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Multilevel Inverter for Induction Motor Connected Photovoltaic Systems

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***Abstract*—Converters for photovoltaic (PV) systems usually consist of two stages are a dc/dc booster and a pulse width modulated (PWM) inverter. This cascade of converters presents efficiency issues, interactions between its stages, and problems with the maximum power point tracking. Therefore, only part of the produced electrical energy is utilized. In this paper, propose a single-phase H-bridge multilevel converter for PV systems governed by optimal PWM switching-angle generator. Most of the required signal processing is performed by a micro controller. The general architecture of the system and its main performance in a large spectrum of practical situations are presented and discussed. This topology features several advantages such as the independent tracking of the MPP of each string and the possibility to scale the system by plugging more strings to the existing plant. This converter topology can reach peak efficiencies up to 96%.**

Index Terms—Embedded systems, micro controller, photovoltaic systems

I. Introduction

One of the merits offered by solar energy sources is their potential to supply abundant electricity in areas not provided by the general power grid. In addition, solar power does not generate any poisonous or dirty substances that pollute the water, air, or land somewhere. So the extending market for solar energy technologies has resulted in the rapid development for the need of power electronics. Most power-electronics technologies, including control skills, are required to convert the dc into ac power. In many stand-alone photovoltaic inverters, alternating current is required to operate 110 V (or 220 V), 50 Hz (or 60 Hz), home, or office appliances. Generally, stand-alone inverters operate at 12, 24, 48, 96, 120, or 240 V_{dc}, relying on the power level [1]. In the case where the amplitude of voltage produced by solar array is low, there is the need for an additional boost converter or a step-up transformer to obtain high-output voltage converting power from dc to ac and commonly connected in series with a pulse width-modulated (PWM) inverter. However, a somewhat high switching frequency of PWM inverter and its dv/dt stress result in low efficiency and occasionally electromagnetic-interference (EMI) problems. In addition, an output filter is required to reduce high-switch-frequency components and to produce sinusoidal output from the inverter [2]-[6]. In points of alleviating these problems, multilevel inverters can substitute the conventional PWM inverter. Generally, multilevel topologies have been studied to increase the power-reducing voltage stress on the power-switching devices and to produce high-quality output voltages [7]-[15]. The paper aims at designing a system which makes the induction motor running through solar energy efficiently.

A solar panel is a large flat rectangle, typically somewhere between the size of a radiator and the size of a door, made up of many individual solar energy collectors called solar cells covered with a protective sheet of glass. A two-level capacitive voltage divider and a neutral point clamped (NPC) branch. The other method is to combine a three-level half-bridge inverter and a two-level half-bridge inverter. The two-level half-bridge inverter is replaced by a two-level dual-buck half-bridge inverter The cells, each of which is about the size of an adult's palm, are usually octagonal and colored bluish black. Just like the cells in a battery, the cells in a solar panel are designed to generate electricity; but where a battery's cells make electricity from chemicals, a solar panel's cells generate power by capturing sunlight instead. They are sometimes called photovoltaic cells because they use sunlight.

The paper consists of solar panel, battery, capacitor voltage driver. The capacitor voltage driver circuit consists of micro controller, buck boost converter. Whatever the voltage getting from the solar panel is varied, the varied voltage gives voltage transitions, and these generates leakage currents. So, to minimize the leakage current through this technique, voltage transitions should be avoided. To avoid the voltage transitions pulse width modulation technique is required. This pulse width modulation technique is provided by the micro controller.

An embedded system is a combination of software and hardware to perform a dedicated task. Some of the main devices used in embedded products are Microprocessors and Microcontrollers. Microprocessors are commonly referred to as general purpose processors as they simply accept the inputs, process it and give the output. In contrast, a microcontroller not only accepts the data as inputs but also manipulates it, interfaces the data with various devices, controls the data and thus finally gives the result. In this paper using PIC16F73 microcontroller is an exclusive paper which is used to store the energy from solar using solar panel.

II. Hardware Description

The block diagram of the paper and design aspect of independent modules is considered. Block diagram is shown in Fig. 1.

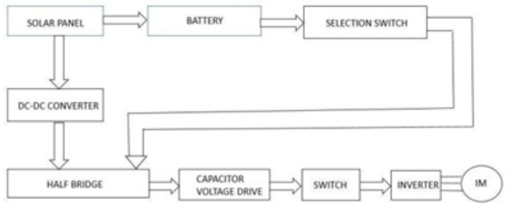

Fig. 1. Block diagram of Multilevel Inverter for PV Systems

The main blocks are: Solar panel, Inverter, Switches, Battery, capacitor voltage driver (Micro Controller, buck boost converter), half bridge, and Induction motor.

