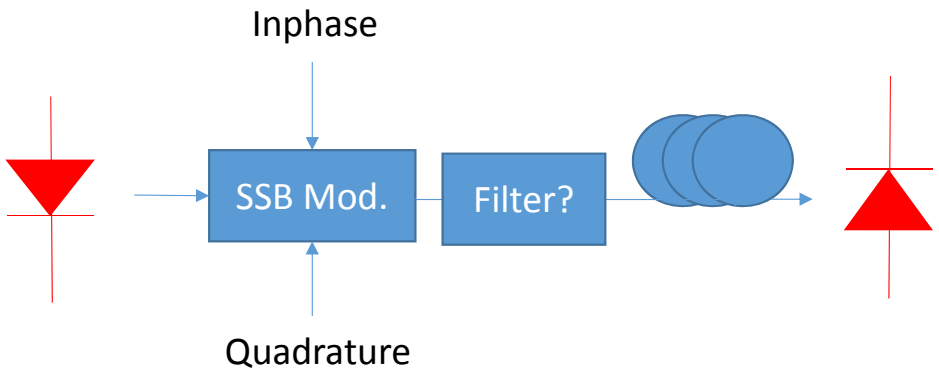
Direct Detection Optical OFDM (DDO-OFDM)

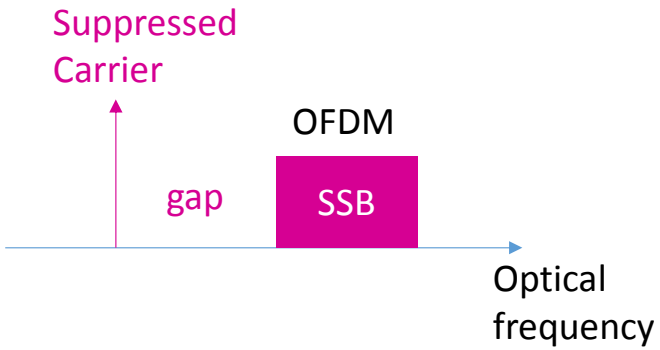
6 Patents in Pictures

Please refer to the patent documents for full disclosures and inventors.

Basic DDO-OFDM

US Patent 8,111,993





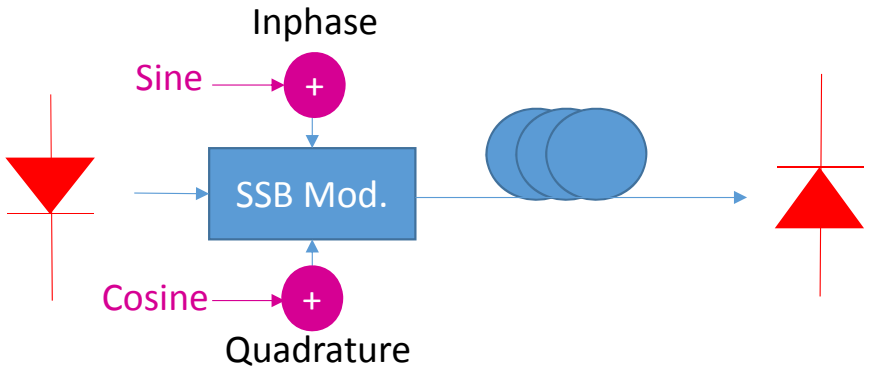
A combination of: SSB, Supressed Carrier, Frequency Gap. Enables electronic dispersion compensation.

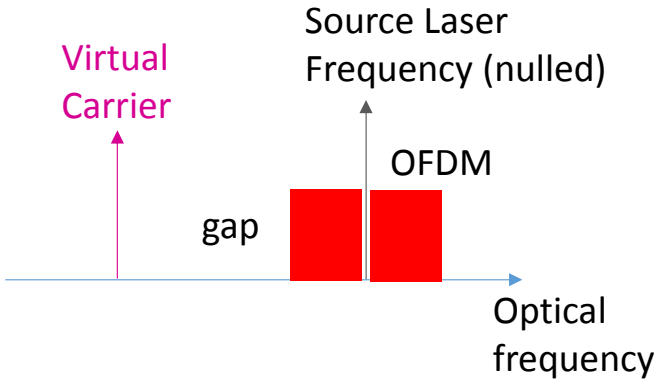
• A. J. Lowery and J. Armstrong, "*Orthogonal frequency division multiplexing for dispersion compensation of long-haul optical systems*", Optics Express. Vol. 14, 2006, pp. 2079-2084 (2006)

• Brendon Schmidt, Arthur Lowery, Jean Armstrong,"Experimental Demonstrations of Electronic Dispersion Compensation for Long-Haul Transmission Using Direct-Detection Optical OFDM", Journal of Lightwave Technology, vol. 26(1), Jan. 2008. pp. 196-203

