

Contactless Position sensors for space mechanisms based on eddy current sensing

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CTEC at a glance

Actuators

 APA®
Amplified Piezo Actuator

 Linear amplifier

 MICA™
Moving Iron Controllable Actuator





Mechanisms

 Piezo XY Stage

 Controller


 Piezo Fast Steering Mirror


 Controller


 Magnetic Fast Steering Mirror


 Controller


Sensors

 Strain gauge

 Conditioner

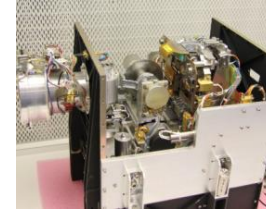
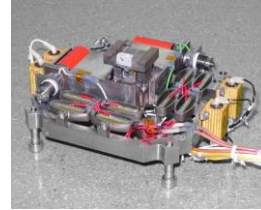
 Eddy current sensor

 Conditioner



CTEC's space heritage

- › 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



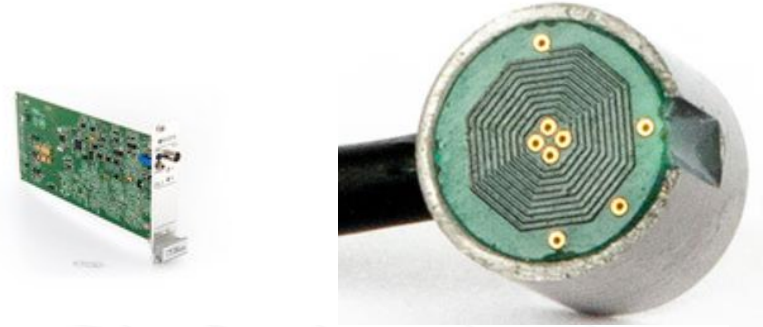
PAM30 specified by JPL for Psyche



Aerospace and Defence Heritage Flyer

Eddy current sensor (ECS) with printed circuit board (PCB) coils

- › 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.



› Typical accuracy achieved after conditioning

Resolution (BW = 20 kHz) ⁽¹⁾	0.010	% FS ⁽²⁾
Resolution (BW = 1 kHz)	0.003	% FS
Resolution (BW = 20 kHz), extended range (1000 µm)	0.015	% FS
Resolution (BW = 1 kHz), extended range (1000 µm)	0.005	% FS

ANNOTATIONS

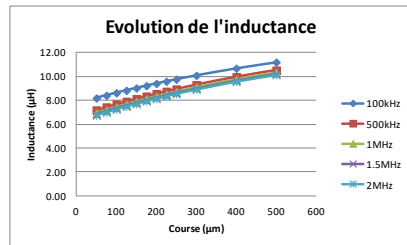
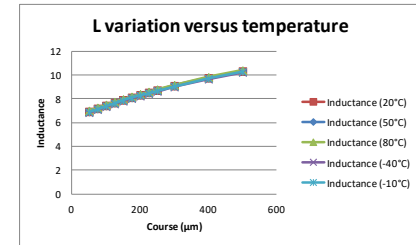
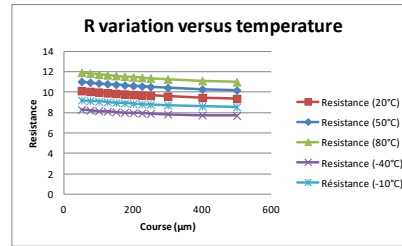
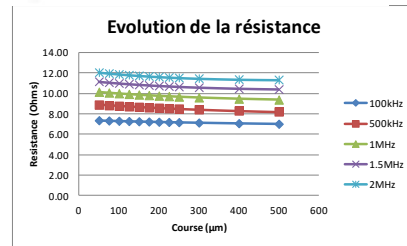
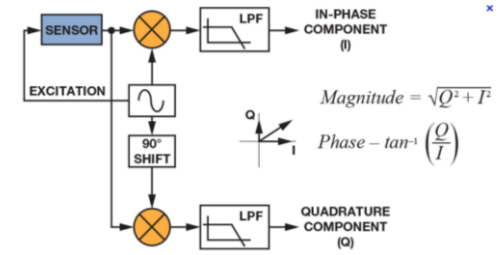
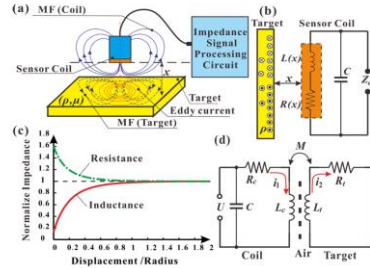
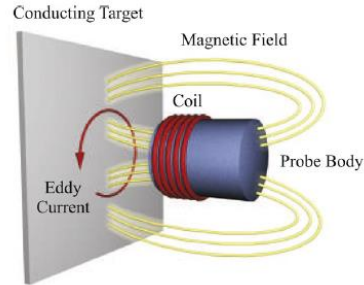
(1) BW : Bandwidth

