Simple Cell Balance Circuit

Lyndon B. Johnson Space Center, Houston, Texas

A method has been developed for continuous cell voltage balancing for rechargeable batteries (e.g. lithium ion batteries). A resistor divider chain is provided that generates a set of voltages representing the ideal cell voltage (the voltage of each cell should be as if the cells were perfectly balanced). An operational-amplifier circuit with an added current buffer stage generates the ideal voltage with a very high degree of accuracy, using the concept of negative feedback.

The ideal voltages are each connected to the corresponding cell through a current-limiting resistance. Over time, having the cell connected to the ideal voltage provides a balancing current that moves the cell voltage very close to that ideal level. In effect, it adjusts the current of each cell during charging, discharging, and standby periods to force the cell voltages to be equal to the ideal voltages generated by the resistor divider. The device also includes solid-state switches that disconnect the circuit from the battery so that it will not discharge the battery during storage.

This solution requires relatively few parts and is, therefore, of lower cost and of increased reliability due to the fewer failure modes. Additionally, this design uses very little power. A preliminary model predicts a power usage of 0.18 W for an 8-cell battery. This approach is applicable to a wide range of battery capacities and voltages.

This work was done by Steven D. Johnson, Jerry W. Byers, and James A. Martin of Lockheed Martin Space Systems for Johnson Space Center. For further information, contact the JSC Innovation Partnerships Office at (281) 483-3809.

Title to this invention has been waived under the provisions of the National Aeronautics and Space Act {42 U.S.C. 2457(f)}, to Lockheed Martin Space Systems. Inquiries concerning licenses for its commercial development should be addressed to:

David P. Wood, Esq.
General Counsel, Intellectual Property
Lockheed Martin Space Systems Company
P.O. Box 179, MS 5120
Denver, CO 80201-0179
Refer to MSC-24673-1, volume and number of this NASA Tech Briefs *issue, and the page number.*
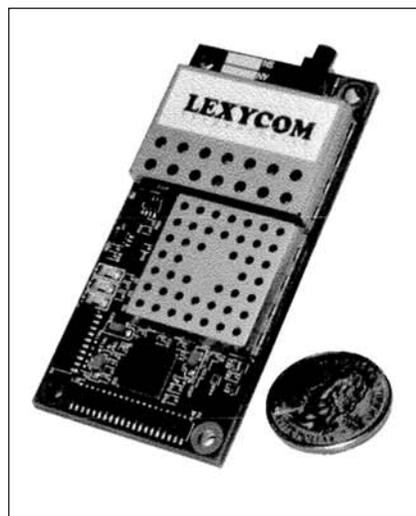
Miniature EVA Software Defined Radio

This technology can be used in homeland security applications, industrial/ power plants, traffic and transportation systems, and by first responders.

Lyndon B. Johnson Space Center, Houston, Texas

As NASA embarks upon developing the Next-Generation Extra Vehicular Activity (EVA) Radio for deep space exploration, the demands on EVA battery life will substantially increase. The number of modes and frequency bands required will continue to grow in order to enable efficient and complex multi-mode operations including communications, navigation, and tracking applications.

Whether conducting astronaut excursions, communicating to soldiers, or first responders responding to emergency hazards, NASA has developed an innovative, affordable, miniaturized, power-efficient software defined radio that offers unprecedented power-efficient flexibility. This lightweight, programmable, S-band, multi-service, frequency-agile EVA software defined radio (SDR) supports data, telemetry, voice, and both standard and high-definition video. Features include a modular design, an easily scalable architecture, and the EVA SDR allows for both stationary and mobile battery powered handheld operations.

Currently, the radio is equipped with an S-band RF section. However, its scalable architecture can accommodate

The **EVA Software Defined Radio**.

multiple RF sections simultaneously to cover multiple frequency bands. The EVA SDR also supports multiple network protocols. It currently implements a Hybrid Mesh Network based on the 802.11s open standard protocol. The radio targets RF channel data rates up to 20 Mbps and can be equipped with a real-time operating system (RTOS) that can be switched off for power-aware applications. The EVA SDR's modular design permits implementation of the "same hardware at all Network Nodes" concept. This approach assures the portability of the same software into any radio in the system. It also brings several benefits to the entire system including reducing system maintenance, system complexity, and development cost.

This software-defined radio is under 3 in.^{3} (49 cm^3) and weighs less than 4 oz. (113 g) with a power consumption averaging at 3 W (see figure). The EVA SDR design incorporates several innovations aimed at miniaturization without sacrificing any of its capabilities and still maintaining the lowest possible power consumption.

The SDR implements a range of technological solutions to achieve this goal. For instance, the SDR's hardware and software were designed as a whole as opposed to being selected separately. In short, the hardware components were selected such that they can be heavily guided by the SDR's software in order to minimize their power consumption. Additionally, the EVA SDR utilizes Lexycom's Hardware Synergy Concept. Per

this concept, the transceiver's software divides the computational tasks performed by the device into small subtasks and designates these tasks to the most suitable hardware module for the task. In a sense, the SDR's software performs micromanagement of the computed tasks well below the commonly used level of task assignment.