Advances: Virtual Carrier

US Patent 8,655,177



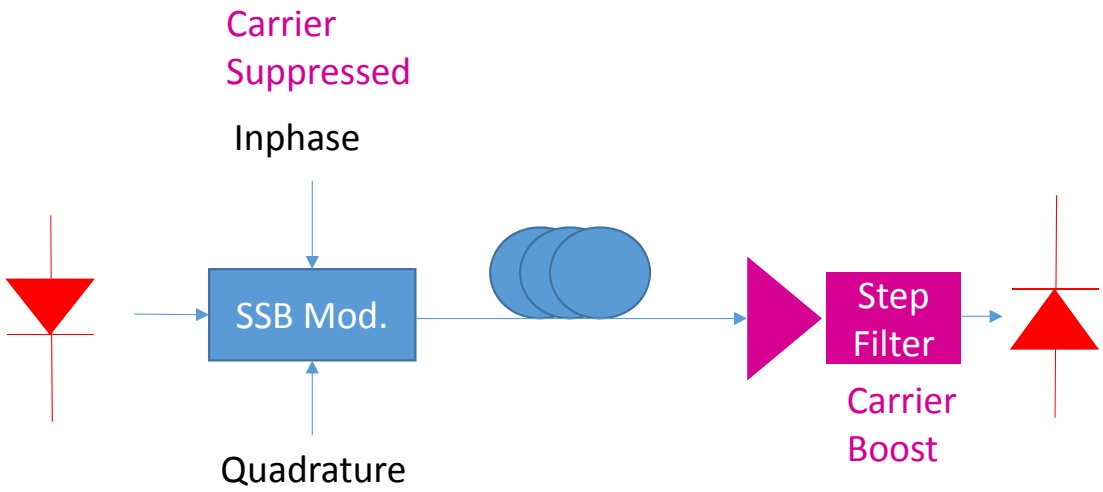


Provides the highest data rate for a given DAC sample rate. This is because the DAC is not used to generate the carrier (or the gap). The frequency and amplitude of the carrier are also easy to control.

• Brendon J. C. Schmdt, A. J. Lowery, Liang B. Du, " *Low Sample Rate Transmitter for Direct-Detection Optical OFDM* ," Optical Fiber Telecommunications (OFC 2009), San Diego, paper OWM4

Advances: Carrier Boost

US Patent 8,233,799



Carrier Boost: Improves the sensitivity of the system (receiver signal quality versus OSNR), and possibly reduces the frequency gap to increase the spectral efficiency.

A. J. Lowery, "*Improving sensitivity and spectral efficiency in direct-detection OFDM lightwave systems*," Optical Fiber Telecommunications (OFC 2008), San Diego, paper OMM4

