wide-angle optics. Examples include a panoramic annular lens (PAL), a convex mirror, a fish-eye lens, scanning optics, or a panoramic refracting optic (PRO), which is described in the next paragraph. If necessary, the transfer optics can include one or more mirror(s) to flip the image. Downstream from the panoramic imaging optic and transfer optics, the image is further conditioned by the camera lens, then detected by the CCD in the camera. The camera output is digitized, processed by the computer, and displayed and/or stored as needed.

A PRO is a recently developed optic that operates partly like a PAL, partly like a fish-eye lens, and partly like a convex mirror. In comparison with a PAL, a PRO provides a wider field of view, yet is simpler and can be fabricated at lower cost. As shown in Figure 2, light from a scene enters the optic at location 1 (where it is refracted), travels through the optic, is totally internally reflected at location 2, leaves the optic at location 3 (where it undergoes a small amount of refraction), then goes through the transfer optics and camera lens into the camera. The net effect of refraction and reflection from surfaces of the optic is to define the wide, approximately cylindrical field of view. The limits of the field of view are determined primarily by the index of refraction of the optic and the curvature of its refracting/reflecting surface. A significant issue that remains to be addressed in subsequent development efforts is that the resolution of the image is approximately inversely proportional to the angular width of the field of view.

This work was done by Jeffrey L. Linder of Marshall Space Flight Center and John Gilbert of Optotechnology, Inc. For further information, contact Jim Dowdy, MSFC Commercialization Assistance Lead, at jim.dowdy@nasa.gov.

This invention has been patented by NASA (U.S. Patent No. 6,580,567). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to Sammy Nabors, MSFC Commercialization Assistance Lead, at sammy.a.nabors@nasa.gov. Refer to MFS-31432/75.
In the present version, the electronic tongue contains 12 analog cells: nine oxidation/reduction (redox) electrochemical cells, an electrical-conductivity cell, and the aforementioned heater and temperature sensor. The interface circuitry (see figure) consists mainly of 12 digital-to-analog converters (DACs) for excitation of the cells, and four analog-to-digital converters (ADCs) for readout from the cells connected to 12 analog cells. Each analog cell is made of two instrument amplifiers, two operational amplifiers and analog filters for reducing signal-to-noise ratios, and control and switching circuits.

The interface circuitry resides on a board mounted immediately below the ceramic substrate and, as in the prior version, is connected to the analog cells via miniature edge connectors on the ceramic substrate. By thus placing the ADCs and DACs near the analog cells, the design helps to minimize pickup of noise and reduce cross-talk on the analog signal lines.

As in the prior version, the control circuitry can be programmed to make the DACs generate the specified excitation waveforms and to make the ADCs acquire the specified response waveform data, and each electrochemical cell can be addressed individually. Depending on the specific application, a given electrochemical cell can be operated in a potentiostatic mode (voltage forced, current measured) or a galvanostatic mode (current forced, voltage measured), or can be made to alternate between the two modes. In one typical application, the main sequence of excitations and responses in a potentiostatic mode is chosen to implement anodic stripping voltammetry or cyclic voltammetry. In another typical application, a working electrode of a cell is operated in a galvanostatic mode at a positive bias for generating oxygen or a negative bias for generating hydrogen.

This work was done by Didier Keymeulen and Martin Buehler of Caltech for NASA’s Jet Propulsion Laboratory.

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:

Innovative Technology Assets Management
JPL
Mail Stop 202-233
4800 Oak Grove Drive
Pasadena, CA 91109-8099
(818) 354-2240
E-mail: iaoffice@jpl.nasa.gov
Refer to NPO-41365, volume and number of this NASA Tech Briefs issue, and the page number.

Inexpensive Clock for Displaying Planetary or Sidereal Time
An external oscillator is substituted for an internal quartz clock oscillator.

NASA’s Jet Propulsion Laboratory, Pasadena, California

An inexpensive wall clock has been devised for displaying solar time or sidereal time as it would be perceived on a planet other than the Earth, or for displaying sidereal time on the Earth. The concept of a wall clock synchronized to a period other than the terrestrial mean solar day is not new in itself. What is new here is that the clock is realized through a relatively simple electronic modification of a common battery-powered, quartz-crystal-oscillator-driven wall clock (which, as unmodified, displays terrestrial mean solar time).

The essence of the modification is to shut off the internal oscillator of the clock and replace the internal-oscillator output signal with a signal of the required frequency generated by an external oscillator. The unmodified clock electronic circuitry includes a quartz crystal connected to an integrated circuit (IC) that includes, among other parts, a buffer amplifier that conditions the oscillator output. The modification is effected by removing the quartz crystal and connecting the output terminal of the external oscillator, via a capacitor, to the input terminal of the buffer amplifier (see figure).

The frequency and amplitude of the external-oscillator signal must be chosen in accordance with the IC design as well as the desired clock speed. Typically, the required amplitude is 0.5 V peak-to-peak and the frequency required for two complete revolutions of the hour hand (two 12-hour cycles) spanning a terrestrial mean solar day is $2^{15} = 32,768$ Hz. Examples of other clock cycles and frequencies based on this typical design include the following:

• For one complete revolution of the hour hand (one 24-hour cycle) during a terrestrial mean solar day, the required frequency is $2^{14} = 16,384$ Hz.

• For two complete revolutions of the hour hand (two 12-“hour” cycles) during a terrestrial sidereal day, the required frequency is $32,859.27577$ Hz.

• For one complete revolution of the hour hand (one 24-“hour” cycle) during a terrestrial sidereal day, the required frequency is $16,429.63788$ Hz.

• For two complete revolutions of the hour hand (two 12-“hour” cycles) during a Martian mean solar day, the required frequency is $31,947.1361$ Hz.

• For one complete revolution of the