

# Solar Powered Patio Umbrella

Project Proposal

Group #37

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## **1.0 Introduction**

### **1.1 Statement of Purpose**

In recent years, electricity prices have skyrocketed and will continue to increase in the future. What better way to save money than to use solar energy. In addition to financial benefits, the use of renewable energy, in particular, solar energy will benefit our environment. Nowadays, the majority of the world depends on electricity supply generated from fossil fuels. These means of electrical production have raised growing environmental concerns over the climate change risks. It is time to make a change and Go Green!

The goal of this project is to develop a solar powered patio umbrella that has a multitude of features that include USB ports, LED lighting system, and a solar tracking system for optimal power generation. This product will be powered entirely on solar energy.

### **1.2 Features**

Currently, there is no product like this in market. Unlike other commercially available solar powered umbrellas, this patio umbrella will include several other features as discussed below:

- 1- Maximum power point tracking (MPPT) built in
- 2- LED lighting system
- 3- USB ports
- 4- Sun tracking ability

### **1.3 Benefits**

- 1- Save the environment by using renewable energy
- 2- Save money
- 3- Charge devices anytime using the USB hub
- 4- Optimize solar power using the sun tracking capability
- 5- Lighting system that is controllable through a dimmer
- 6- Optimize the charging capabilities for the battery by using an MPPT control

