Semiconductors & ICs

Interface Supports Multiple Broadcast Transceivers for Flight Applications

NASA's Jet Propulsion Laboratory, Pasadena, California

A wireless avionics interface provides a mechanism for managing multiple broadcast transceivers. This interface isolates the control logic required to support multiple transceivers so that the flight application does not have to manage wireless transceivers. All of the logic to select transceivers, detect transmitter and receiver faults, and take autonomous recovery action is contained in the interface, which is not restricted to using wireless transceivers. Wired, wireless, and mixed transceiver technologies are supported.

This design's use of broadcast data technology provides inherent cross-strapping of data links. This greatly simplifies the design of redundant flight subsystems. The interface fully exploits the broadcast data link to determine the health of other transceivers used to detect and isolate faults for fault recovery. The interface uses simplified control logic, which can be implemented as an intellectual-property (IP) core in a field-programmable gate array (FPGA).

The interface arbitrates the reception of inbound data traffic appearing on multiple receivers. It arbitrates the transmission of outbound traffic. This system also monitors broadcast data traffic to determine the health of transmitters in the network, and then uses this health information to make autonomous decisions for routing traffic through transceivers. Multiple selection strategies are supported, like having an active transceiver with the secondary transceiver powered off except to send periodic health status reports. Transceivers can operate in round-robin for load-sharing and graceful degradation.

This work was done by Gary L. Block, William D. Whitaker, James W. Dillon, James P. Lux, and Mohammad Ahmad of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-46317

FPGA Sequencer for Radar Altimeter Applications

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A sequencer for a radar altimeter provides accurate attitude information for a reliable soft landing of the Mars Science Laboratory (MSL). This is a field-programmable-gate-array (FPGA)-only implementation. A table loaded externally into the FPGA controls timing, processing, and decision structures. Radar is memory-less and does not use previous acquisitions to assist in the current acquisition. All cycles complete in exactly 50 milliseconds, regardless of range or whether a target was found.

A RAM (random access memory) within the FPGA holds instructions for up to 15 sets. For each set, timing is run, echoes are processed, and a comparison is made. If a target is seen, more detailed processing is run on that set. If no target is seen, the next set is tried.

When all sets have been run, the FPGA terminates and waits for the next 50-millisecond event. This setup simplifies testing and improves reliability. A single vertex chip does the work of an entire assembly. Output products require minor processing to become range and velocity.

This technology is the heart of the Terminal Descent Sensor, which is an integral part of the Entry Decent and Landing system for MSL. In addition, it is a strong candidate for manned landings on Mars or the Moon.

This work was done by Andrew C. Berkun, Brian D. Pollard, and Curtis W. Chen of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-46988

Miniature Sapphire Acoustic Resonator — MSAR

Q values as high as 10^8 may be achieved at room temperature.

NASA's Jet Propulsion Laboratory, Pasadena, California

A room temperature sapphire acoustics resonator incorporated into an oscillator represents a possible opportunity to improve on quartz ultra-stable oscillator (USO) performance, which has been a staple for NASA missions since the inception of spaceflight.

Where quartz technology is very mature and shows a performance improvement of perhaps 1 dB/decade, these sapphire acoustic resonators when integrated with matured quartz electronics could achieve a frequency stability improvement of 10 dB or more. As quartz oscillators are an essential element of nearly all types of frequency standards and reference systems, the success of MSAR would advance the development of frequency standards and systems for both ground-based and flight-based projects.

Current quartz oscillator technology is limited by quartz mechanical Q. With a possible improvement of more than ×10 Q with sapphire acoustic modes, the stability limit of current quartz oscillators may be improved tenfold, to 10^{-14} at 1 second. The electromagnetic modes of sapphire that were previously developed at JPL require cryogenic temperatures to achieve the high Q levels needed to achieve this stability level. However sapphire's acoustic modes, which have not been used before in a high-stability oscillator, indicate the required Q values (as high as $Q = 10^8$) may be achieved at room temperature in the kHz range. Even though sapphire is not piezoelectric, such a high Q should allow electrostatic excitation of the acoustic modes with a combination of DC and AC voltages across a small sapphire disk ($\approx$ l mm thick). The first evaluations under this task will test predictions of an estimated input impedance of 10 kilohms at $Q = 10^8$, and explore the Q values that can be realized in a smaller resonator, which has not been previously tested for acoustic modes.

