Design of Low Cost Solar Based Single Phase Inverter

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***Abstract*— In this paper we have discussed how to convert solar energy into electrical energy in cost effective manner. The main components of this solar system are solar cell, dc to dc boost converters and inverter. In this topology only two MOSFETs are used and isolation requirement between control circuit and power circuit is also less which helps to decrease the cost of solar inverter. In this paper design of components for booster and inverter are done.**

***Keywords*— DC to DC converter, Low cost solar based inverter, Single phase solar based inverter.**

I. INTRODUCTION

There are two types of sources for electrical power generation, one is conventional and other is non- conventional. Today to generate most of electrical power conventional sources like coal, gas, nuclear power generators are used. Some of conventional source are polluted the environment to generate the electricity [1]. And nuclear energy is not much preferable because of its harmful radiation effect on the mankind. After some of ten years conventional sources will not sufficient enough to fulfill the requirements of the mankind. So some of the electrical power should be generated by non-conventional energy sources like solar, wind [3]. With the continuously reducing the cost of PV power generation and the further intensification of energy crisis, PV power generation technology obtains more and more application [2]. In this paper cost effective method is used to implement single phase solar inverter. Solar cell/ PV cells convert solar energy into electrical energy. This electrical energy is in DC form. This dc voltage is boosted using dc to dc boost converter [2]. This boosted dc voltage is fed to inverter. Inverter converts dc voltage into ac voltage. Here sine coded PWM push-pull inverter is used. The output of inverter is given to step-up transformer and low-pass filter which will give 220V 50Hz sine wave output. This output is given to the load.

II. SYSTEM DISCRIPTION AND CONTROL STRATEGY

Block diagram of single phase solar inverter is shown in Figure.1. Solar panel output is 12 volt. Dc to dc boost converter converts 12 volt dc voltage to 12 volt dc. This dc voltage is converted to ac voltage using inverter. Inverter output is sine wave. This sine wave output are stepped up using step up transformer. These sine wave pulses are obtained using low-pass filter. This sine wave ac voltage is fed to the load. The ac output is 220 volt, 50 Hz.

a) Solar Array:

Photovoltaic or solar cell/panel converts sunlight directly into electricity which can be used to power light bulbs, household electrical appliances or recharge a battery. PV cells come in various sizes ranging from 10mm by 10mm to 100mm by 100mm, the most common size being 100mm by 100mm cells. A single PV cell produces about 1 to 2 watts of electricity; an amount that is quite insignificant compared to what is required by most electrical equipment. Two or more PV Cells are built to produce a PV Module to provide higher wattages as required. For instance, a PV module producing 50 watts may comprise of at least 25 of 2 Watts output PV cells.

To meet the electrical need of a home or an industrial setting, PV Modules are assembled together to form a PV Array that meets the total energy requirement. A PVC system design begins with determining the total energy requirement for a facility to be powered.

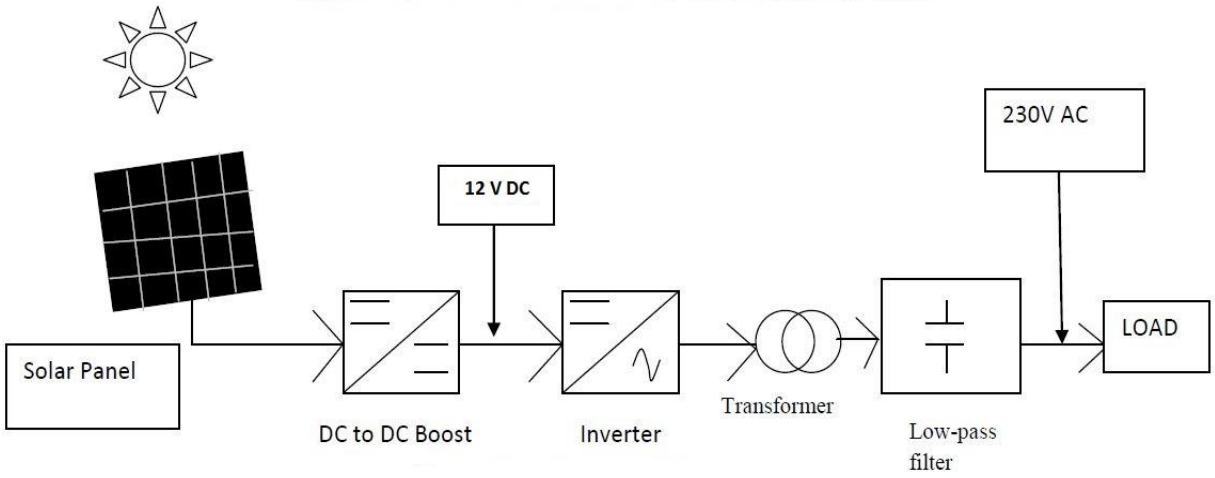

Figure. 1 Block diagram of solar based single phase inverter.

