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Solar Powered Bi-Directional Converter with a Two Wire Interface used in Microgrids

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Abstract: ***A microgrid is an independent electricity grid system which has a distribution generation with a power electronics converter, a controller and loads. A solar powered bidirectional converter is used here with a two wire interface. Two wires, SCL (clock) and SDA (data) is used for communicating between two or more ICs. It provides power and signal transfer channels with safe galvanic isolation. Complex power electronics circuits of converters can be made simple. Thus realization of grid system is more efficient.***

Keywords: bidirectional converter, two wire interface, solar, microgrids, smart grids

1. Introduction

The usage of DC grids to transfer electrical power is well known. One reason why the nowadays common AC grid architecture becomes more popular is that the only way to process electrical power, what means to change voltage and current levels, was to use a transformer. Due to the availability of modern power electronics things have changed. The bidirectional dc-dc converter along with energy storage has become a promising option for many power related systems, including hybrid vehicle, fuel cell vehicle, renewable energy system and so forth. It not only reduces the cost and improves efficiency, but also improves the performance of the system. With its ability to reverse the direction of the current flow, and thereby power, the bidirectional dc-dc converters are being increasingly used to achieve power transfer between two dc power sources in either direction. TWI is a compact and reliable method of integrating smart nano and micro grid. It provides power and signal transfer channels with safe galvanic isolation. Complex power electronics circuits of converters can be made simple. Thus realization of smart nano, micro grid is more efficient.

2. Solar Powered Bidirectional Converter

2.1 Conventional Converter

The conventional converter has four switches. Fig. 1 shows the conventional converter. It can be operated in buck and boost modes. The resonant circuit consists of two auxiliary switches (S_a, S_b), two resonant capacitors (C_a,C_b) and one resonant inductor (L_a) along with the main switches S_1, S_2, L. The additional resonant circuit is introduced for conventional buck-boost converter to obtain zero current switching (ZCS) turn-on/turn-off of the main switches. In order to improve the efficiency of buck-boost converters, the proposed converter will be operated at ZCS turn-on /ZCS turn-off mode.

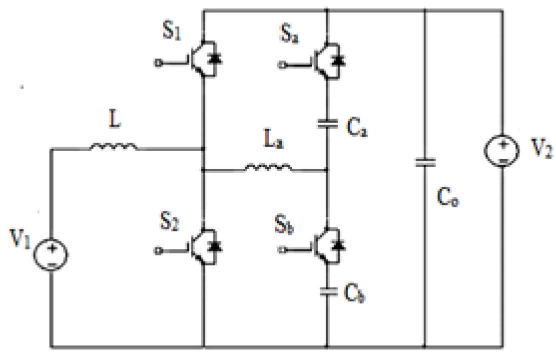

Figure 1: Conventional converter

2.2 Proposed Converter

The solar powered ZCS bidirectional buck boost converter has resonant circuit with capacitors and inductors. Fig. 2 shows the proposed converter.

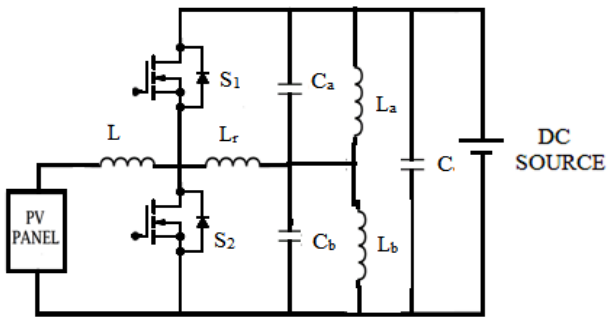

Figure 2: Proposed converter

The bidirectional buck-boost converter with auxiliary resonant circuit consists of three auxiliary inductors (L_a, L_b, L_r), two resonant capacitors (C_a, C_b) along with the main switches and inductor - S_1, S_2, L. There is an output capacitor C.I In boost mode the PV panel is the input while in buck mode we use a DC source as input device. The DC source can be replaced with a AC input with a rectifier to be used in a hybrid AC/DC converter.

3. Two Wire Interface

In TWI the serial data transmission is done in asynchronous mode. This protocol uses only two wires for communicating between two or more ICs. The two bidirectional open drain lines named SDA (Serial Data) and SCL (Serial Clock) with pull up resistors are used for data transfer between devices. One of the two devices, which control the whole process, is known as Master and the other which responds to the queries of master is known as Slave device. The ACK (acknowledgement) signal is sent/received from both the sides after every transfer and hence reduces the error. SCL is the clock line bus used for synchronization and is controlled by the master.

3.1 Control using the two wire interface

The control of switches with gate pulses, the MPPT tracking of solar panel is done by the IPU (Intelligent Power Unit) with two wire interface. The block diagram of two wire system with IPU is given in fig. 3.

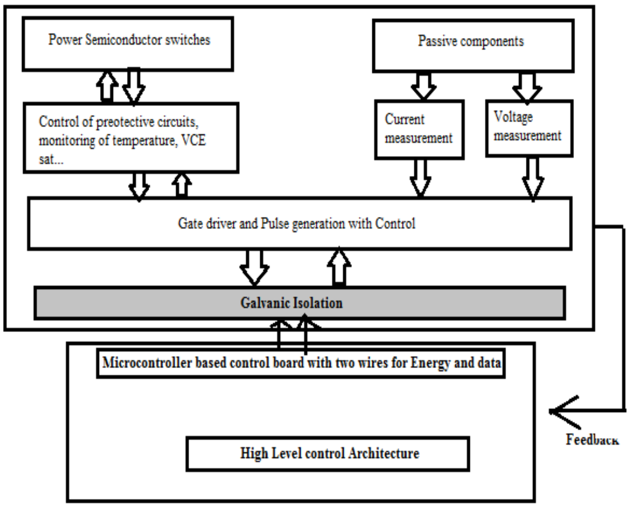

Figure 3: Intelligent Power units connected with a two wire interface

IPU consists of Gate drivers, current measurement, voltage measurement, integrated temperature sensors. This is galvanically isolated from Main control board realized with microcontrollers, DSP or FGPA.

