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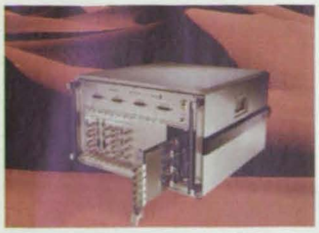

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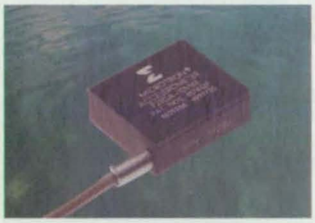

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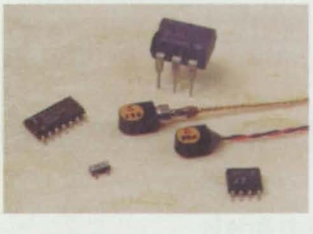

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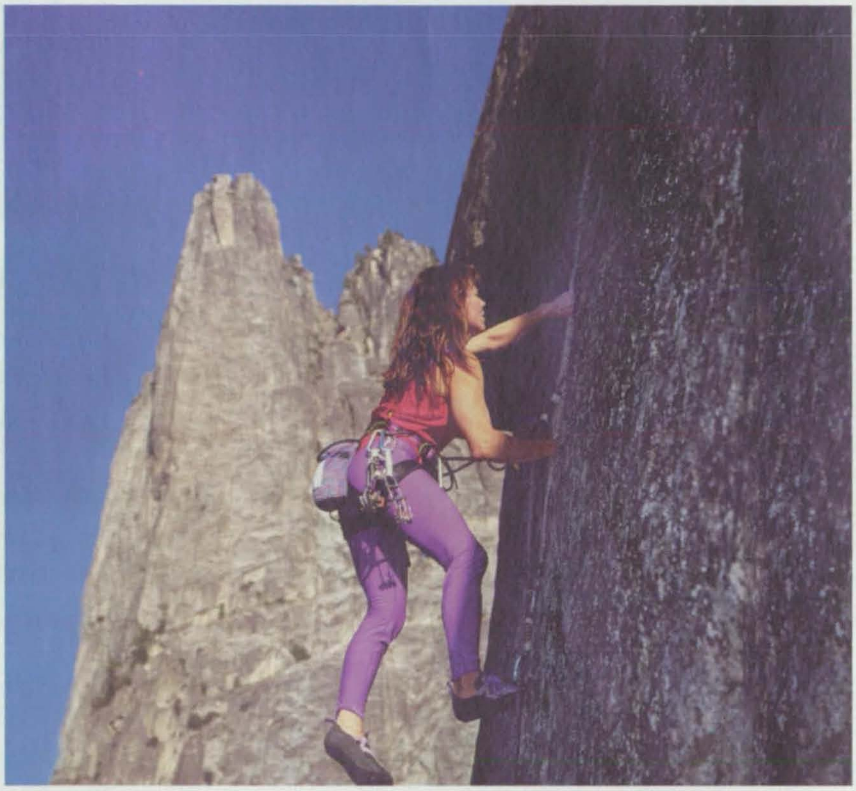

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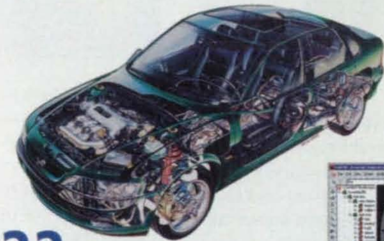

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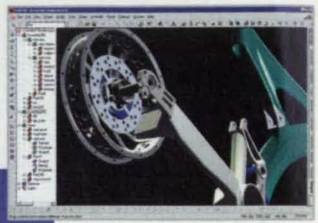

66

DEPARTMENTS

SPECIAL SUPPLEMENTS

Contents *continued*

PRODUCT OF THE MONTH

Autodesk's second release of Inventor™ 3D solid modeling and drawing software is based on the Adaptive Design process that allows users to design the way they think.

18

ON THE COVER

The OCS2500 oscilloscope calibrator from TEGAM, Geneva, OH, is a programmable, automated system for frequencies up to 2.5 GHz. The system is one of six featured products in this month's Special Coverage on Test and Measurement, which begins on page 32. For more information on the TEGAM calibrator, and other new test and measurement products, see page 41.

(Image courtesy of TEGAM)

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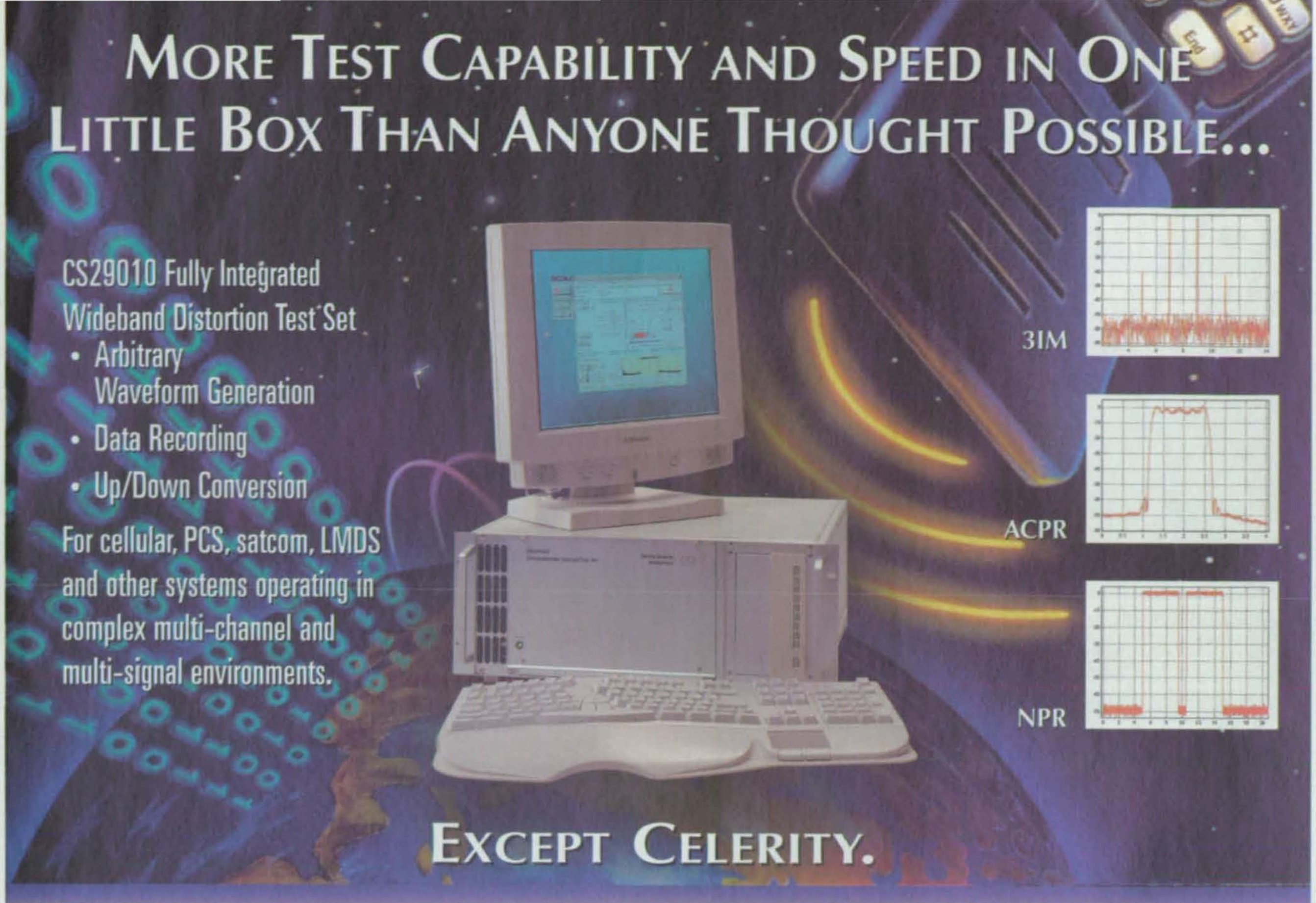

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John H. Glenn Research Center at Lewis Field
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Larry Viterna
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At NASA Headquarters there are seven major program offices that develop and oversee technology projects of potential interest to industry. The street address for these strategic business units is: NASA Headquarters, 300 E St. SW, Washington, DC 20546.

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Rustin
rustin@ny.freei.net

*(**Editor's Note:** Rustin, you can contact DuPont, the manufacturer of Kapton®, at www.dupont.com. There, you will find a list of products, and a contact link for information on how to purchase the polyamide film.)*

I need a gas that emits visible light when compressed or when pressure is released. It will be used in an aerospace application, and the pressure change will be on the order of approximately 2 atm. Thanks for any help.

Tom Psenak
tpsenak@flash.net

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NASA Patents

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Stereo Imaging Velocimetry

(U.S. Patent No. 5,905,568)

Inventors: Mark McDowell and Thomas K. Glasgow, Glenn Research Center

A need exists for a state-of-the-art full-field three-dimensional flow analysis method and apparatus for any optically transparent fluid seeded with tracer particles regardless of size. Such a stereo imaging velocimeter should provide accuracy to within approximately 2 percent of full-field, more accurate than any other three-dimensional system to date. The present invention fills this need. At least two cameras are positioned to view the fluid, approximately perpendicular to one another to provide two two-dimensional views of the tracer particles. Centroid determining means in communication with a signal processor accurately locates a centroid of each tracer particle in a frame and establishes coordinates for each. Stereo matching means determine which individual particle images from synchronized images represent identical particles for calculating three-dimensional coordinates as a function of time and distance.

Microwave Treatment for Cardiac Arrhythmias

(U.S. Patent No. 5,904,709)

Inventors: George W. Raffoul, James R. Carl, G. Dickey Arndt, and Antonio Pacifico, Johnson Space Center

Under conditions that may develop after months or years following a heart attack, the combination of scar tissue and living cells in that tissue may begin to produce undesirable electrical impulses, which can fan through the otherwise healthy heart to produce the dangerous rapid pumping by the heart ventricles called ventricular tachycardia. The treatment for this condition is the ablation by some means of the arrhythmogenic cardiac tissues. This is called transcatheter ablation, in which the doctor inserts a catheter into the heart through a blood vessel. But each of the varieties of this procedure have drawbacks. The present development equips the catheter with a microwave radiator at one end. The microwave power level is chosen so that a temperature increase from absorption of microwave energy in the blood is limited by the blood exchange rate to a desired temperature range. A heating time is determined so that the absorption of microwave energy at the frequency of operation and the thermal conductivity of the arrhythmogenic tissue and surface blood result in a temperature rise sufficient for ablation of the tissue.

Carbon Fiber Reinforced Carbon Composite Rotary Valves for Internal Combustion Engines

(U.S. Patent No. 5,908,016)

Inventors: G. Burton Northam, Philip O. Ransome, and H. Kevin Rivers, Langley Research Center

Over the years engineers have proposed the use of rotary, sleeve, and disc valves to overcome the inherent limitations of the poppet valve. The basic design of these is to rotate a valve body to expose and close intake and exhaust ports. In this way, the need to reciprocate a poppet value is avoided. The principle of these designs is that the rotary valve and the surface it rides in must be very closely mated in order to seal the combustion chamber adequately. But as engine temperatures rise, the different expansion rates of these metallic parts leads either to sealing problems if the parts are not close enough, or to seizure if they are too close. Moreover, if a mechanical rotary valve is used to discharge exhaust it will tend to become extremely hot and difficult to lubricate. The carbon fiber reinforced carbon matrix composite valves meet all these objections. It is possible to mate rotary, sleeve, and disc valves very closely to the housings in which they rotate and thus overcome the principal problem associated with the metallic counterparts.

For more information on the inventions described here, contact the appropriate NASA Field Center's Commercial Technology Office. *See page 12 for a list of office contacts.*

February 2000

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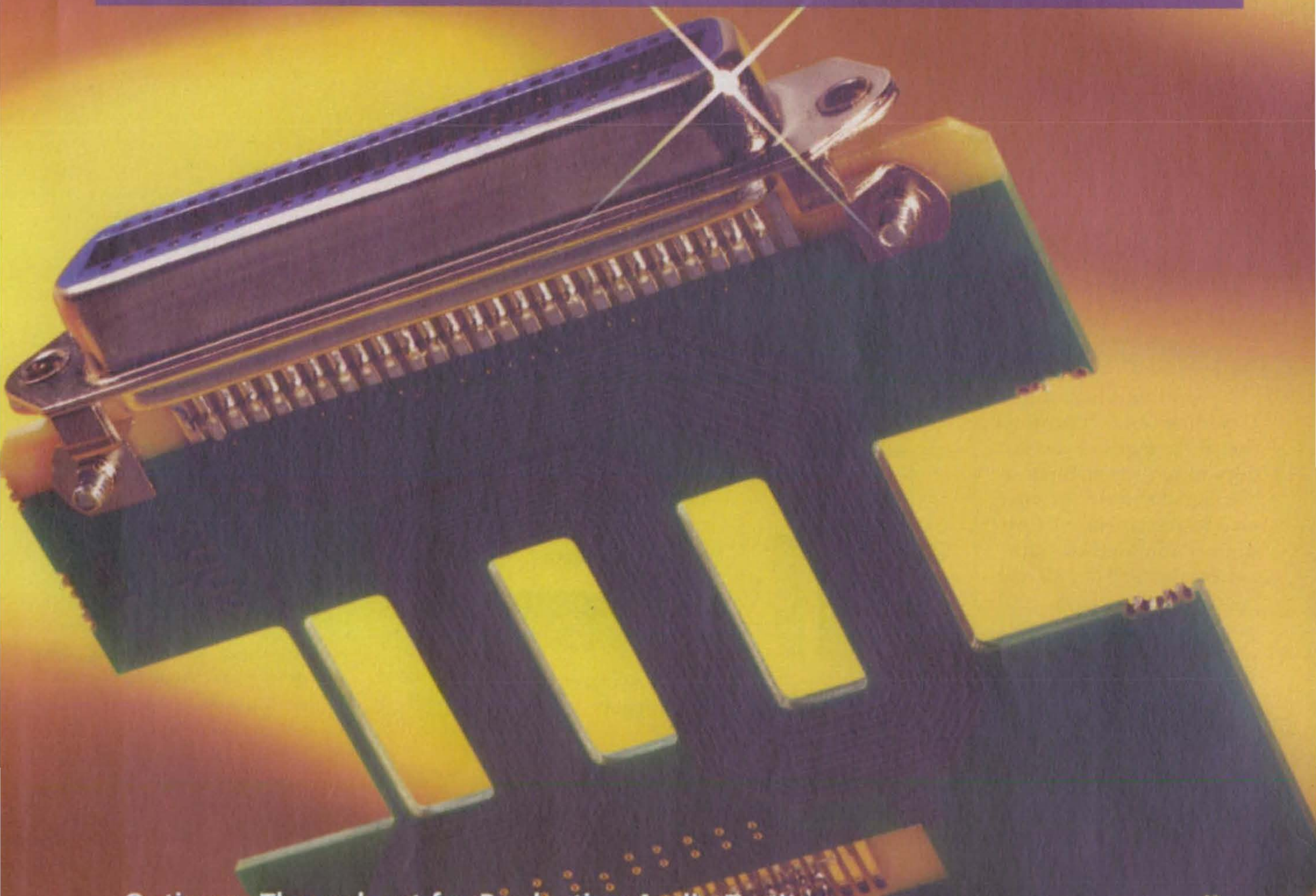
ELECTRONICS TECH BRIEFS



Cover photo courtesy of Ranoda Electronics. See "New Products."

Optimum Throughput for Production Audio Testing

Keithley develops a method of characterizing a communications DUT and the measurement system before digital audio testing.

A revolution in audio recording and reproduction techniques in the last decade has given birth to the digital audio consumer electronics market. Consumers now want the same performance from digital cellular handsets and portable CD players that once was found only in elite audiophile products.

The improvement in audio fidelity allowed by the digital format is a function of decreased distortion and noise, and an increase in dynamic range. To fully realize these improvements, however, the digital format places increased demands on the quality of audio circuitry and transducers. As a result, sophisticated tests previously performed only in a development lab are now specified for production testing. This includes harmonic distortion and frequency response measurements to insure product quality. These developments have led to new types of audio analyzers with digital signal processors (DSPs), which perform accurate measurements at the high speeds demanded in a production environment.

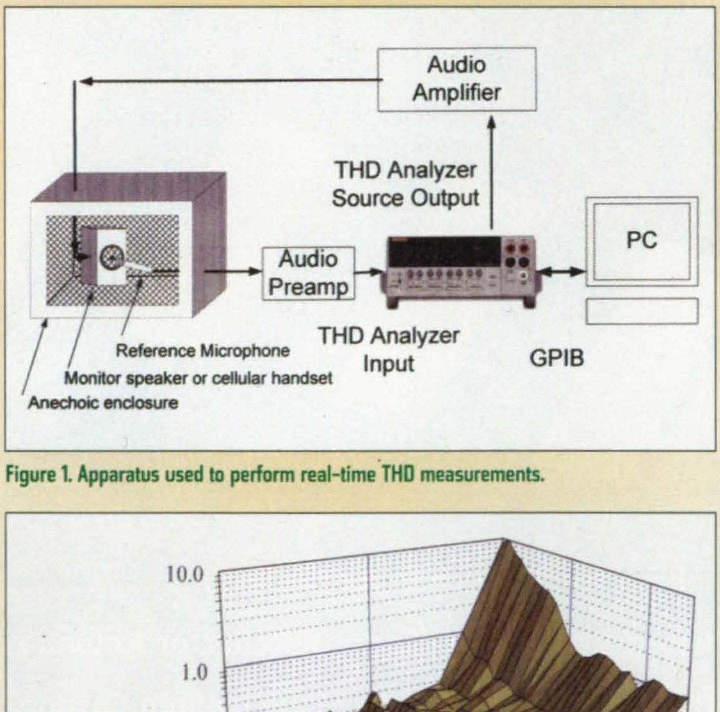


Figure 1. Apparatus used to perform real-time THD measurements.

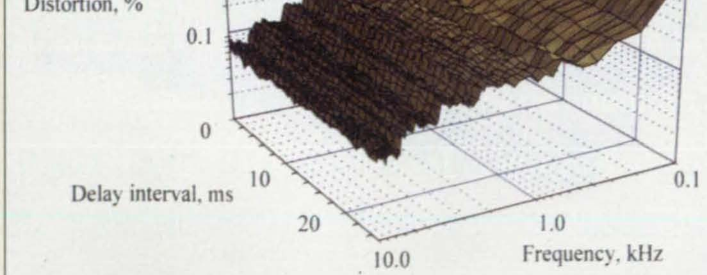


Figure 2. THD of a four-inch-diameter monitor speaker over a frequency range of 100 Hz to 10 Hz, with t_d from 0 to 25 ms.

To optimize test throughput and measurement accuracy, there are several key areas a test engineer should consider. First, careful consideration must be given to the transient response duration of the device under test (DUT), typically an electroacoustic transducer, and the time elapsed between stimulation of the DUT and processing its response. Second, measurement reproducibility must be characterized to determine if there is adequate measurement precision to distinguish between conforming and nonconforming product.

Making THD Measurements

The mechanical and electrical properties of an electro-acoustic transducer determine the acoustical performance, which is characterized by its transient and steady-state response to an input stimulus. To perform steady-state distortion and frequency response measurements accurately, the transducer

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must be relatively free of transients following a stimulus. Thus an appropriate time delay, t_d, may be required between the initial stimulus and the THD measurement.

According to the IEEE, THD is defined as:

$$THD = \sqrt{\frac{h_2^2 + h_3^2 + h_4^2 + ...h_n^2}{f^2}}$$

where f is the RMS magnitude of the fundamental and h_2, h_4...h_n are the RMS magnitudes of the second through the nth harmonics. If THD over a range of frequencies is desired, a sweep of discrete single frequencies must be used.

If the number of THD sweep frequencies is large, an arbitrary choice or excessive value for t_d will incur a significant test-time penalty. On the other hand, if t_d is too short the DUT will not exhibit a steady-state response and measurement precision and reproducibility will be compromised.

High-speed audio analyzers typically have a built-in signal source to stimulate the DUT and a programmable time delay feature. It is up to the test engineer to determine the appropriate delay between generation of the stimulus and subsequent acquisition and processing of the DUT response. To minimize test time and produce accurate results, the delay interval should be no longer than necessary to allow decay of the DUT's transient response. This must be determined for a particular type of DUT and test situation, since the transient response of any audio transducer varies as a function of source frequency, output level, and other factors.

In a test environment requiring high throughput, a fast DSP-based THD meter can be easily programmed for the best tradeoff between speed and accuracy. Using a few simple techniques, the test engineer can determine optimum values for t_d, set up a discrete frequency sweep, and generate simultaneous results for THD and output level. For a DUT with good transient response (i.e., small t_d), results for a 20-point frequency sweep are obtained in approximately one second.

To illustrate, THD measurements on two transducers commonly found in consumer audio products were performed. The tests were performed on a piezoelectric transducer in a cellular handset and on a four-inch-diameter monitor speaker. The apparatus is shown in Figure 1, which includes a THD meter with a programmable source delay, an audio amplifier, a microphone and preamplifier, an anechoic enclosure, and a PC with data acquisition software. The t_d interval determined by this method can be applied to other audio measurements such as intermodulation distortion, noise, etc., where a signal source and audio analyzer are used.

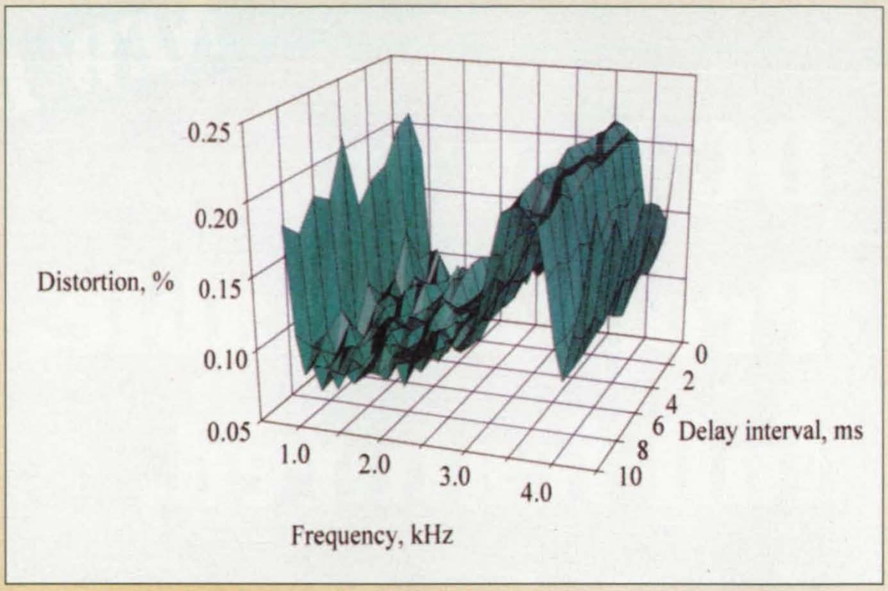


Figure 3. THD of a piezoelectric transducer from 700 Hz to 4.0 kHz and t_d from 0 to 10 ms.

In the transient step response for a 2.0-kHz-to-1.0-kHz signal of a typical four-inch-diameter speaker and piezoelectric element, the transient response of the speaker (≈20 ms) takes longer to decay than the transient of the piezoelectric element (≈4 ms). The slow response of the speaker is due to the relatively large mass of the cone and motor structure compared to the piezoelectric diaphragm. The decay times of the transients taken from oscilloscope plots can be used as rough estimates for t_d and applied when performing production THD measurements on the same devices.

A more complete picture of how t_d affects DUT performance over a wide range of frequencies is shown in Figures 2 and 3. The surface plots show the actual THD measurements versus t_d and analyzer source frequency. The THD measurements include harmonics from the second to the sixth; the high and low frequency limits were chosen to cover the operating range of each transducer. Because they cover a wider span, logarithmic scales are used for the distortion and frequency axes of the speaker plot.

The response of the speaker in Figure 2 shows a relatively large amount of distortion at low frequencies (approximately 1 percent at 100 Hz) and lower levels at high frequencies (<0.1 percent at 10 kHz). For frequencies less than 500 Hz, THD exhibits a visible dependence on t_d; for frequencies above 1 kHz, THD is relatively constant for all values of t_d.

The THD measurements on the piezoelectric transducer shown in Figure 3 cover a frequency range from 700 Hz to 4000 Hz and t_d from 0 to 10 ms. Using a linear scale for the z-axis, the variation of

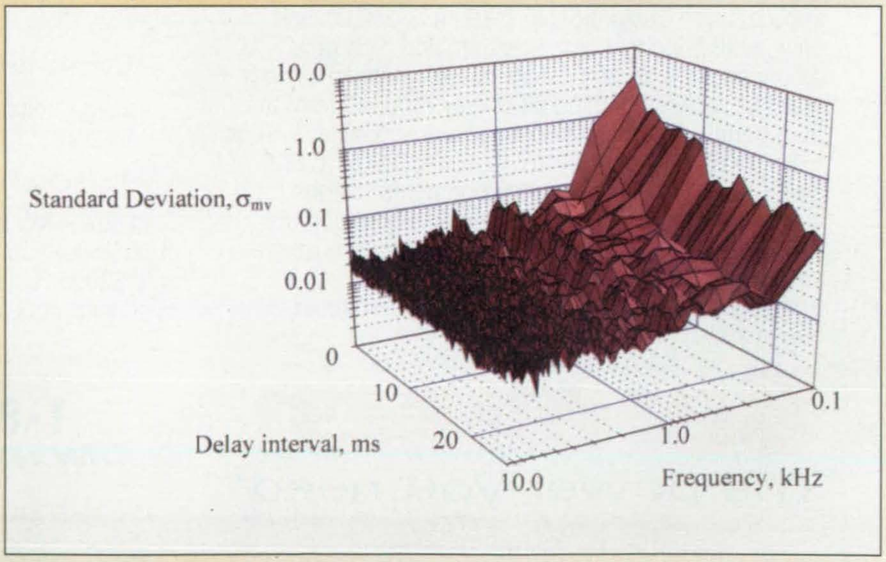


Figure 4. Standard deviation of the speaker THD measurements from 100 Hz to 10 kHz and t_d from 0 to 10 ms.

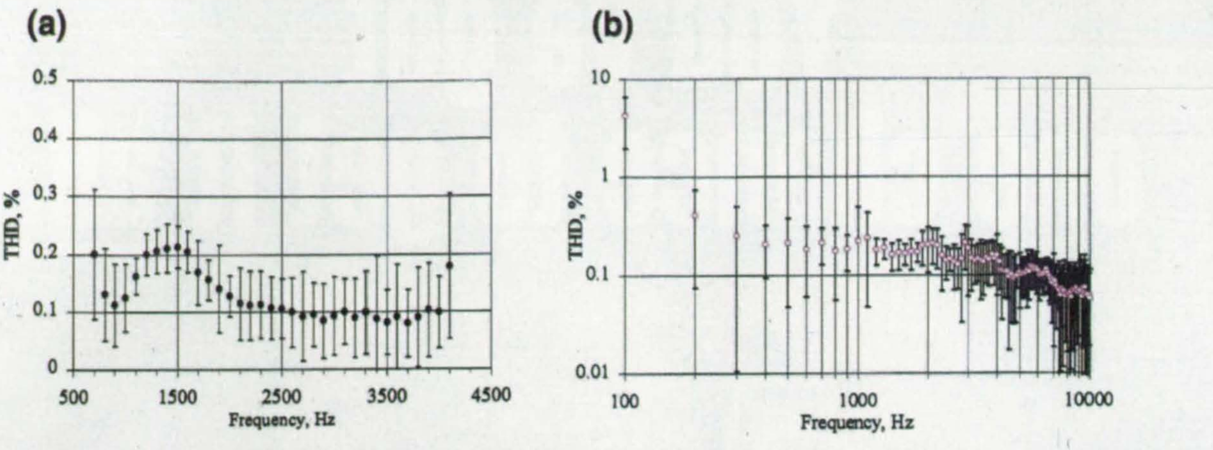


Figure 5. THD vs. frequency plot showing the 99.7-percent confidence interval, <3 s_{mv}, at each measurement for (a) piezoelectric transducer with t_d=1 ms and (b) speaker with t_d=5 ms.

THD with frequency is more pronounced than for the speaker. Unlike the speaker, however, the piezoelectric transducer surface plot is almost flat with respect to the t_d axis.

These results confirm that the value of a THD measurement is highly dependent on the source frequency, the transient characteristics of the DUT, and the time delay between stimulus application and response analysis. To minimize test time, the smallest t_d that produces a stable minimum value for THD at a particular frequency should be used.

Achieving Reproducibility

Establishing the reproducibility, or conversely the variability, of audio measurements in the actual production test environment is a necessary step in determining if there is sufficient measurement precision to distinguish between conforming and nonconforming products. The reproducibility of an audio measurement is affected by factors such as the performance of the audio analyzer, reference microphone or transducer, preamplifier, signal-conditioning electronics, and the acoustic environment in which the test is performed. To keep measurement variability as small as possible, the test configuration must have high-quality measurement electronics, efficient acoustic coupling between the DUT and the input transducer, and high isolation from external interference.

If measurement devices and methods were perfect, it would be possible to make a direct determination of variability in THD measurements. Since there are imperfections, the measured value is the sum of two variables, the quantity measured and the error of measurement.

Under ideal conditions, the variability in measurement error may be observed by repeating the THD measurement many times using a source that remains unchanged. A numerical expression of THD measurement error is the standard deviation of the frequency distribution, referred to as s_{me}, obtained from such repeated measurements. Since the actual quantity measured and the measurement error are likely to be independent of each other, the formula for the standard deviation of the sum of two independent variables may be used:

$$S_{mv} = \sqrt{(S_{tv})^2 + (S_{me})^2}$$

where s_{mv} is the total variability of the measurement, s_{tv} is the variability of the THD from the DUT, and s_{me} is the variability of the measurement error.

Figure 4 shows the standard deviation of the speaker's THD measurements from 100 Hz to 10 kHz and t_d from 0 to 10 ms. The data for the speaker, displayed on a logarithmic axis, shows large values for s_{mv} at low frequencies and small values of t_d. Even after a substantial delay of 25 ms, s_{mv} is approximately an order of magnitude larger at 100 Hz (0.133 percent) than at 10 kHz (0.018 percent). The variation of s_{mv} for the piezoelectric transducer ranges from 0.2 percent to 0.4 percent, and is nearly uniform for all values of frequency and t_d.

To determine s_{tv} and the true confidence limits of the THD measurements using equation 1, the value for s_{me} of the measurement system must also be shown. This is not a trivial task, but the value can be measured to a specified degree of accuracy with calibrated sources and careful calibration techniques. If we choose to provide an upper (conservative) limit on s_{tv}, we can use the following approximation of equation 2:

$$(s_{tv})_{max} = s_{mv}, \text{if } s_{me} = 0.$$

Using the measured values of s_{mv} for s_{tv}, Figure 5 shows the 99.7-percent confidence interval, ±3 s_{mv}, for the piezoelectric transducer (a) and the speaker (b) over the specified frequency range with t_d=1 ms and t_d=5 ms respectively. This is the variability measured with the apparatus in Figure 1. Changes to the measurement system affect results. Experience shows that the "quality" of the acoustic environment in which the measurement is performed can have dramatic effects on measurement variability and often are the most difficult to control.

To optimize throughput and measurement accuracy in a production test system, the transient performance of the DUT and the variability of the THD measurements over the required frequency range must be evaluated to determine minimum time delay. By making surface plots of THD meter measurements versus time delay and analyzer source frequency, the appropriate time delay can be established.

Similarly, the test engineer must determine measurement variability (uncertainty). For a given set of measurement conditions, the standard deviation of THD measurements can be used to quantify this uncertainty. Armed with this information, the engineer can determine if the test system has sufficient precision and reproducibility to differentiate conforming and nonconforming products.

For more information, contact the author of this article, Roland Lowe, Telecomm Applications Engineering Manager at Keithley Instruments, 28775 Aurora Rd., Cleveland, OH 44139; (216) 248-0400; (216) 248-6168; e-mail: lowe_roland@keithley.com; www.keithley.com.

Low-Sidelobe Phased-Array-Fed Cylindrical-Reflector Antenna

Sidelobes can be reduced by choosing a suitable superquadric projected aperture.

NASA's Jet Propulsion Laboratory, Pasadena, California

A phased-array-fed cylindrical-reflector antenna with superquadric projected aperture has been designed to afford the ability to scan the beam over a wide angular range without having to resort to a large focal-to-diameter ratio and without incurring excessively strong sidelobes. The standard of comparison for this antenna is a paraboloidal-reflector antenna, which offers limited scanning capability at a low value of F/D (where F is focal length and D is diameter). The scanning capability of a paraboloidal-reflector antenna is improved by increasing F/D, but for a given large D, this entails an increase in F and thus in the size of the antenna structure needed to support a feed element at the focal point. The present phased-array-fed, cylindrical-reflector antenna would be compact (F/D of only about 0.4, where the cross section of the cylindrical reflector, in x–z plane, is a parabola with diameter, D), yet would feature relatively low sidelobes at beam-scan angles as large as 16° off the geometric boresight axis in the plane that contains the cylindrical axis.

The basic antenna geometry (see Figure 1) is that of a parabolic cylindrical reflector. The cylindrical axis is the y axis, and the geometric boresight axis is the z axis. The phased array of feed elements lies on the focal line, which is parallel to the y axis, at a distance F from the apex of the parabola. The boundary of the reflector and thus of the aperture, as projected onto the x,y plane, is specified by the superquadric curve

$$\left|\frac{x}{a}\right|^n + \left|\frac{y}{b}\right|^n = 1;$$

where a and b are the lengths of the x and y semiaxes, respectively, of the aperture; and n is a parameter that can be chosen to control the rounded shape of the corners. The advantage of the superquadric projected aperture is that it is amenable to computational simulation of the performances of antennas with a variety of projected aperture sizes and shapes represented by various combinations of a, b, and n.

Computational simulations have been performed, following diffraction-analysis procedures based on a physical-optics formulation. The geo-

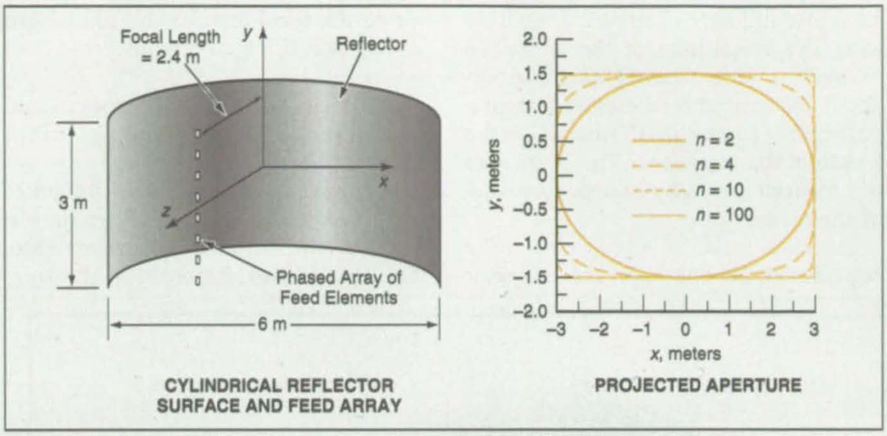


Figure 1. An **Antenna With a Phased-Array Feed and a Parabolic Cylindrical Reflector** can be used to reduce sidelobes at large scan angles with suitable choice of projected aperture-shaping parameter, n. The dimensions shown here are only for the numerical example described in the text; the dimensions specific to other applications could differ.

