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Solar Switched Boost Inverter

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Abstract: *Switched Boost Inverter (SBI) is a power converter. It converts power from DC to AC with boosting in a single stage. This can be applied for micro grid and Nano grid application, hence this converter supplies the power for both DC loads and AC loads in the same time. The operation of SBI is shooting through inverter legs without causing any damage in the converter operation. Control signals for the operation of SBI is given through the sinusoidal pulse width modulation (SPWM), SBI also has good Electromagnetic interference (EMI) noise immunity.*

I. Introduction

Day by day, the power or electrical energy requirement is increasing, to fulfill this requirement apart from using non renewable energy sources the importance is given to the renewable energy sources like photo voltaic, fuel cells, wind etc... But the problem of using this output is that its low efficiency.so we have to boost it before giving to the load. The use of SBI by pulse width modulation will effectively achieve it.

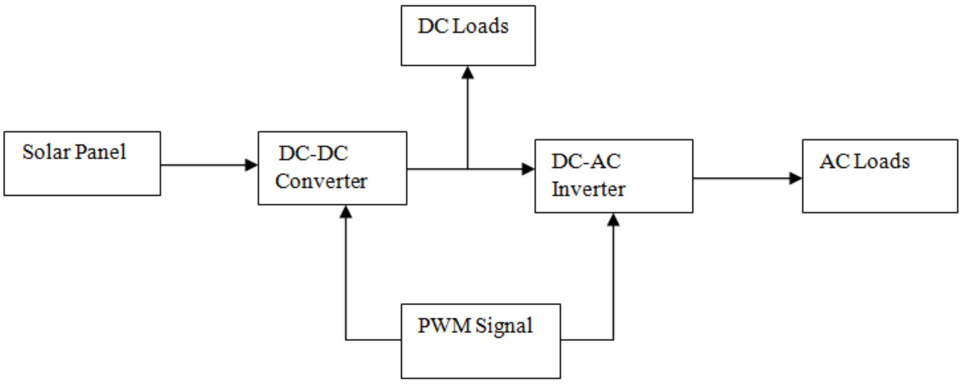


Fig 1. Block diagram of SBI

Figure1 shows the basic Block Diagram of SBI which can be applied for micro and Nano gird application. In a power generation system, the generated power is of variable DC voltage. So we use power converters such as DC-DC converters [1].

- The pulse width modulated signal is used to control both converter and inverter switches.
- SBI exhibits better electromagnetic interference noise immunity.
- No need of dead time compensation.
- Low device stress and high efficiency.

Here we are making use of the solar energy as input for the device. Solar energy is abundant in nature but we can't make use them effectively as well as efficiently. Solar panel is a device, where solar energy is absorbed and corresponding electrical energy is produced. To make use them efficiently, we need to put forward certain methods. That includes maximum power point tracking method, solar concentration and also solar cooling. Maximum power point tracking is an algorithm used for extracting maximum available power from PV module under certain conditions. Maximum power varies with solar radiation, ambient temperature and solar cell temperature. In this method solar panel will track the radiation, where max power is available. Below a certain value, the panel will change the position to have max solar radiation and thus obtaining maximum power always. For solar concentration, we are using a solar concentrator. That is, a solar concentrator uses lenses, called Fresnel lenses, which take a large area of sunlight and direct it towards a specific spot by bending the rays of light and focusing them. The next method is the solar cooling, where the solar panel is placed in water current. A small layer of water is allowed to pass above the panel. This small current will clear the dust and other particles on the panel as well as it cool down the system. In case of household purposes, we can use the watercurrent from the water tank for this purpose. This reduces the miscellaneous costs.

II. Conventional Model

DC NANOGRID is a low-power dc distribution system suitable for residential power applications. The average load demand in the Nano grid is generally met by the available renewable energy sources like solar, wind, etc… In order to give uninterruptible power supply to critical loads and to maintain power balance in the Nano grid an energy storage unit is provided. Fig. 3 shows the schematic of a dc Nano grid consisting of a solar panel as an energy source, a storage unit, and some dc and local ac loads. The series blocking diode DS associated with the solar panel avoid reverse power conduction behaviors of all different units of Nano grid, they are interfaced to a common dc bus using power electronic converters [3]. In the Nano grid structure of Fig. 2, three different power converter stages are used to interface the renewable energy source, energy storage unit, and the local ac loads in the system to DC bus.

