

drives the design to be mirrored, where the two channels are fabricated back-to-back, achieving direct mechanical interface to improve the isothermal performance, which drives RF phase balance. This back-to-back design forces components to have a “left” and “right” handed version, which is not typically possible for packaged components, but with full design control of hybrid design, this is achievable. The radar was designed to have a series of

separate subcarriers, which could be hermetically sealed individually, which is much easier than sealing the entire unit. Also, in the event of late component failure, rather than losing or reworking the entire unit, the subcarrier can easily be replaced by another qualified subcarrier.

This new instrument is a smaller, higher-bandwidth dual-channel interferometer with 500-MHz bandwidth at Ka-band (35.5 to 36 GHz), as compared to

the prior instrument WSOA (Wide Swath Ocean Altimeter), which was Ku-band (13.275 GHz) with 80-MHz bandwidth. The new instrument has six-fold improvement in resolution capability, and better control of factors that contribute to RF phase stability.

*This work was done by James P. Hoffman, Alina Moussessian, Masud Jenabi, and Brian Custodero of Caltech for NASA’s Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-47346*

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## Continuous-Integration Laser Energy Lidar Monitor

**The integrator can be used in developing pulsed lasers for space-based lidar and ground-based laser applications.**

*Goddard Space Flight Center, Greenbelt, Maryland*

This circuit design implements an integrator intended to allow digitization of the energy output of a pulsed laser, or the energy of a received pulse of laser light. It integrates the output of a detector upon which the laser light is incident. The integration is performed constantly, either by means of an active integrator, or by passive components. If an active integrator is used, closed-loop dc biasing is added with a time constant much longer than the laser pulse width. The output of the integrator goes to a track-and-hold amplifier (THA), using a zero-potential switch topology. The track/hold control is derived from timing information obtained either by a threshold comparator on the detector, or a peak detector. Laser pulses of varying widths can be accommodated by adjusting the characteristics of the timing control circuitry. The output of the THA

is available for digitization at a later time. Bandwidth limiting can be used in the signal path as necessary, depending on the noise characteristics of the signal.

Prior integration techniques utilize threshold comparators to “start” and “stop” the integration. Some implementations require reset circuitry, which can create offset at the output. Starting and stopping the integration usually involves clipping off the beginning and/or end of the signal; this introduces greater errors as the signal amplitude decreases. Also, as the signal speed increases, the comparator speed must increase, and thus its power consumption rises. As the signal (pulse) gets narrower, the comparator delay time may cut off significant portions of the signal unless electronic delay is introduced. This adds complexity, mass, and timing uncertainty.

The advantage of this integration technique is that it does not depend on

exact threshold adjustment to start or stop the integrator, nor does it require the use of switches to discharge the integration capacitor. Further, there is no pedestal introduced in the integrator.

This circuit is intended to implement an integrator that does not require time gating, delay, or reset circuitry, in order to avoid the limitations that these elements impose. The integrator is part of a pulsed laser energy monitor. This implementation of a continuous integrator is designed to be used in a laser transmit energy monitor.

The final design had the ability to integrate pulses down to 50 mV at 4.5 ns, and 250 mV at 3 ns, with 0.8-percent electrical accuracy.

*This work was done by Jeremy Karsh of Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-15843-1*

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## Miniaturized Airborne Imaging Central Server System

**This imaging server can be used for natural disaster response and for locating new sources of spring water.**

*Goddard Space Flight Center, Greenbelt, Maryland*

In recent years, some remote-sensing applications require advanced airborne multi-sensor systems to provide high performance reflective and emissive spectral imaging measurement rapidly over large areas. The key or unique problem of characteristics is associated with a black box back-end system that operates a suite of cutting-edge imaging sensors to collect simultaneously the high

throughput reflective and emissive spectral imaging data with precision georeference. This back-end system needs to be portable, easy-to-use, and reliable with advanced onboard processing.

The innovation of the black box back-end is a miniaturized airborne imaging central server system (MAICSS). MAICSS integrates a complex embedded system of systems with dedicated power and sig-

nal electronic circuits inside to serve a suite of configurable cutting-edge electro-optical (EO), long-wave infrared (LWIR), and medium-wave infrared (MWIR) cameras, a hyperspectral imaging scanner, and a GPS and inertial measurement unit (IMU) for atmospheric and surface remote sensing. Its compatible sensor packages include NASA’s 1,024×1,024 pixel LWIR quantum well in-

frared photodetector (QWIP) imager; a 60.5 megapixel BuckEye EO camera; and a fast (e.g. 200+ scanlines/s) and wide swath-width (e.g., 1,920+ pixels) CCD/InGaAs imager-based visible/near infrared reflectance (VNIR) and short-wave infrared (SWIR) imaging spectrometer. MAICSS records continuous precision georeferenced and time-tagged multisensor throughputs to mass storage devices at a high aggregate rate, typically 60 MB/s for its LWIR/EO payload.