(2) FS : Full Scale

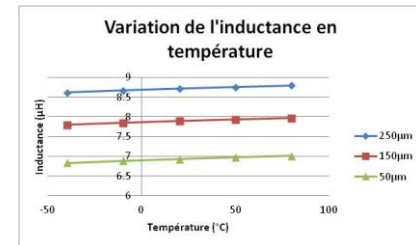
OPERATING ENVIRONMENT

PARAMETER	TYPICAL VALUE	UNIT
Operating temperature range	-25 ... +70	°C
Storage temperature range	-35 ... +100	°C

COTS Eddy current position sensor principle (distance measurement)



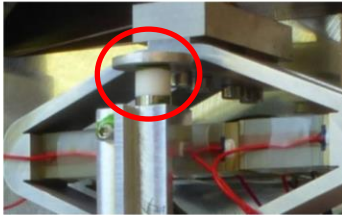
Inductance value is robust against T° variations



Eddy current sensor (ECS) integrated in mechanisms

MEFISTO space mechanism

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



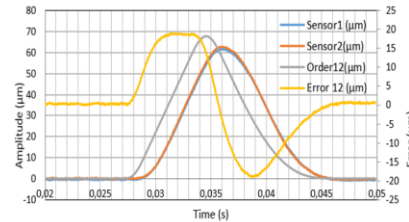
APA120ML foot with ECS75 sensors



MEFISTO mechanism with its 2kg load

MEFISTO space mechanism

- › Close loop control
 - tracking error up to 20 μm
 - speed error is less than 1%



Order, stroke & error of a foot versus time

- › System performance

Tilt stroke	0.7 mrad
Tip stroke	80 μm
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	279×250×293 mm
Mirror mass	730 gr
Mirror size	220×96×23 mm
Total mass	12.7 kg

MEFISTO Performances

Eddy current sensor (ECS) integrated in mechanisms

Magnetic Fast Steering Mirror (MFSM)

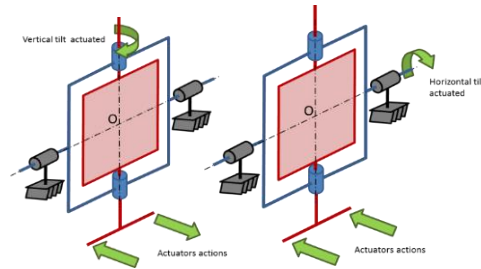
M-FSM Performance
With Ø10 mm mirror
On 31/12/2019



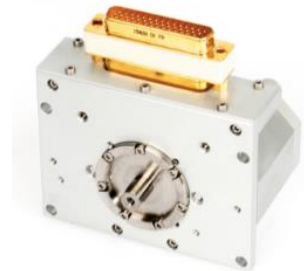
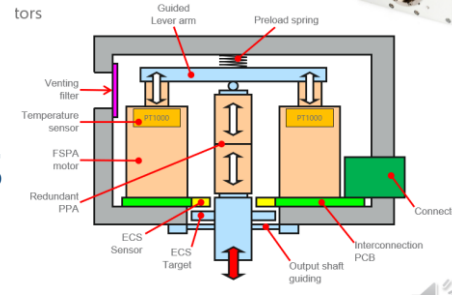
Parameter	Unit	Value
Angular stroke max	<u>mrad</u>	+/- 34
FS Bandwidth	Hz	250
Mirror stroke @200Hz	<u>mrad</u>	+/- 34
1 st resonance frequency	Hz	116
Resolution	μ rad	2-5
Resistance @ 20°C (incl. cables)	Ohm	0.5
Inductance @20°C	mH	0.64
Max drive voltage	V	24
Max drive current	A	10
Dimensions	mm	Ø62 x H56
Total weight	gr	400

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.