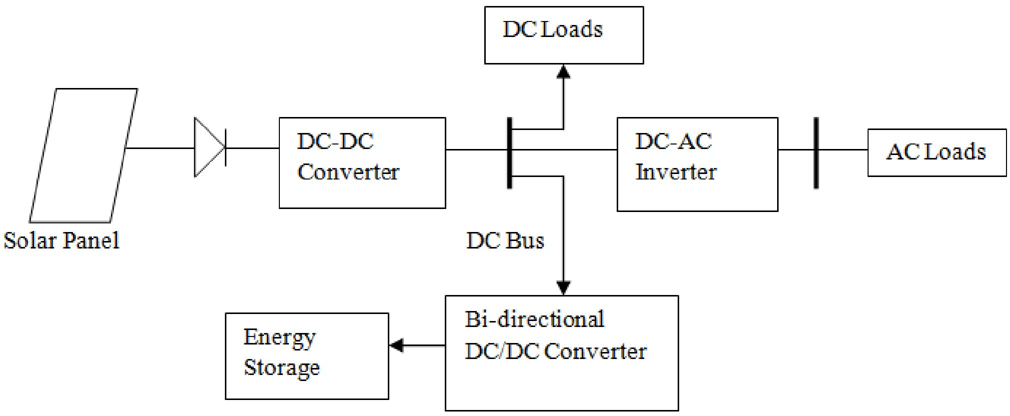


Fig 2. *Schematic of DC Nano grid*

The problem with the conventional system is the large number of power converter stages present which increases the cost of whole system and also different protection circuits must be included in order to avoid conditions like shoot through in inverter legs. This also makes the circuit complex. Also noise immunity and resistance against electromagnetic interference is low in these circuits. So a new structure of power converter which has the capability of driving both AC and DC loads is introduced in the Nano grid structure [1].

III. Proposed Model

In the Nano grid structure of Figure.3, three different power converter stages are used to interface the renewable energy source, energy storage unit, and the local ac loads in the system to the dc bus. This project proposes a structure of the dc Nano grid using switched boost inverter (SBI) as a power electronic interface. Fig. 3 shows the structure of the proposed SBI-based dc Nano grid. The Buck/Boost operation is incorporated due to its ability to utilize shoot through state through the impedance network connected. The SBI also possesses robust electromagnetic interference (EMI) noise immunity, which is achieved by allowing the shoot through of the inverter leg switches. As a result, the output voltage of the converter can be either higher or lower than the input voltage as per the requirement. In addition, the SBI also possesses robust electromagnetic arises when gate signals are given to the switches placed in same leg of H bridge. So utilization of zero intervals for charging the LC impedance by short circuiting the load is named as shoot through state .This state can be achieved by giving gate signals to both switches in the same leg of Inverter Bridge [4].

