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Ground Power Unit with Automated Solar Tracker

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Abstract

The Ground Power Unit with Automated Solar Tracker is a new formation idea and improvise from The Self-Sustainable Ground Power Unit which is this new project operated with automated solar tracker that will automatically detect the higher intensity of sunlight. Basically, this product is mounted with two sections, the solar tracker at upper part and the ground power unit (GPU) also the battery place at the lower part (body of product). This project especially design to operate with two angle of rotation which is 180˚ degree at vertical axis and 360˚ degree at horizontal axis. The purpose of this invention is to reduce the workload of maintenance personnel and workers by tracking itself to the highest intensity of sunlight. Besides, this product operated efficiently automatically shut down when it fully charged. This GPU uses solar energy as it main sources, so it very eco-friendly and save the earth from pollution rather than the normal Ground Power Unit (GPU). Furthermore, this Automated Solar Tracker Project was installed with the ventilation unit to control the temperature inside the cart and prevent the wiring from damage.

Key-word: - ground power unit, automated solat tracker, self-sustainable energy

1. Introduction

Ground supports play an important role in aviation industry. They were used to supports the operation of an aircraft while it is on the ground. They were also known as Ground Support Equipment (GSE). Ground Power Unit (GPU) is an example of GSE that is used for supplying power to the aircraft while it parked on the ground at the airport or hangar.

"A GPU is a ground power unit. It usually is designed to be movable around the ramp from one parking place to another. It does basically the same thing that an APU does, but it runs on diesel fuel and therefore is cheaper and more efficient to operate during long periods of ground operation." (Tom Farrier, 2015)

Referring from the statement above, GPU is parts of ground support equipment that functions similar as Auxiliary Power Unit (APU) but only using the different types of source. Aircraft required 115V 400HZ of Alternating Current (AC) and 28V Directing Current (DC). Most of Ground Power Unit (GPU) used generator to generate electric energy by a 3 phase 4-wire insulated cable that connected to the built-in socket on the aircraft. The socket or connection are ISO 6858 standard across all aircraft.

"Direct sunlight is potentially the most powerful renewable energy source. In less than an hour, the Earth receives the same amount of energy from the sun as is used globally by man during a year. In contrast to most other energy technologies, solar energy is only limited by cost of conversion and intermittency in time. Direct use of sunlight yields up to 100 times more electricity, per land area, than growing biomass for use in power plants. Solar energy at present only amounts to a small fraction of the World's primary energy supply but solar technology markets are developing and growing fast." (Energy Committee, 2008).

From the statement above, sunlight is energy that is renewable energy available for us that can be potentially being a primary energy supply for the future. Solar energy is energy that come from the sun that changed to electrical energy. Furthermore, it also absolutely the cleanest and free from pollution energy that not harmful to us and obviously to the nature. Therefore, this Automated Solar Tracker Ground Power Unit project is designed mainly to a new and greener GPU that is eco-friendly by using solar energy. This GPU will produce a greener and the solar tracker will help the GPU to produce an efficient and maximum energy that it needs. This project also will help the GPU to perform to it efficient and optimum performance because of solar tracker that enhanced it.

Figure 1 Existing Self-Sustainable Ground Power Unit

This project is a modification form the Self-Sustainable Ground Power Unit (refer to Fig.1). From the previous project, author found out that the existing self-sustainable ground power unit(GPU) are the solar panel are manually control to get the maximum light intensity for the GPU to operate. This limitation blocked the advantage of solar panel. Besides, the structure of the self-sustainable GPU is enclosed without any ventilation that could damage the electronic parts inside it (Ganabathi Arumugam, 2016). The important point is any electronic parts should have a ventilation and air cycle or airflow to prevent overheat and damages to the electronic parts. Furthermore, the last project is build up with less safety precaution. The cable management are not neat and the equipment not properly arrange. These issues need to be modifying, as it is very important in the field of aviation industry. The objective of this project are to design and fabricate ground power unit with automated solar tracker, install the ventilation unit for existing Ground Power Unit system and rearrange the wiring of existing GPU

