"I hereby verify that I have read this report and I find it sufficient in terms of quality and scope to be awarded with the Bachelor's Degree in Electrical Engineering (Industrial Power)."

Signature	:	.....
Supervisor's Name	:	PUAN JURIFA MAT LAZI
Date	:	4/05/06

DESIGN INVERTER FOR PHOTOVOLTAIC SYSTEM

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"It is hereby declared that all materials in this thesis are the effort of my own work and materials which are not the effort of my own work have been clearly acknowledged."

Signature : .....

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Date : 4/05/06

For my beloved parents, Noraini Binti Md Junoh & Mohamad Yasim Abd Fatah,
and dearest siblings Sharifah, Mohd Fadhil, Siti Zubaidah, Abdul Hakim,
Mohamad Hafiz, Siti Nur Hafizah and Khairul Fahmi.

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In the name of Allah, the Most Compassionate, Most Merciful. I am most thankful to Him, for it is with His permission that I could complete this project. Praise be upon the prophet Muhammad S.A.W, his family, friends and followers.

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ABSTRACT

Project on sun tracking system still in research in some develop country. And the inverter is most important thing in the generation or using the solar system. Without this component the development of this solar system is un used. Because this component will convert the direct current (DC) energy to the alternative current (AC) for the daily utilization. So this project is about to design an inverter are functioning to convert the solar energy for the utilization. In this paper it discuss about the capacitance and inductance criteria as filter to decrease the value of harmonic. This report are including the comparisons about the voltage, current and the effect of the harmonic at the output before and after using the filter are functioning to reduce the harmonic at the output. And the value for the filter was calculate to make sure that value will give the effect are need. This report are including with the effect of the harmonic, effect to current and voltage after using the LC filter. This filter makes the MOSFET functioning in normal and smooth faster then before use the filter, and the harmonic can be reduce. Harmonic control will produce the smooth output and no noisy.

ABSTRAK

Projek berkenaan tenaga solar giat dijalankan di negara-negara maju. Malahan penggunaan alat ubah inverter adalah amat penting dalam penggunaan sistem solar, tanpa alat ubah ini kewujudan sistem solar tak dapat dimanfaatkan kerana alat ubah ini lah yg akan mengubah tenaga arus terus (AT) kepada bentuk tenaga ulang alik (AU), untuk penggunaan harian, projek ini adalah berkenaan dengan mereka bentuk sebuah inverter yang boleh berfungsi untuk menerima sumber voltan dari cahaya matahari untuk kendalian pelbagai guna kepada manusia. Dalam kajian ini prinsip kendalian inverter juga turut dibincangkan bersama dengan ciri ciri peraruh dan pemuat yg digunakan sebagai penapis untuk memenuhi ciri – ciri rekaan. Laporan projek ini juga turut dimuatkan dengan perbandingan untuk voltan, arus dan kesan harmoni yang wujud antara keluaran sebelum penggunaan penapis dan selepas penggunaan alat penapis yg berfungsi untuk mengurangkan harmoni pada keluaran. Malahan penentuan nilai alat penapis tersebut turut dibuat kiraan untuk memastikan kesesuaiannya. Laporan ini juga melihat kesan harmoni yang wujud, kesan terhadap arus dalam litar apabila menggunakan penapis. Yang jelas penggunaan alat penapis menyebabkan picuan pada MOSFETs akan tetap dan normal dalam masa yang lebih pantas dan gelombang harmoni yang wujud dapat dikurangkan. Kawalan terhadap harmoni akan menghasilkan keluaran yang lancar dan tiada gangguan hingar.

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PWM	–	Pulse Width Modulator
DSPs	–	Digital Signal Processor
AC	–	Alternative Current
DC	–	Direct Current
THD	–	Total Harmonic Distortion
NPC	–	Neutral Point Clamped

CHAPTER 1

PROJECT OVERVIEW

1.1 Introduction

Several government especially for the country have got the high radiance rate of sun shine and an utilities worldwide promote the renewable energy such as Photovoltaic (PV), fuel cell, micro turbine and other conversion technologies for distributes power generator. In some country like Thailand, the PV station is built on many place rural area residential, communal building, the power quality problems are expected to increase with an increasing an utilization of distribution power connected to the home.

The most important thing is the student should come with solution of the problem at the end of the project. I have been focus to the case study with a title "Design Inverter For Photovoltaic System" using PSPICE. The case here is to design an inverter, it can be one incentive to the people in the rural area are not supply with the electricity from the main system electrical or from the sub system or from the grid system, which is mainly fed from hydropower stations and other miniature source of power generation like biomass power station, gas power station, nuclear station, and other.

