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DESIGN AND IMPLEMENTATION OF STANDALONE SOLAR PHOTOVOLTAIC BASED ON ATMEL AT89C51 MICROCONTROLLER FOR ELECTRONIC LABORATORY DC POWER SOURCES.

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ABSTRACT

The global spike in energy costs has led many to find alternative and sustainable fuel sources. There are many options available today including wind, solar and hydropower. Of the three, solar is the fastest growing, and almost everyone can learn to capture its power to perform tasks like cooking, lighting, heating, and many other household chores. Moreover, Malaysia has high potential in generating solar electricity since it is a tropical country that is generally bathed in sunshine all year around. This paper illustrates the design and implementation of standalone solar photovoltaic based on ATMEL AT89C51 for Electronic Laboratory DC Power sources. This includes the detailed overview of all the major solar PV system components. Major aspects of solar PV systems which examines in this paper are solar PV panel, sensors and their working principles, controller used in data acquisition systems, data transmission methods and data storage. The acquaintance of all these aspects are crucial for the development of effective, low cost, and viable solar PV systems for small and medium scale solar PV plant without compromising on the desired performance. The proposed system able to supply electronic laboratory with 12VDC and 5VDC.

1. INTRODUCTION

The growing demand of electricity throughout the world has motivated the use of renewable energy source. Nowadays, solar energy is becoming promising and economical alternate energy source since it provides unlimited, environment friendly, required less maintenance and clean energy[1].

There are many advantages that solar energy has to offer over traditional sources of energy like coal and oil. Not only it is completely renewable but is also protects the environment. Solar energy is a renewable source of energy as it can be used to produce electricity as long as the sun exists. This energy can be harnessed by installing solar panels that can reduce our dependence on other countries for consistent supply of coal to produce electricity. This makes it an attractive energy prospect for most countries that are looking to go completely green in the future. Although solar energy cannot be produced during night and cloudy days but it can be used again and again during day time. Solar energy from sun is consistent and constant power source and can be used to harness power even in remote locations[2][3].

Solar energy also can reduce carbon footprints since solar energy is an alternative for fossil fuels as it is non- polluting[4], clean, reliable and renewable source of energy. It does not pollute the air by releasing harmful gases like carbon dioxide, nitrogen oxide or sulphur oxide[5][6]. So, the risk of damage to the environment is reduced. Solar energy also does not require any fuel to produce electricity and thus avoids the problem of transportation of fuel or storage of radioactive waste.

Solar energy was first observed in 1839 by French scientist Edmond Becquerel who discovered the process of using sunlight to produce an electric current in a solid material. But it took more than another century to truly understand this process. Photovoltaic developed in its modern form in 1953, has been used to power satellites in space[7].

In 1958, solar PV was used for the remote telecommunications, and cathodic protection. Since the mid- 1960s to 1970s, solar PV widely used for remote residential and commercial systems[8]. During 1980s, a lot of improvement by development of film solar cells, allowing instalments in building, vehicles and consumer items. The world's first grid supported photovoltaic system is created in 1990s. Installation initiatives made by leaders around the world and 100,000 Solar Roofs program in Germany, led by Dr Herman Scheer in 2000[9][10]. Solar Roof initiative for 1 million solar roofs was launched in 2017 by Arnold Schwarzeneggar. The average cost of solar PV panels has dropped more than 60% and the cost of a solar electric system dropped by 50% in 2010.

Due the fact that solar power source is main alternative source for conventional energy such as fuel and hydro, this paper attempt to describe the development of stand-alone photovoltaic solar system to supply 12VDC and 5 VDC source to Electronic laboratory at Faculty of Electrical and Automation University College.

2. MATERIAL AND METHODS

This project is design for power supply 12V and 5V by using solar panel system that will be applied in the digital laboratory. By referring to the figure below, the solar panel will be put outside the laboratory on the roof of FTKEA main entrance. The wiring from the solar panel will be connected to the control box inside the laboratory. When power of solar panel has being charge into the battery inside of control box, the voltage from battery will be transferred to every workstation on laboratory to supply 12V and 5V.

2.1 Solar Photovoltaic System

There are two principal classifications are grid-connected and stand-alone systems. Photovoltaic systems can be designed to provide DC and/or AC power service, can operate interconnected with or independent of the utility grid, and can be connected with other energy sources and energy storage systems. Grid-connected or utility-interactive PV systems are designed to operate in parallel with and interconnected with the electric utility grid.