This new formation idea is a combination of two inventions, which are solar tracker and the ground power unit (GPU) that was mounted and build up together in one system that called Automated Ground Power Unit with Solar Tracker. This project is an improvise version of the Self-Sustainable Ground Power Unit that newly design of the solar panel and the structure on top of the Ground Power Unit (GPU). Basically, this innovation is mounted with two sections, the solar tracker at upper part and the ground power unit (GPU) and battery location at the lower part (body of product). The purpose of this invention is to reduce the workload of maintenance personnel and workers by tracking itself to the highest intensity of sunlight. Eventually, this innovation is automated shut off when it fully charged. This innovation uses solar energy so it very eco-friendly and save the earth from pollution. Furthermore, the structure of the Self-Sustainable GPU is enclosed without any ventilation. Thus, the GPU need the ventilation unit by installing an exhaust fan so that the electronic parts inside it does not damage due to extreme heat. Lastly, this product also will solve the cable management inside the GPU and also the equipment arrangement. Thus, there will be a tidier and clean looking innovation.

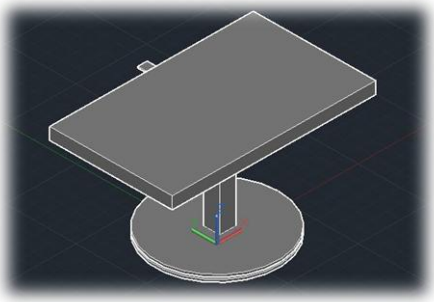

Figure 2 The Solar Tracker View in 3 Dimension (3D)

Due to the existing aviation demands, most of the airliners required to use a portable GPU to supply electrical power to the aircraft (28V of direct current (DC) or 115v 400HZ of alternating current (AC). The rotation of the automatic solar panel is dual

axis that first axis (horizontal) can rotate 360 degrees and 180 degrees (vertical) for the second axis as shown in Figure 2 and Figure 3. This innovation will improve the used of GPU towards a greener and eco-friendly types of GPU that complete with solar tracker for a better performance and maximize the conversion of solar energy to electrical energy.

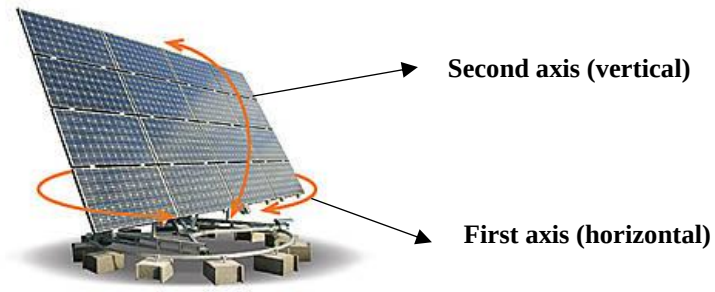

Figure 3 Axis of Solar panel
Source: (http://ample-solar.com/products)

Refers to previous invention, normally ground power unit (GPU) in Figure 4 are manually operated and it use fuel or jet fuel to generate energy. This innovation, the ground power units are using the solar panel to gain energy from the sunlight. Sum up, the panel is automated tracking the intensity of sunlight and has a dual axis system as shown in Figure 5. This innovation also smaller compared to commercial ground power unit (GPU) that was available in aviation industry.

Figure4 Ground power unit used in aviation
Source: (http://www.aerospecialties.com/aviation-ground-support-equipment-gse-products/aircraft-ground-power-units/tld-gpu-409-e-cup-90-kva-diesel-ground-power-unit/)

Besides that, the ground power unit that usually used in aviation field is difficult to operate different with this project, it is easy to operate and automated shut off after fully charge. This innovation is combination between ground power unit (GPU) and solar tracker.

