SIMULATION AND MODELING OF SINGLE PHASE DC-AC CONVERTER OF SOLAR INVERTER

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Abstract - This paper is depicts information about dc-ac inverter used in solar inverter. We will get DC power from solar panels and this converter inverts DC to AC. This design and modulation is based on MATLAB software. In circuit, for switching purpose IGBT is used. There are many other devices also but IGBT has more advantages than others which are shown by comparison with others. The main thing is that this conversion and switching of IGBT is done using different types of PWM methods. Here we are using SPWM method for conversion of AC power. This method is very efficient than other methods and also it reduces harmonics to very much extent in output. Project objective are, to design an inverter model by using MATLAB and making analysis on the output voltage and to study the function of PWM in single phase inverter. Project scope are,

1. Modeling and simulation using MATLAB.

2. Using PWM method for the switching operation. Project application: This Project is based on solar inverter, this inverter will be used in our college for lab applications.

Key Words: *Single phase DC-AC converter, IGBT, MATLAB, SPWM method, harmonic reduction, etc.*

1. INTRODUCTION

 Presently world is facing too much challenges one of them is to generating the enough electrical power that will fulfil the requirements of mankind. Today generation of electrical power based on the conventional coal, gas and nuclear based. World population is increasing day by day so the requirement of them also increased and hence generation of electrical power is also increased. Basically there are two types of power generation sources: 1. Conventional 2. Nonconventional. Today most of generation of electrical power based on Conventional sources such as coal, gas and nuclear etc. Conventional sources are no more after some of the years and which are not sufficient to fulfill the requirement of the mankind. Nuclear energy is not much preferable because its radiation effect. Therefore some part of energy should be generated based on non-conventional sources. There are also problems of increasing pollution and energy demands and hence the exploitation of solar has received more and more attentions. This project is also focus on modeling and simulation of single phase solar inverter by Pulse Width Modulation. Pulse Width Modulation is a technique that use as a way to decrease total harmonic distortion in inverter circuit. The model is implemented using MATLAB software with the SIMPOWER SYSTEM block set based on computer simulation. Computer simulation plays an important role in the design, analysis, and evaluation of power electronic converter and their controller. MATLAB is an effective tool to analyze a PWM inverter. Advantages of using MATLAB are the following: 1. faster response 2. Availability of various simulation tools 3. Various functional blocks, etc.
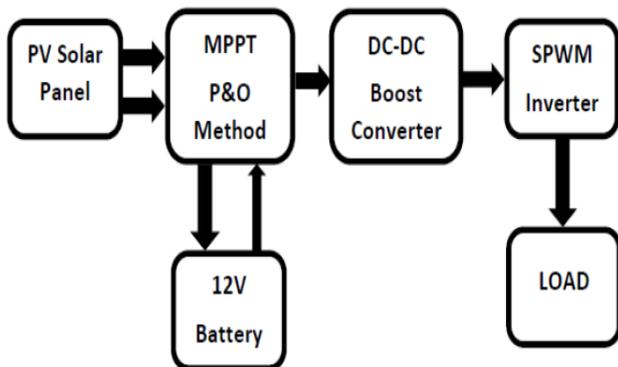
FIGURE 1: GENERAL DIAGRAM OF SOLAR INVERTER SYSTEM

In general diagram it is shows that from energy of sun, solar panel is being heated. Due to heating of solar panel, DC power will be generate. This power will be given to MPPT (maximum power point tracking) which will transfer maximum efficient power to the DC-DC boost converter. Now DC-DC boost converter will boost it to specified DC voltage which will be appropriate to inverter. Inverter will convert this DC voltage into required AC voltage. But this AC voltage will be pulsating and contains some harmonics, to reduce it filter is being placed. After passing from filter, it will be pure AC power and ready for load consumption. Here, generation of electricity is based on photovoltaic effect. Photovoltaic systems are comprised of photovoltaic cells, devices that convert light energy directly into electricity. Photovoltaic offers consumers the ability to generate electricity in clean, quiet and reliable way. Because the source of light is usually the sun, they are often called solar cells. The word photovoltaic comes forms "photo" meaning light and "voltaic" which refers to producing electricity. Therefore, the photovoltaic process is "producing electricity directly from sunlight". Photovoltaic are often refereed as PV. In section III dc-ac bridge inverter, different types of inverters, in section IV filters, in section V PWM techniques and in section VI simulation result are explained.

