SOLAR ELECTRICAL POWER GENERATION STABILAZITON SYSTEM (SELECT_PGSS)

By

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FINAL PROJECT REPORT

Submitted to the Electrical & Electronics Engineering Programme
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for the Degree
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CERTIFICATION OF APPROVAL

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Muhammad Imran Iskandar bin Ibrahim

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Approved:

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Project Supervisor

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

May 2011

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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(MUHAMMAD IMRAN ISKANDAR BIN IBRAHIM)

ABSTRACT

The demand for electricity is increasing annually, where it is projected that in the year 2030, the total demand in Malaysia will be 100Mtoe. Under the earlier Malaysian Plans, the four fuel diversification policy that was introduced focused on oil, gas, coal and hydro. But in the 8th Malaysian plan, the scope was broadened to include renewable energy resources as the new five fuel strategy, which was implemented, starting from 1999. The main challenge facing the renewable power sector is sustainability that is needed to ensure the security and reliability of electricity generation, generally and the need to stabilize renewable based electricity. The conventional electricity generating systems face problems such as high volatility in fuel prices and also possibility of fossil fuel depletion, sooner than projected. The focus of this project is on Solar Electricity Generating Systems (SEGS). Although SEGS are already being implemented, but issues due to the intermittent nature of solar insolation, which is highly dependent on meteorological conditions and on the apparent trajectory of the sun, the electricity generated is not stable. Usually, a simple charge controller is used to control the charging of the batteries. A comprehensive power conditioning system is required to improve the quality of power supplied directly to load, and the batteries as well. A voltage stabilizer plays an important role, and in this study, it is achieved by combining the boost, buck, and buck-boost converters topologies in a single circuit. The prototype stabilizer that was built can produce output as high as 20V and the desired value of the output can be set by the user digitally. The operating range of voltage of the stabilizer is between 3V and 19V. It is controlled by PIC16F877. The ripple of the stabilizer is around 22%.

ACKNOWLEDGEMENTS

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

1.1 Background of Study

This project is related to the energy conversion area, particularly alternative power source for electricity generation. The demand for energy especially electricity is keep rising. Electricity's share of final energy demand is expected to increase from 18% in 2009 to 21% in 2020[1]. The current energy resources used for this conversion are from non-renewable energy resources. However, the high cost of these resources and the possibility of depletion have raised concerns and perhaps giving the opportunity for the development of renewable energy based resources.

Malaysia is located at the equatorial which is specifically between longitudes of 100^0 and 120^0 of the Greenwich Meridian and between 2^0 and 7^0 degrees to the north. The northeast monsoon starts from November until March. Heavy rain in east cost of Peninsular Malaysia, Sabah and Sarawak is expected during this period. While the southwest monsoon starts from April and ends on October. The temperature in Malaysia is range between 29^0C and 33^0C[2].

According to Organisation for Economic Cooperation and Development, renewable energy especially solar power can play a very large role in Malaysia's future energy generation[3].The daily average of sunlight in Malaysia is about 12 hours in the whole year. The average of monthly daily sunlight irradiation is from 4 to 5 KWhm^{-2} and average daily sunshine is about 4 to 8 hours per day.

In the Tenth Malaysian Plan, the Malaysian Government targets to supply for about 6000 additional houses in Peninsular Malaysia, 59000 houses in Sabah and 76000 houses in Sarawak. This means that the government targets the electricity coverage of 100% in Peninsular Malaysia and 99% in Sabah and Sarawak[4]. The amount of electricity expected to be generated by using renewable energy is 985 MW[5]. To reach these targets, RM4.9 billion will be invested.

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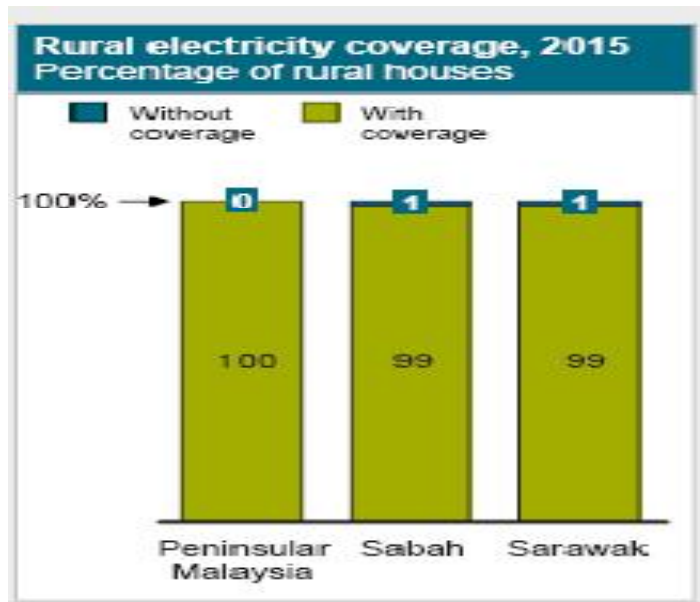
Figure 1 Graph of Rural Electricity Coverage expected by 2015 [4]

1.2 Problem Statement

The input of the solar cell is always unstable due to the transient nature of solar energy. Transient nature is caused by dust, haze and the movement of the sun during the day. Even in a sunny day in Malaysia, the cloud coverage is about 40% of the sky. The cloud coverage could lower the amount of sunshine that arrives to the earth. When the input fluctuates, the output also fluctuates between high and low according solar intensity at a particular time. The fluctuation of the input may cause the damage to the sensitive equipments.

The problem also involves the battery charging process during the day. The output voltage of the solar generator should be greater than the potential difference of the battery in order for the battery to be charged. If the output voltage is lower, the battery will discharge instead of being charged. Then, the low received power is wasted without being used. By referring to those problems, the method for building the stabilizer in the controller will be investigated in order stabilize the input of the solar generator and also to fully utilize the power that is received.

2

1.3 Project Objectives

The objectives of this project are:

- To study the transient nature of the solar insolation
- To design solar electricity generation system
- To build power stabilizing system

CHAPTER 2
LITERATURE REVIEW

2.1   Solar Geometry

The Earth rotation is the spinning of the Earth on its axis. This makes the Earth's surface moves at the equator at a speed of about 467 m per second or slightly over 1675 km per hour. It takes exactly twenty-four hours to complete a rotation and is called a mean solar day. The daily cycles of day and night is caused by the Earth's rotation. The circle of illumination is the edge that divides the daylight from night[6].

The Earth moves around the Sun on an orbit that is called an Earth revolution. This celestial motion completes its one cycle in 365.26 days. The Earth's orbit around the Sun is elliptical in shape. The Earth's distance from the Sun varies over a year because of this shape. As the result, the amount of solar radiation received by the Earth to annually varies by about 6%. The Earth is closest to the Sun (147.3 million km), perihelion, on January 3. The distance between Earth and the Sun becomes the furthest on July 4, or aphelion (152.1 million km). The average distance between the Earth and the Sun for one-year period is about 149.6 million km[6].

The height of the Sun or solar altitude to vary due to the annual change in the relative position of the Earth's axis in relationship to the Sun. Normally, it is measured from either the southern or northern point along the horizon and begins at zero degrees. When the Sun is directly overhead, maximum solar altitude occurs and has a value of 90°. The total variation in maximum solar altitude for any location on the Earth over a one-year period is 47° (Earth's tilt 23.5° x 2 = 47°). The annual changes in the relative position of the Earth to the Sun cause this variation to happen. At the equator, maximum solar height goes from 66.5 degrees above the northern end of the horizon during the June solstice, to directly overhead on the September equinox, and then down to 66.5 degrees above the southern end of the horizon during the December solstice[6].

The subsolar point is the location on the Earth where the Sun is directly overhead at solar noon. This point occurs on the equator during the two equinoxes. The equator is lined up with the ecliptic plane and the poles are in line with the circle of illumination on these dates. The subsolar point moves to the Tropic of Cancer (23.5° N) during the summer solstice because at this time the North Pole is inclined 23.5° toward the Sun. The subsolar point is located at the Tropic of Capricorn (23.5° S) during the December solstice when the South Pole is angled 23.5° toward the Sun[6].

2.2   Photovoltaic Energy

The word photovoltaic is derived from two words, photo means light and voltaic means electricity energy. Therefore, photovoltaic energy is the term used to describe the generation of electricity from the light [7]. To generate electricity from lights, a semiconductor device that generates electricity when light falls on it is used[8]. It is known as PV cells. The most common semiconductor material used is Silicon.