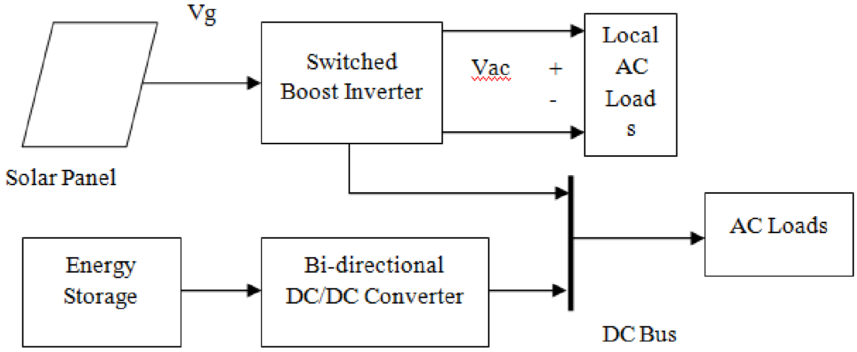


Fig 3. Structure of proposed SBI-based DC Nano grid

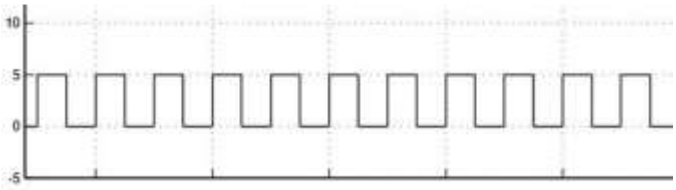
- SBI is single-stage power converter that can supply both dc and ac loads simultaneously from a single dc input. So, it can realize both the DC-to- DC converter for solar panel and the DC-to-AC converter in a single stage. So this reduces size and cost of overall system.
- The output ac voltage of SBI can be either higher or lower than the available source voltage. So, it has wide range of obtainable output voltage for a given source voltage.
- SBI exhibits better electromagnetic interference (EMI) noise immunity when compared to a traditional Voltage Source Inverter(VSI), as the shoot-through (both switches in one leg of the inverter bridge are turned ON simultaneously) due to EMI noise will not damage the inverter switches. This reduces extra burden on the power converter protection circuit and helps in realization of compact design of the power converter.
- As SBI circuit allows shoot-through in the inverter legs, it does not require a dead time circuit and hence eliminates the need for dead-time compensation technologies.

IV. PWM Control Of SBI

Pulse-width modulation (PWM), or pulse-duration modulation (PDM), is a modulation technique used to encode a message into a pulsating signal. Based on the PWM concept, if the duty cycle is changed sinusoidal, a sinusoidal voltage will be generated at the output. There are several different PWM techniques, differing in their methods of implementation. However in all these techniques the aim is to generate an output voltage, which after some filtering, would result in a good quality sinusoidal voltage waveform of desired fundamental frequency and magnitude. When the modulating signal is a sinusoid of amplitude Am, and the amplitude of thetriangular carrier is Ac, the ratio m=Am/Ac is known as the modulation index. Controlling the modulation index therefore controls the amplitude of the applied output voltage.

With a sufficiently high carrier frequency the high frequency components do not propagate significantly in the ac network (or load), due the presence of the inductive elements. However, a higher carrier frequency does result in a larger number of switching per cycle and hence in an increased power loss. Typically switching frequencies in the 2-15 kHz range are considered adequate for power systems applications.

Here we can easily make use of an Arduino Uno for the generation of pwm signal by proper programming. Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). Ithas14digital input/output pins (of which 6 can be used as pwm outputs), 6 analog inputs, a 16MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller. It features the Atmega8U2 programmed as a USB-to-serial converter. The Arduino Uno can be powered via the USB connection or with an external power supply. The power source is selected automatically. External (non-USB) power can come either from an AC-to-DC adapter or battery. The board can operate on an external supply of 6 to 20 volts. The Atmega328 has 32KB of flash memory for storing code. It also has 2KB of SRAM and 1KB of EEPROM [6].



