Microwave-optical fiber lasers stabilized by frequency-shifted feedback

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Microwave-optical fiber lasers stabilized by frequency-shifted feedback

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Distributed-feedback (DFB) fiber lasers can sustain the oscillation of two orthogonal polarizations[1]. Such dual-frequency fiber lasers could be used as sensors or as a microwave optical source.

➡ Phase stabilization needed for microwave photonics applications.

Solutions ? OPLL[2] but uses pump power as the actuator.

➡ Frequency-shifted feedback (FSF) as in bulk lasers[3]?

Stabilization on an external reference using FSF

One laser mode (x) is re-injected in the laser after frequency shift and polarization rotation

Detuning: Δ
 $\Delta = \nu_y - (\nu_x + f_{LO}) = f_b - f_{LO}$
 Reinjection rate: Γ

Frequency locked if $\Delta < \Gamma$

Exp: Locking range 4 MHz when $\Gamma = 3.0 \cdot 10^{-4}$

Optical spectrum

Results for two different DFBs

Self-stabilization using FSF and a delay-line

Hybrid opto-electronic (OEO) scheme[4]

Dynamics governed by:

Relaxation oscillation	$\tau_r \approx 5 \mu s$	200 kHz
FSF loop	$\tau = 50 ns$	20 MHz
OEO delay line	$\tau_{EO} = 25 \mu s$	40 kHz

Beat note electrical spectrum

Results

- Linewidth reduction (/100)
- Few mode hops (40 kHz)
- No RF filter needed (20 MHz resonances filtered by the laser)

Beat note at 1 GHz

Conclusions

- Proof-of-principle of both methods validated
- Methods are independent of the carrier (within limit of EOM bandwidth)
- Reduction of linewidth (at least 100 times) and phase noise (better results on external reference than in the OPLL case)

Perspectives

- Simulation of the laser dynamics with a rate-equation model ✓
- Study on different fiber laser architectures (DBR) ✓
- Increase the beat note for communication application (5G)

References

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