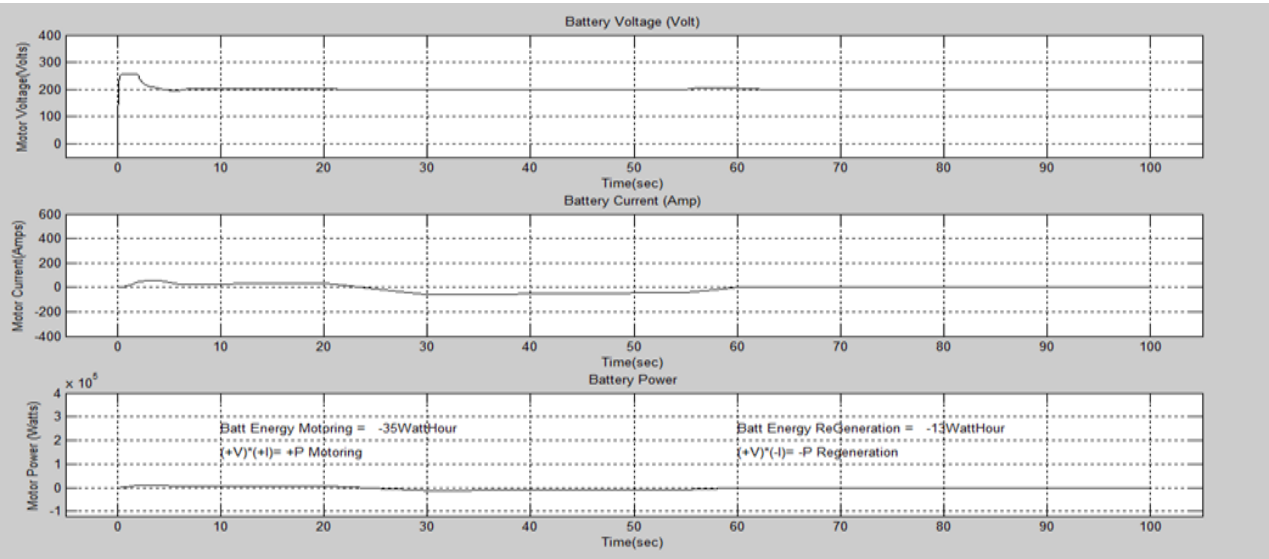


Figure: 8 Battery Voltage, Current & Power

ISSN 2348 – 7968

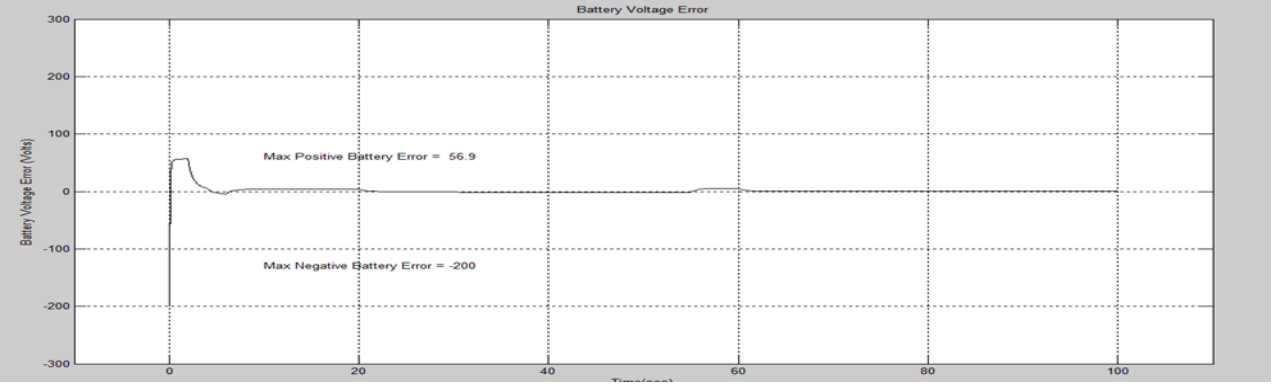


Figure 9: Battery Voltage Error

## CONCLUSION

Electric vehicle simulation is very necessary and real part. In simulation based testing in the hardware–in-loop is also done through it. Simulation also help is reduction of cost of on road test. It also reduces the fuel cost, efficiency can be easily calculated. It also reduces the time of test and fatigue of the test engineer.

The world is now changing the development of electric vehicle is fast and rapidly increasing. Now the engineers of current scenario are playing a key role or we can say important role in the development of electric vehicles.

It vanishes the cost of on road analysis and testing of a particular design which is under development.

## REFERENCES

[1]. Proceedings of the 2012 North-Central Section Conference copyright @ American Society for Engineering Education.

[2]. Introduction to Electric drive by gopal k.dubey

[3]. McDonald, Engineering & Technical education for electric vehicle engr, ASEE AC 2010

[4]. Model Based design of a Plug–In Hybrid Electric Vehicle Control Strategy by johnathan chales king

[5]. Brook, Meeting the technology challenge, AE int'I, SAE Sept 2009

[6]. Fundamentals of Vehicle Dynamics, Gillespie, SAE, ISBN 1-56091-199-9 pgs 110-115

[7]. Hybrid Electric Vehicle, Mi, Masrur & Gao, Wiley, ISBN 978-0-470-74773-5 pgs 42-45

[8]. MATLAB and Simulink for modeling and control, Robert babuska and Stefano stramigioli, November 1999

[9]. Staubel, tesla in article "meeting the technology challenges" AEInt., SAE sept 2009.