MODELING AND SIMULATION OF AN ELECTRIC VEHICLE USING MATLAB

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Abstract:

This project we are presenting the simulation and modelling of a basic electrical vehicle motor-drive system that is used to investigate power flow during both motoring and regeneration. The simulation assumes a DC permanent magnet motor. Electric vehicles are necessary in the shift away from combustion engine vehicles in order to reduce the transport sectors greenhouse gas emissions. Electric vehicles are likely to be an alternative energy mode of transportation for the future as it has shown a great ability to reduce the consumption of petroleum based and other high CO_2 emitting transportations fuels. This project focuses on a step-by-step design procedure which is the estimation of the ratings of different components in an Electric Vehicle . Physical modeling approach has been used for vehicle modelling to improve the modelling efficiency. Regenerative braking control is also been employed at the time of deceleration so that the kinetic energy is not wasted as heat. As some amount of it can be recovered and used for charging the battery, which can increase the Electric vehicle travel range.

Keywords: - Electric Vehicle, DC motors, power converters;

Introduction:

Any automobile that is propelled by an electric motor, using energy stored in a battery is known as a Pure Electric Vehicle or Battery Electric Vehicle commonly known as Electric Vehicles. Battery electric vehicles store electricity onboard with high-capacity battery packs. Their battery power is used to run the electric motor and all onboard electronics. Electric Vehicles do not emit any harmful emissions and hazards. BEVs are charged by electricity from an external source using electric Vehicle (EV) chargers. Electric vehicles (EVs) are one of a prominent solution for the sustainability issues needing dire attention like global warming, depleting fossil fuel reserves, and greenhouse gas (GHG) emissions. Conversely, EVs are shown to emit higher emissions (measured from source to tailpipe) for the fossil fuel-based countries, which necessitates renewable energy sources (RES) for maximizing EV benefits. EVs can also act as a storage system, to mitigate the challenges associated with RES and to provide the grid with ancillary services, such as voltage regulation, frequency regulation, spinning reserve, etc.

Electrical Vehicle System Architecture:

The electric vehicle (EV) is propelled by an electric motor, powered by rechargeable battery packs, rather than a gasoline engine. From the outside, the vehicle does not appear to be electric. In most cases, electric cars are created by converting a gasoline-powered car. Often, the only thing that clues the vehicle is electric is the fact that it is nearly silent. Under the hood, the electric car has A electric motor, A controller & rechargeable battery.

The electric motor gets its power from a controller and the controller gets its power from a rechargeable battery. The electric vehicle operates on an electric/current principle. It uses a battery pack (batteries) to provide power for the electric motor. The motor then uses the power (voltage) received from the batteries to rotate a transmission and the transmission turns the wheels. Four main parts make up the electric vehicle: the potentiometer, batteries, direct current (DC) controller, and motor .

