# Positively Verifying Mating of Previously Unverifiable Flight Connectors

**New approach ensures secure connections.**

*Goddard Space Flight Center, Greenbelt, Maryland*

Current practice is to uniquely key the connectors, which, when mated, could not be verified by ground tests such as those used in explosive or non-explosive initiators and pyro valves. However, this practice does not assure 100-percent correct mating. This problem could be overcome by the following approach.

Errors in mating of interchangeable connectors can result in degraded or failed space mission. Mating of all flight connectors considered not verifiable via ground tests can be verified electrically by the following approach. It requires two additional wires going through the connector of interest, a few resistors, and a voltage source (see figure). The test-point voltage $V_{tp}$ when the connector is not mated will be the same as the input voltage, which gets attenuated by the resistor $R_1$ when the female (F) and male (M) connectors are mated correctly and properly. The voltage at the test point will be a function of $R_1$ and $R_2$. Monitoring of the test point could be done on ground support equipment (GSE) only, or it can be a telemetry point. For implementation on multiple connector pairs, a different value for $R_1$ or $R_2$ or both can be selected for each pair of connectors
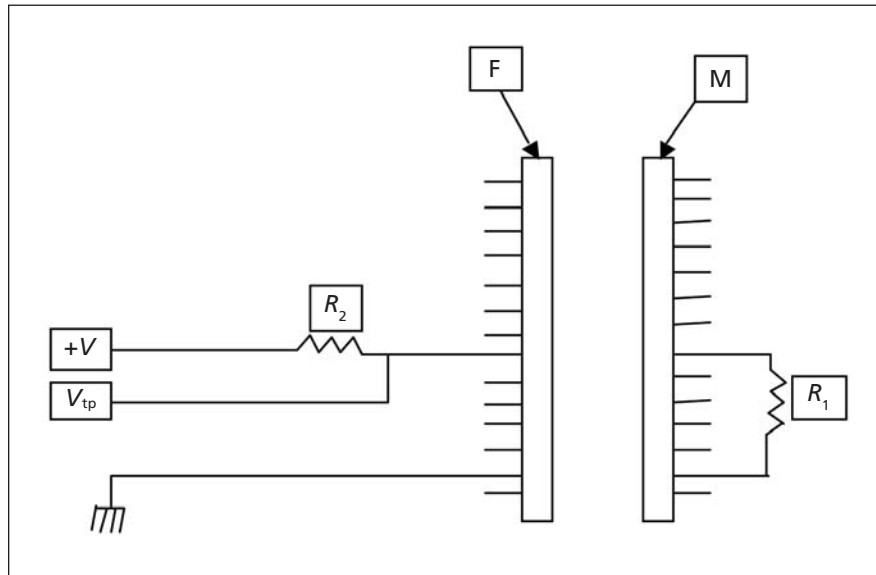


The basic **Circuit Diagram** for verifying secure connection.

that would result in a unique test point voltage for each connector pair. Each test point voltage is unique, and correct test point voltage is read only when the correct pair is mated correctly together. Thus, this design approach can be used to verify positively the correct mating of the connector pairs. This design approach can be applied to any number of connectors on the flight vehicle.

*This work was done by R.K. Chetty Pandipati and Marlon Enciso of Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-15896-1*

# Radiation-Tolerant Intelligent Memory Stack — RTIMS

**RTIMS can be used in real-time data processing, reconfigurable computing, and memory-intensive applications.**

*Langley Research Center, Hampton, Virginia*

This innovation provides reconfigurable circuitry and 2-Gb of error-corrected or 1-Gb of triple-redundant digital memory in a small package. RTIMS uses circuit stacking of heterogeneous components and radiation shielding technologies. A reprogrammable field-programmable gate array (FPGA), six synchronous dynamic random access memories, linear regulator, and the radiation mitigation circuits are stacked

into a module of 42.7×42.7×13 mm. Triple module redundancy, current limiting, configuration scrubbing, and single-event function interrupt detection are employed to mitigate radiation effects. The novel self-scrubbing and single event functional interrupt (SEFI) detection allows a relatively "soft" FPGA to become radiation tolerant without external scrubbing and monitoring hardware.

RTIMS enables significant reductions in the size and mass of mission memory arrays, and is a radiation-tolerant memory suitable for both GEO and LEO space missions through the use of new package-level radiation shielding technology and triple modular redundancy (TMR) FPGA techniques. RTIMS also provides a simplified interface to a large SDRAM (synchronous dynamic random access memory) array with

built-in logic for timing reads, writes, and refresh cycles.