The process of electricity generation starts with sunlight strikes a PV cell. When this happens an amount photons from the absorbed sunlight will loosen up the electrons from the atoms of the cell and frees them. These electrons will then move through the cell, creating and filling in holes in the cell. Because of the movement of electrons and holes, electricity is generated. The process of the conversion is also known as photovoltaic effect [8].

There is no need for a bright sunlight to make photovoltaic system operate. The electricity will also be generated even on cloudy days. In this condition the energy output will be proportionate to the density of the clouds. Days with only a few clouds can even result in higher energy yields than days with a completely blue sky due to reflection effect[7].

2.3   Types of PV

There are a lot of PV types that are currently being used. Each type has different efficiency depending on the materials used to construct it. They can fall into

two major types of cell materials which are Crystalline materials and Thin film materials.

2.3.1 Monocrystalline PV

Single crystal silicon wafer is very thin. The thicknesses of the wafers are about 200-400 micrometers thick. It is produced by using Czochralski (CZ) method. It has a uniform molecular structure. This results in higher energy conversion efficiency. The efficiency if ranged from 15% to 20%[8].

Figure 2 Single Crystal Silicon PV

2.3.2 Polycrystalline Silicon

It is produced by slicing thin wafers from blocks of cast polycrystalline silicon. It is stronger and can be sized as small as 1/3 of the single crystal silicon thickness. The efficiency of polycrystalline silicon is low due to the grain boundaries hinder the flow of electrons. The efficiency is about 10% to 14%[8].
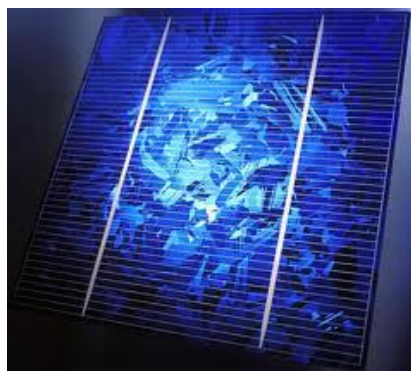
Figure 3 Polycrystalline Silicon PV

2.3.3 Thin Film Materials

A thin semiconductor layer of PV materials is deposited on low-cost supporting layer in a thin film material. The deposited layer is extremely thin due to higher absorbing ability of the thin film materials. Its thickness is between less than one micrometer and a few micrometers. It is a poor energy conversion cell due to non-single crystal structure. It can be divided into amorphous silicon, cadmium telluride and copper indium diselenide. It is a non-crystalline for of silicon which means its silicon atoms are disordered in structure. It has a 40 times higher light absorption ability compared to crystalline silicon. It can be deposited on a various low-cost subtract. This makes the material cost and manufacturing cost become lower. The main problems of amorphous silicon are low in efficiency (ranges between 5% and 9%) and degradation of efficiency within a few months of exposure to sunlight (10% to 15% lost) [8].
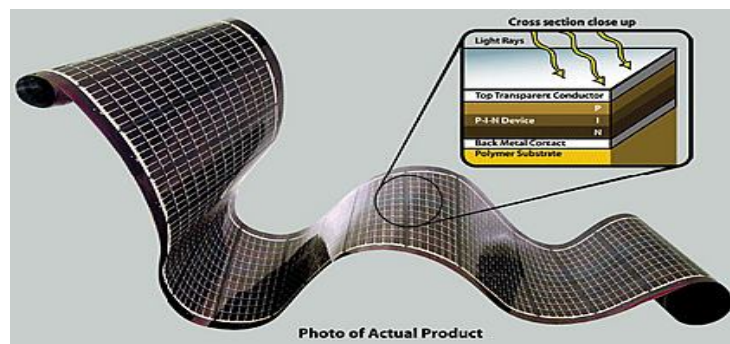
Figure 4 Amorphous Silicon PV

Cadmium Telluride PV is made of cadmium and tellurium. Its absorbtivity level is high where a micrometer thick of it can absorb 90% of the solar spectrum. Its conversion efficiency is about 7%. Its major drawback is the instability of cell and module performance[8].

Figure 5 Cadmium Telluride PV

Copper Indium Diselinide PV has conversion efficiency can be up to 17.7%. It has no outdoor degradation problems. It is one of the most absorbent materials where with the thickness of 0.5 micrometers, it can absorb 90% of solar spectrum. It is not yet commercialized due to complexity in building it[8].

Figure 6 Copper Indium Diselinide PV

2.4 Solar Power Management System
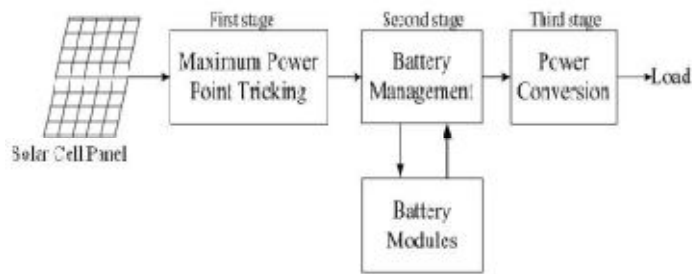
Figure 7 Solar Power Management System Block Diagram

There are three stages of solar power management system which are maximum power point tracking, battery management and power conversion.

2.4.1 Battery Management

The battery management system monitors and controls the storage and delivery of the energy drawn from the solar panels. The input power of the battery management system comes from the output of the MPPT system. The output of the battery management system supplies the required power to the power conversion system. The battery management stage is controlled by charge controller[9].

There are two battery modules which are charging and discharging in the battery management system. For each module, there are four sub modules. The modules are controlled by using relays. During the charging module, the battery is charged at a constant current until the battery voltage reaches the maximum voltage limit. The circuit then switches to voltage regulation, allowing the current to taper to lower values. Accurate voltage regulation is necessary to put the maximum safe charge into the battery[9].
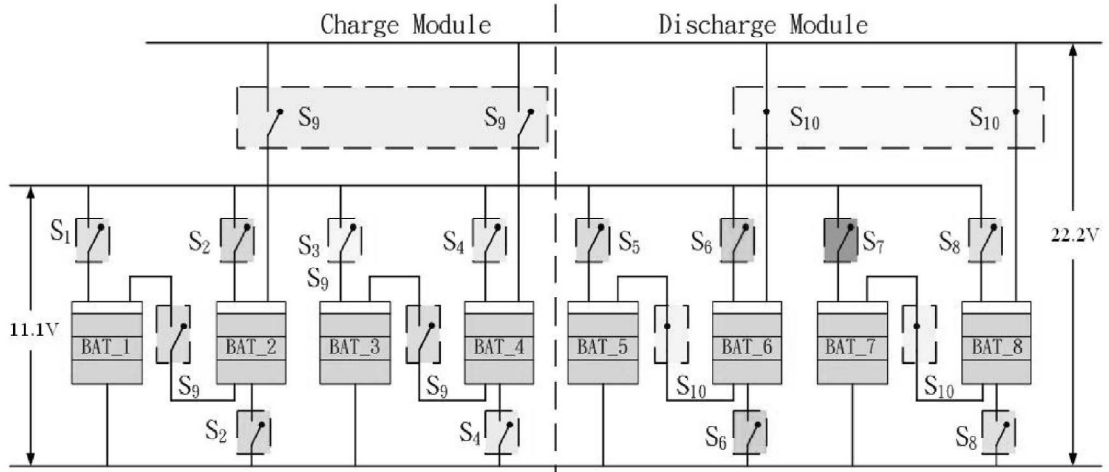
Figure 8 Battery Management Diagram

In constant current mode, the voltage V_1 is kept at a constant voltage by controlling the pulsewidth of the PWM regulator in the auto-ranging power converter. The pulsewidth of the PWM regulator is adjusted in order to maintain V_2 at a constant level while in constant voltage mode. In order to charge submodule 1, the relay S_1 is closed while relays S_2 and S_9 open. To charge the battery submodule2, the relay S_2 is closed while the relays S_1 and S_9 are opened. In discharging mode, the relay S_9 is closed and the relays S_1 and S_2 are opened[9].

2.4.2 Power Conversion

The power conversion converts the voltage level from a higher voltage value to a lower required voltage. It is done by using buck converters. The output of the conversion stage is supplied to the load and to the battery management.

