Mechanical Crank Position Locator

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1 Introduction

1.1 Objective

Engineering Open House is a time of the year when students ranging from elementary school to university level get to see the wonders of engineering, inspiring them to pursue STEM courses and clubs as they get older. The Engineering Open House exposes children to STEM fields via different demonstrations of science principles. However, unlike some of the experiments that college students perform, these demonstrations are meant to be fun and educational. One such experiment that students can play around with is a hand crank generator. This generator is simply constructed with a set of coils which rotate in a strong magnetic field. The output of the generator can be displayed onto an Oscilloscope which shows two sinusoidal waves. Children can have fun cranking the handle to alter the amplitude of the waves. This simple experiment not only shows students how we derive electricity, but it also exemplifies the importance of electrical engineering to humanity.

Although this experiment is already phenomenal, we want to take this demonstration a step further for the next Engineering Open House. In addition to displaying sin waves, we also want to demonstrate the relationship between the position of the crank and the current output to the Oscilloscope. To do this, we need to display the position of the crank on the Oscilloscope in a way that children can understand it well. Taking this a step further, we also want to display the angular velocity of the crank in both rotations per minute (RPM) as well as radians per second (rads/s). This addition to the current Engineering Open House demonstration will allow people to understand the relationship between the crank speed, crank location, and current generator in more depth.

1.2 Background

Currently the Engineering Open House demonstration does an average job in communicating to students the concepts which lead to current generation. However, we want to give more insight to students on how the components in generator relate to one another. Some students know about how the speed and position relate to the current waveform. However, almost none of them have seen the relationship visually.

By building our solution, we will be able to show EOH visitors how everything regarding energy is related to one another. More specifically, how mechanical movements directly translates to output energy. We will make sure that our solution does not distract from the actual demonstration and only adds information for the students.

1.3 High-Level Requirements

- The circuit must be able to output the correct velocity of the crank in both RPMs and rads/sec.
- The circuit must attach onto the current generator setup without blocking the internals of the generator.
- The circuit must output the location of the crank to the oscilloscope in a manner that is understandable to children.

2 Design

We have broken down our solution into three modules: the position locator/display, the generator and the oscilloscope. For the purposes of this project we can treat the generator as a black box. All we know is that the our circuit (the position locator) and the oscilloscope will get outputs from this. The position locator will be able to get the crank speed using a encoder while the oscilloscope will get the current generator. The oscilloscope will also get a voltage output from the position locator so it can display it onto the screen. Finally, the position locator circuit will output a variable voltage that will be used to display the position onto the oscilloscope.

