lows: The analysis begins with a description of the signal and noise in the case of binary PSK. This description serves as a foundation for a statistical connection between Gaussian noise and the SNR. This connection leads to a probabilistic description that establishes a rigorous connection between the SNR and the measured phase error of the BPSK signal entering the receiver demodulator. Then techniques of maximum-likelihood estimation theory are used to obtain analytical expressions for biased and unbiased estimates of the SNR from easily measured phase errors.

The method requires the use of a modified BPSK demodulator to obtain the time-dependent phase error, $\theta_E(t)$ in a composite output signal. The SNR-estimation procedure begins with the acquisition of a sequence of samples $\theta_E(t_i)$ at k successive sampling times t_i ($i = 1$ to k). Next, one calculates a biased estimate, γ^*, of the SNR (γ) by use of the equation

$$\gamma^* = \kappa \left\{ \sum_{i=1}^{\kappa} \sin^2 \theta_E(t_i) \right\}^{-1}$$

Finally, an unbiased estimate, $\hat{\gamma}$, is obtained from a lookup table that contains solution values for a nonlinear equation that describes the relationship between γ^* and $\hat{\gamma}$. Although the method was derived for BPSK, it can be applied (with modifications) to quaternary and higher-order PSK.

This work was done by Robert M. Manning 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, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4-8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-17597-1.

Advanced Ka-Band Transceiver With Monopulse Tracking

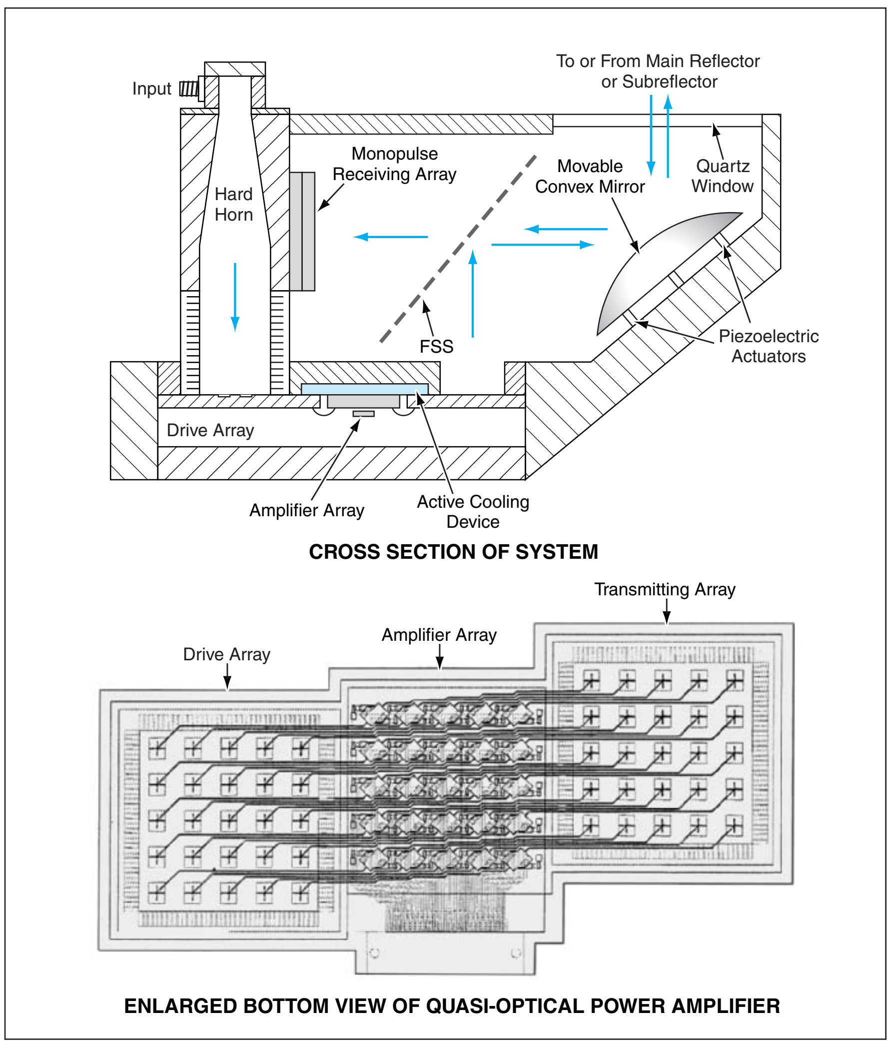
This system would offer advantages over a conventional TWTA-based system.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed Ka-band transmitting/receiving system would embody a unique combination of established and semi-proven design features. Although this system is intended primarily for telecommunication use aboard a spacecraft, its design could be adapted to terrestrial military and commercial radar systems. Systems like this one could be especially suitable as replacements for prior systems in which traveling-wave-tube amplifiers (TWTAs) are used in the final transmitter stages.

The proposed system (see figure) would include a monopulse receiving feedback loop and a mirror that could be moved by piezoelectric actuators in the feedback loop to adjust the aim of the transmitted and received radio beams. Unlike in a phased-array tracking system, phase shifters (which can be complex and expensive) would not be needed in this monopulse tracking system. Moreover, the monopulse-tracking loop could be combined with other subsystems used in established subreflector and antenna designs.

Instead of a TWTA, the final transmitter power amplifier in the proposed system would be a quasi-optical power amplifier (QOPA) — a combination of a planar array of 25 amplifiers and corresponding planar arrays of antenna elements, such that free-space power combining would take place at the output. The goal of this QOPA would be to operate at a power of 20 W and produce a minimum gain



This **Ka-Band Transmitting/Receiving System** would include a monopulse tracking loop in the receiver and a quasi-optical power amplifier in the transmitter.

of 13 dB in the frequency range from 31.8 to 32.3 GHz.

