SEMESTER V

EC621N	DIGITAL SIGNAL PROCESSING*

Module	Content	No. of Lectures
1	**Signals and systems:** Basic elements of DSP, concepts of frequency in Analog and Digital Signals, sampling theorem, Discrete time signals, systems analysis of discrete time LTI systems, Z transform, Convolution, Correlation.	6
2	**Frequency transformations:** Introduction to DFT, Properties of DFT, Circular Convolution, Filtering methods based on DFT, FFT Algorithms, Decimation in time Algorithms, Decimation in frequency Algorithms, Use of FFT in Linear Filtering, DCT, Use and Application of DCT.	10
3	**IIR filter design:** Structures of IIR, Analog filter design, Discrete time IIR filter from analog filter, IIR filter design by Impulse Invariance, Bilinear transformation, Approximation of derivatives (LPF, HPF, BPF, BRF) filter design using frequency translation.	10
4	**FIR filter design:** Structures of FIR, Linear phase FIR filter, Fourier Series, Filter design using windowing techniques (Rectangular Window, Hamming Window, Hanning Window), Frequency sampling techniques.	8
5	**Finite word length effects in digital filters:** Binary fixed point and floating point number representations, Comparison, Quantization noise, truncation and rounding, quantization noise power, input quantization error, coefficient quantization error, limit cycle oscillations-dead band, Overflow error-signal scaling.	8

Text Books:

1. J.G.PROAKIS & D.G.MANOLAKIS, Digital Signal Processing - Principles, algorithms & Applications, PHI, 2000.
2. .B.Venkataramani, M.Bhaskar, "Digital Signal Processors, Architecture, Programming and Application", Tata McGraw Hill, New Delhi, 2003
3. A.V. Oppenheim and Ronald W. Schafer, Discrete Time Signal Processing, 2nd Edition, PHI, 2000.
4. S.K.MITRA, Digital Signal Processing – A computer Based Approach, 2nd Edition, MGH, 2001.
5. Multi Rate Systems and Filter Banks – P.P.Vaidyanathan – Pearson Education.
6. Fundamentals of Digital Signal Processing using Matlab – Robert J. Schilling, Sandra L. Harris, Thomson, 2007

EC503N	DIGITAL COMMUNICATION

Module	Course Content	No. of Lecture
1	**Introduction:** A historical perspective in the development of digital communication, Elements of digital communication system. **Source encoding:** Pulse code modulation, quantization noise, linear and non-linear quantization, companding. Differential pulse code modulation, delta modulation, adaptive delta modulation, Delta sigma modulation, linear predictive coders.	8
2	**Multiplexing:** Introduction to different type of multiplexing, Frequency Division & Time Division Multiplexing, Multiplexing hierarchy, synchronous and asynchronous multiplexing, pulse staffing and word staffing. **Baseband transmission:** Baseband signal receiver, integrate and dump type filter probability of error calculations, optimum filters, coherent reception, matched filter and its transfer function. Probability of error of matched filter. Regenerative repeater, Bit synchronization, In-phase and mid-phase synchronizer. Early late gate synchronizer. Frame synchronization.	8
3	**Different type of line coding:** UPNRZ, UPRZ, PNRZ, PRZ, Manchester, differential encoding and their spectral characteristic, self synchronization properties of some of the encoded signal. **Equalization:** Inter symbol interference (ISI), Purpose of equalization, Eye pattern, Nyquist criterion for zero ISI, fixed equalizer. Design of equalizer, Adaptive equalizer, Decision directed equalizer, Adaptive decision directed equalizer, Partial response signaling.	10
4	**Digital modulation techniques:** BPSK, DPSK. BFSK, MARY-PSK & -FSK, QPSK, MSK principles, QASK, Error calculation. **Spread-spectrum modulation:** Pseudo-Noise Sequence, A notion of Spread Spectrum, Direct-Sequence Spread- Spectrum with Coherent Binary Phase-Shift Keying, Processing Gain, Probability of Error, Frequency-hop Spread Spectrum, Code-Division Multiple Access.	8
5	**Information theory and coding:** Concept and measure of information, Entropy, Discrete and continuous messages, Message source, zero memory sources, extension of zero memory source, Markov source and their entropy, Channel with and without memory, Channel capacity, Hartlay and Shannon's law. **Properties of code:** Uniquely decodable codes, Instantaneous codes, Kraft inequality and Macmillion inequality, Construction of instantaneous codes, Hoffman and Shannon-Fano coding, Error Coding.	6

Text Books:

1. S.Haykin, Digital Communications, John Wiley & Sons, 2009.
2. B.Sklar, Digital Communications, 2 nd Edition, Pearson Education, New Delhi, 2009.
3. John G.Proakis, Digital Communications, 3 rd edition, McGraw Hill, 1995.

