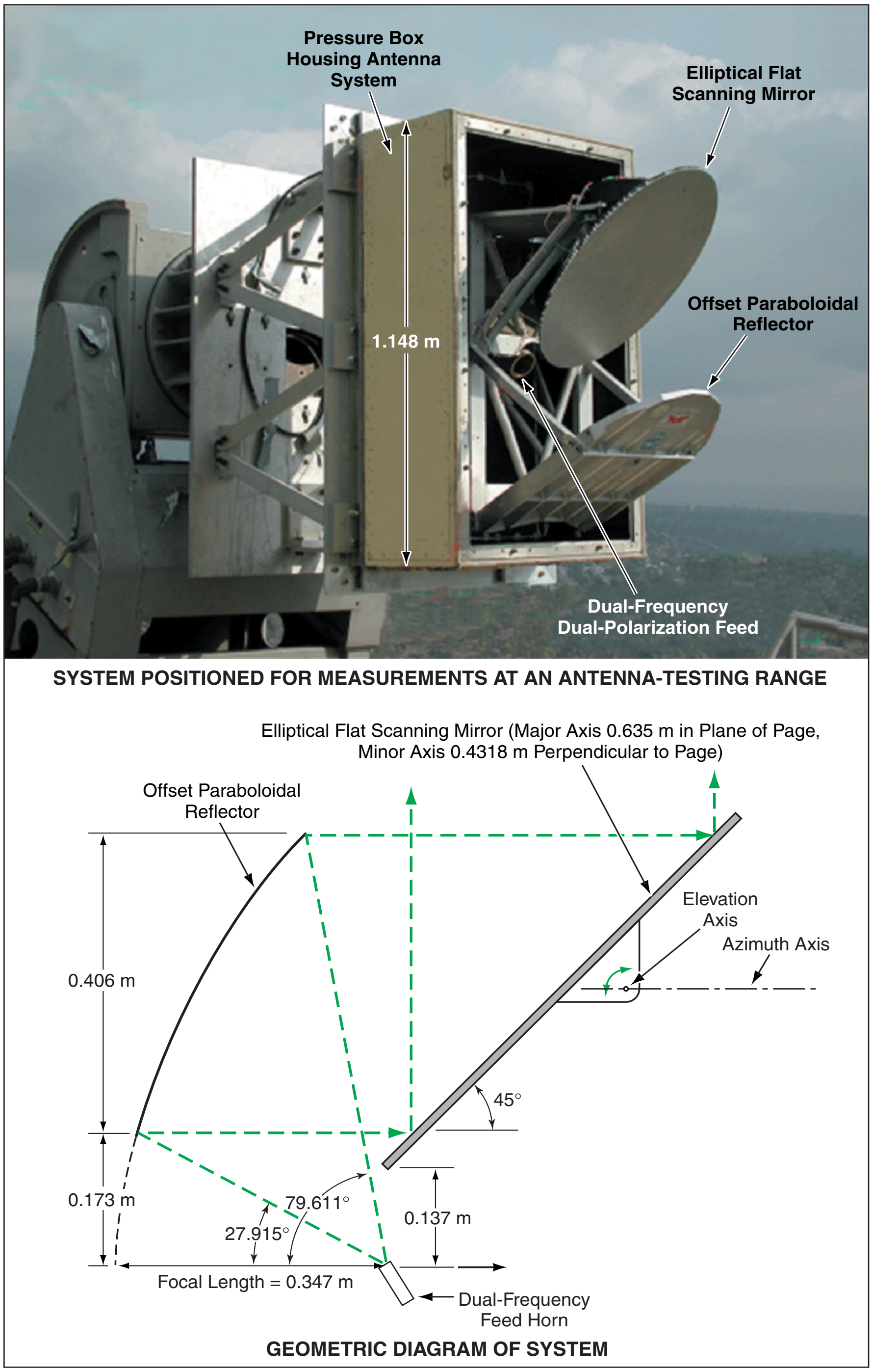
Dual-Frequency Airborne Scanning Rain Radar Antenna System

Spatially coincident horizontally and vertically polarized beams are generated at both frequencies.

NASA's Jet Propulsion Laboratory, Pasadena, California

A compact, dual-frequency, dual-polarization, wide-angle-scanning antenna system has been developed as part of an airborne instrument for measuring rainfall. This system is an upgraded version of a prior single-frequency airborne rain radar antenna system and was designed to satisfy stringent requirements. One particularly stringent combination of requirements is to generate two dual-polarization (horizontal and vertical polarizations) beams at both frequencies (13.405 and 35.605 GHz) in such a way that the beams radiated from the antenna point in the same direction, have 3-dB angular widths that match within 25 percent, and have low side-lobe levels over a wide scan angle at each polarization-and-frequency combination. In addition, the system is required to exhibit low voltage standing-wave ratios at both frequencies.



This **Airborne Rain Radar Antenna System** includes a flat scanning reflector fed by an offset paraboloidal reflector fed by a single feed horn with four ports. Each feed port handles one of four frequency-and-polarization combinations.

The system (see figure) includes a flat elliptical scanning reflector and a stationary offset paraboloidal reflector illuminated by a common-aperture feed system that comprises a corrugated horn with four input ports — one port for each of the four frequency-and-polarization combinations. The feed horn is designed to simultaneously (1) under-illuminate the reflectors 35.605 GHz and (2) illuminate the reflectors with a 15-dB edge taper at 13.405 GHz. The scanning mirror is rotated in azimuth to scan the antenna beam over an angular range of ±20° in the cross-track direction for wide swath coverage, and in elevation to compensate for the motion of the aircraft.

