NEELEFFECTINTHESKY

Magnetic sensors for aircraft applications

State of the art – Background

The current and voltage sensors for aerospace applications are conventionally shunt or resistive dividers, Hall sensors (open loop or closed loop) and transformers (VT and CT). Increasing onboard electrical power in more electrical aircrafts requires adding novel and numerous power equipments which implies a large increase in the number of sensors. These sensors are used for power control, for protection (overcurrent and overvoltage detection, or leakage current), and for the management of energy storage means. The evolution of loads, sources and storage means implies the use of mixed DC and AC networks. Thus, sensors must allow combined DC and AC measurements.
Existing solutions have certain drawbacks, in general size and weight when sensors are accurate. The required accuracy is of the order of 1% over a temperature range from -60 °C to + 125 °C.

Objectives

The key objective is to leverage the breakthrough nanotechnology called Neel Effect® invented by a French SME, Neelogy, for high performance isolated magnetic sensors with no remanence, adapting it to harsh environmental avionics constraints: high amplitude variation of operating temperature -60 °C to +125 °C, depression, humidity, vibration and EMI/EMC constraints. The same technology should be used for both current and voltage sensors. Neelogy is the only participant to this project, supported by subcontractors, who are experts in avionics standards and recommendations, especially for the electronics parts. The project duration is 42 months. The goal was to deliver 5 prototypes of current sensors and 5 prototypes of voltage sensors at the end of the project, as requested in the Call for Proposal. With regard to commercial products, the objective is to have them available 1 to 2 years after the end of the project

Description of work

The project is organized in 16 work packages, in summary:
- simulation tools,
- test benches,
- design of measurement heads for Current and for Voltage,
- design of discrete analogical and digital electronics,
- design of mechanical parts,
- test of mock-ups and prototypes,
- design of PCB,
- specification of ASIC.

A scientific project manager, as well as a project coordinator, have been assigned.

Project expenses finally amount to 631k€ (592k€ for Research & Technology Development, 27k€ for Demonstration, and 12k€ for Management), spread as follows: 88% to Neelogy and 12% to Neelogy's subcontractors. It represents an effort of 72 Person-Months for Neelogy.

Results

a) Timeline & main milestones

The timeline was extended during the project, finally allowing for going through all initially planned work packages. The final duration of the project was 42 months.

Specification for the mock-up, prototype and product has been defined @ t0+6 months.

A specific development tool (simulation) has been developed over the all project. First version was available @ t0+ 12 months.

A mock-up for current measurement has been designed, realized and tested @ t0+ 18 months

A special setup for voltage characterization has been developed @ t0+18 months.

A mock-up for voltage measurement has been designed, realized and tested @ t0+ 24 months

A new electronic has been designed, realized and tested @ t0+ 36 months

An integration study into a power converter has been done @ t0+ 40 months

ASIC were specified @ t0+42 months

b) Environmental benefits

The demonstrators proved the concept of very lightweight sensors. The transducer mass is few tens of grams for a closed loop magnetic sensor of 1kA.

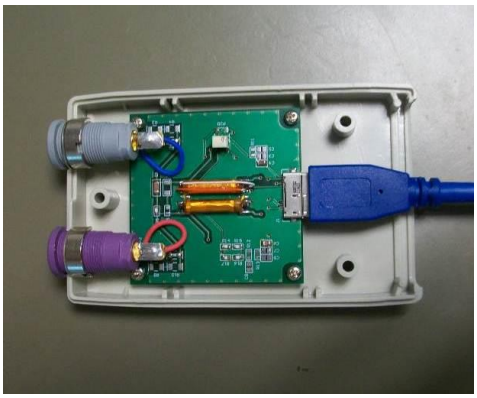
c) Maturity of works performed

The prototype effectively allows for proving several key specifications items permitted by the Neel Effect® technology, such as:
- the frequency bandwidth finally reaches 20kHz
- the total power consumption finally reaches less than 1W for a closed loop 1,000 A sensor,
- the immunity to a specific perturbation, even without magnetic shield,
- the possibility to integrate electronics in an ASIC
- the good accuracy over a wide temperature range
- the small size and mass of the transducer
- the possibility to use the same electronic for a voltage and a current sensor.

However, the following points have not been treated during this project:
- the design of the transducer for voltage insulation up to 10kV
- the design of the transducer to reduce current injection due to high dV/dt of the primary conductor.
- the realization of a very compact electronics (ASIC)

Based on above findings as well as on parallel works, the contractor has decided to continue developing the Neel Effect® technology, improving the three latter items, in order to finally propose a product for aircraft customers.

1kA Neel Effect® Current transducer



1kV Neel Effect® Voltage transducer

Project Summary

Acronym: **NEELEFFECTINTHESKY**

Name of proposal: **Magnetic sensors with no remanence for aircraft applications**

Technical domain:

Involved ITD **SGO: System for Green Operation**

Grant Agreement: **271816**

Instrument: Clean Sky **Article 171 of the Treaty**

Total Cost: **600000€**

Clean Sky contribution: **428750€**

Call: **SP1-JTI-CS-2010-03**

Starting date: **06/12/2010**

Ending date: **05/06/2014**

Duration: **42 months**

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