

Alternative Source Port Tolerant Series-Connected Double-Input DC-DC Converter with Ultracapacitor

Jisha Gopinath¹, Prof. Bindu Elias², Dr. Siny Paul³

¹PG Scholar ^{2,3}Professor

Department of Electrical and Electronics Engineering, Mar Athanasius College of Engineering, Kothamangalam, Kerala

Abstract: Multi-input power electronic converters (MIPEC) are increasingly gaining interest in the fields of renewable energy systems and hybrid electric vehicles (HEV). The main advantage of MIPECs is their ability to interface several energy sources and storage devices using a single power conversion stage. Therefore, they provide simpler control and smaller parts count. For instance, a DI buck-boost topology is proposed for a photovoltaic (PV)/battery energy system. The converter is controlled in a way that maximum power is drawn from the PV array using maximum power point tracking (MPPT) techniques and the additional power is drawn from the battery while keeping the output voltage constant. This paper presents a new charging method for ultracapacitors. Comparing with batteries, ultracapacitor can accept a wide range of charging current and can be fully charged within a few minutes. Common chargers for ultra-capacitors are usually equipped with current transducers and closed loop circuitry for current control, which are expensive and complicated. The proposed circuit consists of a minimum number of components. It does not require any current transducer or dedicated voltage/current control circuitry. A simple open-loop control system is applicable for the whole charging stage. It is free of stability problem and protects itself from being overloaded by ultracapacitor with zero initial charge. Simulations are done using MATLAB.

Keywords: Multi-input converter, hybrid electric vehicle, fault tolerance, bootstrap circuit, ultracapacitor.

I. INTRODUCTION

The limited supply of fossil fuels and conventional energy sources has prompted a thrust on the development of renewable energy and hybrid systems [1]. The main advantages of renewable energy systems are that the sources are not depleted and they provide a clean alternative to the fossil fuels. However, one of the disadvantages of renewable energy sources is they are intermittent and not reliable thus limiting the optimal utilization of these sources. Batteries have high energy density but have low power density while ultra-capacitors have high power density but have low energy density, thus an ideal source for HEV would be the combination of both these sources [3]. A MIPEC can be used to combine both these sources to utilize the high energy density of the battery as well as the high power density of the ultra-capacitor. In other words, when the renewable source is not available, the alternative power port will be charged by the available storage unit such as fuel cell (FC) port to keep the converters output stable, and hereby the scheme enhances the reliability of renewable energy conversion systems, making it robust against renewable source port powering off or failures in one of the inputs [2].

II. ALTERNATIVE SOURCE PORT DOUBLE INPUT DC-DC CONVERTER

II.1 Double input DC-DC converter with ultracapacitor:

Integration of more than one energy source depends on the power electronic converters is an interesting and challenging task for researchers. Integrated converter which can step down, step up or regulate the output voltage according to input

voltage required at the load end. The converter is able to integrate different voltages of various energy sources such as solar photovoltaic, wind energy system, Fuel cell and Diesel etc. relatively low voltage. The converter is designed considering double input, in which same or different type of two inputs can be used individually or simultaneously

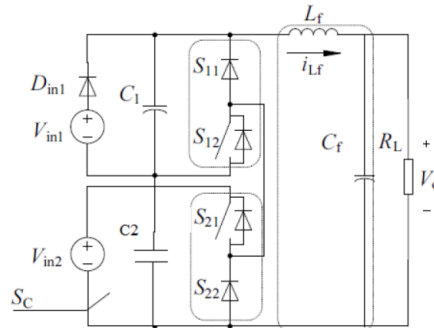


Figure1: Double input DC-DC converter with Ultracapacitor

II.2 Modes of Operation:

The double-input DC-DC converter with the bootstrap circuit is shown in Figure. 1. The bootstrap capacitor C_1 , is connected in parallel with the switch pair of S_{11} , S_{12} and interfaces the first input source, the switch pair of S_{21} , S_{22} interfaces the second input source, and the switches $S_{11}, S_{12}, S_{21}, S_{22}$ are connected in series. The switches $S_{11}/S_{12}, S_{21}/S_{22}$ are operated in a complementary manner. L_f , C_f and R_L represent the filter inductor, capacitor and load resistance respectively. The converter has one input port connected to the renewable source V_{in1} , such as solar panels, wind turbines or fuel cells, D_{in1} is the blocking diode. When input source is short-circuited, the input port is separated from the converter. The other input port is connected to a backup source V_{in2} , such as a mains supply, battery or FC.