MAICSS is a complete stand-alone imaging server instrument with an easy-to-use software package for either autonomous data collection or interactive airborne operation. Advanced multisensor data acquisition and onboard processing software features have been implemented for MAICSS. With the

onboard processing for real time image development, correction, histogram-equalization, compression, georeference, and data organization, fast aerial imaging applications, including the real time LWIR image mosaic for Google Earth, have been realized for NASA's LWIR QWIP instrument.

MAICSS is a significant improvement and miniaturization of current multisensor technologies. Structurally, it has a complete modular and solid-state design. Without rotating hard drives and other moving parts, it is operational at high altitudes and survivable in high-vibration environments. It is assembled from a suite of miniaturized, precision-machined, standardized, and stackable interchangeable embedded instrument modules. These stackable modules can

be bolted together with the interconnection wires inside for the maximal simplicity and portability. Multiple modules are electronically interconnected as stacked. Alternatively, these dedicated modules can be flexibly distributed to fit the space constraints of a flying vehicle. As a flexibly configurable system, MAICSS can be tailored to interface a variety of multisensor packages. For example, with a 1,024×1,024 pixel LWIR and a 8,984×6,732 pixel EO payload, the complete MAICSS volume is approximately 7×9×11 in. (≈18×23×28 cm), with a weight of 25 lb (≈11.4 kg).

*This work was done by Xiuhong Sun of Flight Landata for Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-15817-1*

## Radiation-Tolerant, SpaceWire-Compatible Switching Fabric

**Potential applications include next-generation computer interconnects, production of motion pictures, intra-hospital networks, and inventory management.**

*Goddard Space Flight Center, Greenbelt, Maryland*

Current and future near-Earth and deep space exploration programs and space defense programs require the development of robust intra-spacecraft serial data transfer electronics that must be reconfigurable, fault-tolerant, and have the ability to operate effectively for long periods of time in harsh environmental conditions. Existing data transfer systems based on state-of-the-art serial data transfer protocols or passive backplanes are slow, power-hungry, and poorly reconfigurable. They provide limited expandability and poor tolerance to radiation effects and total ionizing dose (TID) in particular, which presents harmful threats to modern submicron electronics.

This novel approach is based on a standard library of differential cells tolerant to TID, and patented, multi-level serial interface architecture that ensures the reliable operation of serial interconnects without application of a data-strobe or other encoding techniques. This proprietary, high-speed differential interface presents a low-power solution fully compatible with the SpaceWire (SW) protocol. It replaces a dual data-strobe link with two identical independent data channels, thus improving the system's tolerance to harsh environments through additional double redundancy. Each chan-

nel incorporates an automatic line integrity control circuitry that delivers error signals in case of broken or shorted lines.

The complete 4×4 SW switching fabric chip (with dimensions 6,618×5,658 mm<sup>2</sup>), incorporating the switching fabric core synthesized in a standard radiation-tolerant by-process 180-nm CMOS (complementary metal oxide semiconductor) library and four proprietary interfaces, has been fully designed in a BiCMOS technology from Jazz Semiconductor and prepared for fabrication. All critical blocks of the switching fabric have been verified through fabrication of several test chips and demonstrated the radiation tolerance up to TID = 1 MRad. All main blocks of the fabric have been developed as IP (intellectual property) macro-blocks ready to be integrated into other systems in order to minimize the design time, efforts, and risk.

The complete architecture of a 4×4 switching fabric with selectable SW or ML interfaces has been developed based on the Core code supplied by NASA. The architecture of a custom SW/ML routing port has been developed and evaluated. Based on the detailed investigations, the SiGe120 BiCMOS technology has been selected for the implementation of the proposed

SF. A complete library of CML (Chemical Markup Language) cells with full anti-TID and anti-SEE protection by architecture (SPBA) has been developed and simulated. The designed SPBA library has been fully characterized to make it suitable for automatic synthesis procedures. Special techniques required for the adaptation of the new differential library to existing single-ended synthesis software tools have been developed and verified.

A complex test chip based on the SPBA library has been fabricated and tested. The measurement results gathered in accordance with the developed test plan demonstrated the efficiency of the selected approach for the implementation of high-duty logic functions and SerDes systems in particular. The provided SF Core has been fully synthesized and simulated in the SPBA library. In an attempt to minimize the power consumption, the SF Core was re-synthesized in the foundry-provided standard CMOS library. This approach, in combination with a CML-based implementation of routing ports, proved to be optimal.

*This work was done by Vladimir Katzman of ADSANTEC for Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-15818-1*