## 2.0 Design

### 2.1 Block Diagram

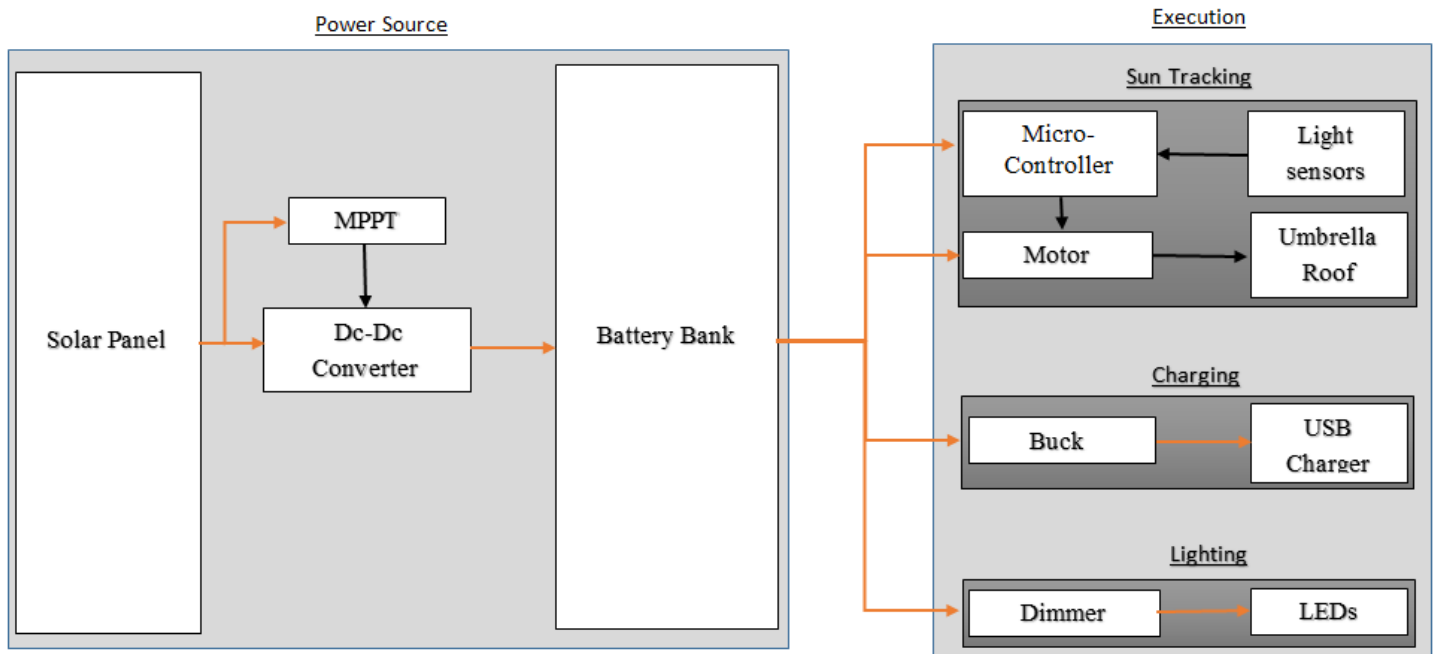


Figure 1: Block Diagram

Black: Signal Output

Orange: Power lines

### 2.2 Block Description

#### 2.2.1 Power Source

- **Solar Panel:** The Solar Panel is designed to absorb the sun's rays as a source of energy for generating electricity. The Solar panel will output 5V and 230mA to the MPPT control and the DC-DC converter.
- **DC-DC converter:** This module is intended to step up the voltage from 5V to 12V to charge the battery bank. The MPPT will optimize this output.
- **MPPT Control:** The MPPT (Maximum Power Point Tracker) is a device, which optimizes the match between the solar array (PV panels) and the battery bank.
- **Battery Bank:** The function of this device is to store up to 35Ah of energy that it receives from the DC-DC converter and distributes 12V and up to 60W of power to the other devices within the system.

### 2.2.2 Execution

*Lighting:* These modules will provide the user the ability to determine the desired lightning intensity.

- Dimmer: The function of the dimmer is to adjust the luminous flux to control the luminosity of the LEDs. It receives 12 V from the battery. Based on internal PWM design, it will reduce the voltage output to the LEDs.
- LEDs: (Light-Emitting Diode) The role of the LEDs will be to give of light when turned on. It receives the set power from the Dimmer.

*Charging:* These modules will provide the user the ability to charge various devices through a USB port.

- Buck converter: The device is used to step down the voltage from the battery bank from 12 V – 5 V in order to supply 5 V to the USB hub.
- USB hub: This module is designed to get 5V from the buck-converter and is intended to be used as a charging port.

*Tracking:* The purpose of these modules is to optimize the use of the solar panels. It is designed to face the sun at all times

- Microcontroller: A TI-MSP430 will be used as the microcontroller. This device will be programmed to receive the input from the LDRs, and use this information to control the motor in order for the solar panels to face the sun at all times.
- Light Sensors (LDR): LDR works in the way that when the light is shown on the resistor the resistance of the sensor decreases, allowing current to pass through it. This drop in resistance is then communicated to the microcontroller, which in turns activates the motor to position the roof of the umbrella towards the sun.
- Motor: The purpose for the motor will be to move the roof of umbrella towards the sun in order to maximize solar power that is stored in the battery. This module will receive 12V from the battery bank. It will be triggered by the microcontroller.

### 3.0 Requirements and Verification

	Requirement	Verification	Points
Solar Panel	<ul style="list-style-type: none"> <li>• Output a voltage 5V +/- 1V</li> <li>• Output a current 215 mA +/- 15 mA</li> </ul>	<ol style="list-style-type: none"> <li>1- Connect a multimeter in parallel with the output terminals of the solar panel</li> <li>2- Verify the output voltage to be 5V +/- 1V</li> <li>3- Connect a multimeter in series with the output terminals of the solar panel</li> <li>4- Verify the output current to be 215 mA +/- 15 mA</li> </ol>	10