These papers propose a PWM inverter to reduce the required filter size, and also investigate the relation between the inverter and the solar cell characteristics.

1.2 Objective

The objective of these project is to design an inverter for photovoltaic system using PSPICE software and it must have some added characteristics, it is, the inverter must have low noisy and it will produce low distortion, it must have the high efficiency, the most important thing is, these design circuit must got the variable alterative current output voltage from the fixed voltage 12 volt direct current.

1.3 Work Scope

The work scope of this project is making a simulation to the PWM circuit design including with the required filter to achieve an objective of this project.

1.4 Problem Statement

Until today the photovoltaic system as usually know as solar system is not popularize in Asian mostly in Malaysia, because the sun resource is not high as the west country, like USA, Africa and other countries. The climate in this country is not suitable for solar system. So one of the problems I can see here is how to market this product in this country.

In process to finishing this research the biggest problem I can detect is, how to make the source functioning in both cycle, in positive cycle and negative cycle, because when the grounding is connected to the circuit, it will make the negative cycle source is not functioning.

The failures to activate the switching device make the output is not producing in AC form, and make the next process be difficult. So the process to produce the pure sinusoidal waveform was stunted.

1.5 Project Contribution

This project is expected to contribute to the work of design an inverter in improving and to extend in utilizing of the solar in the life especially to the all people, because in this case if have the people using solar in their home, it will reduce one the their cost life, in this case, the cost to paid to an electricity bill will reduce or can be minimize, because the daily electricity more came from the solar panel at their home, so at the day light, the electricity from the supplier like TNB in Malaysia, will not be using. This project will contribute one of the facility for the people at the rural area and for the errant because using the inverter they can get electricity for their life from the source like battery and solar cell if an errant using a caravan in their journey. By utilizing a relatively low cost system, the people life will be easily at anywhere.

CHAPTER 2

LITERATURE REVIEWS

These chapters are all about theories of the project. Most of these are from references source.

2.1 Photovoltaic

Malaysia is a place in the center of meridian grand width so it got the balance weather, with an equator situation all over the year. Malaysian hot weather in a day is so short, and the sun shining in this country is not in the good condition to make it have the photovoltaic system as one of the power generation electrical source.

Photovoltaic system is known as solar system, to generate the solar energy we need solar panel or PV array, inverter and other as shown in the figure 2.0 below

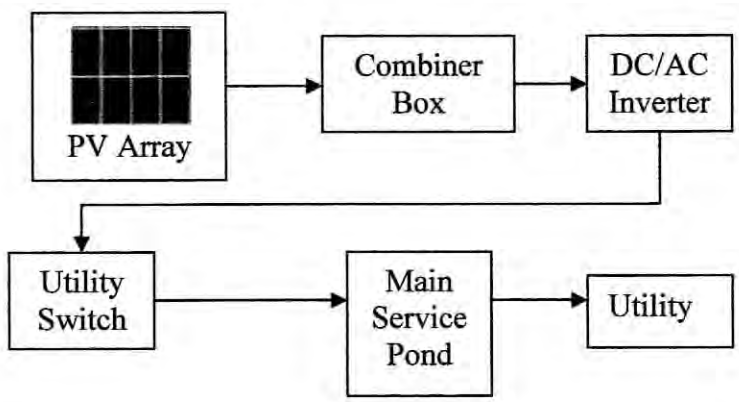

Figure 2.0: Simple PV system diagram

From the figure above, we can see the PV array, it made up of PV modules, which are environmentally sealed collections of PV cells, the devices that convert sunlight to electricity. The most common PV module that is 5 to 25 square feet in size and weight about 3.4 lbs/square feet. Often set of four or more smaller modules are framed or attached together by struts in what is called a panel. This panel is typically around 20 until 35 square feet in area for ease of handling on a roof. This allows some assembly and writing functions to be done on the ground if call for the installation instructions.

Than the figure show the combiner box, it is include with the mounting system and wiring systems used to integrate the solar modules into the structure and electrical system of building, the wiring system include disconnects for the and dc and ac sides of the inverter, ground fault protection, and over current protection for the solar modules.

Then the system will bring to dc – ac inverter, this device that takes the dc power from the PV array and converts it into standard ac power used by instrument. For the safety, this system are ready by the utility switch, it will cut of the circuit from the main service panel when have some problem happened like, short circuit at the main system, leakages current or other where it will be dangerous to the building and people. The main service panel is a panel when the supply come, at the panel the supply will divide to the other portion before it already used for the equipments.