Interferometer's beam splitter orientation



COTS spatialization thanks to CNES and ESA



COTS sensor

CNES R&T
Proximity
Sensor (R-
S16/TG-0002-
118

ESA ExPro
contract
4000126261
CONTACTLESS
MICRO-SWITCH
DEVELOPMENT



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

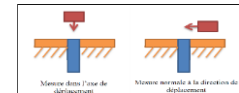
- Position proximity sensors.
- End of stroke detection.
- Rotation counting / teeth counting.

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

- Standalone space product.

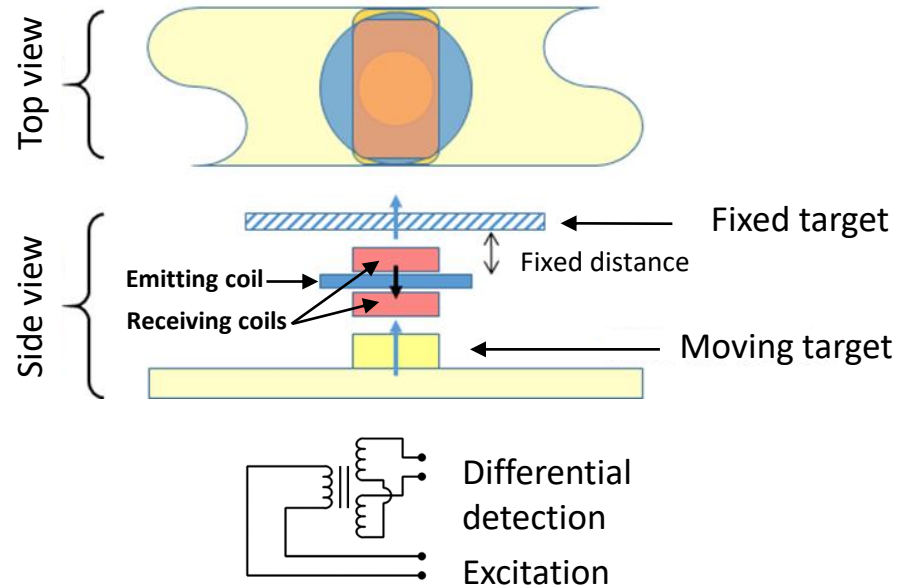
› Next steps ?

- Tangential motion sensing ?

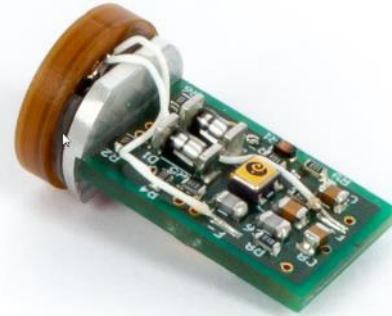
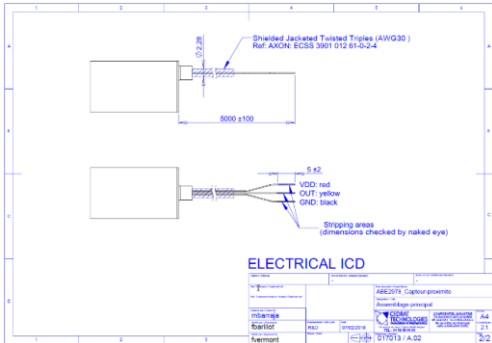
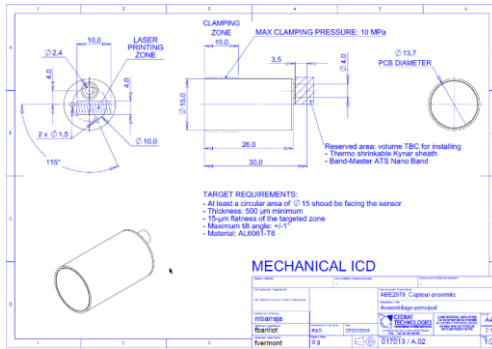


CTEC proximity current sensor: principle (On/Off sensor)

- › 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



R&T CNES PROXIMITY SENSOR : performances

› Trigger distance

- >1 mm
- Repeatability : +/- 0.1mm
- Hysteresis : < 0.1mm

› Dynamic perf.

- Response time < 1ms
- Target speed < 100mm/s

› Electrical perf.

