

DC-DC Converter for Charging Supercapacitor in PV Application

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Abstract - This paper presents simulation results of DC-DC converter for charging supercapacitor in PV application. The proposed system converts photovoltaic power into high current to charge supercapacitor. In this the simulation results supercapacitor based converter system are shown. A buck converter is implemented to raise the current to desired level, and converter will be used to control system parameter like output current and voltage by using controlled PWM scheme and it also used to measure parameter like current and voltage which would be used as reference for regulate system operation. SIMULINK/Sim Power Systems are used for simulation.

Key Words: Supercapacitor, Buck converter, DC-DC Converter, PV, Interleaved Buck converter in SimPowerSystems.

1. INTRODUCTION

In order to utilize renewable energy to save consumption of electricity and fuel, we have to design a more energy efficient system, which can excite the load like electric or electronic system, for this we need to design light weight, highly energy efficient. Considering drawbacks of batteries interleaved DC-DC converter is designed in this work for charging supercapacitor bank. Reference [6] deals with design of energy harvesting system for super-capacitor used for automotive application. Microcontroller based converter system for super-capacitor is presented [4].

Output of PV cell varies with respective light intensities; so in a conventional system, power is not given directly to load it is stored in battery bank and then the load drives on battery. The work proposed here is an attempt to design DC-DC converter system based on supercapacitor and to remove the system limitations incurred due to battery.

In India solar energy is available in abundant amount. But the output characteristics of a PV cell vary non-linearly with environmental conditions such as temperature and irradiation [2]. Also, the operating point of PV cell is playing the main role in full optimization of power, i.e. it important to maintain optimum operating point. The storage devise battery need's maintenance but a supercapacitor does not require maintenance and it is more lightweight, which makes the system portable; hence for energy-aware applications, supercapacitors are an attractive option because of its efficiency, durability and low environmental impact [3]. Conversion efficiency of electric power generation is very low (9-17%), especially on a cloudy day, as per weather conditions the amount of electric power generated by solar arrays differs continuously.

There are two major problems we have with PV generation systems. V-I characteristic of the solar cell varies with temperature and irradiation. To achieve high efficiency, we have to achieve Maximum Power Point It is a unique point on the V-I or V-P curve, at this point PV system operates with maximum efficiency and produces its maximum output power at maximum power point [5]. So we are have this simulation of system which can give a constant output voltage to the load and it's maintenance free due to supercapacitor, and it will give high efficiency.

