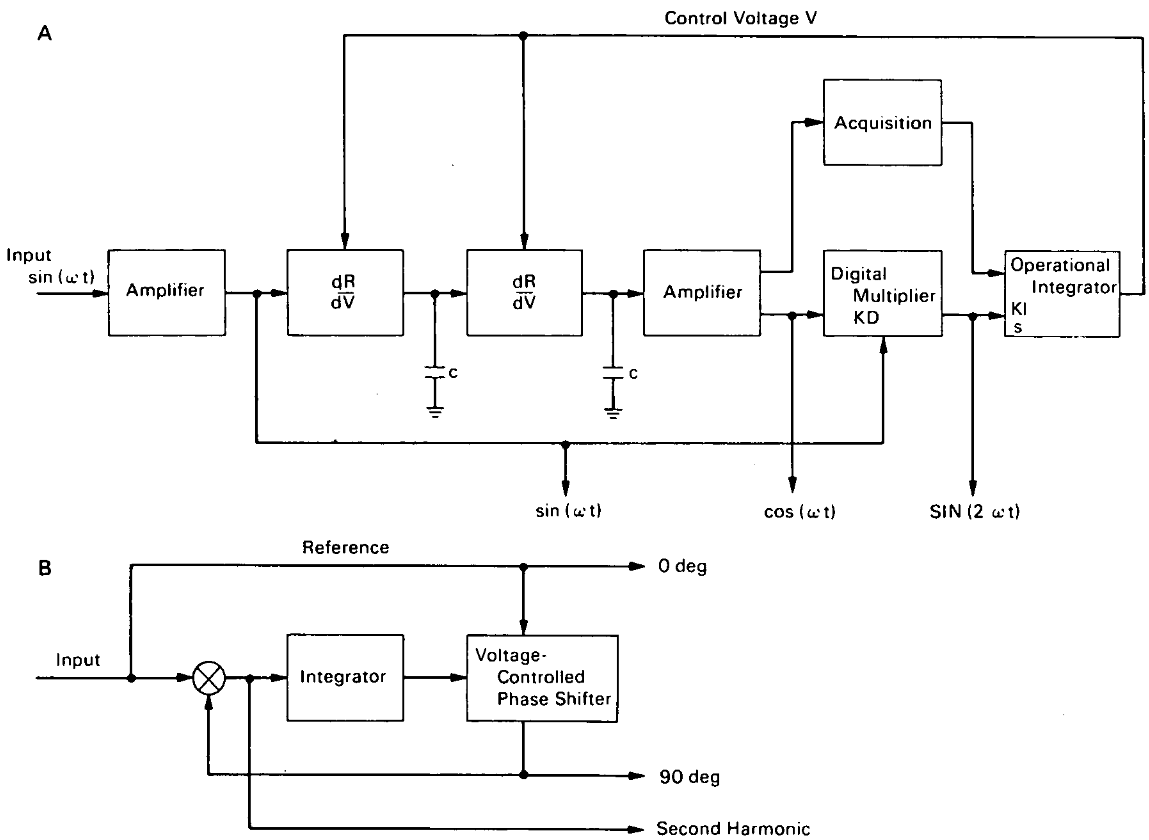
NASA TECH BRIEF

Wide-Band Doubler and Sine Wave Quadrature Generator



Input/Output Phase Relationship

The problem:

To provide a telemetry demodulator signal conditioner having sine and cosine outputs for data subcarrier demodulation from 100 Hz to 100 kHz and a second harmonic signal for synchronization with the locally generated code.

The solution:

A unique-phase locked loop with photoresistive control, which provides both sin (ω t) and cos (ω t), and multiplies these two functions together in the loop phase detector. The difference frequency is used as the error signal to keep the two signals

(continued overleaf)

phase-locked while the multiplier sum frequency yields the second harmonic of the input frequency. This solution to the doubling application yields the proper zero degree input/output phase relationship.

How it's done:

The simplified block diagram illustrates that the phase relationship between the input and output is achieved by having two series R-C phase shifters controlled so that the output is phase-locked 90 deg from the input signal, i.e., the output is cos (ω t) for sin (ω t) input. This is accomplished by using a photoresistor (not shown) as the variable resistor in the R-C circuit. An error voltage is generated at the output of a digital multiplier that is integrated using an operational amplifier and applied to a light source that controls the resistance of the photoresistor.

In a loop analysis, the steady-state phase error between the sin (ω t) input and cos (ω t) output will be zero, providing (dR)/(dv) of the photoresistor is not zero at the operating point. This condition (viz., (dR)/(dv) $\neq$ 0) holds for the particular device used for input frequencies of from 0.1 to 100 kHz. Further, the loop response is one of the first order and is always stable.

One unusual problem was encountered in building the first model. The desired control voltage ranged from −2 to −10 Vdc to control the lamp properly which in turn causes the photoresistor to change its resistance. In checking the prototype it was found, however, that decade step changes in frequency could shock the integrator so that the control voltage (V) momentarily became positive. When this occurred, the loop no longer had control (the lamp being equally sensitive to either polarity control), and the integrator would continue integrating because of the reversal of K until the operational integrator saturated. This problem was solved by designing an acquisition circuit that sensed when the loop no longer had control (i.e., when the light was off and the cos (ω t) signal disappeared) and then applying a discrete command to make the control voltage (V) the approximate correct negative voltage; the loop was again active and could lock onto the input signal.

This wide-band quadrature generator has an output that is 90 degrees displaced from the input (and a square wave second harmonic of the input) over a frequency range of 0.1 to 100 kHz. Operation is automatic and independent of frequency (over the specified limit) and operator controlled.

Notes:

1. This information should interest research personnel in the telemetry and communications industries.
2. Documentation is available from:

   Clearinghouse for Federal Scientific
   and Technical Information
   Springfield, Virginia 22151
   Price $3.00
   Reference: TSP69-10383

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.

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Caltech/JPL
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