Dark Current in Optical Receiver

Article Overview

Dark current is the small electric current that flows through a photodetector even in the absence of light, contributing to noise and limiting sensitivity in optical receivers.

Definition and Origin

Dark current is a DC current generated in photodetectors such as photodiodes, avalanche photodiodes (APDs), CCDs, and photomultiplier tubes (PMTs) even when no light is incident on the device . In semiconducting devices, it arises primarily from thermal generation of electron-hole pairs within the depletion region or via defect states in the crystal lattice . In PMTs, dark current is mainly caused by thermionic emission from the photocathode . This current is distinct from fluctuating thermal noise, which has zero mean.

Impact on Optical Receivers

Dark current contributes to shot noise, which is a fundamental limit on the minimum detectable optical power . In image sensors or communication receivers, it can produce fixed-pattern noise, which can be partially corrected by dark frame subtraction, but temporal fluctuations remain . In APDs, dark current combined with the excess noise factor can reduce the signal-to-noise ratio (SNR) by several decibels, affecting the receiver's sensitivity .

Temperature Dependence

Dark current is strongly temperature-dependent because thermal excitation drives carrier generation. Cooling the detector, for example to cryogenic temperatures for PMTs or thermoelectrically for photodiodes, can significantly reduce dark current and improve sensitivity . Near breakdown voltages in APDs, dark current can increase due to impact ionization.

Mitigation Techniques

o Cooling the detector to reduce thermal carrier generation.
o Optimizing bias voltage to minimize leakage while maintaining gain.
o Electronic or software subtraction of the average dark current, though shot noise remains.
o Using low-defect materials to reduce generation via defect states .

Summary

In optical receivers, dark current is an unavoidable source of baseline current and noise that limits the detection of weak optical signals. Its magnitude depends on device type, temperature, material properties, and

operating voltage, and careful design and cooling are essential to minimize its impact on receiver performance .

Understanding Dark Current in Photodetectors Introduction to Photodetectors Photodetectors are essential components in various

Dark current must be accounted for by calibration if a photodiode is used to make an accurate optical power measurement, and it is

Understanding dark current, its causes, how to calculate it, and ways to reduce its impact is essential for

Dark current is defined as the current that flows through a diode, such as a solar cell, in dark conditions, arising from the

In a PMT such noise will appear across a load resistor at the anode. In practice, Johnson noise is also much smaller then the dark

Abstract This study addresses the challenges of high dark current density and low responsivity in near-infrared organic

Technical guide to photodiode dark current: reverse leakage mechanisms, temperature doubling, shot-noise contribution, and impact

Controlled Electronics for Optical Communication Detectors: Regulating Dark Current in InGaAs Sensor Systems Abstract: Indium

Dark current is a small DC electric current that a photodetector, such as a photodiode or CCD sensor, produces even in the complete

Many different types of detector can be used to measure the amount of electro-magnetic radiation that falls upon them. In this lecture

Even without incident light, a photodiode produces a small but persistent current--the so-called dark current--driven by

Dark current is another intrinsic source of noise present in photodetectors. It is the number of induced electrons per pixel that arise

It is referred to as reverse bias leakage current in non-optical devices and is present in all diodes. Physically,

dark current is due to

Learn what dark current is, why it causes noise in scientific cameras, and practical ways to calculate, subtract, and

In the context of an optical communication system: for a photodiode, given a resposivity (R) and an incoming optical power (Pin),

Optical Receiver Operation Abstract The design of an optical receiver can be quite sophisticated because the receiver must be able

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