affected resistors into devices of the present type makes it possible to control their resistances electrically over wide ranges, and the lifetimes of electrically variable resistors exceed those of conventional mechanically variable resistors. Another and potentially the most important class of applications is that of resistance-based nonvolatile-memory devices, such as a resistance random access memory (RRAM) described in the immediately following article, "Electrically Variable Resistive Memory Devices" (MFS-32511-1).

This work was done by Shangqing Liu, Nai-Juan Wu, and Alex Ignatiev of the University of Houston for Marshall Space Flight Center. For further information, contact Sammy Nabors, MSFC Commercialization Assistance Lead, at sammy.a.nabors@nasa.gov. Refer to MFS-32512-1.

Two-Dimensional Synthetic-Aperture Radiometer

Aperture synthesis is employed to reduce antenna mass.

Goddard Space Flight Center, Greenbelt, Maryland

A two-dimensional synthetic-aperture radiometer, now undergoing development, serves as a test bed for demonstrating the potential of aperture synthesis for remote sensing of the Earth, particularly for measuring spatial distributions of soil moisture and ocean-surface salinity. The goal is to use the technology for remote sensing aboard a spacecraft in orbit, but the basic principles of design and operation are applicable to remote sensing from aboard an aircraft, and the prototype of the system under development is designed for operation aboard an aircraft.

In aperture synthesis, one utilizes several small antennas in combination with a signal processing in order to obtain resolution that otherwise would require the use of an antenna with a larger aperture (and, hence, potentially more difficult to deploy in space). The principle upon which this system is based is similar to that of Earth-rotation aperture synthesis employed in radio astronomy. In this technology the coherent products (correlations) of signals from pairs of antennas are obtained at different antenna-pair spacings (baselines). The correlation for each baseline yields a sample point in a Fourier transform of the brightness-temperature map of the scene. An image of the scene itself is then reconstructed by inverting the sampled transform.

The predecessor of the present two-dimensional synthetic-aperture radiometer is a one-dimensional one, named the Electrically Scanned Thinned Array Radiometer (ESTAR). Operating in the L band, the ESTAR employs aperture synthesis in the cross-track dimension only, while using a conventional antenna for resolution in the along-track dimension.

The two-dimensional instrument also operates in the L band — to be precise, at a frequency of 1.413 GHz in the frequency band restricted for passive use (no transmission) only. The L band was chosen because (1) the L band represents the long-wavelength end of the remote-sensing spectrum, where the problem of achieving adequate spatial resolution is most critical and (2) imaging airborne instruments that operate in this wavelength range and have adequate spatial resolution are difficult to build and will be needed in future experiments to validate approaches for remote sensing of soil moisture and ocean salinity.

The two-dimensional instrument includes a rectangular array of patch antennas arranged in the form of a cross. The ESTAR uses analog correlation for one dimension, whereas the two-dimensional instrument uses digital correlation. In two dimensions, many more correlation pairs are needed and low-power digital correlators suitable for application in spaceborne remote sensing will help enable this technology. The two-dimensional instrument is dual-polarized and, with modification, capable of operating in a polarimetric mode. A flight test of the instrument took place in June 2003 and it participated in soil moisture experiments during the summers of 2003 and 2004.

This work was done by David M. Le Vine of Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-14809-1

Ethernet-Enabled Power and Communication Module for Embedded Processors

This device enables serial-to-Ethernet conversion and provides power to remote locations without adding cables.

John F. Kennedy Space Center, Florida

The power and communications module is a printed circuit board (PCB) that has the capability of providing power to an embedded processor and converting Ethernet packets into serial data to transfer to the processor. The purpose of the new design is to address the shortcomings of previous designs, including limited bandwidth and program memory, lack of control over packet processing, and lack of support for timing synchronization.