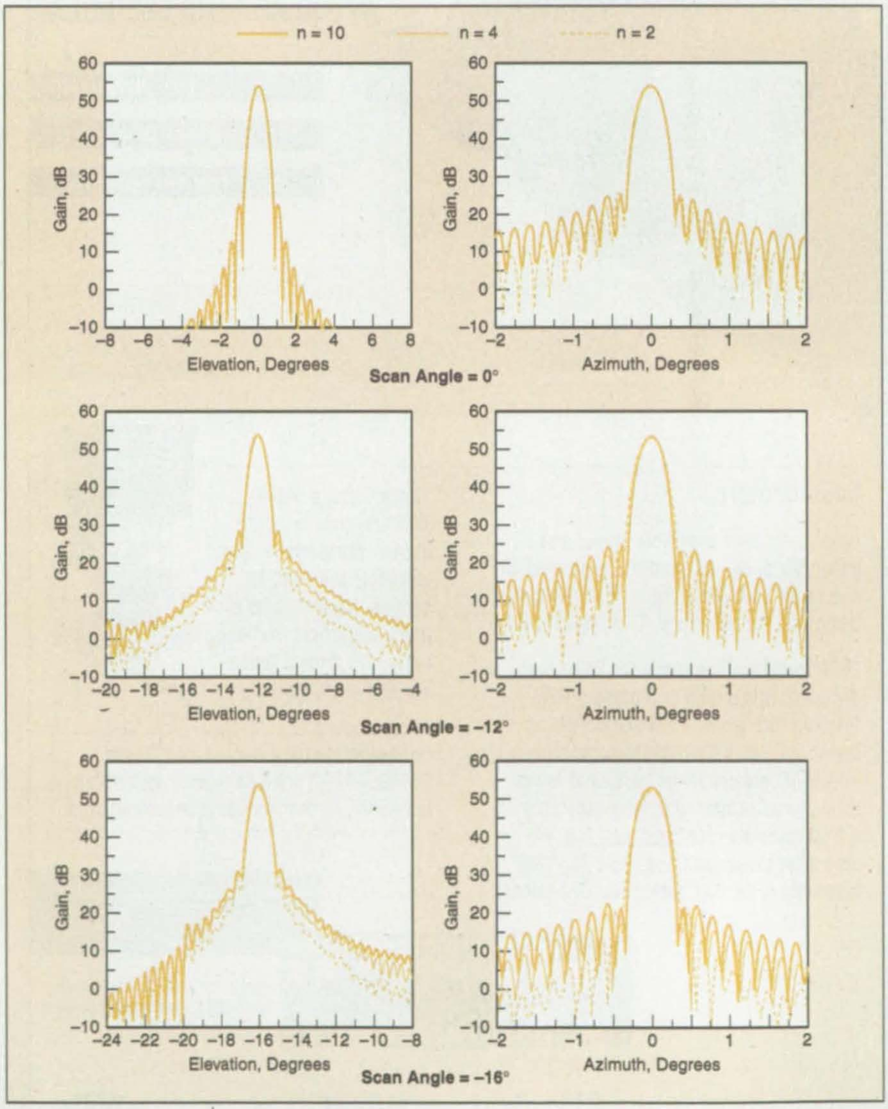


Figure 2. **Some Results of Numerical Simulations** are plotted for three different scan angles in the full-illumination case. In these plots, "elevation" signifies the far-field angle off the z axis in the y,z plane, and "azimuth" signifies the far-field angle off the z axis in the plane that includes x axis and the beam peak for the given scan angle.

metric parameters used in the simulations were $a = 3$ m, $b = 1.5$ m, $F = 2.4$ m, and three different values of n (2, 4, and 10). The feed elements were positioned at half-wavelength intervals (about 1.07 cm for a frequency of 14 GHz) along the focal line and were polarized along the y axis. The amplitudes of the array-feed excitations were tapered symmetrically about the central feed element, in proportion to $[\cos(\pi y/D_1)]^2$, where D_1 is the length of the array feed. The beam scan was realized through phase progression of the feeds.

For each value of n, two cases were considered. In one case, the reflector was under-illuminated: 233 feed elements were disposed symmetrically along the focal line from $y = -1.25$ to $y = 1.25$ m. In the other case, the reflector was fully illuminated: 281 feed elements were symmetrically disposed along the focal line for the full length of the cylindrical axis from $y = -1.5$ to $y = 1.5$ m.

The results of the computational simulation showed, among other things, that for a given beam scan off the z axis in elevation, the sidelobes are higher in the full-illumination than in the under-illumination case. The results also showed that the sidelobe levels for a given beam scan can be monotonically reduced at far angle from the peak of the beam by suitable choice of n, and the impact of the shaping parameter, n, on the sidelobe levels is more pronounced as the beam is scanned away from the boresight axis of the antenna (see Figure 2).

This work was done by Ziad Hussein and Eastwood Im of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Systems category.*
NPO-20494

Lightweight Reflector Dishes Would Be Made by Spin Casting

These dishes could be mass-produced cheaply.

NASA's Jet Propulsion Laboratory, Pasadena, California

Lightweight reflector dishes for radio antennas would be mass-produced cheaply by spin casting of polymers, according to a proposal. These reflector dishes were conceived for compact stowage followed by deployment and operation aboard spacecraft, but might also be useful on Earth in applications in which there are requirements for extremely light weight and stowability but not for highly precise reflector shape.

The spin-cast reflector dishes would be thin and flexible, and thus foldable for compact stowage. In some applications, it could be desirable to rigidize the dishes after deployment. This could be done, for example, by making dishes of an ultraviolet-curable polymer and exposing them to ultraviolet light (e.g., as part of sunlight) immediately after deployment. Alternatively, dishes could be made of a material with a glass-transition temperature above that of the deployment environment; after deployment, these dishes would be allowed to cool naturally, so that they would be rigidized by the rubber-to-glass transition.

This work was done by Celeste Satter of Caltech and Dan Marker of the Directed Energy Directorate, Air Force Research Laboratory, for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Materials category.* *NPO-20548*

Adaptive Filtering of SAR Interferograms

Improves the performance of subsequent phase-unwrapping.

NASA's Jet Propulsion Laboratory, Pasadena, California

An algorithm for filtering synthetic-aperture-radar (SAR) interferograms has been developed which substantially improves the performance of subsequent phase-unwrapping. It accomplishes this task by filtering the interferogram strongly in areas where the scene contains little detail, and weakly where the scene contains much detail. The filter is adaptive in that the amount of filtering is scene dependent.

The interferogram is divided into many small, overlapping patches. Each patch is Fourier transformed in two dimensions. The magnitude of the resulting spectrum is then raised to a user-selected power. An exponent of 1 yields no filtering at all; 2 produces heavy filtering. The patches are then transformed back and accumulated through a rectangular, pyramidal window, which reduces edge effects. It is helpful to normalize the total power of each patch in order to prevent radar-bright areas from unduly influencing their neighbors.

The filter is effective in removing residues, the bane of phase-unwrapping, where the phase is not changing rapidly. However, where the phase does change rapidly, or is noisy, no filtering is applied. This effect prevents phase-unwrapping from occurring where the data does not warrant it.

This work was done by Charles Werner and Richard Goldstein of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Information Sciences category.*
NPO-20440

Retroreflective Communication Systems

This system provides two-way communication with one transmitter.

Lyndon B. Johnson Space Center, Houston, Texas

A retroreflective communication system (RCS), is a state-of-the-art system that provides (1) two-way optical communication using only one transmitter and (2) multipath communication among remote locations. RCSs were conceived for use in communication among stations on the ground and aboard spacecraft in flight.

In the basic mode of operation of an RCS, a laser beam is transmitted from a first station to a second (remote) station that is equipped with a precise retroreflector and a light modulator. The second station can thus modulate the beam with new information and return the beam to the first station. The second station is characterized as passive in the limited sense that it does not contain a laser or other transmitter. Because of this passivity, the size, weight, and power consumption of the second station can be much less than in other communication systems; these characteristics make the RCS particularly attractive for spacecraft communications.

Other spacecraft communication systems can include repeaters mounted on towers or launched into orbit to extend their ranges and/or to enable transmission over the horizon. A typical repeater in such a system consists of a receiver and a transmitter connected to one or more antennas (in a radio system) or lens subsystems (in an optical system). Complicating matters, orbiting transmitters and receivers are often powered by batteries that must be recharged by solar photovoltaic arrays. For long-range communication, the amount of power that must be provided to a transmitter is several orders of magnitude greater than that needed to operate the associated receiver. Therefore, electrical subsystems must be sized to satisfy the peak power demands of transmitters. When multiple remote sites receive simultaneous communications from a transmitter, its power must be shared among these sites. Not surprisingly the weight, size, and complexity of a power system, a transmitter, and an antenna launched on a satellite significantly affect the cost of launching. Yet another disadvantage of maintaining a transmitter in orbit is that the satellite that carries the transmitter must be repeatedly repositioned for precise pointing of the transmitted beam(s). Because of the large amounts of energy that must be expended to reposition the mass of the communication equipment and the rest of the satellite, the useful orbital life of the satellite is limited by the consumption of fuel.

By reducing the consumption of power in a communication satellite, the design of a low-bandwidth RCS can reduce the use of fuel and thereby increase the useful orbital life of a satellite. The modulator in a passive RCS unit is a liquid-crystal shutter (LCS) that varies the polarization of a beam of light. An LCS, which functions similarly to the liquid-crystal display in a wristwatch, is powered by a photocell that generates power when exposed to light from a transmitting source. An LCS consumes so little power that a button-sized lithium cell could well support continuous operations for several years. Although such practical limits as bandwidth and temperature extremes might alter this, an RCS should be capable of communicating data from the Moon to the Earth by use of a laser transmitter and an optical telescope, expending little more energy at the Moon site than is used to power an LCD wristwatch.

Another strength of the RCS is its ability to dramatically reduce requirements for precise aiming. In an RCS, any number of locations on Earth could simultaneously receive information from a passive unit on the Moon, using a few precise points. A typical envelope for capturing and returning a beam of light by a single retroreflector is a 22°-half-angle cone about the main optical axis of the retroreflector. One can group together multiple retroreflectors aimed at different angles to increase the effective capture-and-return envelope. The pointing requirements for communication at extreme distances are dictated only by the capture-and-return envelope. Because the divergence angle of a beam returned by a typical precise retroreflector is ≤1 arc second, a significant fraction of incident light is returned to its source.

An RCS could be used, for example, to communicate information from an active unit on Earth to a similar unit on the Moon, where such information would be stored and reflected back to a second active unit on Earth. In fact, retroreflectors left on the Moon during lunar landings in the 1970s have already been tracked from Earth with laser apparatuses similar to those of RCSs. RCS remote units could also reflect information from microrover landers to parent spacecraft orbiting a planet.

For spacecraft communications, the RCS concept offers the potential for major improvement over systems now in use. Reduced weight and size, the possibility of minimizing transmitting antennas and pointing requirements, and a passive design (consumption of little electrical power and generation of negligible heat) place the RCS concept ahead of its competitors. These characteristics could be exploited to reduce the fuel-to-weight ratios of support spacecraft, thereby promoting deeper penetration of outer space for exploration. Though utility is largely limited to outer-space applications like those described above, RCSs might be useful in some terrestrial applications because the RCS concept offers a unique combination of passiveness of a remote station, a secure link, and very low power or self-powered operation of the remote station; no other communication system offers this combination of features.

This work was done by Leo G. Monford, Jr., of **Johnson Space Center.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Systems category. MSC-22781*

SiC-Based Black-Body Absorbers for Submillimeter Wavelengths

These absorbers can be fabricated at relatively low cost.

NASA's Jet Propulsion Laboratory, Pasadena, California

Open-cell silicon carbide foam coated with a ferrite-filled absorbing resin has been found to be useful for black-body absorbers at millimeter and submillimeter wavelengths. The panels can be used as calibration targets for radiometers that operate at these wavelengths.

Heretofore, black-body calibration targets have been made from lightweight carbon-coated polyurethane foams or from heavy ferrite materials with machined or molded, finely pointed, periodic surface features (e.g., arrays of cones or pyramids) (see Figure 1). These black-body loads have either excessive weight, deteriorate (crumble) over time in vacuum, or have poor thermal conductivity.

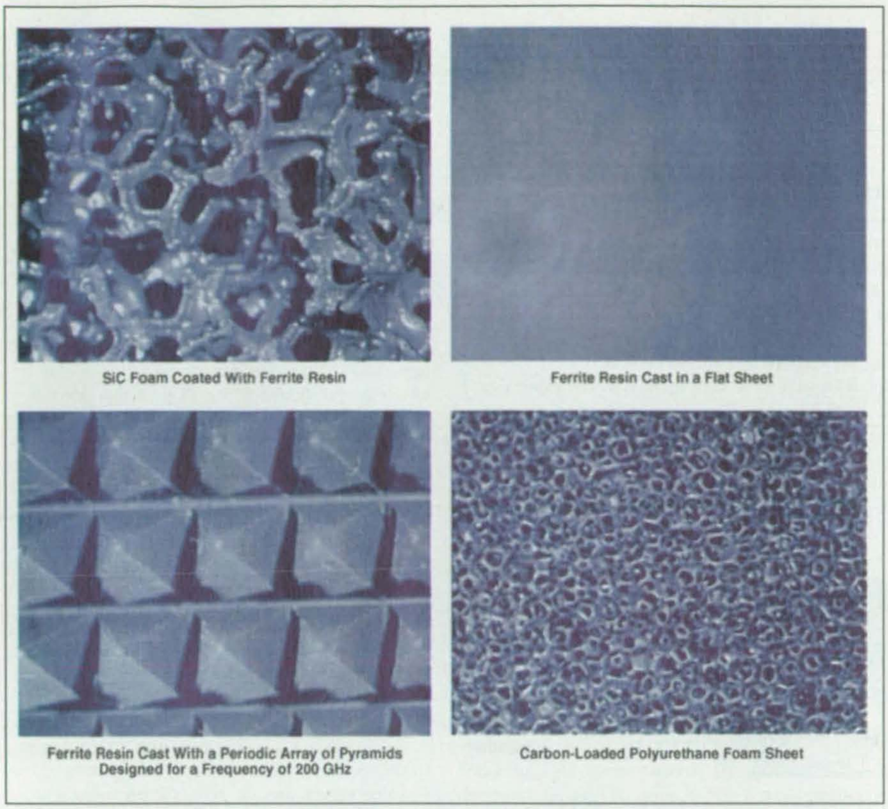


Figure 1. A **Panel of SiC Foam Coated With Ferrite Resin** is shown at the same magnification with three panels of older competing designs. Tests at frequencies from about 120 to 640 GHz showed that the SiC-foam/ferrite-resin panel performed comparably to the panel with the array of pyramids, which cost much more.

The new loads are SiC-based, can be fabricated easily, are lighter in weight than solid ferrite absorbers, do not outgas excessively, and exhibit sufficient thermal conductivity for the intended purposes. Moreover, the silicon carbide base material withstands high operating temperatures.

The absorber works by effecting random scattering and surface impedance matching with absorption of power to produce a low return loss to incident radiation over a broad range of wavelengths. The open-cell foam structure is responsible for the scattering and impedance-matching properties. The ferrite coating increases the absorption coefficient without significantly changing the scattering and impedance-matching properties.

The combination of roughness needed for random scattering and the impedance match to the radio-frequency field is optimized by choice of the foam cell size, which should be of the order of half the wavelength at the frequency of interest. SiC foam can be fabricated with foam cell sizes ranging from a few millimeters down to less than a tenth of a millimeter, corresponding to a frequency range from below 100 GHz to 1 THz or more.

The absorber is fabricated by pouring the castable ferrite resin over the open-cell SiC foam sheet and baking the sheet to cure the epoxy resin. Slabs can then be assembled in wedge or pyramidal geometries to enhance absorption (see Figure 2).

This work was done by Peter Siegel of Caltech and Robert Tuffias of Ultranet Corp. for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category. NPO-20401*

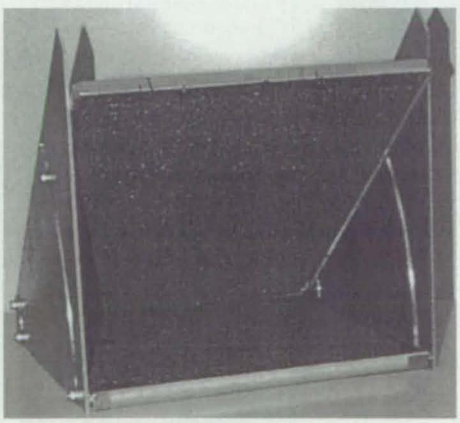
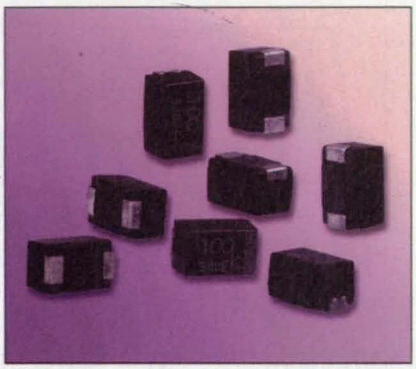


Figure 2. **Two Coated SiC Panels** are mounted in a wedge configuration to make incident radio-frequency energy undergo multiple reflections to enhance absorption. The panels measure 9 x 9 and 9 x 12 in. (229 x 229 and 229 x 305 mm), respectively. The wedge can accommodate a fairly wide beam but the thickness of the panels [0.5 in. (13 mm)] places the lower limit of operating frequency at about 100 GHz. The slots on the sides enable the adjustment of the dihedral angle between about 20° and 45° to obtain the best performance for a given beam diameter.

NEW PRODUCTS

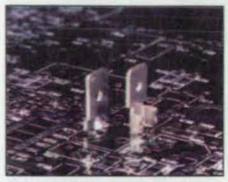
PRODUCT OF THE MONTH



Surface-Mount Capacitor

Cornell Dubilier, New Bedford, MA, introduces the Type ESRE polymerized aluminum electrolytic capacitor, one of which can replace three or more tantalum or electrolytic capacitors, the company says. Rated at 100 µF to 270 µF (2 V DC to 8 V DC), the ESRE has extremely low equivalent series resistance, typically 10 milliohms or less at 100 kHz, yielding low impedance at high frequency. The capacitors are also ignition-free. The company says that this, coupled with the higher 3.0-A ripple current rating, makes the ESRE suitable for applications requiring higher capacitance values at DC-DC power converter outputs and power decoupling around microprocessors.

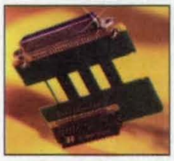
For More Information Circle No. 750



"Quick-Fit" Male Terminals

Keystone Electronics Corp., Astoria, Queens, NY, says its anti-rock Sturdi-Mount male terminals are designed to increase the force necessary to deflect them, which prevents mounting leg breakage that can cause PCB connection failure. The design also serves to keep terminals perpendicular to the PCB so that position is maintained during and permanently after wave soldering. The mounts are available in 0.187-in. (4.75-mm), 0.205-in. (5.2-mm), and 0.250-in. (6.4-mm) tab sizes; the first two are available in 0.020-in. (0.51-mm) or 0.032-in. (0.8-mm) tin-plated brass, whereas the last is made in 0.032-in. tin-plated brass only.

For More Information Circle No. 751



Telecommunications Systems Connectors

The new Model BCS tele-communications systems connector from Ranoda Electronics Inc., Broomfield, CO, is designed to withstand a minimum of 1600 V RMS (2260 V DC or peak) before corona discharge arc-over occurs between any two pins. With a contact pitch of 2.160 mm, the BCS connector maintains the standard board-edge Centronic connector form and dimensions, but increases arc-over protection with a proprietary blue insulating material. Contact resistance is specified at 15 milliohms typical; maximum operating current per contact is 2 A. Minimum operating lifetime is specified at 200 mate/demate cycles.

For More Information Circle No. 752

Voltage Controlled Crystal Oscillator

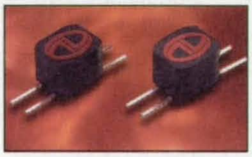
Raltron Electronics Corp., Miami, FL, announces the Model VS-9000 voltage-controlled crystal oscillator (VCXO) in a miniature ceramic-metal SMT package measuring just 5-×-7-×-2 mm. It has an optional enable/disable pin that can be used to tri-state the VCXO's output, saving CMOS switching power when the host product is in a quiescent mode. Pulling range of ±100 ppm over the full voltage control range from 0 to VCC and 5-V supply is available. VS-9000s are available from 1-70 MHz, with 77.76 MHz under development. Jitter is less than 50 ps p-p (5 ps RMS).

For More Information Circle No. 753

Power Meter for Digital Mobile Radio

Anritsu Co., Morgan Hill, CA, offers the single-channel ML2407A and the dual-channel ML2408A RF power meters, specifically designed to measure signals used in both CDMA radio systems and by pulsed RF carriers. Anritsu suggests use of the meters with the MA2469A dual-diode sensor, which has 1.25-MHz video bandwidth, and delivers more than 80 dB of dynamic range. The company says that so used the power meters can perform highly accurate measurements on peak and average power, as well as crest-factor measurements. The meters can conduct 600 readings per second.

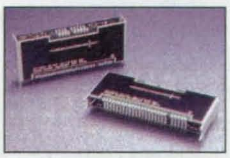
For More Information Circle No. 756



Flat-Top Surface-Mount Inductor

Datatronics, Romoland, CA, recommends its Model DR332 Data-line™ series inductors for balanced data transmission systems and interfaces such as RS-422, RS-423, or RS-485, as well as telecommunications interfaces (ISDN) and automotive databus systems (CANbus). The data-line chokes filter common-mode interference induced on transmission lines at frequencies of 10 kHz and higher while allowing data signals up to about 100 kHz to pass unaffected. Measuring just 0.276 × 0.232 in., the Model DR332 is available in seven different standard inductance ranges from 5-4700 µH ±25 percent at 100 kHz.

For More Information Circle No. 757



Surface-Mount DC/DC Converter

Power Trends Inc., Warrenville, IL, introduces additions to its Excalibur™ series, its new line of 5-W to 100-W isolated and nonisolated DC/DC converters. Among them is the PT4480 that the company calls the industry's first 100-W DC/DC converter available in a surface mount package. It has a full telecom input voltage range of 36-75 V and an ambient operating temperature range of -40 to +85 °C. Other features include digital 5-bit programmable output voltages from 1.3-3.5 V, remote on/ off, differential remote sense, and over-current, over-temperature, and over-voltage protection.

For More Information Circle No. 760

AlGaInP Light-Emitting Diode

Stanley Electric, Irvine, CA, says that its through-hole AlGaInP light-emitting diode (LED) delivers lighting levels that are 10 to 15 times brighter than conventional LEDS, reducing the component count necessary to achieve equivalent levels and thus reducing the total cost of lighting. Luminous intensity is up to 5000 mcd depending on color. Operating temperature range is -40 to +85 °C. The series comes in three colors–red-orange (635 nm), orange-red (609 nm), and amber (592 nm)–with a 10-degree viewing angle. Various package designs, including a 3-mm size, are available.

For More Information Circle No. 754

Vol. 24, No. 2 February 2000 This form expires: July 31, 2000

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Fax this form for quickest processing of your inquiry, or use the on-line LeadNet Service at www.nasatech.com.

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Circle the numbers below to receive more information about products and services featured in this issue.

401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	418	419	420
421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439	440
441	442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457	458	459	460
461	462	463	464	465	466	467	468	469	470	471	472	473	474	475	476	477	478	479	480
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1a. Are you involved in advising, recommending, specifying, or approving the purchase of computer-aided design (CAD) software for your company? ☐ Yes ☐ No

1b. If yes, do you plan to increase your purchase of CAD software in the next 12 months? ☐ Yes ☐ No

2. Which of the following types of CAD software do you now use? (check one) ☐ 2D ☐ 3D ☐ Both

3. Please list the names of CAD packages you (or your department) currently use.

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4. Please list any additional CAD packages you are considering purchasing in the next 12 months.

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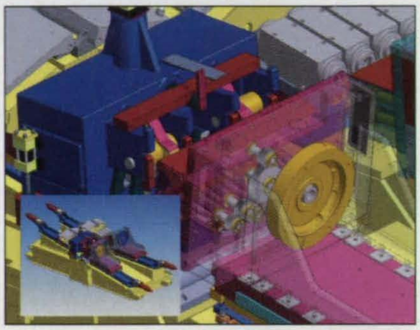
UpFront

PRODUCT OF THE MONTH



Autodesk, San Rafael, CA, has introduced Autodesk Inventor™ Release 2 3D solid modeling and drawing software. It is based on Adaptive Design, a new process that allows users to design the way they think and collaborate with teams, supporting concurrent engineering and the re-use of design and manufacturing knowledge. The software also allows intelligent 2D layouts to become the foundation for 3D assemblies, and enables designers to relate parts and assemblies by specifying shape and position instead of parameters and equations. The new release features improved performance when editing models, and in activities such as pan, zoom, rotate, and highlighting for large assemblies. Other enhancements include greater assembly design capabilities, the ability to capture deeper intent, increased ease of use, an improved Drawing Manager, more detailing functions, added functionality for sheet-metal design, and integrated Net Meeting that allows users to create meetings from within Inventor and host collaborative sessions.

For More Information Circle No. 745

Technology of the Century

We recently asked you to vote for the most important technological development of the 20th century. We wanted to know what innovation you thought had the greatest impact on our society and economy in the past 100 years. Here are the results:

#1: The transistor
#2: The automobile
#3: The integrated circuit
#4: The computer
#5: Television

You also cast votes for the microprocessor, satellites, plastics, nuclear power, and the Internet, but the transistor was a clear winner. Thanks to all of our readers who voted.

FutureFlight Begins

In the July 1999 UpFront, we told you about NASA's full-scale virtual airport-control tower taking shape at NASA's Ames Research Center in California. The $10-million, two-story FutureFlight Central facility opened on December 13. Jointly funded by NASA and the Federal Aviation Administration (FAA), the facility is designed to test — under realistic airport conditions and configurations — ways to solve potential air and ground traffic problems at commercial airports.

FutureFlight Central will allow integration of tomorrow's technologies in a risk-free simulation of any airport, airfield, and tower-cab environment. The facility provides an opportunity for airlines and airports to mitigate passenger delays by fine-tuning airport operations, gate management, ramp-movement procedures, and other airport improvements. It also enables air traffic controllers to provide input and become familiar with new airport operations and technologies before they are constructed.

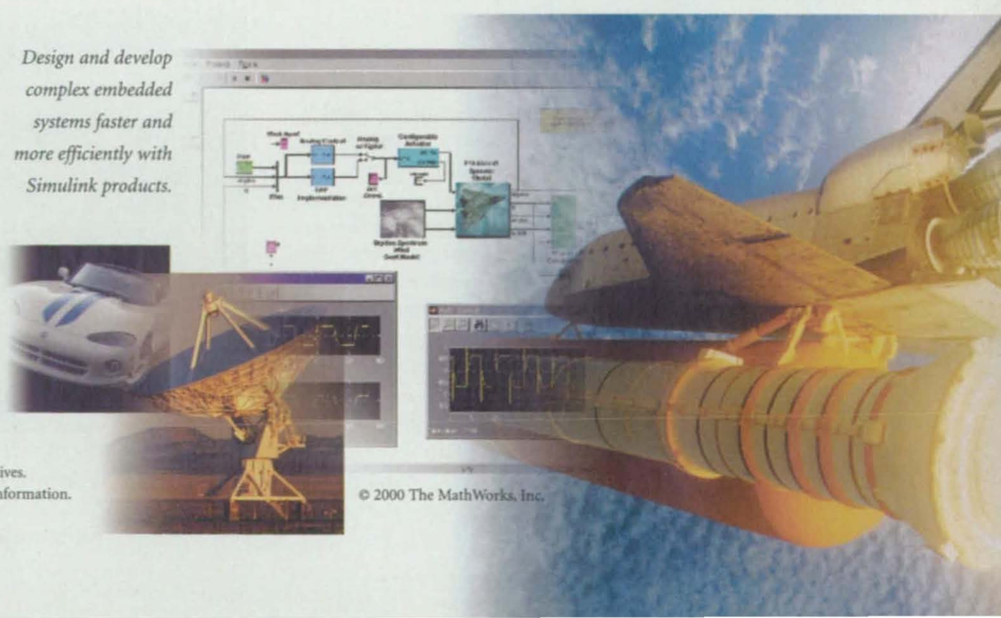
Up to 12 air traffic controllers in the tower cab are in direct communication through a simulated radio and phone system with pilots and ramp controllers at stations on the first floor. "We can simulate any airport in the world," according to Nancy Dorighi, NASA FutureFlight Central facility manager. "The three-dimensional visual model of an airport is viewed out the 360-degree windows in the tower cab. The visual scene, along with specific airport traffic patterns, fleet mix, and procedures makes this a very credible operational test-bed."

The FutureFlight Central cab is capable of replicating the user interface and functionality of existing and emerging air traffic control technologies. Here, the out-the-window field-of-view displays computer-generated images of San Francisco International Airport. (Photo courtesy of NASA Ames Research Center)

Twelve rear-projection video screens provide a seamless, 360-degree, high-resolution view of the airport or other scenes being depicted. The imaging system, powered by high-performance workstations from SGI of Mountain View, CA, provides a realistic view of weather conditions, environmental and seasonal effects, and the movement of up to 200 active aircraft and ground vehicles.

For more information, visit the web site at http://ffc.arc.nasa.gov.

New PC-in-the-Loop products enable real-time rapid prototyping of embedded designs on standard x86 PC hardware in any form factor.



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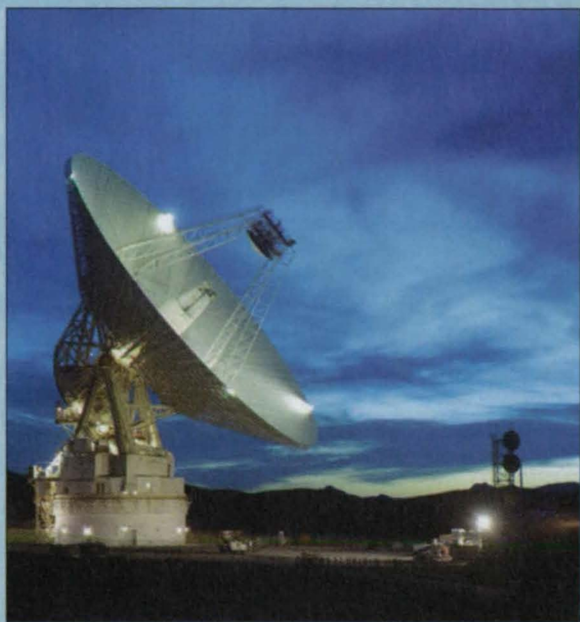
NASA's Jet Propulsion Laboratory (JPL) in Pasadena, CA, has replaced a full rack of tracking and ranging equipment to simplify NASA's Deep Space Network (DSN) operations, which are managed by JPL. DSN is an international network of antennas that supports interplanetary spacecraft missions, and radio and radar astronomy observations for the exploration of the universe. The DSN currently consists of three deep-space communications facilities placed approximately 120 degrees apart around the world. The strategic placement of the steerable, high-gain, parabolic reflector antennas allows constant observation of spacecraft as the Earth rotates.

The existing DSN spacecraft ranging system has been updated using a smaller hardware design. The previous equipment has been replaced by three VME boards, including Pentek's 4290 Quad 'C6x DSP board to handle the main processing, and the 6227 Velocity Interface Mezzanine (VIM) board.



"The old DSN ranging design used custom-made boards to correlate the received ranging signal against the expected patterns and accumulate the correlation result in hardware," according to Scott Bryant, telecommunications engineer at JPL. "This new design reduces the ranging hardware count by eliminating custom correlator VME boards. Usage of COTS (commercial off-the-shelf) DSPs reduces the cost and development time of the spacecraft ranging effort," he said.

The 4290 board provides the processor and FIFO input/output speed required for the new DSN spacecraft ranging system. The mezzanine provides a simple input/output and control connection to the DSN receiver hardware.

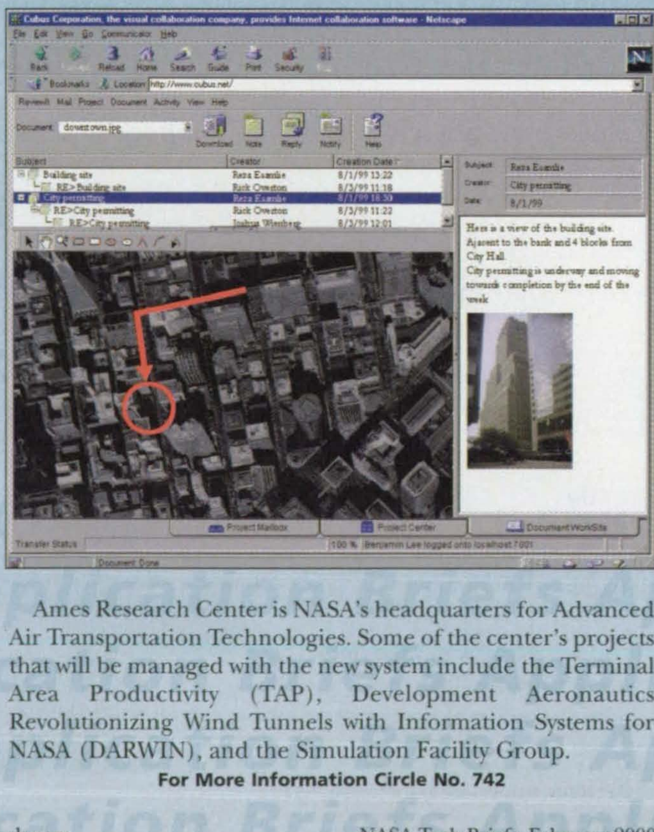
For More Information Circle No. 743

NASA Implements Web-Based Solution to Manage Facilities

ReviewIt™ web-based collaboration technology
Cubus Corporation
San Francisco, CA
877-44-CUBUS
www.cubus.net

NASA has implemented ReviewIt, a web-based collaboration technology, in a series of projects at Ames Research Center in Moffett Field, CA. The technology will be used to share critical facilities information between internal and external teams, and to manage ongoing maintenance and repair projects at Ames.

The technology creates a secure, virtual work environment for teams to share, communicate, and manage projects via the Internet. NASA's facilities teams will use the technology to work in a secure environment on the web, where it is just as easy to collaborate with someone halfway across the world as it is to collaborate with someone in the next office. This technology will enable NASA engineers to interact with complex graphics and data sets, such as plans, blueprints, photographs, and renderings. The system also tracks project activity and communications, creating an electronic audit trail to help teams manage a growing amount of project data.



Ames Research Center is NASA's headquarters for Advanced Air Transportation Technologies. Some of the center's projects that will be managed with the new system include the Terminal Area Productivity (TAP), Development Aeronautics Revolutionizing Wind Tunnels with Information Systems for NASA (DARWIN), and the Simulation Facility Group.

For More Information Circle No. 742

National Manufacturing Week

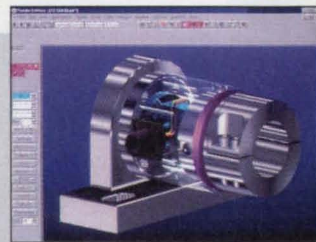
America's #1 Industrial Marketplace™

National Manufacturing Week 2000 — March 13-16 at McCormick Place in Chicago — will feature more than 600,000 square feet of displays from more than 2,000 exhibitors, and will encompass four major shows: National Industrial Automation, National Industrial Enterprise IT, National Plant Engineering MRO & Management, and National Design Engineering Show (NDES). More than 52,000 people attended National Manufacturing Week last year, including professionals from the automotive, software, consumer goods, electronics, materials, and process industries. This year's 10th annual event will include an expanded Motion Hall, as well as pavilions highlighting Rapid Prototyping, CAD, and Medical Design Engineering. Following are some of the products that will be on display by NDES exhibitors. (For more information on the event, visit the web site at www.manufacturingweek.com)

Booth 6755

Newport Electronics, Santa Ana, CA, will display the i™ series of temperature/process meters and controllers. The meters feature 21-mm displays that can be programmed to change color from green, to amber, to red for any set points, range, or alarm points. A standard universal input allows menu selection of thermocouples, RTDs, and ranges of process voltage and current. Other features include 10 and 24 Vdc transmitter excitation CE compliance, NEMA 4/IP65 front bezel, universal power supply, and plug connectors. The instruments feature a single serial communications option selectable for either RS-232 or 485. Control output options include SPDT relays, solid-state relays, DC pulse, and programmable analog voltage and current for control or retransmission of the process value.

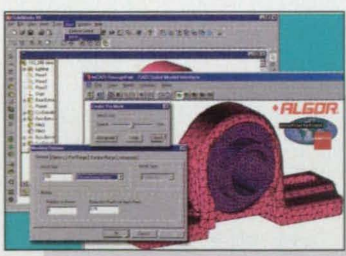
Circle No. 778



Booth 1614

Parametrics for CADKEY 99 and CADKEY Design Suite will be displayed by CADKEY Corp., Marlborough, MA. A new addition to the CADKEY 99 mechanical CAD software, the Parametrics program integrates parametric definition and editing of dimension-driven solid models into CADKEY 99. The Design Suite, available for Windows 95/98/NT 4, incorporates hybrid modeling capability, data translation, and an extensive set of design, edit, and validation tools. Hands-on training for CADKEY users also will be available at the booth. Training sessions will cover parametrics, power design, and productivity tips.