This initial Q measurement and excitation demonstration can be viewed similar to a transducer converting electrical energy to mechanical energy and back. Such an electrostatic tweeter type excitation of a mechanical resonator will be tested at 5 MHz. Finite element calculation will be applied to resonator design for the desired resonator frequency and optimum configuration. The experiment consists of the sapphire resonator sandwiched between parallel electrodes. A DC+AC voltage can be applied to generate a force to act on a sapphire resonator. With the frequency of the AC voltage tuned to the sapphire resonator frequency, a resonant condition occurs and the sapphire Q can be measured with a high-frequency impedance analyzer.

To achieve high Q values, many experimental factors such as vacuum seal, gas damping effects, charge buildup on the sapphire surface, heat dissipation, sapphire anchoring, and the sapphire mounting configuration will need attention. The effects of these parameters will be calculated and folded into the resonator design. It is envisioned that the initial test configuration would allow for movable electrodes to check gap spacing dependency and verify the input impedance prediction.

Quartz oscillators are key components in nearly all ground- and space-based communication, tracking, and radio science applications. They play a key role as local oscillators for atomic frequency standards and serve as flywheel oscillators or to improve phase noise in high-performance frequency and timing distribution systems. With ultra-stable performance from one to three seconds, an Earth-orbit or moon-based MSAR can enhance available performance options for spacecraft due to elimination of atmospheric path degradation.

Process-Hardened, Multi-Analyte Sensor for Characterizing Rocket Plume Constituents

Stennis Space Center, Mississippi

A multi-analyte sensor was developed that enables simultaneous detection of rocket engine combustion-product molecules in a launch-vehicle ground test stand. The sensor was developed using a pin-printing method by incorporating multiple sensor elements on a single chip. It demonstrated accurate and sensitive detection of analytes such as carbon dioxide, carbon monoxide, kerosene, isopropanol, and ethylene from a single measurement.

The use of pin-printing technology enables high-volume fabrication of the sensor chip, which will ultimately eliminate the need for individual sensor calibration since many identical sensors are made in one batch. Tests were performed using a single-sensor chip attached to a fiber-optic bundle. The use of a fiber bundle allows placement of the opto-electronic readout device at a place remote from the test stand. The sensors are rugged for operation in harsh environments.

SAD5 Stereo Correlation Line-Striping in an FPGA

NASA's Jet Propulsion Laboratory, Pasadena, California

High precision SAD5 stereo computations can be performed in an FPGA (field-programmable gate array) at much higher speeds than possible in a conventional CPU (central processing unit), but this uses large amounts of FPGA resources that scale with image size. Of the two key resources in an FPGA, Slices and BRAM (block RAM), Slices scale linearly in the new algorithm with image size, and BRAM scales quadratically with image size. An approach was developed to trade latency for BRAM by sub-windowing the image vertically into overlapping strips and stitching the outputs together to create a single continuous disparity output.

In stereo, the general rule of thumb is that the disparity search range must be 1/10 the image size. In the new algorithm, BRAM usage scales linearly with disparity search range and scales again linearly with line width. So a doubling of image size, say from 640 to 1,280, would in the previous design be an effective 4× of BRAM usage: 2× for line width, 2× again for disparity search range.

The minimum strip size is twice the search range, and will produce an output strip width equal to the disparity search range. So assuming a disparity search range of 1/10 image width, 10 sequential runs of the minimum strip size would produce a full output image.

This approach allowed the innovators to fit 1280×960 wide SAD5 stereo disparity