Electrically Coupled Angular Decoder for Long-Life Mechanisms

Executive Summary Report

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1	2020/01/07	All	Initial issue
2	2020/02/24	4 and 5	Flight Model changed by Engineering Model in sections 2 and 3

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1. INTRODUCTION

The present document provides a brief overview of the "Electrically Coupled Angular Encoder for long-life Mechanism" ESA project. This report concisely summarises the findings of the performed project and it is suitable for non-experts in the field. The document contains information that could be available to public.

2. REFERENCE DOCUMENTS

2.1 Reference documents

[RD1] IPC – Technology Harmonization Advisory Group (THAG), Position Sensors (for mechanisms). European Space Technology Harmonization Dossier.

2.2 Acronyms list

CLAS3	Electrically Couples Angular Sensor/Decoder for Long-Life Mechanism. Third development phase.
DAC	Digital to Analogue Converter.
EM	Engineering Model.
ESA	European Space Agency.
EM	Engineering Model.
LVDS	Low Voltage Differential Signaling.
NA or —	Not Applicable.
PCB	Printed Circuit Board.
SADM	Solar Array Drive Mechanism.

3. BACKGROUND

The system under development consist of a Engineering Model version of a contact-less angular decoder for space applications. This device includes three PCBs, two of them static and other in between that rotates solidary with a shaft that crosses the sensor in the middle. The sensor provides the angular position of the shaft with 0.01 degrees of accuracy in space conditions. Both stators with the rotor in the middle is shown in Fig. 1 below.

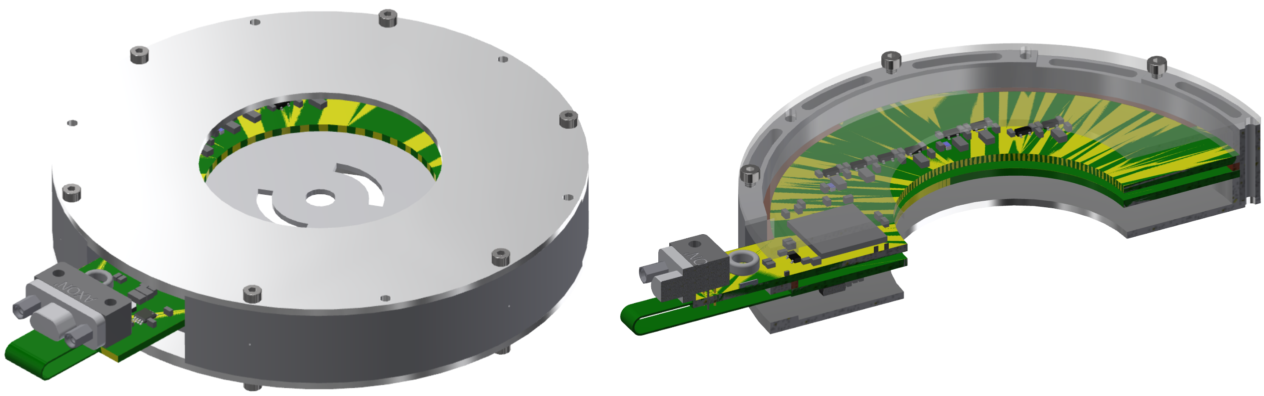

Fig. 1. Sensor device view. The aluminium case encloses both stators in the image on the right, while the rotor is arranged in between of them in the image on the left.

3.1 Market considerations

There is a need within the space sector of medium to high resolutions rotatory position sensors suitable for low cost, space qualified and off-the-shelf solutions, as is described in [RD1]. Those sensors, could be used for SADM, optical pointing mechanisms, antennas drive mechanism among others. Besides, those sensors shall be versatile enough to provide custom solutions or developments if needed.

Apart of this, the addressed market requires sturdy mechanisms for long life use that require no maintenance or manual calibration. The devices accommodated in space vehicles will suffer a wide range of temperatures during their operation time, as well as radiation environment that could affect their performance during their lifetime in orbit, up to 15 years.

The market already offer different solutions based on different technologies, such as potentiometers, encoders, optical or inductive sensor. Each technology offers different advantages, but always a specific drawback that limits the use of that technology in one or other situation. In this sense, the proposed technology, base in capacitive sensors shall achieve almost all requirements for wide variety of space applications with none drawbacks, as is described in [RD1].

3.2 Design considerations

The device designed meets space market requirements in term of dimensions, weight and power consumption. The developed part has achieved all of them for a measurement error lower than 0.1% of the shaft position in a temperature range from -55ºC to 110ºC. The sensor accuracy is variable and may be adapted to any application by changing the dimensions of the sensor diameter. The rotor of the sensor moves independently with respect the static case, so it may turn in any direction as much as the shaft of the system requires.