2. DC-AC BRIDGE INVERTER

There are two types of inverters. 1. VSI (voltage source inverter) 2. CSI (current source inverter). Here we are using VSI. A voltage source inverter (VSI) is one that takes in a fixed voltage from a device, such as a dc power supply, and converts it to a variable-frequency AC supply. Also it easier to convert AC voltage from DC voltage. A solar inverter is a power-electronic circuit that converts dc voltage from a solar array panel to ac voltage that can be used to power ac loads such as home appliances, lighting and power tools. However, getting the most out of such a topology requires careful analysis and the right choice of the high-side and low-side combination of an IGBT. According to our requirement, here we consider single phase 2 Arm Bridge – 4 pulse converter for solar inverter.
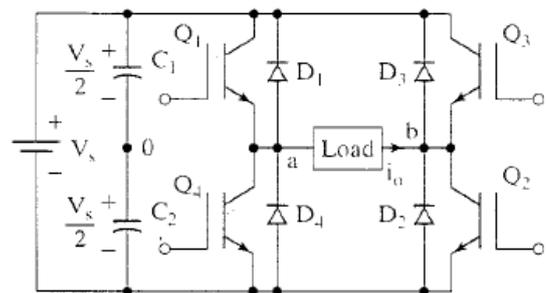

Figure 2: BRIDGE INVERTER

In above figure it is shown that, there are total four converter (IGBT) namely Q1, Q2, Q3, Q4. Q1-Q2 and Q3-Q4 switched on and off alternately. Each pair provide opposite polarity of Vs across the load. Diodes are placed for freewheeling during inductive load.
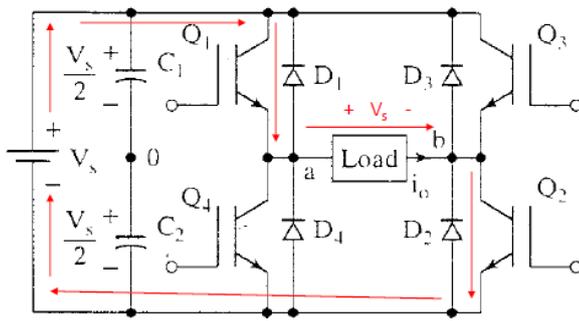
For Vab = Vs

Figure 3: Q1-Q2 on, Q3-Q4 off

At first Q1-Q2 is on and Q3-Q4 is off. During this cycle current passes from load as shown in figure. So that output is Vab = Vs.
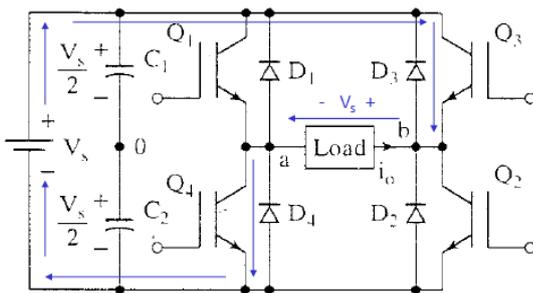
For Vab = -Vs

Figure 4: Q3-Q4 on, Q1-Q2 off

After that Q3-Q4 is on and Q1-Q2 is off. During this cycle direction of current is changed so that negative voltage is produced across load. So that Vab = -Vs.

WHY IGBT IS USED?

IGBT is used due to its easy control and low switching losses. Also it is available in wide range of ratings. Comparison with that different devices is shown below.