(a)   (b)
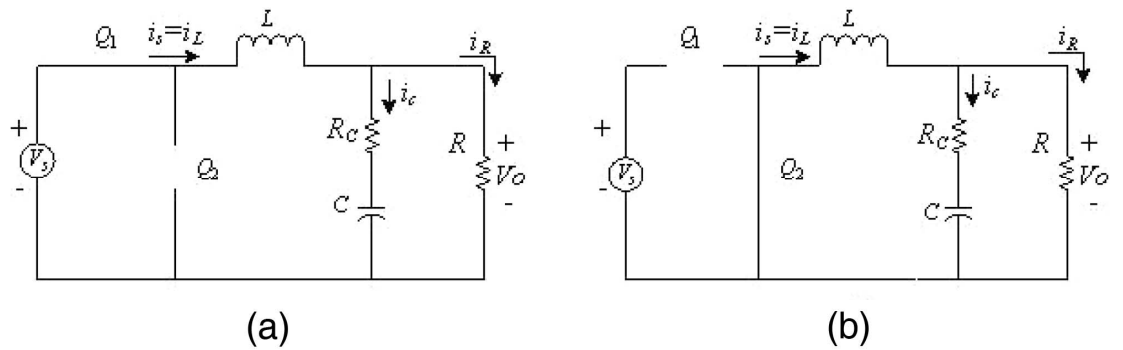
Figure 9 Charging Cycle (a) and Discharging Cycle (b)

The buck converter operation is shown in the figure above. In the charging cycle, the MOSFET Q_1 is conducted and Q_2 is turned off. In inductor discharging state, the operation is reversed [9].

2.5 Charge Controller

The main functions of a charge controller are to maintain the battery at the highest level state of charge that is possible and to protect the battery from being overcharged or overdischarged. Its other function is to provide load control functions which it will automatically connects or disconnects the electrical load at a specified time[10].

2.5.1 Overcharge Protection

A charge controller prevents overcharge of a battery for all system sizing/designs and seasonal changes in the load profile, operating temperatures and solar insolation. To prevent excessive battery overcharge, charge controllers interrupt or limit the current flow from the array to the battery when the battery becomes fully charged. The charge regulation is done by limiting the battery voltage to a maximum value. It can also be done by integrating the ampere-hours into and out of the battery. The current is limited while maintaining the regulation voltage[10].

Charge controller supplies power to the battery where it will fully recharges the battery without overcharging. If charge controller is not used, the current from the array will flow into a battery proportional to the irradiance, whether the battery needs charging or not. Unregulated charging when it is fully charged will cause the battery voltage to reach exceedingly high levels, causing severe gassing, electrolyte loss, internal heating and accelerated grid corrosion. Premature failure of the battery and loss of load may occur if a battery is not protected from overcharge in PV system[10].

2.5.2 Overdischarge Protection

The energy produced by the PV array may not be sufficient enough to keep the battery fully recharged in two conditions. They are periods of below average insolation and during periods of excessive electrical load usage. A battery that is

deeply discharged causes the reaction in the battery occurs close to the grids. This will weaken the bond between the active materials and the grids. Loss of capacity and life will occur if a battery is excessively discharged repeatedly. To prevent batteries from being overdischarged, an optional feature is included in the charge controllers to disconnect the system loads once the battery reaches a low voltage or low state of charge condition[10].

Overdischarge protection is done by open-circuiting the connection between the battery and electrical load when the battery reaches a pre-set or adjustable *low voltage load disconnect (LVD) set point*. When the battery has been charged to a certain level, the loads are reconnected to the battery[10].

2.5.3   Voltage Regulation Set Point

The *voltage regulation (VR) set point* is the maximum voltage that the charge controller would allow the battery to reach. This will prevent the overcharge of the battery. The controller can sense the condition whether the battery reaches the voltage regulation set point or not. When it reaches the set point, the battery charging will be discontinued by the controller or the amount of current delivered to the battery begin to be regulated. Dual regulation set points may be used in some charge controllers. For instance, in the first charge cycle of the day ,a higher regulation voltage may be used to provide a little battery overcharge, gassing and equalization, while on subsequent cycles through the remainder of the day, a lower regulation voltage is used to effectively 'float charge' the battery[10].

2.6   Current Voltage Regulator Used in Solar

The output of solar keeps changing from time to time. Therefore, to keep the voltage equals all the time, DC to DC converters should be used. There are three types of converters that can be used which are boost converter, buck converter and buck boost converter. Boost converter is used when the voltage is lower than the reference voltage. Buck converter is used when the voltage is greater than the reference voltage. Buck boost converter is used when the voltage is equal to reference voltage.

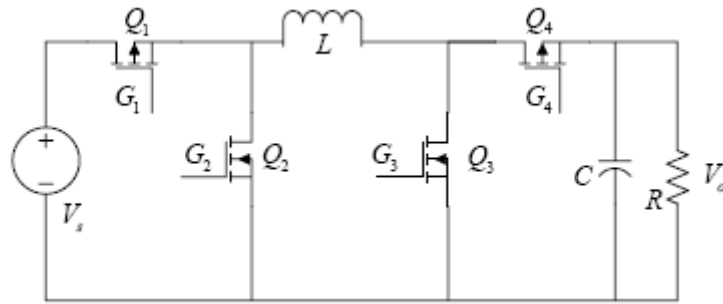The figure shown below is the circuit of the converter.

Figure 10 Converter Circuit

The circuit operation:

Boost Converter Mode : Transistor Q_1 is set to be always on while Q_2 is always off. First, the transistor Q_3 is closed while transistor Q_4 is opened. This will supply voltage to charge the inductor. After a few milliseconds, Q_4 is closed and Q_3 is opened. The inductor will then discharge. The process will be repeatedly done according to the frequency set[11].

Buck Converter Mode : Transistor Q_4 is set to be always on while Q_3 is always off. First, the transistor Q_1 is closed while transistor Q_2 is opened. This will supply voltage to charge the inductor. The inductor current will increase nearly linearly and the capacitor will supply output current to the load. After a few milliseconds, Q_2 is closed and Q_1 is opened. The inductor will then discharge. The energy stored in the inductor will be delivered to the load. The inductor current decrease almost linearly. The process will be repeatedly done according to the frequency set[11].

Buck-Boost Converter Mode : Transistor Q_1 and Q_3 will work as a pair and transistor Q_2 and Q_4 will work as another pair. First, Q_1 and Q_3 pair is closed while Q_2 and Q_4 pair is opened. This will supply voltage to charge the inductor. Then Q_2 and Q_4 pair is closed and Q_1 and Q_3 pair is opened. The inductor will then discharge. The process will be repeatedly done according to the frequency set[11].

2.7 Solar Electrical Power Generation Stabilization System

Solar Electrical Power Generation Stabilization System (SELECT_PGSS) is a system designed to stabilize the input of the solar PV cell. The system is applied after the charge controller. But charge controller is not necessary in order to use SELECT_PGSS. It can be used directly to the output instead. The main part of it is the combined converter where the boost, buck and buck-boost converter is combined in a single circuit. The mode whether boost, buck or buck-boost and the duty cycle of the combined converter is controlled by PIC16F877 depending on the input.

The PIC will detect the value of the input and compare it with the preset value of the desired output. If the input is lower than the preset value, the converter will be set to boost converter mode. It the input is higher than the preset value, the converter will be set to buck converter mode. If the input is equal to the preset value, the converter will be set to buck-boost converter mode. The specialty of SELECT_PGSS is the desired output can be set by only pressing the button. The value of the desired output is presented at the 2 7-segment displays. The users do not have to alter the programming in order to change the desired output value. This makes the system is user friendly. The maximum output it can produce is 20V and the minimum output is 9V. By default, the system is set to produce the output of 9V. The maximum input it can tolerate is 19V and the minimum effective value is 5V.

CHAPTER 3
METHODOLOGY

3.1   Procedure Identification

Intensive investigation will be conducted to ensure that research went on smoothly. Firstly, the study on the solar cell generation should be conducted in order to know the maximum power can be generated, the best location to put the solar cells and its tilt angel, and the changes of output from time to time . After that, identifying the current techniques to charge the battery will be done in order to find the effectiveness of the current charging method and the room for improvement. Next, a research on the concept of stabilizer and how to implement it in the case of solar cell. The research also covers the new method of charging the solar cell battery. After that, simulation process will be done in order to see the results of implementing the voltage stabilizer and the new method of charging the solar cell battery. Finally, prototype of the voltage stabilizer and the new battery charging method will be fabricated and tested in any electronic devices.