EC505N	LINEAR CONTROL SYSTEM	
Module	**Course Content**	**No. of Lecture**
1	**INTRODUCTION:** Concepts of Control Systems- Open Loop and closed loop control systems and their differences, Different examples of control systems- Classification of control systems, Feed-Back Characteristics, Effects of feedback, Mathematical models, Differential equations, Impulse Response and transfer functions.	**7**
2	**TRANSFER FUNCTION REPRESENTATION:** Block diagram representation of systems considering electrical systems as examples -Block diagram algebra – Representation by Signal flow graph-Reduction using mason's gain formula.	**6**
3	**TIME RESPONSE ANALYSIS:** Standard test signals - Time response of first order systems –Characteristic Equation of Feedback control systems, Transient response of second order systems- Time domain specifications–Steady state response-Steady state errors and error constants–Effects of proportional derivative, proportional integral systems. **STABILITY ANALYSIS IN S-DOMAIN:** The concept of stability–Routh's stability criterion – qualitative stability and conditional stability – limitations of Routh's stability.	**10**
4	**ROOT LOCUS TECHNIQUE:** The root locus concept - construction of root loci-effects of adding poles and zeros to G(s) H(s) on the root loci. **FREQUENCY RESPONSE ANALYSIS:** Introduction, Frequency domain specifications-Bode diagrams Determination of Frequency domain specifications and Phase margin and Gain margin Stability Analysis from Bode Plots. Polar Plots, Nyquist Plots Stability Analysis. Compensation techniques – Lag, Lead, and Lead-Lag Controllers design in frequency Domain, PID Controllers.	**10**
5	**State Space Analysis of Continuous Systems:** Concepts of state, state variables and state model, derivation of state models from block diagrams, Diagonalization- Solving the Time invariant state Equations- State Transition Matrix and it's Properties – Concepts of Controllability and Observability.	**6**

Text Books:

1. Control Systems Theory and Applications - S. K. Bhattacharya, Pearson.
2. B.C. Kuo, Automatic Control Systems, 7th Edition, Prentice Hall of India, 2009.
3. I.J. Nagarath and M. Gopal: Control Systems Engineering, 2nd Edition, New Age Pub. Co. 2008.
4. Modern Control System with Advanced topics- S. K. Bharadwaj and S. K. Nagar, New Age Publication.
5. Control Systems - N. C. Jagan, BS Publications.
6. Control Systems - A. Ananad Kumar, PHI.
7. Control Systems - N. K. Sinha, New Age International (P) Limited Publishers

	OPTOELECTRONICS	
Module	**Course Content**	**No. of Lecture**
1	**INTRODUCTION: Difference between electronic, optoelectronic and photonic devices, Electrical and Optical Bandwidth,** Wave nature of light, Polarization, Interference, Diffraction, Absorption, Light Source	**7**
2	**ELEMENTS OF LIGHT AND SOLID STATE PHYSICS:** Basic principles of light propagation. Band structure of metals and semiconductors, Semiconductors - band diagrams, direct and indirect bandgap, degenerate and nondegenerate semiconductors, intrinsic and extrinsic semiconductors.	**8**
3	**OPTICAL SOURCES** :LED Device structure, materials and characteristics. The Semiconductor Laser: Basic structure, theory and device characteristics	**10**
4	Semiconductor Optical Amplifiers(SOA) characteristics and some applications, EDFA.	**10**
5	**OPTICAL DETECTION DEVICES:** Types of photodetectors, Photoconductors, Noise in photodetection, Photodiodes, PIN diodes and APDs: structure, materials, characteristics, and device performance	**8**

Reference :

