DISCO - Develop Inertial Spin Created On-orbit: A Magnetic Spin-Rate Controller for STARSHINE 4

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STARSHINE Mission

• To learn about variations in rate of LEO satellite orbit decay caused by upper atmospheric response to bursts of solar Extreme Ultraviolet (EUV) radiation during solar cycle.
• Accomplished by visually tracking a sunlight-reflecting mirrored sphere with a ballistic coefficient independent of satellite attitude and calculating its orbit decay rate.
Why Build DISCO?

STARSHINE mirrors ground, polished and tracked by students. The satellite must spin at 5°/second.

Earlier STARSHINE satellites have stopped spinning, making amateur observations inaccurate.
Requirements

• The subsystem to Develop Inertial Spin Created On-orbit shall:
  – Maintain a spin-rate of 5°/sec to enhance optical visibility.
  – Function for a minimum of 3 years.
  – Operate on battery power.
  – Be capable of operating in a Low Earth Orbit environment.
  – Fit within a ½-meter sphere.
Electronics

Active System:

Sensors: 3 spin-rate sensors
1 three-axis magnetometer

Actuators: 3 magnetic torque rods

Controller: TI MSP430F149 (ultra low power)
Hardware Design

- Custom 8-layer PCB
- Power Regulation:
  - I/P 9VDC-13VDC
  - O/P 3.3VDC, 5VDC, 15VDC
- Microcontroller & JTAG
- Opto-FET H-Bridge for Torque Rods
- Signal Conditioning:
  - Low-Noise Amps
Embedded Software

- Algorithm Designed to Minimize Power Consumption:
  - Disable sensors when not running.
  - Disable unused microcontroller features.
  - Minimum magnetic field threshold (28 µT).
  - Push in direction of greatest spin.
  - Watchdog timer used to reboot system after radiation lock-up.
# Power Budget

<table>
<thead>
<tr>
<th></th>
<th>Power Consumption</th>
<th>Time</th>
<th>Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sleep Mode</td>
<td>0.011286 W</td>
<td>24 hours</td>
<td>99.977%</td>
</tr>
<tr>
<td>Sample and Torque</td>
<td>3.388286 W</td>
<td>20.4 seconds</td>
<td>00.023%</td>
</tr>
<tr>
<td><strong>TOTAL (if spun)</strong></td>
<td></td>
<td></td>
<td><strong>30.35 Amp-hours</strong></td>
</tr>
<tr>
<td><strong>TOTAL (w/ spin-up)</strong></td>
<td></td>
<td></td>
<td><strong>30.45 Amp-hours</strong></td>
</tr>
</tbody>
</table>

- Lifetime = 3 years
- Moment of Inertia = 1.08 kg*m²
- Torque Rod = 2 A*m²
- Average Field = 3.99 * 10⁻⁵ T
- Deceleration over 2 months (0.0015 rad/s each 24 hours)

**Results in 20 seconds of torque per day**
Ground Testing

Temporary housing built to hold components during ground testing.

Helmholtz coil used to amplify magnetic field to compensate for string and air friction.
Future

- Integration into STARSHINE 4
- Mechanical Mount
- Launch into LEO (2007/2008)

(Courtesy Planetary Systems Corp.)
Design Team

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