AERO ENGINE CONTROLS
FLUID DELIVERY SYSTEM

Torque Motor Subsystem

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ECE 445: Senior Design Presentation
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April 30th, 2012
INTRODUCTION

- Motivation: IUPUI project initiative
- Objective: small scale model of a positional control system for a torque motor
  - For use in a Fluid Delivery System

http://www.aeroenginecontrols.com/Images/Page/im_AEC_NA_resized.jpg
FEATURES

- Reliability
- Accurate estimate of supplied fluid
- Improved control over fluid delivery
- Improved communication with higher level controller
- Dynamic positioning response
- Input dependent torque response
- PIC controller for position and torque modulation
- Extended operating voltage
- Can interface with variable types of motor drives
- Rail voltage drop performance warnings
PERFORMANCE SPECIFICATIONS

- Motor and drive circuitry handle sustained maximum power
- Angular Resolution: ±2° of input angle
- Maximum Positioning Time: 700ms
- Voltage Regulation: rail voltage is 28V ± 2V
- Current Regulation: ripple amplitude less than 0.2 A peak-to-peak
SYSTEM OVERVIEW

- Power Supply
- PC “EEC Interface”
- Torque Module PIC
- Drive Circuit
- Torque Motor Model
- Position feedback

Figure 1. Torque Motor Subsystem Block Diagram
MODULAR DESIGN

Figure 2. Torque Motor System Operation
MODULAR DESIGN

Figure 3. Stepper Motor System Operation
SERIAL PERIPHERAL INTERFACE (SPI)

Figure 4. SPI: PIC to Arduino Master-Slave Communication
Figure 5. Arduino SPI master-in slave-out response
POWER SUPPLY

- Main Input: 28 V supply rail
- Buck Converters
  - 3.3 V out to power PIC
  - 5 V out powers drive circuit

Figure 6. Power Supply Buck Converter
PC “EEC INTERFACE”

- User Interface
- LCD Screen
- Potentiometer

Figure 7. LCD user interface for control system
Figure 8. PIC board for the torque motor system

Figure 9. PIC pin out schematic
DRIVE CIRCUIT

Figure 10. Drive circuit of the torque motor system
DRIVE CIRCUIT

- PMOS FET
- Zener Diodes
- DC motor modeling: inductor and resistor

Figure 11. Drive circuit SPICE model
Figure 12. Drive response for input PWM with 25% duty cycle
Figure 13. Drive response for input PWM with 50% duty cycle
Figure 14. Drive response for input PWM with 75% duty cycle
TORQUE MOTOR MODEL

- Lever arm mounted on the motor shaft
- Spring models fluid pressure on a valve
- Protractor measures angular displacement of motor shaft

Figure 15. Torque motor module FDS dry model
MICROCONTROLLER FLOW DIAGRAM

Figure 16.1. Program Flow Chart
MICROCONTROLLER FLOW DIAGRAM

Figure 16.2. Program Flow Chart Continued
Figure 17. Averaging algorithm for positioning array
Figure 18. PI-D positioning control loop
Figure 19. Motor Position Response to 50° input
Figure 20. Motor Position Response to 44° input
DESIGN ALTERATIONS

- Reduction of hardware within drive circuitry
  - Single PMOS used in final design
  - Only one quadrant drive necessary
  - Drawback: only forward driving
  - Slower positioning time for fluid reduction positioning

Figure 21. Original Drive Circuit for Design Review
ETHICAL CONSIDERATIONS

- Minimal overshoot of controller prevents fluid waste
- Safety measures and warnings given if system performance will drop due to rail voltage loss
- Accurate positioning high priority to regulate flow control
- Fast positioning needed to allow for emergency changes
- Need to comply with restrictions due to Control of Arms list; control methods for certain fluids cannot be published
FUTURE WORK

- Faster response time
- More intuitive control loop
- Fluid pressure sensor
- Fine tuning of the PID loop
QUESTIONS?
CREDITS AND SPECIAL MENTIONS

- Thanks to Professor Krein and the ECE 431 TA’s
- Thanks to Alex, Professor Carney, and the ECE 445 staff
- Thanks to Jim Lange and AEC for providing this project and the guidance throughout the semester
- Thanks to the audience today for listening!

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