runlinc Intermediate Project 3: Wind Power (STEMSEL Version)

Contents

Introduction

Problem

We want to create an electricity generator that does not produce any greenhouse gasses.

Background

We all use electricity every day for all sorts of different purposes, but did you ever stop to think what electricity is made of, and where it comes from? You can find out in the following video: https://youtu.be/ru032Mfsfig.

The word electricity derives from the word *electron.* If you have already learned about atoms, you may have heard of electrons before. Atoms are the tiny particles that make up the world around us, and they are made up of three even smaller particles. The positive *protons* and the neutral *neutrons* are clumped in the middle of the atom and make up the nucleus. The negative electrons orbit around the nucleus. Figure 1[1] shows a well-known simplified model of an atom; however, advances in physics, in the quantum field, reveals a more detailed model that helps us understand more about an atom's behaviour.
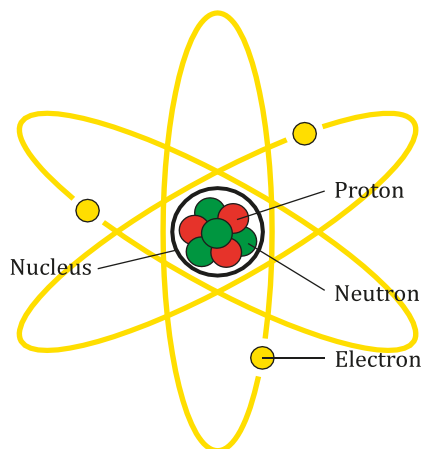

Figure 1 A simplified model of an atom.

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[1] https://commons.wikimedia.org/wiki/File:Atom_Diagram.svg

In certain types of materials, the electrons are only loosely attached to their atoms, and if given a little nudge can move from one atom to another. These materials are called conductors, and it is those loosely bound electrons that allow them to conduct electric current. The moving electrons are what we call electricity, and voltage is how we measure the strength of the push. You can see how moving electrons work in figure 2[2].
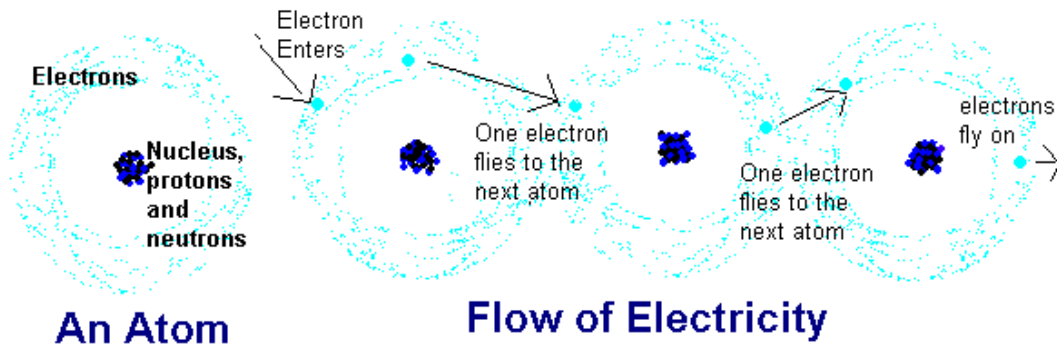

Figure 2 A simplified view on flow of electricity (moving electrons).

So, how can we give these electrons the push they need to become electricity? While there are several ways, one of the most used methods is to pass a magnet close to a metal wire.

The magnetic field generated by the magnet can give the electrons the energy they need to flow from one atom to the next, but only while the magnet is passing by. In this way, the kinetic (movement) energy of the magnet is turned into electrical energy. To continually pass the magnet through the wire, it can be attached to a shaft which is then rotated at high speed. Can you think of something in your kit that rotates at high speed?

Figure 3 STEMSEL Motor with Fan.

The DC motor in your kit, check figure 3, uses this same principle typically in reverse to turn electrical energy into movement energy and spin around. For this project, we want to use the fan on the motor to make electricity. Large fan-like objects called wind turbines are used in some areas as an environmentally friendly source of electricity. Since wind turbines only use the wind, they do not burn fossil fuels and therefore do not produce any greenhouse gases, making them better for the environment than other types of electricity generators. You can find out about wind turbines here: https://youtu.be/qSWm_nprfqE.

