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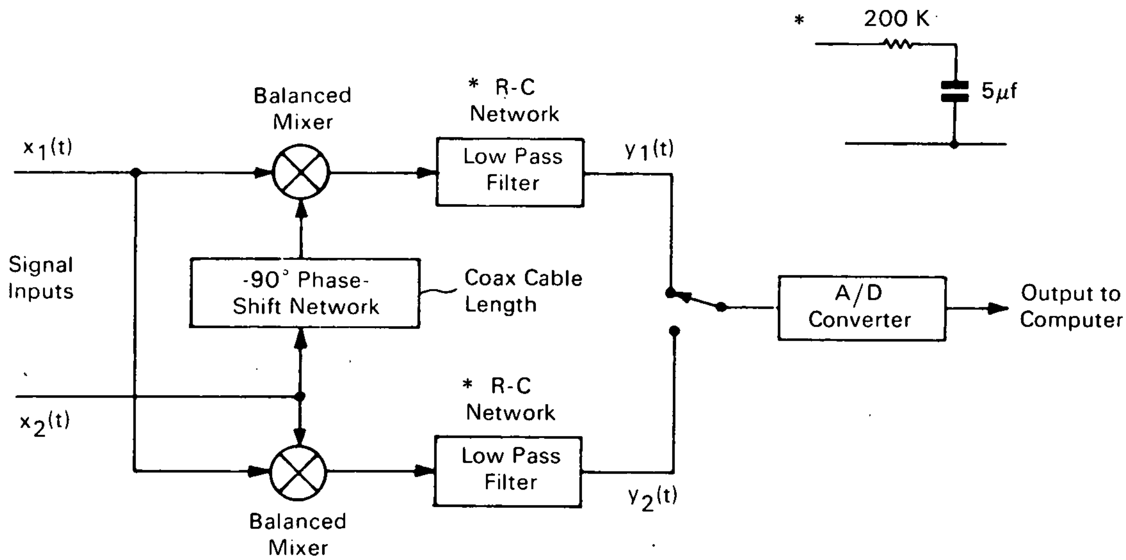
High-Resolution Spectral Analysis



Block Diagram of the Spectrum Analyzer

The problem:

To extend the range and resolution of a digital spectrum analyzer without placing stringent stability requirements on the sampling rate.

The solution:

A new high resolution spectrum analyzer of simple configuration that operates by comparing an unknown signal with a stable frequency standard. This analyzer includes a pair of balanced-mixer devices to which signals from two sources are applied in quadrature. The output of the two mixers is applied through appropriate low-pass filters to an analog-to-digital converter; the output of the converter drives a computer.

How it's done:

A block diagram of the new spectrum analyzer is depicted in the figure. Input signals can be high frequency narrow-band wave forms such as the output of a crystal oscillator or an atomic frequency standard. The two signals are connected to two multipliers, which can be ordinary balanced mixers. Although a multiplexer that causes simultaneous sampling of the two wave forms can be used, alternate sampling is satisfactory. This requires special numerical compensation but it is simpler and less expensive. Two low-pass filters prevent signals above half the sampling frequency from reaching the analog-to-digital converter.

The computer generates a complex autocorrelation function that has a noneven Fourier transform, thus making it possible to obtain a zero-centered spectrum without ambiguity between positive and negative frequencies. The 90° phase-shift network supplies the quadrature component necessary to construct the

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complex autocorrelation function. The input signals shown in the figure are available to the computer in a product form. Because multiplication of two signals in the time domain results in the convolution of their power spectral densities in the frequency domain, the final computed result will be a convolution spectrum. The arrangement shown in the figure is needed to heterodyne the input signals to a lower frequency and to remove stringent stability requirements on the sampling rate.

Although an analog computer is often used for spectral analysis, the use of a digital computer can improve the operation of this spectrum analyzer in three additional ways: (1) by compensating for variations in gain; (2) by compensating for variations in phase shift brought about by the mixers and 90° phase-shift networks; and (3) by removing the requirement that Y_1 and Y_2 be sampled simultaneously. Thus a simple single-pole double-throw relay can be used in place of a more complex and costly multiplexer needed for simultaneous sampling.

Notes:

1. This analyzer has been used to check the stability of an oscillator, and should be of interest to manufacturers of electronic instruments and to facilities engaged in testing.
2. Requests for further information may be directed to:

   Technology Utilization Officer
   NASA Pasadena Office
   4800 Oak Grove Drive
   Pasadena, California 91103
   Reference: B70-10039

Patent status:

This invention is owned by NASA, and a patent application has been filed. Royalty-free nonexclusive licenses for its commercial use will be granted by NASA. Inquiries concerning license rights should be made to NASA, Code GP, Washington, D.C. 20546.

Source: W. F. Gillmore Jr. of Caltech/JPL under contract to NASA Pasadena Office (NPO-10748)