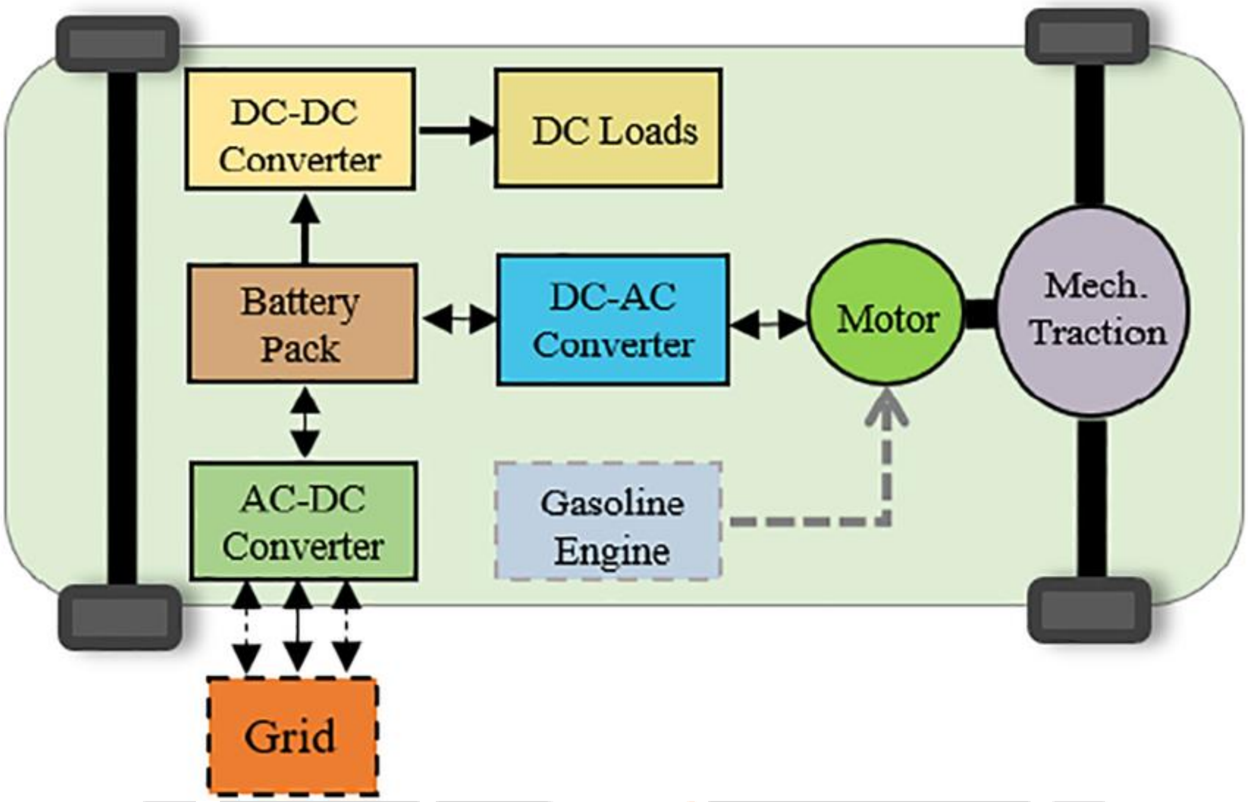


FIG. 1. Block Diagram of Electrical Vehicle

H-Bridge Converter:

The H-bridge arrangement is generally used to reverse the polarity/direction of the motor, but can also be used to 'brake' the motor, where the motor comes to a sudden stop, as the motor's terminals are shorted, or to let the motor 'free run' to a stop, as the motor is effectively disconnected from the circuit.

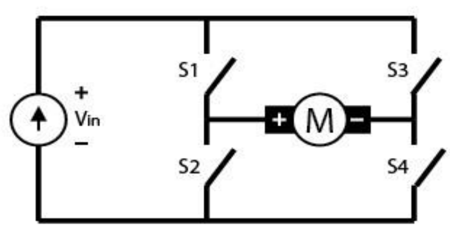


FIG. 2. Basic Circuit of H-Bridge

Vehicle Body:

Vehicle body is most expensive part of a car. Vehicle body is the main supporting structure of a vehicle, to which all other components are attached. The vehicle body has H Hub, S-Tire Slip, N-Normal Force, A-Axel connection, V-Velocity, W-Wind velocity, beta - Inclination angle.

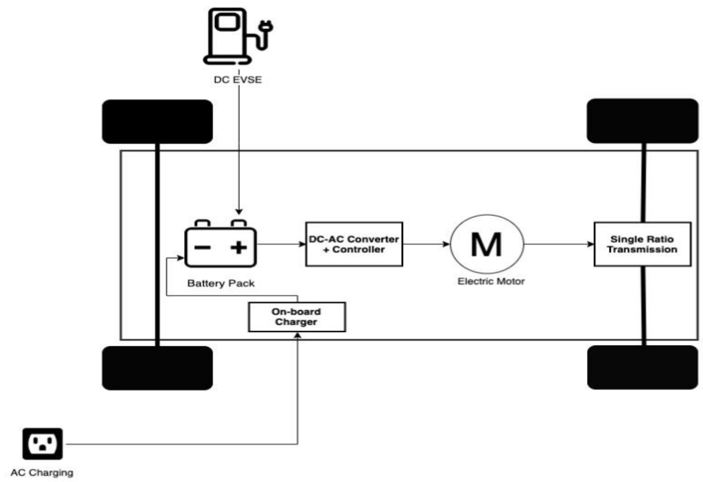


FIG. 3. Physical Vehicle Body

Hybrid vehicles offer several advantages over traditional gasoline-powered vehicles:

1. **Improved Fuel Efficiency:** Hybrid vehicles combine an internal combustion engine with an electric motor and battery. This setup allows them to achieve better fuel efficiency compared to conventional gasoline-powered vehicles. By utilizing both electric power and gasoline, hybrids can reduce fuel consumption and decrease emissions.