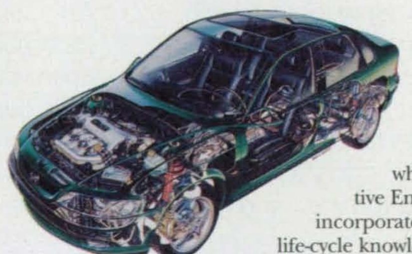
Circle No. 763



Booth 101

InCAD DesignPak is a new addition to the InCAD family of products from ALGOR, Inc., Pittsburgh, PA. DesignPak works from within CAD, providing access to finite element analysis (FEA) tools. It also features a solid tetrahedral mesh engine for faster solid FEA meshes, enhanced plate/shell modeling static stress analysis, and an HTML Report Wizard. Engineers can use the same user interface and operations, regardless of the CAD system used or analysis types needed. DesignPak users can perform linear static stress analyses while working within CAD programs such as Pro/ENGINEER, Mechanical Desktop, Solid Edge, or SolidWorks. Exact images of the CAD geometry can be captured without translation, even when Algor and the CAD solid modeler reside on separate computers.

Circle No. 766



Booth 1225

Unigraphics Solutions, Maryland Heights, MO, offers Unigraphics (UG) Version 16 CAD/CAM/CAE software, which marks the introduction of Predictive Engineering, a set of technologies that incorporates engineering practices and product life-cycle knowledge into the product development environment. UG V16 includes a streamlined user interface, including controls for assemblies, features, and manufacturing operations. It also features integration of Microsoft Excel spreadsheets for controlling and optimizing parametric data and interacting with mechanisms. The software allows CAM users to define and plan the manufacturing sequence up front and store the information for subsequent access and re-use. UG/Scenario for Motion+ is a CAE solution for virtual prototyping of dynamic mechanical systems.

Circle No. 764

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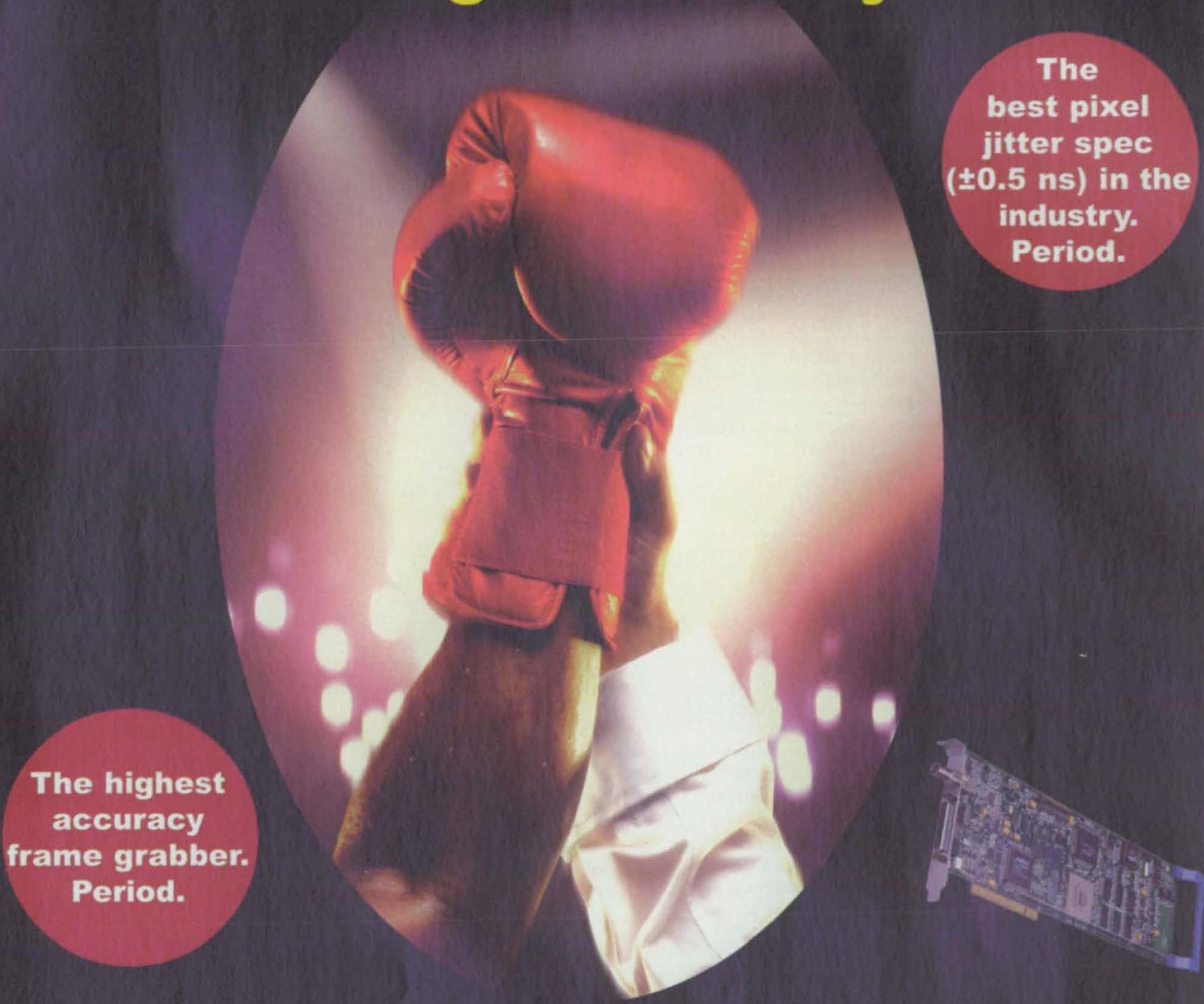

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I-50™	±1.0 ns	up to 50 MHz	10 bits
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IMASCAN™	±2.5 ns	up to 20 MHz	8 bits mono 24 bits color

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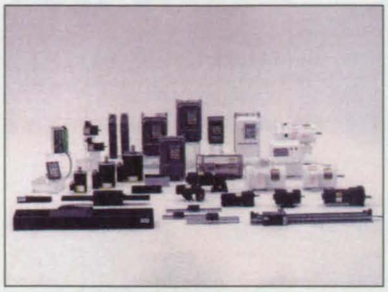
Booth 8930

UE Systems, Elmsford, NY, will exhibit the Ultraprobe 9000 digital ultrasonic inspection system that offers airborne/structure borne ultrasound inspection and data logging. Users can locate a desired inspection frequency, adjust headphone volume, store or download data, locate recorded data, and enter notes with just two controls. A 16-segment bar graph provides a visual representation of intensity swings, and a back-lit panel displays numeric values of frequency and decibel. On-board memory allows users to log in frequency and decibel readings, as well as specialized notations in any of 400 memory locations. The system features the Ultratrend™ filtration system that provides signal processing and sound recognition. Supporting software is on an open platform and may be connected to most vibration analyzers.

Circle No. 770

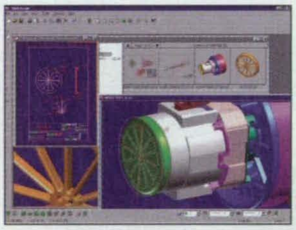
Booth 1219



Baldor Electric, Fort Smith, AR, will exhibit AC induction linear motors and DC brush and brushless linear motors. Also on display will be the LinDrive, Lin+Drive, and MintDrive linear motor controls. Mini and micro inverter products will be featured, along with single- and multi-axis servo and vector drives using a common keypad language. The MINT™ motion control programming language and products, offering positioning capabilities up to 48 axes of coordinated motion, also will be displayed.

Circle No. 768

Booth 1618



think3, Santa Clara, CA, will exhibit thinkdesign™ 4.0 mechanical CAD software that provides a bridge between 2D and 3D design, enabling users to leverage the 2D design process and legacy data while tapping into the flexibility of 3D design. The program features a set of 2D drafting and layout tools that turn 3D designs into 2D drawings. A standard part library management system called thinkparts™ consists of more than 1,000 commonly used parts in both 2D and 3D. Designers can share, create, manage, and re-use components from a central catalog. A capture and playback feature allows users to record, play, and communicate about specific design sessions over the web. thinkdesign is available for Windows 95/98/NT, and comes with 3D game-based learning software.

Circle No. 767

Booth 1225

Solid Edge Version 8 3D solid modeling software from Unigraphics Solutions, Huntsville, AL, provides new tools for machine design and modeling large assemblies. It also includes enhancements to help 2D designers migrate to 3D solid modeling. It provides 3D part modeling, large assembly design, drafting, and process-specific features for sheet metal, plastics, and tubing design. Solid Edge is available for Windows 95/98/NT. The Solid Edge Voyager Program includes more than 130 downstream engineering software applications in disciplines such as finite element analysis, manufacturing, kinematics and dynamics, electromechanical, rapid prototyping, product data management, and hardware solutions.

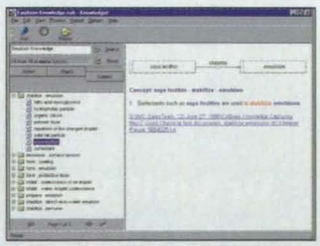
Circle No. 765

Booth 5006

The W.1000 Series 3 x 4 mm chip sensor from SICK, Bloomington, MN, features more than two million gates on one chip. The OES II ASIC silicon is bonded directly to the circuit board to include the light receiver. Users press a Teach-in button and the sensor automatically sets itself up for the application. The Teach-in ability is built into the ASIC, making the feature standard on the energetic proximity and fiber-optic sensing modes. The device features a molded lens used on a photoelectric sensor, IP 67 and NEMA 6 enclosure ratings, and the ability to make adjustments via wire or with a sealed pushbutton.

Circle No. 769

Booth 2202



Knowledgist™ 1.5 technical knowledge analysis software from Invention Machine Corp., Boston, MA, enables engineers to extract relevant technical knowledge out of documents from internal and external sources. The program uses semantic technology to read and analyze documents, extracting the technical knowledge and delivering it automatically in a problem-solution index. It reads the collection of documents, extracts the technical concepts, and automatically generates a semantic index of the whole collection. Users can select the pertinent information from the index, and read only those documents most relevant to their problem. Unlike keyword searches, which return large lists of documents, Knowledgist analyzes and indexes the concepts contained within the documents.

Circle No. 779

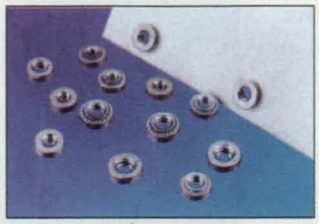
Booth 1019

Spatial, Boulder, CO, will exhibit the third release of 3Dmodelserver.com, a web-based CAD model healing and translation service, which now includes a full translation for CATIA and STEP files, in addition to healing and translating SAT and IGES files. Also on display will be 3Dmodelserver Enterprise, a service for corporate intranets that allows users to keep data totally in-house. ACIS® 6.0, the latest version of the 3D modeling kernel for developing CAD/CAM/CAE applications, features enhancements to tolerant modeling, skinning and lofting, sweeping with topology change, and C2 continuous multi-surface deformations.

Circle No. 762

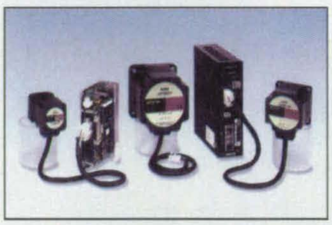
Booth 1434

PEM® Type SMPS™ stainless steel self-clinching nuts will be featured by Penn Engineering & Manufacturing Corp., Danboro, PA. The fasteners are designed for applications where there is minimal space for hardware to attach extremely thin steel sheets. The fasteners can be mounted close to the edge of a sheet, and can be installed in sheets as thin as 0.025". They become a permanent part of an assembly, and are made of 300 Series stainless steel. The nuts are available in unified and metric thread sizes ranging from #2-56 through #6-32, and M2.5 through M3.5.



Circle No. 771

Booth 1454



Oriental Motor USA Corp., Torrance, CA, will display Alpha Step, a two-phase, hybrid, geared step motor and driver package that features a built-in feedback device that constantly monitors the motor shaft to detect and correct for loss of synchronism. The motor runs open loop under normal conditions and runs in closed loop when a position deviation of 1.8 degrees or more is sensed. The motors are available with tapered, planetary, and harmonic gear heads.

Circle No. 773

Booth 5728

The PIPANEL WS 15 compact workstation from Pilz Industrial Electronics, Farmington Hills, MI, is equipped with a slot CPU based on Pentium technology, and is suitable for installation in a cabinet or panel. The front panel provides shielding against water and dust, and features a 15" TFT display with a resolution of 1024 x 768 pixels. Other features include 24 special keys and 12 function keys, a sensor mouse or touchscreen, and an integral Ethernet interface that allows the unit to be integrated into an existing network. A bi-directional parallel and two serial RS-232 interfaces provide the link to other systems. It includes three slots each for ISA and PCI boards. Memory can be expanded to 256 RAM.

Circle No. 774

Booth 1118

Structural Research & Analysis Corp., Los Angeles, CA, will release an integrated version of COSMOS/DesignSTAR for Autodesk Inventor™ software, providing designers with detailed model analysis during the design process. Users can verify Inventor models and perform multiple "what if" scenarios. Other capabilities include basic and advanced analysis bundles that feature stress, displacement, frequency, buckling, dynamic response, and optional assembly analysis; results visualization with OpenGL graphics; automatically prepared Web-enabled design reports in HTML; and loads and boundary conditions applied to the geometry — not to nodes or elements — allowing automatic bi-directional CAD model updates.

Circle No. 775

Booth 2034

E-A-R Specialty Composites, Indianapolis, IN, will exhibit VersaDamp 2000 vibration- and shock-isolation thermoplastic elastomer materials with formulations that can be adjusted to optimize damping performance, durometer, or both. They feature durometers ranging from 40 Shore A to 75 Shore A, and have a variety of energy control capabilities. The materials are injection-molded into isolators and other equipment components. They can be used as anti-shock and anti-vibration mounts for compact devices. The materials contain no free sulfur, carbon, or plasticizer.

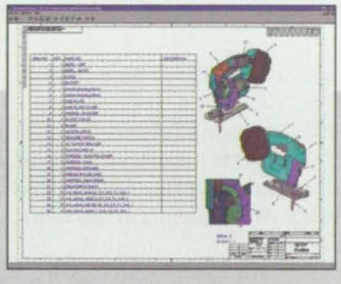
Circle No. 793

Booth 3235

Maxon Precision Motors, Burlingame, CA, offers the RE series of motors that uses rare earth magnets and graphite brushes to maximize the torque available in the 1.57" diameter package. The patented rhombic moving coil design provides low electrical noise, and an ironless rotor allows for zero cogging. The motors weigh 17 ounces, are 2.8" long, and are rated at 150 watts. The motor has three different windings available to match desired speed with available voltage. Maximum speed is 8,200 RPM, and maximum efficiency is 91%. Ambient temperature range is -20 to +100°C. Matching gearheads and encoders are available.

Circle No. 777

Booth 201



eDrawings compressed electronic drawing file from SolidWorks, Concord, MA, enables users to create, view, send, and receive mechanical design drawings via e-mail. Each file includes a self-contained viewer that allows recipients to start using the drawing information immediately. The eDrawings Publisher is available for existing users of SolidWorks, AutoCAD, and any CAD system outputting a DXF or DWG file. An eDrawing file contains Virtual Folding, which allows users to look at several drawing views at one time, regardless of how they were arranged in the original drawing. It also recognizes how drawing views relate to one another, and allows the user to point to a location in all drawing views simultaneously using the 3D Pointer feature.

Circle No. 776

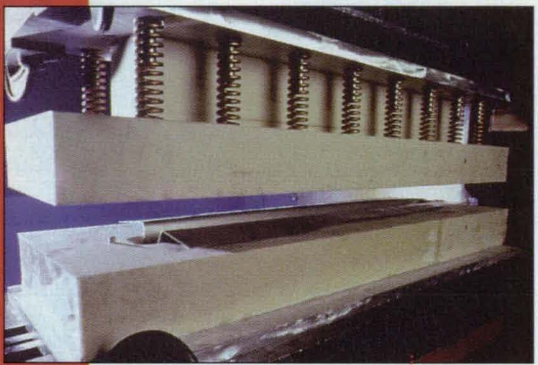
Booth 2190

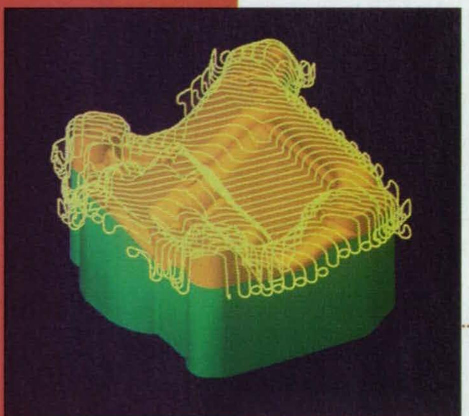
Roper Scientific MASD, San Diego, CA, will exhibit the Model 2000 digital imager that provides a means of recording high-speed images for video playback at variable speeds, and as a data source for computerized motion analysis. The imager enables users to record 24-bit color or eight-bit monochrome images at frame rates up to 2,000 frames per second. A 512 x 384 sensor captures high-resolution images. The imager can be operated with an attached handheld keypad, or remotely from a PC via 100-BaseT Ethernet connection. Images can be downloaded in either compact or TIFF format onto a PCMCIA hard drive or solid-state memory card. Electronic shuttering eliminates motion blur, and an anti-blooming feature prevents image degradation under intense lighting conditions.

Circle No. 780

This Month in
Rapid Product Development Online

A new web publication for *NASA Tech Briefs* readers.





NASA Tech Briefs' new, totally digital publication, Rapid Product Development Online (**www.rapidproducts.net**), helps engineers develop better products faster by giving them immediate, 24-hour access to the latest information on CAD, FEA, modeling, reverse engineering, and rapid prototyping tools and techniques.

RPD Online includes feature stories, industry and product news, product reviews, show coverage, demos, links, and a keyword-searchable supplier guide.

This month's RPD Online includes:

- **Disk Drive Manufacturer Improves Productivity with Integrated Software —** Quantum Corporation, a leading manufacturer of hard disk and tape drives, used software from The MathWorks to replace their traditional process with one that integrates algorithm development with system simulation and verification.

- **Composite Dies Support Fast Drawing of Titanium Aircraft Parts —** To quickly and economically produce high-quality titanium aircraft parts for a major airline, a plastics company machined metalforming dies from an advanced composite tooling board.

- **Show Coverage —** See the latest news on the National Design Engineering Show, which will feature a must-see Rapid Prototyping Pavilion; and the Society of Manufacturing Engineers' (SME) Rapid Prototyping & Manufacturing 2000 conference and exposition.

- **New Products —** Machining software, molding services, and digital development software are among this month's featured new products.

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Commercialization Opportunities

Integrated Optical Voltage-Measuring Apparatus

This apparatus could be highly suitable for automatic control of space-based or aeronautical power management and power-distribution systems. Potential terrestrial applications include measuring voltages and electric fields in power systems, physiological monitoring, measuring pulsed power, and testing for electromagnetic compatibility.
(See page 36.)

Two Approaches to Improvement of InGaAs/InAlAs/InP HEMTs

One approach involves increasing the indium content of $In_xGa_{1-x}As$ channel layer. The second approach involves reduction of the gate length. Both approaches have provided insight on how to build the ultimate cryogenic millimeter-wave solid amplifier.
(See page 42.)

Electronic Modules With a 3-D Interconnection Scheme

This scheme for modular packaging and interconnection of electronic circuits offers electrical, thermal, and mechanical advantages over an older three-dimensional scheme.
(See page 44.)

Protective Shells for Composite Overwrapped Pressure Vessels

An energy-absorbing laminated shell was developed that serves as a lightweight, inexpensive, removable cover that protects composite overwrapped pressure vessels from impacts.
(See page 49.)

Spherical-Coordinates Encoder Module

This is a relatively simple and inexpensive electromechanical apparatus for quickly and easily measuring three-dimensional offsets between objects at distances of the order of a few feet.
(See page 52.)

AlGaN Photodiodes Respond to Ultraviolet C

These are solar-blind photodiodes, for which there are numerous potential applications. Some of these include detection of forest fires, artillery fire, and missile launches.
(See page 58.)

Low-Power, Fast Machine Vision System on a Single IC Chip

The conceptual design of the system takes advantage of recent advances in the design of integrated image-sensor/processor circuits, electronic neural networks, microprocessors, submicron VLSI circuits, and massively parallel computation.
(See page 62.)

Special-Purpose Interface for Fast Writing on a Hard Disk

This interface circuit enables rapid writing of source data on sequential sectors on a hard disk. The circuit can be readily connected to a variety of commercially available hard-disk drives.
(See page 63.)

Chief Technologist Samuel L. Venneri

Each month in this new column, we'll talk with a key NASA official, discussing their responsibilities within the agency, critical issues affecting NASA, and their impact on the engineering community.

Samuel L. Venneri was appointed Chief Technologist at NASA Headquarters, Washington, DC, in November 1996. He reports directly to the NASA Administrator, serving as the principal advisor and advocate on matters concerning Agency-wide technology policy and programs.

***NASA Tech Briefs:* How does the Office of the Chief Technologist (OCT) fit into the overall structure of NASA?**

Chief Technologist Venneri: The Office of the Chief Technologist was created [in 1996] when we were looking at an organizational change at NASA that put technology responsibility within each of our functional enterprises [Space Science, Earth Science, Human Exploration and Development of Space, and Aero-Space Technology]. What we were concerned about was an overarching view of technology in the Agency: Were we looking at the strategy in terms of policy and program investments across the total Agency — not as individual enterprises?

NTB: What do you see as the most critical technologies for the next decade?

Venneri: What we're looking for is revolutionary technologies — how to revolutionize our architectural mission construct. We've looked at a couple of critical areas. One is advanced miniaturization. We're looking at how to functionally package size, volume, and capability at an increasingly smaller feature-size scale that functionally does more than what we were able to do with a size larger.

Where we are today in our miniaturization work is in what is called MEMS technology — microelectromechanical systems. The feature size of MEMS technology is a tenth of a micron. That represents where the electronics industry is today in terms of chip making, and it represents what we can do in terms of using techniques to make mechanical systems at that feature size. That would be using advanced lithography methods, electron-beam forming where you use an electron beam to cut and etch material away. We're working to develop products such as a Mars weather station that you could hold in the palm of your hand. Devices that could be the size of your fingernail would represent the functional state of an advanced navigation system that used to be implemented in terms of black boxes or cards. So we're looking at how you put a spacecraft on a chip.

NTB: What do you see as NASA's greatest technological challenge?

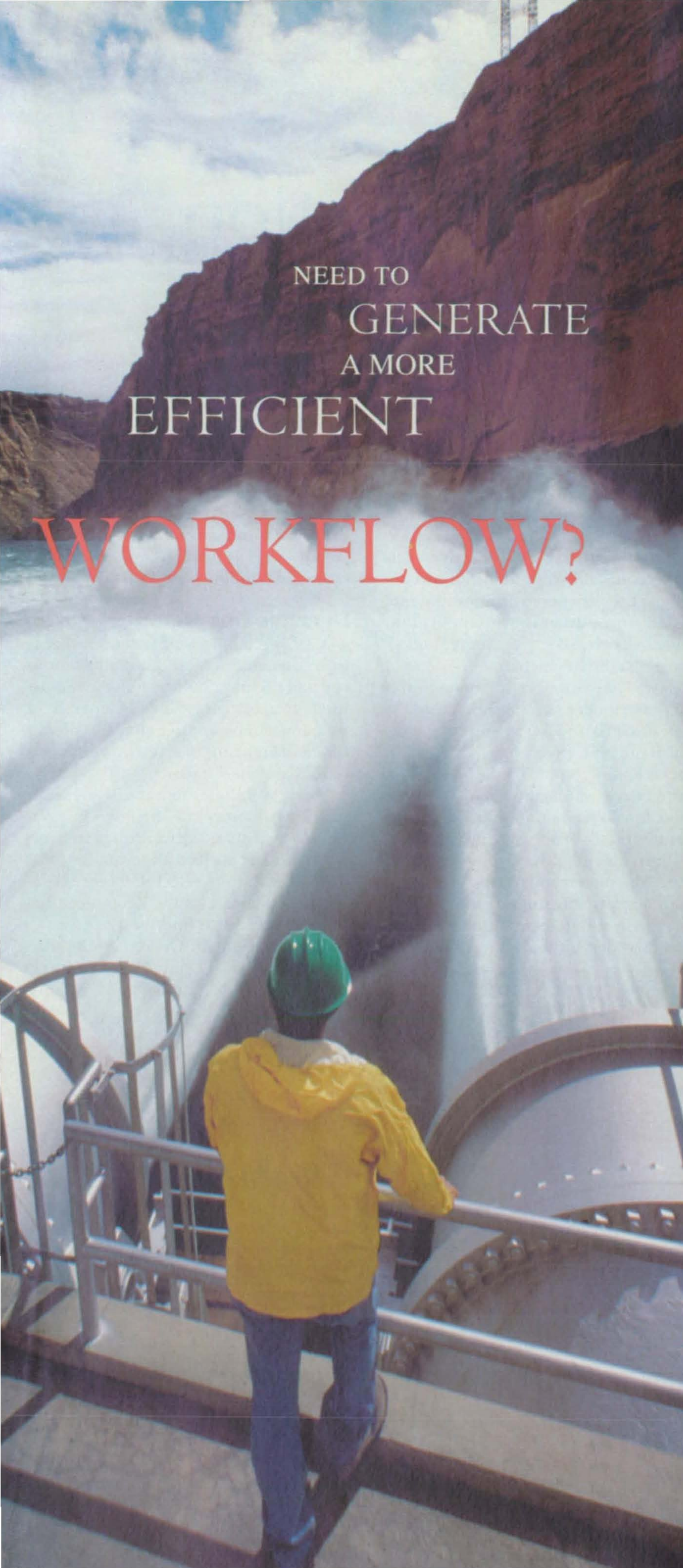
Venneri: The development of intelligent systems: How do we bring intelligence into our space system architectures in terms of spacecraft, transportation systems, and aircraft systems that enable us to move to another, higher level of reliability and safety? Intelligence in systems would free up the way we implement mission architectures, so that they become learning systems that can navigate, that can plan, that can send back requests for help.

If we had herds of robots or fleets of spacecraft, those intelligent entities could communicate and work among themselves, and the sum of the parts becomes greater than any one whole.

NTB: In the next 10 years, what is NASA going to be looking for from commercial industry, and in what areas of technology is NASA most likely to form partnerships?

Venneri: We form partnerships right now with industry across the spectrum. We deal with industry in terms of power and propulsion. We've had partnerships with companies looking at development of arcjets that have flown on commercial satellites. In fact, our partnerships have led to the use of arcjet thrusters for commercial satellites, that have changed the capabilities of these satellites in terms of more payload or downsizing to a lower-cost launch vehicle. Those are the types of partnerships we do today, and we're going to continue those. We're also looking at partnerships that might bring new industry structures that don't exist today.

A full transcript of this interview is available online at www.nasatech.com.



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Easy Instrumentation in Visual Basic

High-level instrument drivers allow users to focus on the application they are building and the function needed, making it possible to quickly and easily create a complete instrumentation system inside Visual Basic.

Instrument driver software is one of the most important components in test systems today. Many manufacturers of measurement hardware provide some form of instrumentation driver because instrument drivers handle the details of control and communication with specific instruments. With higher-level functions like "read waveform," the focus is on working with data to get the information needed.

There are two basic forms of instrument drivers commonly used with Visual Basic. The first — dynamic linked libraries (DLL) — is popular because it interfaces with most programming languages. This means that instrument manufacturers can release one instrument driver for most programming environments. The other — specifically for Visual Basic — is ActiveX controls, which easily can be incorporated into any Visual Basic project with minimal programming.

If an instrument manufacturer does not supply an ActiveX instrument driver, but only the communications commands, the instrument still can be integrated into a software application. Software such as Measurement Studio™ (from National Instruments, Austin, TX) provides support for many different instrument communications — such as GPIB and Serial — for both Visual Basic and Visual C++. This type of software also contains VISA libraries to simplify communication and code creation for GPIB, Serial, and VXI instruments. To talk to an instrument without an instrument driver, one needs to know the commands that the instrument accepts and the way it will return data. Instrument communication software provides ActiveX controls and class libraries that simplify communication by parsing cryptic response strings that come back from instruments. Interactive parsing such as this can save hours of tedious coding time.

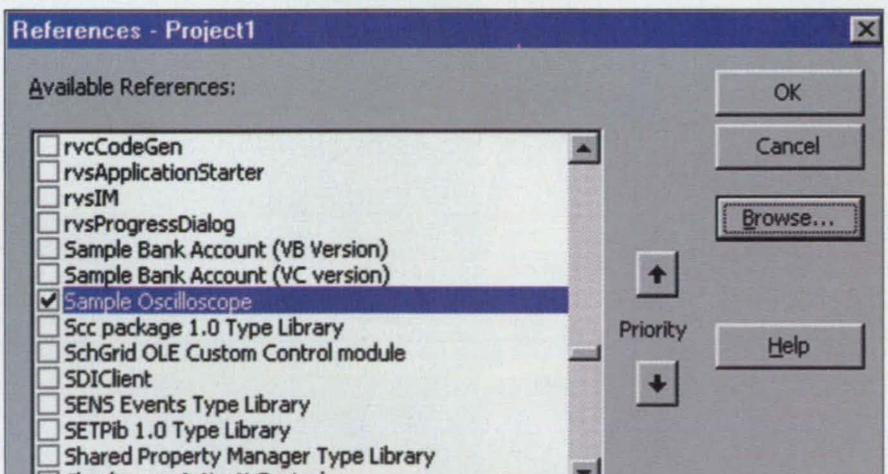

Figure 1

Dynamic Link Libraries

A DLL is a library of functions that is linked dynamically to an application at runtime. This modular library can be used in many programs. To upgrade a function, simply replace the DLL of that function, making distribution and software maintenance easier.

Most DLL instrument drivers ship with a type library enabling easy integration of instrument driver functions into a Visual Basic project. To locate the DLL instrument driver, select Reference from the Project menu. In the References dialog box, browse to find the DLL for the desired instrument. Once the reference is added to the DLL, any of the functions inside the DLL can be used without using any more declarations. (See Figures 1 and 2.)

The Object Browser from the View menu can then be used to display a detailed list of what functions are in the instrument driver. Once the desired function is located, the browser also shows how to call the function and define the variables. This makes calling DLL driver functions into Visual Basic easier.

ActiveX Controls

To provide more integrated support for hardware, some vendors offer ActiveX controls. ActiveX controls integrate easily into Visual Basic because they are built on the Component Object Model (COM) architecture, and therefore interact with other objects and containers by exposing interfaces.

Interfaces usually expose methods and properties that define the services that the component provides. Methods are functional services, and properties expose the data and attributes of these services. Methods return data to the container or other objects by firing events. An event tells the application that the expected activity happened and the data is available for action. This makes event-driven programming easier, and naturally extends Visual Basic.

To add a component to a project, select Components from the Project Menu, or go to the Toolbox, right-click, and select Components. This brings up a list of all of the components installed and registered on the machine. Choose the ActiveX driver from the list and select Okay. A new button will appear in the Toolbox palette. To add the appropriate instrument driver to an application, click on the button and drag it to a form. When the control is highlighted, one can then view and set the properties in the Property Explorer. When methods are added, the code will AutoComplete. (See Figure 3.)

Interchangeable Virtual Instrument (IVI) Drivers

The IVI Foundation has developed standards for instrument driver software that focus on the areas of instrument interchangeability, execution performance, and development flexibility. To accomplish this task, the Foundation defined a two-tiered architecture for instrument drivers. The first tier is composed of instrument-specific drivers that add features like state caching, instrument simulation, and multithreaded development capabilities. The drivers provide significant performance improvements over prior approaches to instrument driver development such as VXIplug&play.

To provide instrument interchangeability, the Foundation has grouped instruments into classes, such as digital multimeters and oscilloscopes. Within each class, there are defined instrument capabilities based on the most popular instruments in that class. The capabilities cover most of the features of instruments in that class and allow instrument interchangeability.

The Foundation defined a second tier of generic class drivers targeted at all instruments in a certain class. With these instruments, program developers write hardware-independent software that can be reused even if instruments are upgraded in the future. Overall, the IVI architecture provides performance improvements within individual instruments, and instrument interchangeability regardless of instrument vendor or I/O bus type.

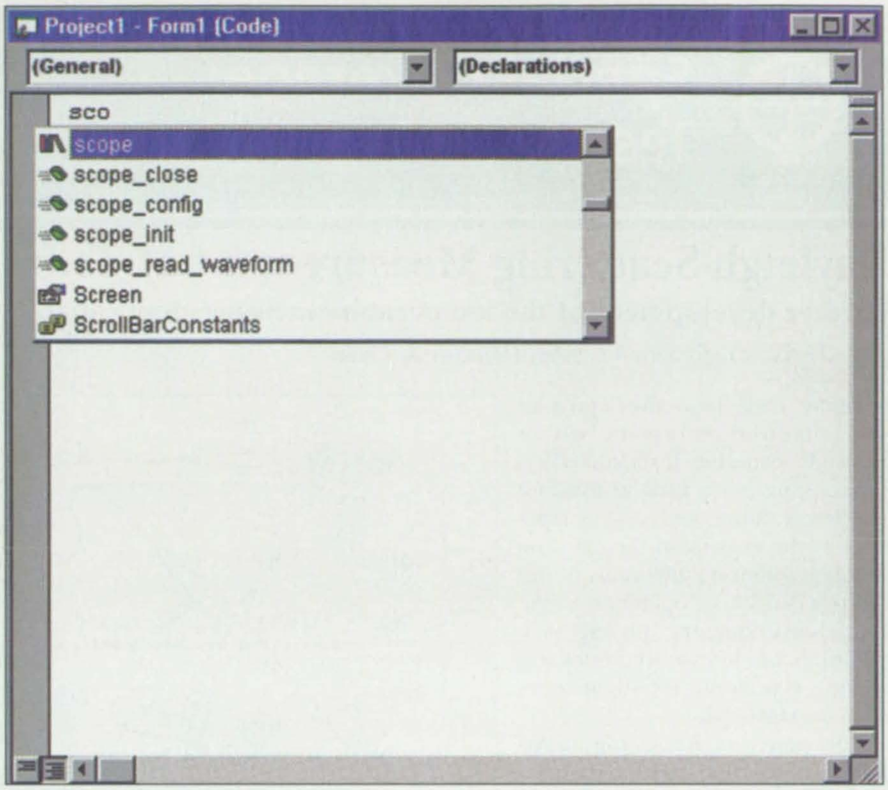

Figure 2

Visual Basic can be used to communicate with instruments in many ways. GPIB, Serial, or VISA commands can be used to directly send commands to instruments. Or, by accessing an instrument through a higher-level driver, there is a much easier way to communicate with the instruments. These instrument drivers allow users to focus on the application they are building and the function needed, making it possible to quickly and easily create a complete instrumentation system inside Visual Basic.

For more information, contact the author, Jeff Laney, Product Manager, at National Instruments, Austin, TX; Tel: 512-683-6681; Fax: 512-683-5569; or visit www.ni.com.

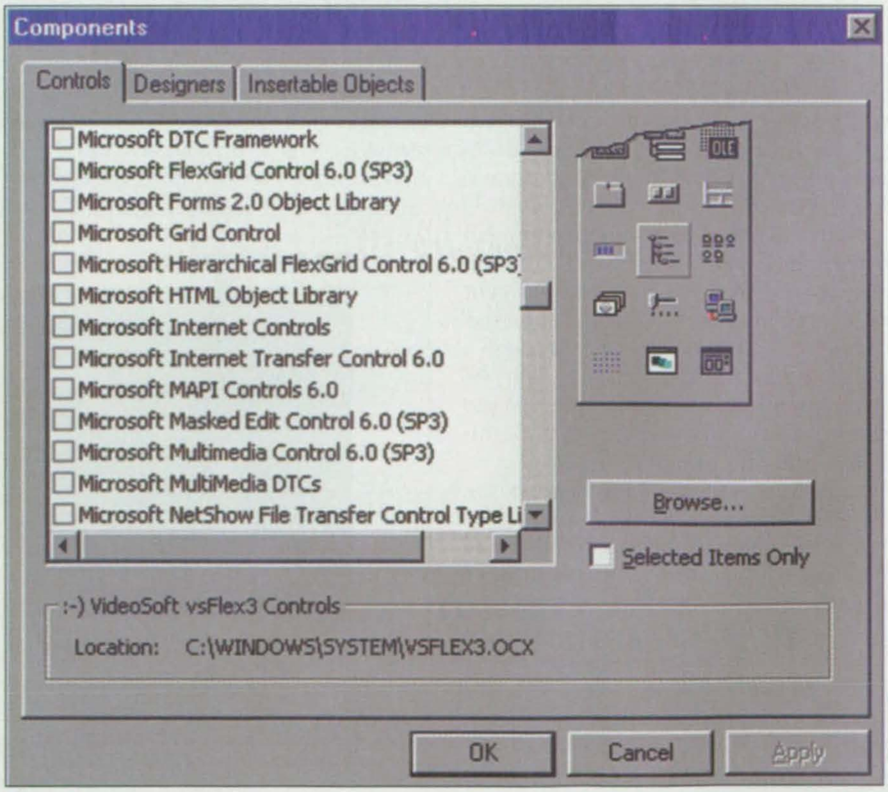

Figure 3

Special Coverage: Test and Measurement

Rayleigh-Scattering Measurement of Temperature and Velocity

Further development of the temperature-measurement capability is needed.

