Daniel Drayss[1]

Dengyang Fang[1], Christoph Füllner[1], Grigorii Likhachev[2], Thomas Henauer[3], Yung Chen[1], Huanfa Peng[1], Pablo Marin-Palomo[1], Thomas Zwick[3], Wolfgang Freude[1], Tobias J. Kippenberg[2], Sebastian Randel[2], and Christian Koos[1]

[1]Institute of Photonics and Quantum Electronics, KIT, 76131 Karlsruhe, Germany

[2]Institute of Physics, EPFL, CH-1015 Lausanne, Switzerland

[3]Institute of Radio Frequency Engineering and Electronic, KIT, 76131 Karlsruhe, Germany

Slice-Less Optical Arbitrary Waveform Measurement (OAWM)

We demonstrate an optical arbitrary waveform measurement (OAWM) technique that exploits time interleaved optical frequency combs as multi-wavelength local oscillators (LO) and an array of in-phase/quadrature receivers (IQR), Fig.1 [1]. The concept does not require optical demultiplexing filters for signal or LO. Therefore, the photonic integration on a high index-contrast platform such as silicon photonics (SiP) or indium phosphide (InP) is simplified compared to approaches based on spectrally sliced coherent detection [2,3]. We use discrete fiber-based equipment to demonstrate in a proof-of-concept experiment a system bandwidth of 610 GHz, thereby relying on a femtosecond laser as calibration reference. We simultaneously record and reconstruct several 60 GBd and 80 GBd QAM signals with an aggregate bandwidth of 600 GHz, Fig.2, [1].

Figures

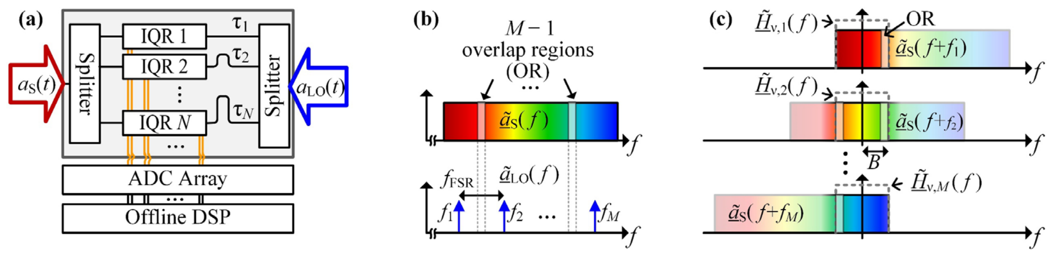

Figure 1: Concept for slice-less OAWM. **(a)** The optical input signal $a_S(t)$ is split into N copies, which are fed to an array of in-phase/ quadrature receivers (IQR). The multi-wavelength LO $a_{LO}(t)$ is also split into N copies. These copies are delayed by τ_ν, $\nu = 1,...N$, and fed to the IQR array. All RF signals gnereated by the IQR array are then digitized by $2N$ ADC (bandiwdth B).A digital representation of the envelope of $a_S(t)$ is reconsturcted offline using digital signal porcessing (DSP) **(b)** Spectrum $\tilde{a}_S(f)$ of arbitrary waveform $a_S(t)$ (top), and spectrum $\tilde{a}_{LO}(f)$ of LO $a_{LO}(t)$ (bottom) with phase coherent tones at frequencies f_μ, $\mu = 1,...M$ and free spectral range f_{FSR}. Assuming $B > f_{FSR}/2$, there are $M-1$ overlap regions (OR) $[f_{\mu+1} - B, f_\mu + B]$, in which spectral components of the signal mix down with both adjacent comb lines to baseband frequencies smaller than B, see (c). **(c)** Visualization of the different mixing products generated in IQR ν and the transfer functions $\tilde{H}_{\nu,\mu}(f)$ accounting for electrical and optical characteristics of the system as well as for the amplitude and phase of the LO tone at frequency f_μ. Adapted from [1].

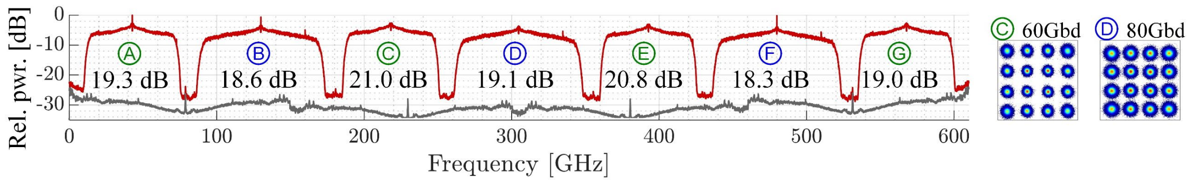

Figure 2: Measurement results obtained in an optical back-to-back experiment with a local oscillator (LO) comb with an FSR of 150 GHz. Left: Normalized power spectrum of reconstructed waveform (red), which comprises four 60 GBd 16QAM signals (ⒶⒸⒺⒼ) and three 80 GBd 16QAM signals (ⒷⒹⒻ). The spectrum of the receiver noise (gray) increases to the edge of each spectral slice $\mu = 1,2,3,4$ due to the digital compensation of the receiver's bandwidth limitation but is reduced in the overlap region by averaging redundant signal components. The constellation signal-to-noise ratio (SNR_c) in dB is provided for all channels (Ⓐ- Ⓖ). Right: Exemplary constellation diagrams. Adapted from [1]

References

[1] Drayss *et al.*, OFC 2022, Paper M2I.1.

[2] Fontaine *et al.*, Nat. Photonics 4, 248–254 (2010)

[3] Fang et al., JLT 40, 1705–1717 (2022).