Sun Tracking Solar Panel

Team Number 35

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Team Members

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1 Introduction

1.1 Objective:

During the course of the day, the sun is at different positions. For a stationary solar panel, it gets the maximum surface area of sunlight at only one point during the day. At the other times, the light is then only partially or not absorbed by the solar panel. This is not the most efficient use of the solar panel as there could be more light absorbed at a given time during the day if the solar panel was facing the direction of light as the sun moves. For example, if in the morning, the solar panel faced east, and gradually throughout the day, moved west,mirroring the movement of the sun.

The sun tracking solar panel which we propose to build, solves the issue of sunlight absorption efficiency by tracking the movement of the sun throughout the day using photo sensors on the panel. At night, or at sunset, we will incorporate a reset mechanism to move the sensor back to its original position, so that at sunrise, the panel is ready to absorb the sunlight again. The solar panel will also move on a second axis to follow the sun throughout the year. As the earth orbits the sun, the tilt of the earth causes to sun to be at different vertical positions relative to the panel.

1.2 Background:

Our project is directly related to the projects being undertaken by another group. The product being approached by these groups is to build a streetlight that relies solely on solar panels to power it and accommodates a user application to control when the light is on. Our project will build on the solar panel portion of this product. Our group aims to optimize the amount of stored energy for this stand alone streetlight by introducing a solar panel that tracks the sun throughout the day. This functionality should allow for optimal charging conditions during an entire day. This will benefit the user by allowing more duration and reliability of light. The final product, integrated with the other team, would be something that could be sold to companies that install street lights. This product could be adapted so that the grid replaces the battery and the solar charging panels provide power to the grid and the grid is used to power the system. The product, integrated with the other team, could also be used to provide lighting for third world countries or customers that don't have access to the grid, or want install a new lighting fixture to the grid.

1.3 High-Level Requirements:

- Solar panel must rotate 150 degrees about the z-axis and 45 degrees about the x-axis and required to track movement of the sun.
- Motors must give us 1 degree resolution on both axis. They are required to have a minimum torque of 6 Nm. The feedback from the motors must provide an accurate location of the solar panel of +/- 3 degrees.
- The position of the panel must reset at the end of each day to a horizontal position to begin absorbing light the next day again.

2 Design

Our design consists of a power unit, control unit, and a motor unit. The power unit allows us to charge our Li-ion battery using a solar panel. The battery would allow provide power to the microcontroller allowing us to continuously control the movement of our solar panel even when the panel is not generating power. This microcontroller will take inputs from photosensors allowing us to locate the location of the sun. The microcontroller will then move the solar panel using panels to face the sun.

Block Diagram:

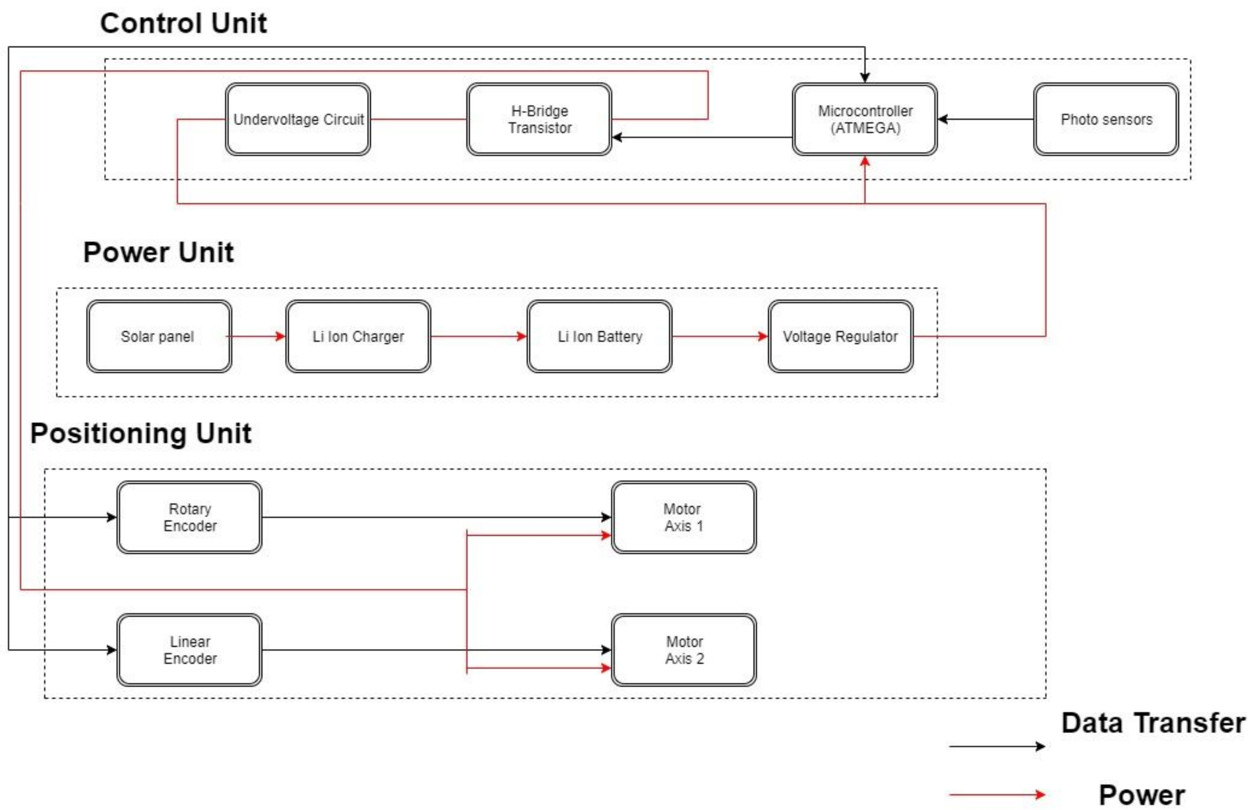

Figure 1: Block diagram of general flow of information and energy

Functional Overview:

Control Unit:

The control unit will receive information from the motors pertaining to current position as well as data from the photosensors that indicate the current light intensity. This feeds into a microcontroller which in turn controls the tilt on the solar panel by varying the angles of the two motors.

Req: Must be able to control the movement of the solar panel within 1 degree, recognize its own position, and when the incident light on the panel is optimized. We want it to control movement to once every hour to minimize power usage from the motors, sensors, and microcontroller. We want the system to read in data for at most the first five minutes of the hours the sensors are getting readings. It will refresh every 5 seconds and the clock will be set to count every second. High level if the 4 sets of detectors are all reading the same non zero value then the panel is in an optimal location. If one of the sensors is higher than the panel will adjust about the vertical axis first and then compensate with the other axis. The value range will be +/- 5% of the average value.

1. Microcontroller
   The microcontroller is responsible for the correct and accurate movement of the motors and in effect, the solar panel. It will need to tell the motors where to move based on the information given from the photo detection sensors and eventually, it will have to co-ordinate the movements between the sensors and the motors. If the solar panel has reached a maneuvering capacity, then the motor has to send a signal back to the microcontroller which will tell it to stop the movement in that particular direction.
   Reqs: 7-12V input and 5V output. Average Power: .5 Watts

2. Photo Sensors
   The sensors are responsible for the detection of the movement of the sunlight. This part of the circuitry is connected to the microcontroller, which will process this information and send the panel to move in the direction of the sunlight.
   We plan to use a TSL261R-LF for our model photosensor chip.
   Req: This has a minimum operating voltage of 2.7V and a maximum operating voltage of 5.5V. It converts the light to volts which can be passed on to the microcontroller. The typical supply current is 1100mA.
   The full specs for this chip are cited at the end of this document.

3. H-Bridge Transistor
   This circuitry will act as a switch to control whether the motors are on or off.
   Reqs: We think that we can manage this with a transistor that uses an input from the microcontroller to open or close.

4. Undervoltage Circuit
   This cirucit will ensure that the voltage coming in from the regulator and transistor is high enough to power the motors. It is essentially a protection against damaging the motors.
   Req: This will be a short circuit if the voltage is above a 5V range, it should become an open if this condition is not met.

Power Unit:

Since we are working in conjunction with another team we have decided that we will take an input from their project that will provide a 12V DC output from a lithium ion battery. We will then provide a connection from the solar panel for the other team's circuit to charge the battery. For testing and demonstrations we will use a DC power supply and oscilloscope to display functionality.
Reqs: Input from a DC source at 12V and output from a solar panel at a maximum of 75-125 watts and max voltage of 12V

1. Solar Panel
   The solar panel will supply enough voltage to charge the 12V battery. We are focusing on charging the battery while the complementary project is focusing on providing the source. *Reqs:* Power range from 75-125 W, 12V, minimal size (40x25x2).

