Power Management of Hybrid Vehicle Equipped with Battery and Super Capacitor

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ABSTRACT **- In this work, modelling of battery power management using boost converter and super capacitor have been proposed. This system employs solar PV array simulation with MPPT technology, a super capacitor and a battery. The proper manage of this hybrid system is important, this will help to ensure the continuous power supply for the long time and hence vehicle can run for long distance. Therefore, the proposed system is efficient and accurate than the existing one. The feasibility of this topology has been proposed to carry out in the simulation study using MATLAB software.**

KEYWORDS: *FLC of MPPT, super capacitor, boost and buck boost converter, DC-link.*

INTRODUCTION

In the recent years, the pollution issues and increase in cost of fossil fuel have become major problems. To overcome these problems the automobile manufacturers started implementing hybrid electric vehicles which uses two energy sources main energy source and auxiliary one. HV manufacturing industries has shifted towards indigenous power management technology for assuring better performance of a vehicle.

Hybrid electric vehicle uses PV array system as a main energy source which is renewable source and requires less maintenance. This main energy source is used for long driving range of HV. The output of PV array system is extracted from fuzzy logic controller based MPPT (Maximum Power Point Tracking). Battery is charged with the help of PV system; it will generate the required energy during the steady state.

Another energy source is the auxiliary one which is used when braking of the vehicle is performed, it provides necessary boost during quick acceleration ultimately increasing the efficiency of vehicle. In order to balance the load condition supercapacitors are used as auxiliary source of energy. Here, the combination of boost and buck boost converter is implemented in order to achieve the desired behaviour.

The flow of power between two energy storage system is done by bidirectional dc-dc converters. As we know, DC to DC converter is connected to the PV array as an input and the inverter as an output which is called as DC link voltage. Any change in load affects the DC link voltage directly hence to control the power flow through DC-link microcontroller is implemented.

This proposed paper shows the performance of PV array system, MPPT, boost converter, buck boost converter and supercapacitor in the combination of battery. The performance and system working are shown by the simulation model using MATLAB/Simulink software.

SYSTEM DESCRIPTION

1. Battery:

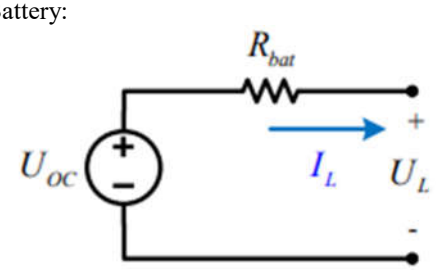

Fig 1- Battery circuit

$$P=V_L I_{BAT}$$

Battery provides majority of energy since they store power and release larger amount of energy over a long period of time.

2. Supercapacitor:

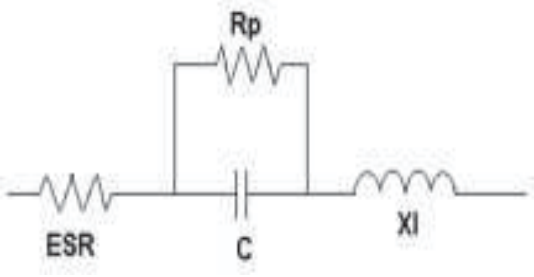

Fig 2- Equivalent simplified model of supercapacitor

$$c = \frac{t}{Rt} = 0.632Vo$$

The ability of the super capacitor to be charged and discharged constantly without degrading is its most major useful fact over

batteries. This is one of the most common while batteries and supercapacitor are used together.

3. Boost converter:

Boost converter is a DC-to-DC power converter that steps up voltage from its input to its output.