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[2] http://www.qrg.northwestern.edu/projects/vss/docs/power/2-whats-electron-flow.html

Ideas

How should we connect the fan to the STEMSEL controller board? Will the electricity be an input or an output? How can we display how much electricity is being produced?

Plan

We will use the fan to generate the voltage and hence electricity. However, we will need to use this as an input to the microchip. We will display the exact voltage the motor can produce on the browser. But when we aren't looking at the browser, we will not be able to view the precise voltage, but we can use several LEDs to display several voltage levels.
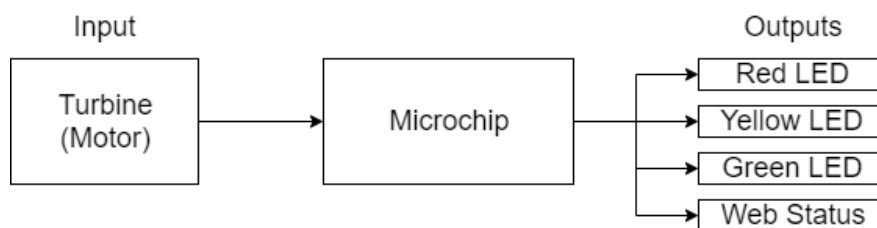

Figure 4 I/O Plan for this project.

Therefore, if the voltage is above the first threshold one LED will be on, two LEDs will be on if it's above the second threshold, and all three LEDs will be on if the voltage rises above the third threshold.
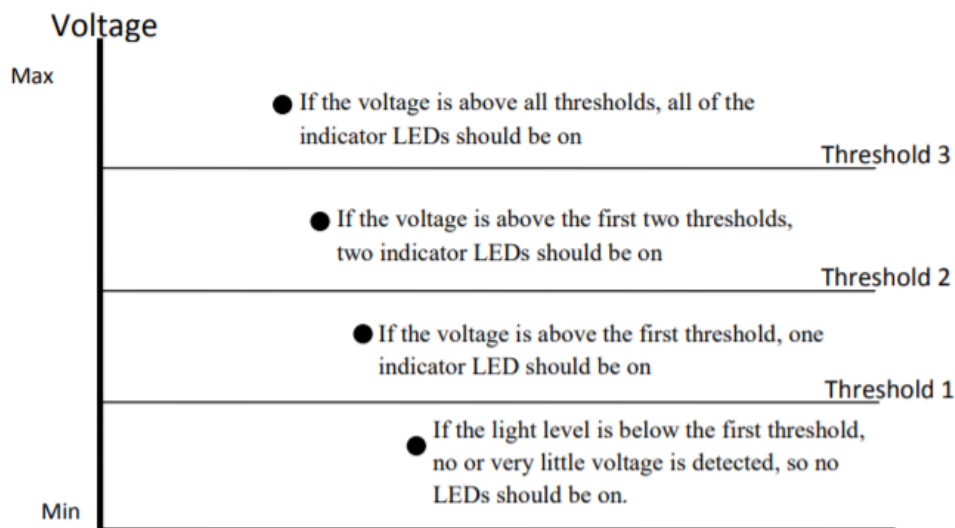

Figure 5 Threshold implementation graph.

runlinc Background

Runlinc is a web page inside a Wi-Fi chip. The programming is done in the browser and sent to the chip over Wi-Fi. The runlinc web page inside the Wi-Fi chip will command the microchips to do sensing, control, data logging Internet of Things (IoT). It can predict and command.

Part A: Design the Circuit on runlinc

Note: Refer to runlinc Wi-Fi Setup Guide document to connect to runlinc
Use the left side of the runlinc web page to construct an input/output (I/O).

In our circuit design,

❖ C7 -> ANALOG_IN: Turbine

❖ C3 -> DIGITAL_OUT: Green

❖ C4 -> DIGITAL_OUT: Red

❖ C5 -> DIGITAL_OUT: Yellow

C3	DIGITAL_OUT ⬦	Green	OFF
C4	DIGITAL_OUT ⬦	Red	OFF
C5	DIGITAL_OUT ⬦	Yellow	OFF
C6	DIGITAL_OUT ⬦		OFF
C7	ANALOG_IN ⬦	Turbine	0

Figure 6 Expected I/O Configuration.