- Voltage : 3V3 or 5V
- Power consumption < 100 mW
- Output : low <0.4V, high > 0.9V

› Dimensions

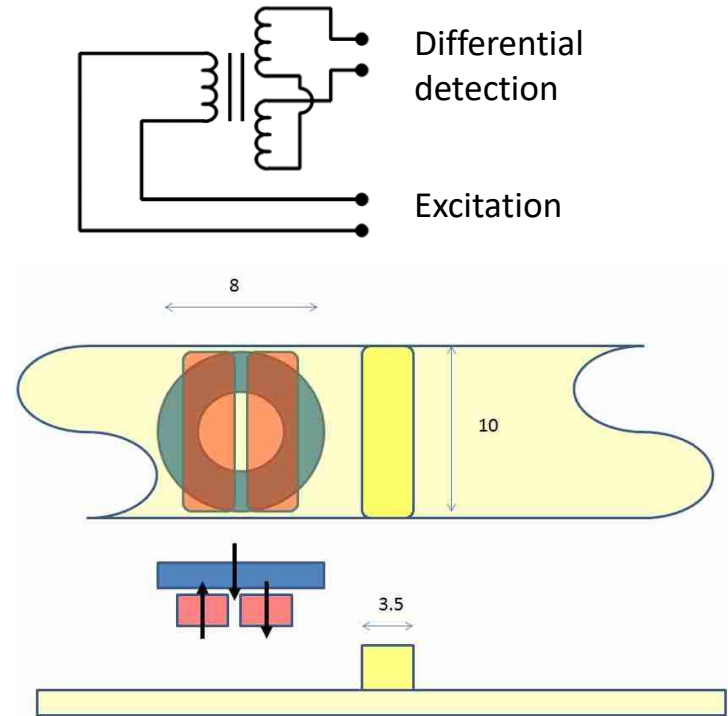
- Mass < 11 g
- Size : Ø15mm x 26mm
- Harness : 0.1m to 5m

› Environment

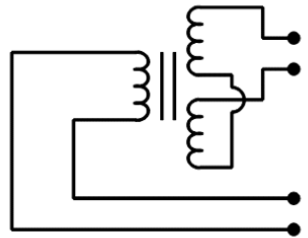
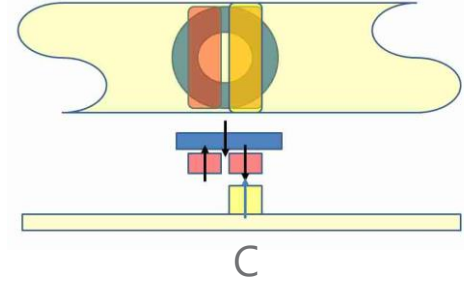
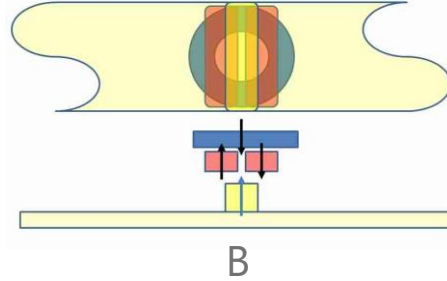
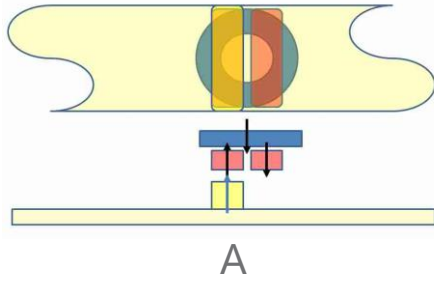
- **Op. : -55°C / +90°C**
- Non Op. : -65°C / +100°C
- **Radiation : 100 kRad**
- Vacuum : 10⁻⁹ Torr