Mission flexibility is added by operating the memory array in the TMR architecture with 1 Gb of storage or in an EDAC (Error Detection And Correction) mode where part of the memory is used to detect and correct errors with 2 Gb of storage (corrects single bit errors and detects double bit errors). This allows RTIMS to be used effectively on many types of missions, because it can be configured for the "harshness" of the expected environment.

RTIMS enables in-flight reconfigurability by using SRAM (static random access memory)-based FPGA technology.

The design overcomes both hardware and software errors that may be detected after launch during mission operations. This reduces overall mission risk, which is increasingly important as flight system development times and budgets decrease. It also allows RTIMS to adapt to changing mission conditions.

The design increases system reliability by distributing the radiation mitiga-tion structure to each component instead of to a singlepoint failure at the system level. The mitigation techniques significantly simplify system design. RTIMS is well suited for deployment in real-time data processing, reconfigurable computing, and memory-intensive applications.

*This work was done by Tak-kwong Ng and Jeffrey A. Herath for Langley Research Center. Further information is contained in a TSP (see page 1). LAR-17257-1*

# Ultra-Low-Dropout Linear Regulator

*Goddard Space Flight Center, Greenbelt, Maryland*

A radiation-tolerant, ultra-low-dropout linear regulator can operate between –150 and 150 ºC. Prototype components were demonstrated to be performing well after a total ionizing dose of 1 Mrad (Si). Unlike existing components, the linear regulator developed during this activity is unconditionally stable over all operating regimes without the need for an external compensation capacitor. The absence of an external capacitor reduces overall system mass/volume, increases reliability, and lowers cost.

Linear regulators generate a precisely controlled voltage for electronic circuits regardless of fluctuations in the load current that the circuit draws

from the regulator. To maximize the efficiency of the regulator, the dropout voltage (a measure of the voltage the regulator itself needs to operate) needs to be as small as possible. Existing regulators use p-channel transistors to minimize the dropout voltage, but p-channel regulators are intrinsically unstable and require an external compensation capacitor to stabilize their operation. The electrical properties of the compensation capacitor (in particular, its equivalent series resistance, ESR) must be well controlled to ensure stability. Changes in the ESR with temperature and/or radiation doses present challenges to stable reg-ulator operation in extreme environments. This innovation allows an n-channel transistor to perform the regulation without the need for an external capacitor.

The n-channel pass transistor of the linear regulator operates in depletion mode thereby allowing ultralow dropout voltages of less than 100 mV.

*This work was done by Trevor Thornton of Arizona State University and William Lepkowski and Seth Wilk of SJT Micropower for Goddard Space Flight Center. For further information, contact the Goddard Innovative Partnerships Office at (301) 286-5810. GSC-16097-1*

# Excitation of a Parallel Plate Waveguide by an Array of Rectangular Waveguides

*NASA's Jet Propulsion Laboratory, Pasadena, California*

This work addresses the problem of excitation of a parallel plate waveguide by an array of rectangular waveguides that arises in applications such as the continuous transverse stub (CTS) antenna and dual-polarized parabolic cylindrical reflector antennas excited by a scanning line source. In order to design the junction region between the parallel plate waveguide and the linear array of rectangular waveguides, waveguide sizes have to be chosen so that the input match is adequate for the range of scan angles for both polarizations.

Electromagnetic wave scattered by the junction of a parallel plate waveguide by an array of rectangular wave-guides is analyzed by formulating coupled integral equations for the aperture electric field at the junction. The integral equations are solved by the method of moments. In order to make the computational process efficient and accurate, the method of weighted averaging was used to evaluate rapidly oscillating integrals encountered in the moment matrix. In addition, the real axis spectral integral is evaluated in a deformed contour for speed and accuracy. The MoM results for a large finite array have been validated by comparing its reflection coefficients with corresponding results for an infinite array generated by the commercial finite element code, HFSS. Once the aperture electric field is

determined by MoM, the input reflection coefficients at each waveguide port, and coupling for each polarization over the range of useful scan angles, are easily obtained.

Results for the input impedance and coupling characteristics for both the vertical and horizontal polarizations are presented over a range of scan angles. It is shown that the scan range is limited to about 35° for both polarizations and therefore the optimum waveguide is a square of size equal to about 0.62 free space wavelength.

*This work was done by Sembiam Rengarajan of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-47943*