II.3 First Operation Mode Two input sources are available:

In this operation mode, two input power sources V_{in1} and V_{in2} (battery) are responsible for supplying the loads. In this mode, S_{12} and S_{21} are in On state and all other switches are in OFF state. For each switch, a specific duty is considered. Here, S_{21} is active to regulate source 2 (battery) current to desired value. In fact, S_{21} regulates attery current to desired value by controlling inductor current. Regulation of total output voltage $V_T = V_{in1} + V_{in2}$ to desired value is duty of the switch S_{11} and S_{22} . According to switches states, there are four different modes.

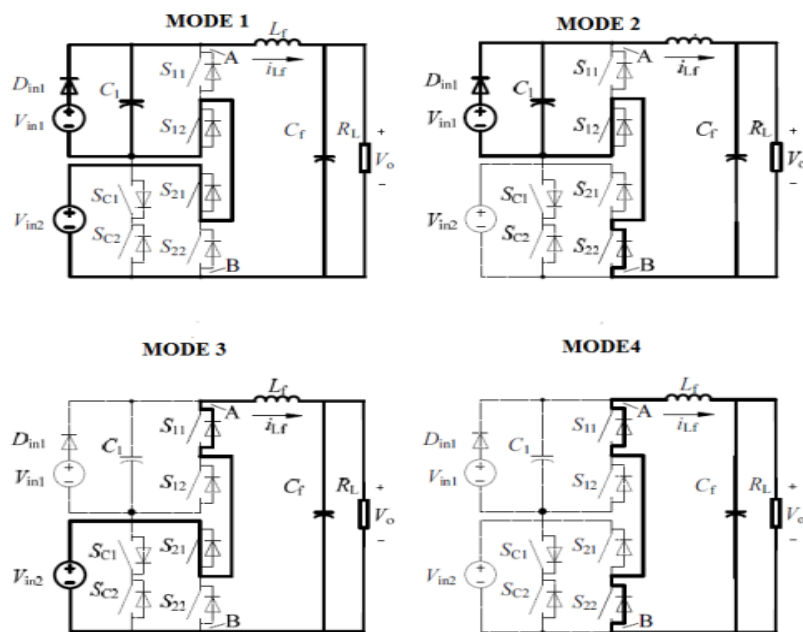


Figure2: Equivalent circuit of Double input DC-DC converter with Ultracapacitor

II.4 Second Operation Mode One input sources are available:

From below figure, it shows that when V_{in1} is out of work, the port can be charged by V_{in2} through bootstrap circuit and converter switches, so the proposed scheme is robust against input source powering off. Therefore, when only V_{in2} is connected, in the steady state, applying the volt-second balance principle to the inductor L_f

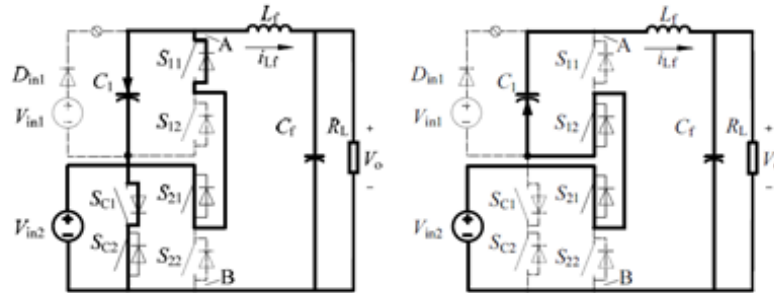


Figure3: Equivalent circuit of Double input DC-DC converter with Ultracapacitor with single source

II.5 Simulation Parameters:

TABLE: I Simulation Parameters

	Specification
Inputs, Output voltages	50,30,40V
Filter Inductance	400 μ H
Filter Capacitance	300 μ F
Bootstrap capacitor	16.5mF,220 μ F
Output Resistor	2.2K Ω
Switch	MOSFET

II.6 Simulink model and results:

