Wind Tunnel Control

Functional Requirements List and Performance Specifications

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Introduction

The controller for the wind tunnel system located in the mechanical engineering lab shall provide students with remote 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 and faculty shall use a LabVIEW based software application to remotely connect to a PC local to the wind tunnel system, which shall be connected to the data acquisition device and will control the system.

Goals

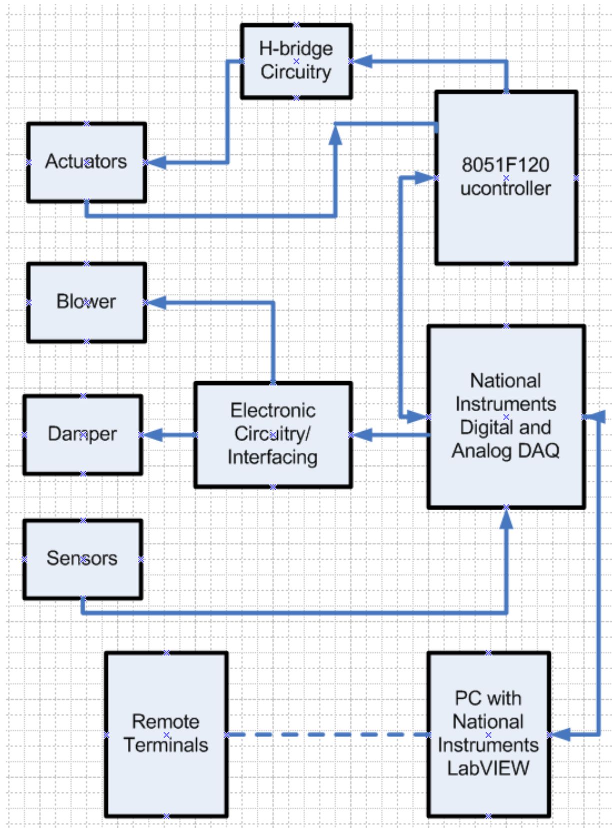
During the course of the project, my goals provide incremental steps toward achieving a complete, network based control/measure system.

- Turn the blower On/Off using LabVIEW.
- Move the wind speed damper Up/Down using LabVIEW.
- Control two actuators using positioning signals from LabVIEW.
- Read measurements from lift/drag/speed sensors in LabVIEW.
- Implement pass-through so that users can use the system remotely.
- Interface local system to remote users via the network.
- Build organized and effective GUI for remote application.

High-Level Block Diagram

The block diagram is shown below in Figure-1. The microcontroller will not need to be reprogrammed or modified after the system is complete, thus will not even need to 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 same device to the remote users.

Figure-1: High-Level System Block Diagram



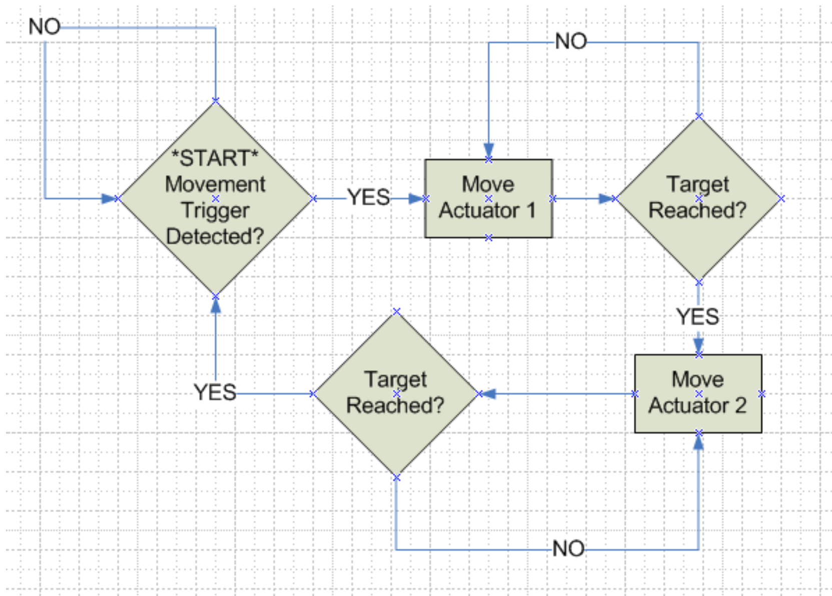
National Instruments Digital and Analog Data Acquisition Device:

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.

8051F120 Microcontroller:

The microcontroller acts as the PWM generator and proportional 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. The software block diagram for the code implemented on the microcontroller is shown on the following page.

Figure-2: Microcontroller Software Block Diagram



Electronic Circuity, Peripherals, and Interfacing:

The H-bridges are used step up the PWM signal from the microcontroller and provide the required current to the actuators. The sensors provide the data to be analyzed and recorded by the LabVIEW sotware, and the interfacing for these sensors includes the power supply and any signal conditioning that must be completed prior to connecting to the DAQ. The remote interface will need to be developed in the LabVIEW software and use the existing network via the PC for remote connectivity.

Functional Requirements

The wind tunnel system is a fairly slow and predictable system, but it was necessary to set minimum system specifications to focus our design approach. These requirements are show below.

Microcontroller:

1. The microcontroller shall have a minimum of 4 channels of ADC in order to be used as a controller for the actuators.
2. The frequency of the PWM signal to control the actuators shall be set to 1KHz.

3. The interrupt routine performing the ADC shall execute significantly fast as to not delay execution of the main controller loop.
4. 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.
5. The ADC shall have a resolution of 0.0013 volts/division.
6. The ADC shall have a tolerance of +- 10 divisions at the desired position, due to line noise, and differences in actuator voltages and potentiometers.

H-bridge Circuitry:

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:

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.

Digital and Analog Data Acquisition Device:

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.

Computer and LabVIEW Software:

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)

Conclusion

While the overall goal is to implement a complete, remote package to control the wind tunnel system, a systematic approach will be the most beneficial. By working through each step, the system will become more complete while remaining in a useable state throughout the process. This is important so ME students can continue to use the wind tunnel throughout the course of the project.

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