

and of the substrate echo in the absence of the sample. Then by use of equations that are readily derived from the basic signal time-of-flight equations, the thickness of the sample and the through-the-thickness velocity in the sample are com-

puted from the various echo times.

This work was done by Donald J. Roth, Jeffrey P. Seebo, and William P. Winfree of Glenn Research Center. Further information is contained in a TSP (see page 1).

Inquiries concerning rights for the

commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steve Fedor, Mail Stop 4-8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18254-1.

Multiparallel Three-Dimensional Optical Microscopy

Lyndon B. Johnson Space Center, Houston, Texas

Multiparallel three-dimensional optical microscopy is a method of forming an approximate three-dimensional image of a microscope sample as a collection of images from different depths through the sample. The imaging apparatus includes a single microscope plus an assembly of beam splitters and mirrors that divide the output of the microscope into multiple channels. An imaging array of photodetectors in each channel is located at a different distance along the optical path from the microscope, corresponding to a focal plane at a different depth within the sample. The optical path leading to each photodetector array also includes lenses to compen-

sate for the variation of magnification with distance so that the images ultimately formed on all the photodetector arrays are of the same magnification.

The use of optical components common to multiple channels in a simple geometry makes it possible to obtain high light-transmission efficiency with an optically and mechanically simple assembly. In addition, because images can be read out simultaneously from all the photodetector arrays, the apparatus can support three-dimensional imaging at a high scanning rate.

This work was done by Lam K. Nguyen, Jeffrey H. Price, Albert L. Kellner, and Miguel Bravo-Zanoquera of the University of Califor-

nia for Johnson Space Center. For further information, contact the JSC Innovation Partnerships Office at (281) 483-3809.

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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Stabilization of Phase of a Sinusoidal Signal Transmitted Over Optical Fiber

Two-way transmissions allow for rapid correction of common reference tones.

NASA's Jet Propulsion Laboratory, Pasadena, California

In the process of connecting widely distributed antennas into a coherent array, it is necessary to synchronize the timing of signals at the various locations. This can be accomplished by distributing a common reference signal from a central source, usually over optical fiber. A high-frequency (RF or microwave) tone is a good choice for the reference. One difficulty is that the effective length of the optical fiber changes with temperature and mechanical stress, leading to phase instability in the received tone. This innovation provides a new way to stabilize the phase of the received tone, in spite of variations in the electrical length of the fiber.

Stabilization is accomplished by two-way transmission in which part of the received signal is returned to the transmitting end over an identical fiber. The returned signal is detected and used to

close an electrical servo loop whose effect is to keep constant the phase of the tone at the receiving end.

The technique is useful in large arrays of Earth-based antennas used for space communication or radio astronomy. It is also useful in any situation where precise timing information must be transferred over distances for which optical fiber transmission is appropriate (~10 m to 30 km). It has been used in a demonstration uplink array as part of a technology development for the Deep Space Network.

In the past, other techniques have been used for a similar purpose, but they involve either manipulation of the optical fibers, or they measure and record the phase variation rather than correcting it immediately via a closed-loop servo. The optical methods are generally slow, so they cannot correct

rapid variations. The open-loop methods are less accurate, and they are not useful in situations where real-time correction is needed. The method described here is fast, accurate, and inexpensive to implement. A method similar in principle to this one has been reported earlier, but the new configuration is different and permits variable transmitted frequency and higher correction speed. Related round-trip stabilization methods have been used for signal transmission in coaxial cable and in waveguide

The new method is illustrated by the block diagram in Figure 1. The signal to be transmitted is at frequency f_0 . It is generated by mixing an input at $f_0 + f_1$ (from the first master synthesizer) with a voltage-controlled crystal oscillator (VCXO) at nominal frequency f_1 (77.76 MHz in this implementation). It