Single-Pole Double-Throw MMIC Switches for a Microwave Radiometer

Switches reduce the effect of gain and noise instabilities.

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In order to reduce the effect of gain and noise instabilities in the RF chain of a microwave radiometer, a Dicke radiometer topology is often used, as in the case of the proposed surface water and ocean topography (SWOT) radiometer instrument. For this topology, a single-pole double-throw (SPDT) microwave switch is needed, which must have low insertion loss at the radiometer channel frequencies to minimize the overall receiver noise figure. Total power radiometers are limited in accuracy due to the continuous variation in gain of the receiver. Currently, there are no switches in the market that can provide these characteristics at 92, 130, and 166 GHz as needed for the proposed SWOT radiometer instrument.

High-frequency SPDT switches were developed in the form of monolithic microwave integrated circuits (MMICs) using 75-μm indium phosphide (InP) PIN-diode technology. These switches can be easily integrated into Dicke switched radiometers that utilize microstrip technology. The MMIC switches operate from 80 to 105 GHz, 90 to 135 GHz, and 160 to 185 GHz. The 80- to 105-GHz switches have been tested and have achieved <2-dB insertion loss, >15-dB return loss (>18 dB for the asymmetric design), and >15-dB isolation. The isolation can be tuned to achieve >20-dB isolation from 85 to 103 GHz. The 90- to 135-GHz SPDT switch has achieved <2-dB insertion loss, >15-dB return loss, and 8- to 12-dB isolation. However, it has been shown that the isolation of this switch can also be improved. Although the 160- to 185-GHz switch has been fabricated, it has not yet been measured at the time of this reporting. Simulation results predict this switch will have <2-dB insertion loss, >20-dB return loss, and >20-dB isolation.

The switches can be used for a radiometer such as the one proposed for the SWOT Satellite Mission whose three channels at 92, 130, and 166 GHz would allow for wet-tropospheric path delay correction near coastal zones and over land. This feat is not possible with the current Jason-class radiometers due to their lower frequency signal measurement and thus lower resolution.

The design work was done by Oliver Montes, Douglas E. Dawson, and Pekka P. Kangaslahti of Caltech for NASA's Jet Propulsion Laboratory. The processing of the InP MMIC circuits was done by Kwok Loi and Augusto Gutierrez from NGST. Further information is contained in a TSP (see page 1). NPO-48083

On Shaft Data Acquisition System (OSDAS)

Applications include helicopter rotor testing, onboard liquid/solid rocket engine data acquisition, and gas-turbine-engine health monitoring.

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On Shaft Data Acquisition System (OSDAS) is a rugged, compact, multiple-channel data acquisition computer system that is designed to record data from instrumentation while operating under extreme rotational centrifugal or gravitational acceleration forces. This system, which was developed for the Heritage Fuel Air Turbine Test (HFATT) program, addresses the problem of recording multiple channels of high-sample-rate data on most any rotating test article by mounting the entire acquisition computer onboard with the turbine test article. With the limited availability of slip ring wires for power and communication, OSDAS utilizes its own resources to provide independent power and amplification for each instrument. Since OSDAS utilizes standard PC technology as well as shared code interfaces with the next-generation, real-time health monitoring system (SPARTAA — Scalable Parallel Architecture for Real Time Analysis and Acquisition), this system could be expanded beyond its current capabilities, such as providing advanced health monitoring capabilities for the test article.

High-conductor-count slip rings are expensive to purchase and maintain, yet only provide a limited number of conductors for routing instrumentation off the article and to a stationary data acquisition system. In addition to being limited to a small number of instruments, slip rings are prone to wear quickly, and introduce noise and other undesirable characteristics to the signal data. This led to the development of a system capable of recording high-density instrumentation, at high sample rates, on the test article itself, all while under extreme rotational stress.

OSDAS is a fully functional PC-based system with 48 channels of 24-bit, high-sample-rate input channels, phase synchronized, with an onboard storage capacity of over ½-terabyte of solid-state storage. This recording system takes a novel approach to the problem of recording multiple channels of instrumentation, integrated with the test article itself, packaged in a compact/rugged form factor, consuming limited power, all while rotating at high turbine speeds.

The hardware components were oriented, secured, and encapsulated by a variety of novel application techniques that allow for the system to continue operation under rotational stress. This full, custom-hardened system was designed to be a comprehensive solution to attaching directly to instrumentation (without external sensor power supplies and amplification). Instead, all instrumentation has a dedicated power supply, integrated inside OSDAS, with the ability to withstand electrical faults (short circuits, etc.) without compromising other sensors. The amplification required for each sensor was configurable at build time to match that of the Kulite instrumentation used in the HFATT article. The entire computing, storage, and acquisition hardware system was custom-encapsulated in a thermally conductive medium that allows heat to passively dissipate by air via the outer shell (indoor/out-