

# SELECTED TOPICS IN ADVANCED ELECTRONICS

Edited by  
Khalid A. S. Al-Khateeb



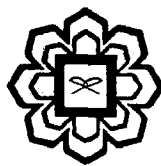
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**CONTENTS**

Chapter 1 .....	1
WIRELESS CONNECTIVITY OF PC PERIPHERALS USING ULTRAWIDE BAND (UWB) PULSES	
Khalid A. S. Al-Khateeb and Ahmed Ramzi Mohammed	
Chapter 2 .....	11
VOLTAGE CONTROLLED OSCILLATOR FOR STANDARD GSM USING MEMS	
<b>Khalid A. S. Al-Khateeb</b>	
Chapter 3 .....	23
MEMS SURFACE ACOUSTIC WAVES OSCILLATOR	
<b>Jamilah Karim, Anis Nurashikin Nordin and AHM Zahirul Alam</b>	
Chapter 4 .....	37
USING MEMS IN CLASS D AMPLIFIERS FOR STANDARD GSM CARRIER	
<b>Khalid A. S. Al-Khateeb</b>	
Chapter 5 .....	52
MEMS CAPACITIVE ULTRASONIC TRANSDUCERS	
<b>Khalid A. S. Al-Khateeb</b>	
Chapter 6 .....	57
DESIGN OF MEMS CANTILEVER ENERGY HARVESTER	
<b>Anis Nurashikin Nordin and Aliza Aini Md Ralib</b>	
Chapter 7 .....	67
THEORY OF QUANTUM CRYPTOGRAPHY	
<b>Ali Sallami and Khalid A. S. Al-Khateeb</b>	
Chapter 8 .....	77
QUANTUM KEY DISTRIBUTION PROTOCOLS	
<b>Ali Sallami and Khalid A. S. Al-Khateeb</b>	

Chapter 9.....	84
FPGA CONTROL OF QUANTUM CHANNEL SECURITY	
<b>Khalid A. S. Al-Khateeb and Mohammed Munther A. Majeed</b>	
Chapter 10.....	97
THE DECOY STATE METHOD IN QUANTUM KEY DISTRIBUTION	
<b>Ali Sallami, Khalid A. S. Al-Khateeb and Mohamad Ridza Wahiddin</b>	
Chapter 11.....	120
EAVESDROPPING ATTACKS ON QKD CHANNELS	
<b>Ali Sallami and Khalid A. S. Al-Khateeb</b>	
Chapter 12.....	126
SECURITY PERFORMANCE OF QKD	
<b>Sellami Ali and Khalid A. S. Al-Khateeb</b>	
Chapter 13.....	132
THEORETICAL ANALYSIS OF A DOUBLE STAGES ERBIUM DOPED FIBER AMPLIFIER	
<b>Khalid A. S. Al-Khateeb and M. A. Mohammed</b>	
Chapter 14.....	142
THEORY OF ERBIUM DOPED FIBER LASERS (EDFLS) AND ERBIUM DOPED FIBER AMPLIFIERS (EDFAS)	
<b>Sallami Ali and Khalid A. S. Al-Khateeb</b>	
Chapter 15 .....	175
ERBIUM DOPED FIBER LASERS WITH DOUBLE TUNABLE BANDPASS FILTER	
<b>Ali Sallami, Khalid Al-Khateeb and Bouzid Billoui</b>	
Chapter 16.....	181
ERBIUM DOPED FIBER AMPLIFIER WITH A QUADRUPLE PASS	
<b>Sellami Ali, Khalid A. S. Al-Khateeb and Bouzid Billoui</b>	
Chapter 17.....	189
TRANSPARENT ELECTRODES FOR OPTOELECTRONIC DISPLAYS	
<b>Khalid A. S. Al-Khateeb</b>	
Chapter 18.....	201
EPITAXIAL GROWTH OF THIN ZnS FILMS	
<b>Khalid A. S. Al-Khateeb</b>	
Chapter 19.....	211
MODERN ELEECTRONIC DISPLAY SYSTEMS	
<b>Khalid A. S. Al-Khateeb and Moaaz Elhag Ali</b>	