John H. Glenn Research Center, Cleveland, Ohio

Figure 1 schematically depicts an experimental setup in which Rayleigh scattering from molecules of a flowing gas is used to measure the temperature and one component of the velocity of the gas. The Rayleigh-scattering apparatus in this setup is capable of operation in the harsh environments (varying temperatures and intense vibrations and sound) commonly found in aerospace test facilities.

The power of Rayleigh-scattered light is proportional to the gas density, the spectral width of the scattered light is related to the gas temperature, and the shift in the frequency of the spectral peak is proportional to one component of the bulk velocity. Because the molecules of the flowing gas of interest are Rayleigh scatterers, no seeding of the flow is necessary. The concept of using molecular Rayleigh scattering to measure temperature and velocity has been reported previously. The novel aspect of the present Rayleigh-scattering apparatus lies in (1) the manner in which its delicate optical and electronic equipment are protected from the harsh flow-test environment and (2) the manner in which the Rayleigh-scattering spectrum is acquired and analyzed.

At the protected location, light from an argon-ion laser is focused by lens 1 into an input optical fiber, which delivers the light to the test location. There, the light is collimated by lens 2, then directed through a polarizing beam splitter. The light reflected by the beam splitter is directed into a light trap (not shown in the figure); this light must be trapped because even though it would not contribute to the Rayleigh-scattering signal, it would contribute to detected stray light if it became depolarized when scattered from surfaces near the probe volume (the small volume from which Rayleigh scattering is to be measured). The beam transmitted by the beam splitter is focused into the probe volume by lens 3. Rayleigh-scattered light is collected by lens 4 and focused by lens 5 into an output optical fiber, which delivers the light back to the protected location.

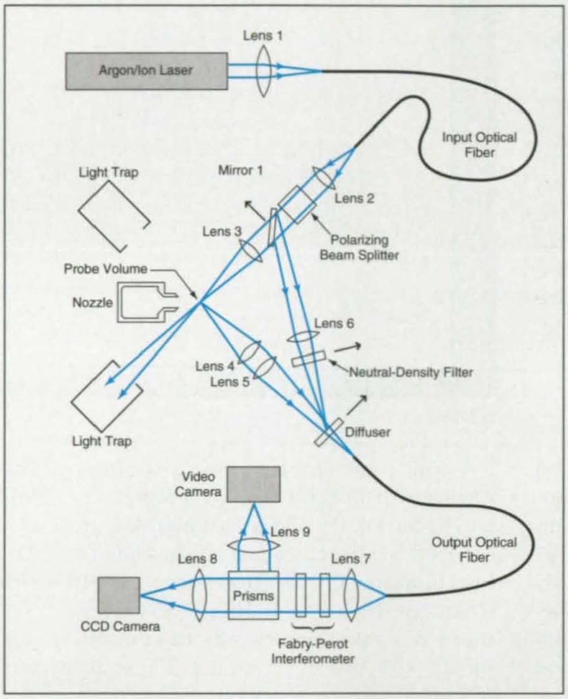

Figure 1. **Rayleigh Scattering** in the probe volume is excited and measured by remotely located equipment connected to the flow-test location by optical fibers.

The light coming out of the output optical fiber at the protected location is collimated by lens 7, then passed through a planar mirror Fabry-Perot interferometer operated in the static, imaging mode, then focused by lens 8 into a charge-coupled-device (CCD) camera cooled by liquid nitrogen.

Additional optics are included to provide for a reference Fabry-Perot image of non-Rayleigh-scattered laser light. These optics include a mirror that intercepts laser light coming out of the polarizing beam splitter. The light reflected by the mirror is focused by lens 6 through a neutral-density filter (if needed to reduce the intensity of the reference light) and a diffuser located in front of the output optical fiber. The diffusely scattered laser light then enters the fiber. The mirror, diffuser, and neutral-density filter are mounted on remotely controlled pneumatic linear actuators so that they can be moved into position for acquiring the reference image or moved out of the way for Rayleigh-scattering measurements. A prism assembly can be placed in the path between the Fabry-Perot interferometer and the CCD camera to direct light into a standard video camera.

The Fabry-Perot interferometer is aligned automatically on the reference

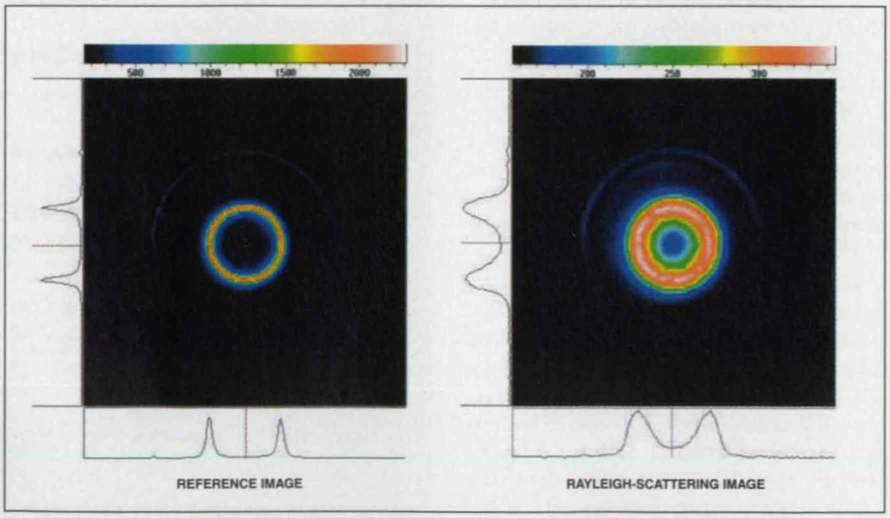

Figure 2. These **Reference and Rayleigh-Scattering Images** were generated in 10-second exposures. The Rayleigh-scattering image was acquired at a temperature of 297 K. In each case, a single fringe is shown, with horizontal and vertical plots of readouts from a single row and a single column of pixels through the center of the fringe.

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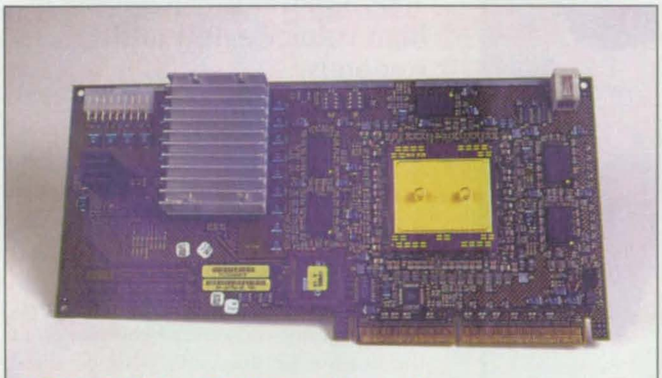

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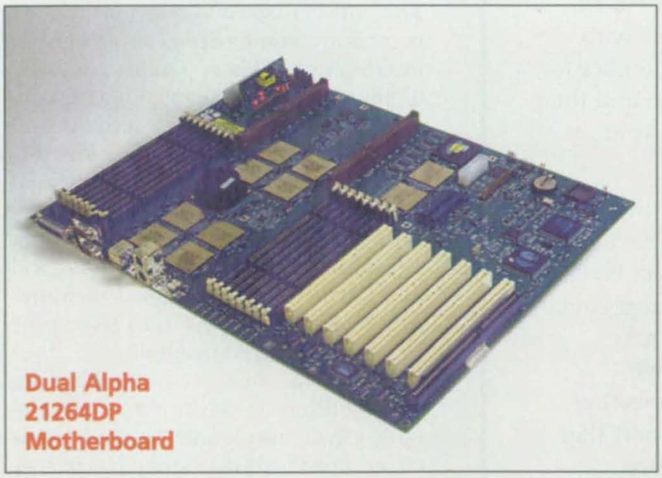

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Company History

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Our hardware products included PC accelerators, coprocessor cards, and motherboards. In 1986, we introduced the first 32-bit Fortran to run on an Intel PC. The first PC to hit a megaflop used a Microway/Weitek coprocessor driven by NDP Fortran. Over the years, NDP Fortran has been used to port hundreds of popular mainframe applications, including MATLAB and ASPEN, to Intel-based PCs.

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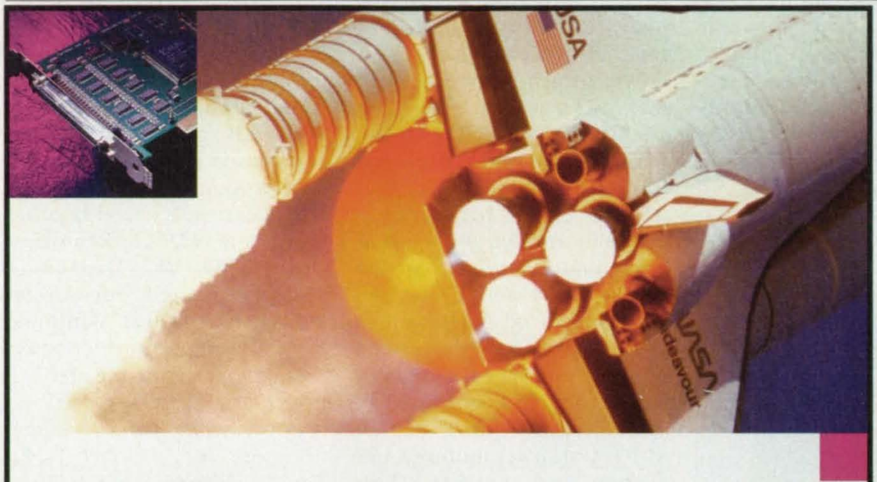
Microway 24 Node Linux Beowulf Cluster

image, then locked in alignment for acquisition of Rayleigh-scattering Fabry-Perot images. A five-parameter mathematical model of the instrument function is fitted to the digitized reference image. Thereafter, each Rayleigh-scattering Fabry-Perot image is digitized, then processed by an algorithm that, using the instrument-function parameters, finds the best fit of the image to a five-parameter mathematical model of the Rayleigh-scattering Fabry-Perot image; the fitting parameters are the amplitude of Rayleigh scattering, velocity, temperature, amplitude of stray laser light, and uniform background (see Figure 2).

In a test on a subsonic free air jet, velocities determined by Rayleigh scattering were in good agreement (within 5 m/s) with velocities calculated from isentropic-flow relations, but temperatures determined by Rayleigh scattering were not in equally good agreement. In a test on slowly flowing heated air, the velocities determined by Rayleigh scattering again agreed within 5 m/s, but the temperatures determined by Rayleigh scattering exhibited systematic errors on the order of 10 to 15 percent. Thus, it appears that the apparatus is capable of accurate velocity measurements, but that additional development of the temperature-measurement capability is needed.

This work was done by Richard G. Seasholtz and Lawrence C. Greer III of **Glenn Research Center.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16747.



Integrated Optical Voltage-Measuring Apparatus

This apparatus can measure high voltage safely and remotely.

John H. Glenn Research Center, Cleveland, Ohio

An integrated optical voltage-measuring apparatus based on a Mach-Zehnder interferometer has been designed and constructed. The main feature of this apparatus is that optical fibers link part of it to an optical sensor head placed at the source of the voltage to be measured, whether the source be a space-based power distribution control system or a ground-based high-voltage system. The optical fibers and sensor of this apparatus are immune to electromagnetic interference. This apparatus could be highly suitable for use in automatic control of space-based or aeronautical power-management and power-distribution systems. Potential ground-based commercial applications include measuring voltages and electric fields in electrical power systems, physiological monitoring and recording, measurements of pulsed power, and testing for electromagnetic compatibility.

Optical measurement of voltage involves utilization of the linear electro-optic effect, also known as the Pockels effect. Previously developed electro-optical voltage sensors have incorporated bulk electro-optic crystals and such bulk optical components as lenses, beam splitters, and polarizers. Because of the deficiencies in the design and construction of these devices, they have proved to be difficult to implement in the field. The use of bulk optical components can lead to difficulties in miniaturization, inadequate stability

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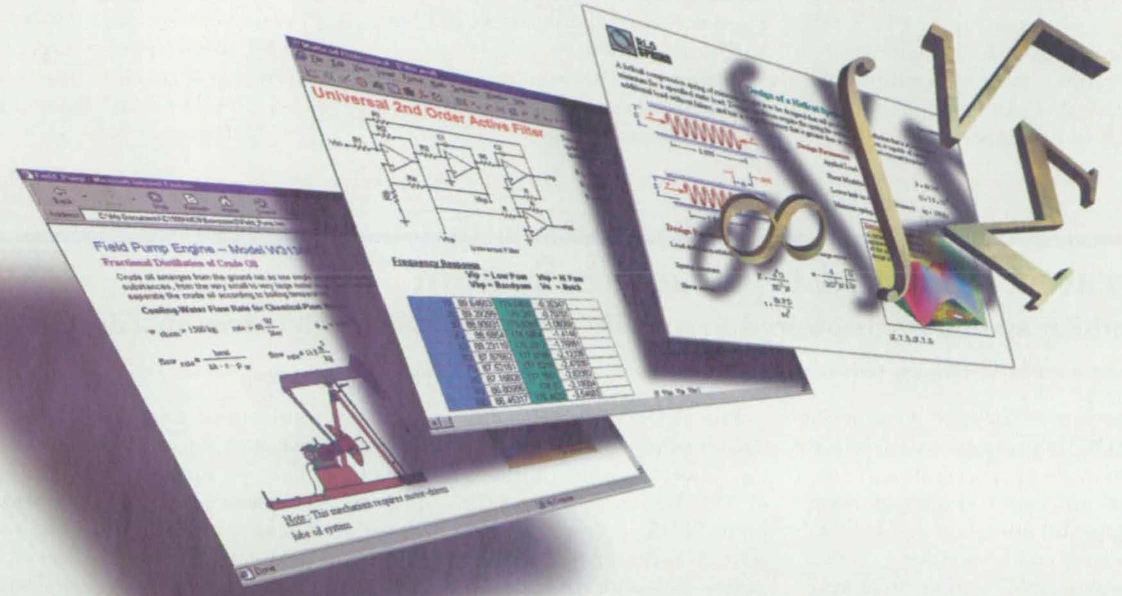

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in outer-space applications, and high manufacturing costs.

The present integrated optical voltage-measuring apparatus overcomes these deficiencies of electro-optical voltage sensors made from bulk optical components. This apparatus is capable of measuring quasi-dc and ac signals at frequencies up to 3 MHz. It displays the true root-mean-square values of signals up to 200 V full scale. Its error is less than 2 percent of the full-scale reading. The maximum safe peak potential that can be applied to the optical head of this apparatus is 1,000 V. This apparatus also provides an analog output that can be used to display the measured waveform on an oscilloscope. The optical voltage-sensing head and the rest of this apparatus can be separated by a fiber-optic cable for remote measurement of high voltage.

The outstanding features, benefits, and capabilities of this apparatus, in addition to those described above, are the following:

- Optical isolation,
- Measurement of continuous-wave and pulsed signals,
- Large dynamic range,
- No need for electrical power at the sensor head,
- Possibility of placing the sensor head in a hostile or harsh environment, and
- Safe measurement.

This work was done by Stuart A. Kingsley and Sriram S. Sriram of SRICO, Inc., for **Glenn Research Center**.

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16731.

Integrated Test and Operations System

This modular system is customized to specific applications through entries in a data base.

Goddard Space Flight Center, Greenbelt, Maryland

The Integrated Test and Operations System (ITOS) is a generic system of software for controlling spacecraft and components of spacecraft during development, testing, and operation in orbit. The ITOS software is an inexpensive, portable, highly configurable system that runs under a variety of UNIX operating systems — including Solaris, FreeBSD, and Linux — on workstations or personal computers. The ITOS evolved from the ground support equipment built in 1990 to support integration and testing of SAMPEX, the first Small Explorer (SMEX) mission, and now is supporting SAMPEX and eleven other missions.

The ITOS software is executed on a cluster of workstations (see Figure 1) interconnected over a local-area network (LAN). Each workstation runs the complete ITOS software. One of the workstations is designated as the primary operator console; this console receives telemetry data from a spacecraft interface and sends commands to the interface via an Internet-Protocol (IP) Ethernet connection.

The primary console relays the spacecraft telemetry data to all other ITOS workstations on the LAN. Such computation-intensive operations as real-time, high-rate processing, distribution, and plotting of telemetric data can be distributed among workstations to achieve high performance at minimal cost of hardware. Each ITOS workstation unpacks the telemetry data packets and performs such data-processing tasks as limit checking, conversions of engineering units, and monitoring of configurations.

The primary ITOS console can distribute telemetry data, via an IP Ethernet connection, to external scientific, engineering, flight-dynamics, mission-planning, and command management systems attached to the LAN. These data are provided in a variety of formats and

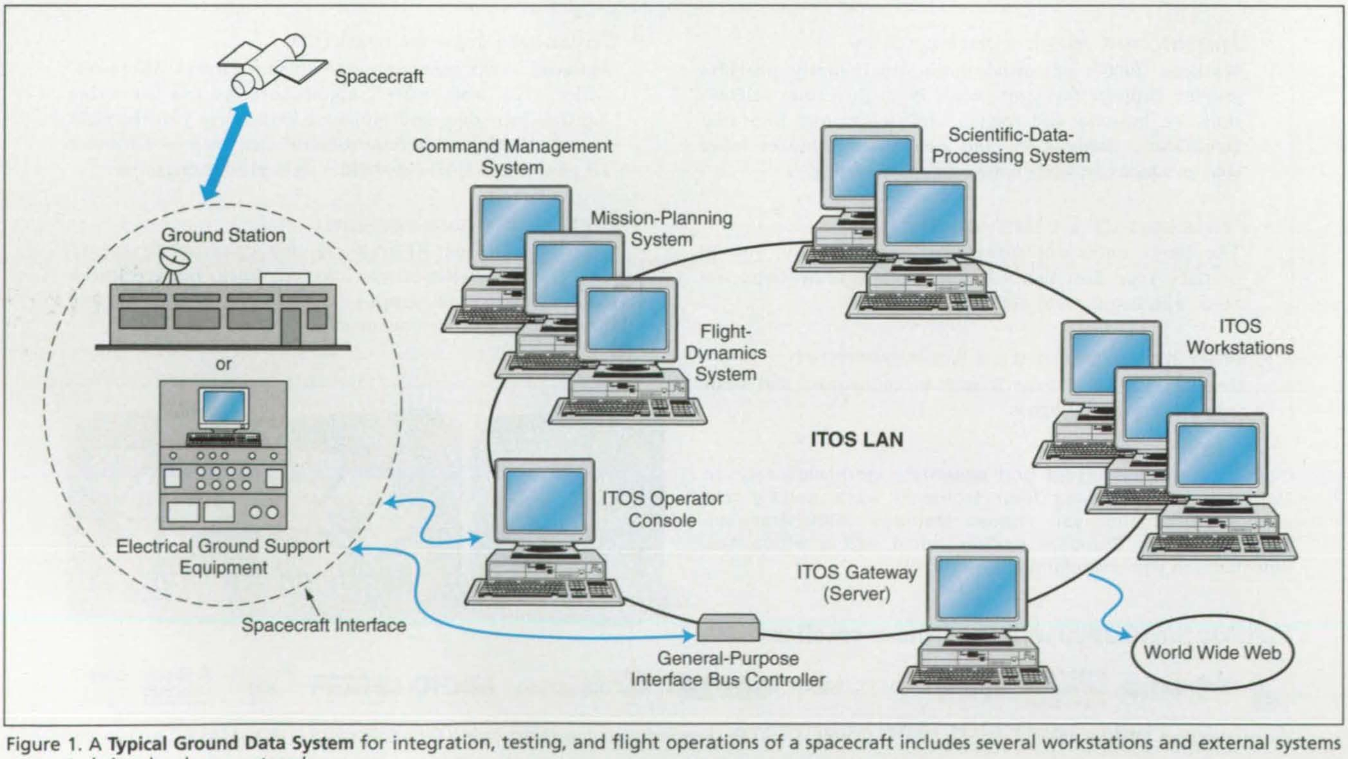


Figure 1. A **Typical Ground Data System** for integration, testing, and flight operations of a spacecraft includes several workstations and external systems connected via a local-area network.

can be transferred by frame, packet, or individual datum. The ITOS uses a protocol that enables each of these external systems to request a particular type of data.

One ITOS computer can be connected to the Internet as a server to provide telemetry and event displays that are viewable through any Java-capable web-browser software. This feature enables engineers to monitor and participate in tests and flight operations from remote locations, including their homes and offices. The server can also provide telemetry and event displays to the public via the Internet.

The ITOS software is customized from mission to mission, through an operational data base (which contains mission telemetry and command specifications), and through a small set of configuration files.

The ITOS can accept telemetry from multiple sources simultaneously. It can, for example, process spacecraft telemetry and ground-station status blocks or telemetry from a dynamic simulator. It can also control and monitor such external devices as receivers, bit synchronizers, and simulators by use of IEEE-488, RS-232, or network connections.

With respect to functionality, the ITOS software system can be characterized as divided into five subsystems: telemetry, command, control, data base, and events (see Figure 2). The telemetry subsystem contains programs for ingesting, unpacking, displaying, and checking telemetric data from spacecraft. The command subsystem contains programs for generating and transmitting spacecraft commands. The control subsystem includes programs for controlling and monitoring the spacecraft and the elements of the ground system. The data-base subsystem comprises programs for creating and gaining access to the operational data base. The event subsystem manages the recording, display, and forwarding of all messages generated by the ITOS programs and by the spacecraft.

The cost of replicating the ITOS is low. This is partly because (1) the only commercial component of the ITOS software is a plotting program for which run-time licensing is not required and (2) the ITOS software is based on open standards. The ITOS software was developed by use of the Open Source GNU development suite. Its graphical user interface is based on Motif and the Java Development Kit. The development team made every effort to ensure that the ITOS code conforms to all relevant standards for maximum portability across UNIX implementations.

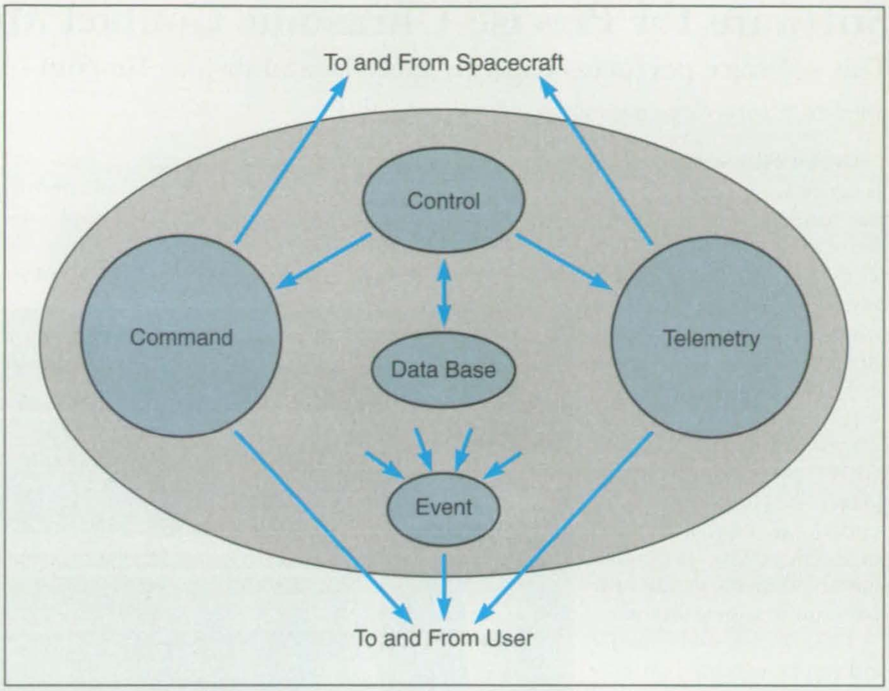


Figure 2. The **ITOS Software System** comprises five subsystems. The software is modular; most of its components can be replaced or augmented.

This work was done by Karen M. Keadle-Calvert and Sharon Orsborne of **Goddard Space Flight Center***; Brian Goldman and Mark Richardson of AlliedSignal Technical Services; Danny Lewis of SGT; and Greg Greer, Tim Singletary, and Bruce Wendel of Hammers Company. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Systems category.*
GSC-14012

Software for Precise Ultrasonic Contact Measurements

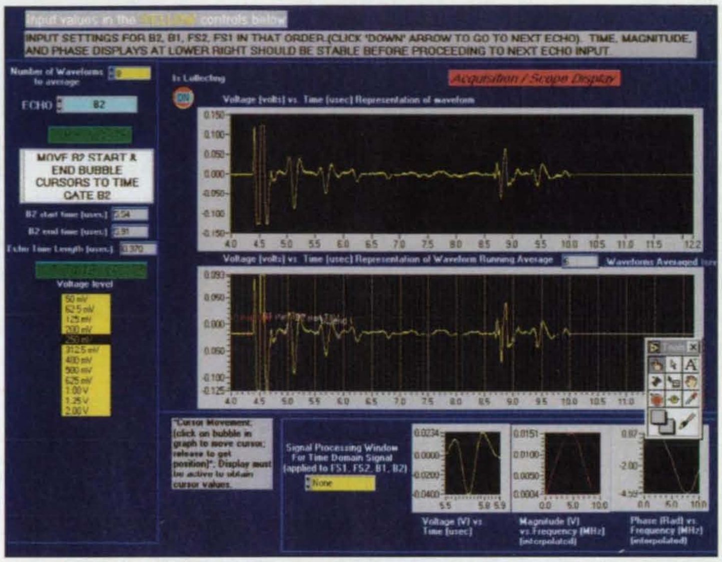
This software performs control, analysis, and display functions.

John H. Glenn Research Center, Cleveland, Ohio

The ULTRA SON computer program is designed for use in precise ultrasonic contact scan measurements for nondestructive characterization of materials. This program performs major functions necessary for controlling an ultrasonic apparatus, analyzing the measurement data generated by the apparatus, and displaying the results of the analysis. Written in the LabVIEW programming language, ULTRA SON is intended to supplant older ultrasonic-testing programs that are difficult to use and that require large computers: ULTRA SON is user-friendly and can be executed on personal computers.

For a given specimen to be characterized, ULTRA SON guides the user by generating an interactive display (part of a LabVIEW "Virtual Instrument") that contains a sequence of buttons and windows through which the user sets the parameters of the sequential measurement, analysis, and display operations pertaining to that specimen. The user provides input via a keyboard, a mouse, or both. The figure presents an example of an ULTRA SON interactive display.

ULTRA SON provides for analog-to-digital conversion at a sampling rate up to ≈1 GHz. Once a set of ultrasonic-echo data for a specimen has been acquired, ULTRA SON processes the data to calculate the ultrasonic properties that are often used to characterize the bulk nonultrasonic physical properties and microstructure of the specimen. These ultrasonic properties include the following:



One of the ULTRA SON Displays is a window containing a raw time-domain waveform (ultrasonic-transducer voltage vs. time). This display prompts the user to enter the times when the front- and back-surface echoes are considered to begin and end ("B2" denotes the second back-surface echo), the voltage sensitivity level for the display, and the voltage offset control to enable calculation of frequency-based properties. The user can also specify the type of time-domain signal-processing window.

- The phase velocity and the attenuation coefficient, both as functions of frequency;
- Reflection coefficients;
- Cross-correlation velocity;
- Peak frequencies, bandwidths, durations, rise times, fall times, slew rates, and overshoots of pulses; and
- Magnitude, phase, and power spectra.

In this program, with the exception of power spectra, ultrasonic properties are calculated on the basis of magnitude (as opposed to power) frequency-domain spectra.

ULTRA SON is written for use on a personal computer with a minimum recommended '586 processor operating at a speed of at least 133 MHz and running the Windows 95 or Windows NT4.0 operating system. A Sonix, Inc., STR*81g card (which contains a 1-GHz analog-to-digital converter) and the associated software must be installed in the computer. The user-interface part of ULTRA SON is designed for a video monitor with a resolution of 1,024 × 768 pixels and a size of at least 20 in. (51 cm).

This program was written by Don J. Roth and Wei Cao of **Glenn Research Center** *and Kevin Furrow of Sonix, Inc. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16703.

Apparatus Records Acceleration and Temperature

John F. Kennedy Space Center, Florida

An apparatus records triaxial acceleration and temperature as a function of time, operating unattended for as long as 3 weeks on power supplied by two D cells. The apparatus, which has dimensions of only 3.5 by 4.5 by 2.2 in. (8.9 by 11.4 by 5.6 cm) and weighs only 28.5 oz (0.81 kg) is designed primarily to be attached to an article of commerce to log the shock, vibration, and temperature to which the article is exposed during shipment. The apparatus contains three digital accelerometers. It is easily programmed through a serial link to a desktop or notebook computer running Windows 95. When activated, the apparatus stores up to 8 MB of acceleration and temperature data in nonvolatile memory. The acceleration data can be stored as sampled (or, for efficient utilization of memory, can be preprocessed into such parameters as peak or root-mean-square acceleration or velocity) at a rate from 1 to 4,000 samples per second. The stored data are subsequently downloaded to a personal computer for display and analysis.

This work was done by John C. Cole of Silicon Designs, Inc., for **Kennedy Space Center**.

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:

John C. Cole, President, Silicon Design, Inc., 1445 N.W. Mall Street, Issaquah, WA 98027. (425) 391-8329

Refer to KSC-11989, volume and number of this NASA Tech Briefs *issue, and the page number.*

Special Coverage: Test & Measurement

National Instruments, Austin, TX, offers Measurement Studio **measurement tools** for Microsoft Visual C++, Visual Basic, and LabWindows/CVI. The software delivers acquisition, analysis, and visualization tools to integrate with popular text-based programming languages. The software extends the programming environments by adding measurement tools and libraries that simplify development of data acquisition and instrument control applications.

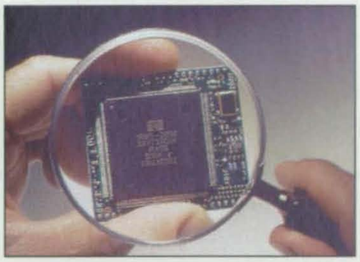
The suite includes user interface controls, mathematical analysis and signal processing routines, and data acquisition and instrument control I/O libraries for Visual C++ and Visual Basic programmers. After launching Visual C++, engineers begin by using the Measurement Studio App Wizard to create a template that includes all measurement tools necessary to build an application. The software also includes ActiveX controls for users building virtual instrumentation in Visual Basic.

For More Information Circle No. 732

The YP20 **3D coordinate measuring machine** from Sony Precision Technology America, Lake Forest, CA, combines non-contact, auto-focusing optical/laser sensing technology and PC-based computer numerical control (CNC). The system provides 3D inspection, measurement, and analysis of microscopic surface features on integrated circuits, printed circuit boards, computer hard disks, and machined materials. Operating within a Z-axis measurement range of 20 mm, the system uses a semiconductor laser to read and measure the surface.

A CCD color video camera comes standard with 50x optical lens to provide image feedback of measured points to a color monitor via a video capture board within the unit's PC. Optional 10x, 20x, and 100x optical lenses are available. CNC movement within all axes is closed-loop controlled by the unit's 450-MHz Pentium II PC. A joystick is included for manually driven X-Y movement.

For More Information Circle No. 729



Hewlett-Packard, Palo Alto, CA, has introduced the BFOOT-10501 Ethernet-ready **measuring device** that can be embedded into a range of products to allow them to be remotely monitored and controlled from any Internet browser. The measurement and control plug accommodates a variety of measurement and automation applications. The web plug module has a 10Base-T interface so that it can be connected to any Ethernet network.

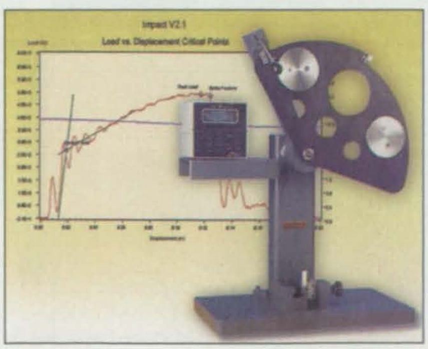
The plug provides standardized interfaces to measure or control devices used in many industries. All hardware and software needed to embed the module into sensors, instruments, and machines is included. The module can mate with existing serial (RS-232) devices. It is suitable for situations requiring continuous monitoring, or where multiple users need access to common data over the Internet from any PC.

For More Information Circle No. 727

TEGAM, Geneva, OH, offers the automated Model OCS2500 **oscilloscope calibrator** with leveled output accuracy traceable to NIST standards. The programmable system is designed for frequencies to 2.5 GHz, and includes a Next-Cal-Date tracking feature that lets the user know when the next calibration is due. Built-in self-test routines and hardware features check the operation of all major circuits each time the system is turned on.

The system consists of the Model SG5050 Leveled Sine Wave Generator, CG5011 Calibration Generator, and TM5006A Mainframe. The sine wave generator provides calibrated output voltages from 4.5 mV to 5.5 V peak-to-peak into 50 ohms. Absolute amplitude accuracy is ±1.5% from 10 kHz to 50 kHz. A standard remote leveling head plugs into the oscilloscope. The calibration generator features a remote pulse head, providing pulse rise times of 160 ps.

For More Information Circle No. 730



Tinius Olsen Testing Machine, Willow Grove, PA, offers an instrumented **impact testing system** for materials characterization. The striker is instrumented with a strain gauge to measure the applied force to standard size and miniature test specimens. Data is collected automatically upon contact with the specimen and is saved in the database of the Windows-based software.

The machine features a high-speed system response of at least 100 MHz. The system consists of an instrumented striker, a power supply/signal amplifier, an oscilloscope card, a copy of the data acquisition and analysis software, and a computer. The electronics are housed with the PC in a ready-to-use package.

For More Information Circle No. 728

Cole-Parmer Instrument, Vernon Hills, IL, offers the Model 98899-00 portable **analytical viscometer** that provides real-time measurements and analyses of fluids such as oils, coatings, lubricants, and adhesives. Results can be viewed graphically or numerically on the LCD. Datalogging capabilities allow users to save results and download them to a PC for later analysis.

The handheld, battery-operated viscometer takes viscosity and temperature measurements, eliminating the need to take lab samples and avoiding incorrect readings due to changing conditions.

For More Information Circle No. 731

Electronic Components and Systems

DRAM Circuit Tolerates Single-Event Upsets

The equivalent of a majority vote is taken among triplicate memory cells.

NASA's Jet Propulsion Laboratory, Pasadena, California

A dynamic random-access memory (DRAM) circuit that tolerates single-event upsets (SEUs) has been developed. A single-event upset is a bit flip caused by ionizing radiation. In a DRAM, the state of each bit (0 or 1) is stored as charge on a buried capacitor. The impingement of an energetic charged particle can change the charge, and thus the state of the bit. There is no way to make a DRAM completely immune to SEUs, but the probability of a bit error in the DRAM output can be reduced significantly by use of redundancy; this is the concept on which the present SEU-tolerant design is based.

For protective redundancy, the DRAM incorporates three memory cells for each single cell that would otherwise be used. During recording, a bit is written in all three cells of a triple at the same time. Upon readout, the bit from the first cell is compared with that from the second cell; if the bits from the first and second cells are equal, then one of these bits is passed on to the data processor that requested the readout. If the bits from the first and second cells are not equal (because one was changed in an SEU), then the bit from the third cell is sent to the processor.

The comparison and selection of bits to pass on to the processor are accomplished by use of comparators and bus buffers. The SEU-tolerant DRAM also contains additional signal lines for full testing and for isolation and correction of faults.

