IOSR Journal of Engineering (IOSRJEN) **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
Vol. 06, Issue 11 (Nov. 2016), ||V2|| PP 30-33

The Solar Power for UPS Scheme

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Abstract :- Nowadays, there is an increasing trend towards use of non-conventional energy resources. Solar power is an important source of alternative energy, that is abundantly available. The paper proposes an Uninterruptible Power Supply(UPS) scheme using solar energy, as an alternative to the normal UPS.The solar photovoltaic array delivers an output of 18V dc during peak insolation. This electrical energy is stored in a lead acid type battery of 30AH,12 Volt output. The IGBTs, which are high speed , high current devices, with simple firing techniques can act as the Inverter H-bridge.The inverter circuit employs Sinusoidal Pulse Width Modulation(PWM) and the firing pulses are generated by the microprocessor. The load from the ac mains to this UPS is transferred through a solid state static switch, without any interruption of the power supply.This microprocessor based system can follow the instantaneous value of the output voltage, as well, can provide overload, overvoltage and undervoltage protection.

***Keywords** : Photovoltaic, UPS, PWM, IGBT, Inverter*

I. INTRODUCTION

The solar photovoltaic system is the low emission, and non-depletable source of energy.A lot of research and development work is being done in the area of solar cells, making the photovoltaic approach increasingly popular. The solar energy has a novel advantage. The solar energy can be an economical alternative as it is a distributed source of energy. In the past 15 years, solar photovoltaic array production has increased exponentially,with annualgrowth numbers ranging from 40% to 250% [1]. The electrical power generation from solar energy changes due to changes in incoming energy from the sun. At standard test conditions, the incoming energy is exactly 1,000W/m^2[3]. The power of 200 W in a photovoltaic area of 1 m^2 shall be available even if a solar panel has an efficiency of 20%.he photovoltaic array or solar array which operates on the principle of photovoltaic effect. , By absorption of solar radiation, the generation of charge carriers with in a material takes place, giving rise to electrical current in the circuit. In this proposed work, the solar PV array are used to charge the dc battery, and the stored dc energy is supplied to the load through an inverter. The load is attached to the AC supply mains, but, can be transferred to the inverter supply in case of the mains failure, through the solid state relay,.The solar cell is not damaged by either a short circuit or open circuit load.A photovoltaic cell provides maximum of about 0.4 mA dc current or an open circuit voltage of 0.6 volt for each square cm of cell surface, at room temperature. In our PV array a open circuit total voltage generated was found to be 18 volt at peak insolation.The storage of solar electricity requires astorage batterykeeping a long life at variable depths of discharge, high overall efficiency and reliability. It should have low self discharge on standing and should be maintenance free. The standby battery is normally either nickel-cadmium or lead-acid type. A nickel-cadmium battery is preferable to lead acid battery. Because the electrolyte of a nickel-cadmium battery is non-corrosive and does not emit explosive gas . It has a longer life due to its ability to withstand overheating or discharging. However its cost is three times more than that of a lead-acid battery[4]. But,in this proposed systemcheap lead-acid battery of 12 Volt,30AH is used which was readily available.The battery bank size can be enhanced to meet the requisite load demand. The power devices like IGBTs can be employed for high voltage, heavy current applications. For low voltage, current applications, MOSFETs may be preferred.

II. SYSTEM OVERVIEW

The UPS systems are required to provide back up electric power in case the AC main power supply fails.In case of a mains supply failure, or even, if the quality of the incoming power is decreased below a threshold level, the inbuilt electronic mechanism connects the battery to the load. Thus, the task of UPS is to maintain the continuity of the power supply as an emergency measure. This back up power to be delivered may be for a time period between a few seconds up to several hours depending on application. The back up time of the UPS isdecided by the size of the battery bank which can be adjusted to the as per the demands of the load.The block diagram for the UPS system is shown in Fig.1. The major components of the system are Photo voltaic Array, DC battery, Inverter circuit and lighting load.

