

Stabilized Fiber-Optic Distribution of Reference Frequency

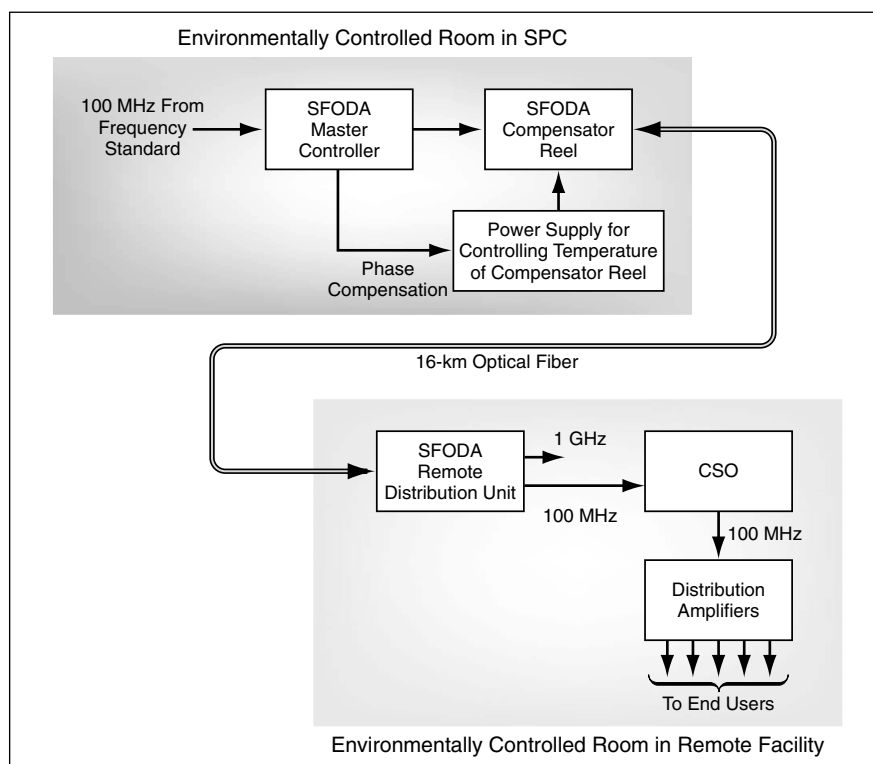
This system includes subsystems that provide short- and long-term stabilization.

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An optoelectronic system distributes a reference signal of low noise and highly stabilized phase and frequency (100 MHz) from an atomic frequency standard to a remote facility at a distance up to tens of kilometers. The reference signal is transmitted to the remote station as amplitude modulation of an optical carrier signal propagating in an optical fiber. The stabilization scheme implemented in this system is intended particularly to suppress phase and frequency fluctuations caused by vibrations and by expansion and contraction of the optical fiber and other components in diurnal and seasonal heating and cooling cycles.

The system (see figure) comprises several subsystems, the main one being (1) a hydrogen-maser or linear-ion-trap frequency standard in an environmentally controlled room in a signal-processing center (SPC), (2) a stabilized fiber-optic distribution assembly (SFODA), (3) a compensated sapphire oscillator (CSO) in an environmentally controlled room in the remote facility, (4) thermally stabilized distribution amplifiers and cabling from the environmentally controlled room to end users, and (5) performance-measuring equipment. Two of these subsystems, considered as separate entities, were the subjects of prior *NASA Tech Briefs* articles: The SFODA was described in "Improved Stabilization of Delay in an Optical Fiber" (NPO-19353), Vol. 21, No. 2 (February 1997), page 4a; and "Alternative for Stabilization of Delay in an Optical Fiber" (NPO-19075), Vol. 21, No. 2 (February 1997), page 6a. The CSO was described in "Temperature-Compensated Sapphire Microwave Resonator" (NPO-19414), Vol. 20, No. 3 (March 1996), page 14a.

To recapitulate: The SFODA includes the transmitter in which the output of the frequency standard is used to modulate the optical distribution signal, the optical fiber used for long-distance transmission, a compensator reel (a wound, electrically controllable fiber-optic delay line in series with the



A Frequency-Standard Signal is transmitted over a long fiber-optic link augmented with equipment at both ends that stabilizes the output frequency and phase to a high degree.

long-distance optical fiber), signal retransmission optics in the remote facility, and equipment in the SPC that measures the overall round-trip propagation delay of the reference signal and adjusts the temperature of the compensator-reel to maintain the overall propagation delay as nearly constant as possible. The CSO is a sapphire-dielectric-ring microwave resonator that operates in a "whispering-gallery" electromagnetic mode and features a paramagnetic-spin-tuned design that provides temperature compensation for ultrahigh frequency stability.

The SFODA and the CSO work in unison in their environmentally controlled rooms to satisfy stringent requirements for stability of frequency and phase: While the SFODA helps to ensure long-term stability, the CSO

helps to ensure short-term stability. In this system, the 100-MHz signal is first multiplied to 1 GHz before applying it as modulation to the optical carrier. At the remote site, a low-noise 100-MHz voltage-controlled oscillator (VCO) that is part of the SFODA is phase-locked to the 1-GHz signal to preserve coherence with the frequency standard. In turn, the CSO is phase-locked to the output of the VCO. The cleaned-up signal is then measured and distributed to end users.

*This work was done by Malcolm Calhoun, Robert Tjoelker, William Diener, G. John Dick, Rabi Wang, and Albert Kirk of Caltech for NASA's Jet Propulsion Laboratory. For further information, access the Technical Support Package (TSP) **free online** at www.nasatech.com NPO-30490*

Delay/Doppler-Mapping GPS-Reflection Remote-Sensing System

This system offers capabilities beyond those of prior GPS-reflection remote-sensing systems.

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A radio receiver system that features enhanced capabilities for remote sensing by use of reflected Global Positioning System (GPS) signals has been devel-

oped. This system was designed primarily for ocean altimetry, but can also be used for scatterometry and bistatic synthetic-aperture radar imaging.

Moreover, it could readily be adapted to utilize navigation-satellite systems other than the GPS, including the Russian Global Navigation Satellite System