

Techsan Wind

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Abstract

Mechanics and electronics of a fully autonomous model wind turbine will be described throughout the report. The purpose of the report is to inform the reader of the goals and workings of the model turbine and how the components will be implemented throughout the spring 2021 semester.

Table of Contents

Abstract.....	ii
List of Figures.....	iv
Introduction.....	v
Controls.....	vi
Sensors.....	ix
Motors.....	xii
Conclusion.....	xiv
References.....	xv

List of Figures

Figure 1:	National Instruments cRIO-9074.....	vi
Figure 2:	National Instruments 9205.....	vii
Figure 3:	National Instruments 9403.....	viii
Figure 4:	Monarch ROLS-P laser.....	ix
Figure 5:	IsoBlock V module	x
Figure 6:	IsoBlock Current-FG module.....	xi
Figure 7:	Zaber X-RSW60A-E03.....	xii
Figure 8:	Pittman/Ametek 24VDC Motor.....	xiii
Figure 9:	Control Box.....	xiii

Introduction

This turbine needs to be fully autonomous, robust, and able to be scaled up in a way. The turbine's base and nacelle will be constructed of either milled or cast aluminum and the microcontroller being used for the brains will be a National Instruments cRIO device. To monitor and control the turbine, there will be a multitude of separate sensors and motors that we will go through in this outline. The outline will break up the project up into chunks such as the controls, sensors, and motors.

Controls

The cRIO-9074 FPGA will be the main brain of the project containing all the LabView code needed to control and mitigate all the information that is needed to be delivered throughout the system. The cRIO-9074 is an embedded controller for advanced control and monitoring applications. The cRIO contains a real-time processor and an FPGA. The cRIO contains 8 slots for 8 separate functioning National Instruments modules, a 400 MHz CPU, 128 MB of DRAM, 256 MB storage, and a 2 million gate FPGA. This is what will be sending the messages to the modules connected to the cRIO.



Figure [1]:

The National Instruments 9205 is a module that will be connected to the cRIO. This module can connect to the cRIO seamlessly and will be handling the analog inputs and outputs. Such as the voltage sensor and the current sensor that will be monitors throughout the operation. The NI-9205 includes 32 single ended or 16 differential inputs with a sampling rate of 250 kS/s and a 16-Bit resolution. The module can take inputs up to +10 Volts and down to -10 Volts before going into a safety mode. The module contains a MUX for switching through the inputs, a PGA acting as a filtered differential amplifier, and a 16-bit isolated ADC.



Figure [2]:

The National Instruments 9403 module is a bidirectional digital module that will be handling all the digital signals going in and out of the cRIO. The signals that it will be handling are for the pitch of the blades, power monitoring, and rpm's. This module will be set inside of the rail of the cRIO just like the NI-9205. The module has an updating rate of 7 μ s with 32 channels. The connection to the module uses a DSUB pinout able to handle 5 V/TTL inputs/outputs. The internals consist of a voltage protection circuit, an unspecified pulldown resistor and isolated bi-directional buffers.



Figure [3]:

Sensors

Controlling the rpm's will be the Monarch ROLS-P which is a remote optical laser sensor that can detect speeds up to 250,000 rpm. The laser is simple to use with a phone plug connector that sends out a digital pulse every time the laser is reflected to the optical sensor. The device uses a visible class 2 red laser with a wavelength of 650 nm. The maximum laser output is 1mW and can operate up to 25 feet away and 60 degrees offset from the target. The pulse output is directly correlated with the power input of the laser which we can control to be 5 Volts for the NI-9403 module.



Figure [4]:

For monitoring the voltage, we will be using the IsoBlock V module from Verivolt LLC. This sensor is designed to isolate and scale down high voltages. The IsoBlock module uses galvanic isolation from the input to the output which will take away any large common mode voltages. In addition, each channel also has a protection stage at the input that guards it from surges. The output of this module will be a $\pm 10V$ range which is what the NI-9205 is created for.



Figure [5]:

For monitoring the current we will be using the IsoBlock Current-FG module from Verivolt LLC. The output of this module will be a $\pm 10V$ range depending on the current from the Pittman 24 VDC motor we will be using as the generator. The IsoBlock Current-FG module provides 1200V primary-to-secondary isolation, which allows for the use of multiple currents at different potentials. The IsoBlock Current-FG also uses Flux-Gate method to measure the current through the input wire.



Figure [6]:

Motors

The Zaber X-RSW60A-E03 is a motorized rotary stage, integrated controller, and motor encoder with 360-degree rotation. This is what will be handling the yaw of the turbine. The motor is accurate up to .02 degrees with a maximum speed of 19 RPM and a minimum speed of 2.496 μ rad/s. The built-in rotary quadrature encoder has a resolution of 800 states/revolution. The information exchange used to control the motor and receive the encoder information is based on RS-232 communication. The device takes a 24-48 Volt power supply, drawing up to .95 Amperes.

Here is an example of the yaw motor running that we posted on Youtube.

<https://youtu.be/e3dbQBgKt9c>



Figure [7]:

A Pittman 24 Volt DC motor was chosen to act as a generator for the turbine. It is a simple DC motor with a built in 2 phase optical encoder attached to the shaft at the rear. The optical encoder will be used to monitor the rpms alongside the monarch laser. The motor can handle speeds up to 10000 rpm and output up to 24 Volts.



Figure [8]:

Conclusion

For the project to work, the devices, sensors and motors will need to work in sync. There will be a challenge getting the timing down to control everything in real time with one control module. The sensors all take time to calculate, these sensors will need to be optimized to be able to get enough data to the cRIO so it can react accordingly in real time, but not take up so much time that the processes neglect the operation of other controls. The focus now is to start getting the controls to work in sync with the sensors.

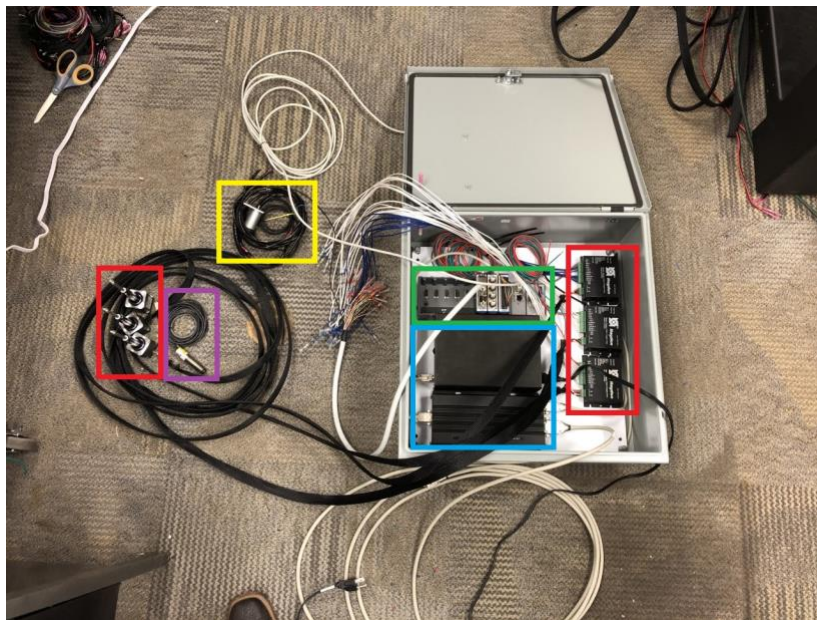


Figure [9]:

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