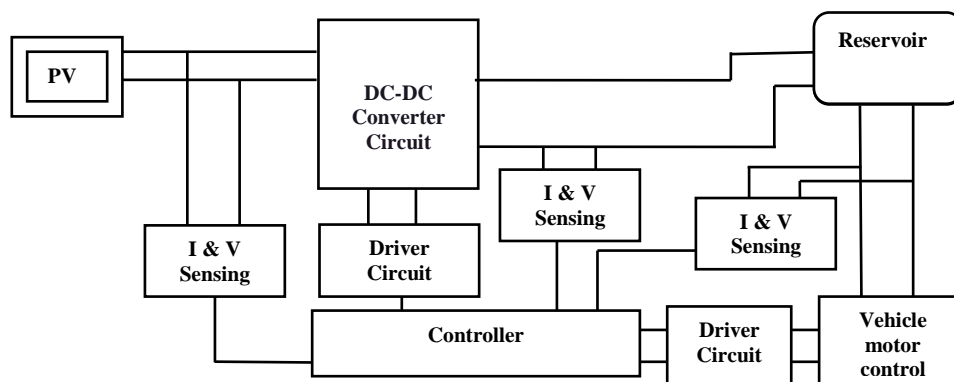


Fig -2: Generalized block diagram of proposed system

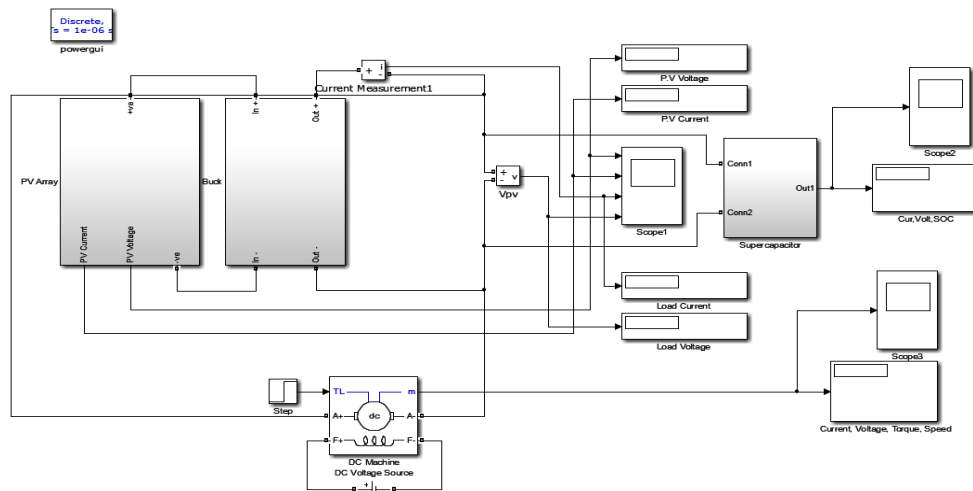


Fig -2: Simulation model of proposed system

2. DC-DC CONVERTER SYSTEM

We can see proposed system in fig. 1. System is powered by solar energy taken from PV panel it can't give to load sensitive load directly because its output is variable and not at appropriate level so we have to use Energy converter with reservoir Circuit which has content manly a Buck converter. The Driver Circuit is used to trigger the IGBT in buck converter. Reservoir is nothing but bank of supercapacitor used to store charge. A control unit shall be developed such that it will monitor current and voltage at varies point and help it will regulate operation of the system. The output of a buck converter is given to load and supercapacitor in parallel to obtain constant power. PWM scheme is used for switching of converter switches.

3. SIMULATION

A simulation model of proposed system is shown in Fig. 2. The MATLAB/ SIMULINK is used for simulation, it contains various blocks such as PV Array, Buck converter, Supercapacitor, DC machine. Output across Supercapacitor and DC Machine is shown in fig.7 and fig.8 in result. The Interleaved Buck Converter bucks voltage but it boosts the current, here to charge Supercapacitor we need high current so this buck converter fulfills our need, here two buck converter work interleaved which result in boosted current get add at output, at 50% duty cycle we get double of input current. In fig 6 we can see the result of simulation

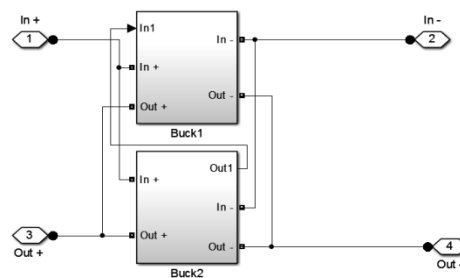


Fig -3: Simulation model of Interleaved Buck Converter

Input current from PV is 4.7 to 5.7 varying and output is 10.4 constant. Here in above figure fig.3 we can see two block Buck 1 and Buck 2 which work connected parallel to each other they will work interleaved, it means buck 1 and buck 2 not get triggered at a time, they get triggered one after one. So 50% duty cycle is best to trigger interleaved buck converter. In figure Fig.4 and Fig.5 we can see circuit of buck converter when pulse is high IGBT get short-circuit and inductor capacitor get charged throw inductor, when pulse is low IGBT get open-circuit but capacitor still charged throw inductor due to diode circuit get completed so capacitor get charged with more current. Same thing will happen with buck 2 but Buck 1 and Buck 2 worked interleave so if we place load across this two buck converter we get double current.

4. DESIGN OF BUCK CONVERTER

In design of buck converter values and type of component are totally depend on what should be our output and input, in buck converter as per our need we have to maintain switching frequency, here in interleaved buck converter we use 10kh frequency with 50% duty cycle so as per formulas given below we select capacitor, IGBT and we have designed inductor.

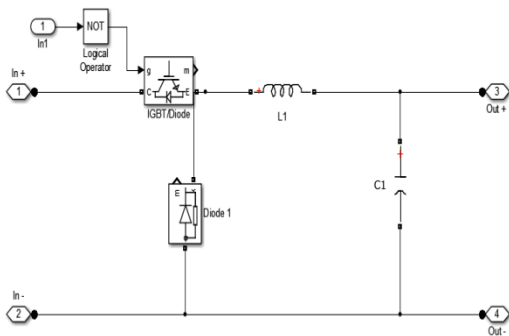


Fig-4: Simulation model of Interleaved Buck 1 Converter

To design buck converter for particular system, we need to consider its expected output and its input as per this information we can design converter of appropriate values we can see in equation 1, 2, 3.