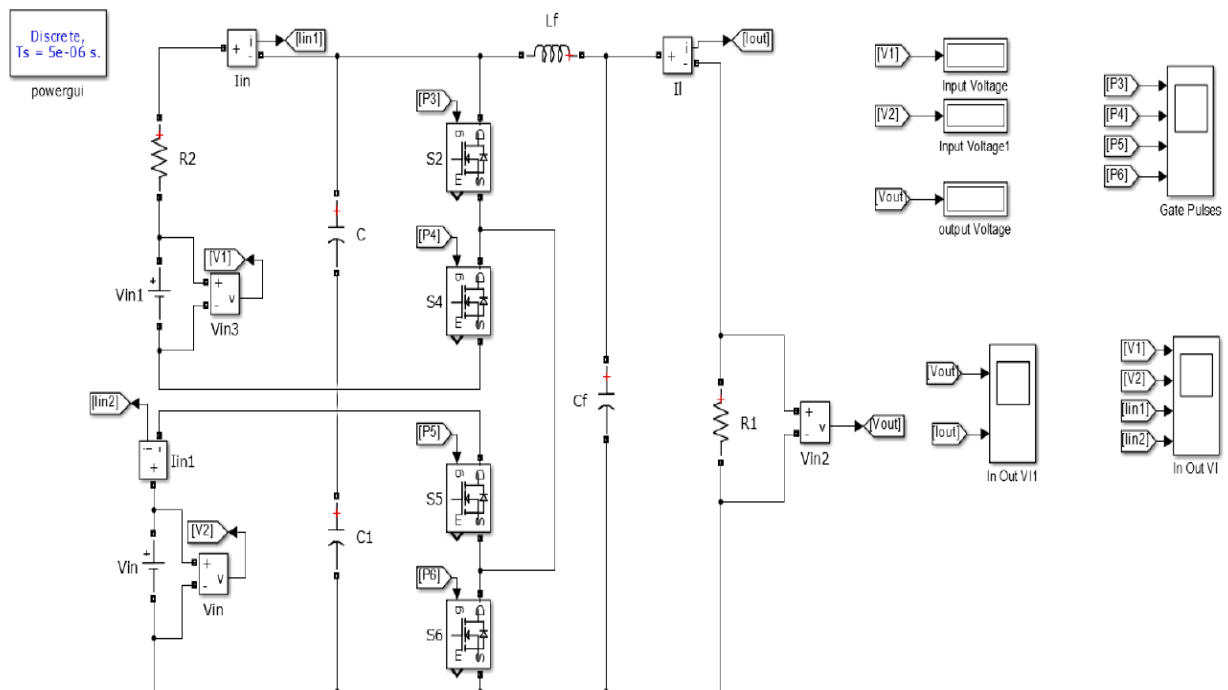


Figure4: Simulink model of Double input DC-DC converter with Ultracapacitor

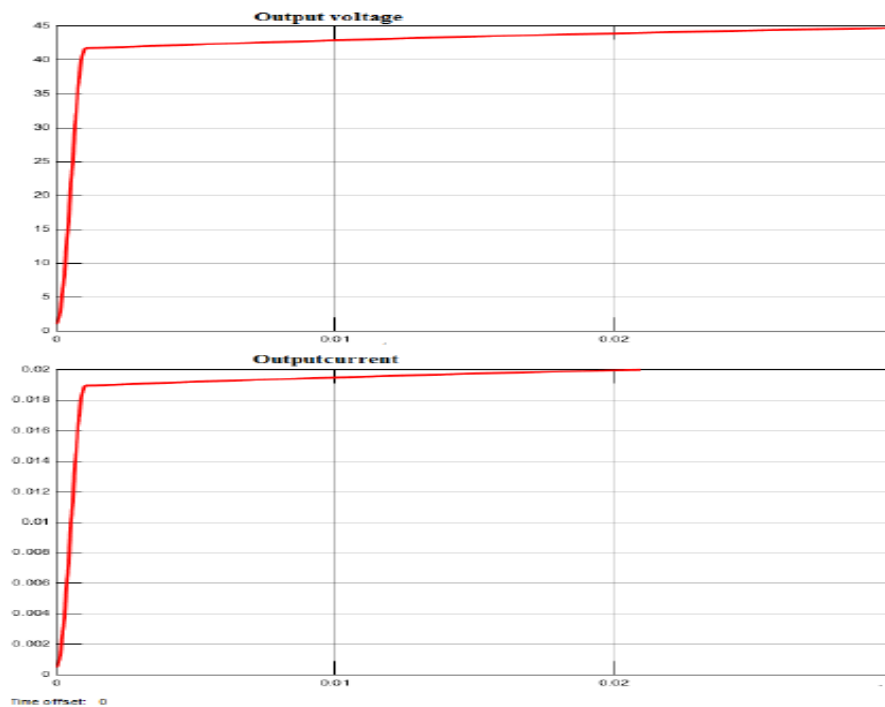


Figure5: Output voltage & current of Double input DC-DC converter with Ultracapacitor