This work was done by Steven Cole of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Systems category.*
NPO-20474

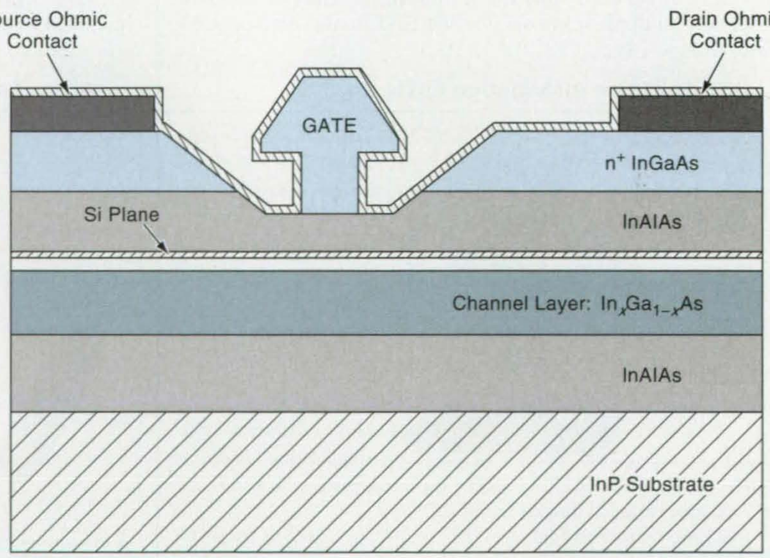
Two Approaches to Improvement of InGaAs/InAlAs/InP HEMTs

It should be possible to increase gains and cutoff frequencies.

NASA's Jet Propulsion Laboratory, Pasadena, California

Researchers are following two approaches in an effort to improve the low-noise performances of InP-based high-electron-mobility transistors (HEMTs) that could be used as front-end amplifiers in millimeter-wave receivers. These devices are designed to operate while cooled to temperatures ≤20 K, where they function with high gain, low leakage, and the lowest noise levels of any transistors operating in the millimeter-wavelength range. However, the low-noise performances of these devices are still slightly below those of nontransistor state-of-the-art devices.

The two approaches to improvement are best explained with the help of a cross-sectional view of a typical InGaAs/InAlAs/InP HEMT (see figure). The first approach involves increasing the indium content, *x*, of the $In_xGa_{1-x}As$ channel layer, which is grown by molecular-beam epitaxy. Increasing *x* results in enhanced electron-transport properties, which translate to higher cutoff frequency and



A Typical InGaAs/InAlAs/InP HEMT is depicted here in cross section (not to scale). Research directed toward improving low-noise performance has followed two approaches: (1) optimizing the indium content and thickness of the channel layer and (2) shortening the gate.

higher gain. Unfortunately, increasing x also increases the strain in the $In_xGa_{1-x}As$ layer with respect to the InP substrate; as a result, the thickness of the $In_xGa_{1-x}As$ must not be allowed to grow beyond a maximum critical thickness that decreases with increasing x. The thickness of the channel layer is important because the thickness of the quasi two-dimensional gas in this layer determines the quantum electron states and the confinement and density of electrons in the channel. If the channel is too thin, then the performance of the device is degraded.

In this research, devices are fabricated with channels of $x = 0.60$, 0.65, and 0.80 and corresponding thicknesses. In the case of the $x = 0.80$ channel, the indium content is not uniformly 0.80; instead, it is graded to a maximum of 0.80 to minimize the strain and thereby make it possible to grow the thickest possible channel layer while benefitting from the transports with the highest feasible x.

The second approach involves reduction of the gate length from 0.1 μm to ≤ 0.07 μm. Reduction of the gate length causes a reduction of internal capacitances, leading to lower noise, higher cutoff frequency, and higher gain. For example, decreasing the gate length to 0.07 μm can increase the cutoff frequency by as much as 25 percent.

There are two challenges to reduction of gate length. The first challenge is the difficulty of developing a high-yield manufacturing process to build 0.07-μm gates. Even electron-beam state-of-the-art electron lithography has thus far been limited to features with dimensions ≥ 0.1 μm. The second challenge is a short-channel effect; if the gate is too short, it cannot effectively pinch off the channel. This short-channel effect can severely limit device yield in mass production.

Both approaches have been followed in the fabrication of HEMTs in a dedicated 8-wafer lot split for the various indium compositions and gate lengths. The information gained from the devices on these wafers has provided insight on how to build the ultimate cryogenic millimeter-wave solid amplifier.

This work was done by Richard Lai of TRW Inc. for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Systems category.*
NPO-20341

Electronic Modules With a 3-D Interconnection Scheme

Features would include versatility for expansion, testing, and integration.

NASA's Jet Propulsion Laboratory, Pasadena, California

An improved three-dimensional (3-D) scheme for modular packaging and interconnection of electronic circuits has been proposed to overcome deficiencies of an older scheme and to obtain additional advantages. In particular:

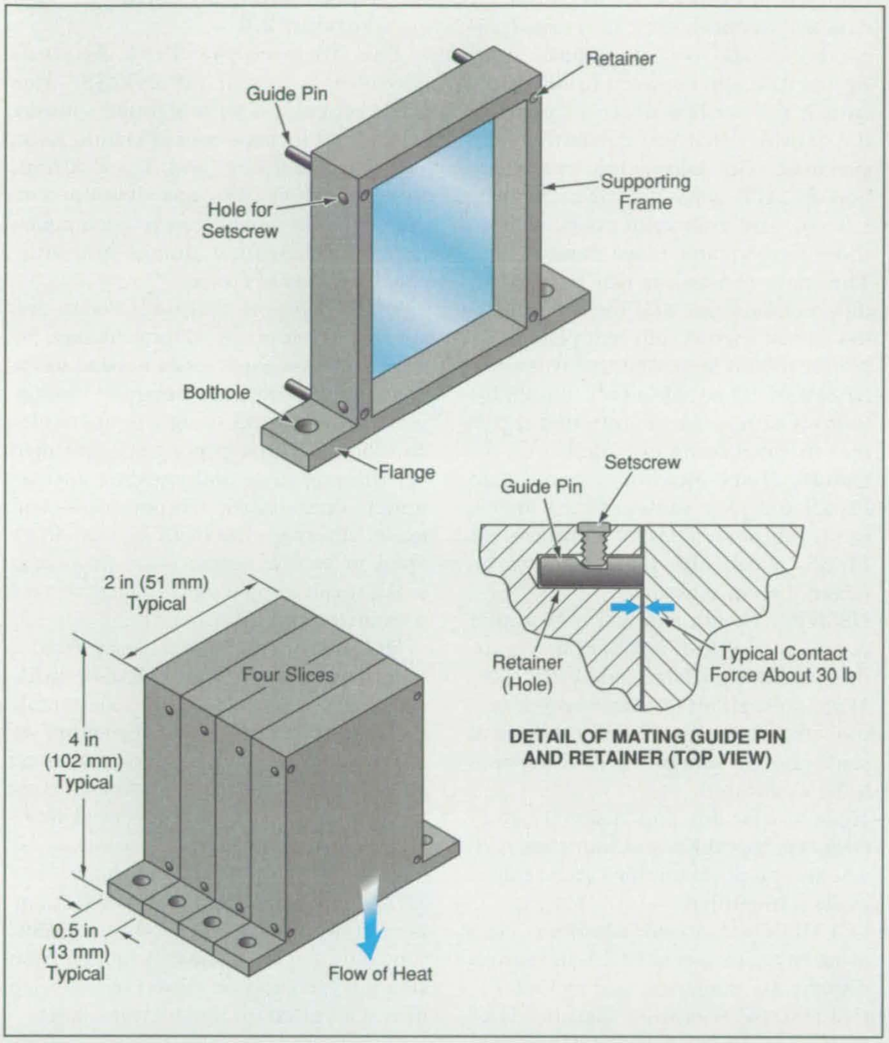
- The older scheme includes elastomer-based interconnections that fail at temperatures below –53 °C. The interconnections in the proposed scheme could function at temperatures from cryogenic to 200 °C.
- In the older scheme, it is necessary to disassemble an entire module in

order to insert or remove individual submodules called "slices." In the proposed scheme, individual slices could be inserted or removed without disassembly of an entire module.

- The proposed scheme provides for better thermal management.
- In the older scheme, the capability for expansion is limited. The proposed scheme would provide versatility for integration of modules into systems, for integration of systems with each other, for expanding systems, and for configuring systems for testing.

An essential part of the scheme is to construct an electronic system with a common modular design for all subsystems. The figure illustrates selected aspects of the proposed scheme as applied to a four-slice module. Each slice would include electronic circuitry held in a supporting frame, which would contain the features needed for mechanical, electrical, and thermal connections to support insertion, removal, expansion, testing, and integration. Optionally, one could use external or internal input/output interfaces. Also, optionally, one could incorporate thermal insulation between slices or between modules.

Slices would be mechanically connected to adjacent slices via guide pins and retainers that would mate in the manner of plugs and sockets. Once the guide pins were inserted in the retainers, setscrews would be tightened to push on slanted guide-pin surfaces to generate contact forces. In a module oriented as in the figure, the contact forces between slices would be horizontal. The thermal path for each slice could be vertical and directly into a heat sink if the slice were bolted down onto the heat sink via the boltholes on the flange of its supporting frame.



This **Three-Dimensional Scheme** for modular packaging and interconnection of electronic circuits offers electrical, thermal, and mechanical advantages over an older three-dimensional scheme.

This work was done by Don Hunter of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Systems category.*
NPO-20362

Software for Monitoring Remote Systems and Executing Plans

The Knowledge Server Tools (KST) computer program comprises a distributed set of software tools for monitoring remote systems. Part of KST implements a knowledge server for monitoring the status of a remote system (e.g., a computer-controlled instrumentation system, a robot, or a spacecraft). Another part of KST executes plans. KST was developed to replace older software that was difficult to use, less capable, and less portable.

The tools (the components of KST) are written in freeware Practical Extraction and Report Language (PERL) and communicate with each other via Unix sockets. The components of KST are the following:

- DSI (Data Server Interface) serves as a bridge between external data and KST. DSI loads data and makes them available for KST clients via the PIEKS tool described next.
- PIEKS (PERL Inference Engine Knowledge Server) connects to DSI to get current data whenever it is requested by a client to make an inference. PIEKS includes PIE, which is a frame-based, backward-chaining inference engine. The knowledge representation (frames) in PIE is a natural one to represent model-based reasoning because frames can be organized into hierarchies. PIEKS can return raw data, data set by the client, or inferred data. Inferred data are returned if there exists a knowledge-base frame that describes the rule that defines the inferred data. When this is the case, the rule is evaluated and appended to the value of the inferred data. Clients for PIEKS are the APE and HSMON tools described below.
- CCLS (Centroid Classifier Server) connects to DSI to get current data whenever it is requested by a client to classify data. CCLS returns "OK" or the name of the group, the centroid of which is closest to the current normalized data. CCLS can be used to classify data in a way that some case-based systems do. CCLS can be used in conjunction with PIEKS and with APE (described next) to solve problems that require the capabilities of all three of these tools.
- APE (A Plan Executor) is a frame-based hierarchical plan executor. APE connects to PIEKS to set its parameter data and to check the constraints (preconditions and postconditions) of activities. APE also connects to APEMON (which is described next) to highlight the activities that are currently being executed. The knowledge representation in APE separates plans, activity strategy, and constraint checking into three simpler and more flexible files. The same constraints can be used in different activities, and the same activities can be used in different plans. APE plans can also be nested to any level.
- APEMON (Ape Monitor) highlights buttons with activity names that represent the plan being executed.
- DMON (Data Monitor) connects to PIEKS and plots values of data in real time. Because DMON connects to PIEKS, it can also plot values of inferred data in real time.
- HSMON (Health and Safety Monitor) connects to PIEKS and simply returns the value of a goal defined by PIE every N seconds. HSMON may evolve into a tool that returns such information as statuses of all subsystems of the system to be monitored.
- HSDOC (Health and Safety Doctor) connects to PIEKS and launches APE whenever a problem that can be solved easily is identified.
- CCLMON (Centroid Classifier H&S Monitor) connects to CCLS and simply displays the value returned by CCLS.
- CCLHSDOC (Centroid Classifier H&S Doctor) is similar to HSDOC but connects to CCLS instead of PIEKS to classify problems and then launch APE to solve the problems.

The knowledge-server concept greatly enhances the power of this set of tools. By connecting to a knowledge server, a client can obtain raw data, inferred data, and user data (data set by the client). Because all of the tools are written in freeware PERL, the software should be highly maintainable. Because all the tools communicate via sockets, each tool can run on a separate workstation.

This work was done by David R. McLean of AlliedSignal Technical Services Corp. for **Goddard Space Flight Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Software category.*

GSC-14137

Monocoque Tank Analysis Spreadsheet System, Version 2.0

The Monocoque Tank Analysis Spreadsheet System (MONTASS) computer program is an integrated software system that incorporates Microsoft Excel worksheet software and Visual BASIC software. MONTASS was developed to enable rapid analysis and preliminary design of structural domes and truncated sections of cones.

MONTASS performs both design and analysis functions by (1) calculating the minimum skin thicknesses needed to enable analyzed and/or designed components to withstand design temperatures and loads (as in a proof test), and then (2) running stress and buckling analyses under operational temperatures and loads. Although MONTASS was developed to analyze monocoque propellant tanks, it can also be used to analyze non-pressurized conical structures.

MONTASS can be run easily from a user-friendly, three-page interface worksheet that controls a propellant-tank-analysis software subsystem. Two other visible worksheets present information on properties of materials as functions of temperature and a table of stored fluids and densities. The user can customize the data on both of these worksheets. The MONTASS system also includes six component worksheets and two Visual BASIC functions that are ordinarily hidden from view but can easily be viewed by following directions given on the interface sheet.

Design and analysis inputs include shapes and sizes, minimum allowable skin thicknesses (constraints imposed by manufacturing or fracture mechanics), properties of fluids, safety factors, a choice of the max principle or the von Mises failure criterion, loads, and temperatures. Properties of materials are interpolated from the data base for the input temperatures specified by the user. The user can also choose to design a dome with either a constant or a tapered skin-thickness distribution.

The primary design data products from MONTASS are internal volumes, skin thicknesses, and a summary of masses. Using these data, MONTASS then performs a stress analysis for all components and a buckling analysis for truncated section of a cone. Analysis load sets can include bending moments, axial forces, ul-

lage pressures, hydrostatic pressures, longitudinal acceleration, and rotations. Analysis data products from MONTASS are a summary of radial and vertical deflections, material-failure margins of safety for all components, and buckling margins of safety for the truncated section of a cone. If the analysis has shown that a tank can be expected to fail in buckling, then MONTASS also calculates the pressure needed to stabilize the tank.

Stand-alone components are included in MONTASS to provide users the option to run the MONTASS computational tools without using the interface that is integral to the MONTASS system. An additional Excel worksheet calculates the skin thickness of a monocoque cylinder that yields the same moment of inertia as that of a cylinder of a given thickness reinforced with integral T stiffeners.

MONTASS was developed as a Microsoft Excel v5.0a workbook program on a Power Macintosh computer. MONTASS has also been implemented on '486- and '586-class personal computers using Microsoft Excel v7.0a for Windows 95. The standard distribution medium for MONTASS is a 3.5-in. (8.89-cm), 1.44MB diskette in MS-DOS format. Power Macintosh computers can read MS-DOS-format diskettes; however, a Macintosh-formatted diskette can be made available if necessary. The documentation is available on the spreadsheets only. MONTASS was developed in 1996. The program is a copyrighted work with all copyright vested in NASA.

This program was written by P. L. Luz of **Marshall Space Flight Center.**

Inquiries concerning this program should be addressed to Larry Gagliano at the Center Software Release Authority at Marshall Space Flight Center (telephone 205-544-7175).
MFS-31223

Automated Planning and Scheduling for a Robotic Vehicle

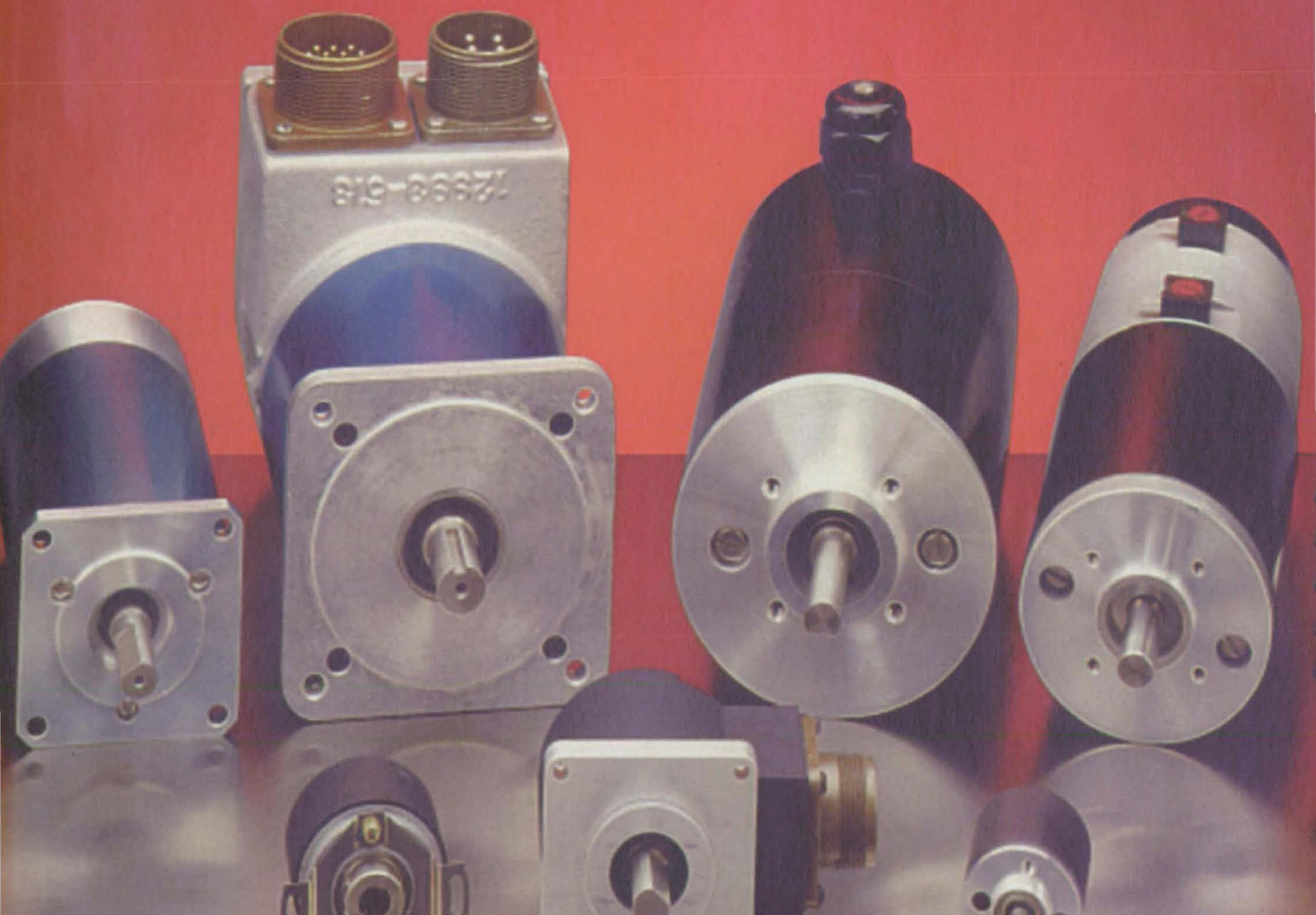
A software system generates sequences of commands for the operation of a robotic vehicle. The system was adapted to control Rocky 7, a semiautonomous instrumented vehicle of the "rover" type used in scientific exploration of Mars. The software system was developed by integrating two software systems reported in previous *NASA Tech Briefs* articles: Web Interface for Telescience (WITS) and Automated Scheduling and Planning Environment (ASPEN). WITS provides a high-level graphical interface, through which a user can specify scientific activities and locations by referencing to images of the environment of the robotic vehicle. ASPEN accepts the scientific goals specified by use of WITS, then reasons about the low-level activities and resources needed to attain these goals. ASPEN then generates an executable sequence of commands to perform the requested scientific observations; these include commands to travel to and/or between specified locations in order to arrive at locations where observations are to be performed. In generating the commands, ASPEN enforces flight rules and detects and resolves conflicts over resources by reordering scientific observations, adding required activities, and/or deleting low-priority observations. The further development of this software system is likely to include installation of the software in the rover itself to enable the rover to schedule its own activities, and thus to behave more autonomously.

This parogram was written by Gregg Rabideau, Steve Chien, Paul Backes, Gene Chalfant, and Tara Estlin of Caltech and Kam Tso of IA Tech, Inc., for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Software category.*

This software is available for commercial licensing. Please contact Don Hart of the California Institute of Technology at (818) 393-3425. Refer to NPO-20574.

February 2000

Motion Control Tech Briefs



Cover photo: Cleveland Motion Control Torque Systems offers the FLAMEMASTER Series of servo motion control products designed for welding and shape-cutting applications.

Software that Simplifies Machine Vision

National Instruments' pattern-matching program delivers performance gains.

National Instruments aims to simplify machine vision so that more test, measurement, and automation professionals can embrace vision as a measurement tool on the production floor. The company has developed easy-to-use, fast, and accurate IMAQ™ Vision pattern-matching software for inspection, guidance, alignment, and identification applications. The patent-pending software locates objects fast—more than ten times faster than traditional methods—and is very reliable. It locates objects even if they vary in size and orientation and are poorly illuminated, degraded in quality, and partially hidden from view.

The latest Automated Imaging Association survey states that 40 percent of all machine vision applications use some form of pattern matching. But National Instruments' is pattern matching with a difference. Because problems such as rotation, poor lighting, and out-of-focus cameras are common in production environments, NI software can be used in a wide range of applications. From guiding the assembly of a car door to aligning printed circuit boards and inspecting semiconductor wafers, NI pattern-matching software is delivering new vision solutions. There is a great need for robust, easy-to-use pattern-matching software because of the demands of the production environment and the unpredictable quality of ambient lighting. NI expects to its new software to find more and more applications in the automotive, semiconductor, pharmaceutical, and electronics industries.

Normalized cross-correlation has been a common approach for years to finding a template in an image. But this method has very low tolerance in searching for objects that undergo changes in angle of rotation, scale, and intensity. The correlation algorithms require millions of multiplication operations; hence the correlation process is time-consuming. A 100-x-100 template correlated to a 640-x-480 image consumes approximately 2.6 billion multiplications and additions. Still, the accuracy degrades with any changes in lighting, contrast, object scale, rotation, and defocusing. The user can speed up the matching process by reducing the size of the template or of the image to search. Overall, the normalized cross-correlation approach does not meet the speed and reliability requirements of many automation applications.

A New Approach

How does NI pattern matching work? Unlike cross-correlation techniques, a model of the template image is created using the minimum number of pixels that can best represent, or model, the image. These pixels, which essentially describe the template, are sampled in a smart nonuniform way. In many cases less than 2 percent of the pixels from the original template are used. The pixels are selected to retain geometric shape

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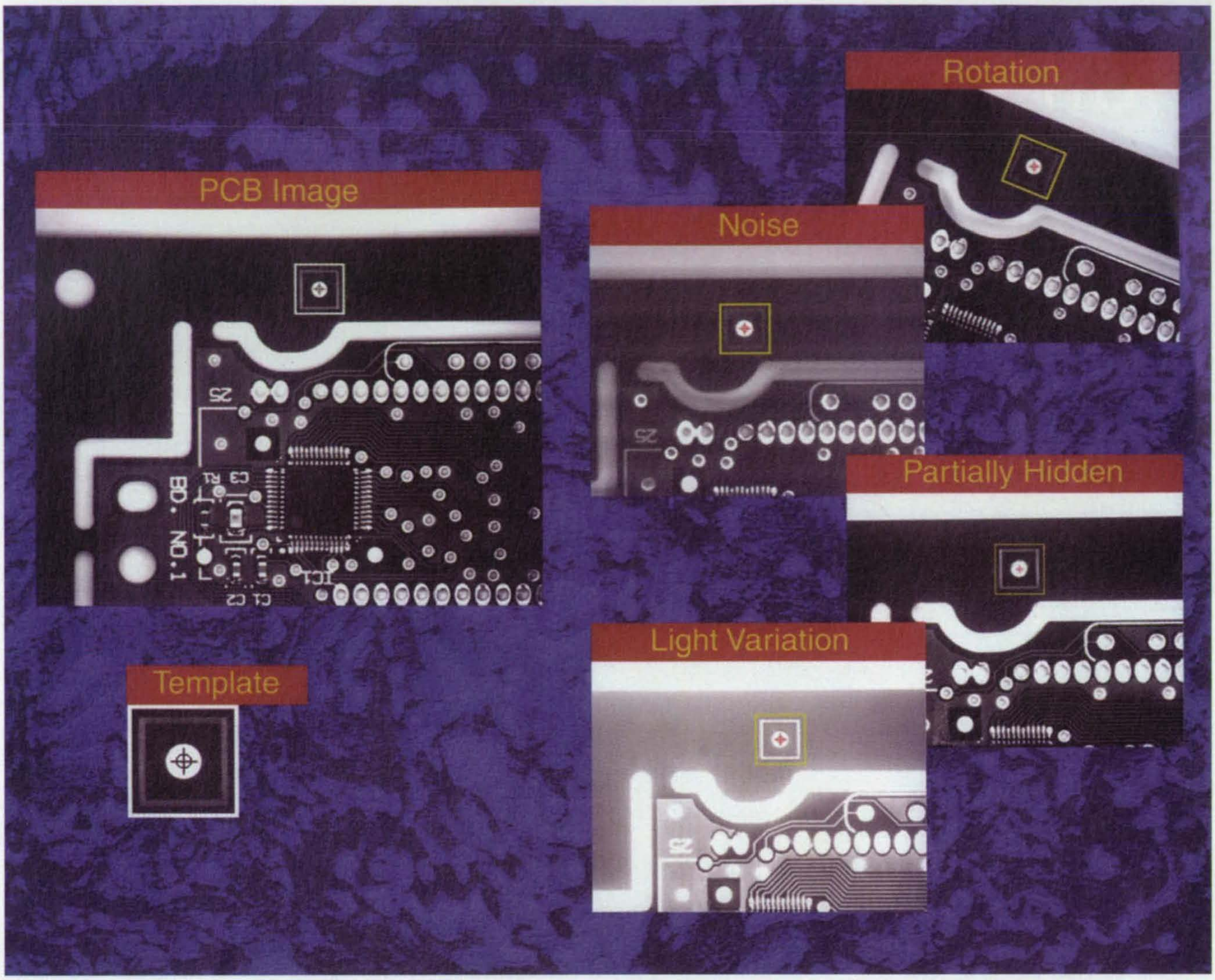

NI IMAQ™ Vision pattern matching locates objects quickly and accurately even when they are out of focus, at various angles, partially hidden, and scaled (varying in size by ±10 percent).

information, edge information, and background information about the template pattern.

NI pattern-matching software typically surprises experienced vision experts because it can find complex patterns in a full 640-x-480 image in less than 80 ms, and the objects can be at any orientation. Then the user can change the illumination, introduce blur by defocusing the camera, and partially hide the object, and still locate the object. A special option can limit the search to find objects that are not rotated. In this mode, the user can find objects in as little as 10 ms. These robust features are key in production environments because of inevitable process variations. With consistent patterns the user can demonstrate location accuracy of 1/40 of a pixel. The bottom line is that NI pattern matching delivers much more than a tenfold improvement in speed over traditional cross-correlation algorithms.

NI pattern-matching software makes vision easier to use. In the past, if the user had to locate a part at any orientation, developing the correlation software was difficult, and the search time could be very long. And if there were potential illumination variations and blurring, the user could not solve the problem with software. NI pattern-matching software is robust enough to handle the types of variations encountered in semiconductor, electronics, and automotive applications.

NI also offers two functions to simplify and speed up machine vision programming. The "learn" function is used to train the search engine, and the "search" function executes the pattern matching. In addition, with the interactive software Vision Builder, the user can quickly test the template on a sample set of images to prove the robustness and speed that is needed for the application. Vision Builder takes the guesswork out of template training and generates the vision code recipe for the application.

NI's pattern-matching virtual instruments quickly and accurately locate objects at high speeds. Typical search times average less than 40 ms, with spatial accuracy of 1/40 pixel and angle accuracy of 0.1 degree. These tools can learn template images in less than 3 seconds. Template height and width can vary from 8 to 16,000 pixels.

These tools work in poor lighting and when images are partially obscured. They find target images even when as much as 30 percent of the object is hidden from view. Finally, NI pattern-matching tools automatically recognize MMX-enabled computer chips for faster processing.

For more information, contact the author of this article, John Hanks, Vision Marketing Manager, at National Instruments, 11500 N. Mopac Expwy, Building B, Austin, TX 78759-3504; (512) 683-6840; fax: (512) 683-5569; e-mail: john.hanks@ni.com; www.ni.com.

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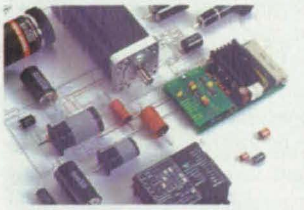

Our patented rhombic wound moving coil motors offer several advantages over conventional DC motors such as much longer brush life and extremely low electrical noise, low mechanical time constant for fast acceleration, low current consumption for extending battery life, no cogging for smooth rotation even at low speeds, and linear speed-torque constants for simple, accurate control.

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For more information, call or fax Mr. James Talent, Maxon Precision Motors, Inc., Burlingame, CA. Tel: 800-865-7540, Fax: 650-697-2887.

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Maxon's new A-max 12 mm (0.47 in) diameter motor delivers the performance and lifetime of a moving coil motor, but at a reduced cost due to improved automated manufacturing processes. The patented rhombic moving coil design provides for long life, low electrical noise, fast acceleration and high efficiency. The ironless rotor allows for zero cogging and simple accurate control. The motor is available either with a single shaft or with a passing shaft, and is rated at .5 or .75 watts. Other standard options include ball bearings/sleeve bearings, and terminals/leads. The motor length is 20.6 mm (0.81 in) and weighs in at 10 to 12 g (.35 to .42 oz) depending on configuration. Several different windings are available to match desired speed with available voltage. Ambient temperature range is from -30° to 85° C (-22° to 185° F), while the maximum efficiency is up to 71% depending on the winding. The maximum continuous torque from the motor alone is up to .99 mNm (.14 oz-in). Matching gearheads are also available with ratios ranging from 4:1 to 1,118:1 capable of delivering up to 530 mNm (75 oz-in) of intermittent torque. Matching encoders are also available.

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Circle No. 603

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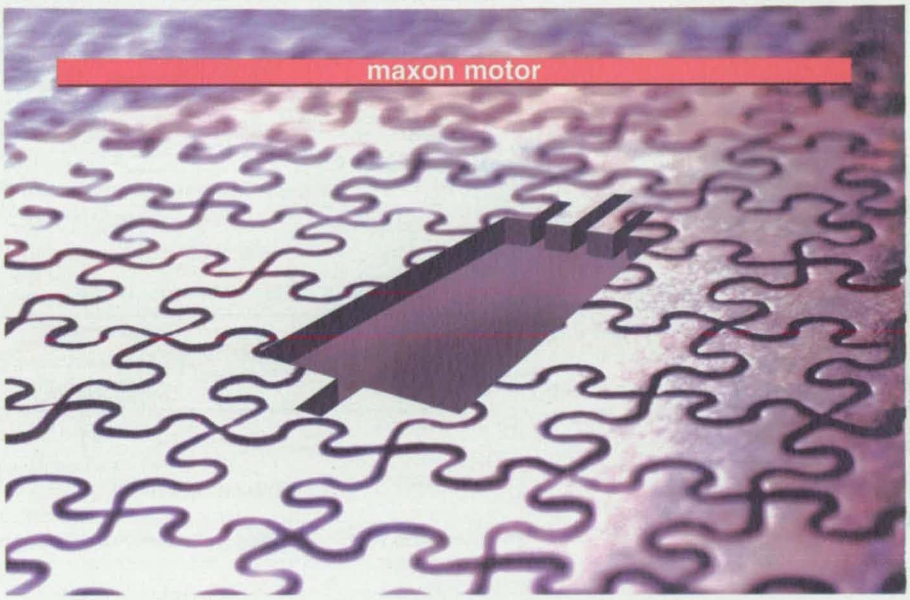
Maxon's new "EC" series of brushless motors are electronically commutated, thus enabling extremely long motor life, since there are simply no mechanical brushes to wear out. Hall effect sensors are built in to the motor in order to provide feedback to the control electronics. By assembling the motor such that the coils are outside the rotor, good heat dissipation and high overload capability are attained. Diameter is 60 mm (2.4 in) while the length is 173 mm (6.8 in). Continuous output power is 500 watts, while maximum speed is 7,000 RPM. Ambient temperature range is -20° to 125° C (-4° to 257° F). Utilizing high-energy neodymium magnets results in a very responsive mechanical time constant of 4 ms, while minimizing overall size. Using electronic commutation allows for minimum electrical noise; in fact these motors are CE approved, signifying electromagnetic compatibility in the European market. Motors are offered with both "Y" or "delta" configurations to optimize performance. Complementing the motors are gearheads with ratios from 3.7:1 to 307.5:1 capable of 180 Nm (132 ft-lb) of intermittent torque. Also offered are encoders, resolvers and brakes.

For more information, call or fax Mr. James Talent, Maxon Precision Motors, Inc., Burlingame, CA. Tel: 800-865-7540, Fax: 650-697-2887.

Circle No. 604



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For More Information Circle No. 605

Mass-Produced Hollow Cathodes Will Cost Less

Design changes preserve functionality while enhancing manufacturability.

John H. Glenn Research Center, Cleveland, Ohio

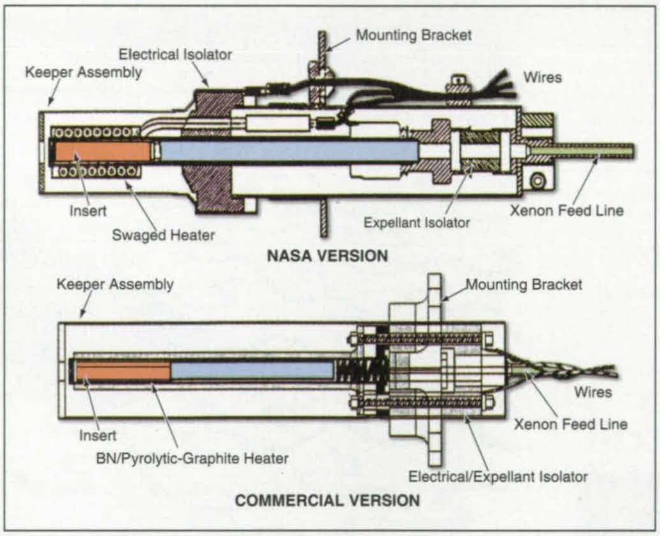
A commercial version of the NASA plasma-contactor hollow-cathode assembly (PC HCA) has been developed. The NASA PC HCA is a highly reliable hollow discharge cathode that is the most thoroughly understood, tested, and mature of all hollow cathodes that have been considered for use in electric spacecraft thrusters. The design of the commercial version preserves all the critical aspects of the technological heritage of the NASA PC HCA necessary for long-term, reliable operation, while incorporating changes that enable mass production at lower cost per unit. Beyond the original intended spacecraft application, the commercial hollow cathodes could prove useful on Earth in plasma research and plasma-based manufacturing processes.

Like the NASA PC HCA, the commercial HCA (see figure) is a plasma source that utilizes an Xe or an Xe/Kr mixture as the feed gas and operates in conjunction with several power supplies, which are typically included within a power processing unit. Both the original NASA design and the commercial version call for a barium-impregnated tungsten insert housed within a 0.25-in. (6.35-mm) molybdenum/rhenium tube, and a molybdenum/tantalum keeper assembly, and both designs share an identical geometry and construction throughout a front subassembly wherein all the critical functions of the HCA take place.

There are only two major differences between the NASA and commercial versions. The first is the substitution of an advanced, commercially available heater for a laboratory-type helical swaged heater used in the NASA version. The commercial heater is expected to resist vibration better than the swaged heater does. The heating element in the commercial heater consists of pyrolytic graphite deposited on chemical-vapor-deposited boron nitride ceramic. Heaters of this type are very lightweight and can be operated at extremely high power densities.

A unique characteristic of heaters of this type is that their electrical resistances decrease with temperature up to about 1,000 °C; this characteristic makes it practical to use constant-voltage (instead of constant-current) heater power supplies. Another characteristic of the heater design include low unit-to-unit variability and precise tailorability of resistance. The net benefit afforded by these characteristics is to make it possible to reduce the complexity (and thus the cost) of power-supply circuitry and to increase the reliability of the heater, relative to those of the NASA PC HCA.

The second major difference between the two designs lies in details of the internal construction and mounting configurations in a rear subassembly. Modifications have been made here to enable cost-effective mass production.



The **Commercial Version of the Hollow-Cathode Assembly** preserves the technological heritage of the NASA version, but can be mass-produced at lower cost.

This work was done by David Manzella of RMS Aerospace Engineering for **Glenn Research Center.**

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16658.

Adaptive Variable Bias Control for Magnetic Bearings

Power consumption is reduced, without sacrificing performance.

