ECEXXXX: SMART SENSING, MEASUREMENT AND INSTRUMENTATION

Programme: B.Tech. **Year:** 4th **Semester:** Odd
Course: Program Elective **Credits:** 3 **Hours:** 40

Course Context and Overview (100 words):

In today's interconnected world, sensors and transducers are the essential elements of the information highway. Billions of sensors are sensing some physical quantity and converting the reading to an electrical form at any given moment. This course will provide the essentials of smart sensing, measurement methodology and instrumentation techniques pertaining to semiconductor technology, RF and microwave communication, photonics communication and IoT enabled systems.

Prerequisites Courses: Mathematics – 1 & 2, BE, ANEL

Course outcomes (COs):

On completion of this course, the students will have the ability to:
CO1: Understand basic knowledge about sensors, interfacing and signal conditioning
CO2: Differentiate and apply different semiconductor measurement and characterization methods
CO3: Analyze different sensing and measurement techniques used in RF and Optical communication systems
CO4: Design and implement IoT based key applications

Course Topics:

Topics	**Lecture Hours**	
UNIT – 1 (Sensors – Fundamentals, Interfacing and Signal conditioning)	12	12
1.1 Introduction and sensor classification.	1.5	
1.2 Thermal, humidity, capacitive, planar, light, moisture and gas sensors.	4.5	
1.3 Key sensor parameters and sensor selection.	1.5	
1.4 Bias levels, loading effect on output of sensors. Study and designing of filters	1.5	
1.5 Instrumentation using Op-amps, Degradation of sensors due to various factors, Overview of signal conditioning circuits like current to voltage converter, ADCs etc..	3	
UNIT – 2 (Introduction to Semiconductor Measurement and Characterization)	7.5	7.5
2.1 Resistivity: Two point, four point probe, wafer mapping, contactless methods.	1.5	
2.2 Series Resistance, Channel Length and Width, and Threshold Voltage: Diodes, solar cells, BJTs and MOSFETs.	1.5	
2.3 Charge based and Probe Characterization: Surface charging, Kelvin probe, scanning probe microscopy.	1.5	
2.4 Optical Characterization: Ellipsometry, spectroscopy.	1.5	
2.5 Chemical and Physical Characterization: Electron beam techniques, ion-beam techniques, X-ray techniques.	1.5	

UNIT – 3 (Introduction to Measurements in Communication Systems)	12	12
3.1 RF and Microwave Communication [1]: Power Measurement Techniques, Scattering Parameter Measurement using Vector Network Analyzer (VNA), SNR Measurement Techniques, Introduction to Spectrum Analyzer.	3	
3.2 RF and Microwave Communication [2]: Communication Receiver Analyzer, SNR and interference characterization and measurement, Bit error rate tester for low and high speed system and modulation measurement.	3	
3.3 Optical Communication [1]: Measurement of LED/ LASER/ APD Characteristics, Fiber Parameters Measurement, Attenuation & Dispersion Measurement, Power Meter, Optical Time Domain Reflectometry.	3	
3.4 Optical Communication [2]: Optical Performance Monitoring, OSNR Estimation, Q-penalty measurement, Receiver Sensitivity, Optical Network Performance Parameters and Measurements, Optical Amplifier: Key Parameters measurements.	3	
UNIT – 4 (Instrumentation in IoT Systems)	8.5	8.5
4.1 Smart sensors, wireless sensor network, test & automated instrumentation for IoT, sensors for environment monitoring, smart homes and smart cities.	4.5	
4.2 Industrial IoT- Instrumentation + Connections (PLC, DCS, SCADA, Interfaces (RS-232, RS-485, RS-422, Ethernet) and Protocols (Modbus Havours, Ethernet/IP), Gateways (kepwave, opto22, Advancetech).	3	
4.3 Case Study: Designing an IoT based sensing system	1	

Text Books:

[1] S. Mukhopadhyay, *Intelligent sensing, instrumentation and measurements*. Berlin: Springer, 2013.

[2] D. Schroder, *Semiconductor material and device characterization*. New York: John Wiley & Sons, 2006.

[3] A. Das and S. Das, *Microwave engineering.* 3ed, Mc Graw-Hill Education, 2015.

[4] G. Keiser, *Optical fiber communications*. S.l.: Mc Graw-Hill Education, 2015.

[5] R. Kamal, *Internet of Things: architecture and design principles.* Mc Graw-Hill Education, 2017.

Reference books:

[1] A. Basu, *An introduction to microwave measurements*. CRC Press, Taylor & Francis Group, 2017.

[2] R. Hui and M. O'Sullivan, *Fiber optic measurement techniques*. Elsevier Academic Press, 2009.

[3] A. McEwen and H. Cassimally, Designing the Internet of Things. John Wiley & Sons, 2013.

Evaluation Method:

Item	Units	Weightage (%)
Quiz 1	1	5
Quiz 2	2	5
Midterm	1 and 2	30
Quiz 3	3	5
Quiz 4 (case study)	4	5
End Term	Complete	50

Please note, as per the notice circulated in the ECE department on 5th March 2018 students having attendance less than 60% will not be allowed to sit in the final examination. Students having attendance <75% will be penalized by 1 grade demotion (A to AB or B to BC etc.)

Updated By: Dr. Gaurav Chatterjee