The design of common-aperture feed horn makes it possible to obtain the required absolute gain and low side-lobe levels in wide-angle beam scanning. The combination of the common-aperture feed horn with the small (0.3) focal-length-to-diameter ratio of the paraboloidal reflector makes it possible for the overall system to be compact enough that it can be mounted on a DC-8 airplane. The input ports are oriented orthogonally and carefully positioned and the depths of the corrugations in the feed horn were chosen carefully, all in an effort to minimize the overall level of cross-polarization and side-lobe level in the system.

For optimum performance, the feed phase center would ordinarily be kept at the focal point of the offset paraboloidal reflector. It would be possible to do so in single-frequency operation, but it is not possible to have a single feed phase center for both of the widely separated frequencies of this system. Instead, the feed horn is designed so that the combination of locations is optimal in the sense that it yields an optimal combination of gains, matched 3-dB widths, low cross-polarization, and low side-lobe levels. The elliptical shape of the scanning mirror was chosen, from among a number of superquadric shapes, as the one that results in the lowest overall side-lobe levels.

This work was done by Ziad A. Hussein of Caltech and Ken Green of Microwave Engineering Corp. for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*
NPO-30506

Eight-Channel Continuous Timer

This timer measures every cycle of every input clock signal.

NASA's Jet Propulsion Laboratory, Pasadena, California

A custom laboratory electronic timer circuit measures the durations of successive cycles of nominally highly stable input clock signals in as many as eight channels, for the purpose of statistically quantifying the small instabilities of these signals. The measurement data generated by this timer are sent to a personal computer running software that integrates the measurements to form a phase residual for each channel and uses the phase residuals to compute Allan variances for each channel. (The Allan variance is a standard statistical measure of instability of a clock signal.) Like other laboratory clock-cycle-measuring circuits, this timer utilizes an externally generated reference clock signal having a known frequency (100 MHz) much higher than the frequencies of the input clock signals (between 100 and 120 Hz). It counts the number of reference-clock cycles that occur between successive rising edges of each input clock signal of interest, thereby affording a measurement of the input clock-signal period to within the duration (10 ns) of one reference clock cycle. Unlike typical prior laboratory clock-cycle-measuring circuits, this timer does not skip some cycles of the input clock signals. The non-cycle-skipping feature is an important advantage because in applications that involve integration of measurements over long times for characterizing nominally highly stable clock signals, skipping cycles can degrade accuracy.

The timer includes a field-programmable gate array that functions as a 20-bit counter running at the reference clock rate of 100 MHz. The timer also includes eight 20-bit latching circuits — one for each channel — at the output terminals of the counter. Each transition of an input signal from low to high causes the corresponding latching circuit to latch the count at that instant. Each such transition also sets a status flip-flop circuit to indicate the presence of the latched count. A microcontroller reads the values of all eight status flip-flops and then reads the latched count for each channel for which the flip-flop indicates the presence of a count. Reading the count for each channel automatically causes the flip-flop of that channel to be reset. The microcontroller places the counts in time order, identifies the channel number for each count, and transmits these data to the personal computer.

This work was done by Steven Cole of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*

The software used in this innovation is available for commercial licensing. Please contact Don Hart of the California Institute of Technology at (818) 393-3425. Refer to NPO-40233.

Reduction of Phase Ambiguity in an Offset-QPSK Receiver

Ambiguity would be reduced to twofold at no cost in power efficiency.

NASA's Jet Propulsion Laboratory, Pasadena, California

Proposed modifications of an offset-quadri-phase-shift keying (offset-QPSK) transmitter and receiver would reduce the amount of signal processing that must be done in the receiver to resolve the QPSK fourfold phase ambiguity. Resolution of the phase ambiguity is necessary in order to synchronize, with the received carrier signal, the signal generated by a local oscillator in a carrier-tracking loop in the receiver. Without resolution of the fourfold phase ambiguity, the loop could lock to any of four possible phase points, only one of which has the proper phase relationship with the carrier.

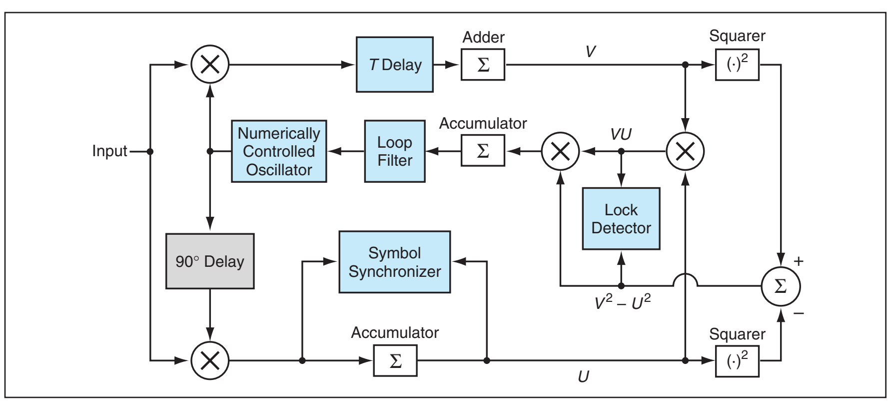


Figure 1. This **Carrier-Tracking Loop** of an offset-QPSK receiver differs from a maximum a posteriori (MAP) carrier-tracking loop of a non-offset-QPSK receiver by incorporating a unit that imposes a delay of one symbol period (*T*).