Simulation of Solar Power based Hybrid Electric Vehicle

A J-COMPONENT PROJECT REPORT

SUBJECT CODE/NAME: *EEE4016 / Electric Vehicles*

YEAR/ SEM: *III / VI*

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May 2020

ABSTRACT

The project is a simulation of a solar powered hybrid electric vehicle. Initially our aim was to simulate a model of a hybrid electric vehicle which consists of two batteries both of which are charged to their full capacity. Initially one battery supplies power to the electric vehicle until it reaches 51.95% of its full capacity. After that, the source is switched to the other battery which then supplies power to the electric vehicle. This was achieved by us. Then our aim was to regenerate energy by braking and use that energy to charge a supercapacitor(which can be used to power various simple loads in a car). This was also achieved by us. The proposed work was simulated using Matlab Simulink.

1. INTRODUCTION

1.1 INTRODUCTION

With levels of pollution increasing everyday, people are slowly moving towards renewable energy sources and therefore the demand for a hybrid electric vehicle is steadily rising.

A hybrid electric vehicle (HEV) is a type of hybrid vehicle that combines a conventional internal combustion engine (ICE) system with an electric propulsion system (hybrid vehicle drivetrain). The presence of the electric powertrain is intended to achieve either better fuel economy than a conventional vehicle or better performance.

One of the biggest advantage of hybrid car over gasoline powered car is that it runs cleaner and has better gas mileage which makes it environmentally friendly. A hybrid vehicle runs on twin powered engine (gasoline engine and electric motor) that cuts fuel consumption and conserves energy. Another major advantage is that each time you apply brake while driving a hybrid vehicle helps you to recharge your battery a little. An internal mechanism kicks in that captures the energy released and uses it to charge the battery which in turn eliminates the amount of time and need for stopping to recharge the battery periodically.

Most of the electric machines used in hybrid vehicles are brushless DC motors (BLDC). Specifically, they are of a type called an interior permanent magnet (IPM) machine (or motor). These machines are wound similarly to the induction motors found in a typical home, but (for high efficiency) use very strong rare-earth magnets in the rotor.

2. PROJECT DESCRIPTION

We are simulating a hybrid electric vehicle. First we implement battery switching, that is, when the charge of one battery goes below 51.95%, this battery is switched off and the other battery starts to supply power to the load.

Then we implement regenerative braking and the energy obtained from regenerative braking is used to charge the supercapacitor and the battery.This is implemented using a Triple Active Bridge converter, which is used to interface or combine multiple sources.

2.1 COMPONENTS / SOFTWARE USED AND THEIR SPECIFICATIONS:

Sl. No.	Specification	Quantity
1.	Matlab Simulink	-

2.2 LITERATURE SURVEY

To meet increasing fuel economy and emissions legislation, the automotive industry will need to undergo drastic changes in vehicle and engine designs. Unlike conventional vehicles on the road today, hybrid electric vehicles (HEV) are designed with a smaller engine and an on-board energy storage system. The smaller engine allows the vehicle to achieve better fuel economy and fewer emissions. The efficiency benefits of diesel engines over gasoline engines make the diesel engine a strong contender for further improving fuel economy. The integration of diesel-engine technology into a hybrid electric vehicle configuration is one of the most promising ways to comply with fuel-economy and emissions legislation. Using simulation software, it is possible to quickly and easily optimise the engine and vehicle prior to investing time and money into testing components and building prototypes. The ability to integrate an advanced engine simulation software output and an HEV simulation for the prediction of engine alterations on overall vehicle performance is a critical tool for the success of meeting vehicle emissions and fuel economy goals.

