Carrier-assisted differential detection

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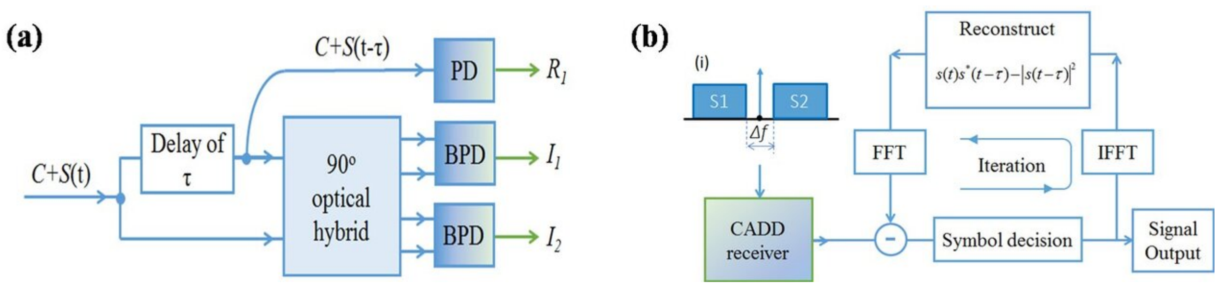

(a) Receiver scheme for CADD; (b) DSP for OFDM modulated signals using the CADD receiver. Inset (i) is the spectrum of signals fed to the CADD receiver, where S1 and S2 are lower and upper sideband signals, respectively. PD: photodiode; BPD: balanced photodiode; FFT: fast Fourier transform; IFFT: inverse fast Fourier transform. Credit: by William Shieh, Chuanbowen Sun, and Honglin Ji

Hyperscale datacenters have sprung up across the globe rapidly. This generate tremendous demand for high-capacity, cost-effective optical communication links that interconnect them. Engineers at the University of Melbourne invented an innovative signal reception scheme tailored for datacenter applications where the complex-valued double-sideband signals can be recovered via direct detection. The receiver architecture opens a new class of direct detection schemes that are suitable for photonic integration analogous to homodyne receivers in coherent detection.

Last decade, various schemes of field recovery with direct detection were investigated in short-reach optical communications. Since direct detection generally provides only intensity information, until now, signals have been mainly restricted to the single sideband (SSB) modulation format in various proposed intensity-only detection schemes. For such detection schemes, signal-signal beating interference (SSBI) is the dominant limitation. Additionally, compared to the optical spectral efficiency (SE), a high electrical SE is a more dictating factor for short-reach applications. The electrical SE is intrinsically limited for the SSB modulation format because one sideband is unfilled, and half of the electrical SE is lost. Apart from the electrical SE, SSB signals suffer from noise folding due to the square-law detection of the photodiode. Consequently, rather than SSB signals, it is highly desirable to investigate the direct detection of complex-valued double sideband (DSB) signals with field recovery.

In a new paper published in *Light: Science & Application*, engineers from the Department of Electrical and Electronic Engineering and the University of Melbourne developed a novel receiver scheme for detecting complex-valued double sideband signals with field recovery called carrier-assisted differential detection (CADD). Compared with conventional single-sideband (SSB) modulation, the electrical SE is doubled without sacrificing the receiver sensitivity. In addition, no precise optical filters are needed for the CADD receiver, indicating the potential of utilizing low-cost uncooled lasers for the CADD receiver scheme.

The new scheme adopts an optical interferometer and 90-degree optical hybrid in the receiver that is capable of detecting both inphase and quadrature components of the linear optical field. Furthermore, the higher-order nonlinear product is mitigated by a novel iterative cancellation algorithm.

The engineers summarize the operational principle of their receiver: "CADD possesses two advantages over conventional carrier-less differential detection (CDD) for field recovery: (i) CADD doubles the electrical SE compared to CDD, as CADD recovers the linear signal while CDD needs to recover the 2nd-order signal-to-signal beating term, and (ii) CADD is insensitive to chromatic dispersion, while CDD is not. This is because without a carrier, the field of CDD can reach zero, which makes differential detection impossible for large chromatic dispersion.

"The advantage of CADD over the Kramers-Kronig (KK) receiver in direct detection is analogous to that of homodyne over heterodyne receivers in coherent detection—although CADD requires a larger number of components, it reduces the optoelectronic bandwidth by half. By adopting photonic integration, either in the InP or silicon photonics (SiP) platform, the large component count in CADD will be much mitigated, while the reduced bandwidth of CADD will greatly reduce the overall implementation cost. Compared to coherent homodyne receivers, CADD does not require highly stable and low-linewidth lasers, leading to a more compact and cost-effective solution suitable for short-reach applications such as intra-data interconnects and ultra-high-speed wireless fronthaul networks."

"The receiver architecture opens a new class of direct detection schemes that are scalable to high baud rate and suitable for photonic integration. It would be very useful for short-reach applications such as intra-data interconnects and ultra-high-speed wireless fronthaul networks," the engineers conclude.

More information: William Shieh et al, Carrier-assisted differential detection, *Light: Science & Applications* (2020). DOI: 10.1038/s41377-020-0253-8

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