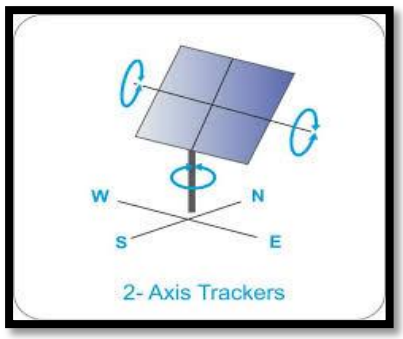

Figure 5 Axis of Rotation

2. Methodology

As the name suggest, the term 'solar' relate to the sun, and the term 'tracker' are something that follow the movement of something. Thus, the combination of 'solar' and 'tracker' means a device that make the solar panel or photovoltaic panel move and follow the direction of sun. The range of tilt will depend on the type of tracker that it uses. The main thing is to be able to moves or tilt the solar panels in the direction of the sun moves throughout the day so that the power that the solar panel produce is maximize and make it more efficient when compare to manually change by human. The simple explanation is the more solar panels that face towards the sun, the more voltage it will generated and also in addition make it efficient.

The use of solar trackers can increase electricity production by around a third, and some claim by as much as 40% in some regions, compared with modules at a fixed angle. In any solar application, the conversion efficiency is improved when the modules are continually adjusted to the optimum angle as the sun traverses the sky. As improved efficiency means improved yield, use of trackers can make quite a difference to the income from a large plant. This is why utility-scale solar installations are increasingly being mounted on tracking systems (Kathie Zipp, 2013).

They are many types of solar tracker depends on the applications. It can be different when the application is for static or moveable. It can be divided into two segments, which is Single Axis Solar Tracker and Dual Axis Solar Tracker. Single Axis Solar Tracker is suitable use when the solar panel fixed and mounted into specific place only. The Single Axis Solar Tracker can either be horizontal axis or vertical axis. The vertical type is commonly used in high latitudes region such as Russia where the sun does not get very, but summer days can be very long. The horizontal type is typically use in tropical regions where the sun gets very high at noon, but the days are short.

Dual Axis Solar Tracker has both axis which is horizontal and vertical axis. Thus, this makes the solar more flexible because it can track the Sun's motion perfectly anywhere. This type of system use microcontroller and so there is a lot of software that available such as Arduino and PIC to automatically sense and estimate the motion of the sun at the sky. This concept of system are exactly been implemented in this innovation (Team ASTS, 2009).

Furthermore, also a Solar Tracker Drives can be classifying into three different types depending on the type of drive and sensing or positioning system that suitable. The first tracker devices are *passive tracker* that uses the sun radiation to heat gases that moves the tracker toward the motion of the sun. Next, *open loop tracker*, which is the devices determine the position of the sun by using the computer controlled algorithms it means that it have set to certain time and knew the position of the sun which is from east to west. Third, is the one that we are focusing are *active trackers*. This device is suitable for our innovation because it measures light intensity from the sun by using sensor or in this case Light Dependent Resistor (LDR) to determine where the solar panel should be pointing. The light sensors are used to compare the difference in light intensity. When it tracked the difference in light intensity it causes the tracker to tilt to the direction that has high light intensity with the help of motor for example our project use servo motor in order the solar panel always positions in the desired angle.

Arduino Uno is a microcontroller board that used for building electronics projects as in Figure 6. Arduino can be programs that can be loaded on to it from Arduino software. Arduino board is based on the ATmega328 which is a single-chip microcontroller. Arduino Uno consists of 20 digital input or output pin that 6 of it can be used as Pulse Width Modulation (PWM) that is basically from analog results with digital means and 6 as analog inputs. The also circuit consist 16 MHz resonator, a USB connection, power jack, in-circuit system programming (ICSP) header and a reset button. Basically, it contains all the need that is use as a microcontroller (Yahya Tawil, 2016).