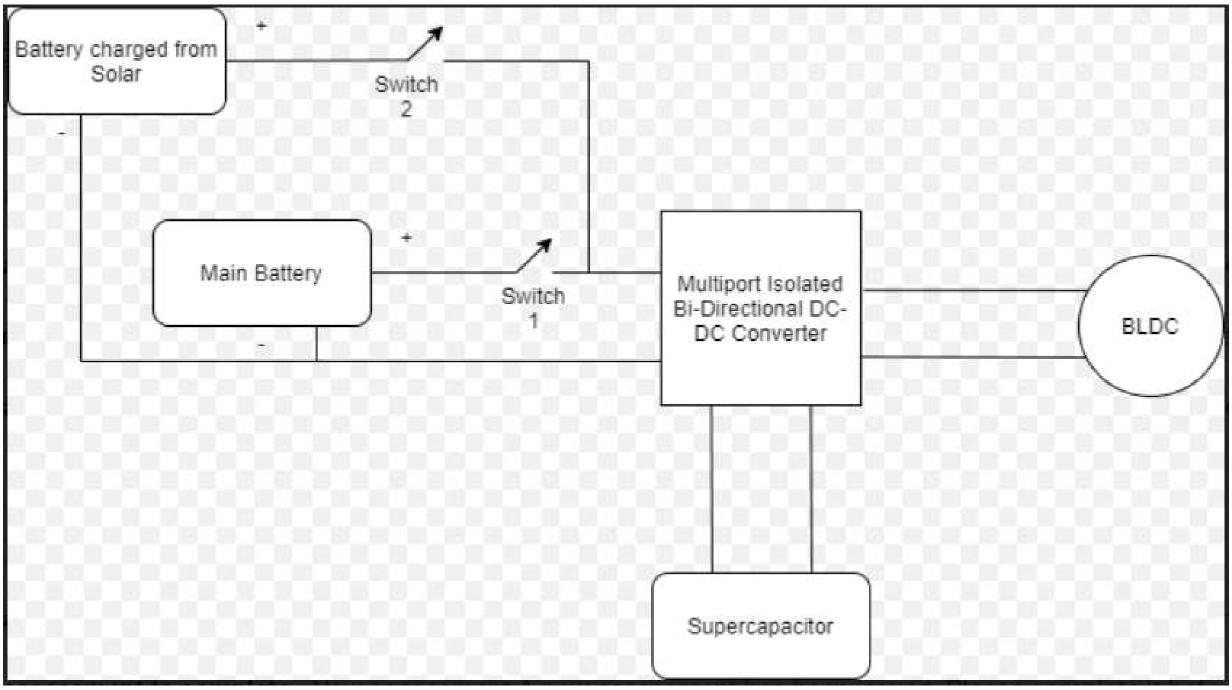
2.3 RELEVANCE TO ELECTRICAL VEHICLE

- Our project is the simulation of a hybrid electric vehicle. We have given two different batteries as sources out of which one is powered by a solar panel, just like a real hybrid electric vehicle.

- We tried to emulate a real hybrid electric vehicle by regenerating energy by braking which is then used to charge a supercapacitor.

- We also used a signal builder to depict road conditions just like how a real electric vehicle is driven through different road conditions.

2.4 BLOCK DIAGRAM REPRESENTATION:



2.5 THEORY / WORKING / DEMO CONCEPTS:

THEORY:

Hybrid electric vehicles (HEVs) combine the benefits of gasoline engines and electric motors. They can be designed to meet different goals, such as better fuel economy or more power.

Most hybrids use several advanced technologies:

- **Regenerative Braking.** Regenerative braking recaptures energy normally lost during coasting or braking. It uses the forward motion of the wheels to turn the motor. This generates electricity and helps slow the vehicle.
- **Electric Motor Drive/Assist.** The electric motor provides power to assist the engine in accelerating, passing, or hill climbing. This allows a smaller, more-efficient engine to be used. In some

