Contactless Position sensors for space mechanisms based on eddy current sensing

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For more than 20 years, CTEC has been involved in various space missions, delivering products designed for severe environment conditions (vibrations, shocks, vacuum, humidity, wide thermal range including cryogenic).

MIDAS AFM for Rosetta

Aerospace and Defence Heritage Flyer

PAM30 specified by JPL for Psyche
Eddy current sensor (ECS) technology, using printed circuit board (PCB) for printed coils.

PCB coils advantages:
- Low thickness.
- **Complex designs capability** (multi-coils, multi-layers) -> differential measurement.
- Production repeatability.
- Production cost.
- Mechanical integration.
- Spatialization.

According to CTEC’s experience, they provide both a good resolution/accuracy and a good robustness against temperature variations.

**These sensors are available commercially off the shelf (COTS).**
- They can be used for quick feasibility development and as a starting point for custom products delta designs.
COTS Eddy current position sensor principle (distance measurement)

Inductance value is robust against T° variations
Eddy current sensor (ECS) integrated in mechanisms

MEFISTO space mechanism

- Actuators: APA120ML
  - Stroke: 130μm @ 170V; Blocked force: 1400N
- Sensors: Eddy Current Sensors ECS
  - Resolution: 10nm; linearity 0.1% on 100μm

MEFISTO space mechanism

- Close loop control
  - Tracking error up to 20μm
  - Speed error is less than 1%

System performance

- Tilt stroke: 0.7 mrad
- Tip stroke: 80μm
- Resonance frequencies: 700-800 Hz
- Speed: 0.5 mrad in 2 ms
- Sine vibration level: 20 g rms @ 100Hz
- Random vibration level: 15 g rms
- Dimensions: 270×250×293 mm
- Mirror mass: 730 gr
- Mirror size: 220×96×23 mm
- Total mass: 12.7 kg

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Eddy current sensor (ECS) integrated in mechanisms

Magnetic Fast Steering Mirror (MFSM)

M-FSM Performance
With Ø10 mm mirror
On 31/12/2019

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Angular stroke max</td>
<td>mrad</td>
<td>+/- 34</td>
</tr>
<tr>
<td>FS Bandwidth</td>
<td>Hz</td>
<td>250</td>
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<tr>
<td>Mirror stroke @200Hz</td>
<td>mrad</td>
<td>+/- 34</td>
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<tr>
<td>1st resonance frequency</td>
<td>Hz</td>
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<tr>
<td>Resolution</td>
<td>μrad</td>
<td>2-5</td>
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<tr>
<td>Resistance @ 20°C (incl. cables)</td>
<td>Ohm</td>
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<tr>
<td>Inductance @20°C</td>
<td>mH</td>
<td>0.64</td>
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<tr>
<td>Max drive voltage</td>
<td>V</td>
<td>24</td>
</tr>
<tr>
<td>Max drive current</td>
<td>A</td>
<td>10</td>
</tr>
<tr>
<td>Dimensions</td>
<td>mm</td>
<td>Ø62 x H56</td>
</tr>
<tr>
<td>Total weight</td>
<td>gr</td>
<td>400</td>
</tr>
</tbody>
</table>
Eddy current sensor (ECS) integrated in mechanisms

- Beam Steering Actuator (BSMA)
- IASI-NG: Infrared Atmospheric Sounding Interferometer New Generation
  - Customer CNES – Prime Contractor Airbus DS
  - Earth observation for numerical weather prediction, atmospheric chemistry and climate monitoring in the 2020 to 2040’s.
- Mechanism qualified.
- 5 flight models delivered to AIRBUS DS.
- ECS sensors from CTEC will fly.
COTS spatialization thanks to CNES and ESA

As a result, CTEC technology has been successfully applied in space field for various functions:

- Position proximity sensors.
- End of stroke detection.
- Rotation counting / teeth counting.

The conditioner is integrated together with the sensor and has been designed to be spatialized.

- Standalone space product.

Next steps?

- Tangential motion sensing?
CTEC proximity current sensor: principle (On/Off sensor)

- Differential measurement with:
  - 1 emitting coil
  - 2 receiving coils
- 1 fixed target
- 1 moving target
- Technology based on eddy current, working at high frequency (typ. 1 MHz)
R&T CNES PROXIMITY SENSOR : prototype

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R&T CNES PROXIMITY SENSOR : performances

› Trigger distance
  ◦ >1 mm
  ◦ Repeatability : +/- 0.1 mm
  ◦ Hysteresis : < 0.1 mm

› Dynamic perf.
  ◦ Response time < 1 ms
  ◦ Target speed < 100 mm/s

› Electrical perf.
  ◦ Voltage : 3V3 or 5V
  ◦ Power consumption < 100 mW
  ◦ Output : low < 0.4V, high > 0.9V

› Dimensions
  ◦ Mass < 11 g
  ◦ Size : Ø15 mm x 26 mm
  ◦ Harness : 0.1 m to 5 m

› Environment
  ◦ Op. : -55°C / +90°C
  ◦ Non Op. : -65°C / +100°C
  ◦ Radiation : 100 kRad
  ◦ Vacuum : 10^-9 Torr
Top Tour proximity sensor

- Sensor based on:
  - 1 emitting coil
  - 2 receiving coils
  - Differential detection
  - Eddy currents
- PCB printed coils
- 2 sensors for redundancy
Top tour proximity sensor

Differential detection

Excitation

Detection signal

Detection signal under other conditions ($T^*$, cable length, ...)

Positive & negative thresholds

Top tour zero

A

B

C

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Top Tour on Euclid mission

- ESA Euclid telescope (launch 2022)
- Cryo mechanism (CM) used for rotating the filter wheel assembly (FBA) and the grism wheel assembly (GWA), with an open loop stepper motor.
- Top tour FM position sensor provided by CTEC for position reference.
Top Tour on VESUV

- ESA M5 EnVision mission
- VenSpec-U instrument (VeSUV)
- Top Tour BBM sensor delivered to IRAP.
Top Tour on Theseus mission

- ESA M5 Theseus mission
- XGIS instrument (X-Gamma rays Imaging Spectrometer)
- Top tour BBM detector for a 7-position filter wheel
What about your projects?

› What kind of proximity sensors do you need for your projects?
› What key specifications are you looking for?

Thank you for your attention

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