Simulation of Closed Loop Control Dual Input Dc-Dc Converter Using Solar Cell

Bhavana V Gowda[1], Leelashri K[2], Kruthi Jayaram[3]
[1, 2] Dept of EEE
[3]Assistant Professor, Dept of EEE
[1, 2, 3] BNMIT, Bangalore

Abstract- *The energy storage unit is one of the most important aspects in the structure of hybrid electric vehicle and photo voltaic systems. Dual input dc-dc converts used in such energy storage unit to improve efficiency, performance, and cost-reduction and count of components is verified. In this paper simulation of closed loop control dual input DC-DC Converter using solar cell is presented. Dual input dc-dc (buck) converter with a renewable energy source is proposed. This converter will give a regulated output voltage to the load. A solar panel is used in this converter to obtain the solar energy and dc voltage is obtained. This converter can deliver power to the load either simultaneously or individually based on battery utilization. The complete converter will reduce the size of the system as well as the cost due to the less number of components. The performance of the converter system is analyzed and simulated using MATLAB/Simulink.*

Keywords- Solar Panel, DC-DC Converter, PI Controller

I. INTRODUCTION

The high specific power of ultra-capacitors is the major reason of them being used as intermediate energy storage unit. Energy storage system consists of battery or ultra capacitors the conventional approach of connecting the energy storage unit is by using independent converter. A dc-dc converter is an electronic switching device that converts fixed voltage to a variable voltage at the voltage side. The output voltage is generally fluctuating and this could be regulated by changing time of the switch, pulse width and switching frequency. The fundamental for a buck converter consists of an inductor, diode, capacitor and switch. The dc input to the converter can be a battery, dc from solar panels and rectified AC from mains supply. A multi input dc-dc converter is used to connect multi sources in a single system to give required load demand. Here, only two inputs are used so it is named as dual input dc-dc converter.

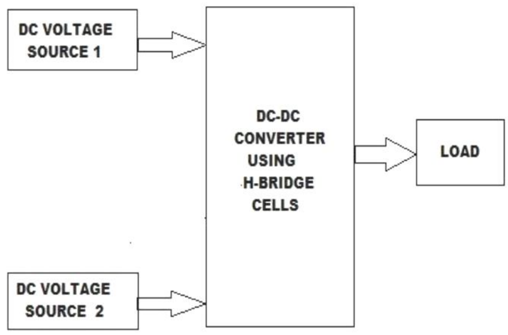


Fig1: Block diagram of dual input DC-DC Buck-Buck converter

For the designing of the capacitor and inductor values in the circuit for the given switching process was a tedious procedure. Design for 50% duty cycle is done. Hence for the designed values of the capacitance and inductance the output is obtained in the simulink/ MATLAB.

The main objective of this paper is to simulate the implementation of the buck-buck converters using solar cell with a closed loop control.

II. ANALYSIS OF DC-DC CONVERTER

The H-bridge cell consists of four switches with one voltage source i.e, S1, S2, S3, S4. The voltage source can be a battery, ultra capacitor or PV cell. The output voltage is equal to +V when the switches S1 and S3 are turned on. The output voltage is equal to -V when the switches S2 and S4 are turned on. The first stage of dual input buck-buck dc-dc converters is constructed by using the two cascaded H-bridge cells in series connection with only one inductor.

The switches in the combination of the H-bridge cells which are not used are replaced by open circuit. The output is obtained across the inductor and the voltage drop across the inductor depends on the switches which are in ON condition. The basic idea in the synthesis of dual input dc-dc converters is to bring a new switching circuit which can be able to connect or disconnect two input sources such as a battery or photovoltaic system to charge an energy storage element individually or simultaneously. Inductor is used as an energy storage element in this circuit.

Considering the dual input buck-buck dc-dc converter, in mode I the V1 supplies the energy to the inductor. In mode II, V2 supplies the energy to the inductor. In mode III, the inductor depletes the energy to the load. In mode IV, V1 and V2 supply the energy to the inductor. The final designed circuit has only four switches. The power sources V1 and V2 are assumed to be power sources. If energy storage units are used for this purpose then it needs to be charged regularly and the converter must have bidirectional power capability which is enabled by connecting a diode in parallel connection to obtain a bidirectional dc-dc converter.

The final designed circuit has only four switches where the number of switches is reduced and the circuit has only one inductor. If the power flow through the inductor is considered to be unidirectional, the current through the inductor il is always positive. As switch S2 conducts positive current and opposes negative current and positive voltage. The switches can be replaced by a MOSFET.