From the point of view of the technology, the sensor consists of a capacitive device that works in close loop, that allows better performance in noisy ambient with temperature variations. Capacitive sensors are quite sensible to small voltage and intensity biasing in electronic components, but a careful selection of space qualified parts in combination with a smart electronic design has made this possible. In addition, the new electrodes geometry design avoids any gap in the measurement for complete turns, unlike other technologies like potentiometers.

On the other hand, the low number of required components, simple geometry and inexpensive materials required for the electrodes allows a significant cost reduction for the sensor. The manufacturing process has been devised to be time effective and simple to avoid fails and allow better inspections. The assembly procedure to arrange the sensor in other system has been designed to be simple as well. The static aluminum case shall be attached by means of 5 points, while the rotor in the middle of the sensor is screwed to the shaft, where the attachment system could be adapted to any kind of morphology. Once the sensor is placed in its final position, the sensor is self-calibrated by the on-board computer and none modifications shall be performed.

The current development of the sensor includes a serial communication, RS-422 compatible, to transmit position measurements in a continuous rate. This standard protocol might be adaptable to other requirements, such as, LVDS communication or analogue output without any electronic modification or DAC.

A picture with the aspect of the final sensor is provided in Fig. 2.

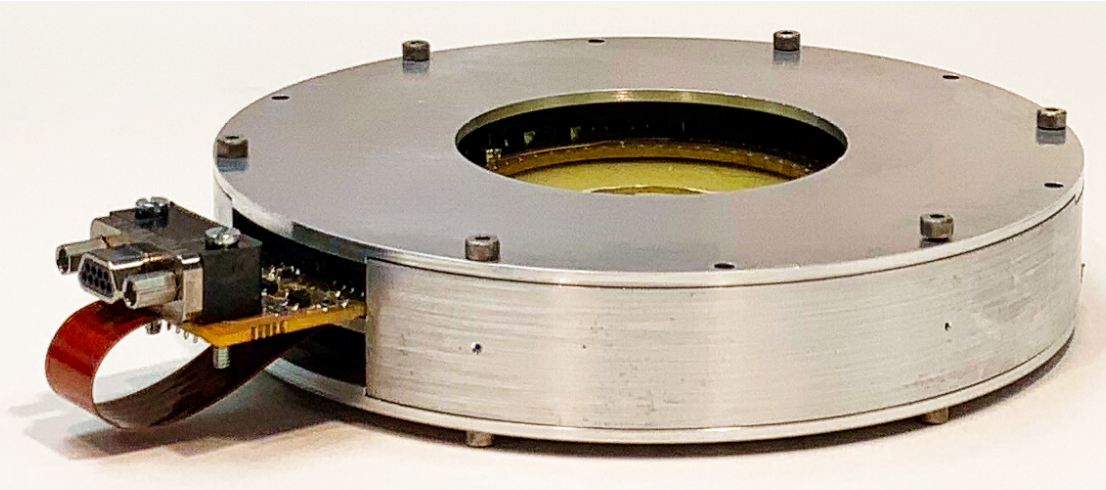

Fig. 2. The contactless angular sensor.

4. FINDINGS AND FURTHER WORKS

The proposed EM sensor developed by EMXYS was manufactured to achieve all points considered in previous section of this report. Besides, the sensor was tested in temperature, from -55ºC to +110ºC and vacuum conditions (taken into account previous project stages for EM validation). Thus, the proved sensor skills are summarized in the following Table 1.

Requirement	Value	Description
Diameter	105mm	Diameter of the cylinder shape of the sensor, see Fig. 1.
Height	19mm	Height of the cylinder shape of the sensor, see Fig. 1.
Weight	<180g	Total mass of the sensor, case and rotor included.
Communication rate	115.2Kbauds	Digital communication.
Supply voltage	Min. 4V / Nom. 5V / max. 6V	DC voltage supply through connector.
Power Consumption	<2W	Considering the whole temperature range and all voltage levels.
Measurement range	360º	The sensor may turn in any direction as much as the shaft requires.
Accuracy	0.01º	Position value.
Linearity, hysteresis and repeatability	0.1%	Considering the whole temperature range.
Hysteresis	None	The kind of measuring that is performed in the sensor does not care the direction of turn to reach any point.
Operating Temperature range	-55ºC to 110ºC	Tested conditions
In orbit lifetime	15 years	

Table 1. CLAS3 specifications summary and absolute maximum ratings.

Further lines of work shall focus on the mechanical attachment of the sensor to even achieve better resolution, higher than 12-bits. The attachment system shall keep the sensor still during movements as well as minimizes the clearance of the rotor respect the shaft. In this sense, the principle of work of the sensor is good enough to achieve better performance, but mechanical limitations may increase the error of high precision system required, such as, in optical pointing mechanism.

5. CONCLUSIONS

The functioning of a contactless sensor for medium applications has been tested and verified to qualify for space applications where a medium range low cost part is required in substitution of potentiometers.