

## Directional Radio-Frequency Identification Tag Reader

John F. Kennedy Space Center, Florida

A directional radio-frequency identification (RFID) tag reader has been designed to facilitate finding a specific object among many objects in a crowded room. The device could be an adjunct to an electronic inventory system that tracks RFID-tagged objects as they move through reader-equipped doorways. Whereas commercial RFID-tag readers do not measure directions to tagged objects, the device is equipped with a phased-array antenna and a received-signal-strength indicator (RSSI) circuit for measuring direction. At the beginning of operation, it is set to address only the RFID tag of interest. It then

continuously transmits a signal to interrogate that tag while varying the radiation pattern of the antenna. It identifies the direction to the tag as the radiation-pattern direction of peak strength of the signal returned by the tag. An approximate distance to the tag is calculated from the peak signal strength. The direction and distance can be displayed on a screen. A prototype containing a Yagi antenna was found to be capable of detecting a 915.5-MHz tag at a distance of  $\approx 15$  ft ( $\approx 4.6$  m).

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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:

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## Integrated Solar-Energy-Harvesting and -Storage Device

Efficiency would be maximized for anticipated ranges of operating conditions.

NASA's Jet Propulsion Laboratory, Pasadena, California

A modular, integrated, completely solid-state system designed to harvest and store solar energy is under development. Called the "power tile," the hybrid device consists of a photovoltaic cell, a battery, a thermoelectric device, and a charge-control circuit that are heterogeneously integrated to maximize specific energy capacity and efficiency. Power tiles could be used in a variety of space and terrestrial environments and would be designed to function with maximum efficiency in the presence of anticipated temperatures, temperature gradients, and cycles of sunlight and shadow. Because they are modular in nature, one could use a single power tile or could construct an array of as many tiles as needed. If multiple tiles are used in an array, the distributed and redundant nature of the charge control and distribution hardware provides an extremely fault-tolerant system.

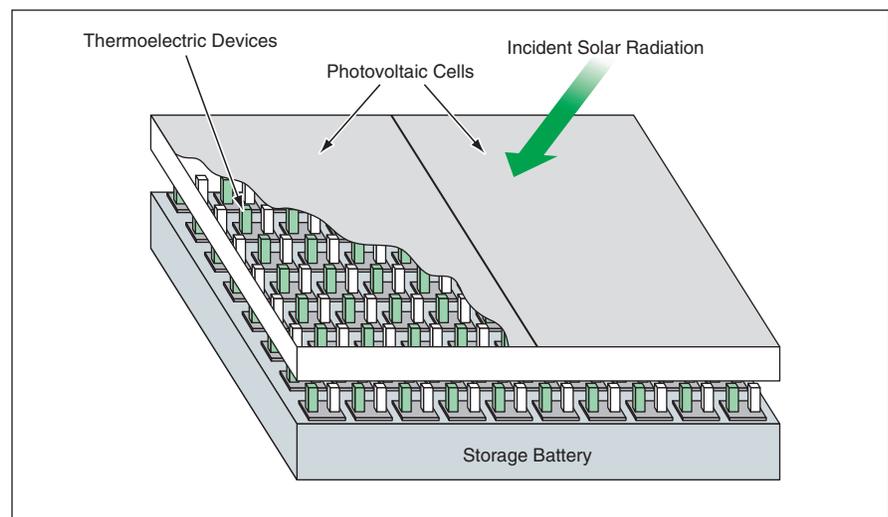
The figure presents a schematic view of the device. High-efficiency photovoltaic cells would be attached to a thin-film array of thermoelectric devices, which, in turn, would be integrated to a multi-layer thin-film solid-state battery packaged in a thermally conductive envelope. The charge control circuitry would be integrated either onto the battery side of the device or into a protective frame that would enclose the device. The entire package is designed to be less

than 2 mm thick.

The thermoelectric devices would harvest some of the thermal energy incurred when solar radiation raises the temperature on the photovoltaic-cell side relative to the shaded backside. The battery would be placed on that opposite side, and the outer surface of its thermally conductive envelope would be coated with a thermally emissive material to aid in creating the greatest possible temperature differential for optimum operation of the thermoelectric device. The same thermoelectric devices could

also be operated in a power-consuming, heat-pump mode to keep the batteries within a desired operational temperature range during intervals of darkness/cold. Microthermoelectric devices that are no more than 500  $\mu\text{m}$  thick are currently under fabrication for intended integration into the power tile device.

The solid-state battery system performs nominally in the temperature range of  $-20$  to  $60$   $^{\circ}\text{C}$ , and has been shown to function at limited discharge rates to temperatures as low as  $-40$   $^{\circ}\text{C}$ . These thin-film solid-state cells, based on mate-



A Power Tile would include energy-harvesting, energy-storing, and temperature-regulating parts integrated into a compact package.