3.2   Flowchart

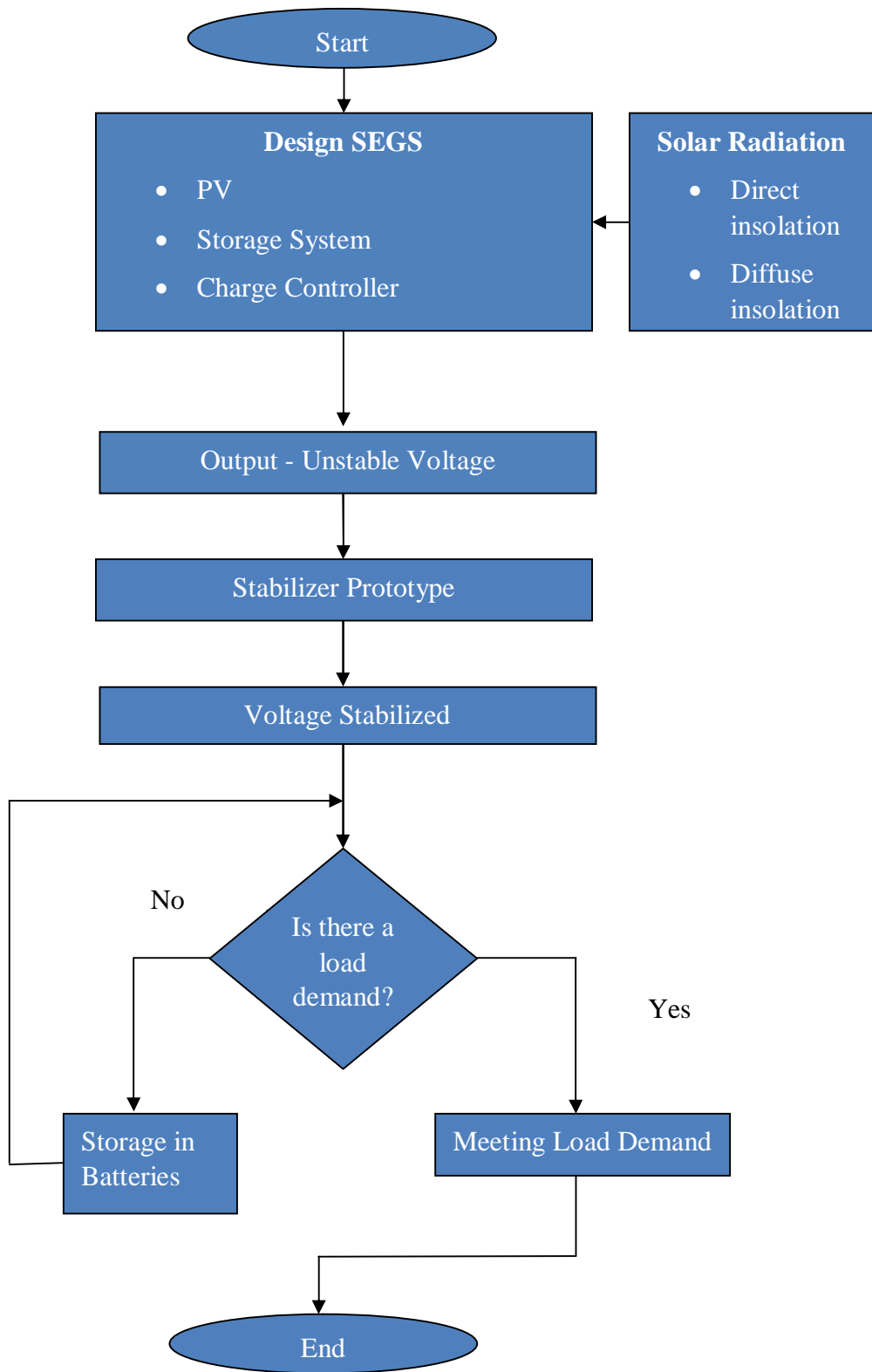Here is the project activities flowchart:

Figure 11 Flow Chart of The Project
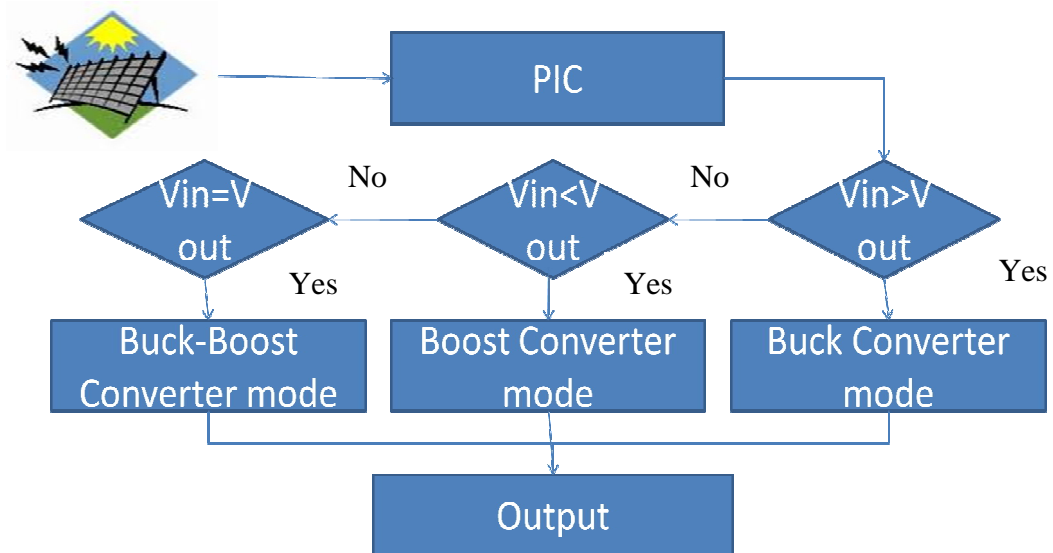
Figure 12 Flow Chart of the Stabilizer

3.3 Software and Equipment Required

Here are the software and equipment required for this project:

Table 1 Software and equipment list

Software/Equipment	Description
PSpice	A simulation program that simulates the circuit
ISIS 7 Professional	An advanced simulation program that can simulate the function of PIC
PIC 16F877	Control the PWM of the converter
Solar Panel	Produce electricity
Inductor 22uH	Charge and Discharge current
Capacitor 480nF	Maintaining the output voltage during the switching process
Resistor 10K ohm	Load

CHAPTER 4
RESULTS AND DISCUSSION

4.1 Solar Radiation in UTP

The solar radiation trend is important to be collected in order to analyze the behavior of the solar energy throughout a day. By doing the analysis, the average power of the solar that can be gathered will be known.
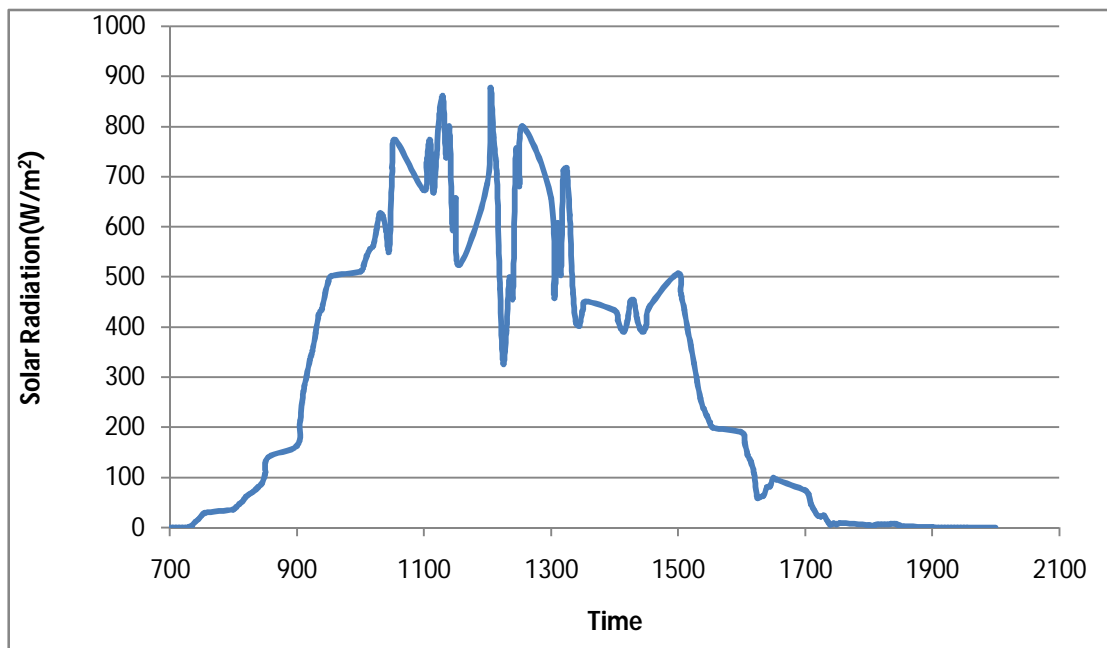

Figure 13 Solar Radiation Trend

In the figure above, the solar radiation starts from $0W/m^2$ at 7.00 a.m and continues to increase until it comes to its peak of $858W/m^2$ at 11.30 a.m. Then, the solar radiation starts to drop at the evening until at 8.00 p.m. at 8.00p.m the solar radiation becomes $0W/m^2$ again. The solar radiation keeps increasing from morning to midday because the sun continues to rise until its peak in the midday. At its peak, the radiation from the sun goes to the earth's surface almost directly without any diversion. The solar radiation gets lower in the evening because the sun is getting lower until it sets in the dusk. When the sun gets lower, the diversion of the radiation

18

increases. At night, there is no more sunlight due to the sun has set. The fluctuations shown in Figure 13 clearly indicate the need to have a stabilization system in order to ensure stable power output.