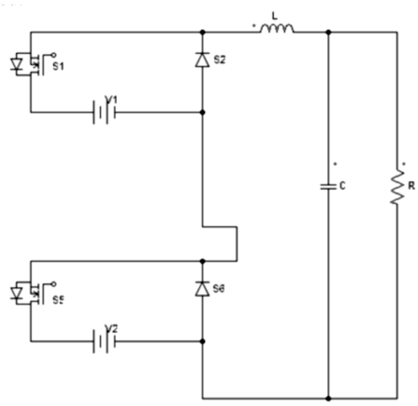


Fig2: Final stage of dual input buck-buck converter using H-bridge cells and MOSFET.

III. SIMULATION OF CLOSED LOOP CONTROL DUAL INPUT DC-DC CONVERTER USING SOLAR CELL

The Dual input D-DC Buck-Buck converter consists of two sources and is a closed loop circuit. Implementation is done by replacing one of the DC sources by a solar panel and making it a closed loop circuit using a PI-controller.

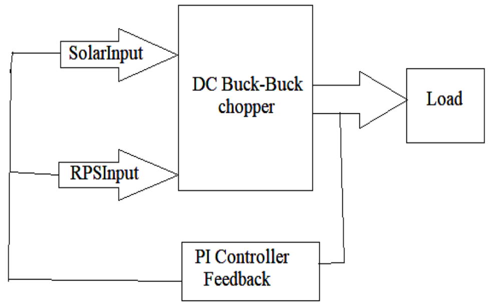


Fig3: Block diagram of the DC-DC converter using a feedback

SOLAR PANEL: Photovoltaic modules use light energy from the Sun to generate electricity through the photovoltaic effect. The majority of modules use wafer-based crystalline silicon cells or thin-film cells. The structural member of a module can either be the top layer or the back layer. Cells must also be protected from mechanical damage and moisture. Most modules are rigid, but semi-flexible ones based on thin-film cells are also available. The cells must be connected electrically in series, one to another. Externally, most of photovoltaic modules use MC4 connector's type to facilitate easy weatherproof connections to the rest of the system.
Module electrical connections are made in series to achieve a desired output voltage or in parallel to provide a desired current capability. The conducting wires that take the current off the modules may contain silver, copper or other non-magnetic conductive transition metals. Bypass diodes may be incorporated or used externally, in case of partial module shading, to maximize the output of module sections illuminated.

Table1: The specifications of the solar panel used in MATLAB

PARAMETERS	VALUES
Module	Bosch solar energy c-Si M 60-225-16
Parallel strings	4
Module/string	5
Max. Power (W)	224.985
Open circuit voltage(Voc)	36
Voltage at max. Power(Vmp)	28.3
Temperature Co-efficient of Voc(% deg.C)	-0.374
Cells per Module(N cell)	60
Short Circuit Current, Isc(A)	8.7
Current at max. power impedance(A)	7.95

The solar panel characteristics can be observed in the MATLAB software

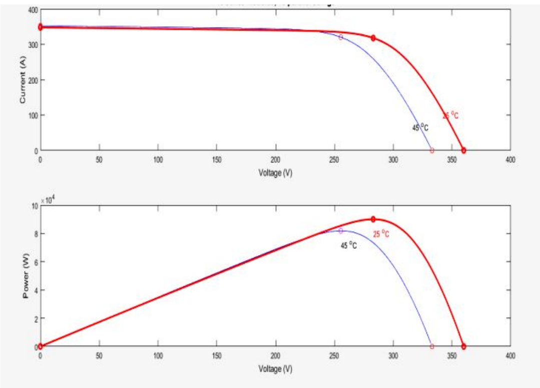


Fig4: IV- and PV- characteristics of the solar panel

PI CONTROLLER: A Proportional-integral-controller is a control loop feedback mechanism widely used in industrial control systems and a variety of other applications requiring continuously modulated control. A PI controller continuously calculates an error value e(t){\display style e(t)} as the difference between the output and the reference voltage and applies a correction based on proportional and integral terms. In practical terms it automatically applies accurate and responsive correction to a control function.

Using proportional control alone in a process with compensation such as temperature control, will result in an error between the output and the reference voltage, because it requires an error to generate the proportional response. If there is no error, there is no corrective response. Using integral control,the integral term seeks to eliminate the residual error by adding a control effect due to the historic cumulative value of the error. When the error is eliminated, the integral term will cease to grow. This will result in the proportional effect diminishing as the error decreases, but this is compensated for by the growing integral effect.