The module includes an RJ-45 with integrated magnetics and power passthrough, integrated Power over Ethernet (PoE) controller, an Ethernet controller [media access controller (MAC)], a Silicon Laboratories C8051F120 microcontroller with synchronous and asynchronous communication ports, a real-time clock, a hardware watchdog timer, a DC-DC converter with triple output, and 1 Mbit of non-volatile ferroelectric RAM. This new kind of RAM, called FRAM, does not require a battery backup, yet is has unlimited read and write cycles, and a much smaller access time (60 nanoseconds) than traditional flash memory. The FRAM may be used to store data from the C8051.

The new design of the module creates a robust serial-to-Ethernet conversion that is powered using the existing Ethernet cable. Not only can the module perform these conversions, it also has the processing capability and memory to implement other protocols (like IEEE 1451, IEEE 1588, etc.) and to offload these tasks from other embedded processors.

This innovation has a small form factor that allows it to power processors and transducers with minimal space requirements. The power for the module is provided over the spare pins of the Ethernet CAT-5 cable from Power Source Equipment (PSE) according to IEEE 802.11a. The power and communication module then converts the power into three different voltage levels: 5 volts DC, +12 volts DC and –12 volts DC, which are provided to the embedded processor or transducer through a power header on the PCB.

The power and communication module is also equipped with an Ethernet Controller and microprocessor that can send and receive Internet Protocol (IP)-based packets over the CAT-5 cable on a 10/100 Megabit Ethernet network. The Ethernet controller takes care of overhead communication with the network, and the microprocessor is able to access packets stored in the Ethernet controller's buffer. The microprocessor translates the packets to and from serial data to packets using a standard serial peripheral interface (SPI). The SPI data can be sent and received to another embedded processor over the digital header on the PCB.

The power and communication module is equipped with a hardware watchdog timer that monitors the SPI communication and resets the processors if communications cease. The power and communication module has the additional feature of a real time clock (RTC) that is used to synchronize the time of the power and communication module and its associated embedded processor(s) with the time of another entity on the Ethernet network. Time synchronization is achieved through a combination of hardware and software using the RTC and IEEE 15888 1588 Precision Time Protocol.

This work was done by Jose Perotti of Kennedy Space Center, and Carlos Mata and Rebecca Oostdyk of ASRC Aerospace Corp. Further information is contained in a TSP (see page 1). KSC-13112

Electrically Variable Resistive Memory Devices

Data are written or read using larger or smaller current pulses, respectively.

Marshall Space Flight Center, Alabama

Nonvolatile electronic memory devices that store data in the form of electrical-resistance values, and memory circuits based on such devices, have been invented. These devices and circuits exploit an electrically-variable-resistance phenomenon that occurs in thin films of certain oxides that exhibit the colossal magnetoresistive (CMR) effect. It is worth emphasizing that, as stated in the immediately preceding article, these devices function at room temperature and do not depend on externally applied magnetic fields.

A device of this type is basically a thin-film resistor: it consists of a thin film of a CMR material located between, and in contact with, two electrical conductors. The application of a short-duration, low-voltage current pulse via the terminals changes the electrical resistance of the film. The amount of the change in resistance depends on the size of the pulse. The direction of change (increase or decrease of resistance) depends on the polarity of the pulse. Hence, a datum can be written (or a prior datum overwritten) in the memory device by applying a pulse of size and polarity tailored to set the resistance at a value that represents a specific numerical value. To read the datum, one applies a smaller pulse — one that is large enough to enable accurate measurement of resistance, but small enough so as not to change the resistance.

In writing, the resistance can be set to any value within the dynamic range of the CMR film. Typically, the value would be one of several discrete resistance values that represent logic levels or digits. Because the number of levels can exceed 2, a memory device of this type is not limited to binary data. Like other memory devices, devices of this type can be incorporated into a memory integrated circuit by laying them out on a substrate in rows and columns, along with row and column conductors for electrically addressing them individually or collectively.

This work was done by Shangqing Liu, Nai-Juan Wu, Alex Ignatiev, and E. J. Charlson of the University of Houston for Marshall Space Flight Center. For more information, contact Sammy Nabors, MSFC Commercialization Assistance Lead, at sammy.a.nabors@nasa.gov. MFS-32511-1