4.2 IV Characteristics Under Different Light Intensity

An experiment has been done in order to obtain the IV characteristics by obtaining the IV curve under different light intensity. The IV curved is obtained by running a simulation in the solar laboratory. The light intensities used are 1 sun, 1/3 sun and 1/10 sun. 1 sun refers to 1000 W/m^2. The solar panel used is rated at 1 W and 10V. The area of the solar panel is 0.01044 m^2. The results are shown in the figures below:
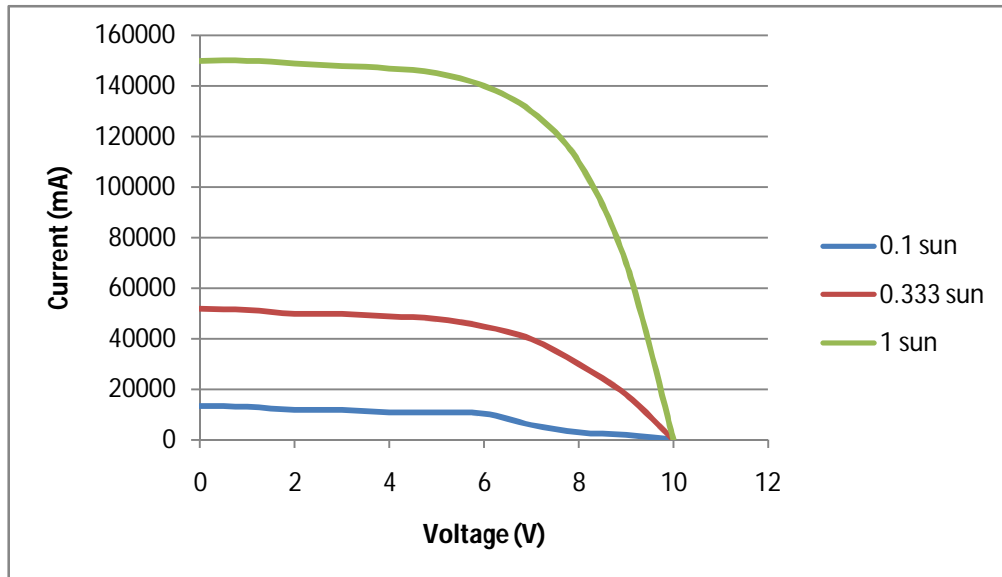
Figure 14 IV curve for 0.1 sun,0.333 sun and 1 sun

The analysis of the result is shown in the table below:

Table 2 The comparison Table of light intensity

Intensity	1 sun	1/3 sun	1/10 sun
Maximum power	917.282 mW	283.965mW	24.990mW
Efficiency	8.786%	8.165%	2.4%

From the result, we can see that efficiency is getting lower when the light intensity gets lower. At 1 sun, the maximum power fails to reach the rated value is

may be caused by the internal resistance. The efficiency of the solar panel is very low.

4.3   Simulation Using Pspice

4.3.1   Simulation of Boost Converter

The simulation is done in order to see whether the circuit can work and produce the correct results when certain value for each component is used. In this simulation, a pulse generator is used to replace the PIC since PSpice does not have any PIC function. The pulse generator is used as the PWM. Initially, the values for each component are as follow:

Resistor = 20 ohm

Capacitance = 147uF

Inductance = 1.8mH

Frequency = 35KHz

Output voltage =15V

Input voltage =7.5 V

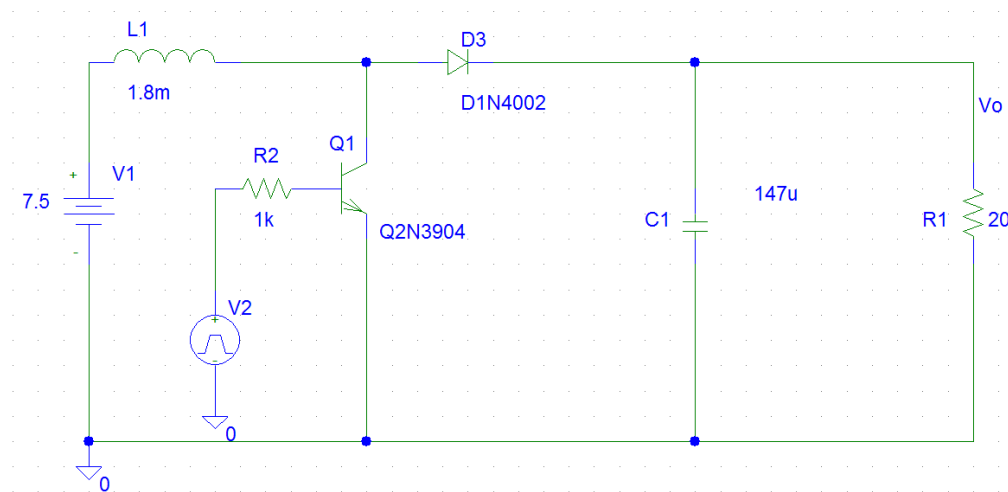By using these values, the result is shown in the figure below

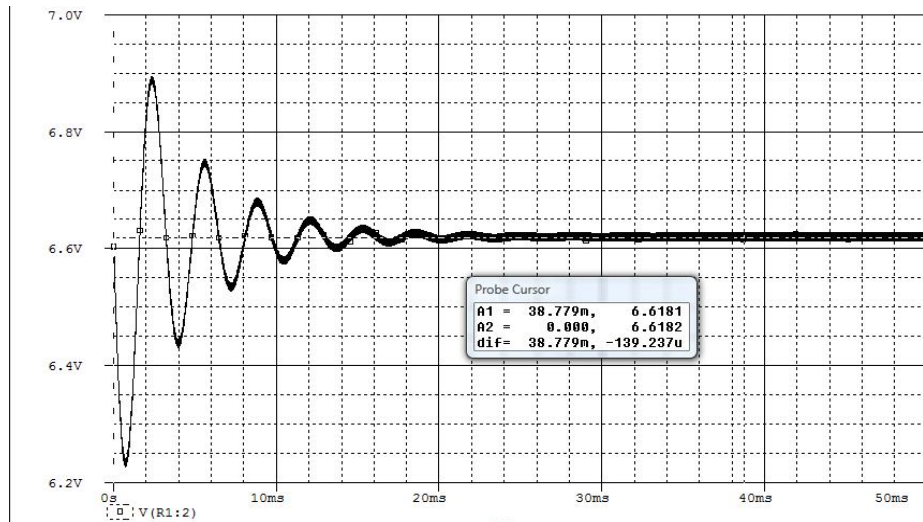Figure 15 The initial circuit configuration

Figure 16 The result of the circuit configuration

From the figures above, it can be seen that the output voltage produced is lower than the desired output voltage. This problem is related to the value of capacitive and resistor. Since current flowing through the capacitor is

$$I_C = C \frac{dVc}{dt}$$

where

I_C=current through capacitor in Ampere

C= Capacitance in Farad

dV_c/dt= the rate of change of the voltage in the capacitor

V_c=Voltage across the capacitor

and voltage across the resistance is V=IR, the higher current will flow into the capacitor when capacitive value is high and this will produce less voltage at the output. The problem can be solved by reducing the capacitive value or increasing the value of resistor or both. Reducing the capacitive value too much will make the output voltage ripple value very high. Increasing the resistor value will make the power efficiency lower. The optimum value must be chosen in order to make the ripple value very small and the power efficiency very high.