Advances: Cyclic Prefix Reduction

US Patent 7,693,429

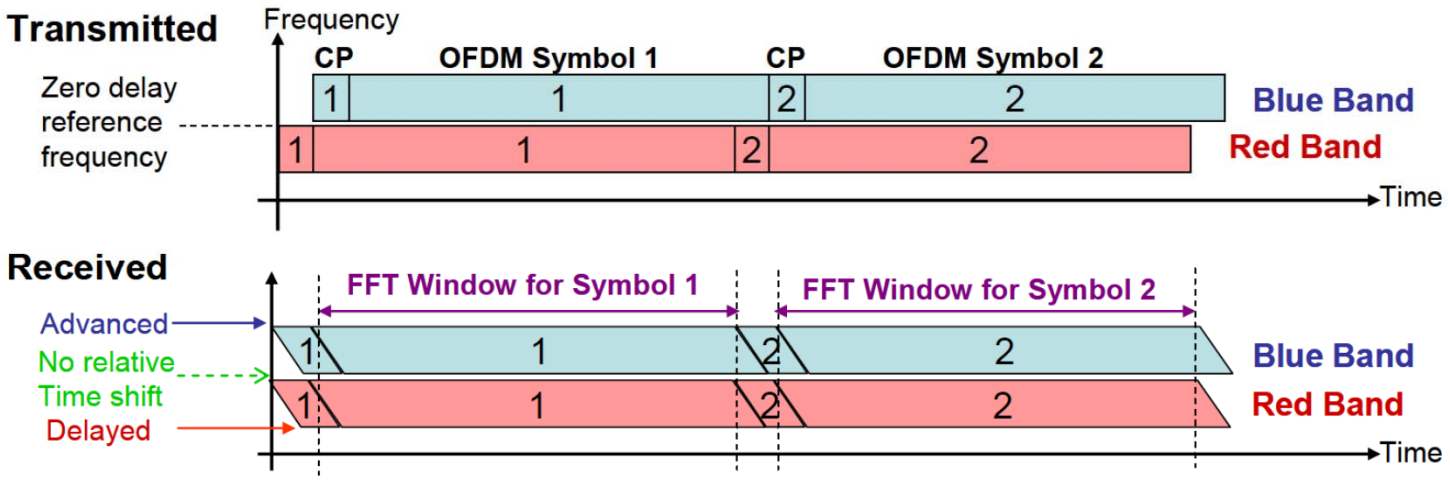


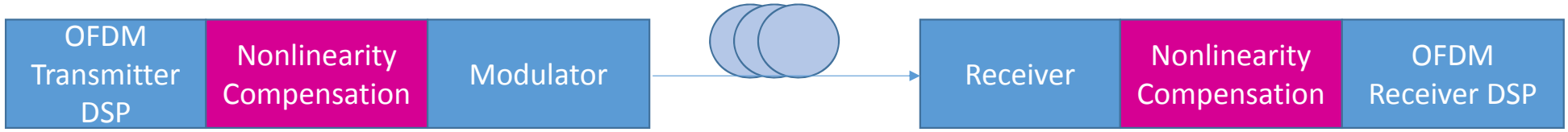
Fig 1: Principle of using delayed bands to reduce Cyclic Prefix (CP) duration.

The idea is to stagger the transmission of bands of OFDM subcarriers so that, after the fiber's differential group delay (DGD), they arrive in synchronism at the receiver. This means that a shorter Cyclic Prefix (CP) may be used, which reduces the CP overhead (i.e. allows more time for data transmission).

A. J. Lowery, "*Reducing Cyclic Prefix Overhead in Optical OFDM Systems*,"European Conference on Optical Communications, (ECOC 2009), Vienna, Austria, paper 1.3.4

Advances: Nonlinearity Compensation (NLC)

US Patent 8,112,001

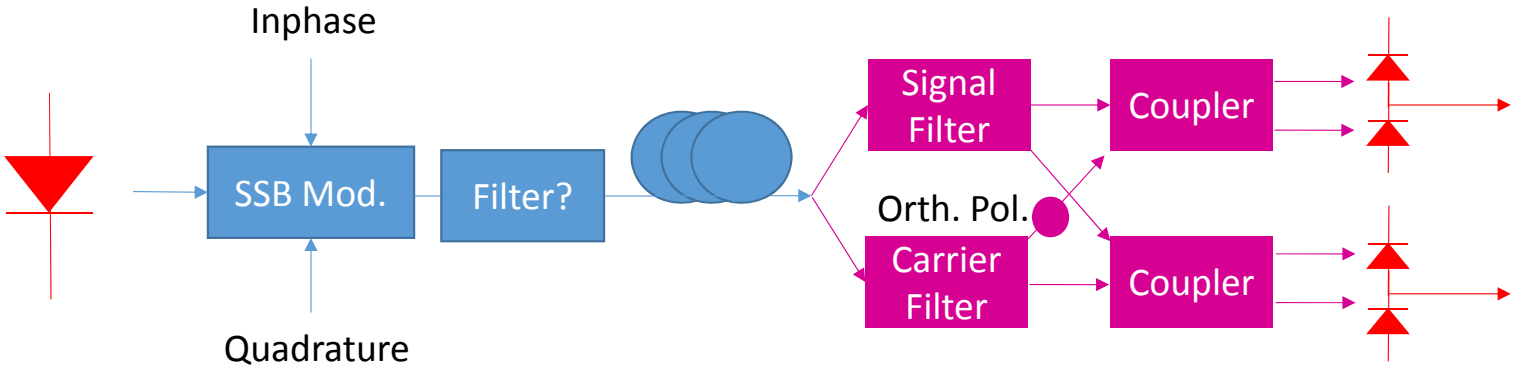


Adds a phase shift proportional to the intensity at the transmitter and at the receiver, to compensate for Kerr nonlinearity. Note, there are many more advances (some patented) in the application of NLC to optical OFDM (coherent and DDO) and other optical signal formats.

A. J. Lowery," *Fiber nonlinearity pre- and post-compensation for long-haul optical links using OFDM*" Opt. Express 15, 12965-12970 (2007)

Advances: Self-Coherent Polmux Receiver

US Patent 8,107,827



The idea is to use a self-coherent receiver with DDO-OFDM, where the carrier is used as the local oscillator in a coherent receiver. This has an advantage that the *signal* × *signal* beat noise is cancelled, so the frequency gap can be reduced. Polarization multiplexing is also supported. A smaller gap is required to enable the carrier to be isolated.

• B.J.C. Schmidt, Z. Zan, L. B. Du and A.J. Lowery, "120 Gbit/s Over 500-km Using Single-Band Polarization-Multiplexed Self-Coherent Optical OFDM", J. Lightwave Technology, vol. 28 (4), pp. 328-335 (2010)

• Brendon J. C. Schmidt, Arthur James Lowery, and Jean Armstrong, " *Impact of PMD in Single-Receiver and Polarization-Diverse Direct-Detection Optical OFDM*", J. Lightwave Technology, vol. 27, No. 14, July 15, 2009, pp.2792-2799