520-Sensors and Actuators for Control Systems

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Course Outline

1. Brief Review of control systems and historical review

Accuracy, repeatability and resolution. Feedback, stability and sampling theorem.. Famous historical sensors and actuators. Valves (fluidic, electrical, electronic) as amplifiers and historical servos. Actuator and sensor phase shifts, resonances, instability and hysteresis. Why it is better to invest in the actuator than the software. Feed forward (predictive) servo systems.

2. What makes a good sensor

Immunity to non-sensed variables ("orthogonality"). Null vs. full range sensors. Accuracy, bandwidth, stability and S/N ratio (resolution). Binary vs. linear sensors and why linear sensors are better even for fixed set-point operation. Examples of the best methods for sensing common variables such as position, acceleration, mass, pressure, flow, magnetic field, current, voltage, viscosity, concentration and others.
The "one ppm limit" and its implications to sensing.

3. Signal conditioning for sensors

Shielding, guarding and grounding. Single point vs. multipoint grounding. Balanced vs. unbalanced lines. Instrumentations amplifiers and CMMR. Advantages of AC output. Frequency and amplitude domain filtering. Linearization and Look-up-Tables. Companders. Active probes. FM output sensors. Sensing in high noise environment. Sensors and information theory.

4. What makes a good actuator

Energy efficiency and self-heating. Linearity and servo gain. Electrical and mechanical matching. Improving phase shift and self resonance. Use of dither. Examples of fluidic, electromechanical, piezoelectric and thermal (memory alloys and other) actuators. Actuators for open loop operation. Analytical derivation of actuator performance. Limits to actuator performance.

5. Common electromechanical actuators

Electromagnets and Solenoids. Moving coil, moving iron and moving magnet actuators. DC motors (incl. brushless). AC motors (induction, synchronous, single phase and polyphase). Variable frequency drives. Stepping motors (including piezoelectric and magnetostrictive steppers). Leadscrew vs. linear motor. Testing actuators.

6. High accuracy position and angle encoders

Optical encoders. Interferometric encoders. White light interferometric encoders. Magnetic encoders (Inductosyn and derivatives). Limits to accuracy. Self –checking and reversal methods.

7. Lab: design and build a sensor or actuator for medical use.

8. Final exam