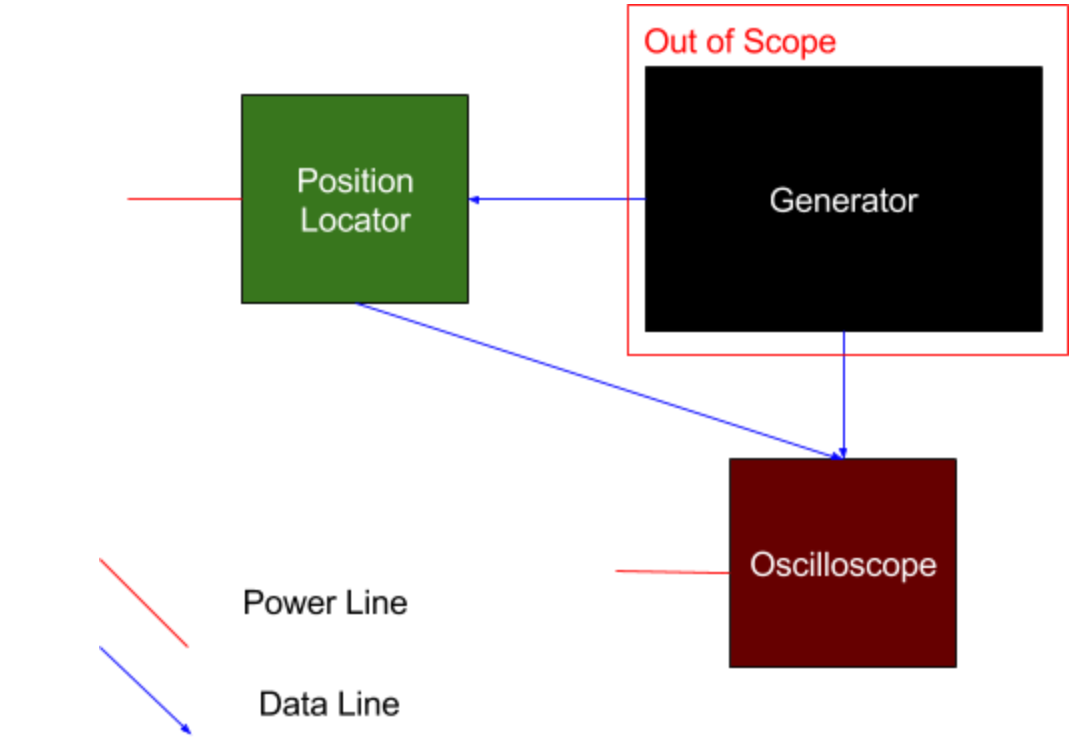

Figure 1: High Level Abstraction of Complete System

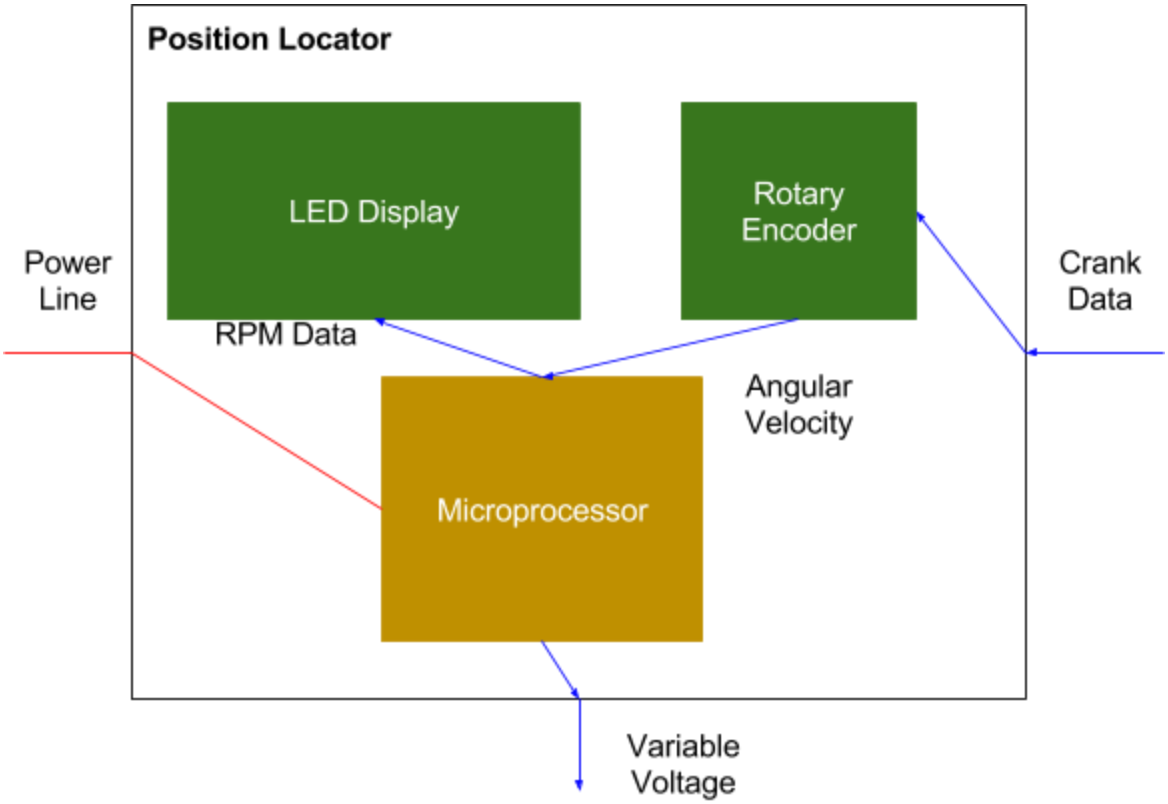

Figure 2: Block Diagram of Position Locator

2.1 Generator

The hand crank generator in this case can be treated as a black box. We know that it will output some current to the oscilloscope. We also know that the crank portion of the generator will give the circuit information about the position. This will be used as an input into the circuit via the rotary encoder.

2.2 Position Locator

The bulk of our project will be designing the position locating circuit. The position circuit will consist of three different internal parts. It will have a microprocessor, an LED display, and a rotary encoder. We do not know how we will power it yet but will investigate different options this week.

Requirements:

1. *Be able to tell the position of the crank*
2. *Output a variable voltage (0-5V) to the oscilloscope based on the crank location*
3. *Display the angular velocity in both RPMs and rads/sec on an LED Display*

2.2.1 Rotary Encoder

The rotary encoder will be used to translate the angular displacement to a digital signal. The output of this module will be the pair pulse train signals [1] (see below) which will give us the information we need to calculate what we need.