A) Solar Panel:

Photovoltaic Cells: Converting Photons to Electrons The solar cells that you see on calculators and satellites are also called photovoltaic (PV) cells, which as the name implies (photo meaning "light" and voltaic meaning "electricity"), convert sunlight directly into electricity. A module is a group of cells connected electrically and packaged into a frame (more commonly known as a solar panel), which can then be grouped into larger solar arrays. Photovoltaic cells are made of special materials called semiconductors such as silicon, which is currently used most commonly. Basically, when light strikes the cell, a certain portion of it is absorbed within the semiconductor material. This means that the energy of the absorbed light is transferred to the semiconductor. The energy knocks electrons loose, allowing them to flow freely.

B) Battery:

An electric battery is a device consisting of two or more electrochemical cells that convert stored chemical energy into electrical energy. Each cell has a positive terminal, or cathode, and a negative terminal, or anode. The terminal marked positive is at a higher electrical potential energy than is the terminal marked negative. The terminal marked positive is the source of electrons that when connected to an external circuit will flow and deliver energy to an external device. When a battery is connected to an external circuit, electrolytes are able to move as ions within, allowing the chemical reactions to be completed at the separate terminals and so deliver energy to the external circuit. It is the movement of those ions within the battery which allows current to flow out of the battery to perform work. Although the term battery technically means a device with multiple cells, single cells are also popularly called batteries. Examples include the lead-acid batteries used in vehicles and lithium-ion batteries used for portable electronics.

C) Buck Boost converter:

A buck-boost converter is a type of SMPS (Switch-Mode Power Supply) that uses the same concept of both a buck converter and a boost converter, but in one combined circuit. We take a look at the circuitry involved and outline what applications can benefit from a buck boost converter. The main objective of a buck-boost converter is to receive an input DC voltage and output a different level of DC voltage, either lowering or boosting the voltage as required by the application. The design of a buck -boost converter is similar to a buck converter and boost converter, except that it is in a single circuit and it usually has an added control unit. The control unit senses the level of input voltage and takes appropriate action on the circuit based on that voltage.

D) Inverter:

An inverter is used to produce an un-interrupted 220V AC or 110V AC (depending on the line voltage of the particular country) supply to the device connected as the load at the output socket. The inverter gives constant AC voltage at its output socket when the AC mains power supply is not available.

E) Multilevel Inverter:

Power electronic device which converts dc power into ac power at desired output voltage and frequency is known as inverter. The inverter producing an output voltage or current with two different levels of ±V is known as 2 level inverters. This two level conventional inverter operates at high switching frequency, with high switching losses and rating constraints for high power and voltage applications. It also faces harmonic distortion, EMI and high dvdt stress. High level of total harmonic distortion is another problem. Because of these problems, it is difficult to interface power electronic switches directly to high and medium voltage grid. Here comes the need for a different topology of multi-level inverter. The multilevel inverter topology concept has been introduced in the early 1975 with three level converters. It is possible to increase the power rating with high number of voltage levels in the inverter. This reduces the device rating in the inverter. A multilevel inverter generates a smooth sinusoidal waveform from several d c voltage levels as its input.

F) Concept of multilevel inverter:

First take the case of a two-level inverter. A two-level Inverter creates two different voltages for the load i.e. suppose we are providing V_{dc} as an input to a two level inverter then it will provide + $V_{dc}/2$ and – $V_{dc}/2$ on output. In order to build an AC voltage, these two newly generated voltages are usually switched. For switching mostly PWM is used as shown in the Fig. 2. Reference wave is shown in dashed blue line. Although this method of creating AC is effective but it has few drawbacks as it creates harmonic distortions in the output voltage and also has a high dv/dt as compared to that of a multilevel inverter.

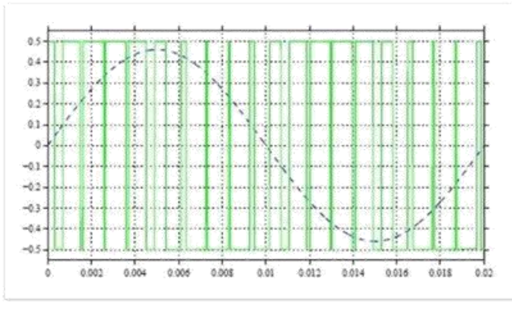

Fig. 2. PWM voltage output of a two-level inverter

Normally this method works but in few applications it creates problems particularly those where low distortion in the output voltage is required. PWM voltage output of a two-level inverter.