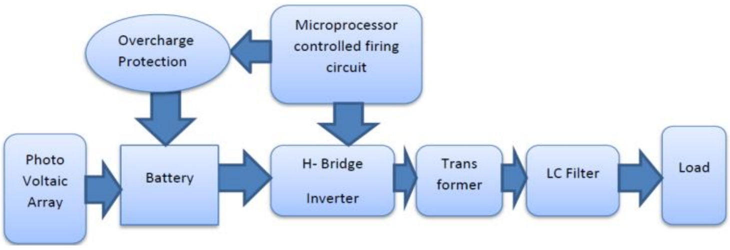

Fig.1 : Block Diagram : Solar Power UPS scheme

In applications, such as UPS, pure sine wave inverters are preferable, as both, modified and square wave inverters introduce harmonics that can be harmful to sensitive equipment.
Harmonic distortions are ripples with frequencies of integer multiplicitiesof the fundamental frequency of the wave. For example an inverter with a 230V, 50Hz AC output may also have non-linear components with frequencies of 100Hz and 200Hz present in the outgoing waveform.

III. SYSTEM OPERATION

The circuit which has been built consists of a solar PV panel used to charge a battery with the DC currentfrom the solar panels. The solar photovoltaic array delivers an output of 18V dc during peak insolation. This electrical energy is stored in a lead acid type battery of 30AH,12 Volt output. . The static switches are solid state relays which gets closed , which in turn supplies output ac voltage to the load on failure of ac mains.For conversion of photovoltaic dc power stored in battery to ac power, an inverter circuit based on Sinusoidal Pulse Width Modulation techniques is employed. The inverter circuit is shown in Fig.(2). The IGBTs, which are high speed , high current devices, have simple firing techniques. IGBTs have advantages over SCRs, as these can be easily turned on and off, and no commutation circuitry is required.Also, these devices can be switched at relatively high frequencies, providing smooth output waveforms. However, these will be always more costly than SCRs of the same power handling capacity. IGBTs used are T0-247AC, which have VCEO =600 V, IC(DC)=70A, up to 8KHz switching frequency. The switching operation of IGBTs is microprocessor controlled, i.e. the microprocessor system delivers the required PWM pulses to the gate of IGBTs. The inverter circuit employs Sinusoidal Pulse Width Modulation(PWM) and the firing pulses are generated by the microprocessor. The actuator, in the cases of advanced inverters, is often an H-Bridge circuit, which contains power semiconductor devices to control the duration and direction of current through a load to get a desired voltage level[5].

