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A PHOTOVOLTAIC BASED MODIFIED CURRENT SOURCE INVERTER FOR TRANSFORMER-LESS GRID FEEDING SYSTEM

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***Abstract*— Nowadays solar photovoltaic (pv) inverters with higher efficiency is needed to fee the grid. Current source inverter provides higher reliability than the voltage source based solar inverters. In the conventional three phase pulse width modulated current source inverter high earth leakage current is injected to the grid. An isolation transformer is used to suppress this high earth leakage current. By using isolation transformer, size and cost increased and efficiency will be reduced. This paper proposes a modified current source inverter that suppresses the earth leakage current without using an isolation transformer therefore cost reduces and efficiency increases. In conventional current source inverter IGBT is used as a switching device whereas in the proposed system MOSFET is used as a switching device which reduces the switching losses and improves the voltage.**

***Keywords*— Current source inverter (CSI), grid feeding system, solar photovoltaic (pv) , switching devices.**

I. INTRODUCTION

Due to the reduction of fossil fuels and increasing energy demand the use of solar energy has become more essential. The electrical energy is generated from the solar photovoltaic system and it is given to the grid using modified current source inverter. The solar photovoltaic panels have the life span of about 20 years while the inverters have short life span around few years. The main reason for the failures occurring in the inverters is due to aluminum electrolytic capacitor (AEC). AEC can withstand higher temperature exposed from the solar panels and also improves the reliability. But the solid film type ac capacitors offers higher reliability than the AEC. In the conventional method of grid feeding system voltage source inverters are used. These voltage source inverters are used with large dc link capacitor requirement. But in the proposed method, current source inverter with smaller dc link arrangement and a dc link inductor which restricts the dc current ripple to a minimum value. So the solar based current source inverter offers higher reliability and efficiency at the time of power consumption. The voltage source inverter needs a boost converter or an ac transformer for boosting up the voltage because the string voltage is very small. But current source inverter has a boosting functionality so it does not need any additional component for boosting. The current source inverter also suppresses the earth leakage current. The functions of current source inverter in the grid are Inherent boosting, Short circuit protection and Direct output controllability. In the three phase pulse width modulated-CSI in between an isolation transformer is used to feed the grid. Use of this transformer increases the size and cost, decreases the overall efficiency. Using sinusoidal PWM technique the lower order harmonics will get reduced. The space vector PWM technique is preferred because it reduces both lower and higher order harmonics. In the conventional method IGBT is used the major disadvantage of IGBT is that they have negative temperature coefficient which leads to the thermal run away. MOSFET is used as a switch generally they have surge current protection build into their design. The MOSFET can be used under the following conditions: (i) high frequency operation, (ii) load variations and (iii) long duty cycle (>200 kHz).Thus the MOSFET will reduce the switching losses and improves the voltage. The current source inverter eliminates high frequency component in the common mode voltage thereby suppressing the common mode earth leakage current.

II. THE EXISTING SYSTEM

In the existing system isolation transformers are used to suppress the earth

leakage current. The conventional three-phase PWM-CSI requires an intermediate isolation transformer to feed power to the grid. The use of this transformer reduces the efficiency of conversion by about 2–3%. Modification for reducing the common mode currents is discussed. It recommends the use of a common mode choke in the dc-link. In addition, a modified PWM strategy is also suggested. However, the strategy does not completely eliminate the common mode voltage. Therefore, this topology is suitable for module integrated inverters (low power), wherein parasitic capacitance is small. Switching losses will be occurred due to the usage of transistors and PWM technique. IGBT is used as a switching transistor for the inversions and sinusoidal pulse width modulation technique is used. ATmega8051 controller is used as open loop controller. It has an external ADC, timer, PWM which increases the circuit complexity. In software part, PI controller is used for the closed loop simulation. This controller did not give the differential value at the load section. The disadvantages of the existing systems are large in size, high cost, weight of inverter is more so cannot be used for module integrated or string inverter applications.

III. The Proposed System

The proposed current source based transformer-less solar inverter are small dc capacitor, single stage conversion, and low leakage currents. To generate ac current waveforms from the dc current, eight semiconductor switching devices are used.

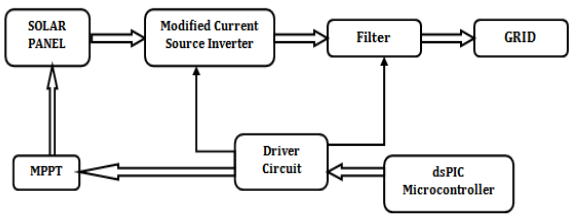

Fig1: Block diagram for the proposed system

Each device has unidirectional current flow capability and can block the reverse voltage. Reverse blocking (RB) MOSFETs or a diode connected in series with MOSFET can be used to realize these switches. Output of three phases is connected to the grid through capacitor–inductor (C–L) filter and that of the fourth leg is connected to the neutral of the system. The block diagram consists of solar panel which is connected to the modified current source inverter. Each module in the solar panel is rated by its dc output power under standard testing conditions. A limited amount of power can be produced by a single solar module. Here perturb and observe MPPT algorithm is used to track the maximum power from the solar panel.

