All-optical clock recovery from advanced modulation formats through injection-locking of fiber laser

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1 Extended Abstract

The use of advanced modulation formats in optical communication imposes stringent requirements on optical signal to noise ratio (OSNR) and thus, 3R (re-amplification, reshaping and retiming) regeneration is increasingly relevant in long-haul communication links. Clock recovery is a critical functionality for performing the mid-span 3R regeneration and an all-optical implementation is desirable to minimise the number of O-E-O conversions [1]. Injection locking of fiber lasers has proved to be a reliable method that yields improved jitter performance [2]. In this paper, we will explain the working principle of injection locking in an nonlinear polarisation rotation-based passive mode locked laser. We also present the details of clock tone enhancement from non-return-to-zero (NRZ) pulses using a nonlinear SOA. We will further discuss the experimental results of clock recovery for 10 Gbaud NRZ signals, and its resilience to carrier wavelength and modulation formats such as OOK, BPSK, QPSK and 16-QAM.
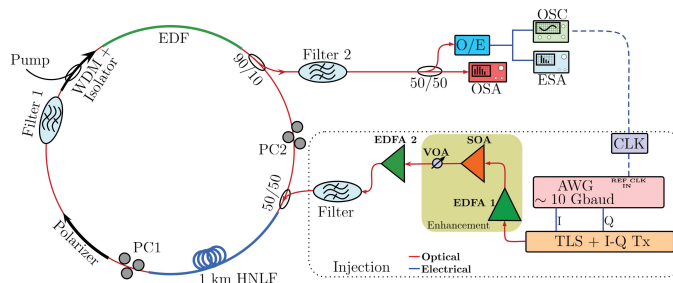

Figure 1. Schematic of fiber laser based clock recovery with SOA-based clock-tone enhancement stage

	OOK	BPSK	QPSK	16-QAM
Clock recovery	✓	✓	✓	✓
Wavelength tunability	✓	✓	✓	✓
CMR (1535 nm)	58 dB	63 dB	62.5 dB	60 dB
RMS jitter (1535 nm)	~ 5 ps*	~ 5 ps*	< 2 ps**	≤ 2 ps**

* Input signal jitter ~ 5 ps   *** Input signal jitter ~ 2 ps*
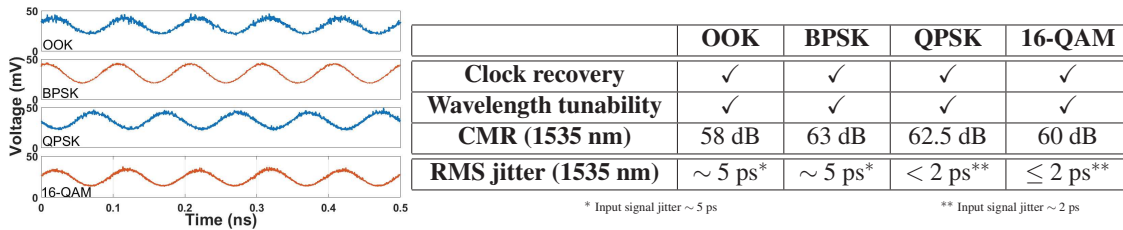
Figure 2. Time-traces of the clock recovered from the various modulation formats (Table) Comparison of the performance metrics of the recovered clock from various modulation formats

The data with appropriate modulation, generated from a tunable laser source (TLS) and an IQ modulator, is subjected to clock-tone enhancement using a nonlinear SOA. The carrier-to-sideband ratio is optimized to achieve injection locking. The enhanced signal is injected into the laser cavity and is haromincally mode locked at the symbol rate. The carrier-to-modulation ratio (CMR) of the recovered clock is found to be $> 60 dB$ for phase modulations and its timing jitter is measured to be < 5 ps for all modulations, across the C-band. We also demonstrate the resilience of the process to input OSNR conditions of the signal.

References

[1] A. Perentos *et al.* , *Opt. Express*, 24 (15)16 649–16 658, 2016.

[2] T. Huang *et al.*, *IEEE Photon. Technol. Lett.*, 24 (8), 682–684, 2012.