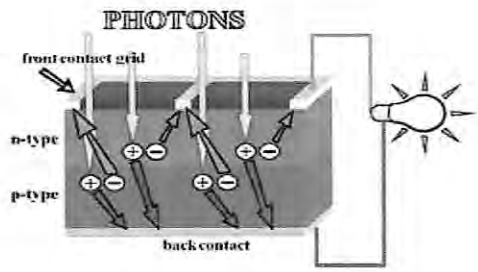

Figure 2.1: Energies conversion process in Photovoltaic

From the figure 2.1 at the top, it showed the process to produce the energy from the sun lightning. When a photon of light hits a piece of silicon, one of two things can happen. First, the photon can pass straight through the silicon. This

happens when the energy of the photon is lower than the band gap energy of the silicon semiconductor. The second thing that can happen is that the photon is absorbed by the silicon. This situation happens when the photon energy is greater than the band gap energy of the silicon.

When photon is absorbed, its energy is given to an electron in the crystal lattice. Usually this electron is in the valence band and is tightly bound in covalent bonds between neighboring atoms sand hence unable to move far. The energy given to it by the photon "excites" it into conduction band.

The covalent bond that the electron was previously a part of now has one less electron and known as a hole. The presence of missing covalent bond allows the bonded electrons of neighboring atoms to move into the "hole" and leaving another hole behind. Thus, it can be said that photons absorbed in the semiconductor create mobile electron hole pairs.

The solar frequency approximates a black body spectrum at 6000K and much of the solar radiation reaching the earth is composed of photons with energies greater than the band gap silicon. These higher energy photons will be absorbed by the solar cell but different in energy between these photons and the silicon band gap is converted into heat.

2.2 Inverter

Inverter is a component to convert the voltage source in dc volt to ac volt. Using this component we can change the input to the desired output voltage of magnitude and frequency, and have two type changing for the inverter, it is a variable output voltage can be obtained by varying the input voltage but maintain the gain, and the one method with varying the gain of the inverter but fix the input voltage, both method will produce the variable output voltage.

That have many type of inverter, but the most simple, it be divide to some type, it is single phase inverter and three phase inverter.

2.2.1 Single phase inverter

Single phase inverter was design for low voltage and low frequency, it have two types of single phase inverter, it is half bridge inverter. Single phase half bridge inverter has two identical dc voltage source connected in series, two static switches, and two diodes. The diodes are needed to protect the switches especially when this switch has to carry currents in the reverse directions. Since most single phase loads are inductive in nature, in case there is only one available dc source, we can split it voltage equally into two by using the circuit shown in figure 2.2 b. once the large electrolytic capacitors are fully charged, they behave as the voltage sources. The two equal resistors in parallel with the capacitors not only ensure that the voltages on the two capacitor are the same but also provide the paths for the capacitors to discharge once the half bridge inverter is switched off.

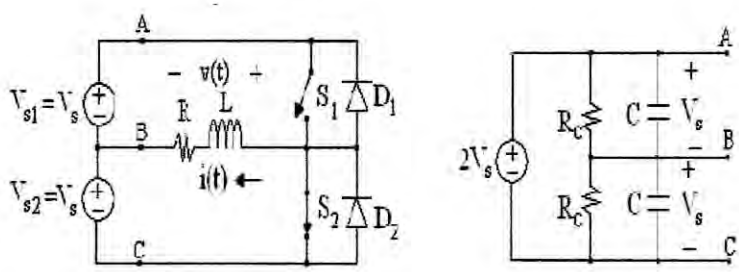

Figure 2.2: (a) Half bridge inverter with dual supply, (b) single supply

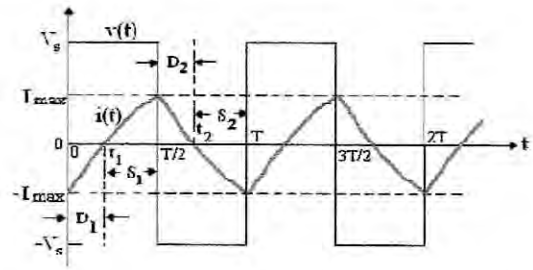

Figure 2.3: The voltage across and the current through the load

Let us assume that the circuit has been operating for some time and it has attained its steady state. In order to obtain an output voltage with zero dc components, each switching action must last for one half of the time period.

