Design and Lessons Learned on the Development of a Cryogenic Pupil Select Mechanism (PSM)

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What is the PSM?
What Does the PSM Do?

Light to ISIM

Fold Mirror

Light From Sources

Fold Mirror
As-Built Design Features

- Machined Mechanical Detent
- Detent Follower Assembly
- 7 Optical Elements in Each Wheel
- Direct Drive BDC Motor, Titanium Drive Housing, Encoder
PSM Design: Initial Concept

Absolute Encoder Provided High Knowledge Accuracy Information

Stepper Motor with High Gear Ratio Preloaded on Wheel, Driving through Friction
So, What Went Wrong?

Several concerns led to changes in design from the initial concept

- Motor Life
- Power Dissipation
- Variability of Friction at Cold Temperatures
- Potential Motor Drive Wheel Slip
Design Modification Constraints

- Constrained Development Schedule
- Long Lead Item Fabrication Had Started
  - Bearing Procurement
  - GSFC Developed Cryogenic Encoder
- Minimal System Impact
  - Maintain Wire Count
  - Utilize Existing Motor Driver
PSM Build: Motor Assembly/ Cable Drum
Encoder Assembly and Alignment
The Problem
Detent Modification

- Torque Profile, Original Detent
- Torque Profile, Modified Detent

- Detent modification greatly reduced peak disturbance torque and reduced discontinuities.
Mode-Switching Controller

Position Profile, Positive Movement

1: Exit detent (open-loop)
2: Null velocity (closed-loop)
3: Trajectory travel (closed-loop)
4: Enter detent (open-loop)
Control System Layout

Motor Driver

Current drive

Motor commands (Serial port)

RS232 Hub

PSM

Mechanical linkage

Encoder

Motor commands (LAN connection)

GMC Labview

LES Labview

CCD interface

Encoder angles (LAN connection)
Functional and Performance Testing
PSM Lessons Learned

• Motors and encoder/sensor selection are key decision points in an electromechanical system.
• Cold treated hybrid bearings consisting of Si3N4 balls, Cronidur 30 races, and a PGM-HT retainer have been shown to be suitable for cryogenic operations.
• When modeling a plant, ensure the plant is of a high enough fidelity to represent the dynamic response of the system accurately.
• Closed-loop control always needs a sensor with sufficient bandwidth and speed range.
• In a two-pole system, use high order compensator.
• Automatic event logging is critical in systems with many operators.
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