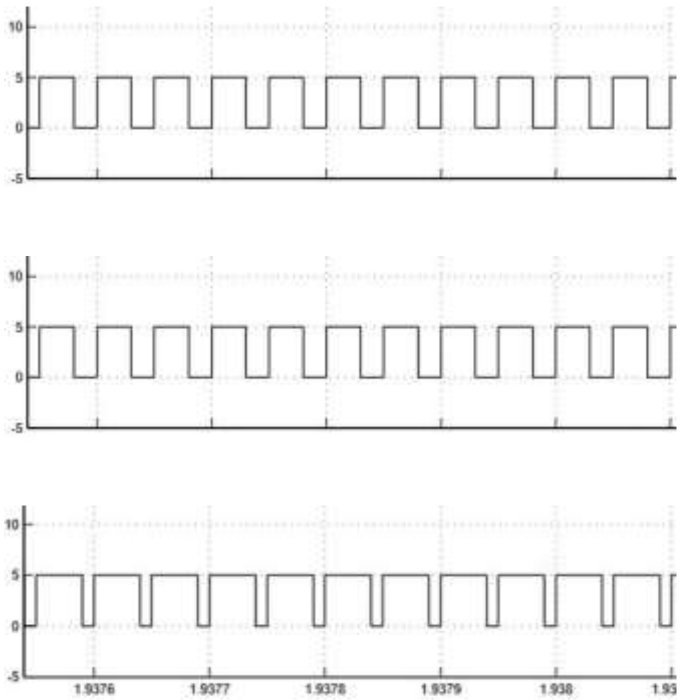


Fig 4. Generated PWM Signals

V. Closed Loop Control

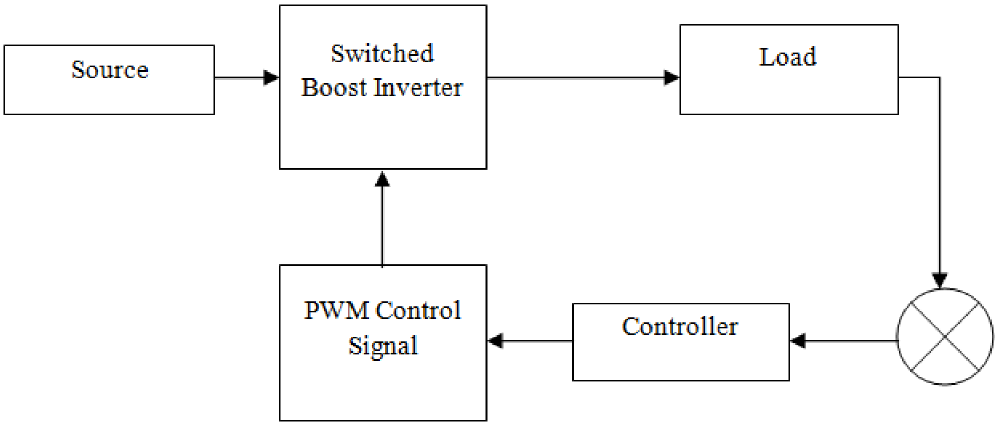


Figure 5. Circuit diagram of SBI supplying both AC and DC loads

The block diagram representation of closed loop control of SBI for AC and DC load is shown in the fig.5. The control systems consists of source it can be a PV module or a DC supply. Switched Boost Inverter and AC load is connected across the LC filter, and DC load can be connect across capacitor(C) of SBI and PI controller is used for minimization of error signal .Initially a reference voltage is given to the summing point and the measured output across the load is compared with the reference, in order to track the reference voltage. The error produced over here is processed with the intervention of PI controller. It has good steady state response.

Due to integral controller steady state error can be minimized. The output of PI controller can be considered to be modulation index (M). So here the controlling parameter chosen is modulation index [5].

VI. WORKING

The available 12 volt obtained from the solar panel which is stored in the battery is booted in boosting section. Using a MOSFET or IGBT we could boost available DC to a higher level by charging and discharging the inductor and capacitor connected across the load.

During the ON time of MOSFET, a short circuit path is established and the current flows through the inductor. Hence the inductor opposes the change in flow of current, flux lines are produced is as shown in Fig. 6.

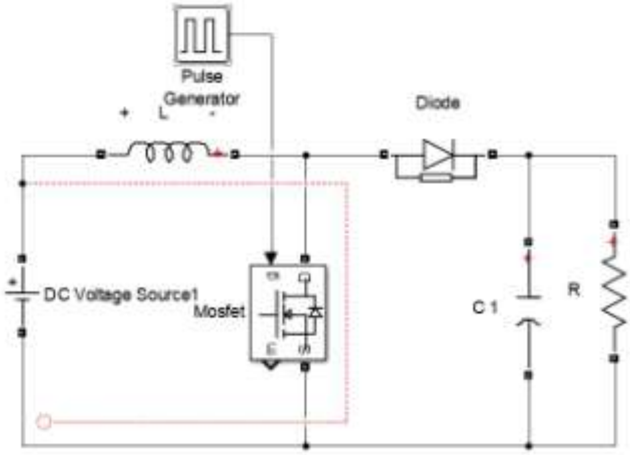


Fig 6. Operation of MOSFET during ON time

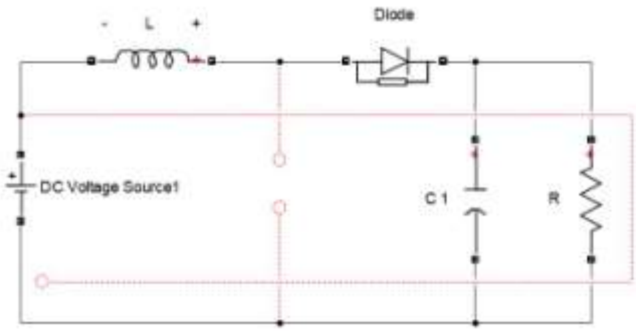


Fig 7. Operation of MOSFET during OFF time

At the instant when the MOSFET is OFF, the inductor gets discharged through the capacitor to the load is as shown in Fig. 7.
The switching frequency of the MOSFET is controlled by the PWM generated by the arduino. Normally, the switching frequencies are in the range of 20-30KHz.