The balance of these effects is achieved by "loop tuning" to produce the optimal control function. The mathematical model and practical loop above both use a "direct" control action for all the terms, which means an increasing positive error results in an increasing positive control output for the summed terms to apply correction.

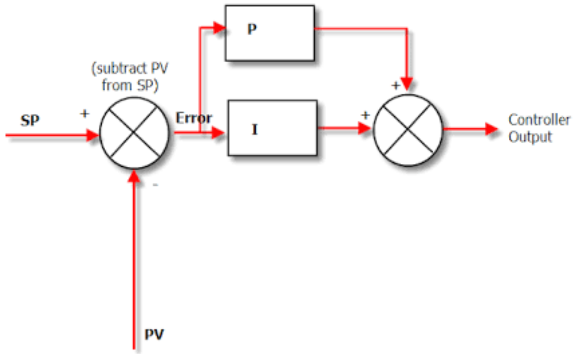


Fig5: PI Controller

III. SOFTWARE IMPLEMENTATION

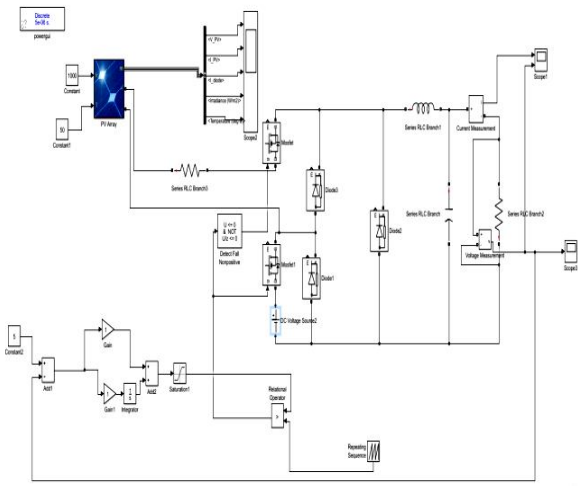


Fig6: Simulation circuit of DC-DC Buck Converter with closed loop and solar panel implementation

Fig6 involves one of the input as RPS and other solar panel which contains the inbuilt values of the voltage, current and diode current values for the given irradiance and the temperature. The circuit also involves the closed loop with feedback as the PI Controller which helps in maintaining the constant output for the required load. The output obtained from the controller circuit is given as pulse to the MOSFET's.

The simulation circuit of DC-DC Buck converter of a closed loop system with solar panel using MATLAB is shown in Fig.6

IV. RESULTS & ANALYSIS

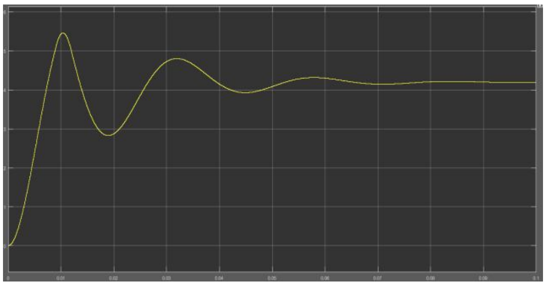
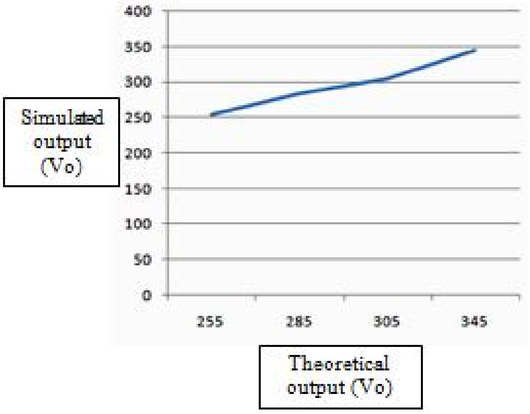


Fig7: The output obtained from the simulation circuit

The comparison of the theoretical and the simulated values for the closed circuit with the solar panel is as follows,

Theoretical Values Vo	Simulated Values Vo
254	127.5
285	142.5
305	152.5
345	172.5



V. CONCLUSION

The main objective of the paper was to implement simulation of closed loop control dual input dc-dc converter using solar cell. Dual input dc-dc (buck) converter with a renewable energy source is proposed. The converter gives a regulated output voltage to the load. Comparison of theoretical and practical values of duty cycle variations is done. The buck-buck converter method is the most effiecient and less cost method to obtain optimum output for a given input voltage.

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