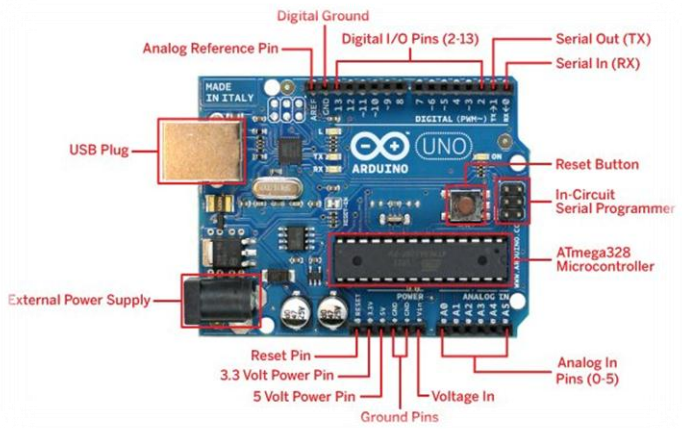

Figure 6 Arduino Uno board

Source: https://www.robomart.com/arduino-uno-online-india

In relation to this innovation, Arduino is the brain that gives the input to servomotor and other operation. The operating voltage for this type of Arduino Uno is 5V that can connect directly to the USB port or also external which mean non-USB either AC-to-DC adapter or battery. Arduino Uno can be programmed with the Arduino Software that can be download from its website. The ATmega328 on this Arduino Uno are preprogrammed with bootloader which is use to upload a new code to it without the use of external hardware programmer. Servo Motor is a special type of motor that operate automatically up to certain limit for a given command with help of error-sensing feedback to correct the performance. Basically, it is a rotary actuator that allow to control an angular motion. Servomotor is a closed loop servomechanism that needs position feedback to control it motion in this situation it uses to control the angle of solar panel. Inside there is a simple set-up: a small DC motor, potentiometer, and a control circuit. The motor is attached by gears to the control wheel. As the motor rotates, the potentiometer's resistance changes, so the control circuit can precisely regulate how much movement there is and in which direction. When the shaft of the motor is at the desired position, power supplied to the motor is stopped. If not, the motor is turned in the appropriate direction. The desired position is sent via electrical pulses through the signal wire. The motor's speed is proportional to the difference between its actual position and desired position. So, if the motor is near the desired position, it will turn slowly, otherwise it will turn fast. This is called proportional control. This means the motor will only run as hard as necessary to accomplish the task. The type of servomotor that we are use is TowerPro MG995R as shown in Figure 7. This Servo motor is a high torque motor that can reach up to 11kg/cm. The servo only weight at 55g that has and operating voltage between 4.8V to 6V. This servomotor uses Metal gear type that is stronger and suitable to our projects that our solar panel is weight about 4 kg.

Figure 7 TowerPro MG995R
Source: (https://www.itead.cc/tower-pro-mg-996r-digital-high-torqe-servo.html)

Light Dependent Resistor (LDR) is a resistor that has a resistance that varies depending of the light intensity. A photoresistor is made of a high resistance semiconductor that absorbs photons and based on the quantity and frequency of the absorbed photons the semiconductor material gives bound electrons enough energy to jump into the conduction band. The resulting free electrons conduct electricity resulting in lowering resistance of the photoresistor. The number of electrons is dependent of the photons frequency. As shown in Figure 8, the resistance is very high in darkness, but when there is light that falls on the LDR, the resistance is falling down and this is how the LDR works (Shahriar Bazyari, et al. 2014). When there is high resistance, the amount of current flow will decrease and when there is low resistance, the amount of current flow will increase. In relation to our project, it will sense the high light intensity to ensure that our solar panel is facing the sun that obviously has high intensity of light (Electrical4u, 2011).

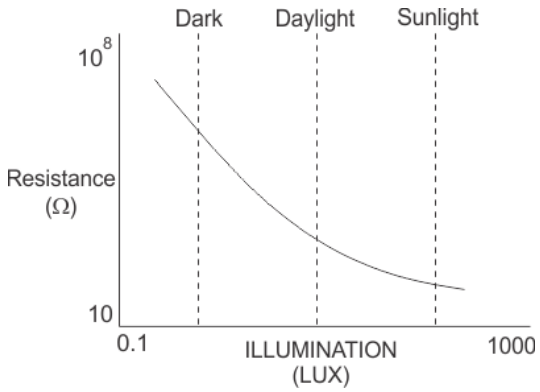

Figure 8 Shows resistance vs illumination curve for a particular LDR
Source: (http://www.electrical4u.com/light-dependent-resistor-ldr-working-principle-of-ldr/)

This innovation is manually and automatic operated. The cart will be move to the place that has sunlight by personnel. This innovation is automatically tracking when the switch is ON. The operation starts when the Light Dependent Resistor (LDR) start to sense the light intensity. When LDR sense the high light intensity and sense the signal to the microprocessor Arduino. The Arduino then will sense the signal to the servomotor to move to the desired angle according to programmed angle. The circuit is shown in Figure 9.