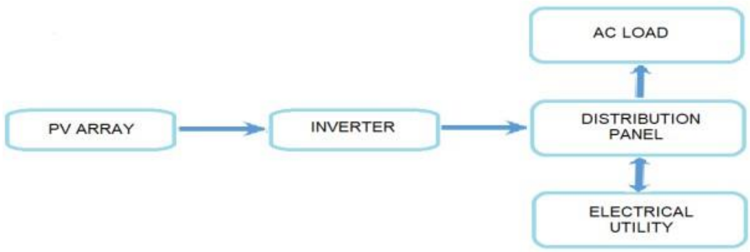

Figure 1. Block Diagram of grid-connected PV System

Stand-alone PV systems are designed to operate independent of the electric utility grid, of the electric utility grid, and are generally designed and sized to supply certain DC and/or AC electrical loads. These types of systems may be powered by a PV array only, or may use an engine-generator or utility power as an auxiliary power source in what is called a PV-hybrid system. The simplest type of stand-alone PV system is a direct-coupled system, where the DC output of a PV module or array is directly connected to a DC load (Figure 2). Since there is no electrical energy storage (batteries) in direct-coupled systems, the load only operates during sunlight hours, making these designs suitable for common applications such as ventilation fans, water pumps, and small circulation pumps for solar thermal water heating systems. Matching the impedance of the electrical load to the maximum power output of the PV array is a critical part of designing well-performing direct-coupled system. For certain loads such as positive-displacement water pumps, a type of electronic DC-DC converter, called a maximum power point tracker (MPPT), is used between the array and load to help better utilize the available array maximum power output.

Figure 2. Diagram of direct-coupled PV System

In many stand-alone PV systems, batteries are used for energy storage. Figure 3 shows a diagram of a typical stand- alone PV system powering DC and AC loads. Figure 4 shows how a typical PV hybrid system might be configured.

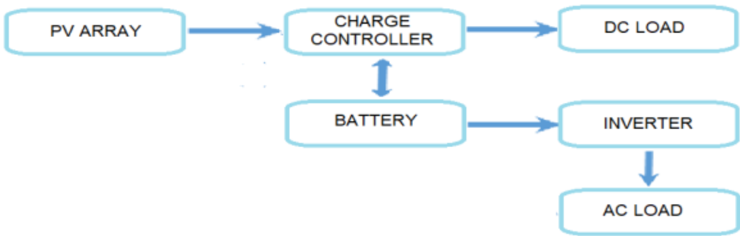

Figure 3. Diagram of stand-alone PV system with battery storage powering DC and AC loads

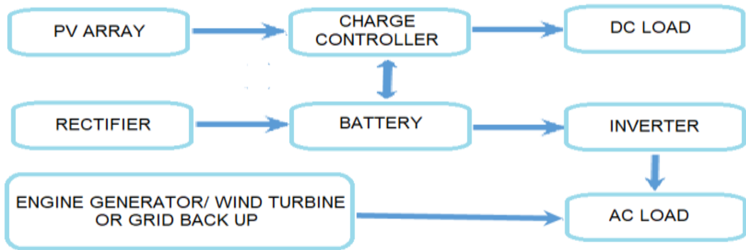

Figure 4. Diagram of PV hybrid system

2.2 Simplified Stand Alone PV System

A stand-alone PV system is an electrical system consisting of an array of one or more PV modules (usually of 12 volts with output if between 50 and 100 watts each). These PV modules are then combine into a single array to give the desired power output. A simple stand-alone PV system is an automatic solar system that produces electrical power to charge the bank of batteries during the day for use at night when the suns energy us unavailable. Figure 5 shows schematically examples of stand-alone systems.

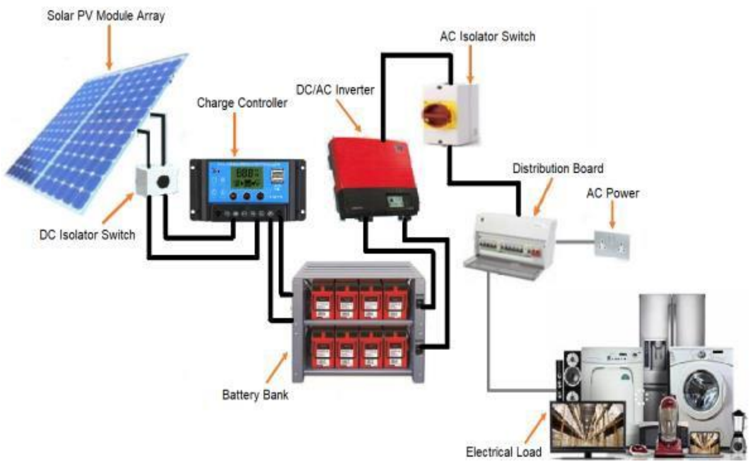

Figure 5. Stand-alone PV system

2.3 Block Diagram propose Stand-alone PV system.

The block diagram is diagram that have three elements which consist of input device, processing device and output device. The project of renewable energy power supply is start with voltage sensor as input device. The voltage sensor is work as a sensor to detect the voltage value that store inside the battery. When voltage value is being read, the voltage sensor will be send data into ATMEL AT89C51 microcontroller to start process system. The LCD display will display the voltage value from output of ATMEL AT89C51 process. Next, buzzer will produce sound as a warning element to pronounce voltage value at low level. The block diagram of this project is illustrated as Figure 6 below:

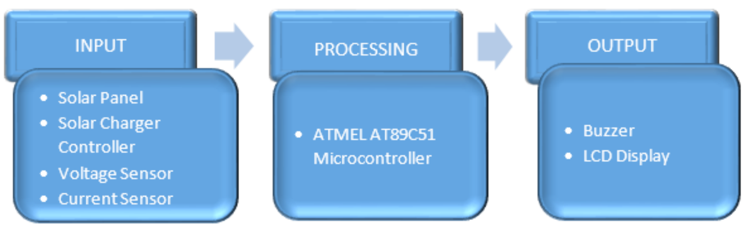

Figure 6. Block diagram of stand-alone PV system

2.4 Solar Panel Modules

Solar modules use light energy (photons) from the sun to generate electricity through the photovoltaic effect. The majority of modules use wafer-based crystalline silicone cells or thin-film cells based on cadmium telluride or silicon. The structural (load carrying) member of a module can either be the top layer of the back layer. Cells must also be protected them from mechanical damage and moisture. Most solar modules are rigid, but semi-flexible ones are available, based on thin-film cells. These early solar modules were first used in space in 1958.

Electrical connections are made series to achieve a desired output voltage and/or in parallel to provide a desired current capability. The conducting wires that take the current off the modules may contain silver, copper or other or other non-magnetic conductive transition metals. The cells must be connected electrically to one another and to the rest of the system. Externally, popular terrestrial usage photovoltaic modules use MC3 (older) or MC4 connectors to facilities easy weatherproof connections to the rest of the system.

Bypass diodes may be incorporated or used externally, in case of partial module shading, to maximize the output of module sections still illuminated. The solar panel are use one unit this project. Solar panel that use are 60 watt/12V. Solar panel will change the energy to the battery at a daylight. Solar panel will absorb sunlight and will generate electric energy and will charger the battery. Solar panel will charge the energy to the battery at a daylight. Solar panel had been install on the roof lobby garage because there is a good location to get the sunlight. Figure 7 show the solar panel.

Figure 7. Solar panel module

2.5 Solar Charger Controller

A charge controller, charge regulator limits the rate at which electric current is added to or drawn from electric batteries. It prevents overcharging and may protect against overvoltage, which can reduce battery performance or lifespan, and may pose a safety risk.

Solar charger controller is used to controller the charge from solar to the battery to protect and avoid over voltage flow to the battery. Solar charger had a three terminal, first terminal is from solar panel, second terminal is connected to the battery. Third terminal is for load. In this project, solar charger controller had been install to the junction box to avoid from struck the rain. It may also damage if struck with the rain. Figure 8 show the solar charger controller.

Figure 8. Solar charger controller

2.6 Voltage Sensor

There are many ways to sense voltage, but in this project, we can easily measure voltage of solar panel using voltage divider. Two capacitors are connecting parallel to voltage divider resistors are R2=10K and R4=2K.The reason that used voltage divider because the maximum input voltage to Analog to digital converter can be greater than 5V. These resistors calculated values according to 4V to increase accuracy of measurement and to ensure protection of ADC in case of greater voltage fluctuation. Voltage sensor are used for this project as shown in Figure 9 below:

Figure 9. Voltage Sensor

2.7 Current Sensor

A current sensor is a device that detects electric current DC voltage in a wire and generate a signal proportional to it. The generated signal could be analog voltage or current or even digital output. It can be then utilized to display the measured current in an ammeter or can be stored for further analysis in a data acquisition system or can be utilized for control purpose. The sensed current and the output signal is digital output, which switches when the sensed current exceeds a certain threshold.

There are many ways to sense current in the component but in this project, we can easily measure current value of solar panel using current sensor. The detection of current using this sensor will be process by microcontroller AT89C51 and will display on the LCD display to show the value of output current power supply using solar panel. Current sensor are used for this project as shown in Figure 10 below:

Figure 10. Current Sensor

2.8 Full Schematic Circuit Design

Schematic design is used to construct the circuit and make the connection to the project. It is an open source software suite designed for electronic design automation. A printed circuit board (PCB) mechanically support and electrically connects electronic components using track, pad and other features attached from copper sheet laminated onto a non- conductive substrate. Figure 12 show full schematic diagram for the propose PV system.

