Opto-Mechanical

Charles Engler
Alfonso Hermida

Opto-Mechanical

Team members and responsibilities

• Jesse Wirth, U.C.	-Optical /mechanical systems
• Fred Mrozek, U.C.	-Optical /mechanical engineering
• Chuck Engler, GSFC	-Mechanical systems
• Joyce Pepe, GSFC	-Mechanisms design /engineering
• Alfonso Hermida, GSFC	-Controls engineering
• Mike Amato, GSFC	-Detector mechanical engineering
• Rick Bitzel, Swales	-Mechanical Designer
• Mike Flick, Swales	-Mechanical Designer

Opto-Mechanical

Systems Requirements

Condition	Value	Verification
Operational temp	$4.2^{o}K$ and $300^{o}K$	Test
Sofia mechanical constraints	Volume, mass, vibration	Analysis
No mechanical redundancy	N/A	N/A
Static Load	2 G	Analysis
Design safety factor	3x static load	Analysis
Instrument life	5 years	Analysis

Opto-Mechanical

Systems Requirements

Condition	Value	Verification
Maximum number of missions per year	25	N/A
Maximum mission duration	12 Hours	N/A
Average science collection time	100 seconds	N/A
Optical prescription indexing time	<30 seconds	Test
Optical Aperture positioning accuracy	+/- 1 arc minute	Test

Opto-Mechanical

Primary Structure

- Dewar cold plate is the primary mount for these components
  - He4 reservoir,
  - ADR
  - 12x32 SPUD Detector assembly

- Single optical bench
  - Mounted to Dewar cold plate by three metering trusses
  - Primary mount for all mechanisms and folding optics

Opto-Mechanical

Design Approach

- Four independently operated lens carousels
  - Six position field lens Carousel
  - Six position shutter Carousel
  - Six position pupil lens Carousel
  - Four position pupil viewing Carousel
- Design based on U. of C. GRIMII indexing mechanism
- Carousel indexing mechanisms feature cryogenic stepper motors, positional switches and rotary potentiometers.
- Stepper motors feature superconducting windings.
- Design phase features Pro-E solid modeling CAD

Opto-Mechanical

Performance Models

- Pro-E Solid modeler used for detailed mechanical layout
- Mechanism performance models -Trade study
- Worst-case power consumption for selected design
- Worst-case heat dissipation for selected design
- Structural analysis
- Thermal analysis
- Jitter analysis if required

Opto-Mechanical

Risk Analysis and Mitigation Plan

- **Risk**
  - Individual motor failure may cause incorrect optical performance.
  - Power failure may result in loss of carousel position knowledge
  - Motors enclosed in Dewar are potential heat source
- **Mitigation**
  - Incorporate redundant motor windings
  - Incorporate rotary potentiometer
  - Motor characterization test

Opto-Mechanical

Development Plan

Design/ Fabrication of (4) Rotary Carousels

- Design phase complete by 21 October, 1998
- Drafting phase complete by 5 November, 1998
- Fabrication phase complete by 15 December, 1998
- Assembly phase complete by 15 January, 1998
- Test phase complete by 15 February, 1999
- Integration to optical bench complete by March, 1999

Design /fabrication of Optical bench

- Complete by 15 January, 1998

Design /fabrication of metering truss

- Complete by 15 February, 1998

Opto-Mechanical

Test/Verification Plan

- Motor Performance Test
  - Characterize Superconductive Stepper Motor (He4)
- Carousel (component) level tests
  - Control electronics and software characterization (ambient)
  - Indexing scheme characterization (ambient /He4)
  - System level tests:
    - Software commands
    - Carousel safety features (end of travel switch, soft-limits)
    - Auto-initialization algorithms
- Fabricate "dummy" optical bench for all performance tests

Support Equipment

Resources

- Environmental Chamber capable of He4
- Precision positioning measurement instrument, theodolite
- Test electronics
- Dummy optical bench
- Computer and support software for mechanism control