- B. E. A. Saleh and M. C. Teich, Fundamentals of Photonics, John Wiley & Sons, Inc., 2nd Ed. (2007), Ch.16, 17, and 18.
- P. Bhattacharya, Semiconductor Optoelectronic Devices, Prentice Hall of India (1997).
- J. Singh, Semiconductor Optoelectronics: Physics and Technology, McGraw-Hill Inc. (1995).
- G. Keiser, Optical Fiber Communications, McGraw-Hill Inc., 3rd Ed. (2000), Ch.4, 6

	ELECTRONIC DEVICES	
Module	**Course Content**	**No. of Lecture**
1	**Crystal Properties and charge Carriers in Semiconductors:** Elemental and compound semiconductor materials, crystal lattice structure, Bonding forces and energy bands in solids, charge carriers in semiconductors, carrier concentrations, drift of carriers in electric field	**6**
2	**Excess Carriers in Semiconductors:** Optical absorption, luminescence, carrier life time and photo conductivity, diffusion of carriers	**6**
3	**Junction Properties:** Equilibrium conditions, biased junctions, steady state conditions, reverse bias break down, transient and AC conditions. Metal semiconductor junctions.	**8**
4	**Transistors:** Metal-semiconductor-field-effect-transistors (MESFET), Metal-insulator-semiconductor-field-effect-transistors (MISFET), Metal oxide semiconductor field effect transistor (MOSFET): Construction, Operation and characteristics of above devices. Bipolar junction transistors: Fundamentals of BJT operation, amplification with BJTs.	**12**
5	**Some special devices:** Photodiodes, photo detectors, solar cell, light emitting diodes, semiconductor lasers, light emitting materials. Tunnel Diode: degenerate semiconductors, IMPATT diode; The transferred electron mechanism: The GUNN diode. P-N-P-N diode, semiconductor controlled rectifier (SCR), bilateral devices: DIAC, TRIAC, IGBT.	**8**

EC515N	Microcontroller and Embedded System

Sl No	Topics	No of Lectures
1	Introduction to Microcontroller and Embedded Processor. The 8051 Architecture- Hardware- Oscillator and clock-program counter –data pointer-registers-stack and stack pointer-special function registers- -memory organization-program memory-data memory -Input / Output Ports –External memory-counter and timer-serial data Input / output-Interrupts.	09
2	8051 Assembly Language Programming-Structure of Assembly language-Assembling and running an 8051 program- Addressing modes-Accessing memory using various addressing modes- Instruction set- Arithmetic operations and Programs-Logical operations and Programs -Jump and Call instructions and Programs -I /O Pot Programs - Single bit instructions and Programs –Timer and counter - and Programs	10
3	8051 Serial Communication -Connection to RS-232- Serial Communication Programming- Interrupts Programming	08
4	**Hardware Interfacing:** Interfacing with Key Board, LEDs, Seven Segment, Basic concepts of LCD, ADC, DAC, Relays and their interfacing to microcontroller.	08
5	Basic concept of PIC microcontroller –Microcontroller Architecture – PIC16F Family	09

	Electronics Measurement and Instrumentation

Module	Topics	No. of Lectures
1	**Measurement Errors and Standards:** Definitions, Accuracy and Precision, Significant Figures, Types of Error, Statistical Analysis, Probability of Errors, Limiting Errors, Time and Frequency Standards, Electrical Standards. **Bridge Measurements:** Wheatstone Bridge, Kelvin Bridge, AC Bridge and their Applications, Maxwell Bridge, Hay's Bridge, Unbalance Conditions, Wein Bridge. Anderson's Bridge, De Sauty's Bridge, Schering Bridge.	8
2	**Electronics Instrument For Measuring Basic Parameters:** True RMS Responding Voltmeter, Digital Frequency Meter, Circuit for Measurement of Frequency, High Frequency Measurements, Period Measurement, Ratio and Multiple Ratio Measurements, Time Interval Measurements, Vector Impedance Meter. **Cathode Ray Oscilloscope**: Introduction, Oscilloscope Block Diagram, Cathode Ray Tube, Delay Line, Multiple Trace, Oscilloscope Scope and Transducers, Oscilloscope Techniques, Digital Storage Oscilloscope.	11
3	**Instrument for Generation and Analysis of Waveforms:** Introduction, The Sine Wave Generator, Frequency Synthesized Signal Generator, Frequency Divider Generator, Signal Generator Modulation, Sweep Frequency Generator, Pulse and Square Wave Generator, Function Generator, Wave Analyzers, Harmonic Distortion Analyzer, Spectrum Analyzer.	6
4	**Transducers:** Electrical Transducers Selection and Considerations, Resistive, Strain Gauges, Temperature Transducers: Platinum Resistance Type, Thermistor, Thermocouples, Inductive, LVDT, Capacitive, Load Cell, Piezoelectric, Photoelectric Transducers. **Signal Converters:** I to P and P to I Converter, Temperature to Voltage Converter, Conversion To Frequency, Period, or Time Duration, Measurement of Phase Difference Using X-OR and SR Flip-Flop Method, Measurement of Active And Reactive Power of Supply Line, Locking Amplifiers, Variable Oscillators, Direct Sensor- Microcontroller Interfacing.	9