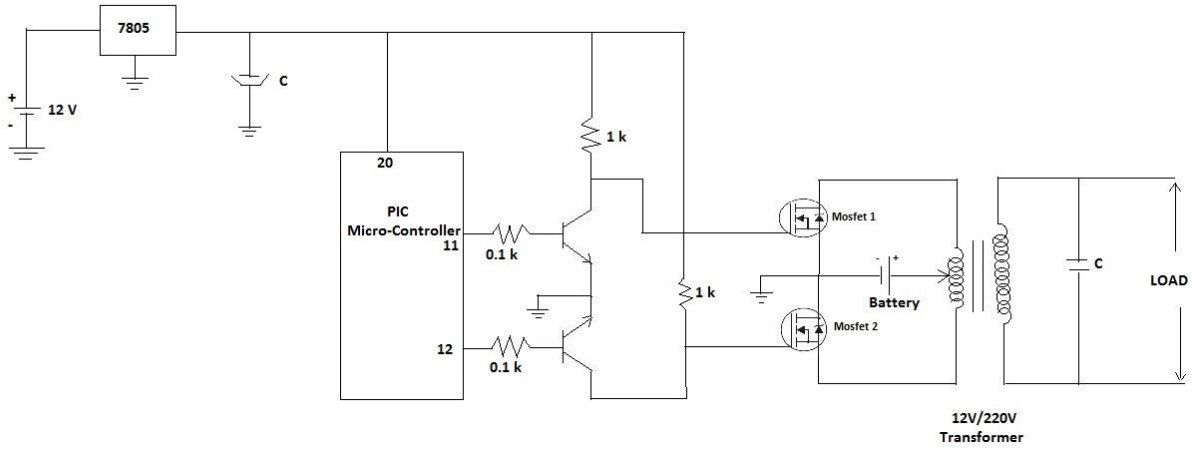

Figure. 2 Circuit diagram of solar based single phase inverter.

Next the number of solar panel units required and other components of the PVC (description below) are determined. A basic PVC system comprises of the following:

• Solar panels – It collects visible light from Sun and converts it to electricity (direct current (DC)

• Batteries (rechargeable) –It store solar energy up to provide electricity for sundown periods (nights and cloudy days).They must be able to discharge and recharge. Rechargeable batteries are a little more expensive than the disposable batteries. Without batteries a PVC system can only provide electricity when it is sunny.

• Charge Controller –It seeds electricity from the solar panel to the batteries in a manner that prevents the solar panel from overcharging the batteries.

Solar panels generate low voltage Direct Current (DC) electricity. Some appliances (e.g. in candescent lights) may be powered directly by the energy from the panels as these appliances are DC compliant. However, most electrical appliances require Alternating Current (AC) electricity and usually at high voltages (110V in North America and 230V in most of Europe and developing world (e.g. Africa)) to function. Inverters are used to convert the low voltage DC to AC at required voltages. In summary, the solar cells collect direct sunlight, converts sunlight into low-voltage DC. Where energy storage in a battery for future use is required, the DC is stored directly in batteries. A charge controller is installed between the Solar panels and the

batteries to ensure the batteries are not overcharged.

b) Inverter circuit:

The DC to AC converter, also known as inverter converts dc power to ac power at desired output voltage and frequency. The output voltage of an inverter has a periodic waveform that is not sinusoidal but can be made to closely approximate this desire waveform. Figure.2 shows the circuit topology for a single phase inverter. It is an electronic power converter that is necessary as an interface between the power input and the load. The switching element available nowadays, such as bipolar junction transistor (BJTs), gate turn off thyristor (GTOs), metal oxide semiconductor field effect transistors (MOSFETs), insulated gate bipolar transistors (IGBTs), metal oxide semiconductor controlled thyristor (MCT's) and static induction transistors (SIT's) can be used as a switch. They are substituting the relays, magnetic switches and other magnetic components as the inverter switching devices. This makes use of microcontroller becomes more significant. But in this topology MOSFETSs are used.

c) Printed Circuit Board:

Printed circuit boards may be covered in two topics namely.

