Wind Tunnel Control

Project Proposal

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Project Summary

The control scheme for the wind tunnel system shall provide students with networked access to both the controls for operation as well as the measuring of data. This configuration shall simplify control of the wind tunnel as well as reduce time required to take measurements using the system. Students shall use a LabVIEW based software application to remotely connect to a PC local to the wind tunnel system. The local PC shall be connected to the data acquisition device and will control the system via digital and analog signals to system peripherals and a microcontroller.

Project Description

The block diagram for the wind tunnel system is shown below in Figure-1. The microcontroller shall not need to be reprogrammed or modified after the system is complete, thus shall not be connected to the PC. The data acquisition device shall pass the necessary signals from the network, through the local PC, to the rest of the system. The measurements shall then be sent out through the network to the remote users.

Figure-1: High-Level System Block Diagram
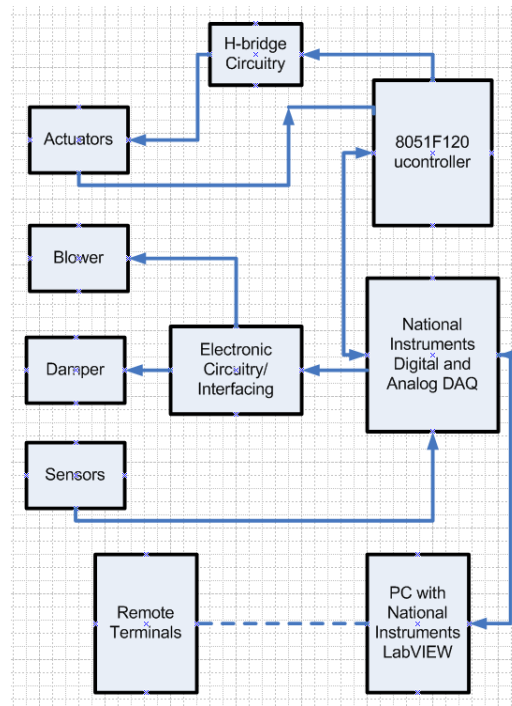
National Instruments Digital and Analog Data Acquisition Device:

This is the main I/O component of the system. All of the control and measure signals must be passed through this device in order to be seen in the LabVIEW software and thus seen by the remote users. For the system, a minimum of 2 analog outputs is required in order to control both actuators. The DAQ interfaces with the PC via the PCI interface and connects to a remote header via GPIB. This header then splits the lines for easy connecting to other components. The DAQ was selected by the Mechanical Engineering Department as they were able to reuse existing equipment. With a more robust DAQ, more actuators and sensors could be used.

DAQ Requirements:

1. The DAQ shall have a minimum of 3 analog inputs and 2 analog outputs used to control the actuators and read in lift, drag, and wind speed measurements.
2. The DAQ shall have a minimum of 5 digital I/O used to control the components of the wind tunnel and trigger movement of the actuators.
3. The DAQ shall be a PCI MIO-16E-4 by National Instruments provided by the Mechanical Engineering Department at Bradley University.
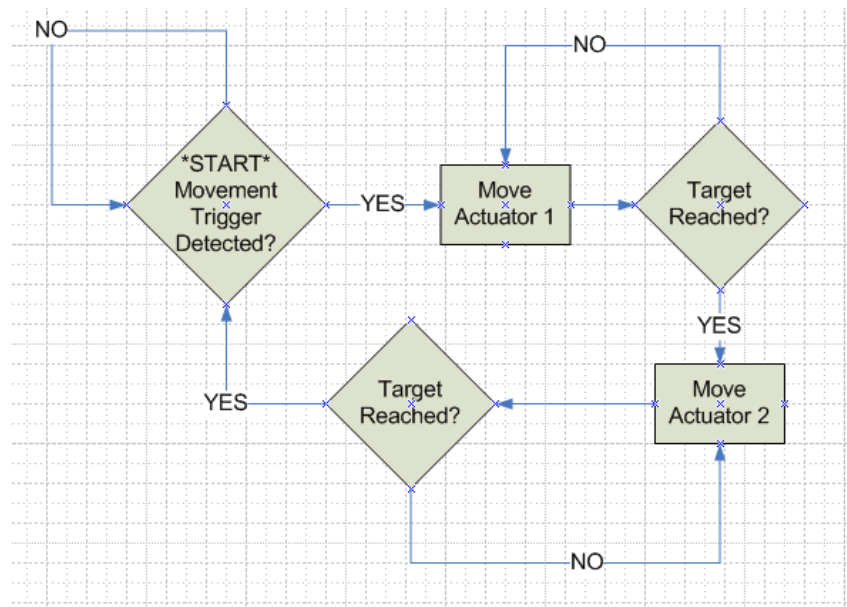