Opto-Mechanical

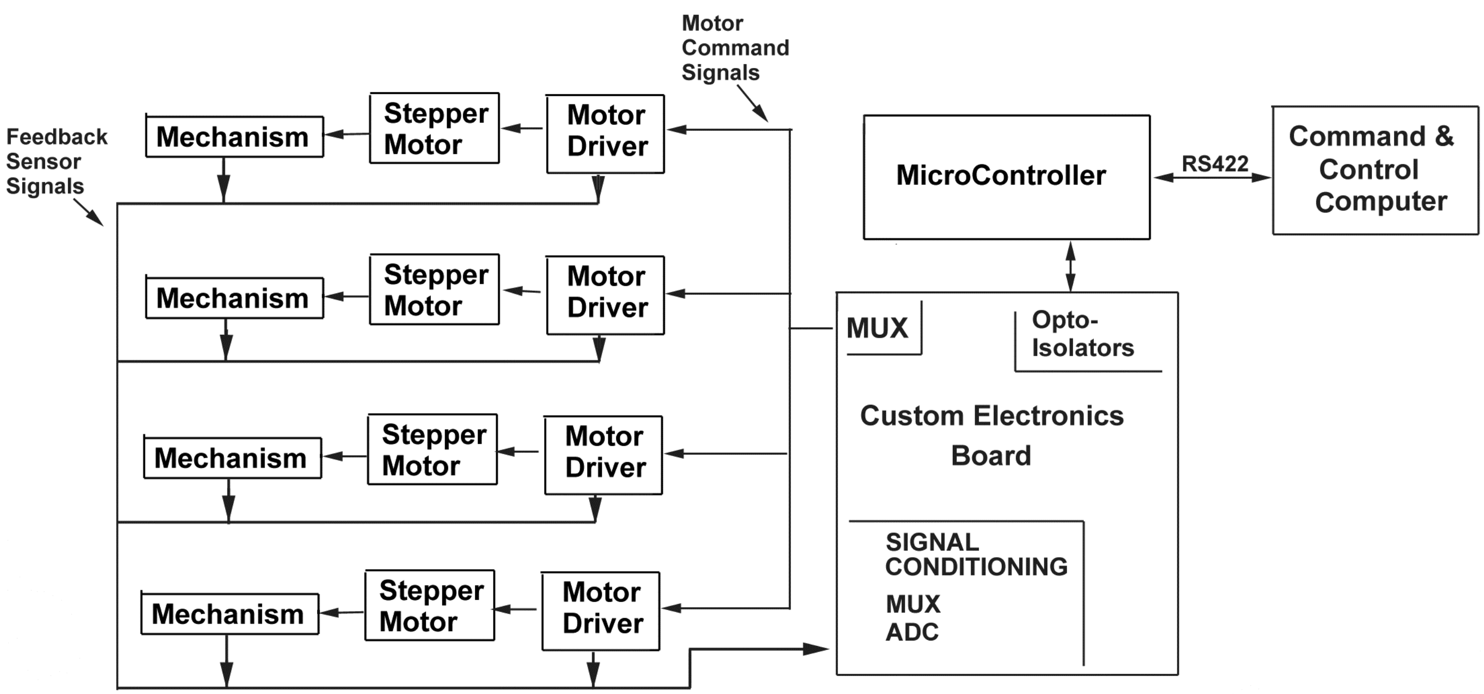
- Carousel Mechanism Electronics
  - Requirements
    - Provide Control Electronics for 4 Carousels
    - Maximum Range of Motion 300 deg. (worst case)
    - Position Optics Accurately Within ± 1 arc min
    - Maximum Indexing Time
      - < 30 sec. With 300 deg. Maximum Rotation
    - Should be Able to Return Each Carousel's Position and Health and Safety Telemetry

Opto-Mechanical

- Carousel Mechanism Electronics
  - Design Goals
    - Use of Commercial Off The Shelf (COTS) Electronics
    - Use Previously Proven Designs Where Possible
    - Electronics Should Perform Auto Initialization Procedures
      - End User Can Override and Perform Manual Init.
    - Supply High/Low Level Commands for Debugging and Creation of New Commands (if needed)
    - Reduce Digital Switching Noise by Optical Isolation

Opto-Mechanical

MECHANISM ELECTRONICS BLOCK DIAGRAM



Opto-Mechanical

- Carousel Mechanism Electronics
  - Design Approach
    - Microcontroller Board (INTEC)
      - Commercial Board, Based on Motorola 68HC16
        - » 16 bit uController
        - » Board Size 6.5” X 5” approx.
      - 16 Data and 10 Address Lines
      - Large Number of Built-In Digital I/O Ports
      - Serial I/O Ports (RS232, RS485)
      - 8 Channels, 10bit A/D Converters (100 kHz max)
      - 256K SRAM, 256K FLASH EPROM