2. **Reduced Emissions:** With their ability to switch between gasoline and electric power, hybrids produce lower emissions than traditional vehicles. This is especially true in city driving conditions where the electric motor can handle lower-speed driving, resulting in fewer emissions of greenhouse gases and pollutants like nitrogen oxides and particulate matter.

3. **Regenerative Braking:** Hybrids use regenerative braking systems to capture and store energy normally lost as heat during braking. This energy is then used to recharge the battery, improving overall efficiency and reducing the workload on the gasoline engine.

4. **Lower Operating Costs:** While hybrid vehicles typically have a higher upfront cost than their gasoline counterparts, they can save money over the long term due to lower fuel consumption and reduced maintenance costs. Additionally, some governments offer incentives or tax credits for purchasing hybrid vehicles, further offsetting the initial cost.

5. **Silent Operation:** When running on electric power alone, hybrids produce minimal noise compared to traditional vehicles with internal combustion engines. This can lead to a quieter and more comfortable driving experience, especially in urban areas.

6. **Enhanced Performance:** The combination of an internal combustion engine and electric motor can provide hybrids with better acceleration and torque compared to similarly sized gasoline-powered vehicles. This can result in a more enjoyable driving experience without sacrificing fuel efficiency.

7. **Environmental Impact:** By reducing fuel consumption and emissions, hybrid vehicles contribute to environmental conservation efforts and help mitigate the effects of climate change. Their adoption can lead to a decrease in dependence on fossil fuels and a transition towards cleaner transportation technologies.

Overall, hybrid vehicles offer a compelling blend of improved fuel efficiency, reduced emissions, and lower operating costs, making them an attractive option for environmentally conscious consumers and those looking to save money on fuel.

Electrical Motor:

An Electric Motor is an electrical machine which converts electrical energy into mechanical energy. Most electric motors operate through the interaction between the motor's magnetic field and the electric current in a wire winding to generate force in the form of torque applied on the electric motors.

➤ DC Motors can be operated at variable speeds by adjusting DC voltage applied to the terminals or by using Pulse Width Modulation (PWM).

➤A.C motors can be operated at both fixed and variable speeds. The motors working with fixed speed are generally powered directly from the grid, while the motors working with variable speed are powered with variable power-invertors, variable frequency drives or even with electronic commutator technology.

Here we are using DC motor over AC motor as per the ease of adjustments in the supply voltage.

DC Motor:

DC motors were the first form of motor widely used, as they could be powered from eusting direct-current lighting power distribution systems. A DC motor's speed can be controlled over a wide range, using either a variable supply voltage or by changing the strength of current in its field windings. Small DC motors are used in tools, toys, and appliances. The universal motor can operate on direct current but is a lightweight brushed motor used for portable power tools and appliances. Larger DC motors are currently used in propulsion of electric vehicles, elevator and hoists, and in drives for steel rolling mills.

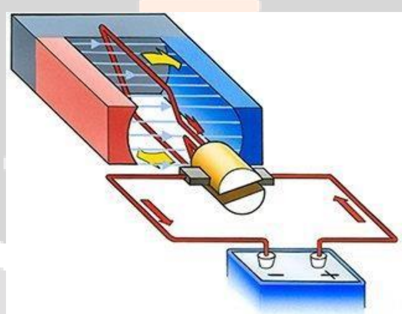


FIG.4. DC Motor

Power Converter:

A power converter is an electrical circuit that changes the electric energy from one form into the desired form optimized for the specific load. A converter may do one or more functions and give an output that differs from the input. It is used to increase or decrease the magnitude of the input voltage, invert polarity, or produce several output voltages of either the same polarity with the input, different polarity.