Sr. No.	Parameter	SCR	Power BJT	Power MOSFET	IGBT
1	Operating frequency	400 to 500 Hz	10kHz	100kHz	10kHz
2	On state voltage drop	< 2 V	< 2 V	4 – 5 V	3 V
3	Maximum VI ratings	10 kV / 5kA	2 kV / 1kA	600 V / 200A	1.5kV / 400A
4	Type of device	Minority carrier	Minority carrier	Majority carrier	Minority carrier
5	Voltage/current controlled	Current	Current	Voltage	Voltage
6	Commutation circuit	Necessary	Not necessary	Not necessary	Not necessary

3. FILTERS

The line filter reduces the high frequency harmonic content of the line current caused by the switched operation of the VSI. While selection of filter cost, size and for which application it used are considered. There are different types of filters. 1. L filter 2. LC filter 3. LCL filter. Generally L-C filter is used which is explained below.
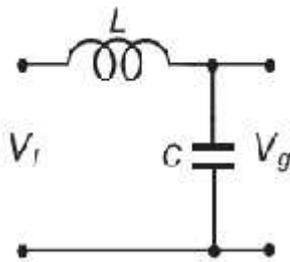
Figure 5: L-C filter

LC filter can be used for minimization of harmonics at output side of the inverter.

Calculation of L and C:

The inductive part of the low pass filter is designed based on the allowable current ripple at switching frequency on the grid side.

$$L = V_{DC} / 4 * f_s * \Delta i$$

Where VDC is the DC voltage, Δi value of the current ripple. fs is switching frequency

For, calculation of capacitor,

$$C = \Delta i / 8 * f_s * \Delta v_0,$$

Where, Δv0 = voltage ripple

4. DIFFERENT TYPES OF PWM TECHNIQUES

The most efficient method of controlling output voltage is to incorporate PWM control within inverters. In this method, a fixed d.c. voltage is supplied to inverter and a controlled a.c. output voltage is obtained by adjusting on-off period of inverter devices. Pulse Width Modulation variable speed drives are increasingly applied in many new industrial applications that require superior performance. Recently, developments in power electronics and semiconductor technology have lead improvements in power electronic systems.

There are many different types of PWM techniques, which is shown in below diagram. In this chapter we will see the different types of PWM techniques are available for controlling the output ac voltage for the inverter. In many industrial applications, to control of the output voltage of inverters is often necessary with varying the DC input voltage. With the help of the PWM techniques we can control the output voltage of the inverter and vary the gain of inverter.

There are number of PWM techniques are available to control the inverter output voltage which are as follows:
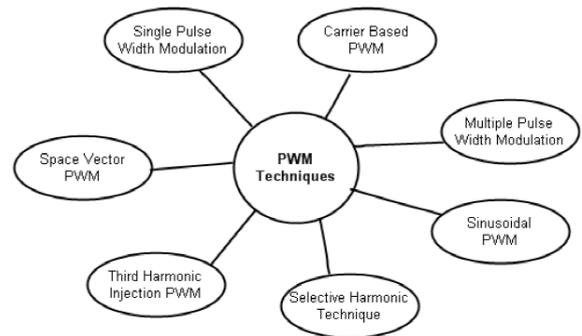

Figure 6: different types of PWM techniques

PWM techniques are characterized by constant amplitude pulses. The width of these pulses is however modulated to obtain output voltage control and to reduce its harmonic content. Here three different PWM techniques which are generally used are explained below. Those are Single-pulse modulation, multiple pulse modulation and Sinusoidal pulse width modulation (Carrier based Pulse Width Modulation Technique). Here only carrier based PWM technique is explained which is used in this project.

1. Carrier based PWM inverter

In this method a triangle carrier wave is compared with the reference sinusoidal voltage with the desired output frequency. An intersection point determines a switching moment at one inverter leg. If the reference signal is greater than the carrier signal, the upper switch becomes on and the bottom switch becomes off, otherwise vice

versa. In other words, the switching signal starts if the reference signal is greater than the carrier signal, and the switching signal ends if the carrier signal is greater than the reference signal. Note that the effective value of the switching signals looks sinusoidal, and each pulse width is related to the reference wave amplitude as seen in figure.
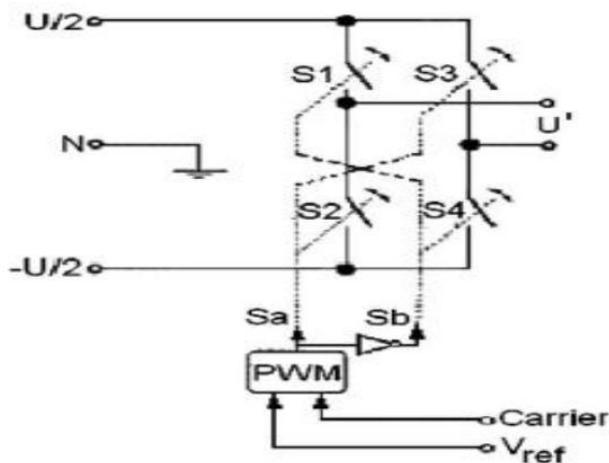