The dsPIC30F4011 controller is used to generate the PWM signal and the input given to the controller is 5v. The input of 12v is given to driver circuit and the PWM signal is given to the CSI. Here MOSFET is used as a switching device and the inversion process takes place. At the time of inversions voltage magnitude increases therefore there is an improvement in voltage. Filters are used to remove the harmonics which is present in the ac and the ripple free ac is given as an output to the grid. The advantages of the proposed system are less leakage current, less cost, reliability, and high efficiency.

IV. The Current Source Inverter

The current source inverter (CSI) has a constant dc input and the output of this inverter will be a constant ac. This inverter will always have current source as an input and six thyristors are used for switching operations. In current source inverter diodes are used to handle the reverse voltage. The diodes are needed in CSI, so as to prevent the capacitors from discharging into the load. CSI accepts input from the power supply that acts as a current source rather than a voltage source.

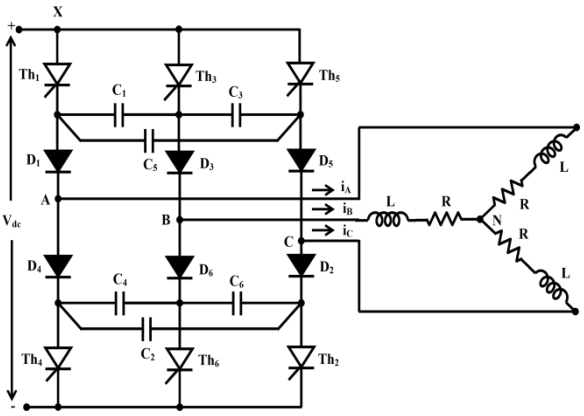

Fig2: Three-phase current source inverter

Electrical connections are made in series to achieve a desired output voltage and/or in parallel to provide a desired current capability. Current input to the CSI is always ripple free. CSI is used to supply high power factor loads whose impedance remains constant or decreases at harmonic frequency. To prevent the problems occurring due to the switching over voltages CSI is preferred. To get constant level of voltage inductance are used in CSI. CSI has extraordinary characteristics of phase angle control of the output current. This inverter is also used in industrial applications.

V. THE MODIFIED CURRENT SOURCE INVERTER

In this proposed system, a modified current source inverter is introduced here by connecting a PV module across the dc-link capacitor.

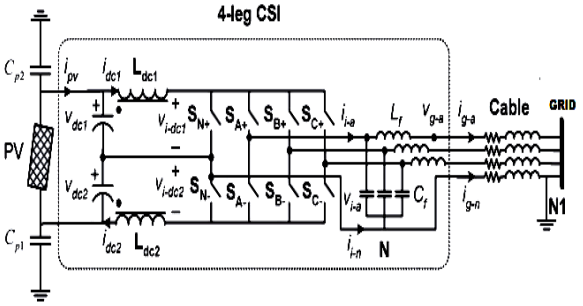

Fig3: Proposed current source based transformer- less solar inverter

The arrangement of these two dc-link capacitors are also known as split capacitors. The capacitors C_{p1} and C_{p2} are the split capacitors which are used for reducing the leakage current and thus it is connected in series with the PV panel. For neutral grounding the midpoint of the capacitor is connected to the grid. Therefore the voltage across the capacitors is dc without high frequency ac. A modified four leg CSI consists of a voltage regulator in order to regulate the supply voltage. From the terminals V_{dc1} and V_{dc2} the regulated voltage can be obtained. The modified current source inverter, has a two dc-link inductor L_{dc1} and L_{dc2} are held to have higher value of mutual coupling. Using this inductor it offers higher impedance and hence, it reduces the earth leakage current magnitude. As the magnitude of the leakage current decreases the current also decreases. In the modified current source based solar inverter there are four pairs of semiconductor switching devices. In each pair it has two devices and they are capable to block the reverse voltage. Hence it provides unidirectional current flowing capability.

The switches used can either be a diode which is connected in series with the MOSFET or with the reverse blocking MOSFETs. In the four leg modified CSI the switches SN+ and SN- are used for the neutral grounding purpose and then it is connected to the grid to prevent the inverter from the overall system failure. During the operation voltage V_{dc1} and V_{dc2} are maintained constant and the voltage difference between the PV terminal and neutral provides a constant dc without high frequency ac. By using dsPIC30F4011 controller the PWM signal is generated. This open loop controller has an inbuilt PWM generator so that the signal is easily generated. This controller also has inbuilt RTC timer and an ADC. This PWM technique is mainly proposed in the modified current source inverter in order to maintain the continuity of dc current. With the help of the driver circuit the generated PWM signal is given to the CSI.

The pulse width modulated signals are triggered with the help of the semiconducting switches. MOSFET was one of the most preferred choices for the power switching devices to reduce the on state losses. The switches will conduct at 120 degree mode. At

instant one of the switches from the upper group and the other switches from the lower group will start conducting except the switches SN+ and SN- which is already connected to the grid for neutral purpose.