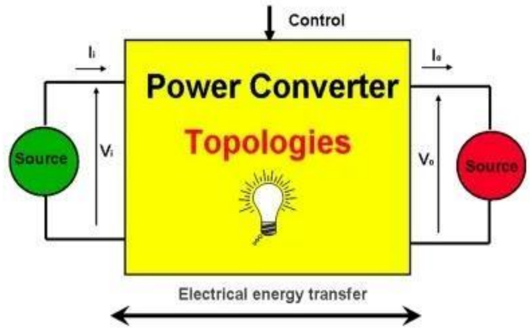
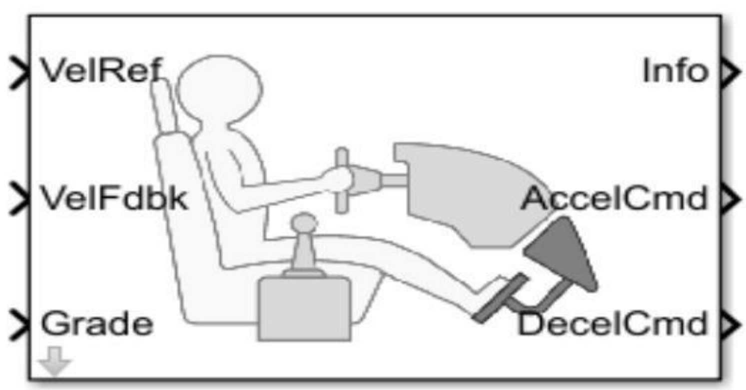


FIG.5. Power Converter

Longitudinal Driver:

This Longitudinal Driver Represents a longitudinal speed controller which produces acceleration and deceleration commands based on input and feedback speed variables provided using a proportional integral (PI) control. This driver uses the external actions to input signals that can disable, hold, or override the closed-loop commands determined by the block. The block uses this priority for the input commands: disable, hold and override. In simple we can say it as a Driver to drive the vehicle. In this block we are seeing three input ports and three output ports. They are as follows.



Longitudinal Driver

FIG.6. MATLAB Model of Controller Driver

Input Ports:

- VelRef - input port associated with input reference velocity of the vehicle (m/s)
- VelFdbk - input port associated with velocity feedback from the vehicle which helps in smooth control of the system.
- Grade - input port associated with inclination of surface in degrees.

Output Ports:

- Info - output port associated with a bus signal for acceleration, deceleration, error in velocity
- AccelCmd - Output port associated with acceleration commands with reference to input signal.
- DecelCmd - Output port associated with deceleration commands with reference to the input drive signal.

Drive Cycle:

The "Drive-cycle" basically is the representative of the road. Drive cycles are used to reduce the expense of on road tests, time of test and fatigue of the test engineer. The whole idea is to bring the road to the test lab or to the computer simulation. Two kinds of drive cycle can be Two kinds of drive cycle can be made. One is Distance dependent (Speed versus Distance versus Altitude) and the other one is Tume dependent (Speed versus Time versus Gear Shift). The Distance dependent is the actual replica of the test road whereas Time dependent is the compressed version of the actual time taken conduct the test on road.

This is a technique for prediction of future driving cycles and patterns for different types of vehicle applications. These cycles are used as an important input in designing and evaluating future power train systems and vehicle concepts. As of today, obsolete drive cycles are used during the design phase and due to this the changes in traffic conditions and infrastructure which has occurred during the last decade are not taken into account. Therefore, the need for new drive cycles representing today or the next few decades is great. This technique can predict future drive cycle by integrating available measurement data, high-fidelity traffic simulators and traffic models for heavy vehicles.