Part B: Build the Circuit

Use the runlinc I/O to connect the hardware. Remember that turning the screws clockwise will close the clamps and turning the screws anticlockwise will open them. All black wires should go in the negative (-) terminal, red wires go in the positive (+) terminal, and white wires go in the terminal we designated in the runlinc web page port.

Figure 7 Circuit connection on STEMSEL.

Wiring Instructions

❖ Connect All White Wires to their Respective Pins
  ➢ Turbine -> C7
  ➢ Green LED -> C3
  ➢ Yellow LED -> C5
  ➢ Red LED -> C4
❖ Connect All Black Wires to negative (-) terminal.

Part C: Program the Circuit

HTML:

Before we program the logic into STEMSEL board, we will first set up an HTML page.

1. Set up the text of the page to the centre of the headline:

```
<div style="text-align:center">
  <h1>Wind Power dashboard by runlinc</h1>
</div>
```

2. Within the <div></div> tags we will setup headings and body texts with respective unique IDs and we'll place a circle which will indicate the same light color as the LEDs:

```
<p>
Instantaneous Power: <font id="currPower"></font> Watt
<br>
Turbine Status: <font id="status">Retrieving Status</font>
<br>
<svg height="25" width="25"><circle id="statusIndicator" r="10" cx="12.5"
cy="12.5" stroke="black" stroke-width="3" fill="black" />
</svg>
<br>
<br>
<hr>
<br>
Power Generated: <font id="accPower"></font> Watt
</p>
```

3. Then, after </svg> and the first <br> we will add input elements that will help us to easily change the limit of the wind power to meet the threshold of that value:

```
Max Idle Limit: <input id="cap_0" step="0.01" type="number" min="0" max="5"
value="0.05"><br>
Near Capacity Limit: <input id="cap_1" step="0.01" type="number" min="0"
max="5" value="0.3"><br>
Max Capacity Limit: <input id="cap_2" step="0.01" type="number" min="0"
max="5" value="0.4"><br>
```

JavaScript Block:

We will initialise three variables that will be used in JavaScript loop.

```
var capacity = [0.05, 0.3, 0.4];
var totalPower = 0;
var currentPower = 0;
```

JavaScript Loop:

Then we will program the code into STEMSEL board using the JavaScript loop.

1. We will first retrieve the limit from the input boxes. It will be used to determine the threshold of each stage of the wind turbine.

```
for(var i = 0; i<2; i++){
    capacity[i] = document.getElementById("cap_" + i).value;
}
```

2. We will now retrieve the values of the motor and process it such that it is within 0 to 5 range by dividing the value by 51 and is read to 2 decimals.

```
currentPower = analogIn( Turbine );
currentPower = currentPower / 51;
showValue = currentPower.toFixed(2);
document.getElementById("currPower").innerHTML = showValue;
```

3. Next, for the first threshold, when the turbine is barely running. Compare the current power to the first limit which is the limit to indicate it is running. If it is more than the limit, indicate it is running and light up green. Or else, it is less than the limit indicate that it is not running and the circle will be black.

```
if (currentPower > capacity[0]){
    turnOn( Green );
    document.getElementById("status").innerHTML = "Turbine spinning at
acceptable capacity.";
    document.getElementById("statusIndicator").style.fill = "green";
}else{
    turnOff( Green );
    document.getElementById("status").innerHTML = "Turbine seems to be not
spinning.";
    document.getElementById("statusIndicator").style.fill = "black";
}
```

4. The second threshold is when the turbine is running near capacity, we will compare the current power to the second limit. If the threshold is met, light up yellow on both the circle and the LED and indicate that it is running at the status text. If the threshold isn't met, turn off the yellow LED.

```
if (currentPower > capacity[1]){
    turnOn( Yellow );
    document.getElementById("status").innerHTML = "Turbine spinning at near
capacity.";
    document.getElementById("statusIndicator").style.fill = "yellow";
} else {
    turnOff( Yellow );
}
```

