Star Trackers Optical Stimulator (OGSE CU)

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THE CHALLENGE

Implementing an embedded control system to drive optical heads needed to test different types of star trackers provided with a local operator interface and remote control.

THE SOLUTION

Providing a rack mountable stand-alone system to drive from one to three optical heads, using NI CompactRIO device equipped with an operator interface based on Touch Panel and controlled from a remote station via Ethernet interface.

Products used

LabVIEW
CompactRIO

Star trackers test requires the realization of a specific optical stimulation unit capable to drive the LEDs of the optical heads and to be used both as stand-alone devices for specific tests and in remote mode, integrated as a subsystem in the testing bench of the navigation system.
Such requirements were met by developing an embedded system based on NI CompactRIO device and Touch Panel Computer that allows to realize an optical stimulation instrument. The design of the hardware and software architecture respects the concepts of the modular implementation in order to allows the adoption of the instrument, properly configured, for the test of different types of star tracker.

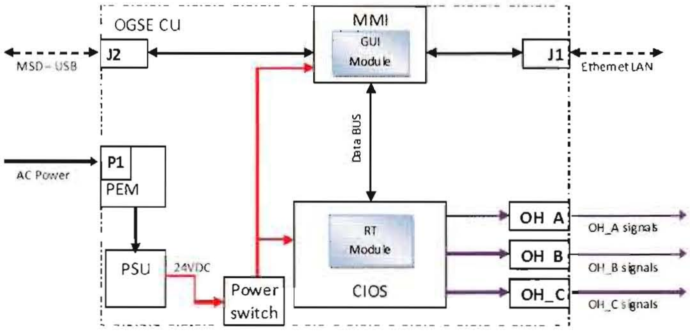

Figure 1

Three different types of sensors: solar, terrestrial and stellar are used in the context of navigation and positioning systems of spacecraft (satellites, probes, etc.). The information collected from such sensors allows the navigation system of the vehicle to localize itself in the solar system.
In particular the star trackers will execute the recognition and the tracking of a specific constellation (Star Tracking). The test of this type of sensors must be executed with a system equipped with an optical head that includes a group of LEDs, a diaphragm provided with micro holes and temperature probes.
The tests must be executed inside a climatic chamber (typical range of temperature is -40° ÷ 60° C) and they must be integrated in a more wide testing system that executes the verification of the entire navigation system.
During the design and development of the OGSE Control Unit (Star Tracker Test Device) it was necessary to analyze and assess all technical and functional aspects regarding the driving of optical head, the data management and the interface system both for local usage by the operator and for remote interaction via TCP/IP communication protocol.
Compared to a first version of the instrument that implemented the control of optical heads suitable to test a single type of star tracker (called AA-STR "Autonomous Star Trackers") it has been realized a revision of the hardware and software architecture in order to permit the use of new types of star trackers such as MHSTR (Multiple Head Star Trackers).

Requirements

First the system to be realized must be used as a "traditional" instrument with an advanced management interface and must be equipped with a remote interface via Ethernet LAN.
The above requirements permit to use the stimulator both directly for dedicated tests and to integrate it in a more complex testing system (called OCOE – Overall Check Out Equipment) in which the optical system is intended as a subsystem.
Since a navigation system can expect the use of a different number of star trackers, the stimulator must be able to drive independently from a minimum of one to a maximum of two optical heads in the case of AA-STR and three optical heads in the case of MHSTR. The stimulator must be implemented in two versions, according to the sensors to be tested, and must be able to control:

"The use of NI hardware and software allowed us to meet completely, rapidly and effectively all system requirements in examination."

a) Optical heads equipped with 4 LEDs group and with a temperature probe (for AA-STR types), each LED can be driven independently with variable level of current (0÷2 mA) and compensated driving current on the basis of specific output characteristics of the LED according to the operating temperature.
b) Optical heads equipped with two separate groups of ten LEDs for each MHSTR sensor, each group is selectable in a mutually