Simulink Circuit of Electric Vehicle:

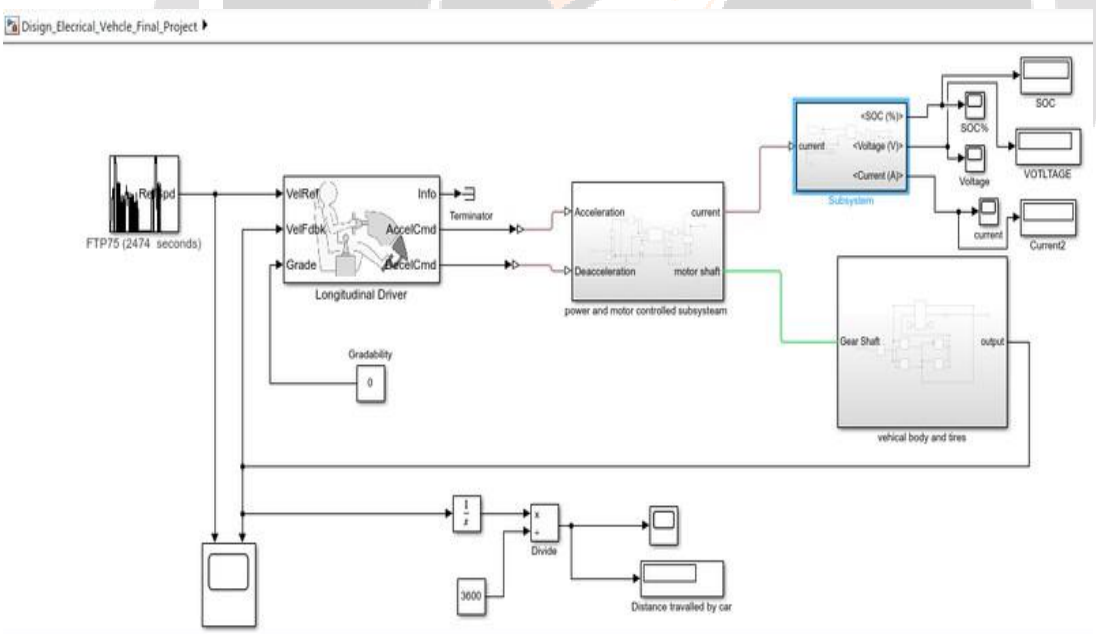


FIG.7. Simulation Circuit of Electric Vehicle

Results:

The following are the simulation results regarding Speed, Distance, SOC, Currents.

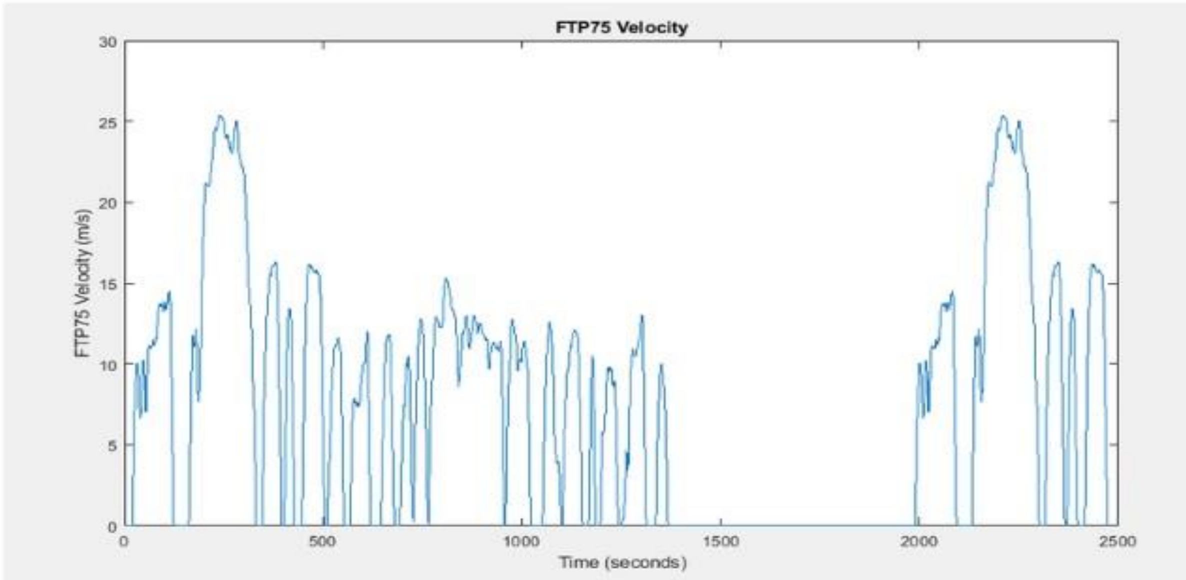


FIG.8. time(s) vs velocity(m/s)