Requirements:

1. *Take the input of the crank displacement in the form of an analog signal*
2. *Output the angular displacement to the microprocessor in the form of two pulse trains [1] (see below)*

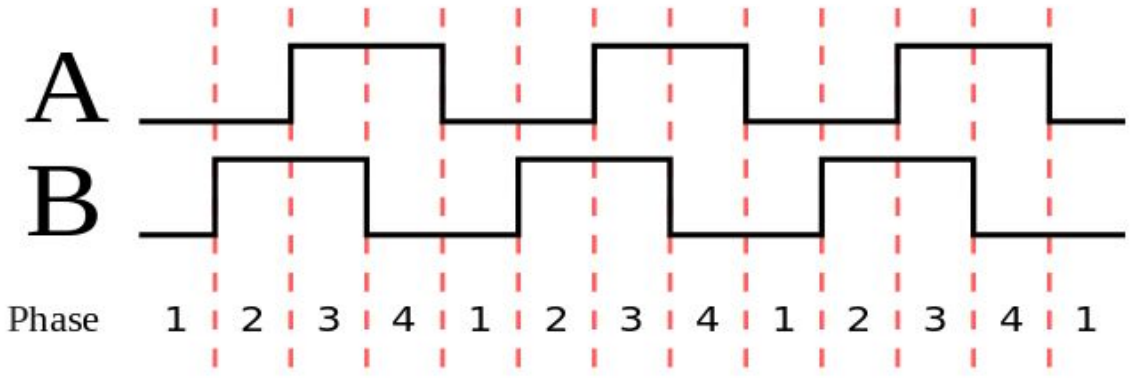

Figure 3: Rotary Encoder output

2.2.2 Microprocessor

The microprocessor will be used to analyze the output of the encoder. The input will be a digital signal like the one in the image. This module will use the data above to extrapolate the angular speed and position of the crank. This chip will output a variable voltage to the oscilloscope.

Requirements:

1. *Take the digital input from the encoder and translate it into useful data*
2. *Output a variable voltage (0-5V) to the oscilloscope based on the crank location*

2.2.3 LED Display

The LED Display will be used to display the angular speeds in both RPMs and rads/sec. The input of this will come from the microprocessor which will be a data signal which contain the right value. The output will be the display of the data on the screen.

Requirements:

1. *Take the digital input from the encoder and translate it into useful data*
2. *Output a variable voltage (0-5V) to the oscilloscope based on the crank location*

2.3 Oscilloscope

The oscilloscope will also act as a black box for this project. We can treat as a system that simply takes either a current or voltage input and displays it on the screen.

2.4 Risk Analysis

We foresee the greatest risk for not completing this project lying within the encoder. Looking online and speaking with Professor Reinhard, the toughest thing in this has been the encoder when people tried to implement it in the past. The reason we think this will be difficult is because of the lack of good documentation online. We will also have to consider the size of the encoder because we do not want the circuit to impede the vision of the students cranking the generator.

Another pain point we see coming up is how to display the information on the oscilloscope. As mentioned above, we will be displaying this information for children. For this reason, we have to put

in a lot of effort in ideating a way to display the information. This will mean iterating through different methods and testing them with children to see if they understand it.

3. Safety and Ethics

The biggest safety problem we see ourselves running into is with accidentally shocking a child. We all know that children find a way to break everything. Since children will be the ones cranking this device we need to ensure that our device is well built and will not expose anything during high stress situations. If something was to get expose, we could hurt a small child and perhaps scare him away from pursuing a career in engineering, which is the opposite of what we want to accomplish.

It also needs to be well built in order to last a long time in the shelves of ECEB, being reused for every Engineering Open House for years to come.

In terms of ethics, we are responsible for the information that is sent through our technology. This spread of valuable knowledge is an implementation of the IEEE Code of Ethics, #5: "To improve the understanding of technology; its appropriate application, and potential consequences" [2].

Our system will be letting people who do not know how things like electricity work. We will be also using this to spark their curiosity to pursue a career in STEM fields. It is our duty to make sure that we portray the right information and do not mislead the public on how basic concepts like this work.

References

[1] Sachs, J. (2012, December 27). How to Estimate Encoder Velocity Without Making Stupid Mistakes: Part I. Retrieved September 26, 2017, from https://www.embeddedrelated.com/showarticle/158.php
[2]"IEEE IEEE Code of Ethics." IEEE - IEEE Code of Ethics, www.ieee.org/about/corporate/governance/p7-8.html. Accessed 26 Sept. 2017.