John H. Glenn Research Center, Cleveland, Ohio

Adaptive variable bias control (AVBC) is an improved technique for controlling the currents supplied to the electromagnets in magnetic bearings. In AVBC, the bias currents are varied in such a way as to reduce overall power consumption.

In a magnetic bearing (see Figure 1), the magnetic forces depend nonlinearly upon the currents flowing in the electromagnet coils and on the distances between the rotor and the stator poles. Because the magnetic forces are attractive only and decrease with increasing distances, magnetic bearings are open-loop unstable and, consequently, closed-loop control is necessary for stable operation. A conventional control scheme for a magnetic bearing includes the decomposition of the total current into a constant bias component and a varying command component in order to linearize the relationship between the command component and the force delivered by the bearing. Usually, such classical feedback control techniques as pro-

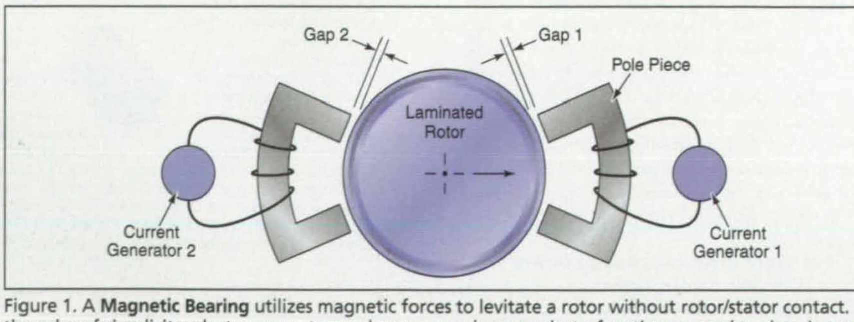


Figure 1. A **Magnetic Bearing** utilizes magnetic forces to levitate a rotor without rotor/stator contact. For the sake of simplicity, electromagnets are shown on only one axis; to function properly, a bearing must include electromagnets on at least two axes.

portional-derivative (PD) or proportional-integral-derivative (PID) are used.

Bias currents give rise to consumption of power, even when no loads are supported by the bearings. AVBC was developed as an alternative control technique in which bias currents, and thus power-consumption levels, are reduced. Another, closely related benefit of reductions in bias currents is reduction in overall generation and dissipation of heat (including eddy-current and hysteretic heating of rotors).

AVBC is based on the conventional bias method, but departs from that method according to the principle that by varying the bias current adaptively as needed, the power consumption in a bearing can be reduced while producing the desired force and maintaining the linearization afforded by using bias. The main static influence in changing the bias current is to change the static stiffness of the bearing. Dynamically, changing the bias current exerts two effects: the control laws depend on bias, and as the bias changes, the force-slew-rate limit changes. Inasmuch as there are many possible ways to vary the bias, adaptive control is introduced. Adaptive control in this application entails monitoring the operation of the magnetic bearing and determining, from the information thus acquired, the best setting for the bias current.

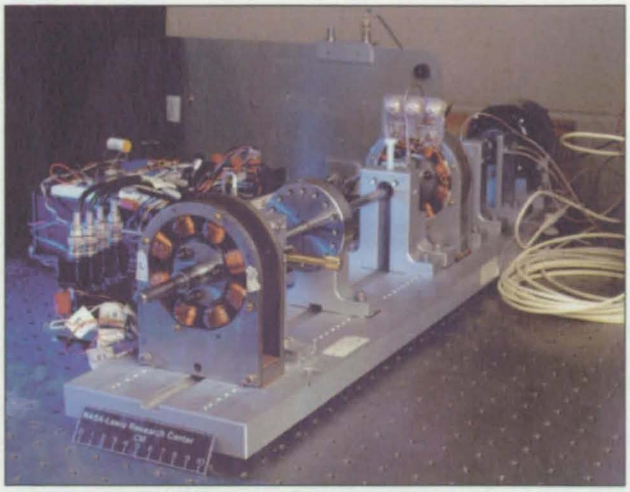


Figure 2. This **Eight-Pole Magnetic-Bearing Test Apparatus** was used in experiments on AVBC.

In this approach, the bias setting is not based on typical parameter estimation; instead, it is based on the commanded current. More specifically, the adaptation law is that the bias current is required to equal the average of the amplitude of the command current over a suitable interval of time. The net result is that an AVBC controller is primarily a PD controller with (1) a bias current that is varied and is usually less than it would be in an equivalent conventional controller and (2) a control gain that varies slowly with time and with the bias current. Theoretical calculations and experimentation (see Figure 2) have shown that AVBC is nominally stable and that in comparison with conventional bias control, AVBC yields reduced power consumption and comparable control performance.

This work was done by Dexter Johnson and Gerald V. Brown of **Glenn Research Center** *and Daniel J. Inman of Virginia Polytechnic Institute and State University. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Machinery/ Automation category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16748.

For More Information Circle No. 606

MEMICA: a Concept for Reflecting Remote-Manipulator Forces

Damping or resistance would be controlled electronically.

NASA's Jet Propulsion Laboratory, Pasadena, California

The term "mechanical mirroring using controlled stiffness and actuators" ("MEMICA") denotes a developmental concept for reflecting contact forces, displacements, mechanical damping, and temperature from the hand of a remote robotic manipulator back to the hand of a human operator who controls the manipulator. The MEMICA concept is expected to result in improvements in the remote control of robots in hostile environments, and may make it possible to perform remote surgery. The concept could also be applied to providing tactile sensations of objects in computationally simulated environments ("virtual reality") and to exercise machines. The MEMICA concept could be implemented by means of various operator interfaces (e.g., joysticks, knobs, or gloves). The purpose of developing MEMICA is to enable a human operator to feel, more realistically, the stiffness, temperature, vibration, and other tactile characteristics of objects to be remotely or virtually manipulated, thereby enhancing dexterity in remote manipulation or increasing the degree of perceived realism in a simulated environment.

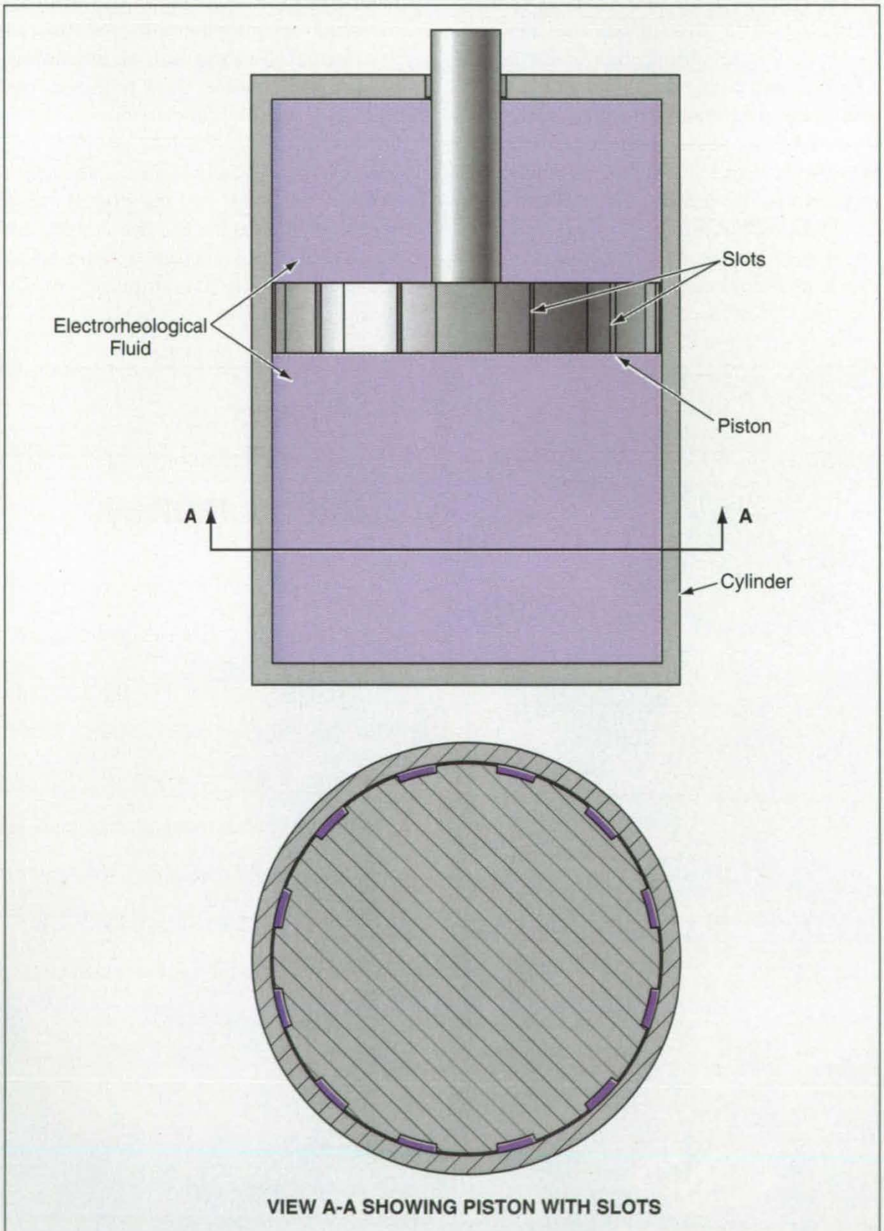


Figure 1. An **ECS Device** would resist elongation or shortening with a stiffness that would depend on the voltage applied across the electrorheological fluid flowing past the piston in the slots.

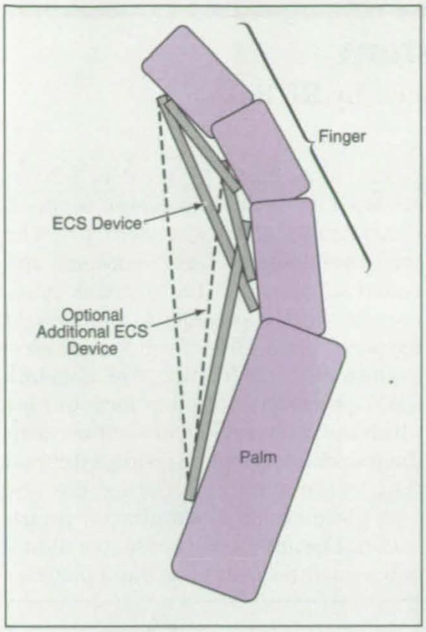


Figure 2. **ECS Devices** would mirror the stiffness distribution at the corresponding locations on a remote robot finger.

In a typical implementation of MEMICA for controlling a remote anthropomorphic robot hand, the robot hand would be equipped with actuators to generate the desired motions and forces, and would be instrumented with contact-force, temperature, and position sensors. The operator interface would be a glove instrumented with (1) mechanical actuators to reflect the displacements and the reaction (contact) forces; (2) operator-hand-action sensors, the outputs of which would be processed to generate commands for controlling the robot hand; and (3) thermoelectric heater/cooler units to provide thermal feedback from the robot hand. Thus, in a sense, the glove and the robot hand would mirror each other.

One of the major features that distinguishes the MEMICA concept from other concepts of force-reflecting robotic control is the proposed use of electrically controlled stiffness (ECS) devices at selected locations on the instrumented glove to mirror the forces of resistance to motion at the corresponding locations on the robot hand. An ECS (see Figure 1) would include a piston in a cylinder filled with an electrorheological fluid. Slots on the cylindrical piston surface would allow the liquid to flow past the piston during displacement of the piston. The slots would be lined with electrodes. The slots and electrodes would be dimensioned so that by application of voltage over a suitable range, the viscosity of the fluid, and thus the force of resistance of the piston to displacement, could be controlled over a desired range. Each finger of the glove would be equipped with ECS devices (see Figure 2) to generate reaction forces to apply the required force feedback to the operator's finger. The ECS part of the MEMICA concept is also potentially applicable to active damping of vibrations in "smart" structures.

While ECS devices could reflect resistance to motion, they could not actively reflect forces and displacements; that is, they could not reflect the action of something pulling or pushing on the robot hand and could not reflect vibrations. For active reflection of forces and displacements (including vibrations), it would be necessary to equip the glove with other actuators. Hydraulic, pneumatic, and shape memory alloy linear actuators have been considered for this purpose. An alternative linear actuator that might be used for this purpose would be, essentially, a motor-driven variant of a common curvature-stiffened metal tape measure.

This work was done by Yoseph Bar-Cohen and Benjamin Dolgin of Caltech and Charles Pfeiffer and Constantinos Mavroidis of Rutgers University for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Machinery/Automation category.* *NPO-20642*

Radio-Frequency Wireless Flight-Control System

Mechanical-cable, hydraulic, and wire control links would be replaced by RF links.

Dryden Flight Research Center, Edwards, California

Technological advances have driven the evolution of aircraft flight-control systems. In the dawn of 20th-century aviation, the Wright Brothers used cables and warping of wing surfaces to change the shapes of flight-control surfaces. As engineers designed aircraft capable of flying faster, higher, and farther, the forces needed for controlling the aircraft surpassed the physical abilities of pilots. Hydraulics were introduced to provide the pilot with the capability to manipulate the flight-control surfaces on the wings and tail of the aircraft. NASA Dryden Flight Research Center (DFRC) has been instrumental in effecting the continuing evolution of aviation technology by exploring ways of replacing hydraulics with "power by wire" actuators; an instance of this effort was reported in "Designing Electrically Powered Actuators for Aircraft" (DRC-96-09), *NASA Tech Briefs*, Vol. 21, No. 10 (October 1997), page 84.

On the verge of the next millennium, NASA DFRC is once again involved in the next major aviation milestone: a wireless flight-control system (WFCS), in which radio-frequency (RF) links would supplement or supplant wire flight-control connections. The ultimate goal is to develop a closed-loop WFCS that will be used to either (1) back up a wired system and provide redundancy for enhanced safety and reliability or (2) replace the wired system and decrease the size, weight, and cost of the affected aircraft.

The WFCS concept (see Figure 1) involves the insertion of spread-spectrum RF data links into the communication paths between the flight-control computers (FCCs) and the actuators for the flight-control surfaces at the ailerons, rudder, and elevators. For a demonstration of the feasibility of this concept, a prototype system (see Figure 2) was designed and demonstrated on the F-18 Iron Bird test facility at Dryden Flight Research Center to establish the ability of the RF links to provide adequate control capability. For demonstration purposes, the testing was limited to the signal paths between the FCCs and an aileron on the Iron Bird.

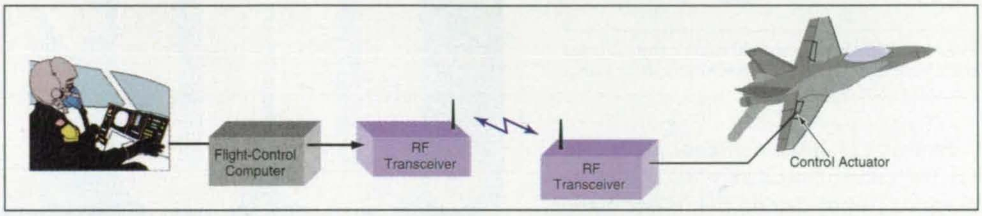


Figure 1. **Spread-Spectrum RF Data Links** would supplant or supplement wire communication links between the flight-control computer and the actuators for the flight-control surfaces.

The RF hardware in the test system includes an input module that receives and sends analog signals to and from the FCC and the control-surface actuators. These analog signals are converted to and from digital values by analog-to-digital and digital-to-analog circuits. The converted analog signals are passed to buffers that are set up in the memory spaces of WFCS computers. From these spaces, digital control movement data are encoded into messages that contain the movement information as well as synchronization and channel-identification data. These messages are then passed to the baseband processor of a spread-spectrum radio transceiver. Here, the baseband data are multiplied with randomized redundant data and sent to a modulation processor.

The modulation processor commands the RF section of the transceiver by phase-encoding the data "chips" to be transmitted. The RF section then transmits the data via a phase-modulated carrier signal. The receiver performs the inverse process that results in an analog signal that replicates the analog command input from the FCC.

For the proof-of-concept test, the data-link hardware was constructed in "breadboard" form. There was no attempt to miniaturize the hardware at this stage of development. The idea was only to prove that the bandwidth of the spread spectrum was sufficient to satisfy a requirement for timing in an inner control loop. Power for the data link was provided by bench-top power supplies. Considerable effort was spent to make the power-supply lines between the bench supplies and the data-link hardware as short as possible so as to shield the power supply lines from outside electromagnetic interference. The data-link transceivers were placed at locations for which there was no line of sight between the transmitting and receiving antennas; thus, communications during the test took place entirely by multipath propagation. The antennas were simple monopole structures with no ground planes.

The WFCS hardware was completely software-driven, with the exception of the analog input and output needed to satisfy the analog front ends on the FCCs and the actuators. The software was designed carefully to maintain a minimum of phase and latency error while sampling the control signals at sufficiently high rates to insure accurate representations of the waveforms without filtering that would inherently introduce phase errors. Analog signals were captured from several locations in the system during the test to verify that the wireless system was reproducing the analog control signals with adequate fidelity. Manual commands were also used to test the full dynamic range of the wireless system and its ability to move the aileron to its maximum extent.

The system performed reliably after installation and debugging. Noise was reduced by shielding the power-supply wires against electromagnetic interference along their full lengths. Junction boxes that contained pass-through wiring were covered by foil tape; this provided shielding against electromagnetic interference (including RF interference) for the signal paths that remained hardwired. Considerable experimentation was done to explore the size and distribution of the near-field diffraction and interference patterns associated with the hangar and the placement of the airframe in the line-of-sight path between the wireless transceivers.

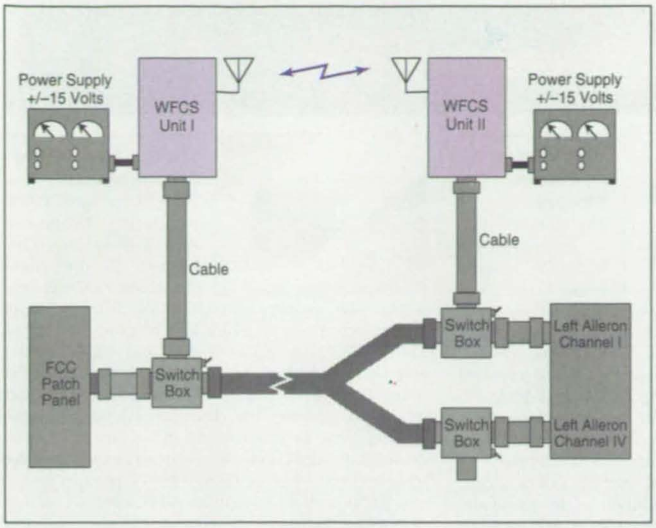


Figure 2. **A Prototype WFCS System** was tested to establish the capabilities of its RF link. The testing was limited to the signal paths between the FCCs and the actuator of one aileron.

The wireless system provided control of the aileron that was equal to the control provided by the production system supplied with the aircraft. The hardware was switchable into and out of operation at any time. One box controlled the signal paths through the aileron actuator. Another box controlled the signals from the FCC. When the control switches were placed in the "pass through mode" position, the Iron Bird flight-control system operated normally. When the control switches were placed in the "RF mode" position, the WFCS digital RF data link passed the control data for the actuator servo valve to control movement of the aileron.

The WFCS was tested for frequency, stability, and amplitude response, using the same test criteria ordinarily used to determine the fitness of the aircraft for flight. The RF system satisfied all the closed-loop-control timing requirements. The RF spread-spectrum system operated in under the non-line-of-sight condition throughout the test, with no direct path between the transceivers. In fact, the devices were positioned so that the entire bulk of the F-18 was in the center of the direct path between the two transceivers.

The demonstrated feasibility of the prototype system provides a solid base on which to proceed to the next stage of development. Future efforts will include more extensive testing in progressive phases and implementation of carrier suppression and code diversity multiple access (CDMA) techniques. The development effort is expected to culminate in a flight test that will include flight-dynamics demonstrations with and without the RF system in operation. The test is also expected to include operations in jamming environments designed to simulate worst-case accidental interference conditions.

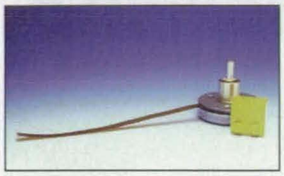
This work was done by Sangman Lee, Linda Kelly, and Arthur Lavoie of **Dryden Flight Research Center** *and Karl Kiefer and Kevin Champaigne of Invocon Inc. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Systems category.*

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:

Karl Kiefer
Invocon Inc.
19221 IH-45 South Ste. 530
Conroe, TX 77385.

Refer to DRC-99-08, volume and number of this NASA Tech Briefs *issue, and the page number.*

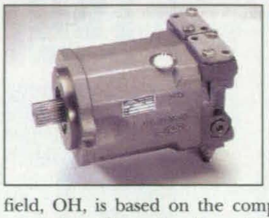
New Products



3-W Brushless "Pancake" Motor

Maxon Precision Motors, Burlingame, CA, offers a new series of brushless "pancake" motors that are electronically commutated. The EC series has no mechanical brushes to wear out, enabling extremely long motor life, according to the company. The motor weighs 32 g (1.13 oz.) and is 32 mm in diameter, and the length of the body excluding shaft is 8.9 mm. Continuous output power is 3 W, and maximum speed is 12,000 rpm. Maxon says good heat dissipation and high overload capability are assured by the motor's construction, with the coils outside the rotor. Hall-effect sensors are an option.

For More Information Circle No. 781



High-Pressure Hydraulic Motors

The HMF02 series of high-pressure hydraulic motors from Linde Hydraulic Corp., Canfield, OH, is based on the company's patented 21° technology. The series offers a 7250-psi peak pressure capability, continuous operating pressure of 6090 psi, and a nominal operating pressure of 5000 psi. Six models make up the HMF series, with displacements of 28 cc/rev up to 135 cc/rev, for either open- or closed-loop applications. The series offers several options: the choice of ANSI or SAE spline shafts, purge/flushing ability to maintain oil temperature, high-pressure relief valves, and ISO high-pressure axial or radial port locations.

For More Information Circle No. 782

Charge Mode Ring Accelerometer

The Shock and Vibration Sensors Division of PCB Piezotronics Inc., Depew, NY, introduces the Model 357A05 that works with existing charge amplifiers or in-line charge converters in shock and vibration testing to ±500 g pk. With a low-profile ring configuration and through-bolt mounting, the unit, housed in titanium, is 0.4 in. tall, 5/8-in. in diameter, and weighs 12 grams. The shear-mode piezoceramic sensing element generates 15 pC/g with a frequency range to 12,000 Hz. The company says that the temperature range of -65 to +350 °F permits a variety of uses such as automotive NHV, thermal cycling in environmental test chambers, and on and around hot machinery.

For More Information Circle No. 783

Metric Linear Motion System

Bishop-Wisecarver Corp., Pittsburg, CA, now offers its Lo Pro linear motion system in a metric configuration. Lo Pro combines Dual-Vee wheels and track in an engineered modular system that can include belt, chain, lead screw, ball screw, and pneumatic drive options. The system can attain speeds of 12 m/s and loads of 26,000 N radial and 40,000 N thrust. The Lo Pro has been built in lengths exceeding 18 meters. The company recommends Lo Pro for fiberboard lines, plasma and laser cutting tables, high-speed textile operations, and pulp and paper processing, among other applications.

For More Information Circle No. 784

Right-Angle Servo Gearmotors

Bayside Motion Group, Port Washington, NY, says its new Stealth right-angle servo gearmotors are designed for high torque and compactness. They combine a brushless DC motor with helical planetary gearing. Available in 60-, 90-, and 115-mm frame sizes, they have ratios from 3:1 to 10:1. Bayside points out that the motor shaft of the integrated unit contains the actual input gear, ensuring perfect alignment and smooth operation while providing significant noise reduction.

For More Information Circle No. 785

Driver/ Controller/ Motor System

The new driver/controller/motor motion control system from Nyden Corp., San Jose, CA, integrates NEMA size 17 high-torque stepper motors and the PLG240 programmable bipolar stepping motor driver/controller. They are available in 11 volt-amp and winding combinations for integration into existing designs. Rated volts go from 0.9 to 7.4 DC per phase, and amps go from 1 to 4.7 per phase. An embedded microcontroller in the controller/driver allows for communication with a host PC. The system is designed for such applications as pick-and-place, linear and rotary stages, circuit-board testing, and medical equipment.

For More Information Circle No. 786

Linear Positioning Table

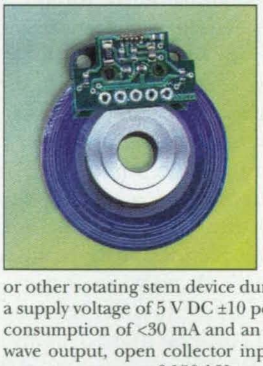
Industrial Devices Corporation, Petaluma, CA, introduces the CE6 continuous-duty linear positioners, which feature recirculating ball/cylindrical rail bearings, helicoil-reinforced fixture holes, and a black anodized finish. They offer leadscrew or ballscrew drives with 0.1-in. to 0.5-in. lead, travel to 24 in., straight-line accuracy to 0.0005 in. per inch of travel, and bidirectional repeatability to 0.0002 in. Load capacity is up to 100 lb. and linear speed is up to 20 in./s. Options include accuracy to 0.00025 in./in., x-y assembly with orthogonality of 60 arcsec, and extended travel to 48 in.

For More Information Circle No. 787

360° Thread Sealant

ND Industries Inc., Clawson, MI, calls its ND ST-3™ thread sealant a tough, resilient material for fasteners with straight or tapered threads. It is dry to the touch, seals instantly, and forms a custom-fitting elastic gasket that prevents the passage of most fuels and chemicals and helps keep joints tight even under severe vibration. It resists natural gas, butane, propane, and motor fuels. A specific application, shown in the photograph, is the preapplication 360° around the internal threads of large nuts for automotive differentials.

For More Information Circle No. 788



Modular Rotary Encoder

CUI Stack Inc., Beaverton, OR, describes its MG30 modular rotary encoder as a compact two-part kit with all housing hardware stripped away, making it easy to mount to a motor or other rotating stem device during assembly. It uses a supply voltage of 5 V DC ±10 percent, has a current consumption of <30 mA and an incremental square-wave output, open collector input, a maximum frequency response of 150 kHz, and resolutions up to 2000 lines per revolution digital output (8000 counts/rev in quadrature).

For More Information Circle No. 789

Compact Indexers for Positioning Applications

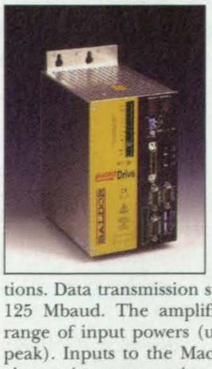
Aerotech Inc., Pittsburgh, PA, announces the BA Intellidrive series of compact indexers. The company says that they operate in indexing and teach modes to drive brush and brushless servomotors, and provide low-cost control for many simple positioning applications. The series has analog and RS-232 interfaces, and accepts standard clock and direction inputs for stepping-system replacements. Simple programs are stored in the indexer and executed in macro form. The device can also accept commands via RS-232 for immediate execution. It is available with continuous output currents from 5 to 50 A and up to 100 A peak.

For More Information Circle No. 790

Open-Loop/Closed-Loop Control System

Baumuller LNI, Bloomfield, CT, says that the operating capabilities of its new Omega configurable open-loop and closed-loop control system with integrated drive technology include high speed, modular component flexibility, a single application development system, and a library of technology modules for efficient programming. The Omega system can close the position loop of motion control systems in 62.5 microseconds. The technology modules include winding functions, synchronous motion, adjustable gearing, dancer control, static control, electronic cam, and additional PLC functions.

For More Information Circle No. 791



Amplifier for Brushless Servo Motors

The new MacroDrive amplifier from Baldor Electric Co., Fort Smith, AR, interfaces with any motion controller that uses a macro, the proprietary interface developed specifically for control of high-speed communications. Data transmission speeds can reach as high as 125 Mbaud. The amplifier is available in a wide range of input powers (up to 15 A continuous, 2X peak). Inputs to the MacroDrive are PWM voltage, electronic commutation, and current loop commands. A fully protected unit, the MacroDrive comes with UL and CE approval.

For More Information Circle No. 792

Materials

Protective Shells for Composite Overwrapped Pressure Vessels

These laminated shells are lightweight, inexpensive, and removable.

Lyndon B. Johnson Space Center, Houston, Texas

White Sands Test Facility (WSTF) scientists have developed an energy-absorbing laminated shell that is a prototype of lightweight, inexpensive, and removable covers to shield and otherwise protect carbon-composite overwrapped pressure vessels (COPVs). Although COPVs are superior to metal vessels in strength and weight savings, shielding and other protection are needed because COPVs are highly susceptible to damage by impacts.

The present protective shell is not only an energy-absorbing laminate that can shield a COPV against damage by impacts but is also instrumented with a piezoresistive force sensor that can be configured as an alarm indicator to warn of impacts that exceed a threshold level. Shells like this one will thus prove invaluable not only to spacecraft and launch vehicles but also to manufacturers of composite structures (e.g., pressure vessels, support structures, aerospace surfaces, and life support vessels); moreover, utility may extend to the automotive industry, wherein protective shells for COPVs could protect fuel tanks against ruptures following severe impacts.

Spacecraft and launch-vehicle designers are increasingly storing high-pressure gases and liquids in COPVs. These vessels are fragile and can be easily damaged by being dropped, by rough handling, or by impacts of dropped tools. Ensolite foam has been used until now to provide some measure of protection. But WSTF studies have concluded that Ensolite foam alone affords scant protection against appreciable impacts. Indeed, the experiments have shown that when a COPV is shielded only by Ensolite foam, when an impact occurs at a speed of about 19 m/s, a maximum deflection of 0.156 in. (3.96 mm) takes place at about 7 ms later, and the impact leaves a permanent deformation of 0.015 in. (0.38 mm). In practice, such damage would necessitate replacement of a COPV — a costly proposition and a potentially hazardous practice in space flight. The WSTF test program has also revealed that COPV unprotected except for a layer of Ensolite foam can be severely degraded by an impact at an energy of 35 ft-lbf (47 J). Thus, the WSTF test program has revealed a need for protection better than that afforded by Ensolite foam.

The present energy-absorbing laminated protective shell has been developed to satisfy this need. This shell has several novel features: Aluminum mesh foam is used as an energy-absorbing material to reduce deflection damage; a composite hard shell material is used to absorb indentation energy; and the aforementioned piezoresistive force sensor is used to indicate impacts with energies above 15 ft-lbf (20 J) — the threshold energy level tested by WSTF. (In research and development to advance the design of the shell, the piezoresistive force sensor has also been used as an oscilloscope trigger.)

The laminate comprises four layers, each performing a specific function: (1) a 0.5-in. (12.7-mm)-thick Ensolite foam layer; (2) a 0.05-in. (1.3-mm)-thick composite inner shell; (3) the aluminum mesh foam layer, which is 0.5 in. (12.7 mm) thick; and (4) a 0.375-in. (9.5-mm)-thick composite hard shell. Ensolite foam gives protection against scuffing; the composite inner shell provides a flat, rigid surface on which the aluminum foam rests; the aluminum foam absorbs most of the impact force from compression; and the composite outer shell prevents penetration by sharp objects. The piezoresistive force sensor is embedded between the Ensolite foam and composite inner shell layers.

In a test performed on a COPV protected by this shell, an impact occurred at a speed of about 20 m/s and a maximum deflection of 0.05 in. (1.3 mm)

For More Information Circle No. 424

took place at about 6 ms later. No permanent deformation remained after the test. These results demonstrate a significant improvement over a COPV shielded with Ensolite foam alone.

This work was done by Ralph M. Tapphorn and Tim E. Roth of Rockwell Space Operations for **Johnson Space Center.** *MSC-22762*

Nonevaporable Getters To Maintain Vacuum in Sealed MEMS

These getters would prolong operational lifetimes.

NASA's Jet Propulsion Laboratory, Pasadena, California

Nonevaporable getters have been proposed for use in maintaining vacuum inside hermetically sealed microelectromechanical systems (MEMS) that rely on vacuum for proper operation. A vibratory microgyroscope is an example of such a MEMS. The proposed getters could also be used in such vacuum components as cathode-ray tubes, microwave tubes, conventional electron tubes, plasma display devices, particle accelerators and colliders, vacuum thermal insulation, ultrahigh-vacuum systems for processing semiconductors, x-ray tubes, lamps, and field-emission display devices.

The need for getters arises as follows: Over time, the vacuum inside a sealed MEMS (or inside any other sealed vacuum device, for that matter) is degraded by outgassing of common atmospheric gases and packaging-material vapors from the surfaces of the vacuum chamber, and by diffusion and/or microleaking of these and other gases. Getters are materials that help maintain vacuum by chemically sorbing gases. Getters have been used in vacuum electron devices since the early years of electronic technology, but until now, there has been little systematic effort to incorporate them into MEMS.

The proposed getters would be components of the MEMS vacuum packaging in which they would be installed. They could be fabricated in simple planar shapes or in more complex three-dimensional shapes. They would be made from Zr-Al-Fe, Zr-V-Fe, or other suitable materials (SAES Getters USA Inc., CO, USA). They would be made highly porous to facilitate access of gases and to provide high active surface area for sorption. The getters would be required to be mechanically stable in the sense that they must endure any vibrations or shocks during use and must not shed particles (which could interfere with MEMS functions) at any time during fabrication, activation, or use.

In general, getters must be activated prior to use. Activation is an integral part of the process of fabrication of the device in which a getter is installed. A getter of the proposed type would be handled, installed, and activated according to the following instructions:

1. A getter should be handled only with clean tools or with rubber or plastic gloves, and never with bare hands.
2. A getter could be cleaned by ultrasonic agitation in highly pure isopropyl alcohol for a few seconds, then dried in an oven.
3. For long-term storage, a getter should be placed in a clean, dry environment; e.g., a phosphorus pentoxide or silica gel dessicator or a dry nitrogen atmosphere.
4. Weld the getter into the MEMS package according to the fabrication procedure for the particular MEMS design.
5. Apply a vacuum pump to the MEMS until the pressure in the vacuum chamber in the MEMS is $<10^{-6}$ torr ($<10^{-4}$ Pa).
6. Activate the getter by heating.
   (a) The activation parameters are temperature, time, and method of heating; the amount of time spent at a constant activation temperature is very important.
   (b) The temperature of the getter should be monitored by use of thermocouples, at least until the heating parameters (e.g., heater power and time) that yield the required activation temperature for the required time have been established.
   (c) The rate of heating during activation should be controlled to prevent excessive outgassing.
   (d) Monitor the maximum pressure during activation to obtain an indication of the gas content of the getter.
7. Allow the getter to cool to its test temperature while still pumping.
8. Carefully pinch off and seal the vacuum chamber in the MEMS package.

This work was done by Rajeshuni Ramesham of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Materials category. NPO-20617*

Spherical-Coordinates Encoder Module

Three-dimensional offsets can be measured with ease.

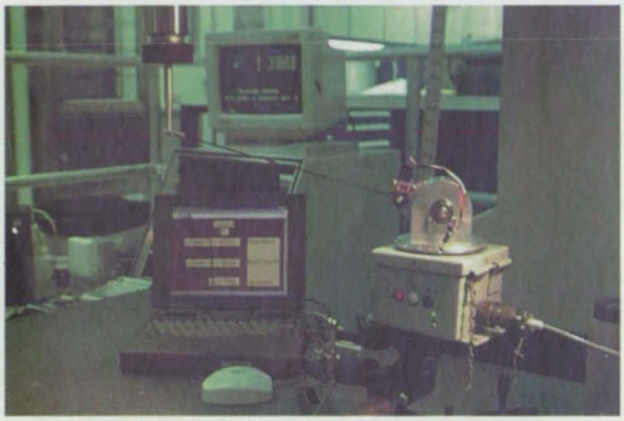
John F. Kennedy Space Center, Florida

The spherical-coordinates encoder module (SCEM) is a relatively simple and inexpensive electromechanical apparatus for quickly and easily measuring three-dimensional offsets between objects at distances of the order of a few feet (≈1 m). The SCEM was developed specifically for measuring offsets between spacecraft payload trunnions and trunnion supports during ground-based payload-transfer operations; it could also be readily used, for example, to measure offsets to guide the maneuvering of large objects during the assembly of heavy machinery or structures. The SCEM eliminates the need for time-consuming, tedious, error-prone measurements by use of such tools as scales, tapes, and protractors, followed by equally tedious and error-prone manual calculations, manual recording of data, and verbal communication of data.

