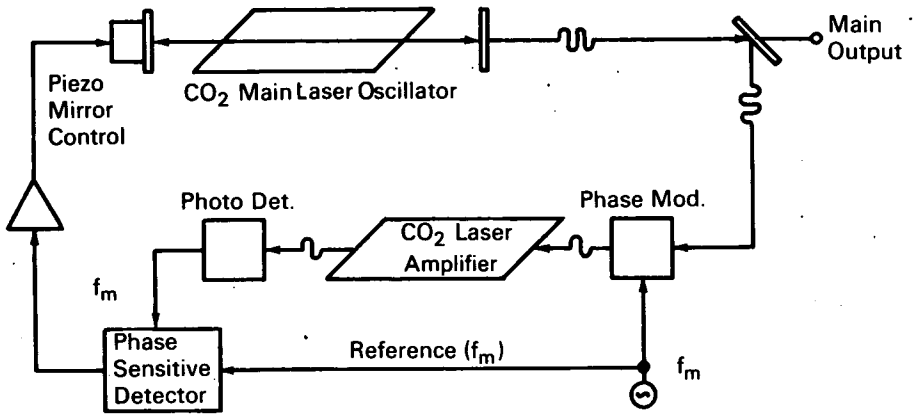
NASA TECH BRIEF

Absolute Frequency Stabilization of Laser Oscillator Against Laser Amplifier



Long-term absolute frequency stabilization of a laser oscillator can be obtained if the laser's oscillation frequency is referenced to the exact center (or some other reproducible feature) of an atomic transition. Several techniques have been proposed and demonstrated for obtaining a discriminant, i.e., an error signal or other indication that the frequency of a laser deviates from the center of its atomic transition.

In the instant technique, a portion of the output of an unmodulated CO_2 laser oscillator is tapped off, frequency modulated at a frequency f_m, and passed through a reference CO_2 laser amplifier that is operated in a nonregenerative and unsaturated linear mode. If the main laser oscillation frequency or carrier frequency f_c coincides exactly with the amplifier's atomic line center f_a, then all sidebands of the frequency modulated signal will receive balanced amplification in the laser amplifier and there will be no fundamental-frequency FM-AM conversion in the amplifier. However, if the carrier frequency f_c deviates from the atomic line center f_a, then the FM sidebands will receive unbalanced amplification and there will be some FM-AM conversion in the amplifier. The amplifier output will then contain an AM component at the modulation frequency f_m, that can be detected by a photodetector following the laser amplifier.

The amplitude of this fundamental AM modulation component will vary linearly with frequency deviation $f_c - f_a$ over a reasonable range about line center. This component provides a useful discriminant or error signal to indicate frequency deviation from atomic line center. Correction of the main laser's oscillation frequency can then be achieved by standard feedback techniques using thermal, magnetorestrictive, or piezoelectric tuning.

In general, a strongly frequency modulated signal contains sidebands spaced by the modulation frequency f_m, and it could be expected that beating between these sidebands in a square-law photodetector would produce a strong beat note at f_m. No such beat

(continued overleaf)

note is observed from a pure FM signal because the sideband phases and amplitudes are so delicately balanced that the beat components between all possible pairs of sidebands exactly cancel. However, passing the FM signal through the laser amplifier off line center, upsets the phase and amplitude balance, destroying the beat cancellation and producing a net observable beat.

Notes:

1. The gas fill, pressure, and pumping conditions of the reference laser amplifier can be adjusted for optimum frequency stability and reproducibility, while the same operating parameters in the main laser oscillator can be adjusted for maximum output power, efficiency, or other considerations, independent of frequency stability considerations.
2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama 35812
   Reference: B67-10255

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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