ACC2006 Hard-Disk-Drive Servo Workshop

Instructors: Fred Hansen, Rick Ehrlich
Intended Audience: Engineers with a good servo-controls background, but without extensive hard-disk-drive servo design/debug experience.

As is the case for most control system applications, the area of HDD (**H**ard-**D**isk-**D**rive) servo control involves a broad range of technologies beyond pure control theory. A successful HDD servo engineer must understand issues associated with the sensors, the mechanical system being controlled, details of the disturbance environment, and the limitations of finite computation resources, in addition to being able to "stabilize a loop". The instructors will give a broad overview of the current state of disk-drive servo technology. They will start with a brief review of the basic technologies involved in HDDs, to show the constraints that the rest of the system place upon the servo. Next, they will present more detailed information about the mechanical system, the position-sensing system, and actuator-drivers. Finally, they'll put together an example state-space controller for a fictional (but typical) HDD servo-loop. The session will end with a discussion of the current challenges faced by HDD servo engineers.

Outline

1) Drive Industry/Technology Overview
    a. Communicate the fact that the drive industry is "real" today, and most likely will be for at least the next decade. Survey the extent of drive applications today (3.5" FF in servers, desktops, and "TiVOs", 2.5" and 1.8" in laptops, 1.8" and 1.0" in the iPOD, 1.0" and 0.85" proposed for cell-phones, etc).
    b. Review of the basic technologies involved (R/W, ASIC, interface, mechanics, servo). The intent here is to show the constraints that the rest of the drive places upon the servo.
        i. R/W head OTC constraints on acceptable servo TMR
        ii. Disturbance environment
        iii. Seek performance requirements
2) Servo System Overview
    a. Actuator mechanics
        i. Rigid-Body Dynamics
        ii. Resonances
        iii. Disturbances (does this belong here?)
        iv. Friction
        v. Variability in all of above (Process and environmental)
    b. Sensor (PES)
        i. Patterns and modern demodulation schemes
        ii. Noise
        iii. RRO (does it belong here?) and defective wedges
    c. Drivers
        i. Bandwidth limitations
        ii. Resolution limitations
        iii. Saturation
        iv. Power dissipation limitations
    d. Controller
        i. State-Space versus Compensator-Based
        ii. Ontrack design
            1. General LQG design
            2. Multirate control
            3. H-infinity design

iii. Seek design
    1. General PTOS design
    2. Tradeoff between seek-time and post-seek TMR

3) “Hot development areas
    a. Servowriting (including SSW and possibly alternative schemes)
    b. Wedge Offset Reduction Field (WORF)
    c. PES-linearization
    d. Dealing with high shock/vibration
        i. Acceleration-FF
        ii. IBM’s “drop-sensor”