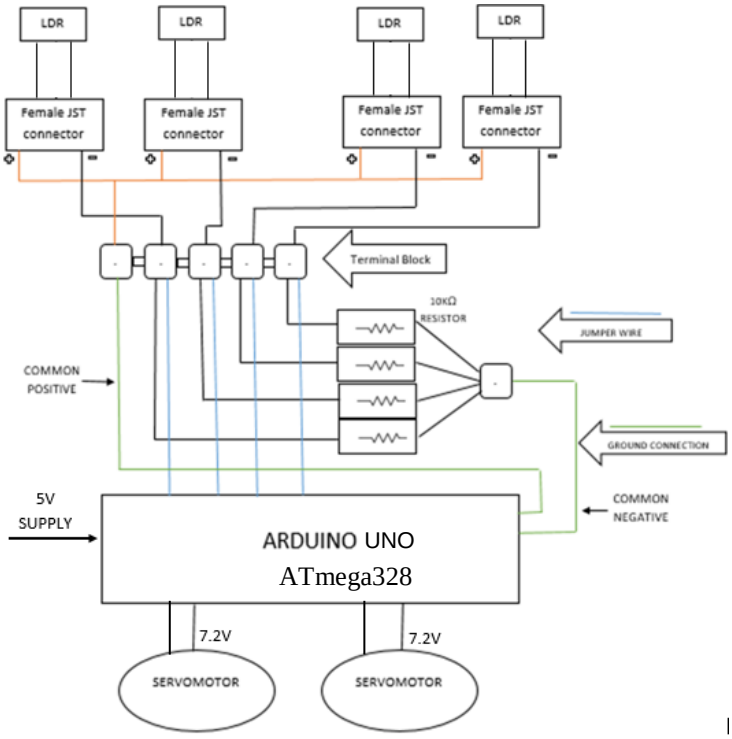

Figure 9 Schematic Block Diagram

The Female JST connect is used to be easily connected to the terminal block and make the connection longer. The terminal block is used easily group up the wire. Furthermore, this innovation comes with dual-axis system that uses two servomotors. The vertical axis servo is use to incline reclined the angle that focus on high light intensity. Next, the lateral-axis is rotatable base that make it more convenience and can be place at any position to detect the sunlight. The LCD connected to Arduino is to display the voltage reading. In addition, the exhaust fan connected to the USB supply and it will start function when the switch of the GPU is ON. Lastly, this project also will work under a rainy weather because of the waterproof that implemented in this innovation.

3. Conclusion

The prime purpose of this product designed is to tracking the light intensity by itself with two angle rotations, 180˚degree for vertical axis and 360˚degree for horizontal axis. As the main used of Ground Power Unit (GPU), it used to recharge different types of batteries with automated shut down when fully charge. It can power up a 5V smartphone as well as a 12V car accumulator. This innovation also can be used to recharge Cessna 172N, 24V battery cells located at Politeknik Banting Selangor (PBS) hangar. This GPU has a maximum capacity of 24V 26Ah. To reach its maximum output capacity, it has to be fully charged by leaving it under the sun for at least eight hours on a sunny day. An external cell can be charged using this product. If it is a smartphone, it just needs to be connected to the USB port available using any suitable USB cables. A 12V car cell can be recharge by connecting the recharge clips to the cell's terminal and switching it to 12V charging at the components setting. Likewise, a 24V Cessna cell can be recharged by connecting the recharge clips to the cell's terminal and switching the GPU to 24V charging mode at the components setting. The solar panel angle can be adjusted by Arduino Uno as the microcontroller. It uses servo motor as a motor to rotate the solar automatically according to the sun directly. The Solar Panel will detect the high intensity of sun by using LDR as a sensor to send the signal to Arduino Uno to rotate the servo to the desired angle. Thus, the charging process will be more efficient that manually adjusted and reduces workload of a personnel.

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