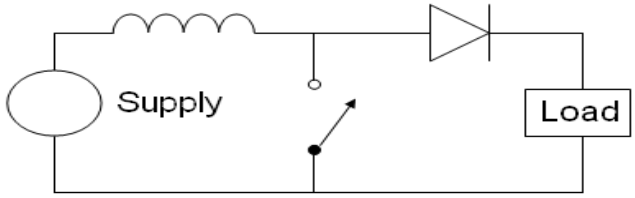

Fig 3- Boost converter

This unique capability is achieved by storing energy in an inductor and releasing it to the load at a higher voltage. Boost converter can reduce number of cells of the batteries.

4. Buck boost converter:

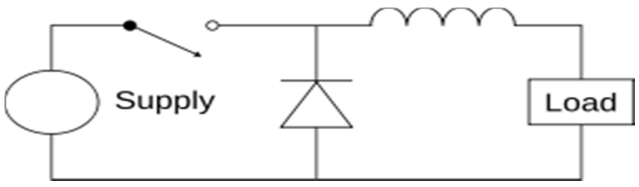

Fig 4- Equivalent circuit of buck boost converter

It is a type of DC-to-DC converter that has an output voltage magnitude that is either greater than or less than the input voltage magnitude. two different topologies are called buck-boost converter. Both of them can produce a range of output voltages ranging from much larger than input voltage, down to almost zero.

5. Fuzzy logic controller based MPPT:

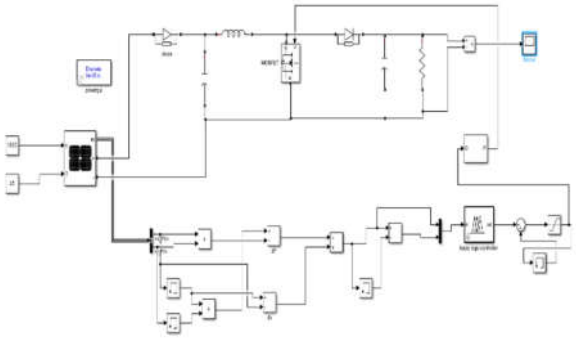

Fig 5- Model of FLC based MPPT using MATLAB/Simulink

This work implements a maximum power point tracker that uses fuzzy logic control algorithm. This proposed work used FLC to initiate the control command to the output boost converter as there is a change in voltage and current across the PV panel.

PROBLEM STATEMENT

A hybrid electric vehicle is a type of hybrid vehicle that combines a conventional internal combustion engine system with an electric propulsion system. The presence of the electric powertrain is intended to achieve either better fuel economy than a conventional vehicle or better performance. But still this kind of vehicles face some challenges like low reliability, limited/short driving range, battery system issues, limited fuelling stations, longer recharge time etc. Hence the work is proposed to overcome these challenges by backup i.e., by managing battery power of HEV using boost converter and super capacitor. Super capacitor charges and discharges rapidly which provides energy storage solution. And to step-up an input voltage to some higher level which is required by load is done by boost converter. This capability is achieved by storing additional energy and releasing it to the load when the vehicle is out of fuel and electricity.

METHODOLOGY:

A. SYSTEM CONFIGURATION

In this paper, the proposed design of power flow in hybrid vehicle is shown in the block diagram below;

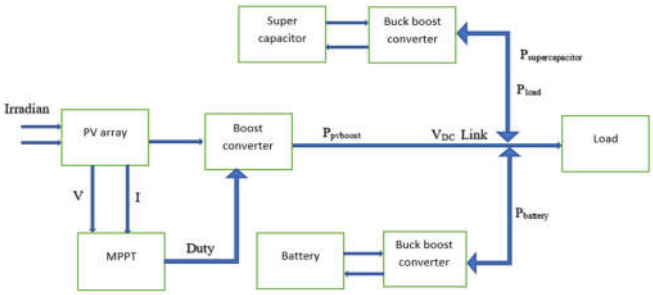

Fig 6-Schematic block diagram of proposed work.

This proposed work consists of primary components i.e., PV array module, boost converter, buck- boost converter and MPPT control. The PV array system provides power supply for boost converter. The need for power is met by PV power flowing, which is consumed by load(motor) and also stored in a battery with super capacitor.