Module	Topics	No. of Lectures
5	**Isolation Techniques:** Transformer Isolation, Optical Isolation, Digital Techniques For Optical Isolation, Hall-Effect Principle And Measurement Of Displacement, Current And Power Using Hall Sensors, Amplifications Of Low Level Signals, Guarding, Shielding. **Data Acquisition And Conversion:** Analog Signal Processing, Sample And Hold Operation, S/H Circuits Using Op-Amps, Introduction To Data Acquisition System, Various DAS Configurations, Single Channel DAS, Multi-Channel DAS, IC Based DAS, Data Acquisition, Data Acquisition in PLC.	12

EC515N	BIOSENSORS

Module	Course Content	No. of Lecture
1	**General principles:** A historical perspective, Signal transduction, Physico-chemical and biological transducers, Sensor types and technologies, Definitions and Concepts Terminology and working vocabulary, Main technical definitions, calibration, selectivity, sensitivity, reproducibility, detection limits, response time.	8
2	**Physico-chemical transducers:** Electrochemical transducers (amperometric, potentiometric, conductimetric), optical transducers (absorption, fluorescence, SPR), Thermal transducers, piezoelectric transducers.	5
3	**Bio recognition systems: Enzymes:** Oligonucleotides and Nucleic Acids, Lipids (Langmuir-Blodgett bilayers, Phospholipids, Liposomes), Membrane receptors and transporters, Tissue and organelles (animal and plant tissue), Cell culture, Immuno receptors, Chemoreceptors, Limitations & problems, Immobilization of biomolecules.	10
4	**Biosensor Engineering:** Methods for biosensors fabrication, self-assembled monolayers, screen printing, photolithography, micro-contact printing, MEMS, Engineering concepts for mass production.	8
5	**Application of modern sensor technologies:** Clinical chemistry, Test-strips for glucose monitoring, Urea determination; Implantable sensors for long-term monitoring, Environmental monitoring, Technological process control, Food quality control, Forensic science benefits, Problems & limitations.	8

Text Books:

1. Donald G. Buerk, Biosensors: Theory and Applications, First Edition, CRC Press, 2009.
2. Alice Cunningham, Introduction to Bioanalytical Sensors, John Wiley& Sons, 1998.
3. Brian R. Eggins, Chemical Sensors and Biosensors, John Wiley& Sons, 2003.

EC615N	COMMUNICATION SYSTEM	
Module	**Course content**	**No. of Lectures**
1	Signals and Signal Analysis: Periodic and nonperiodic signals, Composite signals, Signal analysis, Time and frequency domain representation. Introduction to Data and signal fundamentals, Analog and digital signals.	**8**
2	Analog Transmission: Concepts of carrier signal, noise, modulating signal and modulated signal; Amplitude modulation – double sideband suppressed carrier, double sideband transmitted carrier, single sideband; Frequency modulation – Narrowband FM and wideband FM; Digital to analog conversion – Amplitude shift keying, Frequency shift keying, Phase shift keying, Quadrature amplitude modulation, Performance.	**8**
3	Digital Transmission: Problems with digital transmission, Different line coding schemes, Block coding schemes, Scrambling techniques; Analog to digital conversion – Sampling techniques, Sampling theorem, Pulse amplitude modulation, Pulse code modulation, Differential pulse code modulation, Delta modulation (along with advantages and disadvantages of each technique), Transmission modes (serial and parallel).	**10**
4	Multiplexing and Spreading: Concept of multiplexing, Frequency division multiplexing, Time division multiplexing – Synchronous and Statistical time division multiplexing.	**10**
5	Error Detection and Correction: Types of errors, Basic concepts of error detection and correction, Redundancy, Hamming distance, Error detection – Simple parity check codes, Two-dimensional parity check, Cyclic redundancy check, Polynomials and cyclic code analysis, Checksum, Error correction – Hamming code.	**8**