- A feedback is given from the IPUs to the microcontroller based control system.
- Galvanic isolation is given to have a protected working of the IPUs and microcontroller based control system.

3.2 Equations

The equations used here are, characteristic impedance (Z) and angular frequency (ω) formula

$$Z = \sqrt{\frac{La}{Ca}}$$

$$\omega = \frac{1}{\sqrt{LaCb}}$$

where La is the resonant inductor and Cb is the resonant capacitor.

4. Working and simulation

The simulation is done in MATLAB R2013A. Table 1 shows the parameter values of the bidirectional converter.

Table 1: Parameters and Value

Parameter	Value
Input Voltage(boost mode)	12V
Output Voltage(boostmode)	24V
Inductor (L)	3mH
Resonant Inductor(La and Lb)	0.6μH
Resonant Capacitor(Ca and Cb)	10μF
Output Capacitor	1000μF

4.1 Boost mode

During boost mode the PV panel will be working as the input. The low value of PV panel that is 12 V is boosted to desired value here 24 V and it is either used or stored in a battery energy storage system. If used it is fed into the grid system.

4.2 Buck mode

Buck mode can be operated in two ways. If the input is DC voltage source it is adjusted to desired level using a buck mode converter. Next is direct connection from AC grid. For the energy storage this is rectified and reduced to desired level with buck mode.

Fig. 4 below shows the simulation diagram of solar powered bidirectional buck boost converter.

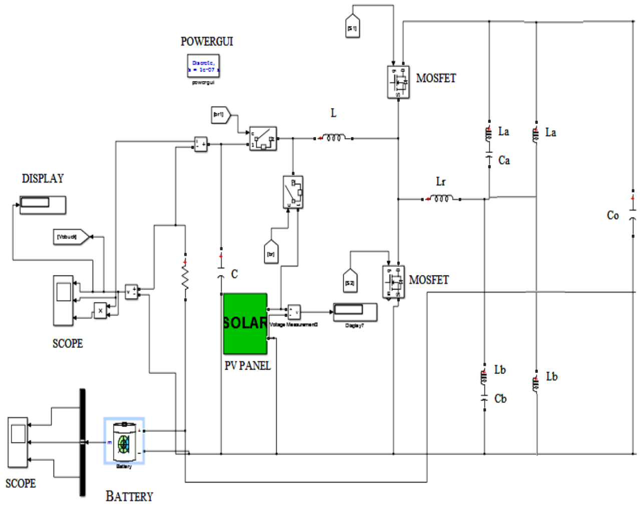

Figure 4: Simulation diagram

Fig. 5 shows the input and output of boost mode and

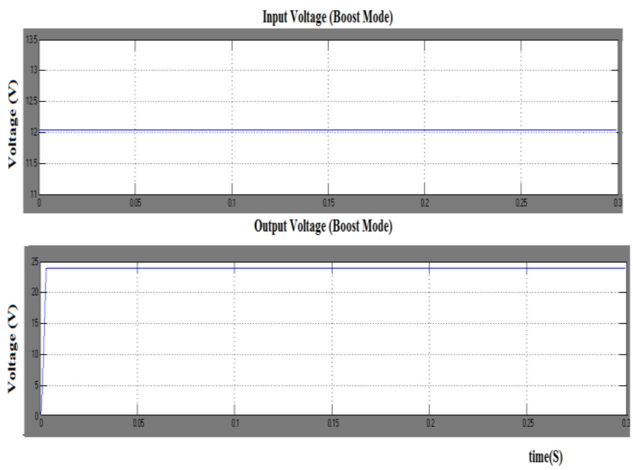

Figure 5: Input and output of boost mode

Fig. 6 shows the input and output of buck mode. For boost mode input is 12 V solar panel and output is 24V.

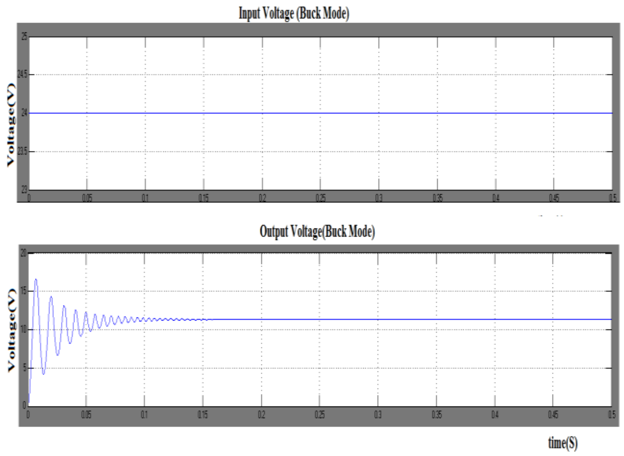

Figure 6: Buck mode operation

For buck mode input is 24V and 12 V. For simulation the input of buck mode is a DC voltage source.

5. Conclusion

As the conventional energy sources are being depleted, and with an increasing energy demand, renewable energy has become the center of public interest. Renewable energy sources such as photovoltaic generation, fuel cell and wind power generation can be effectively harnessed with the application of power electronics. A converter acts as an interface between renewable sources and energy storage systems. For the effective operation of a converter, the control system has to be the best. A solar powered bidirectional buck boost converter with two wire interface has been proposed. Two wire system is highly reliable and we can transfer energy and data with safe galvanic isolation. Thus the complexity of power electronic circuits can be reduced.

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