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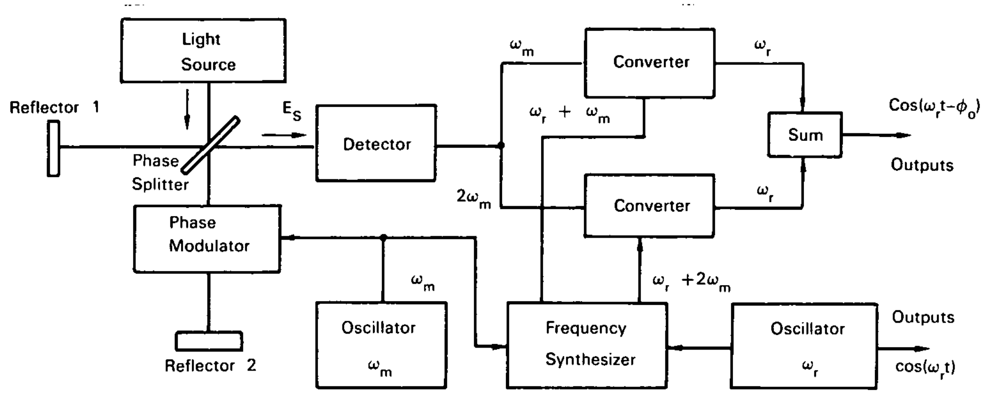
NASA TECH BRIEF

System Converts Optical Phase Changes to RF Phase Changes



The system, represented in the block diagram, was developed to convert phase changes at optical (light) frequencies to equal phase changes at rf (radio frequencies). This system can operate in conjunction with either a Michelson interferometer (block diagram) or other conventional interferometer.

Light from the source arrives at the detector by way of reflector 1 and reflector 2. Light from the latter passes through a light phase modulator. The sum of the light fields at the detector can be represented as

(1)
$$E_s = E_1 \cos \omega t + E_2 \cos(\omega t - \phi),$$

where E_1 and E_2 are the light field, and ω is the light frequency. The two light beams differ in phase by some arbitrary amount, ϕ. The detector output signal is proportional to the total input light power:

(2)
$$\overline{E_1^2} = \tfrac{1}{2}E_1^2 + \tfrac{1}{2}E_2^2 + E_1E_2\cos\phi$$

The phase modulator applies sinusoidal phase modulation to one arm of the interferometer at a frequency ω_m, with a deviation amplitude $\Delta\phi$:

(3)
$$\phi = \phi - \Delta\phi \sin \omega_m t$$

The average phase difference between interferometer arms, ϕ_o, is to be measured. The quantity of interest in Equation (2) is $\cos \phi$. Using Equation (3) and expanding $\cos \phi$ in terms of trigonometric and Bessel function identities, and selecting only the first and second harmonics, gives detector outputs of:

(4)
$$2J_1(\Delta\phi) \sin \phi_o \sin(\omega_m t) + 2J_2(\Delta\phi) \cos \phi_o \cos(2\omega_m t)$$

Conventional frequency synthesizer and frequency conversion techniques shown in the block diagram are used to convert these two terms to a common frequency, ω_r. The modulation index $\Delta\phi$ is adjusted to make the Bessel coefficients equal: $J_1(\Delta\phi) = J_2(\Delta\phi)$. Then Equation (4) can be reduced to:

(5)
$$\sin \phi_o \sin(\omega_r t) + \cos \phi_o \cos(\omega_r t) = \cos(\omega_r t - \phi_o)$$

Thus the two light inputs are of the form $\cos(\omega t - \phi)$ and $\cos \omega t$, and the two output electrical signals are $\cos(\omega_r t - \phi_o)$ and $\cos(\omega_r t)$, which is the desired conversion. The phase between the two outputs is measured with conventional phase meters.

(continued overleaf)

Note:

No additional documentation is available. Questions may be directed to:

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Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

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