B. WORKING

The PV array generates DC which will be boosted to required level by boost converter and then the same is used to charge the battery and super capacitor. In order to obtain maximum power from PV system MPPT technology is used. Hence optimum power can be generated. Buck boost converter are used at sides of battery and super capacitor which is bidirectional converter.

A DC link is used between converter and load(motor). An automatic state of charge detection controller is used which will prioritise that which is once used to feed power to load. This is also embedded with a switch (relay) for this purpose. This will ensure life time fuzzy logic.

SIMULATION MODEL

System is proposed using MATLAB/Simulink according to the characteristics of the system shown in figure.

The model of PV array system and auxiliary energy storage device such as battery and super capacitor are connected to BLDC motor(load) with DC-link.

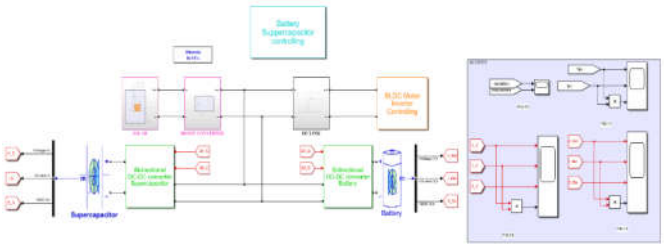

Fig 7- Simulation model of proposed work

Here, the electricity from solar PV array is delivered to a boost converter, which boosts the DC voltage. The boost converters output is routed to the hybrid storage units i.e., battery and super capacitor. Then through the buck boost converter the power is delivered to BLDC motor through DC-link.

SIMULATION RESULT

1. Irradiation and Temperature graph:

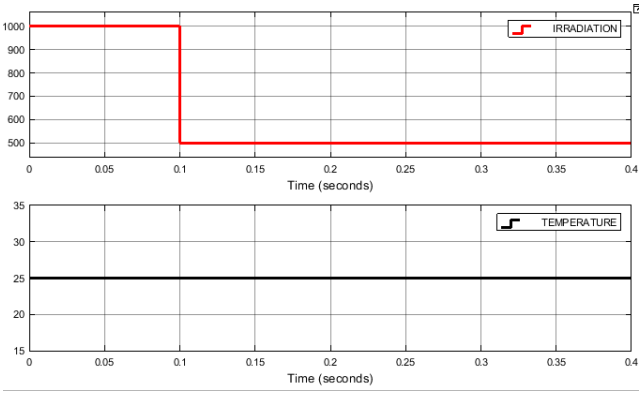

Fig 8- PV system input

Irradiation is the measure of the power density of sunlight, The Irradiation starting from 1000 at the time of 0 to 0.1 and then it is decreased to the half of it initial value and then the irradiation will remain same at every point of time.
Temperature remains constant throughout the time in the system. So, it is a linear graph.

2. PV voltage, current, and power:

Voltage: At the starting the Irradiation are high so the voltage is at the maximum level at 25V at the beginning and there will be disturbance in the system and it is also almost linear if the irradiation remains constant.

Current: The current will be zero at the starting of the system, as the temperature increase the voltage and current will be increase as shown in the figure.

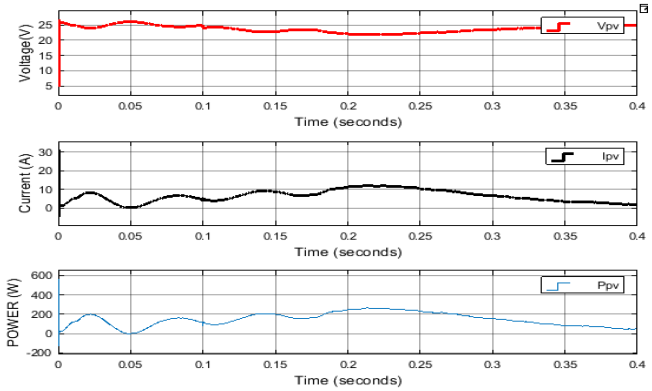

Fig 9- PV system output

Power: The power is the product of both voltage and current. So, we get power graph as shown in figure(9).

