is compatible with proven Schottky diode mixer/detector technologies.

The development of such technology will benefit applications where submillimeter-wave heterodyne array designs are required. The main fields are national security, planetary exploration, and biomedicine. For national security, wideband submillimeter radars could be an effective tool for the standoff detection of hidden weapons or bombs concealed by clothing or packaging. In the field of planetary exploration, wideband

submillimeter radars can be used as a spectrometer to detect trace concentrations of chemicals in atmospheres that are too cold to rely on thermal imaging techniques. In biomedicine, an imaging heterodyne system could be helpful in detecting skin diseases.

This work was done by Goutam Chattopadhyay, John J. Gill, Anders Skalare, Choonsup Lee, and Nuria Llombart, and Peter H. Siegel of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

Automated Cryocooler Monitor and Control System

Small-scale cryogenic cooler applications include medical imaging for MRI systems and infrared sensor cooling.

NASA's Jet Propulsion Laboratory, Pasadena, California

A system was designed to automate cryogenically cooled low-noise amplifier systems used in the NASA Deep Space Network. It automates the entire operation of the system including cool-down, warm-up, and performance monitoring. The system is based on a single-board computer with custom software and hardware to monitor and control the cryogenic operation of the system. The system provides local display and control, and can be operated remotely via a Web interface.

The system controller is based on a commercial single-board computer with onboard data acquisition capability. The commercial hardware includes a microprocessor, an LCD (liquid crystal display), seven LED (light emitting diode) displays, a seven-key keypad, an Ethernet interface, 40 digital I/O (input/output) ports, 11 A/D (analog to digital) inputs, four D/A (digital to analog) outputs,

and an external relay board to control the high-current devices.

The temperature sensors used are commercial silicon diode devices that provide a non-linear voltage output proportional to temperature. The devices are excited with a 10-microamp bias current. The system is capable of monitoring and displaying three temperatures.

The vacuum sensors are commercial thermistor devices. The output of the sensors is a non-linear voltage proportional to vacuum pressure in the 1-Torr to 1-millitorr range. Two sensors are used. One measures the vacuum pressure in the cryocooler and the other the pressure at the input to the vacuum pump. The helium pressure sensor is a commercial device that provides a linear voltage output from 1 to 5 volts, corresponding to a gas pressure from 0 to 3.5 MPa (≈500 psig).

Control of the vacuum process is accomplished with a commercial electrically

operated solenoid valve. A commercial motor starter is used to control the input power of the compressor. The warm-up heaters are commercial power resistors sized to provide the appropriate power for the thermal mass of the particular system, and typically provide 50 watts of heat.

There are four basic operating modes. "Cool" mode commands the system to cool to normal operating temperature. "Heat" mode is used to warm the device to a set temperature near room temperature. "Pump" mode is a maintenance function that allows the vacuum system to be operated alone to remove accumulated contaminants from the vacuum area. In "Off" mode, no power is applied to the system.

This work was done by Michael J. Britcliffe, Theodore R. Hanson, and Larry E. Fowler of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-47246

Broadband Achromatic Phase Shifter for a Nulling Interferometer

A uniform broadband phase shift is achieved while minimizing intensity, polarization, and chromatic spread differences between interferometer beams.

Goddard Space Flight Center, Greenbelt, Maryland

Nulling interferometry is a technique for imaging exoplanets in which light from the parent star is suppressed using destructive interference. Light from the star is divided into two beams and a phase shift of π radians is introduced into one of the beams. When the beams are recombined, they destructively in-

terfere to produce a deep null. For monochromatic light, this is implemented by introducing an optical path difference (OPD) between the two beams equal to λ/2, where λ is the wavelength of the light. For broadband light, however, a different phase shift will be introduced at each wavelength and the

two beams will not effectively null when recombined.

Various techniques have been devised to introduce an achromatic phase shift — a phase shift that is uniform across a particular bandwidth. One popular technique is to use a series of dispersive elements to introduce a wavelength-de-