Therefore, the new values are set for the components in the circuit and simulated. The input voltage, output voltage and inductive value of the inductor is fixed. The result is shown in those figures:
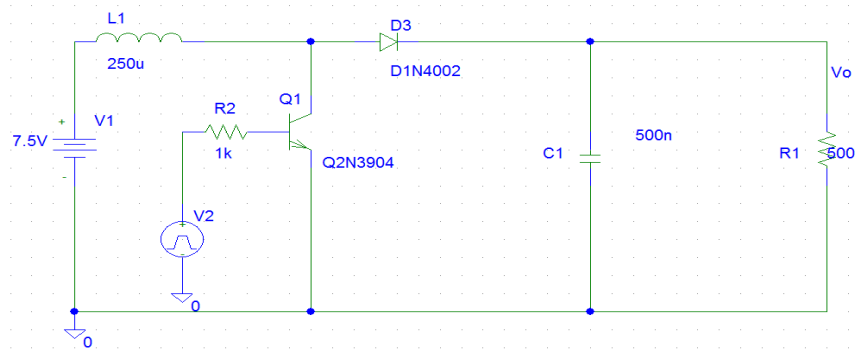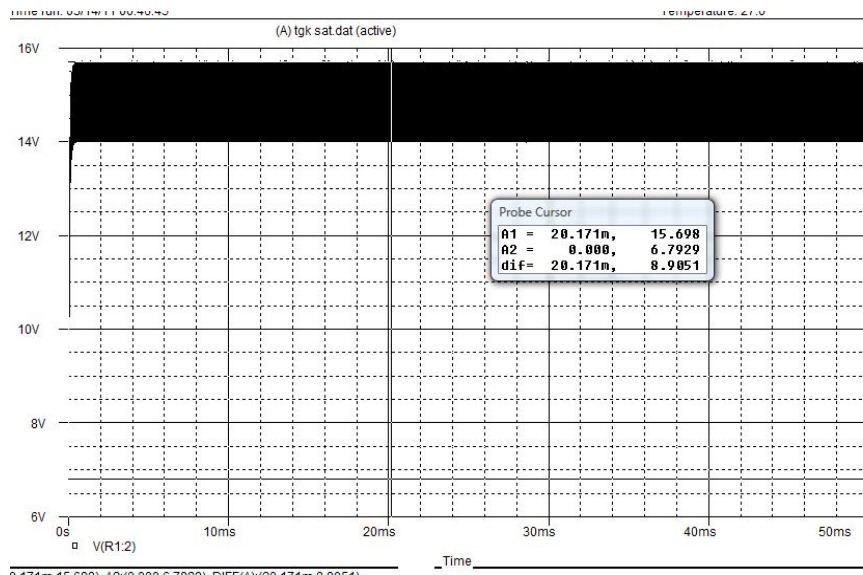
Figure 17 The altered circuit configuration

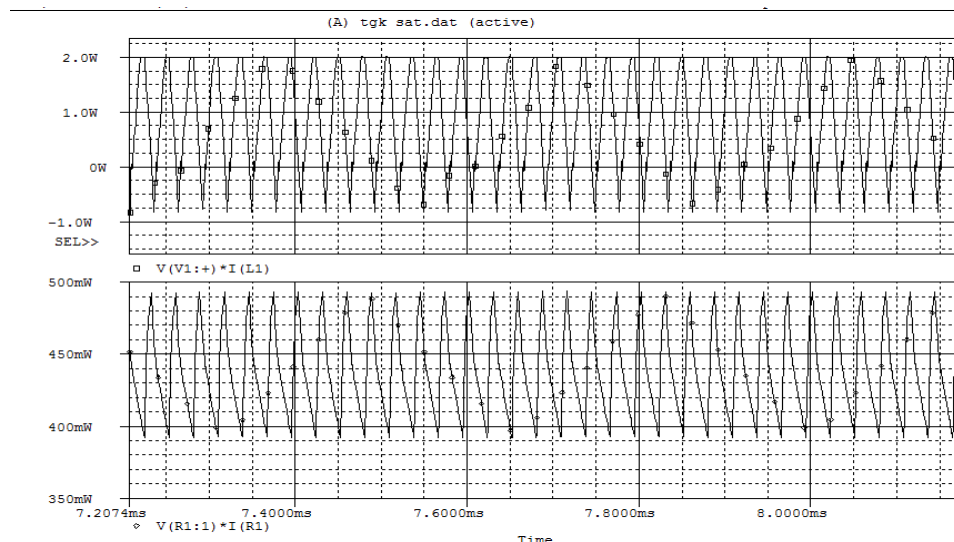Figure 18 The result of the altered circuit configuration

Figure 19 P_{in} (top) and P_o (bottom)

From the result, it can be seen that reducing the value of capacitor and increasing the value of resistor can increase the output to the almost desired voltage. The average efficiency of this system is calculated to be around 73%.

4.3.2 Simulation of Combined Converter

After the simulation for boost converter has succeeded, the progress is continued to the simulation of combined converter, a circuit that combines boost, buck and buck-boost converters. In this simulation, the pulse generator still functions as the PWM. In this simulation, combination of MOSFET and BJT are used. The MOSFET draws a lot of current when it is turned on. If the MOSFET is connected to the ground instead of BJT, a lot of current will flow to the ground instead to the output when it is turned on.
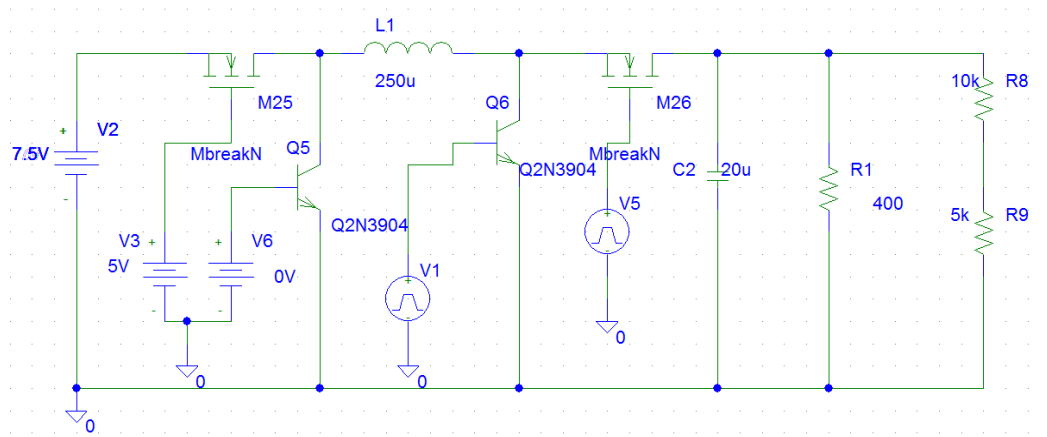
Figure 20 Combined converter boost converter mode
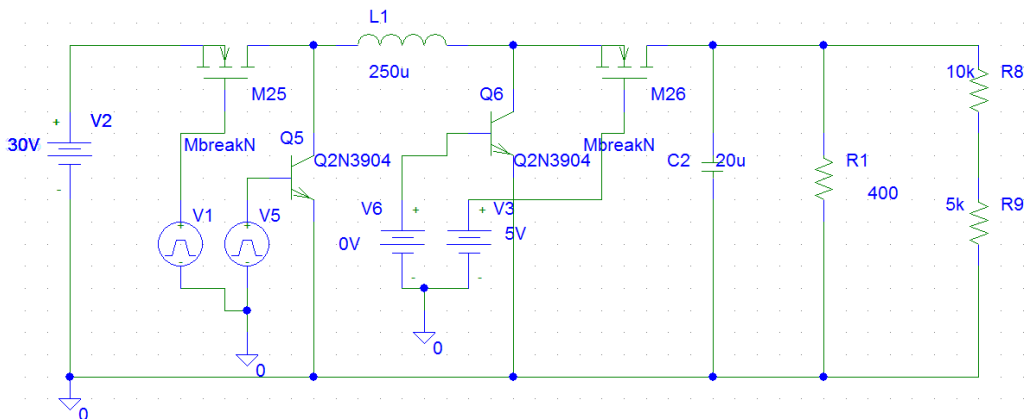
Figure 21 Combined converter buck converter mode
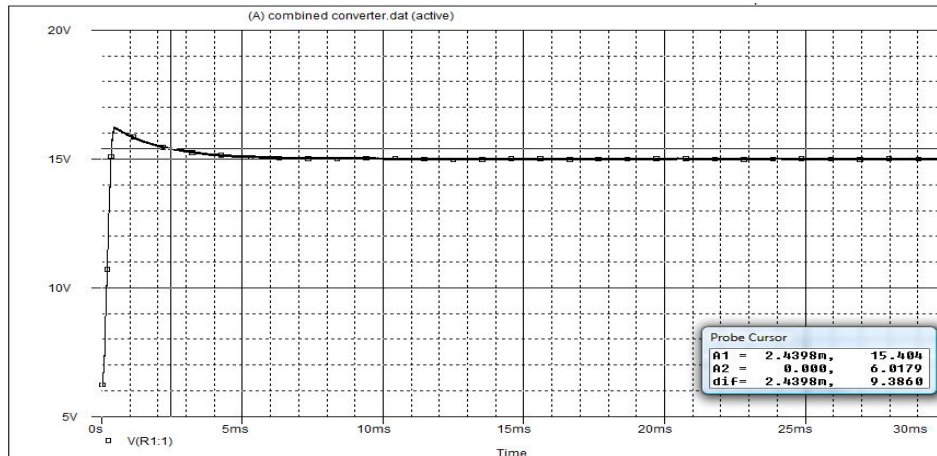
Figure 22 Result of Combined converter boost converter mode
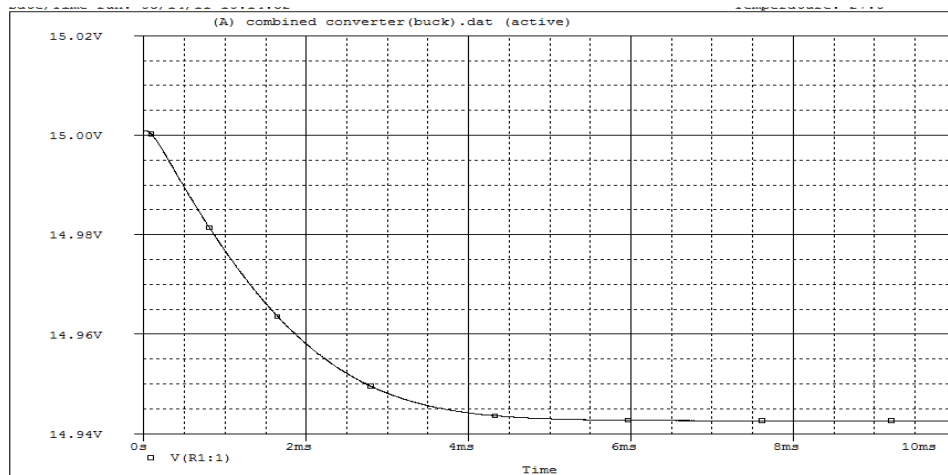
Figure 23 Result of Combined converter buck converter mode