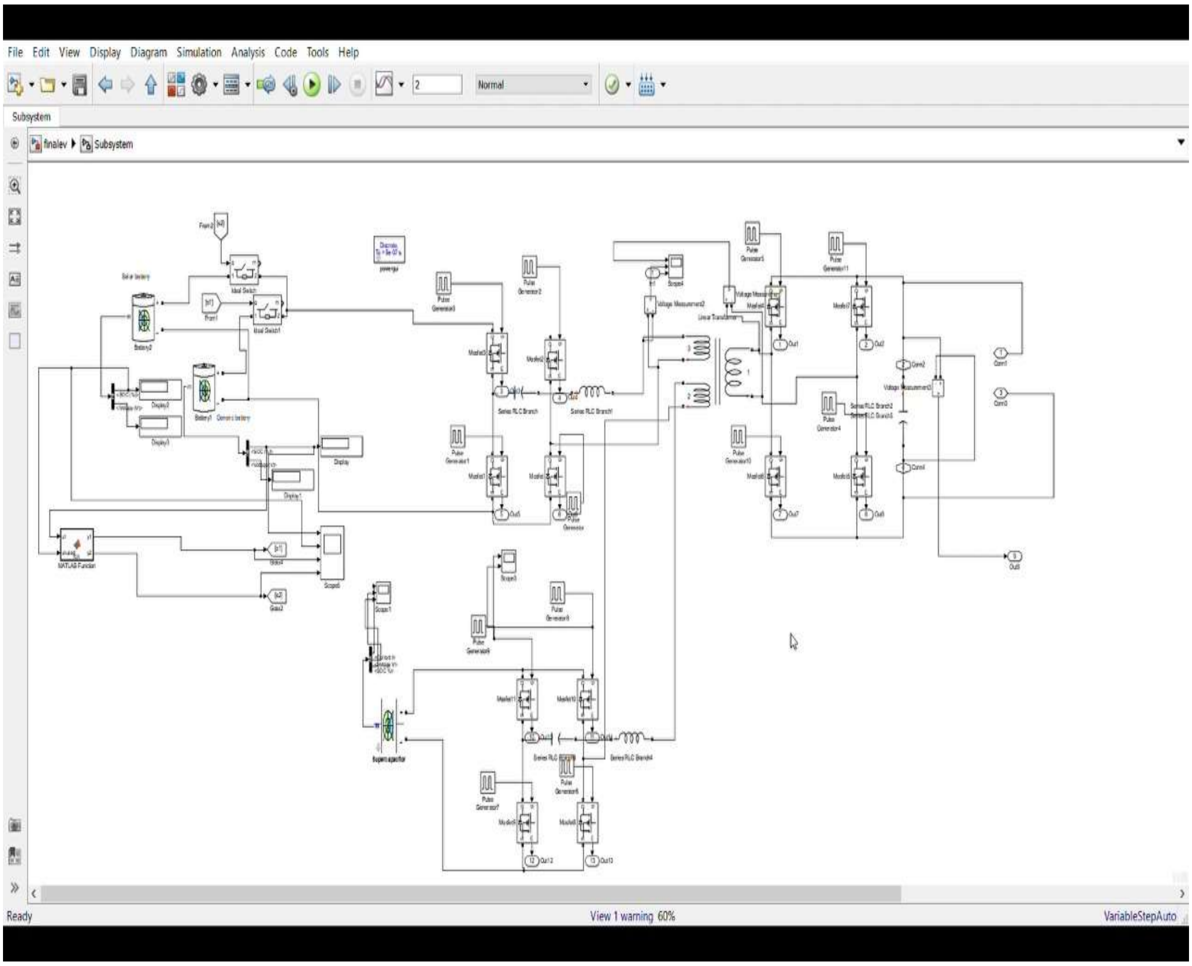
hybrids, the electric motor alone propels the vehicle at low speeds, where gasoline engines are least efficient.

- **Automatic Start/Stop.** Automatically shuts off the engine when the vehicle comes to a stop and restarts it when the accelerator is pressed. This reduces wasted energy from idling.

WORKING:

- We use a three port bidirectional DC-DC converter for which power will flow in both the directions. In the first port, two batteries; one which is charged by solar power and the other, which is a conventional battery, is connected through two sets of complimentary switches. Initially one battery is discharged for power. When the SOC of this battery becomes 51.95%, this battery is turned off and the other battery is turned on and thereafter that battery powers the load.
- Port 2 is connected to a supercapacitor and port 3 is connected to a BLDC motor. When power is positive,ie. When speed and torque are positive,port 1 and port 2 acts as an inverter and the voltage is converted from DC to AC. Then the transformer steps up the voltage. Port 3 acts a rectifer and the converted DC voltage goes to the BLDC motor. When power flow reverses, the battery and the supercapacitor will get charged and port 1 and port 2 will act as a rectifier.
- When the torque is negative,regenrerative braking takes place and and the supercapacitor is charged.

