FPGA for Power Control of MSL Avionics

NASA's Jet Propulsion Laboratory, Pasadena, California

A PLGT FPGA (Field Programmable Gate Array) is included in the LCC (Load Control Card), GID (Guidance Interface & Drivers), TMC (Telemetry Multiplexer Card), and PFC (Pyro Firing Card) boards of the Mars Science Laboratory (MSL) spacecraft. (PLGT stands for PFC, LCC, GID, and TMC.) It provides the interface between the backside bus and the power drivers on these boards. The LCC drives power switches to switch power loads, and also relays. The GID drives the thrusters and latch valves, as well as having the star-tracker and Sun-sensor interface. The PFC drives pyros, and the TMC receives digital and analog telemetry. The FPGA is implemented both in Xilinx (Spartan 3-400) and in Actel (RTSX72SU, ASX72S). The Xilinx Spartan 3 part is used for the breadboard, the Actel ASX part is used for the EM (Engineer Module), and the pin-compatible, radiation-hardened RTSX part is used for final EM and flight.

The MSL spacecraft uses a FC (Flight Computer) to control power loads, relays, thrusters, latch valves, Sun-sensor, and star-tracker, and to read telemetry such as temperature. Commands are sent over a 1553 bus to the MREU (Multi-Mission System Architecture Platform Remote Engineering Unit). The MREU resends over a 'remote serial command bus' c-bus to the LCC, GID TMC, and PFC. The MREU also sends out telemetry addresses via a 'remote serial telemetry address bus' to the LCC, GID, TMC, and PFC, and the status is returned over the remote serial telemetry data bus.

This work was done by Duo Wang and Gary R. Burke of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-47022

UAVSAR Active Electronically Scanned Array

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The Uninhabited Airborne Vehicle Synthetic Aperture Radar (UAVSAR) is a pod-based, L-band (1.26 GHz), repeat-pass, interferometric, synthetic aperture radar (InSAR) used for Earth science applications. Repeat-pass interferometric radar measurements from an airborne platform require an antenna that can be steered to maintain the same angle with respect to the flight track over a wide range of aircraft yaw angles.

In order to be able to collect repeat-pass InSAR data over a wide range of wind conditions, UAVSAR employs an active electronically scanned array (AESA). During data collection, the UAVSAR flight software continuously reads the aircraft attitude state measured by the Embedded GPS/INS system (EGI) and electronically steers the beam so that it remains perpendicular to the flight track throughout the data collection.

This work was done by Gregory A. Sadowy, Neil F. Chamberlain, Mark S. Zawadzki, Kyle M. Brown, Charles D. Fisher, Harry S. Figueroa, Gary A. Hamilton, Cathleen E. Jones, Vatche Vorperian, and Maurio B. Grando of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-47503

Lockout/Tagout (LOTO) Simulator

This tool can be used to train hands-on workers, safety personnel, and engineers writing LOTO procedures.

John F. Kennedy Space Center, Florida

The Lockout/Tagout (LOTO) Simulator is a portable training aid, or demonstration tool, designed to physically illustrate real-time critical-safety concepts of electrical lockout/tagout. The objective is to prevent misinterpretations of what is off and what is on during maintenance and repair of complex electrical systems. The simulator is designed in the form of a hinged box that opens up and stands on its own as an easel for demonstrations.

On the outer face of the unit is a simulated circuit breaker box housing the switches. The breakers control the main power to the unit, a light bulb, and an electrical control cabinet. The light bulb is wired so that either of two breakers can provide power to it. When power is sent to the electrical control cabinet, a red indicator light illuminates.

Inside the cabinet is the power supply from a personal computer. The power supply produces a 12-V dc output that is sent over to a small fan next to it, also from a computer, and an amber light on the front of the cabinet illuminates. A separate switch powers the fan on and off. The power supply is behind a plastic shield to protect against exposure to live conductors. Electrical banana jacks are mounted in the plastic shield to allow a voltmeter to be connected safely when opening the cabinet and taking a meter reading to verify de-energization as part of a simulation exercise.

This LOTO simulator prototype is designed and fabricated as an all-in-one unit. All accessories can be stored inside the hinged case, and there is a handle on top for ease of transport.

The circuit breaker labels attach with hook and loop fasteners so that they may be moved and changed to fit the training or demonstration scenario. The warning signs and labels on the electrical control box are magnetic, allowing for easy reconfiguration to emulate different equipment setups. A specially designed magnetic cover was made to disguise the indicator lights for demonstrations when these indicators are not used. The cover is disguised as an arc flash safety label that would typically be found on such a cabinet.

One indicator light has a separate switch that can take it offline. This is to allow for demonstration to trainees on why it is important not to completely rely on indicator lights, but that they should always take a meter reading at the exposed conductors to absolutely verify de-energization before exposure. A clear plastic barrier and banana jacks inside the cabinet provide a safe way to plug in a voltmeter for demonstrations without exposure to the hazards of energized equipment.

A small remote control unit is wired into the fan circuit. The remote allows the demonstrator to turn the fan on and off, provided that all of the breakers and switches leading to it are configured on as well. The remote feature was added in order to demonstrate the importance of starting the lockout/tagout task with energized equipment, then powering it down, isolating it, and locking it out to ensure that the correct breakers have been locked out.

This work was done by Jennifer Scheer of Kennedy Space Center. Further information is contained in a TSP (see page 1). ***.*** *KSC-13389*