MPPT	<ul style="list-style-type: none"> <li>Supply the battery with 12V +/- 1.5V</li> </ul>	<ol style="list-style-type: none"> <li>Hook up MPPT to power source.</li> <li>Set voltage of power source to be 17V</li> <li>The output of the MPPT should read 12V +/- 1.5V</li> <li>Set voltage of power source to be 9V</li> <li>The output of the MPPT should read 12V +/- 1.5V</li> </ol>	20
Battery	<ul style="list-style-type: none"> <li>The battery should output a constant 12VDC +/- 1V</li> <li>The battery should output 60 W +/- 5W at any given time</li> </ul>	<ol style="list-style-type: none"> <li>Connect a multimeter in parallel with the output terminals of the battery.</li> <li>Verify the output voltage to read 12V +/- 1V</li> <li>Measure the current and voltage across the battery using a multimeter.</li> <li>Compute the power using <math>P = IV</math></li> <li>Check to see if the output power is 60W +/- 5W</li> </ol>	20
Microcontroller	<ul style="list-style-type: none"> <li>Output 5V +/- 0.5V to the motor when LDR's resistance is between 21 k<math>\Omega</math> +/- 9 k<math>\Omega</math></li> </ul>	<ol style="list-style-type: none"> <li>Program controller to get a preset input from the LDR of 21 k<math>\Omega</math> for 10 seconds by using a timer</li> <li>Check to see if the motor turns on and starts moving</li> <li>After 10 seconds, program the controller to get an input of 500 k<math>\Omega</math>.</li> <li>Check to see if motor stops</li> </ol>	20
Motors	<ul style="list-style-type: none"> <li>Produce a torque of 10 kg.cm +/- 1 kg.cm to move the umbrella</li> </ul>	<ol style="list-style-type: none"> <li>Find the voltage, current using a multimeter</li> <li>Use <math>\tau = (I * V * E * 60) / (rpm * 2\pi)</math> to calculate torque, where efficiency is 60% from the data sheet</li> <li>Make sure we have a torque of 10 kg.cm +/- 1 kg.cm to move the umbrella</li> </ol>	20
Sensors	<ul style="list-style-type: none"> <li>LDR should record a resistance of 500 k<math>\Omega</math> +/- 10 k<math>\Omega</math> ohms when no light</li> <li>LDR should record a resistance of 21 k<math>\Omega</math> +/- 9 k<math>\Omega</math> when light is shown directly on the LDR</li> </ul>	<ol style="list-style-type: none"> <li>Build a simple circuit and record resistance on a multimeter</li> <li>The multimeter should output a resistor of 500 k<math>\Omega</math> +/- 10 k<math>\Omega</math>.</li> <li>Shine light on the circuit</li> <li>The multimeter should output a resistance of 21 k<math>\Omega</math> +/- 9 k<math>\Omega</math></li> </ol>	10

#### 4.0 Tolerance Analysis

Assuming that the PV solar panels are working in its nominal conditions, they will provide:

$$P_{panels} = 5 * (5V * 230 mA) = 5,750 mW = 5.75 W$$

The design includes a MPPT control, which optimizes the match between the solar array (PV panels), and the battery bank. The efficiency of this MPPT control is 97% +/- 1%. With an efficiency of 97%, it will provide the battery with,

$$P_{MPPT} = 5.75 W * 0.97 = 5.58 W$$

We plan to build our prototype using a LP12-35/NB battery, with a nominal output of 12V and a nominal capacity of 35 Ah. The battery will store

$$P_{Battery} = 12 V * 35 Ah = 420 Wh$$

Assuming that the battery is not ideal, its efficiency is around the 85%:

$$P_{Battery-Real} = 0.85 * 5.58 W = 4.74 W$$

To conclude, the time that the solar panels would work to fully charge the battery would be:

$$t = \frac{420 Wh}{4.74 W} = 88.59 h$$

Assuming now that the efficiency of the MPPT is 96% since the tolerance level is +/- 1%. Repeating the calculations made before:

$$P_{MPPT} = 5.75 W * 0.96 = 5.52 W$$

$$P_{Battery-Real} = 0.85 * 5.52 W = 4.692 W$$

$$t = \frac{420 Wh}{4.692 W} = 89.51 h$$

It can be observed that with a higher efficiency, a lower time is needed for fully charging the battery. If the efficiency goes below 96%, it will take longer time for the battery to be charge, which may interfere with the design of our system.

Also as we know that the voltage provided from the MPPT is not exactly 12 V as its tolerance is +/- 1.5 V. It will not happen nothing as the battery is prepared for this changes. It may damage the battery cells and hence reducing the battery life.

## 5.0 Cost and Schedule

### 5.1 Labor

Name	Hourly Rate	Hours Invested	Total = Hourly Rate x 2.5 x Total Hours Invested
Viren Mascarenhas	\$ 27.5	150	\$ 10,312.5
Christian Ngeleza	\$ 27.5	150	\$ 10,312.5
Luis Pe-Ferrer	\$ 27.5	150	\$ 10,312.5
<b>TOTAL</b>	<b>-</b>	<b>450</b>	<b>\$ 30,937.5</b>

#### 4.2 Parts

Item	Quantity	Cost
Patio Umbrella	1	\$ 56.99
Solar Panel	5	\$ 49.75
Battery	1	\$ 44.89
Microcontroller	1	\$ 10.37
MPPT	1	\$ 67.50
USB (Buck Converter)	1	\$ 6.99
LEDs (LED Driver)	12	\$ 47.88
Motor	1	\$ 8.99
Dimmer	1	\$ 12.99
Light Sensor (LDR)	4	\$ 3.16
<b>TOTAL</b>	-	<b>\$ 309.52</b>