From the result obtained here, it can be seen that the output is more stable when using the combined converter. This is due to this converter allows the usage of higher value capacitance of the capacitor. But, the result is slightly different from the desired value due to some internal resistance. To make the output to the desired value, the correction mode must be done by using PIC.

4.4 Simulation Using ISIS PRO

ISIS PRO is software that can simulate the circuit and also simulate the PIC. The simulation is done to test whether the programming can work with the circuit or not. The simulation is done by using the combined converter circuit.

24

The configuration of the circuit in the simulation is shown in the figure below:

Figure 24 Combined converter Circuit configuration

The result of the simulations are as follows:

Figure 25 Output voltage(yellow) when input voltage(red) is 5V
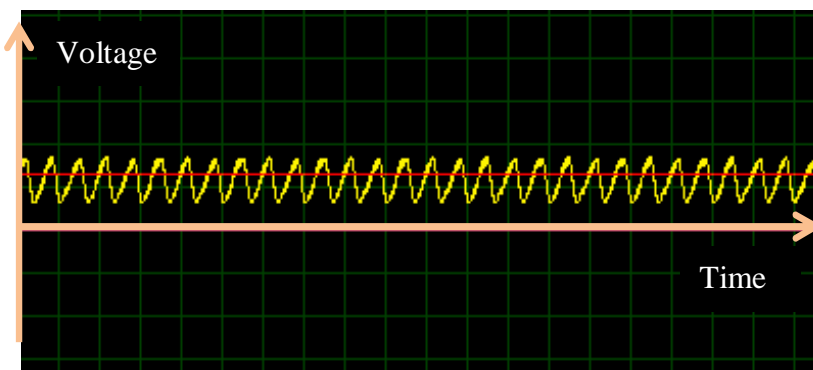
Figure 26 Output voltage(yellow) when input voltage(red) is 6V
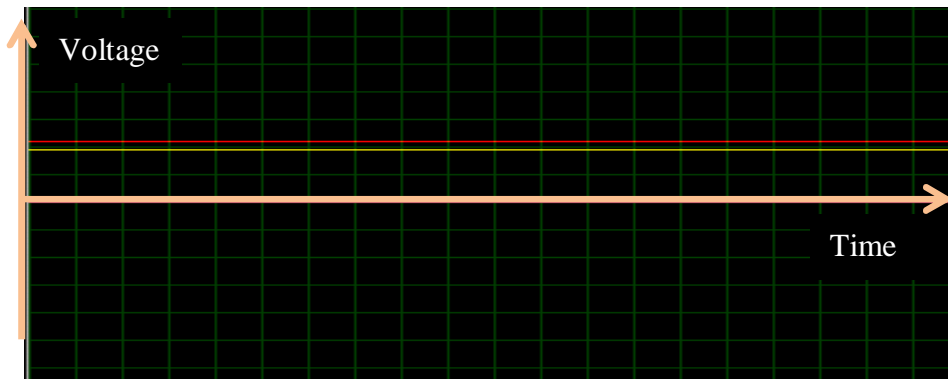
Figure 27 Output voltage(yellow) when input voltage(red) is 11V

From the figures above, it can be seen that the output is always 9V regardless of the input. The ripple voltage for this simulation in the boost converter mode is quite high. The ripple voltage is around 66%. This happe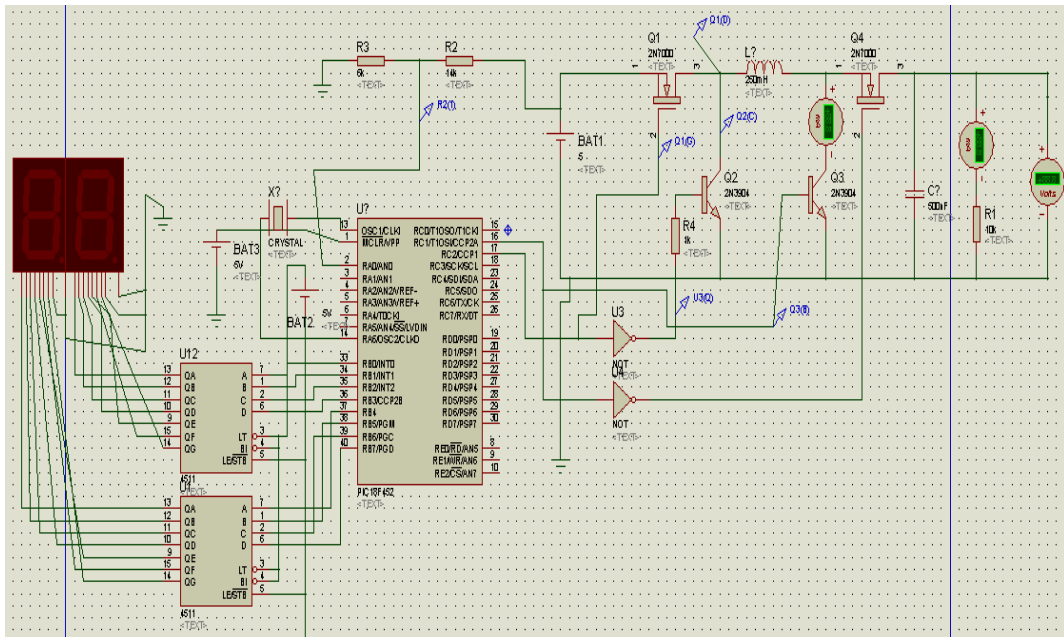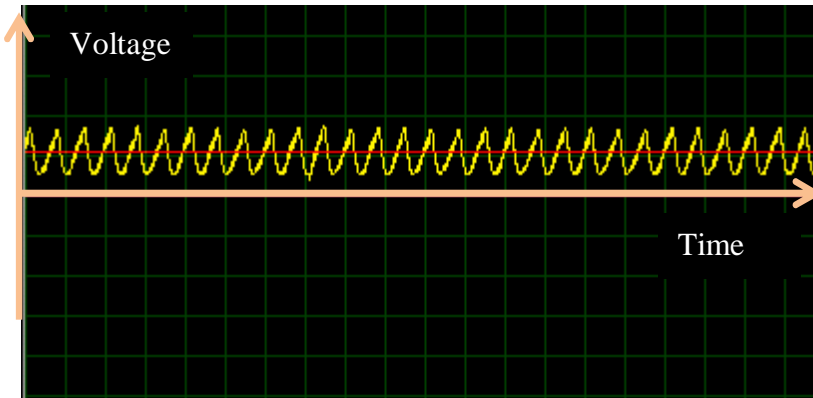ns because, in this simulation, 250mH inductor is used. This is quite high. The value of inductor should be brought down in order to get less ripple voltage. While in the buck converter mode, the ripple is very small and almost cannot be seen.