Chapter 20.....	230
AVALANCHE PHOTO DIODES AS SINGLE PHOTON DETECTORS	
<b>Khalid A. S. Al-Khateeb</b>	
Chapter 21.....	243
COOLING TECHNIQUES FOR SINGLE PHOTON AVALANCHE DIODE	
<b>Nurul Fadzlin Hasbullah, Nurul Izzati Samsuddin and Salmiah Ahmad</b>	
Chapter 22.....	256
SUPERVISORY CONTROL AND DATA ACQUISITION SYSTEM (SCADA) USING MICROCONTROLLER	
<b>Khalid A. S. Al-Khateeb and Mohamad Azman Shah</b>	
Chapter 23.....	268
ELECTRONIC REMOTE MONITORING OF INDUSTRIAL SYSTEMS	
<b>Khalid A. S. Al-Khateeb</b>	
Chapter 24.....	276
MEDICAL CARE SYSTEM FOR REMOTE MONITORING OF FOETAL ECG	
<b>Khalid A. S. Al-Khateeb and Mohammed I. Ibrahimy</b>	
Chapter 25.....	287
INTELLIGENT AUTO TRACKING IN 3D SPACE BY IMAGE PROCESSING	
<b>Khalid A. S. Al-Khateeb and Othman O. Khalifa</b>	
Chapter 26.....	300
CIRCUIT DESIGN FOR RADIO FREQUENCY IDENTIFICATION DEVICES (RFID)	
<b>Aisyah Jaafar, Nurul Syuhadah Izwar Arfani and Othman O. Khalifa</b>	
Chapter 27.....	309
DYNAMIC TRAFFIC LIGHT SEQUENCE ALGORITHM USING RFID	
<b>Khalid A. S. Al-Khateeb, Jaiz A.Y. Johari and Wajdi F. Al-Khateeb</b>	
Chapter 28.....	326
ADVANCED RFID SECURITY FRAMEWORK FOR DYNAMIC TRAFFIC MANAGEMENT	
<b>Khalid A. S. Al-Khateeb, Jaiz A. Y. Johari</b>	
Chapter 29.....	337
MODELING CMOS WAFER PRODUCTION LINE USING PROMODEL SOFTWARE	
<b>Khalid A. S. Al-Khateeb and Khairul Hakim B. Zainiddin</b>	

Chapter 30.....	348
ASIC DESIGN FLOW	
<b>Sreedharan Baskara Dass, Aisha_Hassan A. Hashim and Loay Faisal</b>	
Chapter 31.....	355
ELECTRONIC DESIGN AUTOMATION TOOLS	
<b>Sreedharan Baskara Dass, Aisha_Hassan A. Hashim and Loay Faisal</b>	
Chapter 32.....	365
CIRCUIT DESIGN OF A CLOCK DATA RECOVERY	
<b>Z. M. Ashari and Anis N. Nordin</b>	
Chapter 33.....	376
EFFECTS OF NEUTRON IRRADIATION ON VARIOUS ELECTRONIC DEVICES	
<b>Nuurul Iffah Che Omar and Nurul Fadzlin Hasbullah</b>	
Chapter 34.....	384
NEUTRON SOURCE AND NEUTRON SHIELDING	
<b>Nuurul Iffah Che Omar and Nurul Fadzlin Hasbullah</b>	
Chapter 35.....	390
QUANTUM DOTS AS A SOLUTION TO RADIATION HARDNESS	
<b>Nuurul Iffah Che Omar and Nurul Fadzlin Hasbullah</b>	

# CHAPTER 20

## AVALANCHE PHOTO DIODES AS SINGLE PHOTON DETECTORS

By

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### 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  $1.55\mu\text{m}$ . 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.