The SCEM is so named because the raw measurement data that it produces are essentially spherical coordinates. The SCEM includes a mechanical unit, part of which rotates about a nominally vertical and a nominally horizontal coordinate axis (see top part of figure). The coordinate axes are defined by mating of the nominally stationary base of the mechanical unit with a mounting bracket on the first of the two objects, the offsets between which one seeks to measure. The mechanical unit contains a spring-loaded reel, on which is wound a 0.25-in. (6.35-mm) timing belt. Two optical encoders measure the rotations about the vertical and horizontal coordinate axes (azimuth and elevation angles, respectively). A third optical encoder measures the rotation of the reel for determining the length of timing belt pulled off the reel and thus the radius from the origin of coordinates to the tip of the outstretched belt.

To perform a measurement, a technician simply pulls the wire from the wheel and places the tip of the wire on the point of interest on the second of the two objects, the offset between which one seeks to measure (see bottom part of figure). The spring tension keeps the belt straight and pulls the rotating part of the mechanical unit into

SCEM Mechanical Unit



SCEM IN USE

The **SCEM** is an electromechanical apparatus for measuring three-dimensional offsets. To measure the offset of a nearby object, one simply stretches a spring-tensioned wire from the unit to the object.

an orientation along the offset vector of interest. Thus, the azimuth and elevation optical encoders provide data on the offset direction, while the reel optical encoder provides data on the offset radius.

The outputs of the optical encoders are fed to a portable computer, which is programmed with data-collection and user-interface software. The software includes components that implement the trigonometric formulas of transformation from spherical to Cartesian coordinates. The offset in Cartesian coordinates is displayed on the computer screen.

The mechanical unit fits within a 7.5-in. (19-cm) cube. At a radial offset of 18 in. (45.7 cm), the SCEM can measure azimuth angles from 0° to 340°, accurate to within an 0.30°; and it can measure elevation angles from 10° to 100°, accurate to within an average of 0.300°. The SCEM measures radius to within an average of 0.005 in. (0.13 mm). The basic SCEM can be expanded to include as many as 18 to 20 mechanical units communicating with a single computer. The information displayed on the computer screen can be updated at a rate of four times per second.

This work was done by Eduardo Lopez Del Castillo and Felix A. Soto Toro of **Kennedy Space Center.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Mechanics category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Technology Programs and Commercialization Office, Kennedy Space Center, (407) 867-6373. Refer to KSC-11973.

For More Information Circle No. 427

For More Information Circle No. 408

Bio-Medical

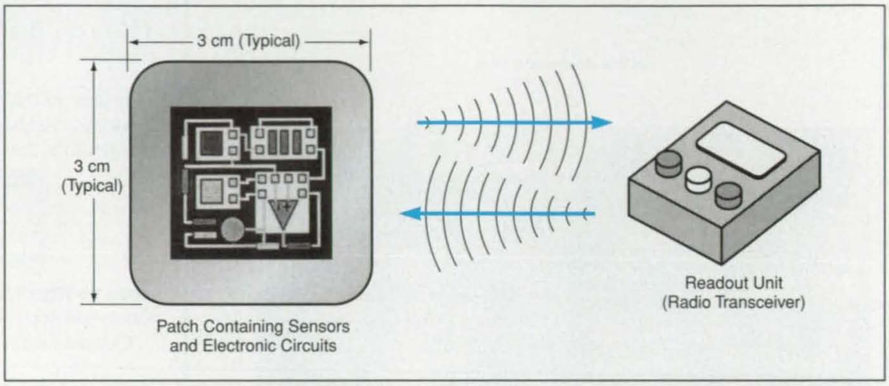
Wearable Sensor Patches for Physiological Monitoring

Noninvasive sensors resembling adhesive bandages would be interrogated by nearby hand-held units.

NASA's Jet Propulsion Laboratory, Pasadena, California

Wearable sensor patches — miniature biotelemetric units — have been proposed for use in measuring temperature, heart rate, blood pressure, and possibly other physiological parameters. The sensor patches would be small and could be mass-produced inexpensively by use of state-of-the-art techniques for batch fabrication of integrated circuits and microelectromechanical systems.

Each patch would be no larger than a few centimeters on a side — comparable in size to an ordinary adhesive bandage. The patch could even be held on the wearer's skin by the same adhesive as that used on bandages. The patch (see figure) would contain a noninvasive microelectromechanical sensor integrated with electronic circuitry that would process the sensor output and transmit a radio signal modulated by the processed sensor output.



Microelectromechanical Sensors and Electronic Circuits for radio telemetry would be contained in a small patch worn on the skin. A nearby hand-held radio transceiver would provide radio-frequency excitation to energize the circuits and would receive the sensor-readout radio signal from the patch.

The patch would not contain a battery. Instead, the patch would contain a circuit for extracting power from an incident radio beam that would be present during readout. For readout, a hand-held radio transceiver would be positioned near the patch; the transceiver would transmit the radio beam to supply power to the patch circuitry and would receive the modulated radio signal transmitted from the patch.

This work was done by Gisela Lin and William Tang of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Bio-Medical category.*

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

Technology Reporting Office
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Pasadena, CA 91109
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Refer to NPO-20651, volume and number of this NASA Tech Briefs *issue, and the page number.*

Improved Sensor Pills for Physiological Monitoring

These pills would measure temperature and sense the presence of blood, bacteria, and chemicals.

NASA's Jet Propulsion Laboratory, Pasadena, California

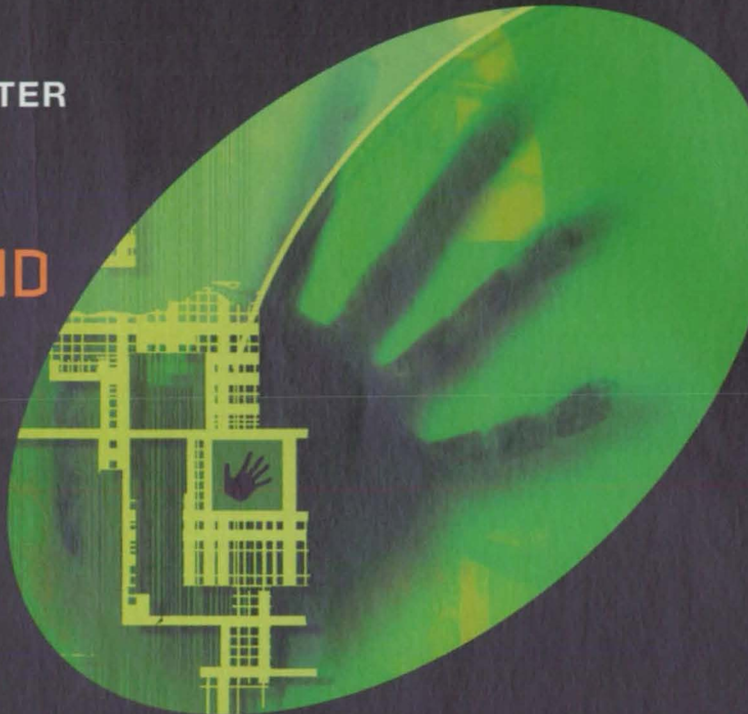
Improved miniature biotelemetric units resembling large pills have been proposed for use in physiological monitoring of the gastrointestinal tract. The broad principles of design, operation, and inexpensive mass production of these sensor pills would be the same as those of the sensor patches described in the preceding article. Of course, the details of design and operation would differ because the patches and pills would be used in different locations and would sense different phenomena.

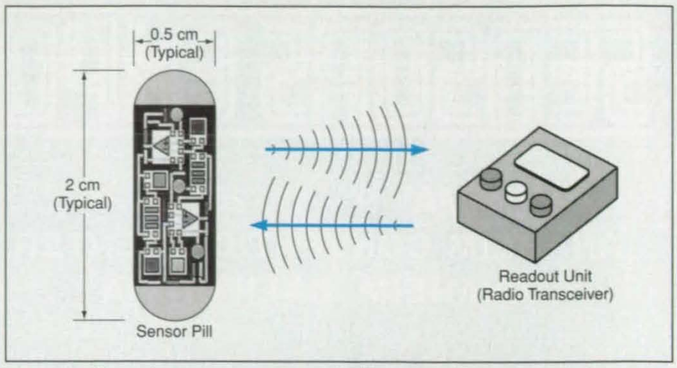
A sensor pill would be swallowed and would pass through the gastrointestinal tract in about 24 hours. Like the sensor patches described in the preceding article and like some sensor pills now available commercially, a sensor pill of the proposed type would emit a radio signal that would convey its sensor readings to an exterior monitor. Like some other commercially available sensor pills, the proposed sensor pills could include reservoirs of drugs and actuators to deliver the drugs to designated sites.

The proposed pills would incorporate some advances beyond the commercial units. The only sensor readings provided by the commercially available sensor pills are temperature measurements. The proposed sensors would also provide indications of the presence of blood, bacteria, and chemicals of interest. Unlike the commercial sensor pills, the proposed sensor pills would not contain batteries. A sensor pill of the proposed type would be interrogated by use of a hand-held radio transceiver, and would derive its power from a radio beam emitted by the transceiver (see figure), in the same manner as that of a sensor patch described in the preceding article.

The pH sensors would most likely be based on ion-sensitive field-effect transistors (ISFETs), integrated onto the same chips that contain the communication circuits. The temperature sensors could also be integrated onto the same chips.

The bacteria sensors would exploit surface acoustic waves on membranes





A **Large Pill** would contain sensors and electronic circuits for radio telemetry, and perhaps devices for local delivery of drugs. The pill would be interrogated and/or controlled by use of a hand-held radio transceiver. Recent developments in integrated circuits and microelectromechanical system would be exploited in designing and fabricating improved sensor pills.

coated with antigens to the species of interest (for example, H. pylori — the species that causes gastrointestinal ulcers). The bacteria of interest would either attach themselves to the antigens on the membrane or else pull the antigens off; in either case, the result would be a change in the mass of the membrane and thus a change in the acoustic resonance frequency.

Most likely, the sensory areas on a pill would be protected by a cap or by a single-use coat made of a biocompatible polymer, until the time for sensor readings. In preparation for sensor readings, a microelectromechanical actuator could remove a cap; alternatively, a polymer coat could be melted or could be torn off by a microelectromechanical actuator. In the case of an array of sensors, the polymer coat could be removed from any or all sensor(s) at the same time or at different times; thus, even if the sensors were single-use devices, it would be possible to take readings at different times.

This work was done by Gisela Lin, William Tang, and Linda Miller of Caltech and Shlomo Raz of UCLA Medical School for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Bio-Medical category.*

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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Refer to NPO-20652, volume and number of this NASA Tech Briefs *issue, and the page number.*

Urine-Sample-Collection Device for Use on the Space Shuttle

Lightweight design, small size, and ease of use encourage routine collection of samples.

Lyndon B. Johnson Space Center, Houston, Texas

The in-flight urine collection absorber (IUCA) is a Johnson Space Center (JSC) breakthrough. It features a lightweight, compact design and is easy to use for collection of urine samples by male and female space shuttle crewmembers. The IUCA is superior to currently available hardware for flight urine-sampling protocols that do not require measurement of sample volumes. In addition, its lightweight design makes it desirable for space flight, where weight is a prime concern. Its utility has been confirmed in tests employing stable isotopes (oxygen-18 and deuterium) conducted at JSC. These tests showed that the IUCA, which can be placed in either male or female urine-collection funnels of the shuttle-waste-collection system, outperforms the standard urine collection device (UCD). Although there is no apparent commercial use at this time, the IUCA will benefit the space program by increasing capabilities for research in life sciences research capabilities.

On shuttle missions, collection of urine by use of UCDs has typically been restricted to male crewmembers. In order to collect samples from female crewmembers, it has been necessary to add flight hardware — a urine-monitoring system. This system was infrequently manifested on flights because of its considerable size and weight. Although the UCDs typically employed on the shuttle are cumbersome and are susceptible to leakage, they continue to be used to satisfy the urine-collection requirements of many flight experiments.

While many scientific protocols require information on urine volume, experiments in which stable isotopes are used typically rely on the ratio between concentrations of two compounds in urine; hence, urine-volume data are not required. While recent modifications have improved UCD function, constraints on volume and weight of equipment carried aboard the spacecraft limit space for storage of both empty and filled UCDs, and this limitation profoundly affects missions of any duration. Thus, identifying a means of collecting small urine samples from male and female crewmembers that required minimal volume and weight became a critical concern for JSC scientists.

The IUCA addresses this concern for urine-volume-independent studies. Prototype IUCA units were developed to collect small samples during flight. Each unit has a conical shape and an area ≈75 cm². It was built from a material that is known to absorb 20.4 g of water per 100 cm² of area. Its assembly weighs ≈20 g empty and 35 g full, as compared, to the UCD assembly, which weighs 65 g empty and can weigh from 300 to 500 g when full. The IUCA is placed in either a male or female urine-collection funnel of the shuttle-waste-control system (WCS). As a crewmember voids, the vortex action created by the shuttle vacuum system causes urine to saturate the IUCA. Upon completion of the void, the IUCA is removed from the WCS, placed in two zipper-locked bags, and stored in an absorber containment bag for return. The prototype was tested several times for volume recovery by use of a WCS mock-up in Building 5 at JSC. However, due to gravitational effects, results were inconclusive. Flight safety testing was completed, and the prototype units were subsequently certified for use in flight.

Preliminary studies were performed at JSC to evaluate the effect of the absorbent paper on the analysis of deuterium and oxygen-18 — two isotopes currently used to determine energy expenditure, water metabolism, and body composition in flight. Data obtained by use of the absorbent paper were identical to those obtained in sampling by use of conventional methods.

The IUCA will benefit the space program for which it was intended, where it can advance life sciences research by making it easy for all crewmembers to collect urine samples. While its compact nature assures compliance with shuttle mission requirements, its advanced design will prove equally adaptable to the International Space Station and to future long-duration space missions.

This work was done by Scott Smith and Helen Lane of **Johnson Space Center** *and Janis Davis-Street and Jeannie Nillen of Lockheed Martin Engineering & Science. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Bio-Medical category.*
MSC-22748

AlGaN Photodiodes Respond to Ultraviolet C

These are solar-blind photodiodes, for which there are numerous potential uses.

Dryden Flight Research Center, Edwards, California

Solar-blind photodetectors respond only to ultraviolet light at wavelengths shorter than those of the solar radiation that can penetrate atmosphere of the Earth. This wavelength range, traditionally defined as wavelengths <280 nm, is known as ultraviolet C (UV-C). Terrestrial solar light in this range is absorbed in the atmosphere, primarily by ozone, and does not reach the ground. However, UV-C radiation can also be produced on the ground by such combustion processes as forest fires, artillery fire, or missile launches. Detection of UV-C under the atmosphere without background interference from longer-wavelength solar radiation can serve to identify these terrestrial fire sources. Solar-blind detectors include gas-ionization chambers (e.g., Geiger-Muller tubes) and conventional photodiodes and photomultipliers when used in combination with blocking filters and phosphor down-conversion techniques.

The material system that consists of nitrides of elements of column III of the periodic table offers the potential for solid-state photonic devices that are inherently solar-blind. These materials are a subset of the semiconducting compounds that comprise elements from columns III and V of the periodic table. More familiar III-V semiconductors include GaAs, GaP, and such ternary variations as AlGaAs. The distinctive aspect of the III-nitrides is that their bandgaps fall in the energy range that corresponds to blue and ultraviolet wavelengths. The bandgap of a ternary III-nitride material, (e.g., InGaN or AlGaN) can be tailored by varying the proportions of the column-III elements. For example, the bandgap of $Al_{0.37}Ga_{0.63}N$ is 4.4 eV, which, as a photon energy, corresponds to a wavelength of 280 nm — the long wavelength edge of the UV-C band. In comparison, silicon, the most common semiconductor material for photodetectors, has a bandgap of 1.1 eV, corresponding to a wavelength of 1.1 μm, which is in the infrared region.

AlGaN Schottky photodiodes that respond primarily to radiation in the UV-C spectral band have been developed. Single-element Schottky photodiodes, each having an active area of 0.5 mm², have been fabricated. The AlGaN layers of such a device are deposited by molecular beam epitaxy (MBE) on a sapphire

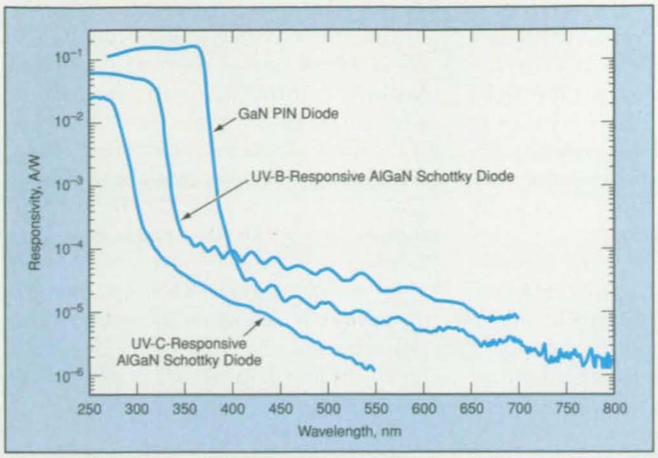

Figure 1. The **Photovoltaic Spectral Responsivities** of three column-III nitride photodiodes are plotted together for comparison.

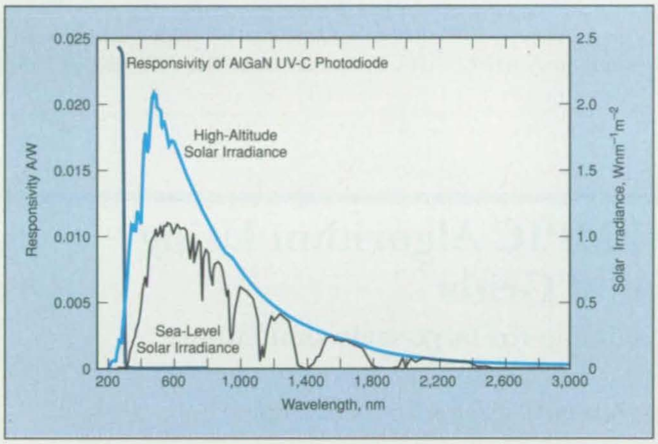

Figure 2. The **Photovoltaic Spectral Responsivity** of an AlGaN UV-C Schottky photodiode is overlaid on solar irradiance spectra from above the atmosphere and from sea level to show that the AlGaN UV-C photodiode is blind to solar light that penetrates the atmosphere.

substrate. The device consists of an underlying 0.5-μm-thick n^+ layer of AlGaN doped with silicon and an overlying 1.0-μm-thick layer of undoped AlGaN. Standard photolithographic techniques are used for patterning the device. Inductively coupled plasma (ICP) etching is used to form a mesa of undoped AlGaN layer and expose the underlying n^+ layer for ohmic-contact metallization. A semitransparent nickel layer is used for the Schottky contact on the undoped AlGaN layer.

Figure 1 depicts the photovoltaic spectral responsivity of a UV-C-responsive photodiode of this type. Also shown for comparison is the responsivity of an $Al_{0.17}Ga_{0.83}N$ Schottky photodiode that exhibits a peak response at 320 nm (the long-wavelength cutoff of UV-B) and the responsivity of a GaN p-type/intrinsic/n-type (PIN) photodiode that exhibits a peak response at 365 nm.

The logarithmic responsivity scale of Figure 1 helps to emphasize the long-wavelength rejection of the UV-C-responsive photodiode. The response of this photodiode at a wavelength of 370 nm is only 10^{-3} times its peak response. As the wavelength increases to 500 nm, the response falls another order of magnitude, and as the wavelength increases further to 650 nm, the response decreases to 10^{-5} times the peak response. With its peak response at 280 nm, the UV-C AlGaN Schottky photodiode is the shortest-wavelength group-III nitride photovoltaic device demonstrated to date. The absolute response at 280 nm is considered to be fair. At 0.022 A/W it exhibits an external quantum efficiency of about 10 percent; this level of quantum efficiency is comparable to the quantum efficiencies of photocathodes in this spectral range.

Figure 2 shows an overlay of the responsivity of the UV-C sensor to the solar irradiance spectra at sea level and at high altitude. The AlGaN UV-C photodiode is blind to solar light at sea level because the portion of the sunlight in its spectral-response range is absorbed in the atmosphere.

Photodetectors made from column-III nitride compounds are uniquely well suited for numerous ultraviolet-detection applications, including sensing of flames in industrial settings, monitoring UV curing and drying, detection of arcs, controlling UV sterilization, monitoring UV in phototherapy, and solar-blind detection of fires. Because the column-III nitride material system is stable at high temperatures and during exposure to intense radiation, it is a good choice for photodetectors that must operate in harsh environments.

This work was done under a under 1998 NASA Phase I Small Business Innovation Research (SBIR) Contract by Jody J. Klaassen, James VanHove, Robert Hickman II, Andrew Wowchak, Christina Polley, David King, Matt Rosamond, and Peter P. Chow of SVT Associates/Blue Lotus Micro Devices, Inc., for **Dryden Flight Research Center.**

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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Refer to DRC-99-25, volume and number of this NASA Tech Briefs *issue, and the page number.*

Parallel 3D EMPIC Algorithm Using Nonorthogonal Grids

This algorithm is suitable for large-scale simulations of plasmas.

NASA's Jet Propulsion Laboratory, Pasadena, California

Electromagnetic particle-in-cell (EMPIC) codes provide a capability for numerically simulating the motions of electrically charged particles in electromagnetic fields, and hence have become standard software tools in plasma physics research. Most existing EMPIC codes are based on the use of orthogonal computational grids (Cartesian or cylindrical). The applicability of such codes is restricted to problems with simple geometries.

A new, three-dimensional (3D) EMPIC algorithm using nonorthogonal grids has been developed recently for parallel supercomputers. The algorithm and a computer code that implements this algorithm can be used to study plasma problems involving complex geometries, such as those related to microwave devices.

One prior EMPIC algorithm using nonorthogonal grids is based on a finite-element approach. The present algorithm and code are based on a finite-volume approach. The major features of the present algorithm are the following:

- The building blocks of computational grids are logically connected, nonorthogonal, deformable hexahedral cells. As a result, grids can be made to accommodate complex geometries for large-scale simulations of plasmas.
- The electromagnetic-field-update phase of the computational cycle is based on a discrete-volume generalization of the standard finite-difference time-domain (FDTD) algorithm; this formulation makes the algorithm simpler than the corresponding finite-element-based algorithm.
- The particle-push phase of the computational cycle involves a hybrid logical/physical-space operation.
- The implementation of this algorithm uses a domain decomposition of a grid and particles that is almost identical to that of a Cartesian grid based EMPIC algorithm.

The combination of features makes it possible to perform 3D large-scale simulations of plasma physics problems involving complex geometries with a very high parallel-computing efficiency (> 96 percent).

This work was done by Joseph Wang, Paulett Liewer, Dimitri Kondrashov, and Steve Karmesin of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category.*
NPO-20496

Information Sciences

Parameterizing Shape Perturbations for Multidisciplinary Design Optimization

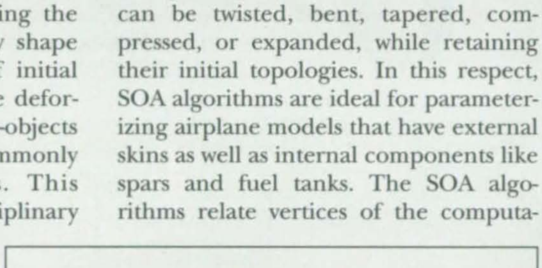
Shapes are deformed by use of soft-objects animation algorithms.

Langley Research Center, Hampton, Virginia

A recently developed method of parameterizing complex shapes that one seeks to optimize differs from prior such methods in two major respects: (1) instead of entirely parameterizing the shapes, one parameterizes only shape perturbations (deformations of initial or baseline shapes) and (2) the deformations are computed by soft-objects animation (SOA) algorithms commonly used in computer graphics. This method is suitable for multidisciplinary design-optimization processes, in which shapes of structures are optimized along with other aspects of design (e.g., aerodynamics). This method can be applied, for example, to the shapes of both exterior aerodynamic surfaces and internal structural components of aircraft.

For example, in the case of an airplane wing (see figure), one starts with a known wing design and seeks to improve the performance of the wing by applying numerical optimization techniques to perturbed wing shapes. Small changes in the shape of a wing can engender substantial changes in aerodynamic performance; as a result, the perturbations between a baseline and an optimized wing design are typically very small. Perturbations of a wing shape can readily be expressed as changes in thickness, camber, twist, dihedral angle, shear, and planform; this fact affords a computational advantage in that fewer parameters are needed to express such changes than are needed to describe the wing shape in its full complexity.

SOA algorithms have been chosen for this method because they are powerful computational tools for modifying shapes. In particular, SOA algorithms are suitable for deforming models represented by either sets of polygons or sets of parametric curves and surfaces. The SOA algorithms treat the models as though they were made of rubber that can be twisted, bent, tapered, compressed, or expanded, while retaining their initial topologies. In this respect, SOA algorithms are ideal for parameterizing airplane models that have external skins as well as internal components like spars and fuel tanks. The SOA algorithms relate vertices of the computational grid of an analysis model to a small number of design variables. Consequently, the SOA algorithms can serve as part of the basis of an efficient shape-optimization technique.



Baseline and Deformed Planforms of a transport airplane are analyzed in a design-optimization process. Deformations can be represented with computational efficiency by use of SOA algorithms.

This work was done by Jamshid A. Samareh of **Langley Research Center.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Information Sciences category. L-17841*

Low-Power, Fast Machine Vision System on a Single IC Chip

This system would function as an electronic "eye/brain machine."

NASA's Jet Propulsion Laboratory, Pasadena, California

A versatile, ultrafast, low-power machine vision system in the form of a single integrated-circuit chip has been proposed for use in military targeting, industrial robotics, and other applications in which there are requirements for utilizing visual information in real time. The conceptual design of the system takes advantage of recent advances in the design of integrated image-sensor/processor circuits, electronic neural networks, microprocessors, submicron very-large-scale integrated (VLSI) circuits, and massively parallel computation. The system could be characterized as an eye/brain machine (EBM) because the conceptual design is intended to mimic basic functions of biological vision systems. The system would be programmable to perform vision processing at all levels analogous to those of vision processing in the human eye and brain. The system would be capable of computation at the rate of 10^{12} operations per second — about 100 times the rate achievable with state-of-the-art microcomputers and digital signal-processing chips.

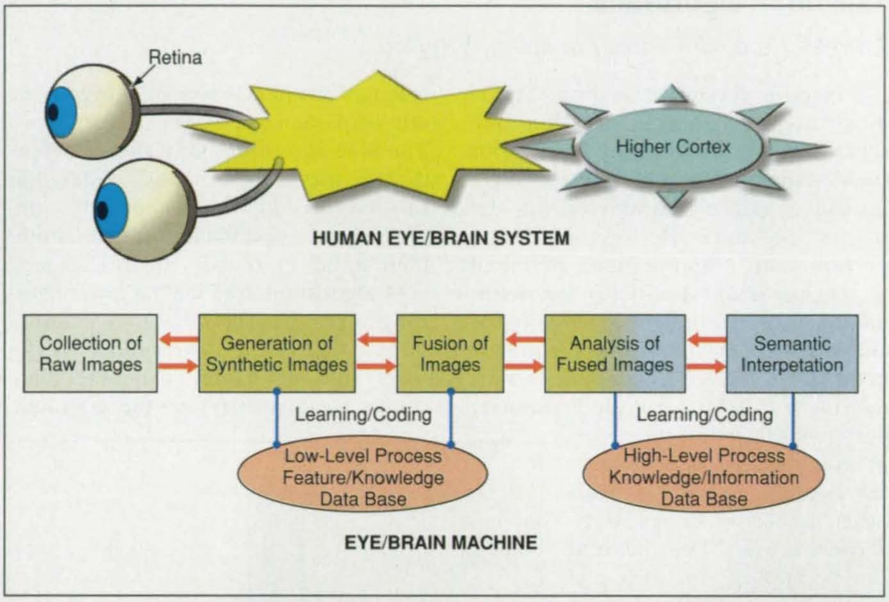


Figure 1. The **Computational Aspect of the Proposed System** is based on a simplified model of the human vision system, with five stages of processing of image data.

Figure 1 depicts the computational aspect of the conceptual EBM design. Visual information would be processed in five stages: (1) collection of raw images from sensors, (2) generation of synthetic images that augment raw images with additional information, (3) fusion of all images, (4) analysis of fused images, and (5) semantic interpretation of fused images.

The EBM would comprise the following two major subsystems:

- The EBM eye would be a compact optoelectronic subsystem that would integrate a variety of sensors with different geometric, radiometric, and spectral parameters chosen to satisfy requirements for a specific application.
- The EBM brain would be a high-performance control and data-handling subsystem that would contain most of the computational resources needed to perform machine-vision tasks.

An earlier version of the EBM, called the "Viewing Imager/Gimballed Instrumentation Laboratory and Analog Neural Three-Dimensional Processing Experiment" (VIGILANTE), was described in "Smart" Optoelectronic Sensor System for Recognizing Targets" (NPO-20357), *NASA Tech Briefs*, Vol. 22, No. 8 (August 1998), page 46. A prototype of the VIGILANTE was assembled largely from commercially available components. The conceptual design of the proposed system is based partly on lessons learned from the VIGILANTE prototype.

Figure 2 depicts the electronic aspect of the conceptual EBM design. An active-pixel-sensor (APS) camera, a "smart" window handler, a programmable neural computer, and a microcomputer, and other subsystems would be put together on a single chip. All subsystems on the chip would be connected in a row/column-parallel image-data-flow architecture that would eliminate the data-bandwidth bottlenecks of older data-bus architectures.

The APS camera would constitute the array of sensors of the system. Under control by the "smart" window handler, windowed image data from the APS camera would be fed to the neural computer.

The neural computer would generate synthetic images, fuse all images, and

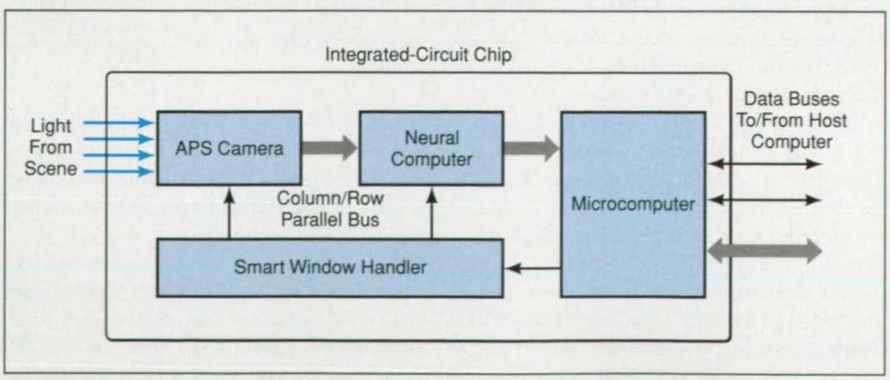


Figure 2. **All of the Subsystems** of the proposed system would be put together on a single IC chip.

analyze the fused images (stages 2, 3, and 4 of image-data processing) at a high speed that would be achieved by a combination of programmability and massively parallel computing structures. A prototype of the neural computer was described in "VLSI Neural Processors Based on Optimization Neural Networks" (NPO-19989), *NASA Tech Briefs*, Vol. 22, No. 1 (January 1998), page 58.

The microcomputer would control the overall operation of the system and would perform the scene-interpretation functions (stage 5 of image-data processing). The system could communicate with a host computer via a multibus interface unit.

The following are the anticipated advantages of building the system as a single IC chip instead of assembling it from components that are now commercially available:

- A higher degree of system-level integration could be achieved. System-level integration offers the capability to implement innovative parallel-processing architectures and ultrafast data-transfer structures while increasing the robustness of the system.
- The power consumed by the proposed single-chip system would be about 10 W, whereas a version of system capable of equal data throughput and assembled from commercially available components would consume about 100 W.
- Integration of all subsystems onto a single chip would entail shorter interconnections with fewer contacts and driver circuits, enabling the proposed system to operate at greater frame rates and processing speeds.
- The size of the proposed system would be about one-tenth that of the version of the system assembled from commercially available parts. The cost of mass-producing the system would be reduced accordingly.

This work was done by Wai-Chi Fang of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Systems category.*
NPO-20449

Special-Purpose Interface for Fast Writing on a Hard Disk

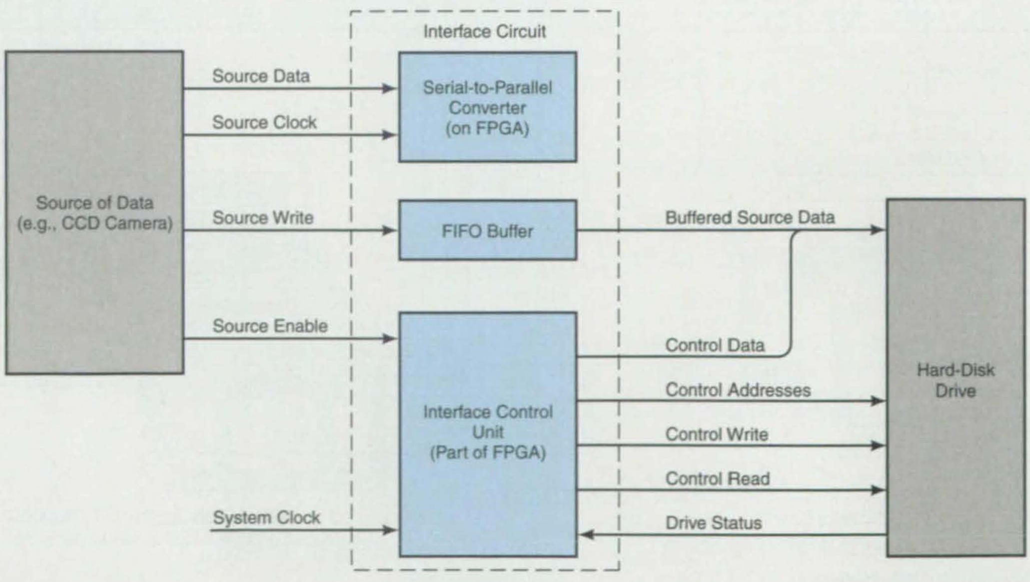
Size, weight, and power consumption are less than those of a general-purpose HDD interface.

Goddard Space Flight Center, Greenbelt, Maryland

A special-purpose interface circuit for a computer hard-disk drive (HDD) enables rapid writing of image data from a scientific instrument to sequential sectors on the hard disk. The design of this interface exploits the fact that most of the hardware and software components typically used to control the flow of data to the HDD of a general-purpose personal computer (PC) are not needed in a special-purpose instrument application; as a result, the size, weight, and power consumption of the data-storage portion of the instrument can be made less than they would be if a general-purpose interface were used. This interface can be connected directly to any of a variety of commercially available HDDs.

In the original application for which the interface was designed, the image data originate in a charge-coupled-device (CCD) camera that generates 12 bits per pixel, there being 3,072 pixels per line and 1,024 lines per image frame. Image data are read out from the CCD at a rate of 11.4Mb/s. Header information that is included with the data from each line increases the data rate to 15.2Mb/s. The HDD must be capable of accepting data at this rate to store complete images.

The interface (see figure) includes a serial-to-parallel converter, a first-in/first-out (FIFO) buffer, and a custom interface control unit. The serial-to-parallel converter and the interface control unit are implemented on a field-programmable gate array (FPGA). The FPGA contains instructions in read-only memory (ROM) that initialize the HDD by use of an industry-standard interface protocol called "ATA-3." For each image line, the starting sector address is written to the HDD control registers. All of the source data (image data) pass through the serial-to-parallel converter, then through the FIFO buffer. The FIFO



The **Interface Circuit** enables rapid writing of source data to sequential sectors on a hard disk. The interface circuit can be connected directly to any of a variety of commercially available HDDs.

buffer can store several image lines simultaneously, making it possible for the control unit to wait while the HDD seeks the desired sector addresses.

After a complete line has been written, the control unit determines the status of the HDD and waits until the HDD is ready to receive more data. When the HDD is ready, it accepts header information, then accepts the source data. During acceptance of the source data, 16-bit words are written from the FIFO buffer to sequential HDD sectors at a system clock rate of 10 MHz. Later, stored data are retrieved from the hard disk by use of a separate commercial parallel input/output PC card.

Going beyond the original application, this interface can be used in other applications in which it is necessary to write data on sequential hard-disk sectors at high speeds. Because the interface includes an FPGA, it can be modified to satisfy requirements of different applications.