8051F120 Microcontroller:

The microcontroller shall act as the PWM generator and controller for the three actuators. It is configured to simply read analog inputs to determine the current setting desired and generate PWM pulses for each actuator to position them correctly. It is turned on when the system is turned on and will not need to be connected to the PC. Presently, the code for the controller lacks robustness and should be updated at a later date with proper system modeling and controller design. Due to the focus of the project being on remote access and LabVIEW, this will not be done. The controller has a constant ADC interrupt loop that samples the 8 channel ADC every 1 millisecond. These samples are used to determine present and desired actuator positions and to determine position error. The actuators are controlled via PWM generated in another 1 millisecond interrupt.

Microcontroller Requirements:

The microcontroller shall have a minimum of 4 channels of ADC in order to be used as a controller for the actuators.

1. The frequency of the PWM signal to control the actuators shall be set to 1KHz.
2. The interrupt routine performing the ADC shall execute significantly fast as to not delay execution of the main controller loop.
3. The positioning value input to the ADC shall have a range of 0.5 to 2.9 volts when the reference voltage is set to 3.28 volts.
4. The ADC shall have a resolution of 0.0013 volts/division.
5. The ADC shall have a tolerance of +- 10 divisions at the desired position, due to line noise, and differences in actuator voltages and potentiometers.

Figure-2: Microcontroller Software Block Diagram

H-Bridge Circuitry:

This circuitry is used to convert the digital PWM signal from the microcontroller into 12VDC power signals used by the actuator. The circuitry is set up for bi-directional

operation. A schematic of the circuitry can be found in the senior project lab notebook on page 11.

H-Bridge Circuitry Requirements:

1. The H-bridge circuitry shall carry a maximum in-rush current of 3 amps to the H-bridges and actuators.
2. The H-bridge circuitry components shall be capable of dissipating power with 3 amps of current through the circuit (about 36 watts for less than 1 millisecond, 2 watts nominal).

Electronic Circuitry/Interfacing:

The wind speed damper and blower on/off are 110 and 220VAC, high-amp motors and as such, require certain caution during control design. This challenge is overcome by using solid-state relays, which can use small, low-current DC signals to switch very high amp circuits. Also, a double-pole, double throw relay is required to enable directional control of the damper motor. These components will be laid out on a board to be permanently, conveniently, and safely mounted to the wind tunnel system. A schematic of the damper control can be found in the senior project lab notebook on page 3.

Interfacing Requirements:

1. The interfacing between the LabVIEW control and wind tunnel system shall completely isolate the DAQ, microcontroller, and PC from the wind tunnel system using solid state relays.
2. The interfacing component specifications shall match the voltage and current specifications of the DAQ and microcontroller.

Wind Tunnel Components:

The wind tunnel currently has lift and drag sensors attached. We shall use these sensors and interface them to our system. The actuators are also present and shall be connected to the h-bridges and microcontroller as shown. A useable wind speed sensor is not currently in the system but shall be added at a later date.

