NASA TECH BRIEF

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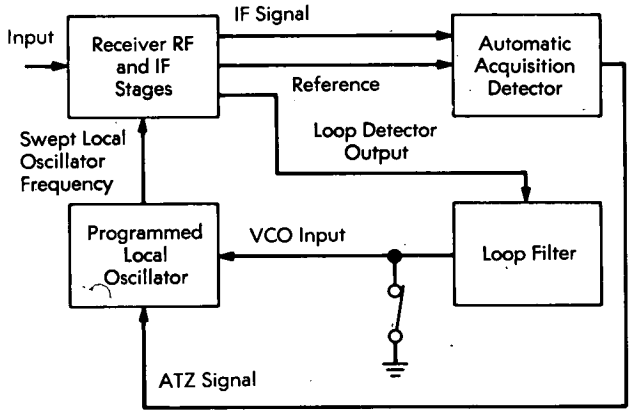
Automatic Carrier Acquisition System for Phase-Lock-Loop Receivers

The problem:

To minimize the time required to acquire carrier signals of very low power from communications satellites or telemetry systems.



The solution:

Automatically acquire phase-lock of the carrier by frequency scanning, using a programmable oscillator and a zero-beat detector. The generation of a high-level dc pulse at the instant of zero crossing provides a positive trigger for a decision gate to stop the search and close the loop for phase-coherent tracking.

How it's done:

The method combines the linear frequency-sweep capabilities of a programmed local oscillator (PLO) assembly with an optimized automatic acquisition detector. Acquisition search is conducted with the receiver in an open-loop mode. During search, the PLO frequency-sweeps the receiver, tuning across the carrier uncertainty range until zero beat, when the carrier (translated to be within the last IF passband) crosses the IF reference frequency. At this instant, the acquisition detector generates a binary change-of-state, or acquisition-trigger-at-zero-beat (ATZ) signal. The ATZ signal is fed to the PLO, which in turn actuates the sweep-stop and main loop closure. The loop then completes acquisition by automatically pulling into phase-lock in the usual manner, cancelling any residual frequency error associated with the ATZ instant. The open-loop acquisition method appears to be a distinct improvement over ordinary closed loop procedures since it inherently avoids false-lock conditions and gives promise of performing automatically over the entire signal level dynamic range. In principle, the acquisition system is not as rapid as a full computerized process might prove to be, but is considerably less complex and expensive than an all-digital approach.

The acquisition system is shown in the diagram. A sinusoidal carrier (with additive noise) of uncertain frequency, amplitude, and frequency rate is mixed with a varying local oscillator frequency (swept PLO) to create a (nominally) linear swept IF carrier. The IF signal-plus-noise spectrum is band-limited through a predetection filter, then amplitude limited; it appears as one input to the automatic acquisition detector subassembly; the other major input is the IF reference frequency. The automatic acquisition detector is functionally a zero-beat detector. As the swept IF carrier signal frequency crosses the IF reference, the subassembly produces the simple binary ATZ decision, changing state at the instant of zero

(continued overleaf)

beat. This pulse is used to stop the local sweep (or return it to a predicted and/or programmed Doppler rate level) and to close the receiver main phase-lock loop. Any frequency error associated with the decision instant will fall well within the acquisition bandwidth of the loop and, as can be determined, away from any potential false-lock condition. A one-second delay is mechanized within the PLO; it smooths the ATZ signal when it is unstable because of low signal amplitude and frequency jitter.

Notes:

1. The receiver of the feasibility model operated at 66 MHz, and was single-conversion with an IF of 498 kHz. White noise with controllable spectral density was injected at the front-end mixer to simulate the desired S/N ratios.
2. Requests for further information may be directed to:

Technology Utilization Officer
NASA Pasadena Office
4800 Oak Grove Drive
Pasadena, California 91103
Reference: TSP 73-10343

Patent status:

This invention has been patented by NASA (U.S. Patent No. 3,746,998). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to:

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