Text Books:

1. S. Haykin, Digital Communications, John Wiley & Sons, 2009.
2. B. Sklar, Digital Communications, 2nd Edition, Pearson Education, New Delhi, 2009.
3. John G. Proakis, Digital Communications, 3rd edition, McGraw Hill, 1995.
4. BP Lathi Communication System BS Publication
5. Singh & Sapre, Analog Communication, TMH.

EC511N	SIGNAL AND SYSTEM

Module	Course Content	No. of Lecture
1	**SIGNALS AND SYSTEMS:** Continuous Time and Discrete Time signals, Exponential and Sinusoidal Signals, Unit Impulse and Unit Step Functions, Continuous and Discrete Time Systems, basic System Properties. **LINEAR TIME INVARIANT SYSTEMS:** Discrete Time LTI Systems, Continuous Time LTI Systems, properties of LTI Systems, causal LTI Systems Described by Difference equations.	6
2	**FOURIER SERIES REPRESENTATION OF PERIODIC SIGNALS:** Response of LTI systems to Complex Exponentials, Fourier series Representation of CT periodic Signals, properties of CT Fourier Series, Fourier Series representation of DT periodic Signals, properties of DFS, Fourier series and LTI Systems, Filtering, Examples of CT filters, Examples of DT filters. CONTINUOUS TIME FOURIER TRANSFORM: Representation of a periodic Signals by continuous FT, FT of periodic signals, convolution and multiplication property of continuous FT, systems characterized by Linear Constant Coefficient Differential Equations.	9
3	**TIME AND FREQUENCY CHARACTERIZATION OF SIGNALS AND SYSTEMS**: Magnitude and phase representation of FT, Magnitude and phase response of LTI systems, Time domain and Frequency domain aspects of ideal and non-ideal filters. **DISCRETE TIME FOURIER TRANSFORM (DTFT) and DISCRETE FOURIER TRANSFORM (DFT):** Properties of DTFT and DFT, convolution property, multiplication property, Duality, Systems characterized by Linear Constant Coefficient Difference Equations.	9
4	**SAMPLING:** Sampling theorem, Impulse sampling, sampling with zero order Hold, Reconstruction of signal from its samples using interpolation, Effect of under sampling **Z-TRANSFORM:** Z-transform, Region of convergence and its properties, Inverse Z transform, properties of ZT, Analysis and characterization of LTI systems using ZT, LTI Systems, System function algebra and block diagram representations.	9
5	**SIGNAL FLOWGRAPHS:** Impulse Response and Transfer function of linear Systems, Block diagrams, Signal flow graphs, Basic properties of SFG, SFG Terms, SFG Algebra, Gain formula, Application of gain formula to block diagrams.	7

Text Books:

1. Alan V. Oppenheim, Alan S. Willsky, S. Hamid Nawab, Signals and Systems Prentice Hall India, 2nd Edition, 2009.
2. John G. Proakis, Dimitris G. Manolakis, Digital Signal Processing, Principles, Algorithms, and Applications, 4th Edition, PHI, 2007.
3. Robert A. Gable, Richard A. Roberts, Signals & Linear Systems, 3rd Edition, John Wiley,1995.