2. DC power supply
   For the final product this will be integrated into the solar streetlight team. They will be providing our DC voltage source. We have decided that this will be done by a lithium ion battery.
   Req: 12V regulated source where the voltage should not exceed 12.5V but can drop to about 7V if necessary.
3. Lithium Ion Charger
   This is connected to the solar panel. It will be collecting the voltage generated from the solar panel and charging the battery.
4. Lithium Ion Battery
   This is being charged by the Lithium Ion charger and will in turn power the street lamp that is connected to this battery.

Positioning Unit:

The positioning unit will be the physical control, the physical mounting of the panel, and the current tilt of the panel.

Reqs: We intend to monitor the position of the panel by using a pair of DC motors with feedback. The motors will tell the microcontroller the exact position of the panel, which we will use to monitor the movement and make it stop or move, etc.

1. Motors axis 1 & 2

   These are in charge of the movement of the solar panel. There will be a two way feedback loop between the microcontroller and the motor so that the movement of the solar panel is executed in an orderly and controlled fashion.

   Reqs: The motors will be 12V DC and should have minimal current draw (<2.5A). There will be two of these for both axis of motion. The motor must also be able to provide feedback on its position to the microcontroller. The estimate minimum torque required of these motors is around 5.5 Nm for the angular motor and about 6 Nm for the radial turn motor. The motors will be able to resolve to about 1 degree. Our margin of error for the degree angle can be within +/- 3 degrees.

2. Solar Panel Movement Fixture

   The solar panel fixture will move along two axes of motion.

   Req: A mechanical build that will change the radius from the center mount and the angle about that mount. The radius adjustment will create a max angle of 45 degrees and a minimum of 0 degrees when looking in the negative Z direction. The polar angle will range from 15 degrees to 165 degrees when looking in the positive Z direction.

3. Rotary and Linear Encoder

   Provide feedback from the 2 motors to the microcontroller.

   Req: Must be accurate within +/- 3 degrees of the actual position of the panel.

Risk Analysis:

Tracking the sun is a significant risk to successful completion of this project. Tracking the sun can be difficult as the weather changes day to day. We will design our sensors in a way to track the sun, however on a cloudy day this can be a challenge. We plan to compare the voltages registered by the photosensors. There is not a minimum threshold voltage we plan on using right now. We want to quantitatively measure the voltage output from each sensor and align the solar panel in a way such that the panel faces the side with the sensor that reads the most voltage. Possible inaccuracies could result from foreign objects in the sky casting shadows (birds, planes, etc.) and clouds, as we mentioned earlier. We would implement our sensors to follow the brightest point in the sky. This would maximize the amount of power we can generate with the solar panel. The tracking system must also do this accurately without using large amounts of power. These requirements are difficult because weather changes day to day and throughout the entire year.

Ethics & Safety:

A major component of our project will be to collaborate with another team to ensure that when integrated the product will be able to operate as we have described. This follows from the IEEE code of ethics item number item number 7. We want to make sure that we are able to wC we express any concerns that the customer may have with the final product. One issue that we came across early on was the operating ranges of the batteries that we intended to use. It became clear that there was a very strong likelihood that the extreme cold of Minnesota could cause an unsafe usage of the batteries. Some other safety considerations include the possibility of birds or other animals walking by and getting stuck in the wiring or the set up. Damage from hail,water, and snow is another area that could damage this unit. For this, we plan to put the motor and other wires into a sealed unit that will provide some protection. This will provide at least a first level of deterrence from external obstacles. We wanted to make sure that the customer and the other team were made aware of this. This follows the IEEE code of ethics item number 1 and 10. In regards to our stand alone product we want to make sure that we are in constant communication with the customer to make sure that their opinions and decisions are made clear. This follows item number 2 from the IEEE code of ethics.

Bibliography:

[1]"TSL261R-LF by ams AG | Sensors", Arrow.com, 2017. [Online]. Available: https://www.arrow.com/en/products/tsl261r-lf/ams-ag?utm_source=google&utm_campaign=g-shp-us-sensors&utm_medium=cpc&utm_term=PRODUCT+GROUP&gclid=EAIaIQobChMIv96qq5i31gIVC1uGCh1l7QyFEAQYBSABEgJIa_D_BwE&gclsrc=aw.ds&dclid=CIWo_bKYt9YCFVCQaQod-w8EYw. [Accessed: 22- Sep- 2017]

[2]"IEEE IEEE Code of Ethics", Ieee.org, 2017. [Online]. Available: http://www.ieee.org/about/corporate/governance/p7-8.html. [Accessed: 22- Sep- 2017]