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NASA TECH BRIEF

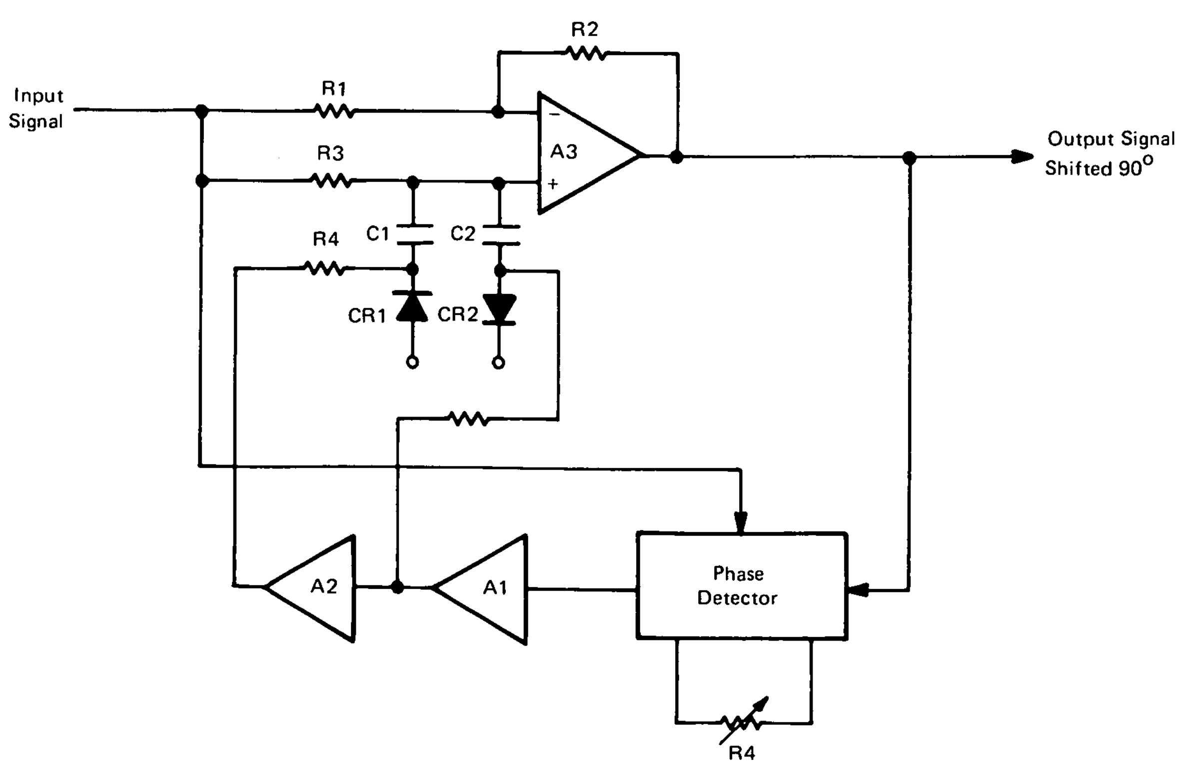
Marshall Space Flight Center

Low Distortion Automatic Phase Control Circuit

In the generation and demodulation of quardrature double side band signals in a frequency division multiplexing system, a 90° phase shifter is required. The 90° phase shift must be independent of frequency over small frequency changes and must also be capable of handling large amplitude sine wave signals without distortion. In this automatic phase control circuit (see figure) the phase shifter uses an operational amplifier with external resistors and capacitors which control the gain and phase shift of the output voltage relative to the input voltage. The operational amplifier, in conjunction with R_1 and R_2 forms an inverting amplifier with a gain approximately equal to the ratio of R_2/R_1 and a 180 degree phase shift. An additional phase shift of 90 degrees results from the use of the second (positive input) of the two differential inputs of the operation amplifier. Signal applied to the positive input through a resistor-capacitor network increases the overall phase shift by an additional 90 degrees. For R_2=R_1 the phase lag, θ_{lag} may be found from the expression:

$$\theta_{lag}=(180-2\tan^{-1}\omega C_t R_3)$$

Where C_t is the series-parallel combination of C_1, C_2, CR_1 and CR_2 and $\omega = 2\pi f$ where f is the modulated carrier frequency. Varactors CR_1 and CR_2 are biased



Automatic Phase Control Circuit

(continued overleaf)

in opposite directions and driven from inverted voltages provided by amplifier A_2 such that the reverse bias on each varactor is equal to the other for any given control voltage.

The capacitance across the varactor diode junction depends on the reverse bias voltage. The two varactors are operated on the same portion of their capacitance versus voltage curve. For matched curves, the capacitance, and therefore phase lag, is independent of the input voltage swing. As a result, there is no distortion of the input signal either in phase or in amplitude such as would occur when a nonlinear element such as only one varicator or FET is used.

It can be seen from the phase lag equation that θ is a function of frequency as well as capacitance. Therefore, to provide a constant phase over a small frequency range, a closed loop phase control system is required. The control loop consists of a phase detector and associated amplifiers. The input and output voltages of the phase shifter are compared in the phase detector with the resulting error voltage amplified by A_1 and A_2 to control the bias applied to the varactors. This automatically compensates for any phase variation caused by variations in input frequency or component changes. The output phase can be held to 0.1% of any given phase lag between 180° and 360° with frequency changes of up to 10%. R_4 in the phase detector allows for a small amount of phase adjustment for phase alignment of the system. This circuit has been operated with an input and output voltage of 6V p-p with harmonic distortion down 70 dB or better.

Notes:

No additional information exists on this innovation. Specific questions, however , may be directed to:

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Patent status:

Inquiries concerning rights for the commercial use of this invention should be addressed to:

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