Figure 2

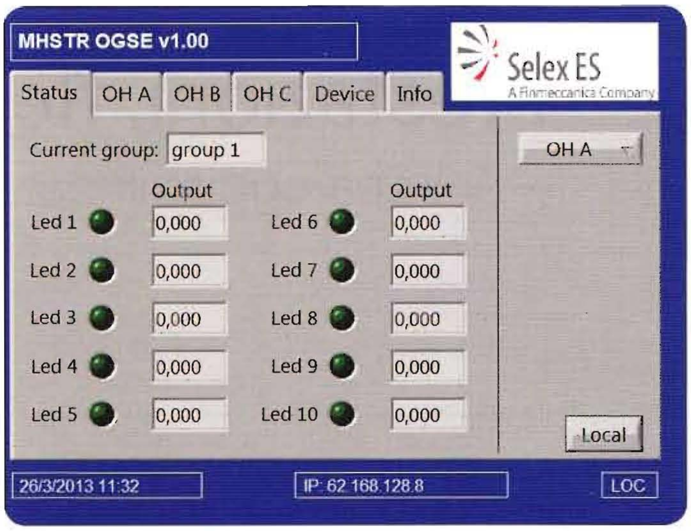

Figure 3

exclusive manner and each LED can be driven independently with variable level of current (0÷20 mA).

On the basis of probe type the system must provide:

AA-STR

- From 4 to 8 channels of analog current stimulation (organized in groups of 4)
- From 4 to 8 channels for the acquisition of analog voltage (organized in groups of 4) to be used for diagnostic purposes.
- From 1 to 2 channels for the acquisition of temperature from RTD to be used for compensation of the stimuli
- From 10 to 30 channels of analog current stimulation (organized in groups of ten) to be used for diagnostic purposes.
- From 10 to 30 channels for the acquisition of analog voltage (organized in groups of 10) to be used for diagnostic purposes.
- From 2 to 6 SSR output channels to select the group of LEDs to be driven.

Operator interface is implemented through Touch Panel Computer and must permit:

- The view of optical heads status (it will include the signalling of malfunctions).
- The control of the optical heads status (group selection; LEDs power on; output current setup, compensation activation on the basis of temperature...).
- The management of system configuration: setup of network parameter (IP address, Net mask, communication port dedicated for remote management); management of compensation outputs table according to temperature; setup of optical heads serial number; management of configuration file of optical heads.

All settings and readings available from the operator interface can be managed through communication protocol via Ethernet interface. During power on, the system must also perform self-test sequence with a result report.

Implementation

Device architecture was designed in order to meet functionality, modularity, accuracy and interoperability requirements.

Fig. 1 shows the block diagram of the system architecture that identifies: a CIOS (Controller and Input Output Sub-system) module made up by a CompactRIO system (Master controller combined with EtherCat slave) and I/O modules, a MMI module based on TPC, a power supply module and all interfaces to optical heads, external LAN and external power supply.

PAC (Programmable Automation Controller) based on CompactRIO architecture has been adopted for the implementation of control system and I/O.

CompactRIO system uses a real-time controller integrated system and FPGA connected to EtherCAT chassis. I/O modules, needed to manage optical heads, are installed on the two chassis:

- Analog output current module to drive LEDs of optical heads (from one to three optical heads according to the type of system).
- Analog input voltage module to verify the correct functioning of LEDs.
- 8-channel solid-state relay (SSR) sourcing or sinking digital output module to select group of LEDs for each optical heads (implemented only for MHSTR systems).
- RTD acquisition module (only for AA-STR systems).

A TPC (5.7" wide) was selected for the implementation of MMI, equipped with a Windows XP embedded O.S that meets the dimensional constraint required by the device. cRIO master unit and TPC communicate through local Ethernet port and with the external, through the other Ethernet port on the TPC. All components of the Optical Stimulator are mounted in a 19" – 4U chassis suitable for housing in a system rack.

The management and control software installed on the real-time controller is developed using LabVIEW 2011 RT module and implements the following functionalities:

- Command management via operator interface;
- Sending of status information via operator interface;
- Selection of group of LEDs belonging to the optical heads;
- Current driving of LEDs;
- Acquisition LED voltage with diagnostic system purposes.
- Temperature acquiring of optical heads in order to compensate driving current (through LUT loaded on the system).
- Command management via protocol.
- Management of configuration files of the optical heads.
- Updating management of the firmware.
- Execution of initial self-test sequence.
- Serial number management of optical heads.

The communication between the TPC and RT controller is based on the use of the Network-Published Shared Variable library on the