In order to maintain continuity in dc current the switches during turning ON and OFF conditions it should provide pulse advancement. The pulse advancement can be made by turning ON the incoming switch before the outgoing switch turned OFF. Therefore space vector pulse width modulation (SVPWM) is preferred for the modified three phase current source inverter. Once the pulses are triggered then the inversion process takes place and the amplitude gets increased, as a result the voltage will also get increased. Therefore harmonics (some of the dc component present in the ac) can be reduced by using high pass filter. Thus the ripple free output is fed to the grid.

VI. Simulation Results

Solar input

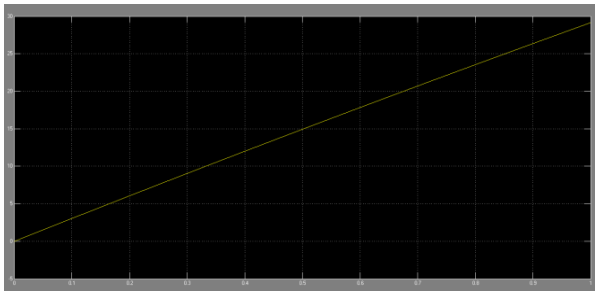

Fig4(a) Input Current Waveform of solar panel

Current waveform for grid feeding system

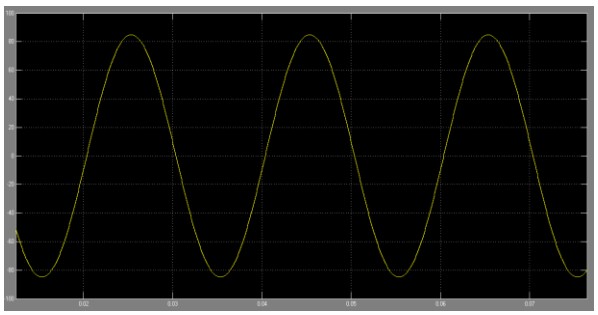

Fig.4(b) Output Current waveform of Current Source Inverter

Voltage waveform for grid feeding system

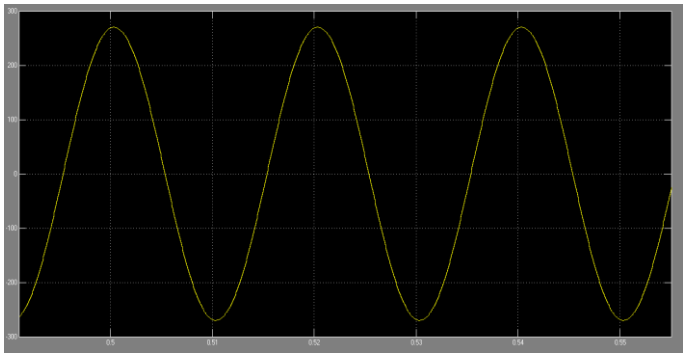

Fig.4(c) Output voltage waveform of Current Source Inverter

In order to verify the efficiency of the proposed system simulation studies are done. The output of the solar panel is a DC source which is steadily increasing. By using 5W solar panel we are generating 20V and this is given as an input to the modified current source inverter. When the solar is exposed to light it starts generating from zero to a particular voltage. Using maximum power point tracking (MPPT) system the maximum power is generated from the solar panel.

The current waveform of the grid feeding system which represents the current on y-axis and time on x-axis shown in fig. 4(b). This graph represents the output current of current source inverter to the grid in which the inverter current leads the grid voltage, while the grid current is in phase with grid voltage and the power factor is found to be 0.95. The voltage waveform of the grid feeding system which represents the voltage on y-axis and time on x-axis shown in fig.4(c). The AC voltage generated from the modified current source inverter will have some harmonics, through the filters the harmonic will be suppressed and ripple free input is given to the grid. The mode voltage between the ground and the negative dc-link in the proposed scheme is compared with that in conventional three phase PWM-CSI.

VII. Conclusion

This paper concludes that the use of current source based solar inverter which

gives higher reliability than the voltage source based inverters. Thus using the modified current source based solar inverter with MOSFET as a switch the power quality is improved. The experiments were conducted and the results have been verified using the simulation studies.

To eliminate the flow of leakage current in the system the following techniques are used.

(i) Common mode inductor is introduced in the dc link which offers high impedance to the flow of common mode leakage current.

(ii) Addition of fourth leg avoids the possibility of undesired current flow through neutral or any phase during the zero state.

(iii) Split capacitor arrangement and connection of neutral to midpoint of split capacitors eliminates high-frequency component from the common mode voltage, which in turn restricts the flow of common mode leakage current.

Main advantages of the proposed current source based transformer-less solar inverter are single stage conversion, low leakage currents, small dc capacitor, MOSFET acts as a switching device which reduces the switching losses, the open loop controller is used to reduce the complexity. Therefore this proposed suitable for inverter applications and distribution systems.

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