SELECTED TOPICS IN ADVANCED ELECTRONICS

Edited by

Khalid A. S. Al-Khateeb

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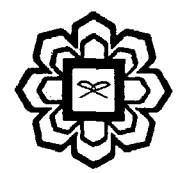

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EMAIL: iiumprinting@yahoo.com

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CONTENTS

CHAPTER 20
AVALANCHE PHOTO DIODES AS SINGLE PHOTON DETECTORS

By
Khalid A. S. Al-Khateeb,
Department of Electrical and Computer Engineering
International Islamic University Malaysia,
Gombak, Selangor, Malaysia.

Synopsis

There are many modern applications in Electronic Engineering which depend on the measurement of extremely low light levels that require highly sensitive photo detectors. One such application is cyber security, which is based on Quantum Key Distribution (QKD). The detector in this type of systems should be able to sense a limited number of photons; hence they are called single photon detectors. Avalanche Photo Diodes (APD) with very high multiplication factors and low noise levels may provide the solution if they are properly designed and manufactured.

Modelling and design of a single photon detector and the setting of its various characteristics should normally precede the manufacturing process. The device is usually modelled to operate in a gated mode at very low temperatures like liquid nitrogen temperature to reduce the noise to a minimum, while operating it at a maximum gain with high multiplication factor. Then, different types of APDs are compared for the assessment of best performance.

In a QKD system the APD is usually part of an optical communication link, which is a private channel used to transmit the key signal. Then encrypted message can be sent via a public channel. Mostly the optical link operates at a wavelength of 1.55μm. The design of the APD is based on InGaAs which has a quantum efficiency of more than 75% and a can be operated with multiplication factor in excess of 1000.

A model for the design of an APD has been set and various calculations are carried out to ascertain its characteristics. The obtained results were a dark current of below 10^{-12}Amps, with an overall signal to noise ratio better than 18dB. The device sensitivity is found to be better than -40dBm, which is more than an order of magnitude higher than the dark current, corresponding to a detection sensitivity of two photons in a pico-second pulse.