PC and LabVIEW Software:

A PC shall be provided by the Mechanical Engineering Department and come installed with the LabVIEW software. This PC shall be located near the wind tunnel and be physically connected to the DAQ header and, during testing, the microcontroller. This system shall be on at all times to allow remote connection to the wind tunnel and to run the DAQ installed in the PC.

PC and LabVIEW Requirements:

1. The PC shall be equipped with Windows XP and the most recent version of LabVIEW available at the time of assembly. This machine shall be specified and provided by the Mechanical Engineering Department at Bradley University at a later date.

2. The LabVIEW application shall format any gathered data into a user-definable file after a data acquisition session is complete.

3. The LabVIEW application shall contain the following end-user I/O:
    a. System on/off. (input)
    b. Positioning settings for two actuators (height and pitch). (input)
    c. Wind-speed damper open. (input)
    d. Wind-speed damper close. (input)
    e. Wind-speed sensor reading. (output)
    f. Lift sensor reading. (output)
    g. Drag sensor reading. (output)

Remote Interface:

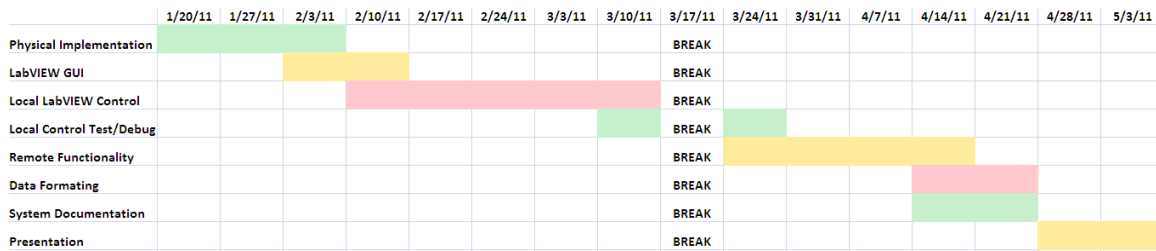The remote interface will need to be developed in the LabVIEW software and use the existing network via the PC for remote connectivity.

Schedule

Currently, the microcontroller, h-bridges, and actuators are working using position inputs from a DC power supply. The schematics for damper and on/off control are also completed and ready to be implemented on the physical system. The LabVIEW GUI and

control is incomplete, as is the physical implementation of any components on the actual wind tunnel.

Figure-3: Project Schedule

	1/20/11	1/27/11	2/3/11	2/10/11	2/17/11	2/24/11	3/3/11	3/10/11	3/17/11	3/24/11	3/31/11	4/7/11	4/14/11	4/21/11	4/28/11	5/3/11
Physical Implementation									BREAK							
LabVIEW GUI									BREAK							
Local LabVIEW Control									BREAK							
Local Control Test/Debug									BREAK							
Remote Functionality									BREAK							
Data Formating									BREAK							
System Documentation									BREAK							
Presentation									BREAK							

Equipment List:

Below is a list of equipment required for this project:

1. PC with LabVIEW software installed.
2. 2 DC Controlled, AC Solid State Relays (Omron G3NA-225B).
3. 1 DC Controlled, DC Solid State Relay (Omron G3NA-D210B).
4. 1 Double Pole, Double Throw AC Relay (Dayton 1EGX1).
5. National Instruments Analog and Digital Data Aquistion Device (PCI MIO-16E-4).
6. Wind Tunnel System and Peripheral Components
7. Silicon Labs 8051F120 Microcontroller.

References

[1] Ben Morrison, "Senior Project - Webwind", Senior Project, Electrical and Computer Engineering Department, Bradley University, March 2002.

[2] Silicon Laboratories, C8051F12x Development Kit User's Guide.

[3] Silicon Laboratories, C8051F120 Datasheet

[4] National Instruments, PCI-6229 Datasheet

[4] Omron, G3NA-225B Datasheet