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Bandwidth Enhancement by Optical Modulation of Injection-Locked Semiconductor Lasers

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Abstract: We experimentally demonstrate optical modulation of injection-locked lasers, resulting in a resonant amplification of the transmitted signal. We enhance the 3-dB bandwidth of a 25-GHz electro-optic modulator to >59 GHz and demonstrate the system's tunability.
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OCIS codes: (140.3520) Lasers, injection-locked; (140.5960) Semiconductor lasers; (060.4080) Modulation

Optical injection locking (OIL) has been shown to increase the bandwidth of a directly-modulated semiconductor laser [1]. In this paper, we utilize the enhanced laser dynamics of OIL to selectively enhance a dynamically-tunable bandwidth of an amplitude-modulated (AM) optical signal.

In the master AM-OIL (MAM-OIL) system, rather than directly-modulating the slave laser (SL), the master laser light is modulated [2, 3]. Here, the MAM is created by an electro-optic modulator (EOM), but the technique is not limited by the modulation source type. The SL is a 1550 nm distributed feedback laser. Fig. 2 shows the frequency response of the EOM, with a 3-dB bandwidth (f_{3dB}) of ≈ 25 GHz. All response curves are normalized for cables, network analyzer, and photodetector response. The EOM exhibits a resonant notch at 55 GHz. By injection-locking the SL with the modulated light, we can tune the enhanced resonance of the OIL system to compensate for the notch, resulting in an enhanced f_{3dB} = 59 GHz (line (a), Fig. 2). The tunability of the resonance can be used to create a broad resonance that can compensate for the typically slowly-decreasing response of an EOM, resulting in a flatter frequency response (line (b), Fig. 2). We achieve a relatively flat response over >70 GHz bandwidth, interrupted only by the 55 GHz resonant notch caused by the EOM. By tuning the detuning frequency (Δf), the resonance frequency can be tuned over a very wide range. Fig. 3 shows the RF transmission response of the MAM-OIL laser, by subtracting the EOM response from the EOM plus MAM-OIL response. Here, we changed Δf from 7 to 32 GHz, resulting in resonance frequencies of 73 to 107 GHz, respectively. To the authors' knowledge, this is the first time that resonance frequencies > 100 GHz have been electrically measured in semiconductor lasers.

This technique can potentially be used as an all-optical equalization technique for 100 Gbps systems or ultra-high frequency, dynamically-tunable filter.

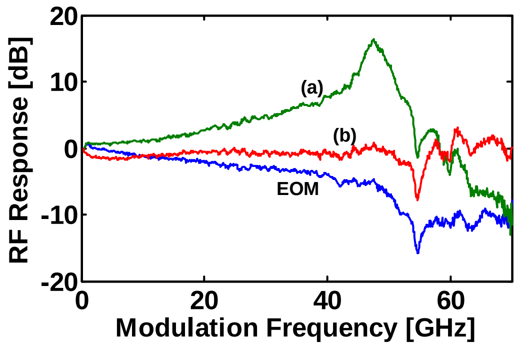

Fig 2. Frequency response of EOM (f_{3dB} = 25 GHz) and EOM + MAM-OIL for two different bias conditions: (a) is optimized for 3-dB bandwidth (f_{3dB} = 59 GHz) while (b) demonstrates >70 GHz flatness .

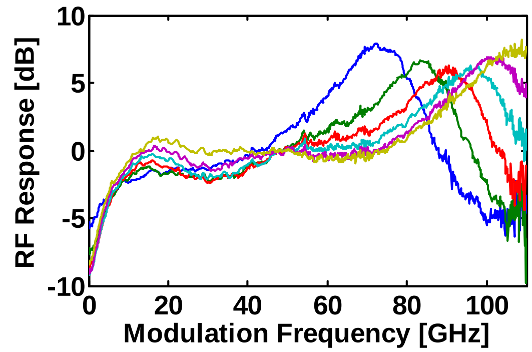

Fig 3. Optical response of MAM-OIL, demonstrating tunability of resonance frequency, from 73 to 107 GHz.

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