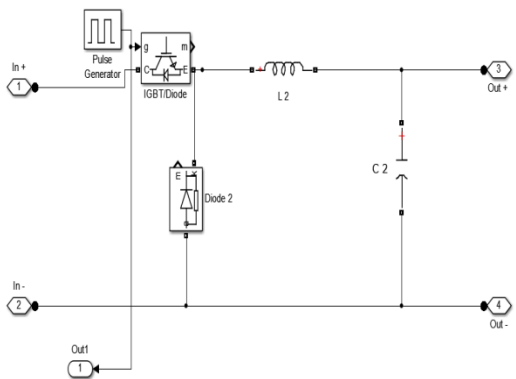


Fig-5: Simulation model of Interleaved Buck 2 Converter

$$D = 50\% \quad (1)$$

$$L = \frac{V_{in} \times (V_{out} - V_{in})}{\Delta I_L \times f_s \times V_{out}} \quad (2)$$

$$C_{out(min)} = \frac{I_{out(max)} \times D}{f_s \times \Delta V_{out}} \quad (3)$$

Inductor and capacitors values are selected using expressions provided in [1].

5. RESULTS AND DISCUSSIONS

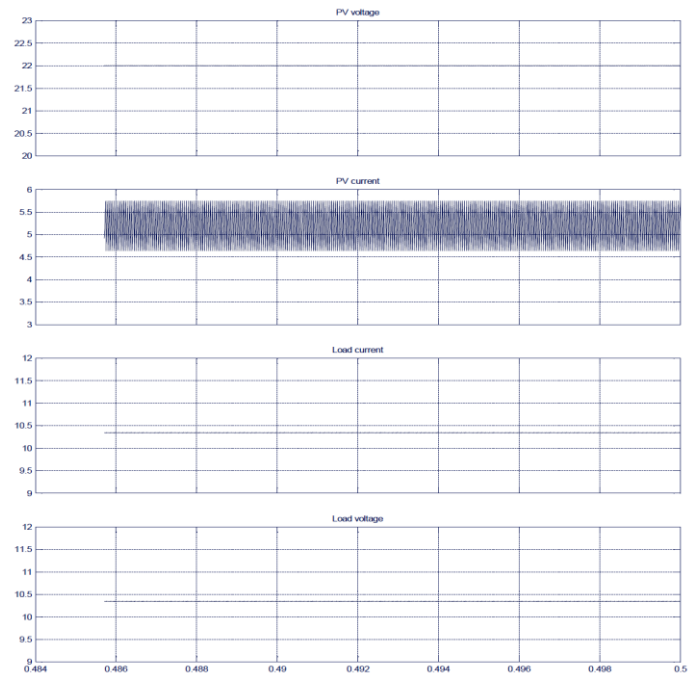


Fig -6: Output voltage and current of PV cell and Buck converter at no load condition