VII. MODELING OF SBI USING MATLAB / SIMULINK MODEL

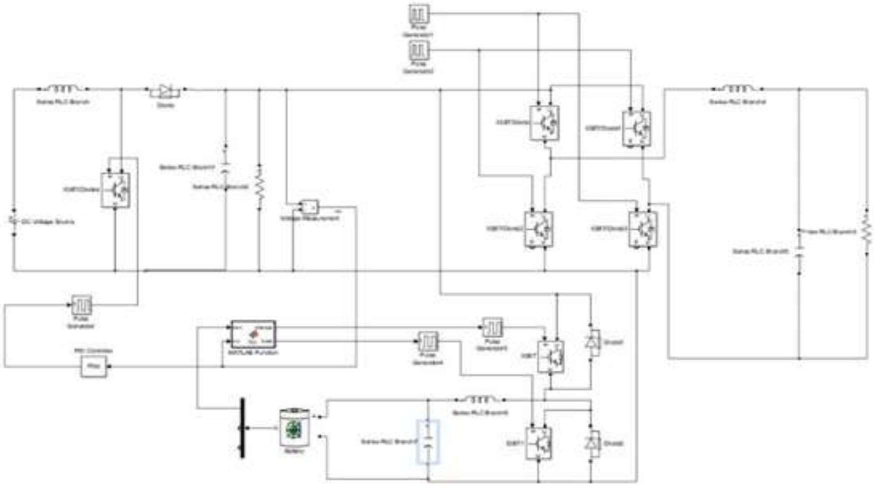


Fig 8. Simulation model of proposed SBI

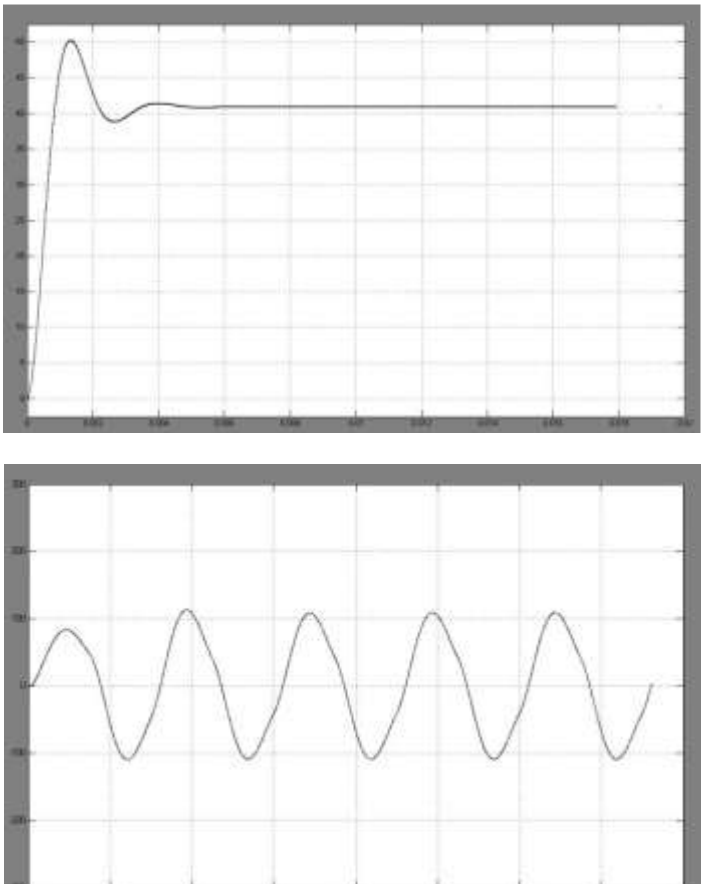


***Fig 9.** Simulation output*

VIII. Conclusion

The control strategy of SBI shows excellent performance during steady-state as well as during step change in either DC or AC load in the system. This confirms the suitability of SBI and its closed-loop control strategy for dc Nano grid applications. It is also proven that the SBI can generate an ac output voltage that is either higher or lower than the available source voltage. The open-loop as well as closed loop simulations are obtained in this project.

Switched boost inverter, which is derived from Z-source inverter, has better electromagnetic interference, noise immunity when compared to traditional voltage-source inverter. Furthermore, it can continue to provide a power supply when blackout occurs in the bulk power system.

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