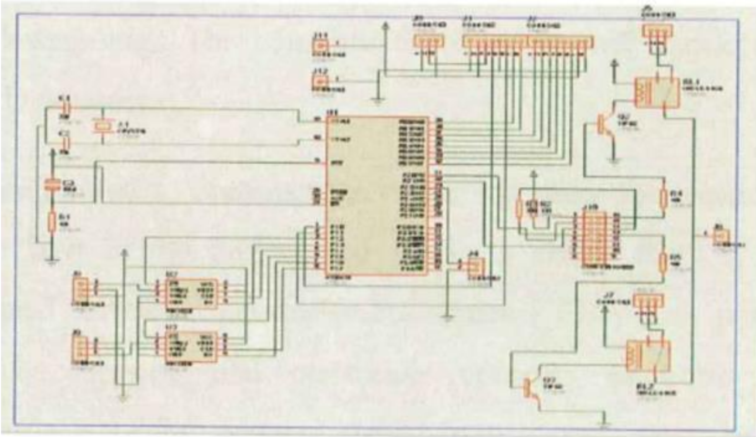

Figure 12. Full schematic Renewable Energy Power Supply

2.9 PCB Circuit of the system

PCB designer is used to design the circuit of the project. The user must use tracks and pads to build the circuit using thus software. The user are recommended to used tracks and pads to build the circuit using this software. The user is recommended to used tracks and pads size 3 and 4 to build the circuits so that it can easily trace on the PCB board soon. The complete circuit design will transfer to the PCB layout design by using PCB designer.

PCB designer is used to construct the circuit and make the connection to the project. It also design the flow of the project and makes a simple flow. It is an open source software suite designed for electronic design automation (EDA). A printed circuit board (PCB) mechanically supports and electrically connects electronic components using conductive tracks pads and other features attached from copper sheets laminated onto a non-conductive substrate. PCB's can be single (one copper layer), double sided (two copper layers) or multi-layer.

A PCB populated with electronic components is called a printed circuit assembly (PCA), printed board assembly or PCB assembly(PCBA). The IPC preferred term for assembled board is circuit card assembly (CCA), for assembled backplanes. It is backplane assemblies. The term PCB is used informally both for bare and assembled boards.

After done a connection in this software, print out the design on transparent shield. Then, iron on PCB boards. Iron until the pad and line stick on the PCB board. When finish it,do follow the next step. The complete circuit design will transfer to the PCB layout design by using PCB designer. Figure 13 shows the PCB design circuit.

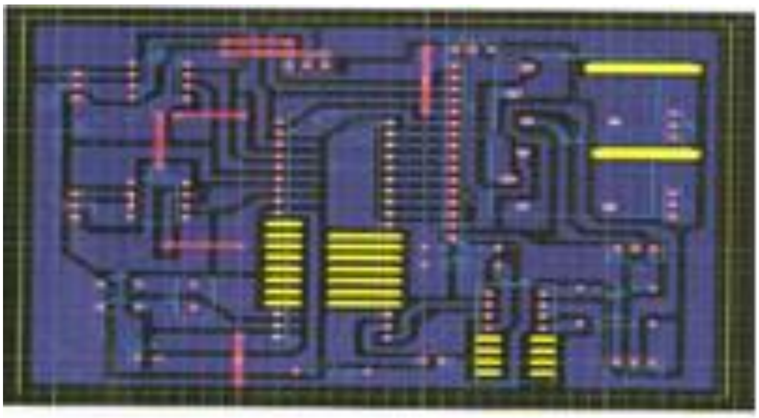

Figure 13. PCB design circuit.

3.0 HARDWARE FABRICATION AND INSTALLATION

In engineering, hardware design refers to the identification of a system's physical component and their interrelationships. This description, often called a hardware design model, allows hardware designers to understand how their components fit into a system design. Clear definition of a hardware design allows the various traditional engineering disciplines to work more effectively together to develop and manufacture new devices and component.

3.1 Project Setup

Project setup is the process before making the installation wiring inside the Sensor Lab at FTKEA. All component and element are needed to be carry out to make a suitable casing of hardware project. In this case, all the components are ready to be apply, components and other items were located in the room. This process made with caution and the situation of environment are clear and safe from any accident that could occur during this process. Figure 14 shows the component and other items that be used for this project.

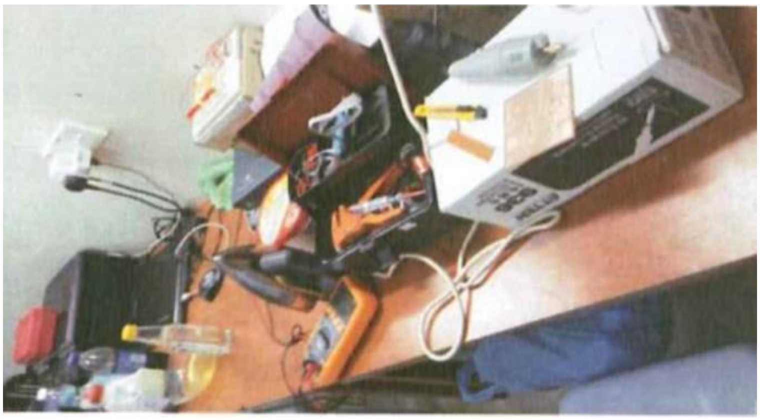

Figure 14. Component and other items

Next step is to install the main component and other items inside the junction board. The PCB board of IC AT89C51 is screw with nut inside the junction board to make sure that the below board site not touching with the other connection. This will cause short circuit if this process is skip. Besides voltage sensor and current sensor are put next to circuit breaker to avoid wire become stringy.