We begin our analysis when the switch S1 is about to close and S2 is about to open at t = 0. At this instant, the current is negative and its minimum. Since each switch can conduct current only in the direction shown by the arrow when it is closed, diode D1 provides the path for the current to flow. Prior to the closing of the switch S1, the current was flowing in the lower part of the circuit in the clockwise direction through the RL load, the switch S2, and the source V_{s2}. As soon as the switch S_1 is closed and S_2 is opened at t = 0, the current begins to flow in the counterclockwise direction in the upper half of the circuit through the diode D_1 toward the positive terminal of the source V_{S1}, its reversal is expected. After some time, $t = t_1$, the current became zero and reverses it direction. As soon as the current reversal takes place, the switch S_1 begins to conduct and the diode D_1ceases to conduct as it is reverse biased. The current continues to build up until t = T/2 when its attains its maximum value. Owing to the symmetry of the current waveform as shown in figure 2.3, the minimum and the maximum values of the current are equal in magnitude as the average current through the load is zero.

For the full bridge inverter is one of the categories in the single phase inverter, the differential between full bridge and half bridge is it has four choppers, and two transistors will turn on simultaneously but it will alternate with other two transistors. But the output for both type inverters is same.

2.2.2 Three phase inverter

Three phase inverters are used to transform the DC power into three phase AC power. Today inverters use high power switching transistor call IGBT or MOSFETS. A single phase inverter consists of two switches, one from the positive DC rail tied to a common node and one from the negative DC rail tied to the common node. The AC power is extracted from the common node with respect to a center tapped ground between two capacitors. A good example of an inverter though not a very efficient one, is an audio amplifier. The only modification to the amplifier is that the input to the amplifier need be a constant AC signal representing the desired output frequency.

A three phase inverter is a combination of three single phase inverter along with synchronization so that the three phase voltage is separated by 120 degrees. Below is a schematic of the simplest three phase inverter topology.

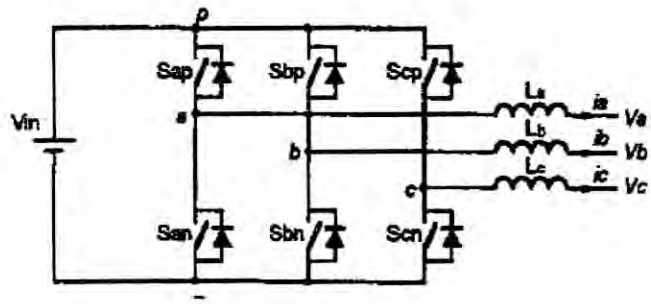

Figure 2.4: Conventional three phase voltage source.

2.3 PWM Inverter.

Pulse width inverter (PWM) is a powerful technique for controlling analog circuits with a processor's digital outputs. PWM is employed in a wide variety of applications, ranging from measurement and communications to power control and conversion. For the detail of application for the PWM inverter like in analog circuits, an analog signal has a continuously varying value, with infinite resolution in both time and magnitude, as example, a nine volt battery in an analog device, it's output voltage is not precisely 9 volt, the changes over time, and can take any real number value. Similarly the amount of current drown from the sell is not limited to a finite set of possible values. Analog voltages and currents can be used to control things directly, like the volume controller because it connected to the variable resistor. The current will increase or decreases follow the low or high value of the resistor, it will drive the current to the speaker volume.

Otherwise PWM including using in the digital control, by controlling analog circuits digitally, it make the power consumption and system cost can be drastically reduce, because many microcontroller and digital signal processor (DSPs) already include on the chip PWM controllers, it make the implementation easy. PWM is a way of digitally encoding analog signal levels when it completed with a nutshell.

Through the use of high resolution counters, the duty cycle of square wave is modulating to encode a specific analog signal level. Its throw signal still in digital because, at any given instant of time, the full DC supply is either fully or not. The voltage or current source is supply to the analog load by mean of repeating series to on and off pulses.

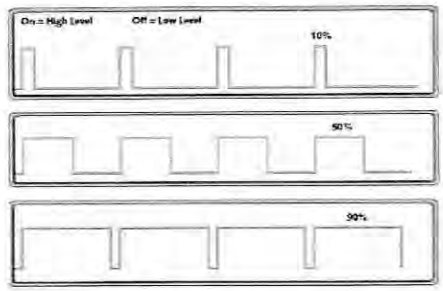

Figure 2.5: Pulse signal

The on time is the time when the dc supply is applied to the load, and the off time is the time when supply in switch off. That table showed the three different PWM signals. The upper figure shows a PWM output at 10 % duty cycle. It's mean that signal on for 10% of the period and off for the other 90% period of time. For the middle figure, it shows the output at 50% and the last figure show the on period of the signal is 90%. The entire full signal is operate from the full strength.

PWM inverter is accomplished because the dc input voltage is fixed and it is not controllable, and the output can be obtained by varying the gain of the inverter. This circuit will absorb the acoustic noise better than normal inverter. We know this type of inverter will modulate the pulse width of wave form. The PWM inverter can be classification to some type like:

1. Single PWM,

2. Multiple PWM,

3. Sinusoidal PWM,