3. RESULTS AND DISCUSSION



Design Value:

- V(battery)=48V
- V(supercapacitor)=35V
- Switching Frequency=100kHz
- D=Ton/T=0.5

- L=(1-D)/V

L1=0.5/48=10mH

L2=0.5/35=14mH

- C=D/(2*f*R)=0.5/(2*100*1000*80)=3.1*10^-7uF
- Transformer Ratio:

n1:n2=1:4

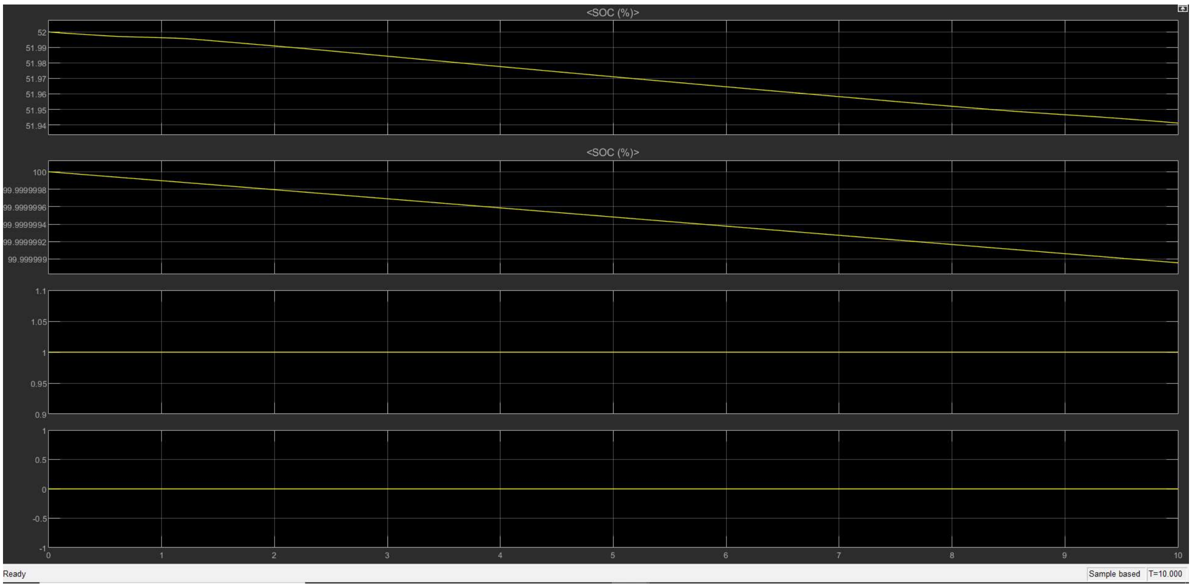
n1:n3=1:4

n2:n3=1:1

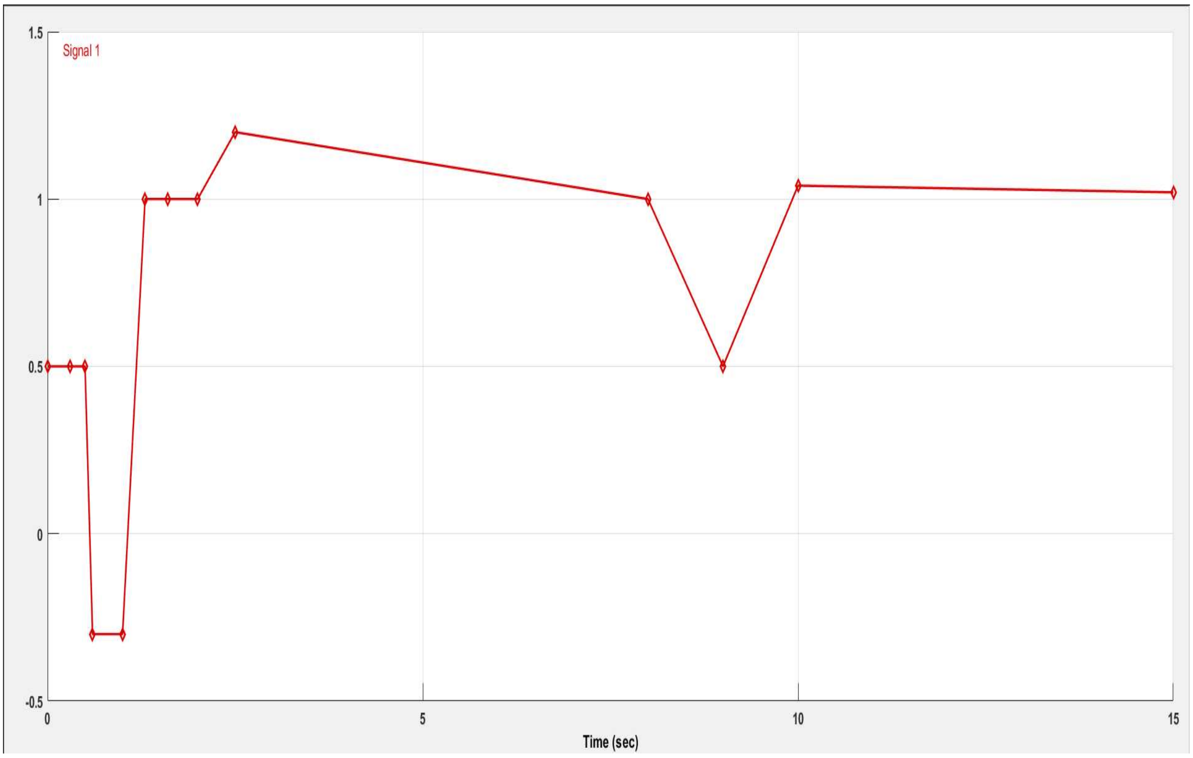
<u>Supercapacitor Cell Specifications:</u>