This work was done by Joseph Miko of **Goddard Space Flight Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Systems category.* *GSC-14177*

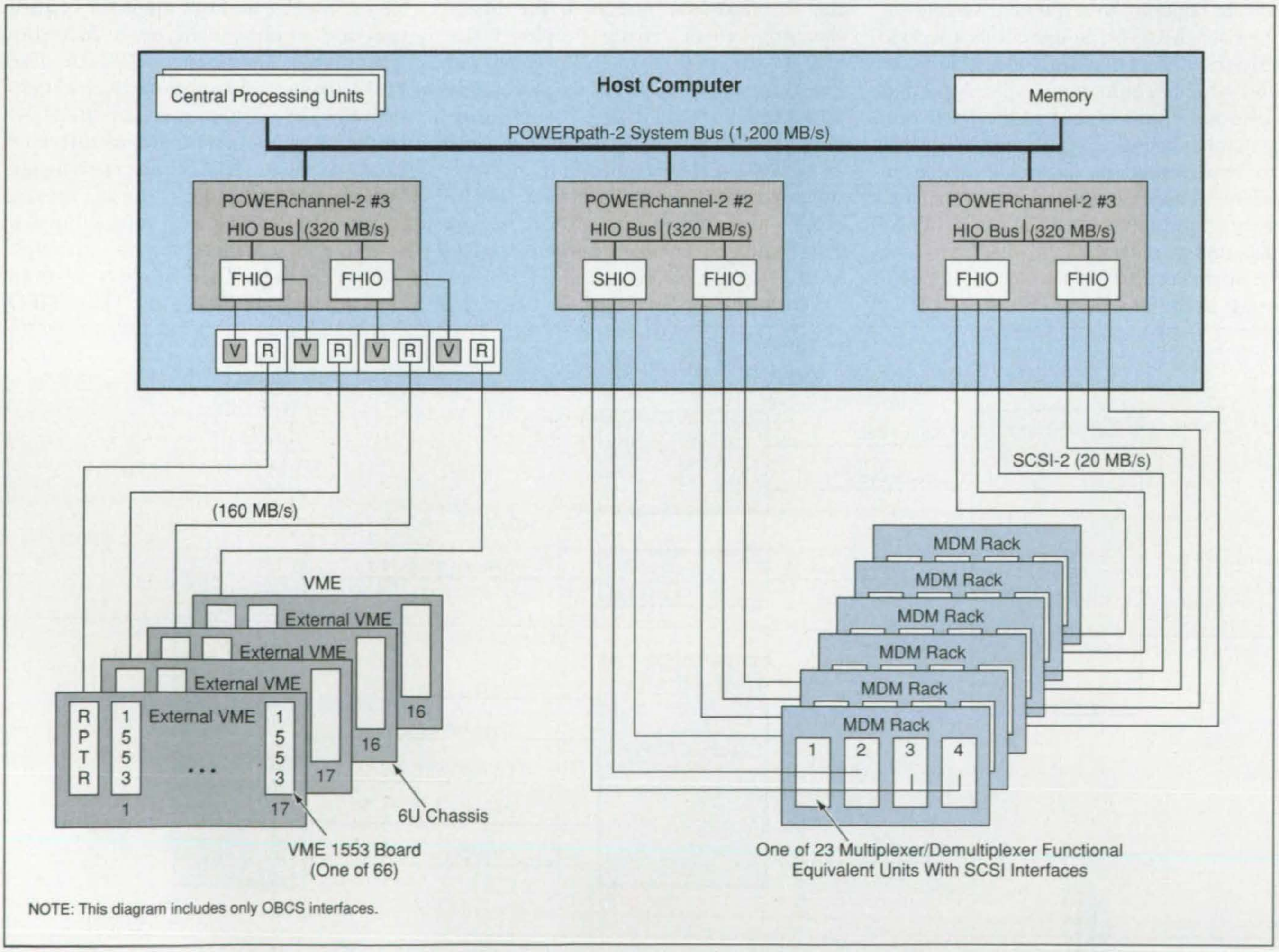
SIBless Interface Design for Space-Station Training Computer

Commercially available hardware and software are used.

Lyndon B. Johnson Space Center, Houston, Texas

NASA has developed a system of hardware and software that can accommodate all necessary interfaces between (1) space-station flight computers and (2) a simulation host computer used in training, with the least host-computer processing overhead, least cost, and least complexity. This system is said to be "SIBless" because it does not include a simulation interface buffer (SIB). The SIBless design is specific to the hardware and software systems of the station; it could also be moderately useful as a basis for similar systems in other applications that involve training simulation computers and data-acquisition systems that process large amounts of input and output (I/O) information.

The original design for space-station trainers called for a hardware and software system — a simulation interface buffer (SIB) — that would enable the host computer (a general-purpose avionics computer) to interact with all required devices. However, a redesign of the space station greatly affected this original requirement and led to the so-called SIBless design (see figure). The SIBless design succeeds on two levels: First, it succeeds as a means of quantifying the performances of various I/O methods. The analysis method involved in the SIBless design makes it possible to



The SIBless Design accommodates all necessary interfaces in the original application, with the least host-computer processing overhead, least cost, and least complexity.

understand the architecture of the simulation host computer (an SGI Challenge XL computer) and to quantify the performance of this computer in different design alternatives. This analysis results in an understanding of the "sweet spots" and "dead spots" in the I/O performance of this computer with various commercial off-the-shelf interface cards and programs. Test results match estimates within about 5 percent.

The SIBless design also succeeds as one that requires few interrupts per frame. Analysis of the performance of the simulation host computer in handling VersaModule Eurocard (VME) and POWERchannel hardware interrupts revealed a need to reduce the number of interrupts as much as possible. A review of 1553-standard board vendors and an analysis of 1553 traffic characteristics and the SGI VME performance lead to a design that stayed within the "sweet spot" of the simulation host computer for some of the 1553 traffic; it also resulted in no interrupts for any of the 1553 traffic. The final design of a Small Computer Systems Interface (SCSI) device driver required only 1 interrupt per frame instead of the original 26 interrupts per frame.

The novelty of the SIBless design is that it provides an example of how much I/O can be accomplished when a simulation host computer is used in real time and engineers employ a smart design. Although it is only a modified version of a previous design, the SIBless design succeeds on a couple of levels because it can contribute to significant cost and time savings. Unfortunately, its commercial applications are limited because it was designed for space-station support.

This work was done by Robert Horton and Cary Cheatham of Hughes Training and Dave Thornton of Loral for **Johnson Space Center.** *MSC-22765*

Forward-Link/Simulator PCI Card

Improvements include decreases in size, cost, and power consumption and an increase in speed.

Goddard Space Flight Center, Greenbelt, Maryland

The forward-link/simulator card (FLS) performs the fundamental satellite-telemetry data-transmission function for the forward (Earth-to-spacecraft) link in real time at rates up to 400 Mb/s. The FLS also simulates a Consultative Committee for Space Data Systems (CCSDS) telemetry data source that outputs data at rates up to 150 Mb/s, using industry-standard interface circuitry and standard connectors. Previously, at least two cards, each containing a central processing unit (CPU), were needed to do what the FLS now does. CPU-based cards are complex; are expensive to build, operate, and maintain; are susceptible to malfunction; and require a great deal of power and cooling.

The FLS is a single industry-standard, full-length, 32-bit, 33-MHz, 5-V peripheral component interface (PCI) expansion card. In addition to the industry-standard PCI connector, it contains industry-standard subminiature B connectors for emitter-coupled-logic (ECL) input, an industry-standard DB-9 connector for RS-422 output, and a connector for programming nonvolatile logic devices. It contains an ECL output interface circuit, an RS-422 output interface circuit, a PCI bus interface application-specific integrated circuit (ASIC), three large reprogrammable nonvolatile logic devices, two large reprogrammable volatile logic devices, and miscellaneous active and passive devices.

In a typical data-source simulation, a test data pattern is loaded into a base pattern memory, control registers are set up by the host computer in which the FLS is installed and the card proceeds to generate test data automatically until it is stopped by the host computer. During typical forward-link operation, a pre-formatted uplink data stream, (comprising, for example, CCSDS telecommand frames), is loaded into a command buffer by the host, and the card proceeds to output the data automatically. Setup, control, insertion of data, and monitoring are performed through an entirely memory-mapped PCI interface by software running on the host computer.

In comparison with the previous assembly of at least two cards, the FLS is smaller, less expensive, faster, and more energy-efficient. The CPU-less, memory-mapped mode of operation of the FLS is simpler and more robust than was the CPU-based operation of the assembly of at least two CPU-based cards. The FLS is more flexible in that all logic is implemented in reprogrammable logic devices.

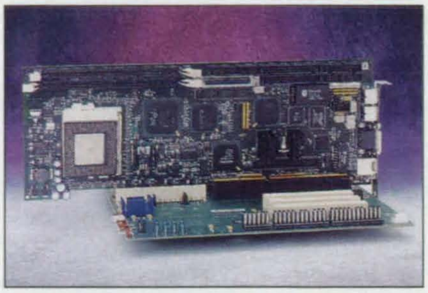
This work was done by Robert C. Kunz of RMS, Jason Dowling and Terry L. Graessle of Lockheed Martin, and Christos Karasiotos and David Fisher of SGT for **Goddard Space Flight Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Systems category.*
GSC-14034

Special Coverage: Computers and Peripherals

CTI Electronics, Stratford, CT, has introduced the KIA6800 Series Arrowmouse™ NEMA 4 **miniature keyboard** that features eight unique keys that replicate all mouse functions, and provides 101/104-key functionality. The sealed keyboard is available in a full enclosure for workstation applications, and an OEM version that measures 8 x 5" with a depth of less than 1".

The keyboard is made of custom-molded silicone keys with 2-mm travel. Each key has gold-plated contacts. Key legends are fused into each key for long life and abrasion resistance. The keyboard is suitable for medical, process control, and NC machining, and features an integral sealing gasket and evenly spaced mounting holes. It provides port-compatible mouse functionality without the addition of software drivers or hardware.

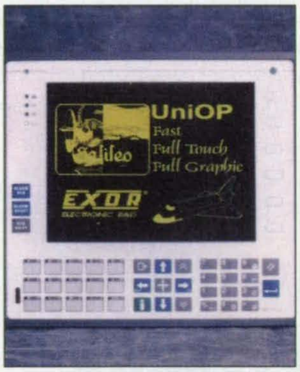
For More Information Circle No. 736



The Computer Systems Division of Carlo Gavazzi, Waltham, MA, offers the SBCP2BX370 Celeron-based **single-board computer** that is designed for PICMG-compliant PCI/ISA backplane systems. It uses Intel's socket-370 PPGA Celeron processor and 440BX chipset. Integrated features include a PCI Ultra2 SCSI bus, AGP Video controller, 10/100 Base-T LAN, two USB ports, and a parallel port.

The board provides connectors on its rear I/O bracket for a PS/2 keyboard and mouse, LAN, and display monitor. The board is available with CPU speeds ranging from 300 MHz to 433 MHz, and is compatible with backplanes and systems that meet the PICMG 2.0 PCI-ISA standard.

For More Information Circle No. 739



The MKDL-VGA UniOP industrial **color operator interface** from EXOR International, Wellington, FL, features a TFT active matrix display, with passive STN, EL, or LCD also available. The interface also features a 10.4" diagonal display with VGA resolution. A full keypad provides 49 alphanumeric configurable keys and 26 user-definable LEDs. Along with passwords, alarming, graphics capabilities, and multilanguage features, the interface offers 2 MB of user memory and 32 KB of recipe memory.

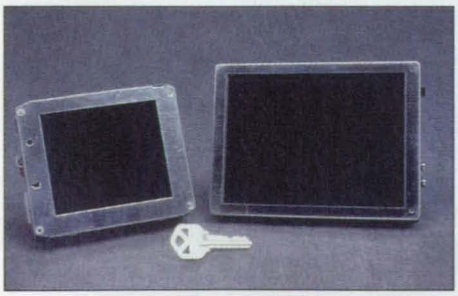
Standard Windows-based software allows the user to connect up to 32 different operator interfaces together, or they can be connected to multiple PLCs. More than 130 different drivers connect to a range of PLCs and motion controllers. The interface also can be connected to high-speed bus networks such as DeviceNet and Profibus DP.

For More Information Circle No. 737

Teknor Applicom, Boisbriand, Quebec, Canada, has introduced the SxB6S and SxB6L ShoeBox industrial steel/nickel-plated cold roll steel **computer platforms** with either a 6-slot ISA or 6-slot PCI/ISA backplane. The platforms can be configured for benchtop, wall-mount, floor-mount, or machine-bolted positioning, in either vertical or horizontal orientations. They feature an 86.5-CFM fan for positive pressure cooling.

The SxB6S measures 7.4 x 6.8 x 10.1" and accepts up to six half-length ISA boards. It has a front-accessible bay with floppy, CD, and 2.5" hard disk bays. The SxB6L measures 6.8 x 10.2 x 16", and accepts up to six full-length or half-size boards. The platform also has a front-accessible 3.5" floppy bay, a 5.25" bay, and an internal 3.5" bay. Both platforms are designed for applied computing applications in process/machine control, data acquisition, and similar markets.

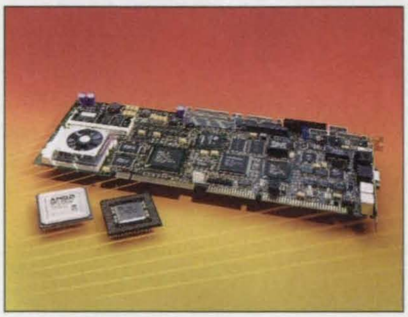
For More Information Circle No. 740



Two compact **LCD displays** are available from Peter Parts Electronics, Ontario, NY. The active matrix displays are available in 4" and 5.6" diagonal sizes, and accept 1V p-p NTSC composite signal video inputs. The 4" display features 442 x 238 pixel resolution, and the 5.6" model has 960 x 234. Both displays allow adjustment of brightness, color, tint, and volume.

The displays can be used in handheld PCs, small desktop monitor applications, and mounted in dashboards as readouts for GPS systems in vehicles. They also have applications in security systems, and electronic devices. Both displays require 12V input voltage and consume a few watts of power.

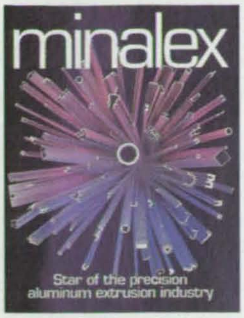
For More Information Circle No. 735



Microbus, Houston, TX, offers the MAT 891 **single-board computer** that combines an AMD K6-3 500-MHz processor, Ultra2 SCSI, 10/100 Base Ethernet, and 4 MB AGP video, all in a single-slot in a PICMG™ PCI/ISA backplane. The board supports voltage and software watchdogs, a processor thermometer, and a fan speed monitor. Based on the ALI 1541 chipset, the card supports the 100-MHz front side bus, 512K or 1 MB of cache, and PC100 SDRAM.

The AGP video provides 4 MB of SGRAM video memory. Standard interfaces on the board include two USB ports, IrDA, two serial ports, one parallel port, a floppy drive, and keyboard and mouse ports. Other features include fused power outputs, on-board headers, and BIOS customization.

For More Information Circle No. 738



PRECISION ALUMINUM EXTRUSIONS

New! An informative brochure from MINALEX, leader in close tolerance shapes to 3 1/2", illustrates typical applications and describes capabilities including short runs. MINALEX, quality leader, delivers on time, every time. MINALEX, PO Box 247, Whitehouse Station, NJ 08889; Tel: 908-534-4044; Fax: 908-534-6788.

Minalex

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MEDCO coats, laminates, and slits a wide variety of film, paper, foam, foil, cloth, and nonwoven webs for custom medical and industrial applications. Adhesives can be developed with any of these materials. MEDCO also provides contract R&D and process-development services, along with sophisticated high-volume manufacturing. MEDCO offers low minimums, quick turnaround, and flexible scheduling, putting customer needs first. MEDCO Coated Products, Div. MEDCO Labs, 5156 Richmond Rd., Bedford Hts., OH 44146. Tel: 216-292-7546; Fax: 216-292-5900; e-mail: medcolabs@aol.com; www.medcolabs.com

MEDCO Coated Products

For More Information Circle No. 616

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Instrument Technology, Inc.

For More Information Circle No. 617

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New, full-color brochure describes the dynamic properties of Sorbothane, the unique vibration isolation and impact absorption material. New test data details the damping properties of Sorbothane compared to other elastomers. Sorbothane is a patented visco-elastic polymer. Includes information on Sorbothane's new line of advanced vibration isolation/shock absorption products, as well as applications engineering, manufacturing capabilities, and the many applications for Sorbothane. Sorbothane, Inc.; Tel: 330-678-9444; Fax: 330-678-1303; e-mail: webmaster@www.sorbothane.com; http://www.sorbothane.com

Sorbothane, Inc.

For More Information Circle No. 618

LIGHTED INTERFACE SWITCH CONTROLLER-XT

Literature from StacoSwitch details the Interface Controller-XT (IFC-XT) — a flexible, low-cost digital I/O controller designed to manage clusters of lighted pushbutton switches, LEDs, and incandescent lamps. Features include 32 input and 32 output channels, audible tone generation, adjustable output levels of all lamps individually, and RS-232 and RS-422 capability; simple software driver set; compact size; easy direct mount. StacoSwitch; Tel: 714-549-3041; Fax: 714-549-0930; e-mail: sales@stacoswitch.com; www.stacoswitch.com

StacoSwitch Co.

For More Information Circle No. 619

PRECISION DRAWN METAL STRUCTURES

A full-color brochure outlines ShapeForm's exclusive metal-forming technology and unique equipment. ShapeForm engineers and produces superior close tolerance, deep-drawn parts from most metals at competitive prices. Our engineering, tooling, and manufacturing capabilities produce complex, seamless, one-piece shells, tubes, and other shapes for the commercial, military, and aerospace industries. Buckeye ShapeForm, 555 Marion Rd., Columbus, OH, 43207; Tel: 800-728-0776; Fax: 614-445-8224; www.buckeyeshapeform.com

Buckeye ShapeForm

For More Information Circle No. 620

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By accessing www.goodfellow.com, researchers and design engineers will find an extraordinary selection of pure metals, alloys, polymers, ceramics, composites, and honeycombs, available in small quantities and ready for immediate shipment. More than 40,000 items are included. Print and CD-ROM catalogs are also available. Goodfellow Corp., 800 Lancaster Ave., Berwyn, PA 19312-1780; Tel: 800-821-2870

Goodfellow Corp.

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National Instruments

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National Instruments

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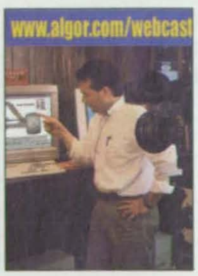

TUESDAYS AT TEN: ALGOR LIVE WEBCASTS

Join Algor every Tuesday at 10:00 a.m. Eastern Time for a live Webcast to learn more about Algor's software from the most basic to full Mechanical Event Simulation. Engineers can phone or email questions to be answered by Algor engineers during the Webcast. Address: 150 Beta Dr., Pittsburgh, PA 15238; Phone: +1 (412) 967-2700; Email: webcast@algor.com; or Fax: +1 (412) 967-2781; www.algor.com/webcast

Algor, Inc.

For More Information Circle No. 624

ALGOR SOFTWARE ELIMINATES TIME & COST OF PERFORMING PHYSICAL TESTS

Use Algor's Mechanical Event Simulation (MES) and kinematic element technology to simultaneously replicate motion and flexing for linear and nonlinear events on CAD solid models. MES eliminates the need to determine forces by external calculation because it does not require internal dynamic loading input. Use InCAD^Plus to import designs from popular CAD solid modelers into Algor's MES. 150 Beta Drive, Pittsburgh, PA 15238-2932; Phone: +1 (412) 967-2700; Fax: +1 (412) 967-2781; E-mail: info@algor.com; website: www.algor.com

Algor, Inc.

For More Information Circle No. 625

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Now engineers can buy the hardcover versions of the best-selling books, *Finite Element Modeling in Engineering Practice* and *Linear and Nonlinear Finite Element Analysis in Engineering Practice*, at a special clearance price. Dozens of drawings, charts, graphs, equations, tables and other visual aids help make these books stand out from other "heavy and boring" engineering texts. Address: 150 Beta Dr., Pittsburgh, PA 15238; Phone: 1-800-48-ALGOR; E-mail: apd@algor.com; Web: www.algor.com/apd; or Fax: +1 (412) 967-2781.

Algor, Inc.

For More Information Circle No. 626

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DCC's data logger displays eight thermocouple channels on monitor, printer, and disk for $349 complete. Designed specifically for laboratory and industrial temperature monitoring, it is easy to set up. An RS-232 interface powers the converter, eliminating sensor wires at the computer. QuickBasic® MS source code and compiled program are provided. Other features include 16-channel and linear options. DCC Corporation, 7300 N. Crescent Blvd., Pennsauken, NJ 08110; Tel: 856-662-7272; Fax: 856-662-7862; www.thomasregister.com/dcc

DCC Corporation

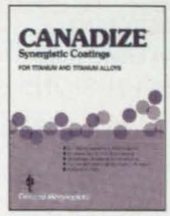
For More Information Circle No. 627

SMALL PARTS CATALOG NO. 20 QUALITY COMPONENTS, MATERIALS, AND TOOLS

This catalog is packed with products for engineering design, research and development, prototypes and modeling, and industrial assembly. Thousands of items are in stock, including miniature fasteners, specialty components, fluid and motion control devices, select materials, and precision tools. SMALL PARTS, INC., 13980 NW 58th Court, Miami Lakes, FL, 33014, Attn: Free Catalog - Dept. 200F; Tel: 800-220-4242; Fax: 800-423-9009; www.smallparts.com

SMALL PARTS, INC.

For More Information Circle No. 628



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CANADIZE® for titanium is a super-hard, fracture-free surface-enhancement coating developed to prevent hydrogen absorption. It dramatically increases surface resistance to abrasion and wear while eliminating galling, binding, and seizing. Magnaplate-applied CANADIZE also protects parts against chemical attack and corrosion. Operating temperature ranges from -200° F to +1200° F. General Magnaplate, Linden, NJ 07036; Tel: 800-852-3301; Fax: 908-862-6110; e-mail: info@magnaplate.com; www.magnaplate.com

General Magnaplate

For More Information Circle No. 629

KEITHLEY'S 2000/2001 CATALOG

Keithley's 2000/2001 catalog of computer-based measurement products provides specifications, selection guides, and background on measurement techniques. Products include voltage, current, and resistance meters; sources, switches, software, real-time control hardware, signal conditioning hardware; acquisition, digital I/O, and motion control boards; and semiconductor products. Keithley Instruments, Inc., 28775 Aurora Rd., Cleveland, OH 44139; Tel: 1-888-KEITHLEY; www.keithley.com

Keithley Instruments, Inc.

For More Information Circle No. 630

TEMPERATURE MEASUREMENT AND CONTROL CATALOG

Lake Shore Cryotronics' new Temperature and Control catalog features information on the company's cryogenic temperature sensors; temperature controllers and monitors; current sources, temperature transmitters, and temperature accessories. The reference section compares available sensor types and outlines installation techniques for low-temperature measurements. Lake Shore Cryotronics, Inc., 575 McCorkle Blvd., Westerville, OH, 43082; Tel: 614-891-2244; Fax: 614-818-1600; e-mail: sales@lakeshore.com; www.lakeshore.com

Lake Shore Cryotronics, Inc.

For More Information Circle No. 631

OMEGA PRESSURE, STRAIN AND FORCE MEASUREMENT HANDBOOK AND ENCYCLOPEDIA®

OMEGA's new 21st Century™ Pressure, Strain and Force Handbook™ contains more than 1,200 pages of new, advanced products for measurement, display, and control of pressure, differential pressure, barometric pressure, absolute pressure, and vacuum. A special section covers dynamic pressure and force transducers, and accelerometers. To obtain a request form by fax, call 1-800-848-4271 and request Document #2000. OMEGA Engineering, One Omega Dr., P.O. Box 4047, Stamford, CT 06907-4047; Tel: 203-359-1660; Fax: 203-359-7700; e-mail: info@omega.com; www.omega.com

OMEGA Engineering

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The SR700 Series LCR meters measure R+Q, L+Q, C+R, and C+D with a basic accuracy as high as 0.05%. Features include variable test frequencies from 100 Hz to 100 kHz, internal or external DC bias, series and parallel equivalent circuits, and external capacitor biasing. An RS-232 computer interface is standard. GPIB (IEEE-488) and parts handler interfaces are optional. SR715 (0.2% basic accuracy), U.S. list price: $1,295; SR720 (0.05% basic accuracy), U.S. list price, $1,995. Stanford Research Systems, Tel: 408-744-9040; Fax: 408-744-9049; e-mail: info@thinkSRS.com; www.thinkSRS.com

Stanford Research Systems

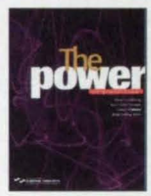
For More Information Circle No. 633

FREE CATALOG OF TOOLING COMPONENTS

The Reid Tool Supply catalog offers more than 40,000 items. Products include handwheels, handles, knobs, spring and ball plungers, vibration-isolation items, leveling pads, clamps, set-up accessories, locating devices, linear motion slides, latches, hinges, thread inserts, bearings, and more. Most items are available in inch and metric. All items are in stock for same-day shipment, with no minimum-order requirement. Reid Tool Supply Co., 2265 Black Creek Rd., Muskegon, MI 49444; Tel: 800-253-0421; Fax: 800-438-1145; www.reidtool.com

Reid Tool Supply Co.

For More Information Circle No. 634



POWER LINE FILTERING & SURGE SUPPRESSION SYSTEMS

Control Concepts offers a broad range of power line filters and state-of-the-art surge suppression to meet all of your power-quality needs. Our products make it easy and cost-effective to safeguard any electronic equipment from malfunction, downtime, or failure. Send for a free brochure and our handy informational guide to Surge Suppression and Filtering, or call us toll free at: 800-288-6169. Control Concepts, 328 Water St., P.O. Box 1380, Binghampton, NY 13902-1380; Tel: 607-724-2484; Fax: 607-722-8713; e-mail: cconcepts@control-concepts.com; www.control-concepts.com.

Control Concepts

For More Information Circle No. 635

FIRESTONE MARSH MELLOW® SPRINGS

The fabric-reinforced rubber springs from Firestone Industrial Products Co. provide constant vibration isolation with changing loads, have a high load-carrying capacity, and do not bottom out. They are low noise, low cost, and low maintenance. Call Firestone at 1-800-798-5005 for a free Marsh Mellow® design manual. Firestone Industrial Products Co., 12650 Hamilton Crossing Blvd., Carmel, IN, 46032; Tel: 800-888-0650; e-mail: support@firestoneindustrial.com; www.firestoneindustrial.com

Firestone Industrial Products Co.

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POROUS CERAMIC VACUUM CHUCK

PhotoMachining offers a porous ceramic vacuum chuck for use with thin films and other flat samples. Pore sizes under 25 microns assure uniform suction and holding power for even the smallest parts. PhotoMachining also provides contract laser-manufacturing services, and designs and builds custom laser-based manufacturing equipment. PhotoMachining, Inc., 4 Industrial Dr., Unit 40, Pelham, NH 03076; Tel: 603-882-9944; Fax: 603-886-8844; rschaeffer@photomachining.com; www.photomachining.com

PhotoMachining, Inc.

For More Information Circle No. 637

MAGNETIC MEASURING INSTRUMENTATION

Walker Scientific has over 50 models to choose from. Fluxmeters, gaussmeters, magnetometers, field monitors, calibrator equipment, precision reference standards, and much more are included in our brochure. This family of precision magnetic measuring instruments, reference standards, and calibration equipment is designed to meet the most demanding magnetic-field measuring applications ... the broadest range available. For a free copy, contact: Walker Scientific Inc., Rockdale St., Worcester, MA 01606; Tel: 508-852-3674, 800-962-4638; Fax: 508-856-9931; www.walkerscientific.com

Walker Scientific Inc.

For More Information Circle No. 638

New on the MARKET

Servo Drive

The PC800 servo drive from Pacific Scientific, Rockford, IL, offers all-digital servo capabilities. It measures 3.5 x 8 x 6.25" and accepts step and direction or analog commands. An internal profile generator allows the user to accomplish pre-set index moves. The PC800 also features the patented Digital Resolver to Digital Conversion (DRDC) algorithm. With 24-bit position resolution, DRDC provides the drive with position accuracy as low as five arc minutes. With greater than 400 kHz, the drive offers high velocity-loop bandwidth for faster drive set-up and tuning. **Circle No. 718**

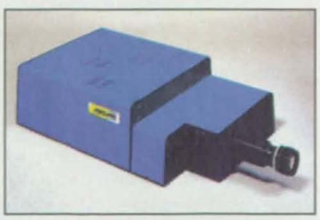
Digital Signal Processors

Neff Instrument Corp., Monrovia, CA, offers individual digital signal processors designed to provide identical time delay even with different filter cutoff frequencies. The self-contained system offers transducer conditioning, including programmable excitation, excitation readback, and auto-identification of channel configuration. Other features include programmable gain amplifier, built-in auto calibration, programmable filter cutoff frequency, and rolloff rates greater than 290 dB per octave. Phase mismatch between channels is unaffected by channel cutoff frequency, temperature changes, or aging of components. Applications include wind tunnels, materials and structural testing, and detection and analysis of vibration generated by rotating machinery. **Circle No. 719**

Color Mark Sensor

Omron Electronics, Schaumburg, IL, has introduced the E3M-V color mark sensor that features remote-control functionality and push-button programming to allow adjustments to be made from anywhere on the plant floor. The sensor's green LED enables detection of yellow-on-white and other color mark combinations that are difficult to sense. The sensor was designed to provide detection even on shiny surfaces. Its IP67 watertight construction allows use in water-washdown environments. Applications include use on high-speed packaging and production lines to detect index marks on labels, containers, and film. **Circle No. 721**

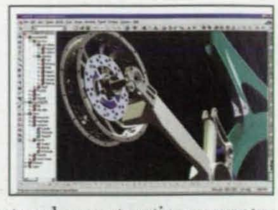
Digital Camera



The Cooke Corp., Auburn Hills, MI, offers the HSFC-Pro CCD-based digital camera designed to capture up to eight high-resolution images with an exposure time down to 1.5 nanoseconds. Features include a 1280 x 1024 scientific-grade CCD and 12 bits of dynamic range. Light is imaged with a standard lens input, and is then channeled to four intensified CCD modules, where images are displayed on a computer monitor for analysis. Light sources such as pulsed lasers can be synchronized with the camera to image the dynamics of events such as hypervelocity impact studies, ultrasonic flame propagation, and laser ablation. **Circle No. 724**

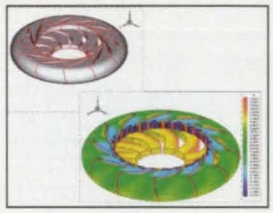
New on DISK

Solid Modeling



Visionary Design Systems, Santa Clara, CA, has released IronCAD™ 3.0 solid modeling software that incorporates more than 300 enhancements. The new Unified Modeling Engine simultaneously incorporates multiple solid modeling kernels, enabling users to import and export native geometry from most of the leading CAD, CAE, and CAM systems. The software supports both ACIS® and Parasolid™ kernels. Other features include innovation in drag-and-drop, handle-based solid modeling; 2D drawing enhancements; enhanced part and assembly modeling; and flexible parametric relationship and constraint extensions. **Circle No. 715**

Data Visualization and Analysis



Amtec Engineering, Bellevue, WA, has introduced Tecplot Version 8.0, which enables Web-based visual analysis and collaboration. It also allows users to publish results in HTML; read and write to ftp and http sites; or save data in a new packaged layout format. Users can add, edit, and change data, saving updates in formats such as AVI, BMP, and PNG. Other enhancements include new plotting features and capabilities for value blanking and frame linking. Users can specify precise thresholds or constraints for 2D contour lines and flooded contour regions. **Circle No. 710**

Scientific Imaging Software

Data Translation, Marlboro, MA, offers GLOBAL LAB Image/2 (GLI/2), a customizable, object-oriented application package for scientific imaging. It can be used at three levels: as an out-of-box, standalone application; as a base for user-written custom tools; and as an object-oriented application programming interface (API) for custom imaging applications. The software is divided into a main application and a set of imaging tools. The main application allows users to load, view, save, print, and modify images with the included tools. Pre-built tools cover measurement, line profile, and blob analysis. **Circle No. 712**

Engineering Simulation

ANSYS 5.6 CAE software from ANSYS, Southpointe, PA, is designed to provide a virtual product development environment for applications ranging from mechanics to MEMS. The new version includes enhancements in nonlinear structural mechanics, including multibody contact. Advances in multiphysics capabilities include computational fluid dynamics, electromagnetics, and coupled-field simulations. Other features include enhancements for modeling contact, such as plasticity, creep, and elastomeric material behavior; and an electrostatic-structural solution that yields capacitance results used by circuit simulation packages. **Circle No. 713**

Web-Based Design

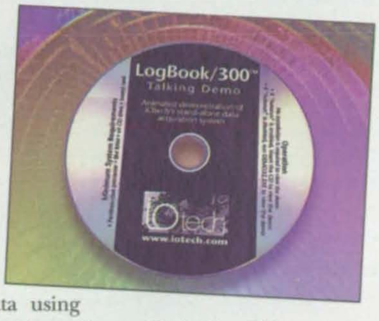
Alibre, Richardson, TX, has introduced Web-centric mechanical design that provides a distributed Web environment where design services can be accessed from anywhere at any time, with flexible, secure data sharing. The subscription-based service also will help companies avoid the large capital expenditures and restrictive licensing associated with mechanical design software. The system is compatible with Microsoft Windows 2000 and Windows DNA technologies. **Circle No. 714**

New LITERATURE

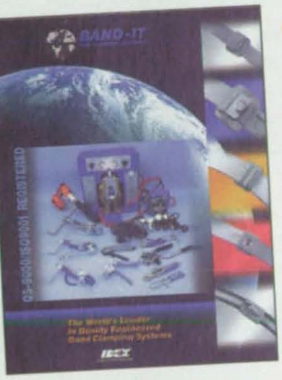
Motion Control Systems

Parker Hannifin, Compumotor Div., Rohnert Park, CA, has released a 248-page catalog of motion control systems. Products include controllers, drives and drive/controllers, and servo motors. Also included is a tutorial focusing on motion control product selection for specific applications. **Circle No. 700**

Data Acquisition System



A demo CD from IOtech, Cleveland, OH, describes the LogBook/300™ standalone data acquisition system, a 16-bit, 100-kHz system that stores data on removable PC-Card memory. The CD features voice-over narration and movie-like clips of software demos. It also shows how to configure an acquisition and manage data using IOtech's LogView™ Out-of-the-Box software. **Circle No. 701**



Clamps and Accessories

BAND-IT, Denver, CO, offers a full-line catalog of stainless-steel clamps, fittings, installation tools, and accessories. New products include Band-Lok, a tie featuring single-piece construction and self-locking Ball-Lok ties. A series of free-end clamps also has been added to the Ultra-Lok Band Clamping System, along with a rechargeable, battery-operated application tool. **Circle No. 702**

Touch-Sensitive Switches

A 10-page brochure from EAO Switch Corp., Milford, CT, describes touch-sensitive, solid-state switches. Series 75 devices, including keypads and keyboards, employ high-frequency switch technology. They can be sealed behind glass against chemical attack, operator abuse, vandalism, and hygienic washdown in a variety of indoor and outdoor public-access and process-control applications. **Circle No. 703**

Infrared Cameras

FLIR Systems, North Billerica, MA, offers an eight-page brochure describing the ThermaCAM® PM 595 handheld infrared camera system designed to make predictive and preventive maintenance inspections. The brochure details new camera features and specifications, applications, report generation, image and trending analysis software, camera accessories, and training programs. **Circle No. 704**

Editorial Index

Use the phone numbers listed below to obtain more information from the following companies featured editorially in this issue.

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Amtec Engineering	800-676-7568	710	70
ANSYS	800-WE-R-FEA1	713	70
Autodesk	415-507-5000	745	18
Baldor Electric	501-646-4711	768	24
Band-It	303-320-4555	702	71
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National Instruments	512-794-0100	732	32, 41
Neff Instrument Corp.	626-357-2281	719	69
Newport Electronics	714-540-4914	778	22
Omron Electronics	800-55-OMRON	721	69
Oriental Motor USA	800-406-7484	773	26
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Peter Parts Electronics	716-265-2000	735	66
Pilz Industrial Electronics	248-473-1133	774	26
Roper Scientific MASD	858-535-2909	780	27
SICK	612-941-6780	769	24
SolidWorks Corp.	978-371-5000	776	27
Sony Precision Technology America	949-770-8400	729	41
Spatial	303-449-0649	762	26
Structural Research & Analysis	310-207-2800	775	26
TEGAM	440-466-6100	730	41
Teknor Applicom	450-437-5682	740	66
think3	408-987-2200	767	24
Tinius Olsen Testing Machine	215-675-7100	728	41
UE Systems	914-592-1220	770	24
Unigraphics/Solid Edge	256-705-2544	765	24
Unigraphics Solutions	314-344-5290	764	22
Visionary Design Systems	408-969-8000	715	70

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