Controller solar panel is install inside the junction box with the 12V battery. First controller solar panel will control the input power from solar panel to charge the battery, this step is to make the battery life more longer and one of the safety precaution. The controller already connected with the battery and DC to DC converter is install beside the battery to convert 12V battery to 5V that will supply to every workstation in the sensor lab.

The junction is applied inside the sensor lab to avoid from placed at the area expose from rain. This will save all the component from damages and short circuit. All the component had to be install inside the junction board as shown in Figure 15.

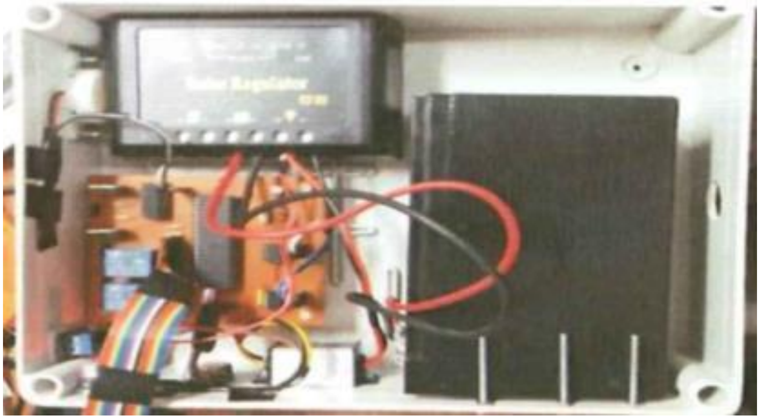

Figure 15. Component had to be install inside the junction board

Next, make sure the liner of solar panel. The liner was being made by using a piece of wood that easy to be made and long lasting. Liner is to be put in the solar panel top surface easy to facing the sun and easy to be wiring on the roof. The wood was cut with hand tool saw drill and screw to be form triangle. Figure 16 shows the liner of solar panel.

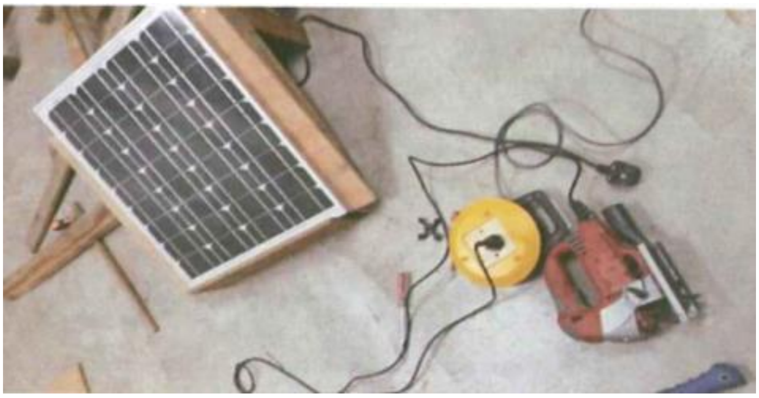

Figure 16. Liner of solar panel.

The solar panel need to be install to the place that expose to the sun. In this case, the solar panel was being install on the lobby FTKEA roof that near to the Sensor Lab. The liner was also applied with solar panel on the roof and clearly expose to the sun. The installation wiring process occur to connect the solar panel to the controller inside the Sensor Lab for battery charging. Figure 17 shows the location of solar panel.

Figure 17. Location of solar panel

Then, make sure the power supply connection pin by using banana socket. Banana socket is a single hole that functioning as electrical connector used for joining wires to the equipment. Then banana socket will be attached to the plane plate as a liner to place at every workstation inside the sensor lab. Figure 18 shows the banana socket with plane plate.

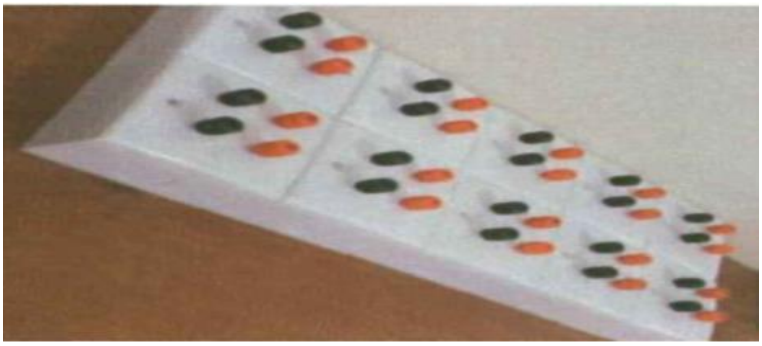

Figure 18. Banana socket with plane plate.