EC519N	DIGITAL SYSTEM DESIGN

Module	Course Content	No. of Lecture
1	**INTRODUCTION:** Introduction to Number Systems and Boolean Algebra Digital and Analog Basic Concepts, Number Base Conversion - Complement Codes, Binary Arithmetic , Binary codes: BCD, Weighted codes -2421, 8421, gray code - Binary Logic functions, Boolean Algebra, Theorems and Properties of Boolean Algebra. **MINIMIZATION OF BOOLEAN FUNCTION:** Minimization techniques in digital Logic Canonical forms, Generation of Switching Equations from Truth Table - K-map (Karnaugh map) 2 ,3 and 4 variables, K map with Don't care terms - Quine Mc-Cluskey minimization technique, Quine Mc-Cluskey using Don't Care Terms - Mixed logic Combinational circuits.	**8**
2	**COMBINATIONAL CIRCUIT DESIGN:** Design with basic logic gates, comparators, data selectors, priority encoders, decoders, full adder, serial binary adder, parallel binary adders-ripple-carry adder, carrylook ahead adder; Parallel prefix adders- Carry select Adder, Conditional sum adder, Kogge-stone Adder, Brent-kung adder, Verilog models.	**8**
3	**SEQUENTIAL CIRCUIT DESIGN:** Memory elements and their excitation functions SR, JK, T, and D latches and flip-flops, master slave JK flip-flop, edge-triggered flip-flop, synchronous and asynchronous counters, finite-state machine, sequence detector, minimization and transformation of sequential machines, Registers, Verilog models.	**10**
4	**TESTING OF COMBINATIONAL CIRCUITS:** Fault models, structural testing: path sensitization Logic families: TTL and CMOS Logic circuits, Transfer characteristics, fan-in, fan-out, noise margin, rise time and fall time analysis, realization of Boolean equations using CMOS logic.	**8**
5	**MEMORY:** Types of memories, MOS SRAM cells, DRAM, SDRAM, DDR SDRAM, DDR2 SDRAM, DDR4 SDRAM, organization of a SRAM, Organization of SDRAM, Periphery circuitry of Memory, Flash memory, SD card.	**6**

SEMESTER VI

EC601N	VLSI DESIGN

Module	Content	No. of Lectures
1	**Introduction:** Review of MOSFET characteristics, scaling and small-geometry effects, and MOSFET capacitances. MOS resistor, MOS current source, current mirror circuits. MOS voltage source, linear voltage and current converters.	**6**
2	**CMOS operational amplifier (OPAMP) design:** Differential amplifier, level shifter, source follower, output stage voltage and power amplifiers. Cascode OP-AMP. Compensation techniques. **Analog Filters:** Switched capacitor (SC) fundamentals, first order SC circuits, second-order SC circuits and cascade design. Analog to digital and digital to analog converters, speed of conversion and over sampling issues. **VLSI Interconnects:** Distributed RC model, transmission line model. Future inter connect technologies.	**14**
3	**Digital VLSI Circuit Design:** MOS inverters, CMOS inverter, state characteristics, switching characteristics, power dissipation issues. **CMOS logic gates:** NAND, NOR, XOR, CMOS logic design of half and full adders. CMOS transmission gates, pseudo-nMOS, domino logic gates.	**9**
4	**Sequential MOS Logic Circuits:** The SR latch circuit, clocked latch and flip-flop, CMOS D-latch and edge-triggered circuits, Schmitt trigger circuit, Comparator. **Dynamic Logic Circuits:** Pass transistor logic, synchronous dynamic circuit techniques.	**8**
5	**Semiconductor Memories:** ROM circuits, SRAM circuits, DRAM circuits, drivers and buffers, Buffer scaling and design issues	**5**

Text Books:

1. Sung-Mo Kang, Yusuf Leblebici Chulwoo kim, Digital Integrated Circuits: Analysis and Design, 4th Edition, McGraw Hill Education, 2016.
2. Behzad Razavi, Design of Analog CMOS Integrated Circuits, 2nd Edition, McGraw Hill Education, 2016.
3. Jan M RABAEY, Digital Integrated Circuits, 2nd Edition, Pearson Education, 2003.
4. Neil H.E. Weste and David Harris, CMOS VLSI Design: A circuits and systems perspective, 4th Edition, Pearson Education, 2015.