The concept of multilevel Inverter (MLI) is kind of modification of two-level inverter. In multilevel inverters we don’t deal with the two level voltage instead in order to create a smoother stepped output waveform, more than two voltage levels are combined together and the output waveform obtained in this case has lower dv/dt and also lower harmonic distortions. Smoothness of the waveform is proportional to the voltage levels, as we increase the voltage level the waveform becomes smoother but the complexity of controller circuit and components also increases along with the increased levels. Where we clearly see that as the levels are increasing, waveform becoming smoother. There are several topologies of multilevel inverters available. The difference lies in the mechanism of switching and the source of input voltage to the multilevel inverters.

III. Schematic diagram Description

In this paper, schematic diagram and interfacing of circuit with each module is considered.

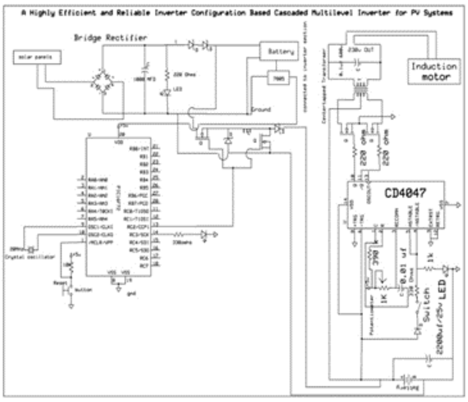

Fig. 3. Schematic diagram of multilevel inverter for PV systems

The above schematic diagram of a highly efficient and reliable inverter configuration based multilevel inverter for PV systems explains the interfacing section of each component with circuit. Crystal oscillator connected to 9th and 10th pins of micro controller and regulated power supply is also connected to micro controller and LED's also connected to micro controller through resistors.

IV. Result

The paper "A highly efficient and reliable inverter configuration multilevel inverter for PV systems" to design a system which makes the induction motor very efficiently by suppressing leakage currents.

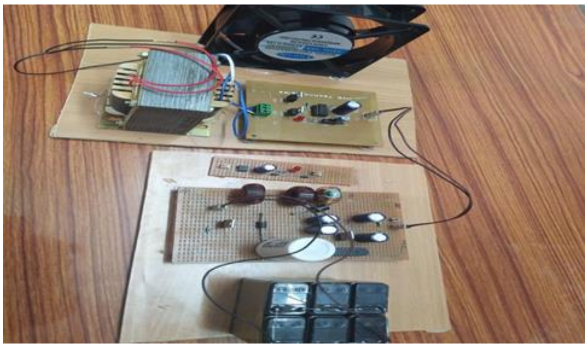

Fig. 4. The kit is under OFF POSITION and connected to the battery

The battery which stores electrical dc supply which is given to circuit which purifies the dc supply and is given to the inverter section and the switch is in off position in the inverter which doesn't allow current to the step-up transformer and induction motor.

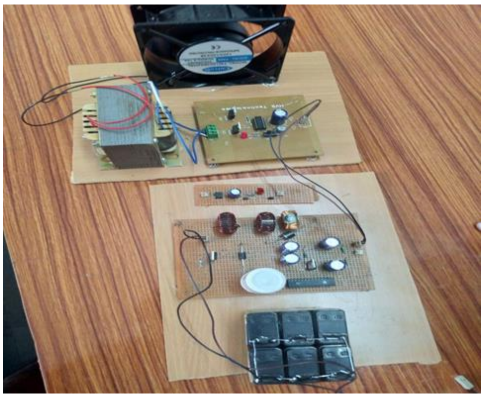

Fig. 5. The kit is under ON POSITION when switch is ON through which battery is connected

The DC supply is given from battery to the circuit which purifies the dc current and it is given to inverter section which converts DC to AC. Now the switch is in ON position. Which allows the current to step-up transformer which converts low voltage to high voltage up to 240 volts which it is given to the induction motor. And the motors run in efficient way.

Fig. 6. The kit is connected to solar panel as an input source

In this solar panel is given as an input source which converts solar radiation into electricity DC supply is produced. Which is given to the DC purifier section and converts dc to pure dc and eliminating the leakage currents by avoiding voltage transitions. DC-DC converter is used to boost the DC supply and it was given to inverter section which converts DC to AC simultaneously battery gets charging and from inverter it is given to the step-up transformer which converts low voltage to high voltage up to 240 volts which is given to the induction motor. It runs the induction motor efficiently.

V. Conclusion

The project consists of solar panel, battery, capacitor voltage driver. The capacitor voltage driver circuit consists of micro controller, buck boost converter. Whatever the voltage getting from the solar panel is varied, the varied voltage gives voltage transitions, and these generates leakage currents. So, to minimize the leakage current through this technique, voltage transitions should be avoided. To avoid the voltage transitions pulse width modulation technique is required. This pulse width modulation technique is provided by the micro controller.

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