• Technology and Design.

• Introduction to Printed circuit boards

It is called PCB in short, Printed circuit board consists of conductive circuit pattern applied to one or both sides of an insulation base, depending upon that, it is called single side PCB or double sided PCB (SSB and DSB). Conductor materials available are silver, brass, aluminum and copper is most widely used .The thickness of conducting material depends upon the current carrying capacity of conducting material depends upon the current carrying capacity of circuit. Thus a thicker copper layer will have more current carrying capacity. The printed circuit board usually serves three distinct functions.

- It provides mechanical support to the components mounted on it.
- It provides necessary electrical connections
- It acts as heat sink i.e. it provide a conduction path leading to removal of most of the heat generated in the circuit.

d) Transformer:

A transformer (as shown in Figure.3) makes use of Faraday's law and the ferromagnetic properties of an iron core to efficiently raise or lower AC voltages. It of course cannot increase power so that if the voltage is raised, the current is proportionally lowered and vice versa.

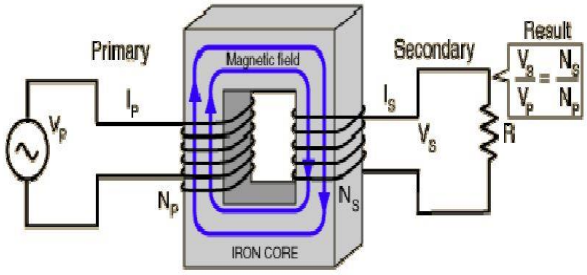

Figure. 3 Transformer.

e) PIC Micro-Controller:

The family 18F offers the advantages of all PIC18 microcontrollers– namely, high computational performance at an economical price – with the addition of high-endurance, Flash program memory. On top of these features, the PIC18F2XK20/4XK20 family introduces design enhancements that make these microcontrollers a logical choice for many high performance, power sensitive applications. Some of the attractions in going for these microcontrollers include:

- High computational performance at an economical price
- High endurance
- Flash program memory
- 10-bit A/D Converter
- We are using 18F25K20 PIC micro-controller.

Features:

- Operating Voltage Range: 1.8V to 3.6V.
- Self-Programmable under Software Control.
- Programmable 16-Level High/Low-Voltage Detection (HLVD) module Interrupt on High/Low-Voltage Detection.

- Programmable Brown-out Reset (BOR):- With software enable option.
- Extended Watchdog Timer (WDT):- Programmable period from 4 ms to 131s.
- Single-Supply 3V In-Circuit Serial Programming™ (ICSP™) via Two Pins.
- In-Circuit Debug (ICD) via Two Pins.

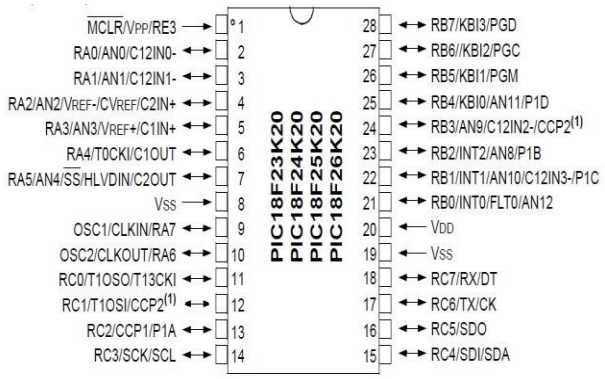

Figure. 4 Pin Diagram of PIC18F25K20.

f) Power MOSFET:

Third generation Power MOSFETs provide the designer with the best combination of fast switching, ruggedized device design, low on-resistance and cost-effectiveness.

The Z540 package is preferred for commercial-industrial applications where higher power levels preclude the use of TO-220AB devices. The Z540 is similar but superior to the earlier TO-218 package because it's isolated mounting hole. It also provides greater creep age distances between pins to meet the requirements of most safety specifications.

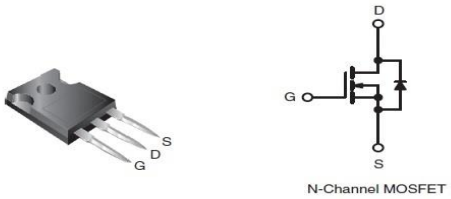

Figure. 5 Power MOSFET.