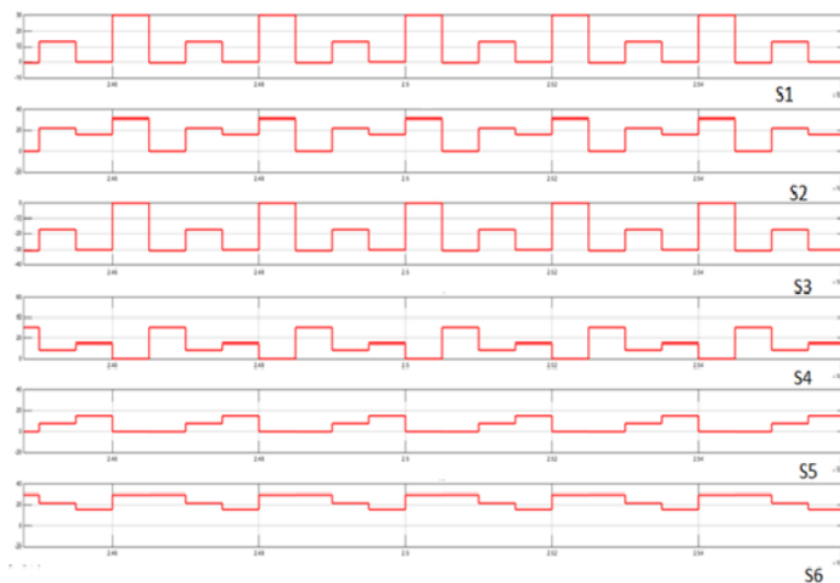


Figure.6: Voltage Stress of all switches of Double input DC-DC converter with Ultracapacitor

III. CONCLUSION

In this paper, a robustness design of a double-input DC-DC converter under one port powered off is proposed to overcome distributed power source randomness and intermittency, in which with the help of bootstrap switch pair, the renewable source port can be charged by the FC port and keeps to work then the alternative source is shut down. Simulation and experimental tests were carried out to validate the effectiveness of the proposed scheme against input source powering off. The proposed converter offers the advantage of simple topology and control, and high efficiency, which is suitable for renewable power system. Voltage gain increased to 20% and switching loss reduced to 13%.

REFERENCES

- [1] A. Kwasinski, Identification of feasible topologies for multiple-input dc-dc converters IEEE Trans. Power. Electronics vol 24, pp.856 - 861, Mar. 2009.
- [2] D. Yang, M. Yang, and X. Ruan, "One-cycle control for double-input DC/DC converter" IEEE trans. On industrial application, vol.27, no.11,pp.4646-4655, Nov 2012.
- [3] Y. C. Liu, and Y. M. Chen, A systematic approach to synthesizing multiple input dc-dc converter, IEEE transaction on industrial electronics, volume 24,pp.116-127,jan. 2009.
- [4] Y.-M. Chen, Y. C. Liu, and S. H. Lin Double-input PWM DC-DC converter for high/low-voltage sources, IEEE transaction on industrial applications, vol. 53, no. 5, pp. 15381545, Oct. 2006.
- [5] K. Jin, X. Ruan, M. Yang, and M. Xu, "A hybrid fuel cell power system," IEEE Trans. Power. Electronics, vol 56, pp.1212 - 1222, Apr. 2009
- [6] Y. Li, X. Ruan, D. Yang, F. Liu, and C. K. Tsc, "Synthesis of multiple-input DC/DC converters" IEEE Trans. Power. Electronics vol. 25, no. 9, pp. 2372- 2385, Sep. 2010.
- [7] Q.Wang, J. Zhang, X. Ruan, and K. Jin, "Isolated single primary winding multiple-Input converters" IEEE Trans. Power. Electronics, vol 26, pp. 3435 - 3442, Dec. 2011.