EC611N	MICROWAVE ENGINEERING

Module	Content	No. of Lectures
1	**Introduction:** RF and microwave spectrum, historical background, application of RF and Microwave Impedance Matching–Unknown impedance measurement using shift in minima technique and impedance matching using single and double stub matching.	8
2	**Microwave waveguides and components**: Rectangular waveguide and circular waveguide, mode structure, cutoff frequency, wall current, attenuation; microwave cavities – rectangular cavity resonator, Q factor, power divider, scattering matrix and transmission matrix, attenuator, phase shifter, directional coupler, Bethe hole coupler, magic tee, hybrid ring, circulator, isolator, Ferrite Devices	10
3	**Planar structures:** Strip line, microstrip line, coplanar structure **Microwave Tubes:** Limitations of conventional tubes, Multicavity Klystron, Reflex Klystron, Magnetron, Travelling Wave Tube, Backward Wave Oscillator Semiconductor Microwave Devices – Tunnel diode, Gunn diode and their waveguide mounts	10
4	**Avalanche diodes:** IMPATT, TRAPATT, Microwave bipolar transistor, heterojunction bipolar transistor. **Microwave field effect transistor:** JFET, MOSFET, MESFET **Applications of microwave:** Industrial Applications of microwave.	8
5	**Microwave Measurement:** VSWR measurement, power measurement, impedance measurement, frequency Measurement Equivalent RF circuit parameters Low pass filter, high pass filter, band pass filter, RF amplifier.	6

Text Books:

1. Golio M, Golio J (2008) The RF and Microwave Handbook. CRC Press.
2. Pozar DM (2005) Microwave Engineering. John Wiley & Sons.
3. Hong JS, Lancaster MJ (2001) Microstrip Filters for RF/Microwave Applications. John Wiley & Sons.

EC605N	BIOMEDICAL SIGNAL PROCESSING

Module	Content	No. of Lectures
1	**Introduction to Biomedical Signals**: The nature of Biomedical Signals, Examples of Biomedical Signals, Objectives and difficulties in Biomedical analysis. **Electrocardiography**: Basic electrocardiography, ECG lead systems, ECG signal characteristics. **Signal Conversion :**Simple signal conversion systems, Conversion requirements for biomedical signals, Signal conversion circuits	**8**
2	**Signal Averaging:** Basics of signal averaging, signal averaging as a digital filter, a typical averager, software for signal averaging, limitations of signal averaging. **Adaptive Noise Cancelling:** Principal noise canceller model, 60-Hzadaptive cancelling using a sine wave model, other applications of adaptive filtering	**8**
3	**Data Compression Techniques:** Turning point algorithm, AZTEC algorithm, Fan algorithm, Huffman coding, data reduction algorithms The Fourier transform, Correlation, Convolution, Power spectrum estimation, Frequency domain analysis of the ECG	**8**
4	**Cardiological signal processing:** Basic Electrocardiography, ECG data acquisition, ECG lead system, ECG signal characteristics (parameters and their estimation), Analog filters, ECG amplifier, and QRS detector, Power spectrum of the ECG, Bandpass filtering techniques, Differentiation techniques, Template matching techniques, A QRS detection algorithm, Realtime ECG processing algorithm, ECG interpretation, ST segment analyzer, Portable arrhythmia monitor	**8**
5	**Neurological signal processing:** The brain and its potentials, The electrophysiological origin of brain waves, The EEG signal and its characteristics (EEG rhythms, waves, and transients), Correlation. **Analysis of EEG channels:** Detection of EEG rhythms, Template matching for EEG, spike and wave detection	**8**

EC615N	INTERNET OF THINGS

Module	Course Content	No. of Lecture
1	**Introduction to IOT:** IoT and the connected world, Architecture of IoT, Security issues, Opportunities for IoT. **The Web of Things:** Linked data, Enterprise data, Importance of security, privacy, and authenticity, Industry standards, Web of Things layer as the driver for IoT systems.	8
2	**Lessons from the Internet:** Relevance of internet to network of things, network management, security, mobility and longevity.	5
3	**Technologies:** Wireless protocols, Connectivity options. **Data storage and analysis:** Managing high rate sensor data, Processing data streams, Data consistency in an intermittently connected or disconnected environment, Identifying outliers and anomalies.	10
4	**Use cases:** Smart Buildings, Smart health, Home automation, Location tracking.	6
5	**Smart Cities:** Collection of information including opportunistic sensing, crowd sensing, and adhoc sensing Response of the system including analytics and optimization, distributed action, people as intelligent actuators, the risk for cyber-attacks in centralized and distributed systems	10

Text Books:

1. Designing the Internet of Things, by Adrian McEwen, Hakim Cassimally Wiley 2013.
2. Enterprise IoT Naveen Balani Create Space Independent Publishing Platform 2016.