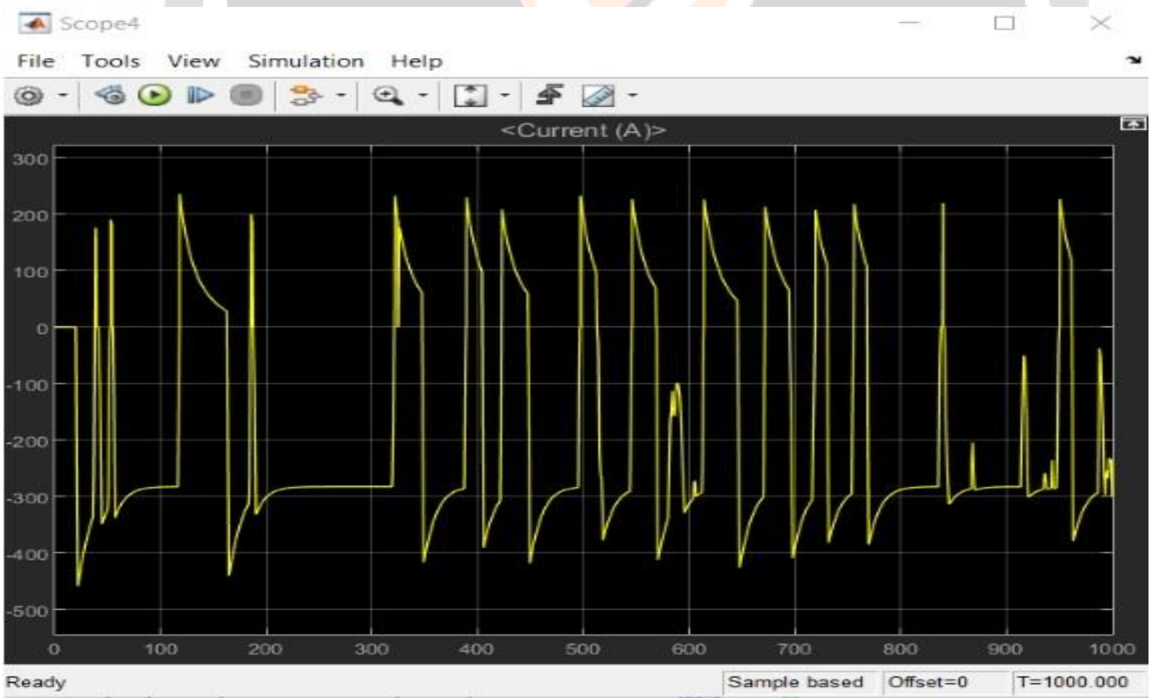


FIG.9. test time(s) vs vehicles speed(mph)