Figure 19 shows the installation of banana socket at every workstation. The banana socket is install with 4 pieces of socket, two pair of black and red are have different supply value of voltage that supply 12V and 5V for each pair. All the workstations are being install with same function from the same supply. The casing has been noticed by using sticker of 12V and 5V voltage supply that shown in Figure 20. Lastly, the installation wiring was been install inside the sensor lab and lobby FTKEA roof. Installation is a wiring or electrical system used in a building or its surrounding areas. The wiring process is fairly time consuming and requires planning for the varying power needs of electronics appliances.

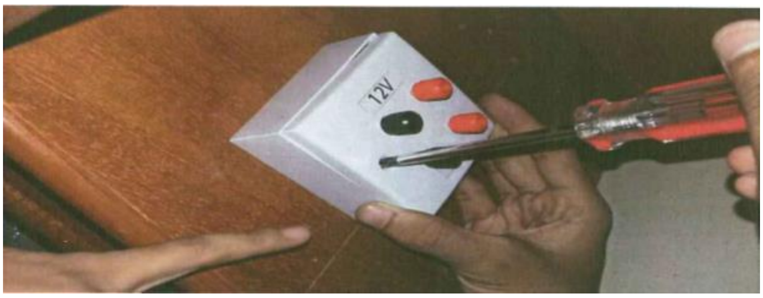

Figure 19. Installation of banana socket at every workstation

Figure 20. Sticker to noticed the voltage value

Wiring the building requires the use of three different colours of wire in addiction to a bare ground wire. The bare wire serves as the ground and does not transfer any power. This is the wire that will trip the circuit breaker in the event of a short circuit and eliminate any electrical current moving to the device. Both black and red wires are called 'hot' wires in industry and carry current from the breaker to the appliances. In this process the wiring inside the sensor lab and on the lobby roof are installed and function together properly to keep all the connection from getting the signal and can proceed this process to the given output.

4.0 RESULTS AND DISCUSSION

This section will discuss all result obtained of this project. The problem that had been faced now is the usage of electric current in daily life at very high and may give many disadvantages, resulting high cost to the user. Power supply that had been using at such laboratory is one of the element that contribute high usage of electric current that make high cost in the electricity bill. This is due to the laboratory that been always used by student daily. Furthermore, the cost for every power supply is high and expensive. This project may solve the problem as the renewable energy power supply will save the usage of electricity. This system has a three stages for the power supply active. It is beginning when LCD display the voltage value 12V-10V.Then, when the value is 9V-7V and stop at 6V. When battery decrease from 6V, this system will automatically off. This system will automatically on after the battery more than 6V. more than that, this system is a green technology because it uses a renewable solar panel to generate the battery.

For this project, five days testing have been made to take the reading of voltage that solar can charge battery during the day. The data of battery took a day, it begin at 9 a.m,11 a.m,1 p.m,3 p.m, and 5 p.m. The battery level was measured by multimeter and LED display on controller solar panel. When load has been connect with the power supply of 12V and 5V,data for the load had been collect to measured how long the load can be use with battery that was been charged by solar panel.

During the five days that data had been collected, voltage level can be divide into three condition such as minimum level voltage and maximum level voltage. Minimum level voltage is on the 04.09.2016 with voltage is 16.63V because the weather is cloudy and rainy on that day. Normal voltage is on 08.09.2016, the level voltage measured is 17,63V and the weather is sunny. The minimum voltage is on 05.09.2016, the voltage measured is 17.78V. Result for the battery charge every two hours shown in Table 1.

Table 1. Battery charge every two hours

Date/ Weather	**Battery charge every two hours**			
	9.00	**11.00**	**1.00 p.m**	**3.00**
09.04.2018 (Sunny)	13.63V	15.73V	17.13V	17.78V
10.04.2018 (Sunny, Haze)	12.7V	14.8V	15.38V	17V
11.04.2018 (Cloudy, Rainy)	12.54V	13.49V	15.24V	16.71V
12.04.2018 (Sunny)	13.6V	15.70V	17.3V	17.82V
13.04.2018 (Sunny, Haze)	12.5V	13.64V	15.82V	16.82V

After the voltage input value of solar panel charging the battery has been measure for five days, result for the battery voltage value is being record every two hours for four days. This activity process happened when two days are being test with 2 pieces of LED for 6 workstations and using 4 DC motor for four workstations. The 5V DC power supply are being used by the supply to the component to see the different value of voltage value inside the 12V DC battery.