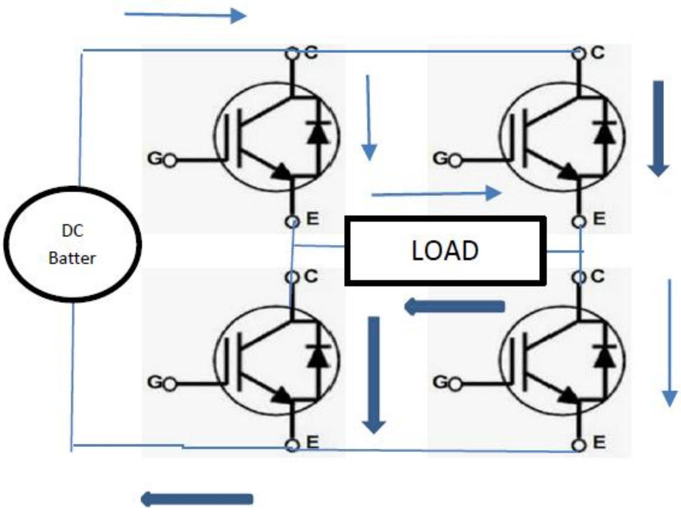

Fig.2 : Inverter switching scheme

As shown in fig 2., a solid state h-bridge is built using four switches. When switch S1 (upper left) and S2 (lower right) are closed and switches S3(upper right) and S4(lower left) are open, a positive voltage will be applied across the load, while the direction of current is as shown by the thin arrow. By closing S3 (upper right) and S4 (lower left) switches and opening S1(upper left) and S2 (lower right) switches, a reverse voltage will be applied to the load, and the direction of the current is shown by the thick arrow. Using these nomenclature, switches S1 and S4 should never be closed at the same time as it shall cause a shot circuit between the power supply and ground, potentially damaging the devices or draining the power supply. The same applies to switches S2 and S3. This condition is known as shoot-through.The Pulse Width Modulation(PWM)is popularly used to generate a smooth output signal. An algorithm can be implemented to generate square signal pulses of variable duty cycle. To create a sinusoidal signal, PWM uses high frequency square waves with varying duty cycles.As the duty cycle increases, more power is transmitted. Initially, the duty cycle of the square signal increments till it reaches 100% and then the duty cycle of square signal decrements till it reaches 0%, thereby generating a PWM signal, as shown in Fig.3, which represents a sinusoidal form. The PWM signal provides rapid on and off changes, which can be handled using high power IGBTs. It should be noted, however, that when aIGBT is in transition between on and off, the power loss can be significant. For this reason, the transition times and frequency should be engineered to be as short as possible. This can be achieved by minimizing the amplitude between the on and off stages and lowering the PWM frequency; however as the frequency decreases so does the signal quality. Some microcontrollers like PIC16F877A can generate Sinusoidal PWM outputs directly[6].

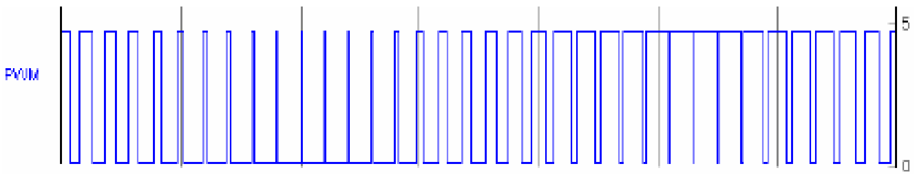

Fig.3 : PWM signal

The output of inverter, raised to necessary level using transformers, is subjected to external low pass filters to shape the analog voltage..The frequency-domain behavior of a filter is described mathematically in terms of its transfer function or network function

given by : $H(S) = (1/LC)/(S^2+1/LC)$……………...(1)

It is easy to see by inspection that this transfer function is a second order and by equating this equation with that of a standard second order:

$T(S)=Wc^2/ S^2+Wc^2$………………………………………………………………(2)

Hence, Cutoff frequency will be given by :

$Wc=1/ \sqrt{LC},=1/ 2\pi\sqrt{LC}$………………………………………………………….(3)

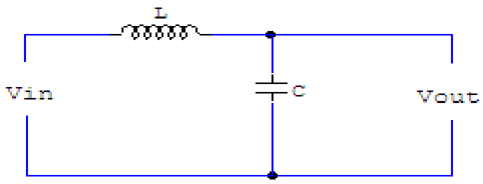

Fig.4 : Low pass filter

The filter shall attenuate all the excess frequencies above the cutoff frequency, and shall provide a pure sine wave.The objective for this filter circuitis to bring the critical frequency as close as possible to the desired frequency of 50 Hz, removing other harmonics. The distortion factor,(i.e. the amount of harmonic distortion that remains in a particular waveform after the harmonic of that waveform have been subjected to second order attenuation) and lower order harmonics are reduced significantly. The component of LC filter need be higher ratings to handle AC volage magnitude of 230V, 50Hz.The final output of the UPS scheme is obtained across the filter terminals. By proper choice of the filter components, output waveform is a pure sine wave of 50Hz.
The microprocessor system can measure output voltage and current, and the output voltage is maintained quickly at the required value using a feedback. The additional protections as overload, overvoltage and overcurrent are provided through microprocessor controls.

IV. CONCLUSION

The PV array delivers an output voltage to charge a battery during a day time. The UPS can be used at any time on ac supply failure.The IGBTs are the extremely suitable components for the switching functions required in the inverter.The microprocessor controlled system is flexible and faster. The load like personal computers, lighting loads can be conveniently supported through these system with necessary protections.

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