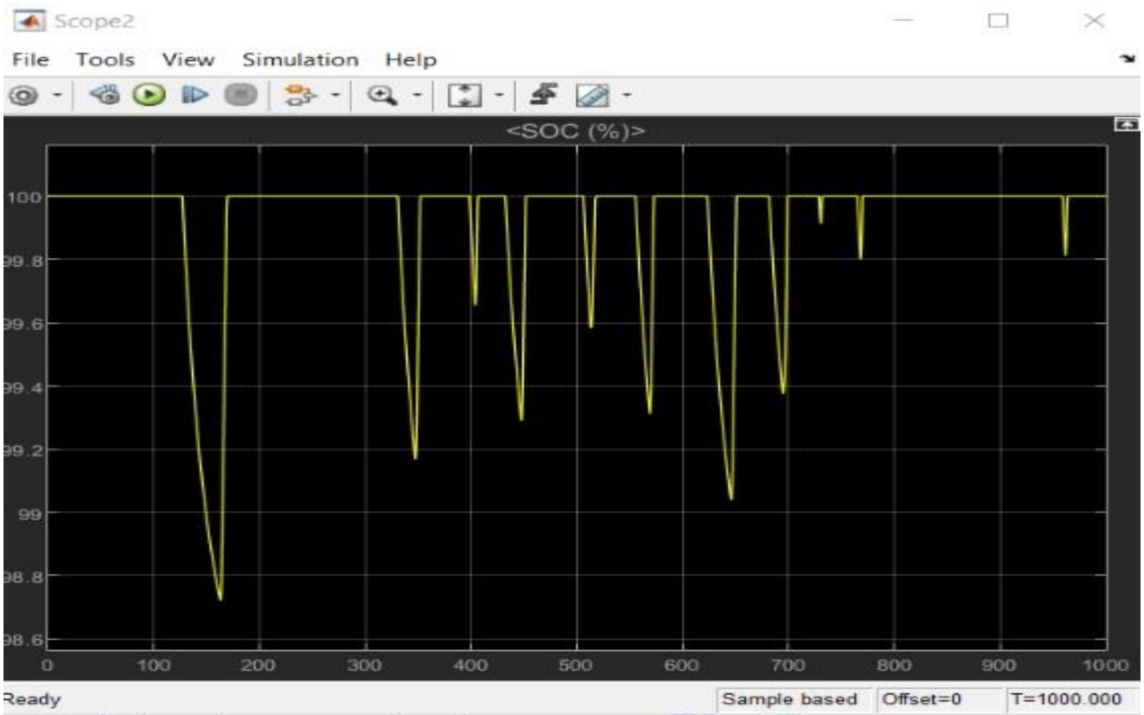


FIG.10.test time(s) vs current (amp)

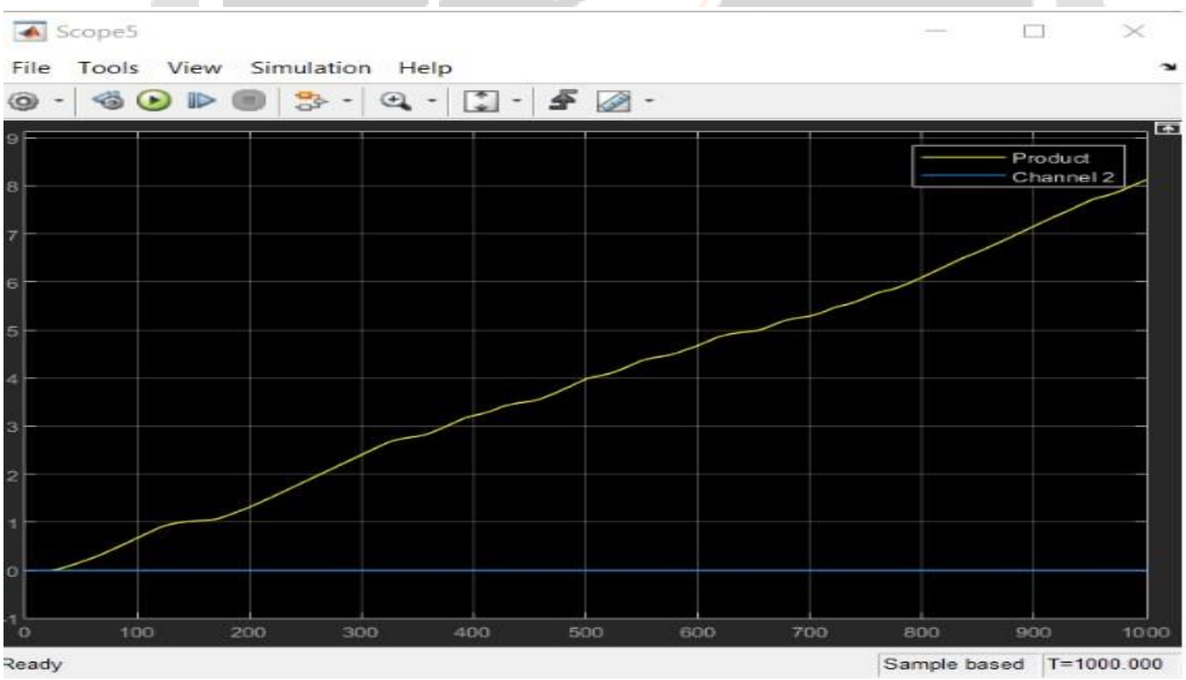


FIG.11. time(s) vs distance(miles)

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