MONITORING SYSTEM FOR ROTATING TURBINES:

Project Proposal

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INTRODUCTION:

Objective: The goal of our project is to develop a monitoring system for turbines (which exist in airplanes, various cooling systems, etc.), or other sub systems that have mechanical components that rotate and/or oscillate with fixed RPM/frequencies, using low-power, high-output VCSELs. Its small size and simple, modular design make it a very efficient, low-powered and inexpensive mechanism that, with simple spatial considerations, can be fitted into any system that requires the measuring of a rotating mechanical object.

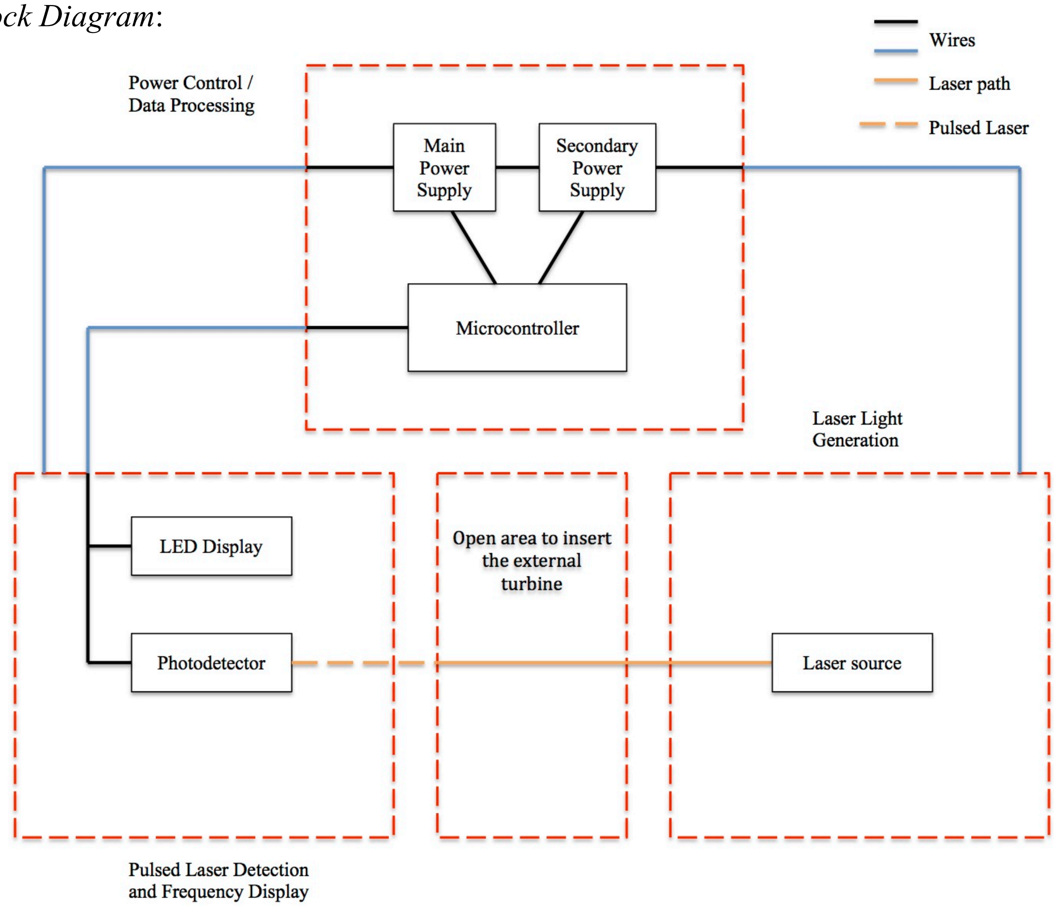
Background: The prevalence of turbines in transportation systems makes the need for a monitoring system to ensure their continual operation important. Usually, a monitoring system is developed as part of a larger project involving the testing and controlling of turbines. Our design, however, removes the need for that and creates a standalone, easy-to-transport, modular and cheap system.

High-level requirements:

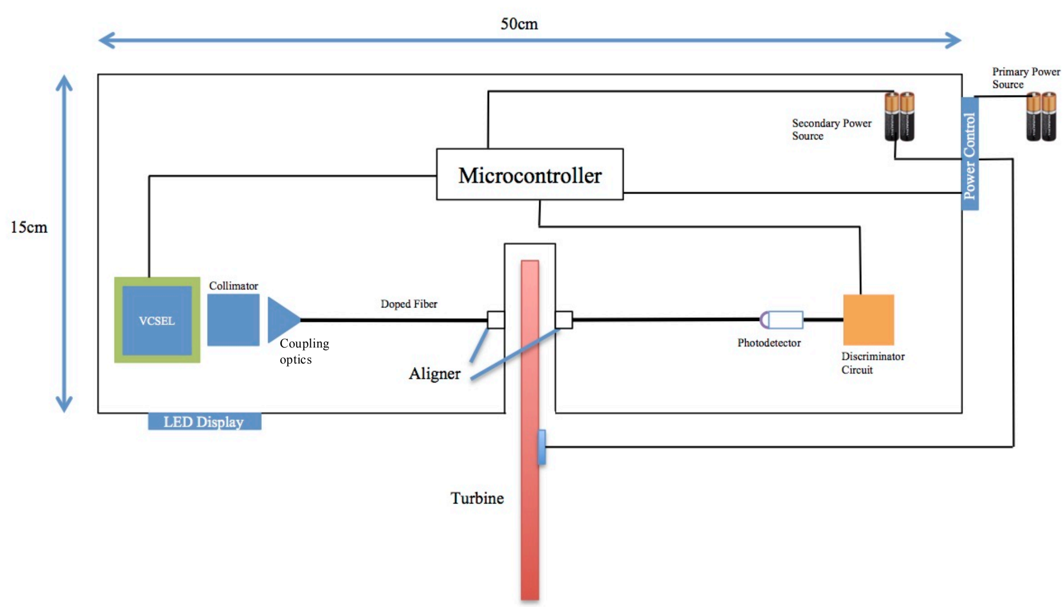
- Portable and mobile, with an overall width that does not exceed 50cm, and a height or depth that don't exceed 20cm.
- An area to insert the rotating turbine or mechanical object for detection, with an adjustable size to accommodate different turbine diameters.
- Operates on ~5V battery power

DESIGN:

Block Diagram:



Physical Diagram:



Block Description:

- Laser Light Generation -

  Our implementation is centered primarily on using a photonic integrated system that employs a fiber coupled laser diode.

  Requirements: 1. The laser takes power from the power supply in the Power Control / Data Processing blocks, around 3-5V. 2. Laser output is incident on photodetector in Pulsed Laser Detection and Frequency Display block. 3. Provided by Professor Dragic.

- Gap -

  To introduce the armature of the rotating fan/turbine. This will allow us to mechanically pulse the laser at the frequency of the turbine.

  We can use a doped fiber to introduce gain inside the fiber cladding in order to account for any losses at the gap. The VCSEL in the coupler will now drive the new gain medium.

  Requirements: Our scope is for small turbines at the moment, so gap should not exceed 10cm.

- Pulsed Laser Detection and Frequency Display -

  The detector will have to once again be selected accordingly (to prevent saturation). However, instead of Q-switching a fiber laser we can pulse the output of a fiber ring amplifier should we need a more substantial laser output. This may be easier to implement.

  We will use a discriminator circuit to generate alternating electrical signals from the fluctuating detector photocurrent.

The micro-controller in the Power Control / Data Processing block will send back processed information on frequency that it received from the photodetector for display on the LED display.

Requirements: Discriminator circuit should output only 2 values, a high voltage (5V) and low voltage (0V), and provides it to the microcontroller for processing.

- Power Control / Data Processing

A microcontroller will be used to calculate the time between zero signals (corresponding to a low Q for the fiber cavity; meaning the laser was clipped by the armature). The inverse of this time will give us the frequency of the turbine.

We will use it to determine if the frequency (which is constantly being calculated at every point in time while the system is operational) is held at a predetermined and programmable optimal value, or if it is falling or rising.

If it is falling below optimal value the microcontroller will turn on a backup power supply and turn off the current one which is now losing power (we can test this by manually disconnecting the primary power source).

In the rare case that the frequency is going above optimal (we can simulate this with a potentiometer which will raise the power supplied to the turbine), the microcontroller will perform the same function.

Requirements: 1. We will allow for a small tolerance in the optimal RPM so that the backup isn't constantly being turned on and off for very minute and insignificant changes in RPM. 2. This is the “brain” of our device, so it should be provided with a reliable power source and adequate physical space.

Risk Analysis:

We believe the greatest risk to completion is the collimator and coupling optics part of the device. Through our experiences from previous courses and research work, we found coupling to a fiber to be the most tedious and intricate part of an experiment, so our design should be robust and stable enough to keep the collimator and coupling optics stable enough for coupling to still be achieved after/with the movement/mobility of our overall device.

ETHICS AND SAFETY:

Safety:

The most dangerous part of our project appears during testing, where we will be using an actual turbine. The turbine will be rotating at a high frequency, its size will be relatively large and its material rather strong, so it poses a threat of physical injury. In addition, we will be placing it in a narrow area provided by our device, so damage to this device is another risk we need to consider.

To address those risks, however, thought that performing our testing with extreme care is the best course of action. This entails having all members of the group present during testing and having at least two people perform the tests together, one for handling the turbine, and another to handle the device.

Another risk is eye damage from the laser, but we will deal with this by wearing appropriate goggles that correspond to the class of laser we are using. This is a reference we used when thinking about this: http://www.lasersafetyfacts.com/laserclasses.html .

Ethics:

We need to be careful whenever we use Prof Dragic's equipment, as he was generous enough to allow us to use them. We will try to think about the risks behind our procedures before going ahead and implementing them to ensure that we are as careful as possible when doing so.