Aero Engine Controls Fluid Delivery System: Torque Motor Subsystem

Project Proposal

Team #21

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Motivation

This project was selected because it was in the group members' field of concentration. Additionally, this project is intriguing since it requires interfacing with engineers who currently work in the field and in meeting performance specifications given by the company. This is a great opportunity to experience practical engineering work prior to joining the workplace.

This project is going to contribute as a part of a vehicular fluid delivery system. It will be a continuation of the work done by a previous group last year. The purpose of this project is to simulate the torque motor that is used by the fluid delivery system in industry. This motor will have an equivalent load of torque that gives an amount of torque analogous to the fluid being delivered.

Objective

The goal is to design a system that will receive positioning command from a PC controller and input a variable current though a drive circuitry to drive the motor into desired position. A spring and lever arm will be mounted onto the motor in an effort to simulate fluid resistance. The DC motor used in the project will be equipped with a RVDT sensor, which will provide the positioning information of the motor. This information will be fed back through the PIC controller and into the Node controller. The Node controller will take this RVDT sensor information to adjust the motor controls (by varying the driving current). The RVDT sensor will provide important information which will be used to maximize the efficiency and reliability of the system.

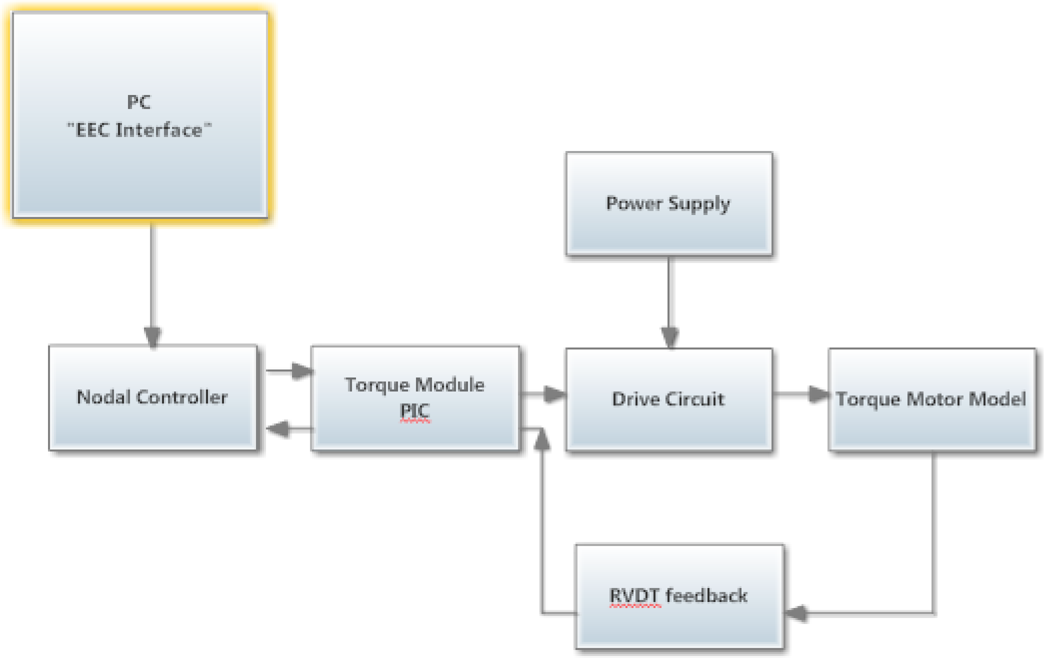
Benefits

- Insure the reliability of the fluid delivery system
- Insure the efficiency of the fluid delivery system
- Provide motor status to a higher level controller

Features

- Dynamic positioning response for motor through use of the RVDT sensor
- Motor with input dependent torque response
- Programmable PC controller for position and torque modulation

Block Diagram



Block Diagram Descriptions

I. Power Supply: the power supply will be the primary voltage source and will simulate the 28V supply rails used in the industry counterpart of this project. The supply will simply be two charged 12V batteries connected in series.

