yond those achievable with the prior cross-sectional shapes.

At the beginning of the program to develop these HBTs, some of the HBTs were fabricated to contain self-aligned base metal structures and some to contain non-self-aligned base metal structures. For the ones containing self-aligned base metal structures, fabrication lots exhibited low yields and high degrees of nonuniformity, which were attributable to inadequate definition of base/emitter junctions. Yields were reduced by the need to reject transistors that had leaky junctions. One of the primary causes of leakage at the junctions was short-circuiting of the base metal to emitter semiconductor epitaxial material that had not been sufficiently removed from the vicinity of the base metal during the wet-etch undercut procedure. The existence of this cause was observed in some cases from scanning electron microscopy and indirectly deduced from the observation that the yields of HBTs containing non-self-aligned base metal structures were more than double the yields of HBTs containing self-aligned base metal structures.

The incidence of leakage is smaller in the non-self-aligned case because the base metal is spaced farther from the emitter at the outset. In contrast, in the self-aligned case, the base metal is separated from the emitter epitaxial material by only the amount of the emitter undercut effected in the aforementioned etching. Self-aligned base metal structures are preferred over non-self-aligned ones because the resulting base resistances are smaller, leading to better transistor performances.

The T-shaped cross section reduces the likelihood of short-circuiting of base metal to epitaxial emitter material, thereby helping to increase fabrication yield, in the following way: The overhang portion of the T acts as an awning-like deposition mask. The base metal is deposited predominantly unidirectionally (vertically downward in the figure) by evaporation, and deposition is prevented or reduced in the shadow area that lies under the overhang and adjacent to the emitter epitaxial material.

The T shape also offers other benefits:

- Requirements for controlling undercut etching are relaxed; as a consequence, emitter/base definition processes are simplified.
- The relaxation of requirements makes it possible to use thicker base metal deposits, thereby reducing the inductances and the electrical and thermal resistances of base metal structures.

This work was done by King Man Fung, Lorene Samoska, James Velebir, Richard Muller, Pierre Echternach, and Peter Siegel of Caltech; Peter Smith of Cree, Inc.; Suzanne Martin of Wavestream Corp.; Roger Malik of RJM Semiconductor; and Mark Rodwell, Miguel Urteaga, Vamsi Paidi, and Zack Griffith of UC Santa Barbara for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*
NPO-41034

Rigorous Estimation of SNR of a PSK Communication Link

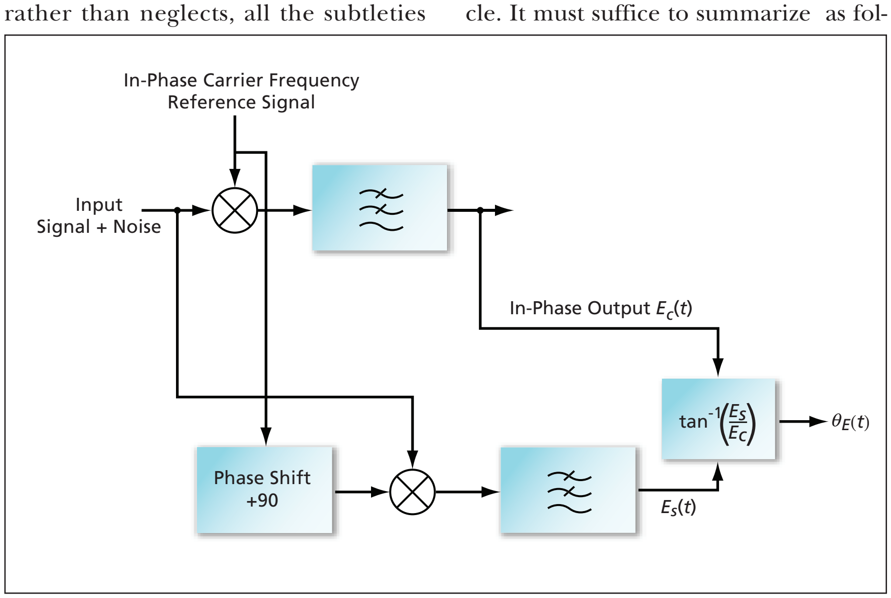
It is not necessary to use a separate link to assess propagation conditions.