4.5 Combined Converter Assembly

The assembly process starts with completing the programming for PIC. The PIC's function is to generate PWM pulse to turn on and off the transistors. The PIC will detect the input voltage, then compare it whether higher, lower or equals to a preset value. The default value for preset value is 9V. It can be changed by pressing the button. This experiment uses the default voltage of 9V. If the input is higher than 9V, the buck converter mode will be turned on. When the input is lower than 9V, the boost converter mode will be turned on. If the input voltage is equal to 9V the buck-boost converter mode will be turned on.

After the programming is completed, the program is burnt into PIC18F877. Then, the components are assembled on the breadboard and the result is tested. The test result is shown in the figures below.
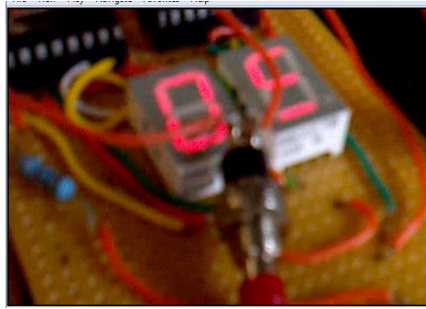
Figure 28 The preset Value is set to 9V
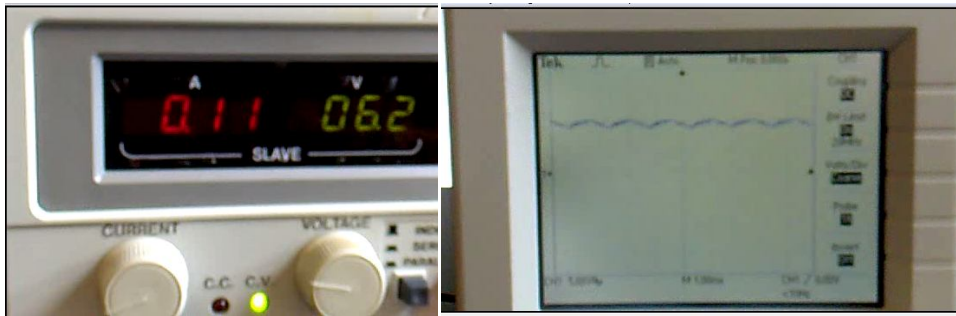
Figure 29 Input voltage=6.2V and the output wave
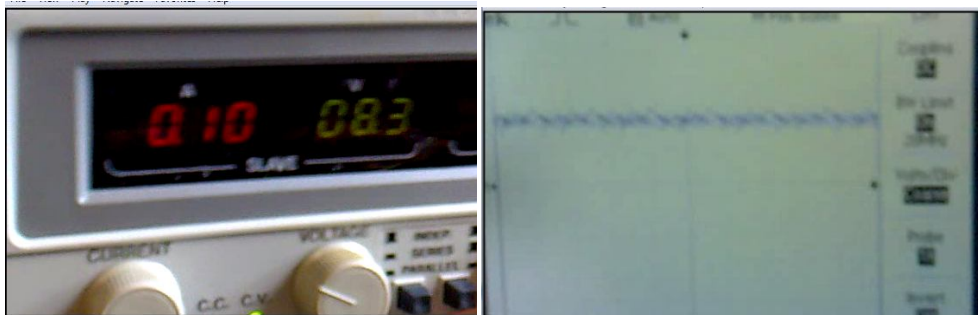
Figure 30 Input voltage=8.3V and the output wave

Figure 31 Input voltage=11.8V and the output wave

From the figures, it can be seen that the output voltage is still the same even when the input is changed. This means that the PIC responds correctly with the value of the input. For boost converter, there is some ripple. The percentage of ripple voltage is approximately 22 %. For buck converter, the ripple is very small and negligible.

CHAPTER 5
CONCLUSION AND RECOMMENDATION

5.1   Conclusion

As the conclusion, the most possible method to stabilize the input of the solar PV cell is by using the combined DC to DC converters. Its ripple is only 10% and the output remains at the same level even the input is changed. Furthermore, it can respond quickly to the changes of the input and produce the desired result. This shows that the input from the solar can be stabilized by using the combined DC-DC converter. All the objectives of this project have been achieved.

5.2   Recommendation

The output has some ripple which causes some minimum losses. In order to solve this problem, a higher frequency should be used. This is because the higher frequency circuit will cause the switching of the transistors becomes faster. The other solution is by using higher value of capacitor and higher value of resistor. This is less recommended since higher capacitor and higher resistor will consume more power.

The PIC has its limitation where it will become hot when it is used for a very long time. To solve this, a heat sink should be applied on the circuit. For further development, a microcontroller can be used since it is more stable than the PIC.

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APPENDICES

APPENDIX A
GANNT CHART FYP 2

No.	Detail \ Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	SW
1	Programming	■	■	■	■											
2	Assemble the circuit					■	■									
3	Testing the circuit							■								
4	Submission of Progress Report								■							
5	Touch up the project									■						
6	Pre-EDX										■					
7	EDX											■				
8	Submitting draft report													■		
9	Submitting Final Report														■	
10	Submitting technical paper														■	
11	Viva															■

APPENDIX B
SOURCE CODE

```
void main() {
unsigned
doubleVin,Vinconv,D,Vout,Vomax,Vomin,Vo,Voconv,Vinnow,Vinnowconv;
int initial=0;
int i=0;
int
voltageoutput[12]={0X09,0X10,0X11,0X12,0X13,0X14,0X15,0X16,0X17,0X18,0X
19,0X20};
int j;
 TRISA = 0xFF;
 TRISB=0;
  TRISC = 0;
 TRISD=0XFF;
  ADCON1 = 0x84;
     Vout=9;
   PWM1_Init(5000);                 // Initialize PWM1 module at 5KHz
   PWM2_Init(5000);

  do {   initial=0;
     portB=voltageoutput[i];

   if (RD2_bit)
     {if(Vout>9 && i>0)
     {Vout=Vout-1;
      i=i--;
      delay_ms(500);}}
      else
      if(RD3_bit)
       {if(Vout<20 && i<11)
      {Vout=Vout+1;
```

```c
    i=i++;
    delay_ms(500);}}
Vinconv=adc_read(0);
Vin=(Vinconv/1023)*19;
 if(initial==0)
 {PWM1_Start();                 // start PWM1
 PWM2_Start();
 PWM1_Set_Duty(0);      // Set current duty for PWM1
 PWM2_Set_Duty(0);
 initial=1;}


 //setting boost
  if(Vin<Vout)
 {D=(1-(Vin/(Vout)))*255;
 PWM1_Set_Duty(255);
 PWM2_Set_Duty(D);}


 //setting buck
 else
 if (Vin>Vout)
 {D=((Vout)/Vin)*255;
 PWM1_Set_Duty(D);
 PWM2_Set_Duty(0);}


  //setting buck-boost
 else
 { D=1/((Vin/(Vout+2))+1); }


 }
 while(1);

}
```

APPENDIX C
PIC 16F877 LAYOUT

PDIP

$\overline{\text{MCLR}}$/Vpp/THV →	1	40	↔ RB7/PGD
RA0/AN0 ↔	2	39	↔ RB6/PGC
RA1/AN1 ↔	3	38	↔ RB5
RA2/AN2/VREF- ↔	4	37	↔ RB4
RA3/AN3/VREF+ ↔	5	36	↔ RB3/PGM
RA4/T0CKI ↔	6	35	↔ RB2
RA5/AN4/$\overline{\text{SS}}$ ↔	7	34	↔ RB1
RE0/$\overline{\text{RD}}$/AN5 ↔	8	33	↔ RB0/INT
RE1/$\overline{\text{WR}}$/AN6 ↔	9	32	↔ VDD
RE2/$\overline{\text{CS}}$/AN7 ↔	10	31	↔ VSS
VDD →	11	30	↔ RD7/PSP7
VSS →	12	29	↔ RD6/PSP6
OSC1/CLKIN →	13	28	↔ RD5/PSP5
OSC2/CLKOUT ←	14	27	↔ RD4/PSP4
RC0/T1OSO/T1CKI ↔	15	26	↔ RC7/RX/DT
RC1/T1OSI/CCP2 ↔	16	25	↔ RC6/TX/CK
RC2/CCP1 ↔	17	24	↔ RC5/SDO
RC3/SCK/SCL ↔	18	23	↔ RC4/SDI/SDA
RD0/PSP0 ↔	19	22	↔ RD3/PSP3
RD1/PSP1 ↔	20	21	↔ RD2/PSP2

PIC16F877/874