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A "dual", feed-forward + feed-back frequency control for efficient and convenient diode laser line narrowing

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Abstract

DFB diode lasers have linewidths in the MHz range. Narrowing the linewidth can be obtained by locking the diode to a frequency discriminator (Michelson interferometer,...). But the lock bandwidth has to reach 10 MHz or higher.

The current-to-frequency transfer function of DFB lasers is complex: thermal effects at low frequency, carrier physics at high frequency, and a [1MHz-20MHz] transition zone in which the phase and amplitude show variations that prevent from locking in the MHz range.

Adding a phase modulator in feed-forward (FF) configuration allows convenient control of the laser frequency, in excess of 15MHz, and convenient and efficient line narrowing with commercial, off the shelf components of the telecom industry.

Pros and cons

- Double feed-forward loop (nested loop)
- Feed-back + feed forward control
- Difficult to implement (loop delay, complicated transfer function)
- Using an integrated electrooptic phase modulator

Implementation

Characterization

Conclusions

Feed-forward is the ideal frequency control when using large bandwidth electrooptic phase modulator: control bandwidth >10MHz, if delays are compensated by a fiber loop (impossible with a nested loop)

Achieves narrowing of DFB diodes, with 4kHz FWHM, More than 99% opt. power in the ±150kHz central peak

Implementation using off-the-shelf telecom components @ 1.5um and commercial servos

Settings (gain,..) are stable. If current change needed, gain can be readjusted

M LDF = unit gain frequency

Spectral narrowing @ 125mA

Spectral narrowing vs laser diode current

"occupied bandwidth" of the free-running laser

Feed-forward loop