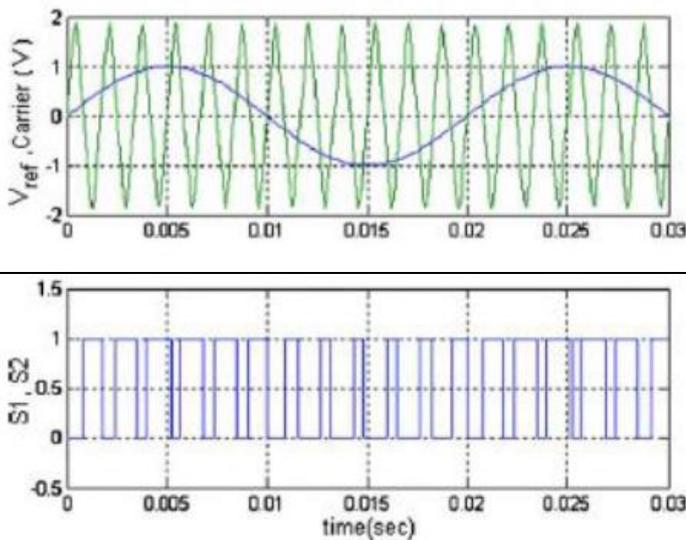Figure 7: switching of IGBT using PWM technique

Figure 8: Generating PWM waveform

The reference wave amplitude is changed to adjust the output voltage of the inverter. The output voltage harmonic component is in the following form

$MPxc \pm Nxs$

where xc is the carrier wave frequency, xs is the reference (modulation) frequency, M and N are integers, M + N is an odd number and P is a constant that is proportional with the carrier/reference frequency.

$mf = fs / fl$

And an amplitude modulation index:

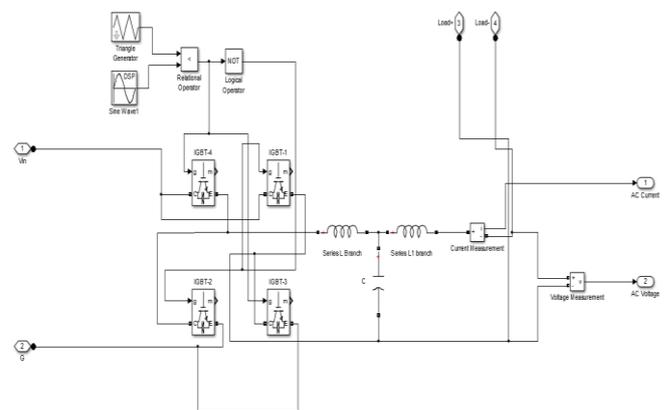$ma = vcontrol / vdiscrete$

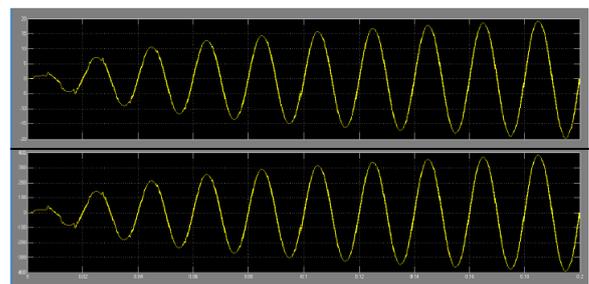## 5. SIMULATION RESULT

Figure 9: Simulation circuit

Figure 10: Current and voltage waveform

6. CONCLUSION

From above discussion it is concluded that, nonconventional energy source is free and available in wide range and time. So that we should use it in our daily purpose. By inspiring this we are making solar inverter for

our college lab load for example tube lights, fans, etc. by this we can save energy to some extent.

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