

## Simple Cell Balance Circuit

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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 cur-

rent 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.

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*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:*

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## 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.**

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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.<sup>3</sup> (49 cm<sup>3</sup>) 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