The procedure took the voltage battery reading followed from the step before. This process is install with the monitoring from supervisor for the safety precaution to avoid short circuit and component damage. Table 2 and Table 3 show the voltage value of battery for every 2 hours for four days using multimeter test.

Table 2. Voltage value of battery using 5V DC

Date/ Weather	**Battery Voltage Value Level Using 5Vdc Power Supply**			
	9.00	**11.00**	**1.00 p.m**	**3.00**
14.04.2018 (Sunny)	13.63V	13.89V	13.54V	13.3V
15.04.2018 (Sunny)	13.56V	13.66V	13.45V	13.39V

Table 3. Voltage value of battery using 12V DC

Date/ Weather	**Battery Voltage Value Level Using 12Vdc Power Supply**			
	9.00	**11.00**	**1.00**	**3.00**
09.04.2018	13.76V	13.62V	13.54V	13.19V
10.04.2018 (Sunny, Haze)	13.95V	13.61V	13.56V	13.21V

The procedure of this project has three main elements from the solar panel system. Next, the process of the voltage and current value that will display in the LCD display and the output element power for every workstation. This process of procedure is the detail on how the function of the final year project has been done.

Firstly, the project starts to function from the solar panel will give the power supply to operate and active in all project element. The power from solar panel will supply to the solar charger controller. Figure 21 shows the power input to the solar charger controller.

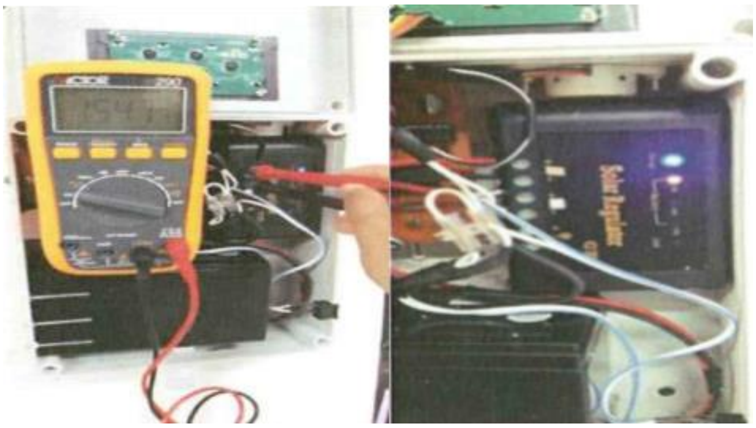

Figure 21. Power input to the solar charger controller

The solar charger controller is to control the input voltage from the solar panel supply to charge the 12V battery. This method will save the battery from damage and long lifetime.

Figure 22 shows the using and the connection of 12V battery. The battery after that will supply to all workstation in Sensor Lab.

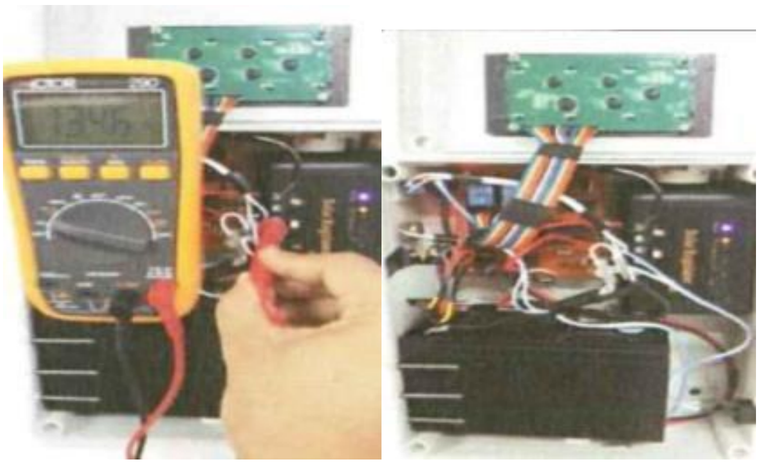

Figure 22. Connection of 12V battery

Next, when the supply is flow through to the workstation, the LCD at the junction box will display the title project 'Renewable Energy Power Supply' and the maximum voltage and current value. This process happened after the microcontroller receive the signal from the input and the process to send signal to the LCD display. Figure 23 shows the LCD display at the junction box.

Figure 23. LCD display at the junction box

The voltage value display at LCD display is getting by using Voltage Sensor inside the junction box. The voltage sensor is connected parallel with the solar charger controller to the indicates the accurate value of level voltage in 12V battery. At the same time, the current value that display at LCD is getting current sensor inside the junction box. The current sensor is connected with one pin of the load and one pin of the load and one pin with the negative pin of 12V battery to show the accurate value of current flow to the load user.