Opto-Mechanical

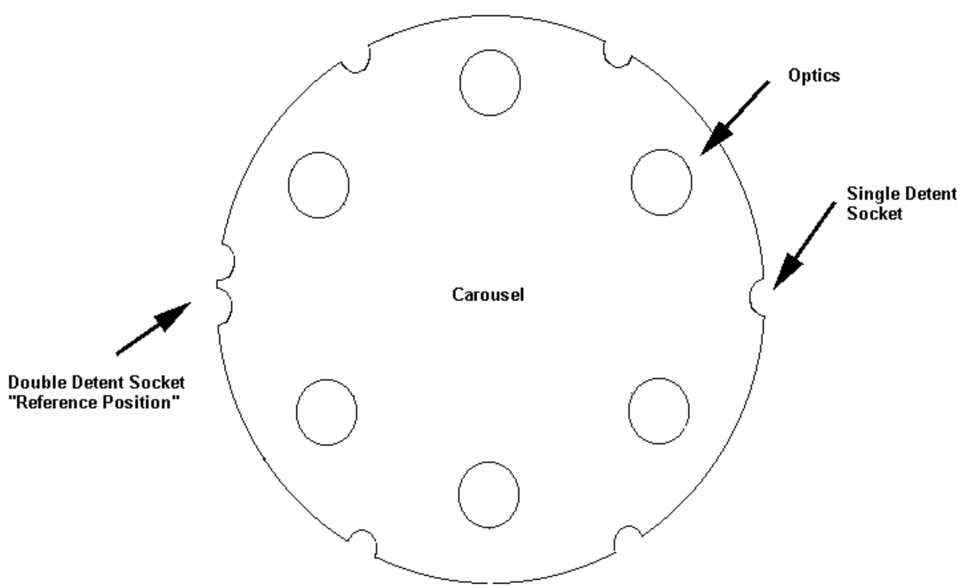
- Carousel Mechanism Electronics
  - Design Approach (Cont..)
    - Custom Electronics Board
      - All Decoding Logic
      - Opto-Isolation Interfaces
      - Signal Conditioning for Feedback Sensors
        - » Motor Current and Rotary Potentiometer Sensors
      - RS422 Port
    - Stepper Motors and Motor Drivers
      - Phytron VSS Stepper Motors
        - » Flight: Cryogenic Version, Superconducting Wires
        - » Lab: Standard Version, Runs at Room Temperature

Opto-Mechanical

- Carousel Mechanism Electronics
  - Design Approach
    - Stepper Motors and Motor Drivers (Cont..)
      - Phytron SINCOS-L Stepper Motor Drivers
    - Feedback System
      - » Indexing Implemented Using Detent Mechanism
      - » Detent Switch Flags Controller When Detent Roller is Inside Socket
      - » Use of “Double Detent Socket” as Reference Position
      - » Two End Of Travel Switches
      - » Rotary Potentiometer Used as Low Resolution Position Sensor (Approx. 1 deg. Resolution)

Opto-Mechanical

- Carousel Mechanism Electronics
  - Design Approach (Cont..)
    - "Double Detent Socket" Reference Position



Opto-Mechanical

- Carousel Mechanism Electronics
  - System Operation
    - Command Computer "talks" to Carousel Mechanism Electronics (CME) Through RS422 Port
    - CME Allows High Level Commands Such as:
      - Move Carousel #*N* to Position #*M*, Direction *Dir*
    - CME Allows Low Level Commands Such as:
      - Move Carousel #*N*, #*S* Step Counts, Direction *Dir*
      - Get Rotation Sensor #*N* Value
    - CME Can Command Individual/All Carousels To Move at the Same Time (Minimizes Indexing Time)

Opto-Mechanical

- Carousel Mechanism Electronics
  - System Operation (Cont..)
    - CME At StartUp (or by Means of a Reset Command) Will Initialize Itself
    - Auto Init Is Accomplished by
      - Finding "Double Detent Socket"
      - Reading the Rotary Potentiometer Value
      - Finally Moving to a Predetermined Position
    - End of Travel Switches Are Available (if Needed)

Opto-Mechanical

- Carousel Mechanism Electronics
  - System Operation (Cont..)
    - After Completion of Init Procedure, CME Goes to Standby Mode
      - CME Waits for Commands from Command and Control Computer
    - Power Off Procedure Commands Each Carousel To Go To Respective “Home” Position

Opto-Mechanical

- Carousel Mechanism Electronics
  - Safety Features
    - Motor Driver Has Built-In Current Limiter
    - Motor Driver Outputs Temperature Status Bit
    - CME Measures Stepper Motor Current
    - End Of Travel Switches Prevent > 300 deg Rotation
    - Software Based "Soft Limits" Add Redundancy to End Of Travel Switches and Rotary Potentiometer Sensor