#### 4.3 Grand Total

Section	Total
Labor	\$ 30937.5
Parts	\$ 309.52
<b>Grand Total</b>	<b>\$ 31292.26</b>

#### 4.4 Schedule

Week	Task	Responsibility
2/8	• Set up Meeting With Solar Expert	Christian Ngeleza
	• Look Up Parts for Project	Luis Pe-Ferrer
	• Complete Proposal	Viren Mascarenhas
2/15	• Design interaction between sun tracking modules	Christian Ngeleza
	• Order Parts	Luis Pe-Ferrer
	• Design Test Environment for Power Source	Viren Mascarenhas
2/22	• Assemble Charging modules	Christian Ngeleza
	• Assemble Lighting modules	Luis Pe-Ferrer
	• Start PCB Design	Viren Mascarenhas
2/29	• Begin Writing logic code for sun tracking modules	Christian Ngeleza
	• Assemble Power Source Modules	Luis Pe-Ferrer
	• Continue PCB Design	Viren Mascarenhas
3/7	• Continue writing Logic code for sun tracking module	Christian Ngeleza

	<ul style="list-style-type: none"> <li>• Start Test for Power Source</li> </ul>	Luis Pe-Ferrer
	<ul style="list-style-type: none"> <li>• Finalize PCB Design</li> </ul>	Viren Mascarenhas
3/14	<ul style="list-style-type: none"> <li>• Finalize logic code for sun tracking module</li> </ul>	Christian Ngeleza
	<ul style="list-style-type: none"> <li>• Optimize Power Source Interaction based on test results</li> </ul>	Luis Pe-Ferrer
	<ul style="list-style-type: none"> <li>• Assemble Motor, LDR, Micro-controller and Umbrella Interface</li> </ul>	Viren Mascarenhas
3/21 Spring Break	<ul style="list-style-type: none"> <li>• Optimization of code based on experts' suggestions/results</li> </ul>	Christian Ngeleza
	<ul style="list-style-type: none"> <li>• Optimization of code based on experts' suggestions/results</li> </ul>	Luis Pe-Ferrer
	<ul style="list-style-type: none"> <li>• Optimization of code based on experts' suggestions/results</li> </ul>	Viren Mascarenhas
3/28	<ul style="list-style-type: none"> <li>• Starting test of sun tracking modules based on code</li> </ul>	Christian Ngeleza
	<ul style="list-style-type: none"> <li>• Start testing interaction between power source and Execution modules</li> </ul>	Luis Pe-Ferrer
	<ul style="list-style-type: none"> <li>• Start assembling modules together</li> </ul>	Viren Mascarenhas
4/4	<ul style="list-style-type: none"> <li>• Modular Testing for lighting modules</li> </ul>	Christian Ngeleza
	<ul style="list-style-type: none"> <li>• Final optimization of Power Source and Execution modules interface</li> </ul>	Luis Pe-Ferrer
	<ul style="list-style-type: none"> <li>• Modular Testing for charging modules</li> </ul>	Viren Mascarenhas
4/11	<ul style="list-style-type: none"> <li>• Assemble all modules</li> </ul>	Christian Ngeleza
	<ul style="list-style-type: none"> <li>• Prepare Demos</li> </ul>	Luis Pe-Ferrer
	<ul style="list-style-type: none"> <li>• Optimize code based on test results</li> </ul>	Viren Mascarenhas
4/18	<ul style="list-style-type: none"> <li>• Finish Demos preparation</li> </ul>	Christian Ngeleza
	<ul style="list-style-type: none"> <li>• Finalize debugging of code</li> </ul>	Luis Pe-Ferrer

	<ul style="list-style-type: none"> <li>• Finalize circuit optimization</li> </ul>	Viren Mascarenhas
4/25	<ul style="list-style-type: none"> <li>• Start Final Paper</li> </ul>	Christian Ngeleza
	<ul style="list-style-type: none"> <li>• Make sure Demonstration is ready</li> </ul>	Luis Pe-Ferrer
	<ul style="list-style-type: none"> <li>• Start Presentation</li> </ul>	Viren Mascarenhas
5/2	<ul style="list-style-type: none"> <li>• Finish Final Paper</li> </ul>	Christian Ngeleza
	<ul style="list-style-type: none"> <li>• Finish Presentation</li> </ul>	Luis Pe-Ferrer
	<ul style="list-style-type: none"> <li>• Proof read all documentation</li> </ul>	Viren Mascarenhas