The final element is the process that the voltage from 12V battery is supply to every workstation in the sensor lab. Figure 22 shows the voltage value of each pair of banana socket at the workstation by using multimeter. The 12V voltage supply is directly connect with the 12V battery but the 5V voltage supply is connected with connected with DC to DC step down converter due to the voltage of 12V battery needed to be step down becoming to 5V. Every workstation in the sensor lab will have two fixed voltage value supply of 12V and 5V.

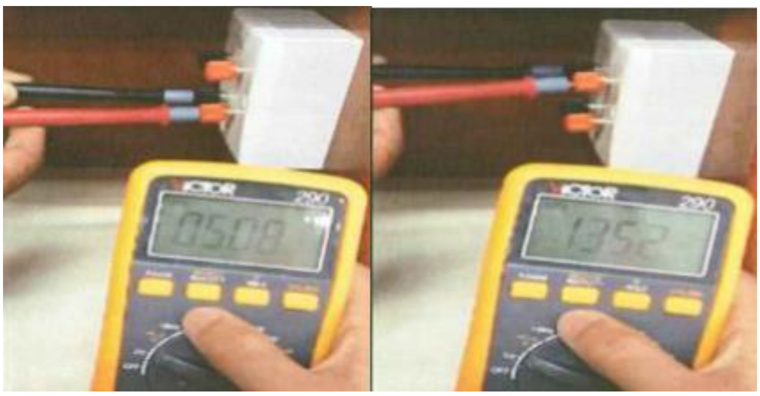

Figure 22. Voltage value of each pair of banana socket at the workstation

The final touch is to test the result power of workstation power supply. Figure 23shows the results with different voltage supply. This activity has been done by using the colour LED and buzzer produce on breadboard. The connection load with 5V active all the LED and buzzer produce sound. Next, the load is connected with 12V and the result shows the different the LED active more bright and buzzer produce sound higher sound that 5V connection. This prove that this project has been done with successful and achieve the objective to build 12V and 5V power supply.

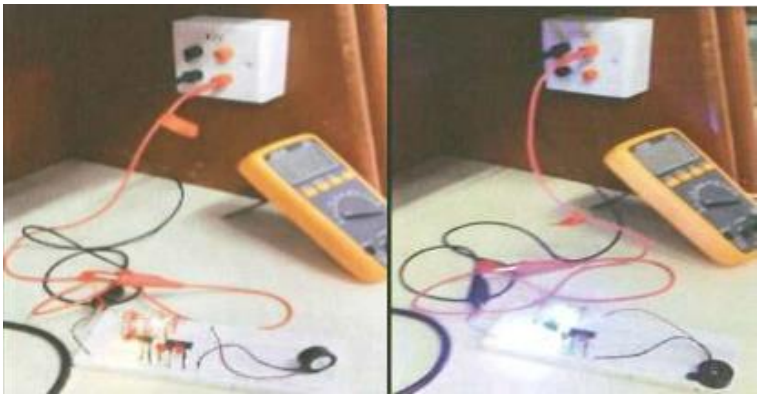

Figure 23. Results with different voltage supply

During end of this project, there are various factor in the project that called a problem but all the problems can be overcome with troubleshoot. The problems can give effect to this project. One of the problem is when the circuit is complete and do a little troubleshoot solder on the circuit to ensure that the circuit is function properly.

After doing some troubleshoot, found the circuit have a little trouble when there is contact between line to line which should not be in contact. This occurs because the solder is messy and disorganized with each other. A solution to this problem is using a multimeter to trace a connection that occur in contact to make sure the circuit can work properly.

Other problem is at the wiring connection of solar panel positive and negative pin to the inside junction box as a power supply to the microcontroller board. This process being troubleshoot by using multimeter. The buzzer will sound beep to declare with the connection are correct. The process was carry out in order to avoid short circuit that will cause all the component damaged.

CONCLUSIONS

In the nutshell, the usage of electric current in daily life is very high and will give many disadvantages, resulting high cost to the user. Power supply that had been using at such laboratory is one of the element that contribute high usage of electric current that make high cost in the electricity bill. This is due to the laboratory that been always used by student daily. Furthermore, the cost for every power supply is high and expensive. This project may solve the problem as the renewable energy power supply will save the usage of electricity.

By using renewable energy solar panel system, the implementation of this project will reduce the using of electric current and save the cost of buying power supply equipment at the laboratory in the FTKEA. Furthermore, preserve the nature from the pollution, becoming more effective and user friendly. Besides that, it can reduce the cost of electricity bill and make the environment better.

This project has achieved the objective to development of fixed power supply 5V and 12V by using power solar panel system to display the measurement parameters of voltage value solar panel system and to control output voltage from solar panel system 12V to 5V.

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