The EVA SDR also incorporates a dynamic waveform selection algorithm that minimizes the SDR's power consumption based on the channel QoS. To do so, the SDR collects the channel characteristics on a regular basis while in the normal mode of operation and adjusts the modulation type, RF channel data rate, output power level, and some other characteristics of the transmitted signal based on the gathered QoS. This method results in, essentially, 1000s of continuously changing waveforms.

In sum, the EVA SDR bridges the gap that has historically inhibited the coexistence of flexibility, power efficiency, and miniaturization in the same mobile handset radio.

This work was done by Aleksey Pozhidaev of Lexycom Technologies for Johnson Space Center. For further information, contact the JSC Innovation Partnerships Office at (281) 483-3809.

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

Lisa Livdahl, CFO
Lexycom Technologies, Inc.
425 South Bowen Street, Unit 1
Longmont, CO 80501
Phone No.: (303) 774-7822
URL: www.lexycominc.com
Refer to MSC-25125-1, volume and number of this NASA Tech Briefs *issue, and the page number.*

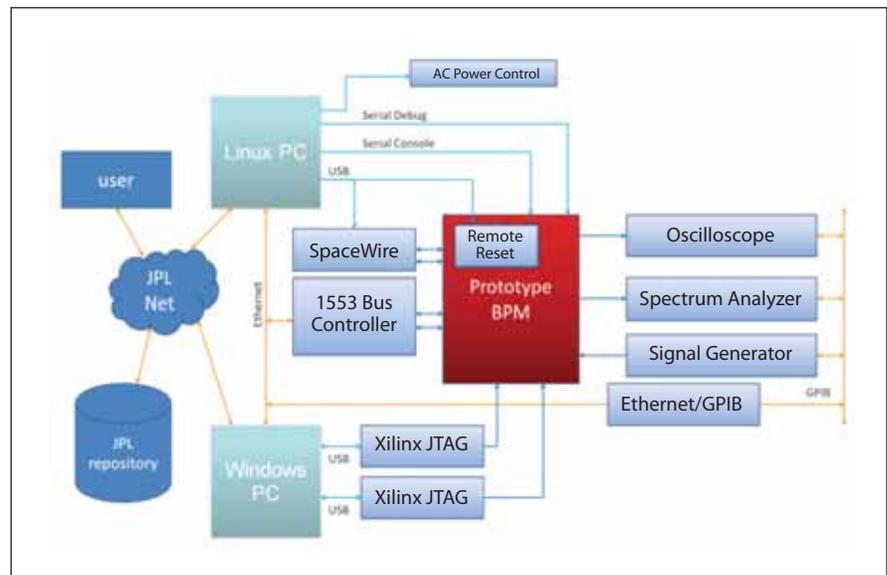# Remotely Accessible Testbed for Software Defined Radio Development

This testbed enables a geographically scattered development team to collaborate on a testbed.

NASA's Jet Propulsion Laboratory, Pasadena, California

Previous development testbeds have assumed that the developer was physically present in front of the hardware being used. No provision for remote operation of basic functions (power on/off or reset) was made, because the developer/operator was sitting in front of the hardware, and could just push the button manually. In this innovation, a completely remotely accessible testbed has been created, with all diagnostic equipment and tools set up for remote access, and using standardized interfaces so that failed equipment can be quickly replaced. In this testbed, over 95% of the operating hours were used for testing without the developer being physically present.

The testbed includes a pair of personal computers, one running Linux and one running Windows. A variety of peripherals is connected via Ethernet and USB (universal serial bus) interfaces. A private internal Ethernet is used to connect to test instruments and other devices, so that the sole connection to the "outside world" is via the two PCs.

An important design consideration was that all of the instruments and interfaces used stable, long-lived industry standards, such as Ethernet, USB, and GPIB (general purpose interface bus). There are no "plug-in" cards for the two PCs, so there are no problems with finding replacement computers with matching interfaces, device drivers, and installation. The only thing unique

The **Remotely Accessible Testbed** includes a pair of personal computers with a variety of peripherals connected via Ethernet and USB interfaces.

to the two PCs is the locally developed software, which is not specific to computer or operating system version. If a device (including one of the computers) were to fail or become unavailable (e.g., a test instrument needed to be recalibrated), replacing it is a straightforward process with a standard, off-the-shelf device.

This strategy has paid off several times over the developmental effort. It made it very easy to construct a "portable" version of the testbed to take to a remote site to test the flight model radio: the two PCs were rented laptops, and copies of the required interface boxes were rented or borrowed. Everything was plugged together, the software was loaded, and a few hours later, testing could commence. Compared to the traditional approach of a rack full of customized interface drawers and customized PCs, it was much simpler and less expensive, as well as immediately responsive to changing project needs.

In fact, the experience of creating an *ad hoc* test capability at a remote site has