II. PC “EEC Interface”: this is a PC that runs existing software which controls the nodal controller. This block has been developed by Aero Engine Controls (AEC), the industry partner for this project.

III. Nodal Controller: this high level controller will produce modular microcontroller software to drive the torque motor subsystem

IV. Torque Module PIC: this is a programmable PIC controller which will interpret actuation signals from the node controller and send low level actuation signals with which to drive the torque motor model.

V. Drive Circuit: this is the actuation hardware required to interpret control signals from the PIC board into usable analog signals that will manipulate the motor position. For this project, the drive circuitry will produce a current to drive the motor. (Since we will be implementing this circuit, no additional special circuit is needed)

VI. Torque Motor Model: this is a current driven brushed DC torque motor which will act against a compressing spring force to simulate fluid resistance within the delivery system. The motor will operate at 14.5V maximum and 6A maximum (87 Watts).

VII. RVDT feedback: this is the RVDT sensor which will feed positional and torque information back into the PIC controller for dynamic positioning response and efficiency.

Performance Specifications

-Output Power: 87W on the motor (14.5V at 6A)

-Working Angle: approximately $60°$

-Positioning angle accuracy: $0.5°$

-Positioning speed: less than 200ms

-Torque Output at $14.5V_{DC}$: 0.3 N·m

-Drive Circuit Response Time: TBD

-Power Supply Stability: total battery charge within 26V $\pm$ 2V

-Current Control Stability: $\pm 3\%$ of desired output current

-Drive Circuitry Voltage Stability: $\pm 3\%$ of motor drive voltage

Testing Procedures

1) Positioning Speed: measure the position using the RVDT sensor feed from motor angle change of 30° and compare with position versus time data from RVDT feedback
2) Torque: Calculate generated torque based on current input and compare to measured torque based on spring displacement and force
3) Frequency Response of Drive Circuitry: Measure input and output of circuit with oscilloscope; drive with sinusoid to compare peaks
4) Power Measurements (e.g. voltage, current, etc.) will be done with typical watt meters
5) Positioning Angle Accuracy: Compare final RVDT sensor position data after angle change (wait 5 seconds for stabilization) with actual input angle change
6) Working Angle: gradually increase torque until RVDT indicates angle change equal to or exceeding desired working angle

Tolerance Analysis

The most critical parameter for tolerance analysis is the motor drive current generated by the drive circuitry. If the current is controlled well within performance specifications, then the motor torque for the design will also be sufficiently well controlled. However, small fluctuations of the drive current will result in position and output torque errors which will in turn reduce angle accuracy. Since RVDT position and torque information is part of a feedback loop, small errors may propagate into much larger errors and reduce system performance and efficiency. The lab multi-meters are more than accurate enough to display current within the $\pm 3\%$ constraint from the performance specifications, so this measurement method is sufficient.

Cost Analysis

a) Microcontroller/PIC: $25
b) Demo Board: $130
c) DC brushed Motor: $25
d) Fans/Heat Sink: $15
e) RVDT Sensor: TBD
f) Drive Circuitry (preliminary estimate): $30
g) 28V Battery for power supply: $175
h) Labor: ($30/hour)(50 days of labor)(3 hours/day)(3 workers) = $13,500

Total Cost Estimate = 25+130+25+15+TBD+30+175+13,500 = $13,900

Schedule

Date	Task	Team Member
2/8/2012	Project Proposal Posted to PACE	David
2/10/2012	Part Selection and place order	Zhimin
2/13/2012	Hardware Design Completed	Ross
2/17/2012	Software Design Outlined	Zhimin
2/20/2012	Design Review Sign-up	David
2/23/2012	Drive Circuitry Assembled	Zhimin
2/25/2012	Spring-Motor Contraption to Shop	David
3/16/2012	Software Coding Written	Zhimin
3/26/2012	Begin Preliminary Testing	Ross
3/26/2012	Mock Demo	David
4/2/2012	Mock Presentation	Ross
4/16/2012	Final Demo and Presentation Sign-up	Zhimin
4/23/2012	Final Project Demo	David
4/26/2012	Final Project Presentation	Ross