Technology Focus:

Advanced Signal Conditioners for Data-Acquisition Systems

"Smart" circuitry repairs itself by switching in spare parts as needed.

John F. Kennedy Space Center, Florida

Signal conditioners embodying advanced concepts in analog and digital electronic circuitry and software have been developed for use in data-acquisition systems that are required to be compact and lightweight, to utilize electric energy efficiently, and to operate with high reliability, high accuracy, and high power efficiency, without intervention by human technicians. These signal conditioners were originally intended for use aboard spacecraft. There are also numerous potential terrestrial uses — especially in the fields of aeronautics and medicine, wherein it is necessary to monitor critical functions.

Going beyond the usual analog and digital signal-processing functions of prior signal conditioners, the new signal conditioner performs the following additional functions:

- It continuously diagnoses its own electronic circuitry, so that it can detect failures and repair itself (as described below) within seconds.
- It continuously calibrates itself on the basis of a highly accurate and stable voltage reference, so that it can continue to generate accurate measurement data, even under extreme environmental conditions.
- It repairs itself in the sense that it contains a microcontroller that reroutes signals among redundant components as needed to maintain the ability to perform accurate and stable measurements.
- It detects deterioration of components, predicts future failures, and/or detects imminent failures by means of a real-time analysis in which, among other things, data on its present state are continuously compared with locally stored historical data.
- It minimizes unnecessary consumption of electric energy.

The design architecture divides the signal conditioner into three main sections: an analog signal section, a digital module, and a power-management section. The design of the analog signal section does not follow the traditional approach of ensuring reliability through total redundancy of hardware: Instead, following an approach called "spare parts — tool box," the reliability of each component is assessed in terms of such considerations as risks of damage, mean times between failures, and the effects of certain failures on the performance of the signal conditioner as a whole system. Then, fewer or more spares are assigned for each affected component, pursuant to the results of this analysis, in order to obtain the required degree of reliability of the signal conditioner as a whole system.

The digital module comprises one or more processors and field-programmable gate arrays, the number of each depending on the results of the aforementioned analysis. The digital module provides redundant control, monitoring, and processing of several analog signals. It is designed to minimize unnecessary consumption of electric energy, including, when possible, going into a low-power "sleep" mode that is implemented in firmware. The digital module communicates with external equipment via a personal-computer serial port. The digital module monitors the "health" of the rest of the signal conditioner by processing defined measurements and/or trends. It automatically makes adjustments to respond to channel failures, compensate for effects of temperature, and maintain calibration.

This work was done by Angel Lucena and Jose Perotti of **Kennedy Space Center,** *and Anthony Eckhoff and Pedro Medelius of Dynacs, Inc. Further information is contained in a TSP (see page 1).*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Technology Programs and Commercialization Office, Kennedy Space Center, (321) 867-8130. Refer to KSC-12301.

Downlink Data Multiplexer

Bandwidth is allocated as needed among four data streams of various rates.

Lyndon B. Johnson Space Center, Houston, Texas

A multiplexer/demultiplexer system has been developed to enable the transmission, over a single channel, of four data streams generated by a variety of sources at different (including variable) bit rates. In the original intended application, replicas of this multiplexer/demultiplexer system would be incorporated into the spacecraft-to-ground communication systems of the space shuttles. The multiplexer of each system would be installed in the spacecraft, where it would acquire and process data from such sources as commercial digital camcorders, video tape recorders, and the spacecraft telemetry system. The demultiplexer of each system would be installed in a ground station. Purely terrestrial systems of similar design could be attractive for use in situations in which there are requirements to transmit multiple streams of high-quality video data and possibly other data over single channels.

The figure is a block diagram of the multiplexer as configured to process data received via three fiber-optic channels like those of the International Space Station and one electrical-cable channel that conforms to the Institute of Electrical and Electronic Engineers (IEEE) 1394 standard. (This standard consists of specifications of a high-speed serial data interface, the physical layer of which includes a cable known in the art as "FireWire." An IEEE 1394 interface can also transfer power between the components to which it is connected.) The fiber-optic channels carry packet