5. The third threshold is when the turbine is running at max capacity, we will compare the current power to the third limit. Similar to the last step, light up red and indicate the threshold if the threshold is met or turn off the red LED if it is not met.

```
if (currentPower > capacity[2]){
   turnOn( Red );
   document.getElementById("status").innerHTML = "Turbine spinning at max
capacity.";
   document.getElementById("statusIndicator").style.fill = "red";
} else {
   turnOff( Red );
}
```

6. And lastly, we will accumulate the power that has been measured. We will show the value to 2 decimal places. We will also add a delay to avoid very fast measurements.

```
totalPower = totalPower + currentPower;
document.getElementById("accPower").innerHTML = totalPower.toFixed(2);
await mSec( 50 );
```

Bonus

What happens if you use your finger to turn the fan in the opposite direction? Do any of the LEDs turn on? No matter how fast the fan turns, none of the LEDs will turn on if it spins backwards. This is because when the fan spins in reverse, the electricity flows the other way, and the microchip can't detect it. We found that the faster the fan spins, the more electricity is generated. What other factors affect the amount of electricity made by wind turbines? To find out, follow this link:

http://environment.nationalgeographic.com.au/environment/global-warming/wind-powerinteractive/

Summary

By using a magnetic field to interact with the conductive wire, the fan can turn one form of energy into another, either movement energy into electricity, or electrical energy into movement. During this project, we found that the harder we blew on the fan, the faster it spins around, and the more electricity was made, shown by all three LEDs turning on. Wind turbines work in the same way to create electricity without producing greenhouse gases.

Appendix – Expected Results

Wind Power dashboard by runlinc

Instantaneous Power: 0.00 Watt
Turbine Status: Turbine seems to be not spinning.

⚫

Max Idle Limit: 0.05
Near Capacity Limit: 0.3
Max Capacity Limit: 0.4

Power Generated: 0.00 Watt

Figure 8 Expected HTML Result.

Figure 9 Expected runlinc result.

JavaScript Block:

```
var capacity = [0.05, 0.3, 0.4];
var totalPower = 0;
var currentPower = 0;
```

HTML block:

```
<div style="text-align: center;">
  <h1>Wind Power dashboard by runlinc</h1>
  <p>
    Instantaneous Power: <font id="currPower"></font> Watt
    <br>
    Turbine Status: <font id="status">Retrieving Status</font>
    <br>
    <svg height="25" width="25"><circle id="statusIndicator" r="10" cx="12.5" cy="12.5"
stroke="black" stroke-width="3" fill="black" />
    </svg>
    <br>
    Max Idle Limit: <input id="cap_0" step="0.01" type="number" min="0" max="5"
value="0.05"><br>
    Near Capacity Limit: <input id="cap_1" step="0.01" type="number" min="0" max="5"
value="0.3"><br>
    Max Capacity Limit: <input id="cap_2" step="0.01" type="number" min="0" max="5"
value="0.4"><br>
    <br>
    <hr>
    <br>
    Power Generated: <font id="accPower"></font> Watt
  </p>
</div>
```

JavaScript Loop Block:

```
for(var i = 0; i<2; i++){
  capacity[i] = document.getElementById("cap_" + i).value;
}
currentPower = analogIn( Turbine );
currentPower = currentPower / 51;
showValue = currentPower.toFixed(2);
document.getElementById("currPower").innerHTML = showValue;
if (currentPower > capacity[0]){
  turnOn( Green );
  document.getElementById("status").innerHTML = "Turbine spinning at acceptable capacity.";
  document.getElementById("statusIndicator").style.fill = "green";
}else{
  turnOff( Green );
  document.getElementById("status").innerHTML = "Turbine seems to be not spinning.";
  document.getElementById("statusIndicator").style.fill = "black";
}
if (currentPower > capacity[1]){
  turnOn( Yellow );
  document.getElementById("status").innerHTML = "Turbine spinning at near capacity.";
  document.getElementById("statusIndicator").style.fill = "yellow";
} else {
  turnOff( Yellow );
}
if (currentPower > capacity[2]){
  turnOn( Red );
  document.getElementById("status").innerHTML = "Turbine spinning at max capacity.";
  document.getElementById("statusIndicator").style.fill = "red";
} else {
  turnOff( Red );
}
totalPower = totalPower + currentPower;
document.getElementById("accPower").innerHTML = totalPower.toFixed(2);
await mSec( 50 );
```