The amplifiers would be identical to commercially available GaAs monolithic microwave integrated circuits (MMICs). Accompanying the QOPA, on the same circuit board, there would be two arrays of antenna elements: a drive array (a planar array of identical input antenna elements) and a transmitting array (a planar array of identical output antenna elements). The drive array would be fed via a hard horn, providing uniform illumination to each array element. By use of microstrip transmission lines, all of equal length, the input and output terminals of the MMIC amplifiers would be connected to the corresponding drive and transmitting antenna elements, respectively. This QOPA design would offer the following advantages (among others):

- The separation of the input and output drive arrays helps eliminate the problem, encountered in prior QOPA systems, of oscillation and allows the use of high-gain amplifiers.
- Unlike a TWTA, the MMIC amplifiers would not necessitate a high-voltage power supply.
- The array of MMIC amplifiers could be actively cooled from its back side; unlike in prior QOPA arrays, it would not be necessary to rely on edge cooling, which is less effective and thus limits the achievable power to a lower level. This is important for future inclusion of wide band-gap devices such as GaN.
- The failure of a single amplifier would not be catastrophic: as long as the other amplifiers continued to operate, the loss in performance would be relatively small. For maximum efficiency, the independent bias lines allow individual modules to be turned off as output power demands change.

The system would include a frequency-selective surface (essentially, a radio-frequency dichroic reflector) intended to reflect the transmitted beam while passing the received monopulse beam. The FSS would provide between 40 and 60 dB of isolation between the transmitted and received beams.

This work was done by Abdur Khan, Dan Hoppe, Larry Epp, and Raul Perez of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*
NPO-30559

EMI Filters for Low-Temperature Applications

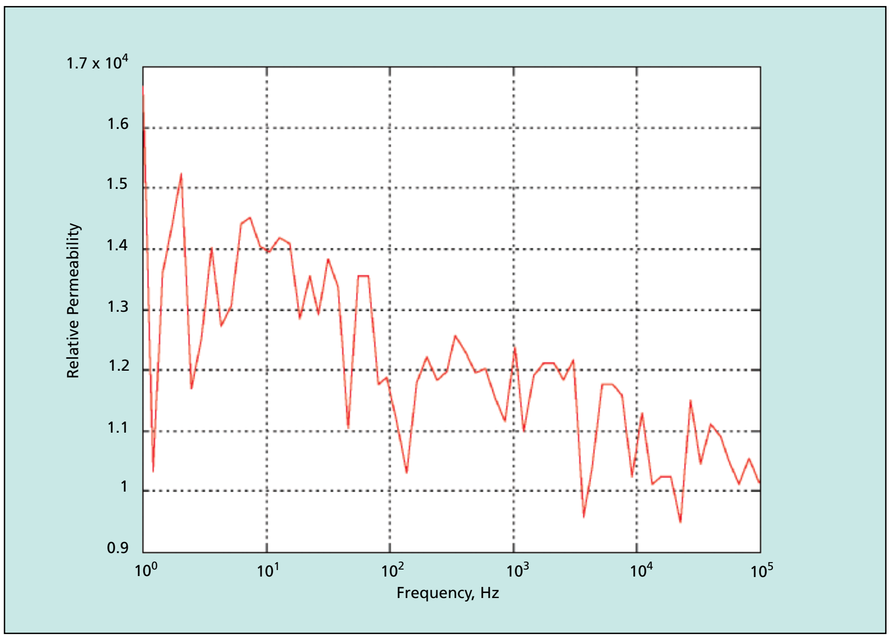
Unlike ferrite-core filters, these should work well under cryogenic conditions.

NASA's Jet Propulsion Laboratory, Pasadena, California

Filters that suppress electromagnetic interference (EMI) on signal cables connected to cryogenic electronic equipment can be made from cores consisting of high-permeability materials. The basic principle of operation of these filters is the same as that of the ferrite-core common-mode EMI filters now commonly used on cables that connect computers with peripheral equipment.

The ferrite-core filters are effective at room temperature but not at low temperatures, because their relative permeabilities decrease from ≈15,000 at room temperature to ≈20 at a temperature of 4 K. In cases of cables that connect cryogenic electronic equipment with room-temperature electronic equipment, it has been common practice to place the ferrite filters at the room-temperature ends of the cables. This makes it necessary for the filtered signals to traverse the cables; during such traversal, crosstalk with other cables can cause the filtered signals to become recontaminated with EMI before they reach the cryogenic equipment. Hence, it would be preferable to place the EMI filters at the cryogenic ends of the cables. The present development makes this a viable option.

An inductive EMI filters blocks EMI due to its impedance to high frequency EMI signals. Since the impedance is proportional to the permeability, a material with high permeability forms the core of such a filter. Several metallic alloys like Cryoperm 10 and VITROVAC are known to have relative permeability exceeding 14,000 at low temperature. However, their relative permeabilities decrease rapidly at frequencies higher than a few hundred hertz due to eddy current, which prevents the magnetic field from penetrating the material. Because ferrite is an insulator, eddy current is not present. Therefore it works at high frequencies. However, all known materials with high permeabilities at low temperatures are metallic. Therefore, for the purpose of constructing cores for low-temperature EMI filters, it is desirable to prepare the high-permeability materials in the form of thin foils or fine powders to reduce the effects of eddy currents. Preliminary



Relative Permeability was measured with a superconducting quantum interference device (SQUID) magnetometer at 4 K.