Features:

- Dynamic dV/dt Rating.
- Repetitive Avalanche Rated.
- Isolated Central Mounting hole.
- 175 °C Operating Temperature.
- Fast Switching.
- Ease of Paralleling.
- Simple Drive Requirements.
- Compliant to RoHS Directive 2002/95/EC.

g) Three Pin Voltage Regulator:

In the past, the conversion was to provide a single regulator to regulate a line which then supplied power to all circuits comprising an electronic system. This regulator would generally be made up of several discrete components or a low power voltage regulator IC with associated series pass elements. Such a regulator was bulky and would be required to dissipate a large amount of power. With the development and ready availability of three terminal regulators both fixed and adjustable. In a wide range of current and power ratings the trend has moved towards localized regulation with single three terminal regulators fitted on each circuit card.

A functional schematic of a three terminal regulator is shown in figure 6. It is seen that the device is a complete with built –in reference error amplifier, series pass transistor and protection circuits. The protection circuits include current limiting to limit peak output current, safe area protection to limit dissipation in the series pass transistor, and thermal shut down to limit die and junction temperature to a safe value.

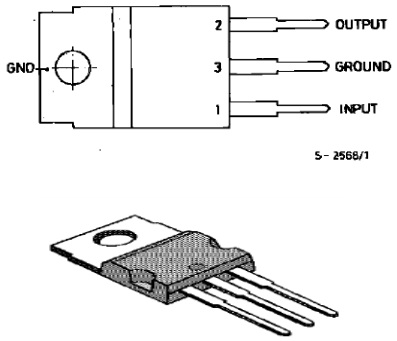

Figure. 6 Voltage regulator.

The reference voltage VREF is a temperature stabilized voltage developed either a zener or a band–gap circuit. The error amplifier is a no inverting amplifier which constantly compares a fraction of the output voltage developed across R2 against the reference voltage at its non-inverting input. The error amplifier

controls the base drive of the series pass transistor in such a way that the output voltage remains constant, thus achieving Regulation.

The current limiting and safe protection circuits, when activated, limit the base drive to the series pass transistor thus limiting output current of the thermal shutdown circuit. On the other hand, when activated completely turns off the base drive to the series pass transistor. Thus reducing output off the base drive to the series pass transistor, thus reducing output current to zero.

IC 7805 Series:

An example of a Motorola IC 7805 series of three terminal positive fixed voltage regulator used in basic regulator circuit. The input capacitance C1 is required to cancel inductive effects associated with long power distribution leads, Output capacitor C2 improves the transient response. These devices requiring no adjustment have an output present by the manufacturer to an industry standard of 5, 69, 12, 15, 18 or 24 volts. Such regulators are capable of output current in excess of 1Amp. These have internal short circuit protection which will limit the maximum current; the circuit will pass thermal shut down and output transistor safe operating area protection.

Basic circuit using three terminal positive regulators:

Typical values for the stabilization coefficients are

Sv = 3x 10 Ro =30 milliohms, and

St = 1 mV / Centigrade

The level of complexity affected by monolithic IC techniques. The IC 7805

IC consist of:

- O/P current in excess of 1 amp.
- Internal thermal over load protection.
- No external component required.
- Internal short circuit current limit.
- Available in aluminum 2-3 package.

h) Capacitor:

A capacitor is an electrical/electronic device that can store energy in the electric field between a pair of conductors (called "plates"). The process of storing energy in the capacitor is known as "charging", and involves electric charges of equal magnitude, but opposite polarity, building up on each plate. Capacitors are often used in electrical circuit and electronic circuits as energy-storage devices. They can also be used to differentiate between high-frequency and low-frequency signals. This property makes them useful in electronic filters.

III. APROACH AND METHOD

The software development includes designing suitable switching pulses with the use of the variable frequency and variable duty cycle PWM available inside the PIC microcontroller. It is desired to control the inverter with proper switching purposes. The digital implementation of the so called scalar modulation is usually achieved with a timer based card inside microcontroller. The turn on and turn off time of the switches is determined by the control signal. Before this control signal being generated, proper calculation is done to determine the suitable switching pulses condition.

IV. CONCLUSION

By varying the pot value we can get analog voltage and by this we can get the required frequency for operation. As we apply DC input voltage we get output AC line voltage for dummy load operation. Due to voltage drop present in MOSFET switches there is reduction in output voltage.

- We can vary the frequency from 10 Hz to 100 Hz.
- Higher efficiency and easier installation. The low voltage cable losses are reduced to 40% and the low voltage installing costs (excl. inverters and transformers) are reduced significantly.
- Pollution free system
- Energy saving: An average plant can save as much as 20% of its total energy.

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