3. Super capacitor voltage, SOC, current and power:

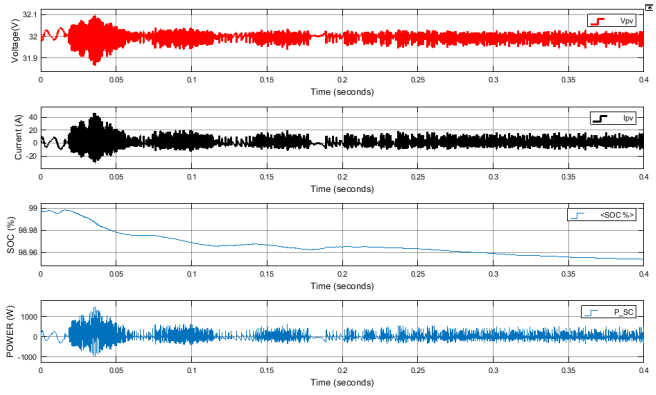

Fig 10- Super capacitor output parameters.

As shown in the figure, the supercapacitor is charged when supercapacitor current is positive and discharged when

supercapacitor current is negative super capacitor will be charged using the PV array system.

Starting the voltage of supercapacitor is high at 32V and gradually as the time increase the voltage will be linear.
They will be increase and decrease in supercapacitor current becomes of the motor which draw the current to accelerate the system.

State of charge of the supercapacitor is full at the starting point as the time increase the charge in the supercapacitor get discharged and reach the zero level.

4. Battery, voltage, current, SOC and power:

There is a sudden increase voltage as shown in the figure. As the time increase voltage remain constant.

Same as voltage but in verse method they is a sudden down fall of the current at starting point and then again increase at certain level and remain constant at no time.

State of charge of the battery will be at low at the starting point and gradually increases as shown in figure.

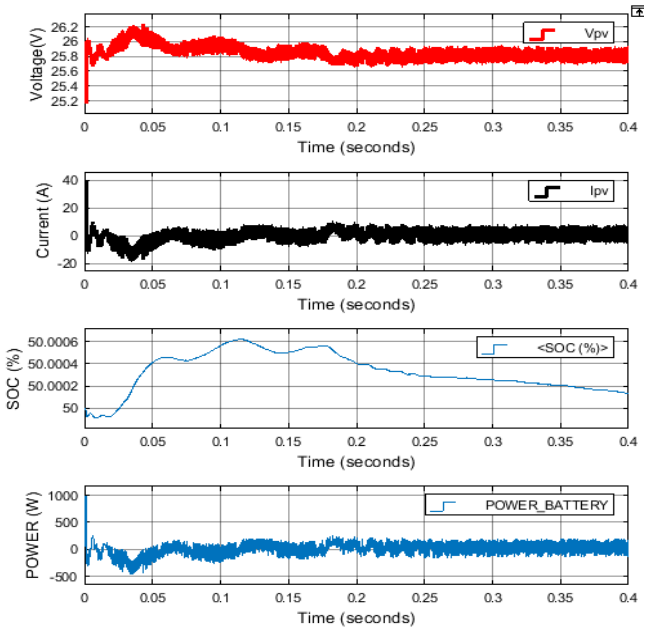

Fig 11- Battery output parameters

CONCLUSION

This paper deals the power management of hybrid vehicle using super capacitor and boost converter. It is expected that new emerging technologies will be implemented in the HEVs. The new technologies enhance their battery performance. This would probably include super capacitor which hold promise for reducing the high-voltage battery energy requirements.

The usage of super capacitor as an auxiliary energy storage source results in reliability, long drive range for long distance, and works when sudden acceleration is required or

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