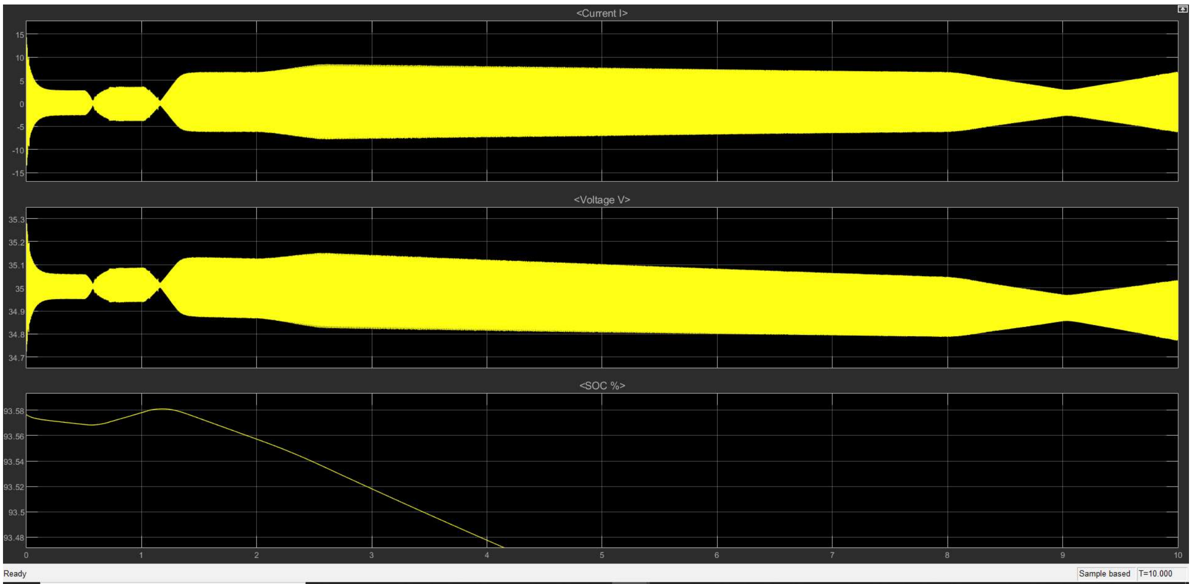
- Equivalent Capacitance of Supercapacitor cell=50F
- Voltage rating of supercapacitor cell=2.7V
- Equivalent Dc Series Resistance ESR=20milliohms
- Maximum surge voltage of a cell=2.85V
- Maximum leakage current=0.075mA

WAVEFORMS:

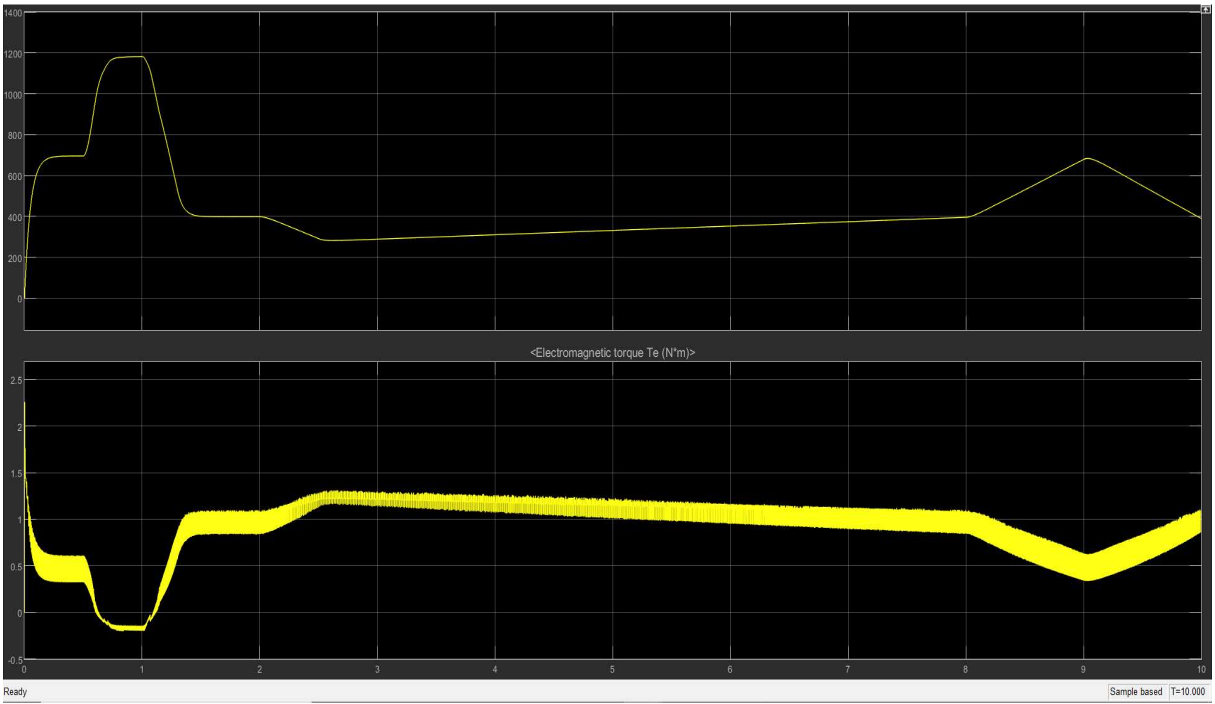


Initially battery 1 supplies necessary power(denoted by SOC1 in graph). When SOC1 drops below 51.95%, battery 2(denoted by SOC2 in graph) takes over the task of supplying power.





When negative torque is applied in the signal builder, there is a rise in the SOC of the supercapacitor. This is the part where regenerative braking takes place.



4.CONCLUSION / FUTURE SCOPE

CONCLUSION

Hybrid Electric Vehicles are one of the promising challenges in energy management

applications. Exact simulation and control of the possible states of hybrid power train

can achieve many numerous virtues such as fuel consumption optimization and

emissions reduction. The proposed model in this work shows some promising results

for the different modes of operation matching the real case. As the model behaved in

an accepted matter, many optimization and control methods can be applied on the model to experience their effect on the overall vehicle’s efficiency.

FUTURE SCOPE

This project can be developed in a lot of ways. Some of the ways are:

- More efficient converters can be used which may have less switching stages or even lesser components or switches involved.
- Various other auxillary sources can be interfaced.
- Study and comparison can be done to tune the PID controller using various Optimization techniques
- Can incorporate cruise control by means of a PID controller

5.LEARNING OUTCOME ACHIEVED

We learnt a lot about a hybrid electric vehicle and how it works during the course of the project.

- We learnt on how to implement a hybrid electric vehicle in Matlab Simulink.
- We learnt a lot about regenerative braking and how to simulate it.
- We learnt about how to use this regenerated energy to charge a supercapacitor.
- We learnt about a Triple Active Bridge Converter and its working.

6. REFERENCES

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