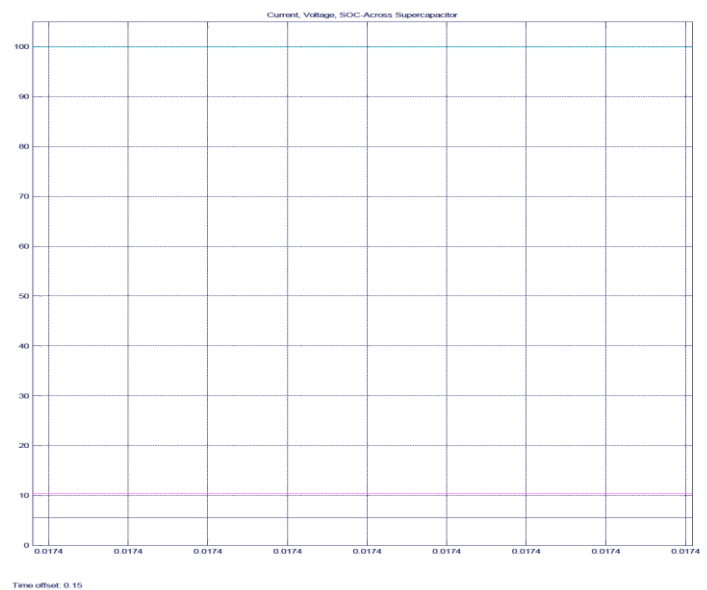


Fig -7: Output voltage and current and SOC-across Supercapacitor

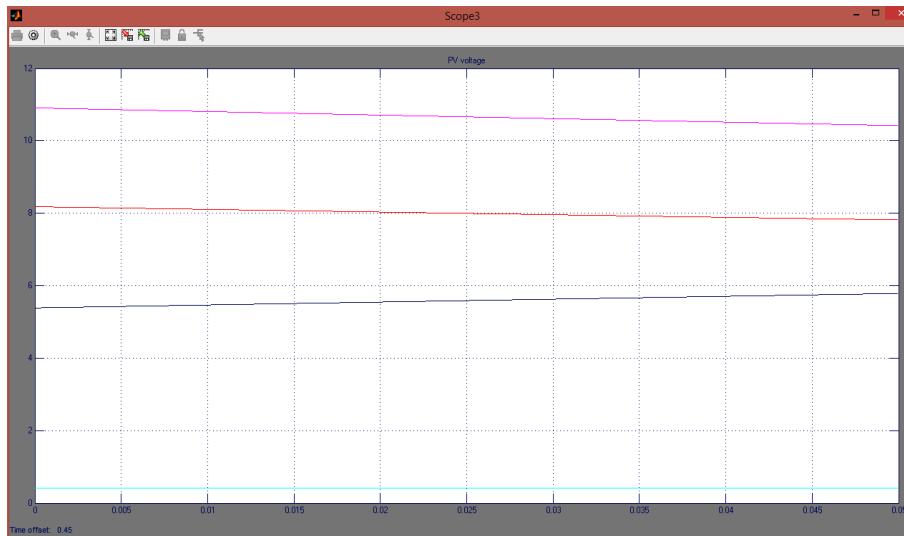


Fig -8: Output voltage, current, torque, speed-across DC Machine

7. REFERENCES

Figure 6 we can see the result of simulation where input current from PV is 4.7 to 5.7 varying and output is 10.4 constant. We can see in above figure input voltage 22V and input current is varying between 4.7 to 5.7 but at output of buck converter current (Load current) is 10.4 constant and output voltage is get bucked from 22V to 10.3V hence we can conclude that by using above system we can increase current and decies voltage which is needed to charge supercapacitor output is taken from Scope1. In above figure we can see voltage, current and SOC (State Of Charge) across supercapacitor here we find current is around 5.48A, voltage is around 10.4V and SOC is 99.91% output is taken from Scope2. In fig.8 we can see output parameter at DC Machine they are current, voltage, torque, speed of machine, here we can see output current is around 5.78A, voltage is around 10.3V, and torque is around 0.41N and speed is around 7.81RPM output is taken from Scope3.

6. CONCLUSIONS

We developed model of system, it can provide constant energy to sustain the operation of load, in varying environmental conditions.

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1. Brigitte Hauke "Basic Calculation of a Buck Converter's Power Stage" Texas Instruments Incorporated SLVA477B–December 2011–Revised August 2015, pp.1-8.
2. Moeen Hassanaliheragh, Tolga Soyata, Andrew Nadeau, Gaurav Sharma , "Solar-Supercapacitor Harvesting System Design for Energy-Aware Applications" University of Rochester, Dept. of Electrical and Computer Engineering, Rochester, NY 14627, 2014, pp.280-285
3. Andrew Nadeau, Gaurav Sharma, Tolga Soyata, "State-of-charge eestimation for supercapacitors: A Kalman filtering formulation," inP roceedings of the 2014 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP 2013), Florence, Italy, May2014, pp. 2213-2217.
4. Jorge Querol Borràs, "MCU Controlled DC-DC Buck/Boost Converter for Supercapacitors", Master of Science Thesis at KTH Royal Institute of TechnologyStockholmSweden 2012, pp.1-73.
5. Davide Brunelli, Clemens Moser, Lothar Thiele, Luca Benini, "Design of a solar-harvesting circuit for battery less embedded systems,"Circuits and Systems 1: Regular Papers, IEEE Transactions on, 2009, vol. 56, no. 11, pp. 2519-2528.
6. H. Zhang, Y. Sun, S. Ding, and Y. Wang, "Application of super capacitor with full-digital converter in hybrid electric vehicle energy transmission system," in 27th Chinese Control Conference, 2008, pp. 212-215.