Coherent Detection using Balanced Photodetectors

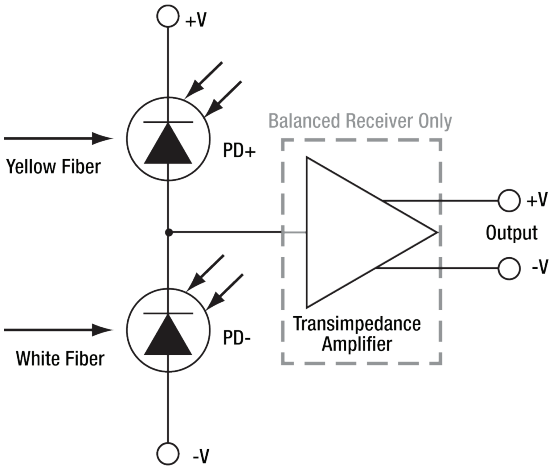
THORLABS
APPLICATION NOTE

OVERVIEW

Thorlabs' high-speed, balanced photodetectors and photoreceivers are designed for wavelength ranges between 700 and 1650 nm. Each module contains a pair of well matched, InGaAs, differential detectors. The user can couple its 50 Ω outputs to subsequent stages of amplification unique to their application.

A balanced detector consists of only photodetectors, while the photoreceiver module adds a transimpedance amplifier as a first stage of pre-amplification. See the diagram to the right for details.

The balanced photodetectors are ideal for use in any application in which the signal of interest is small compared to the total light reaching the detector, including LIDAR, Optical Time-Domain Reflectometry, and Coherent Detection.



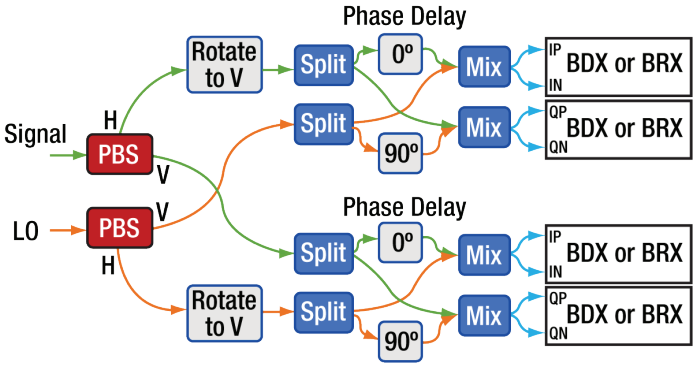
Schematic of Thorlabs' Balanced Photodetector and Photoreceiver Electronics

COHERENT DETECTION

Coherent detection means that the phase of the incoming light is intact when it reaches the receiver. The detector can then extract phase and frequency information carried in the transmitted signal.

In a coherent detection system, the incoming light signal is split, phase shifted, and combined with light from a local oscillator. This results in two pairs of signals incident on the matched detectors. Using balanced photodetectors enables high-sensitivity measurements, as the differential output removes the common mode noise from the input signal.

Optical Coherence Tomography (OCT) is a coherent detection application where balanced photodetectors are used in order to achieve a high sensitivity to the variation between the signal and the reference.

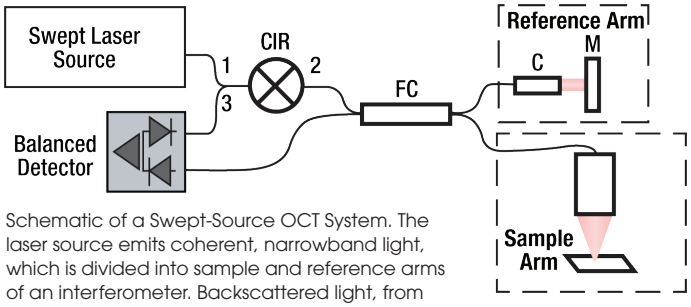


Dual-Polarization Hybrid Mixer Setup for Coherent Detection. In this system, four pairs of balanced detectors are necessary to perform the optical subtraction of the positive and negative signals.

LO = Local Oscillator; BDX or BRX = Balanced Photodetector or Balanced Photoreceiver

OPTICAL COHERENCE TOMOGRAPHY

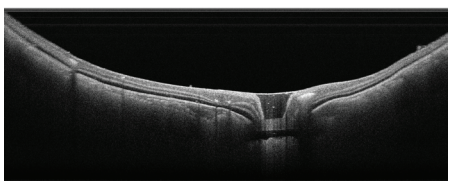
OCT is a noninvasive optical imaging modality that provides real-time, 1D depth, 2D cross-sectional, and 3D volumetric images with micron-level resolution and millimeters of imaging depth. Backscattered light from the sample combines with reflected light from a reference arm, creating an interference pattern. The interference pattern is measured by a detector and then processed by software to form an image.

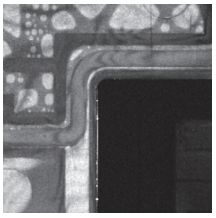


Schematic of a Swept-Source OCT System. The laser source emits coherent, narrowband light, which is divided into sample and reference arms of an interferometer. Backscattered light, from variations in the index of refraction within the sample, is recoupled with light from the reference arm. The resulting interferogram is measured by the balanced detector.

CIR = Circulator, FC = Fiber Coupler, C = Collimator, M = Mirror

In this configuration, the light returning from the sample is very low intensity, and it is mixed with the light coming from the reference arm. This gives two large DC signals with a small AC modulation. The balanced detector subtracts the DC and common-mode noise signals from each other, leaving only the AC signal being measured with a high signal-to-noise ratio. The balanced receiver adds an initial level of pre-amplification to the signal coming from the balanced photodiodes.





Example OCT Images using Balanced Detectors. **Top:** Human Eye Retina. **Right:** Ink Cartridge Weld.