John H. Glenn Research Center, Cleveland, Ohio

An improved method of estimating the signal-to-noise ratio (SNR) of a phase-shift keying (PSK) communication link is founded on a rigorous statistical analysis of the input to, and the output from, the PSK demodulator in the receiver. Many methods to estimate SNR ratios of PSK communication links have been developed previously, and all of them are defective (that is, not rigorous) in that all of them are based on tacit and unwarranted assumptions made for the sake of analytical simplification. In addition, some of the prior methods involve (1) the use of a separate receiver, denoted the propagation receiver, to measure a beacon signal distinct from the PSK communication signal and (2) extrapolation of the result of the measurement to an estimate the SNR of the PSK communication channel. In contrast, the improved method is free of unwarranted simplifying assumptions and does not require the use of a propagation receiver.

One basic concept shared by both the improved method and the prior methods is that the effect of noise in the communication link is not only present in the input to the demodulator but is also convolved within the output of the demodulator. The mathematical analysis in this method is based on (1) established theories of statistical analysis of flows of the signal and noise through a generic *M*-ary PSK demodulator, and (2) techniques of maximum-likelihood estimation theory. In this analysis, one employs, rather than neglects, all the subtleties of the statistics that characterize the stochastic nature of the phase-modulated signal to derive an estimation procedure that utilizes the inherent phase characteristics of the input to and the output from the demodulator.

The complexity of the analysis precludes a detailed description in this article. It must suffice to summarize as fol-



A **BPSK Demodulator Is Modified** to obtain the phase error, $\theta_E(t)$, in a composite signal.

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

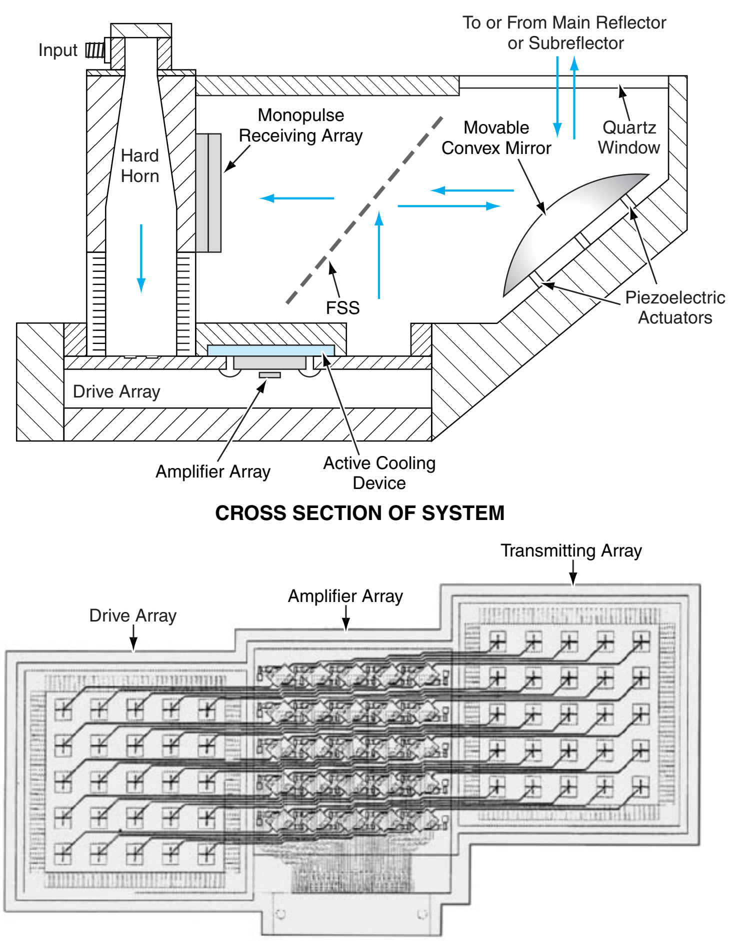
This system would offer advantages over a conventional TWTA-based system.

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.