Top Tour proximity sensor

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

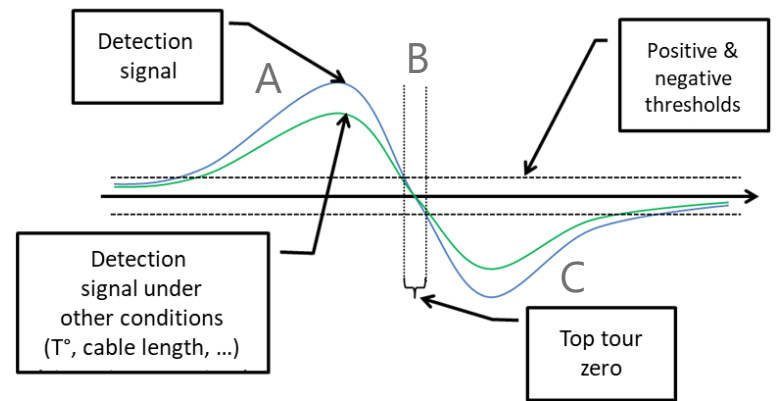


Top tour proximity sensor



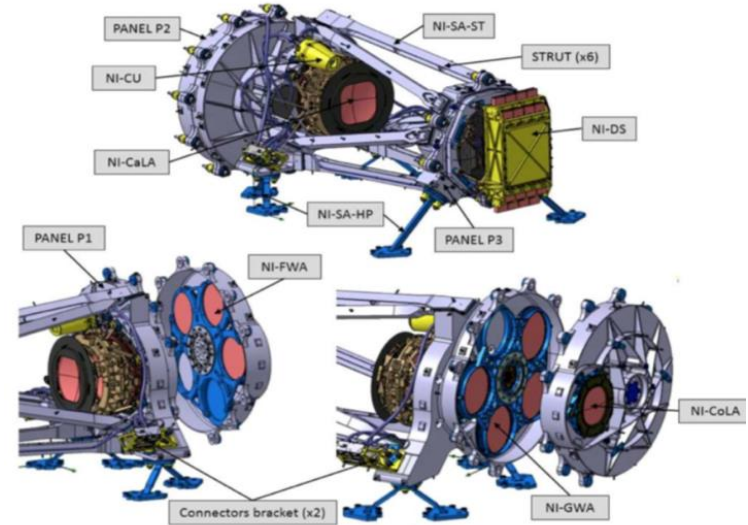
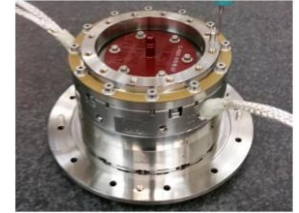
Differential detection

Excitation



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.



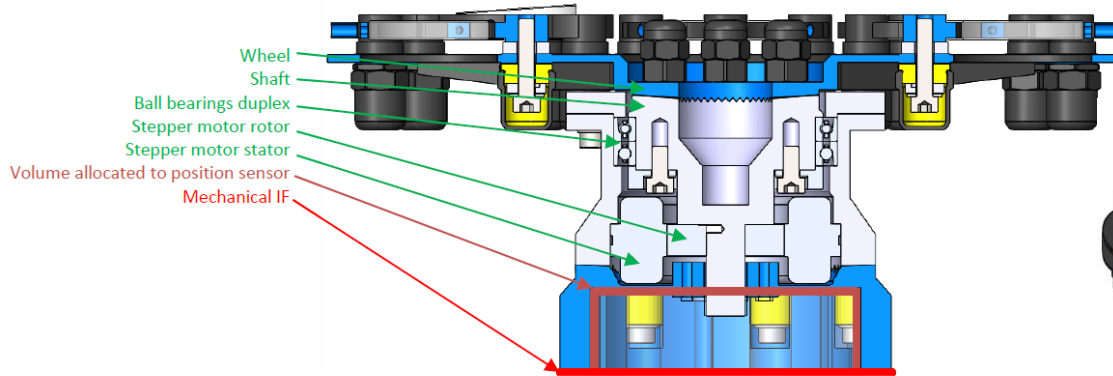
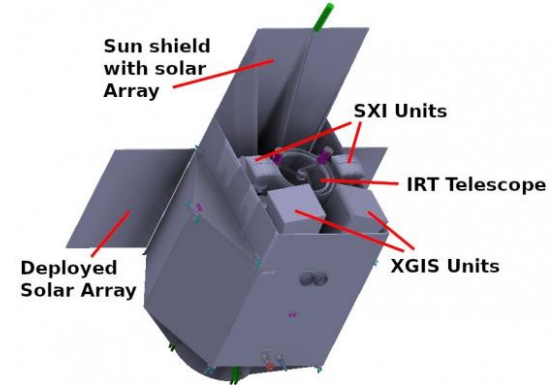
Top Tour on VESUV

- › 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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