Semester VI

Theory/ Practical	**Sl. No**	**Course Type**	**Course Code**	**Course Name**	**Hours per week**			**Credit**	**Mark**	
					L	T	P	C	IA	EA
THEORY										
T	1.	PCC	BEC23401T	Microwave and Antenna theory	2	1	0	3	40	60
T	2.	PCC	BEC23402T	Control System	3	0	0	3	40	60
T	3.	PCC	BEC23403T	Digital system Design- VHDL & Verilog	2	1	0	3	40	60
T	4.	PE-1	BEC23420T	Wireless Communication /	2	1	0	3	40	60
T	5.	OE-2	BEC23430T	Digital Image Processing /	3	0	0	3	40	60
		HM		Finance & Accounting / Constitution of India	2	0	0	2	40	60
PRACTICAL										
P	6.	PCC	BEC23401P	Microwave and Antenna theory Lab	0	0	2	1	50	50
P	7.	PCC	BEC23402P	Control System Lab	0	0	2	1	50	50
P	8.	PCC	BEC23403P	Digital system Design- VHDL & Verilog Lab	0	0	2	1	50	50
T	9.	HM	BEC23404P	Mini Project	00	0	4	2	40	60
				Total	**14**	**3**	**10**	**22**	**390**	**510**

BEC23401T	MICROWAVE AND ANTENNA THEORY	**3L:0T:0P**	**3 Credits**

Pre-requisites: Electromagnetic Wave, Calculus, Differentiation

Course outcomes:

At the end of this course students will demonstrate the ability to
CO 1 Understand* functioning of Passive and Active microwave devices *(Understanding,)
CO 2 Apply mathematical models for transmission lines and waveguides. (Applying)
CO 3 Analyzing basic microwave circuits and do microwave measurements. (Analyzing)
CO 4 Understand antenna characteristics, and design linear antennas and their arrays. (Creating)

Course Contents:

MODULE	***CONTENT***	***No. of CLASSES***
MODULE 1	Mathematical Model of Microwave Transmission-Concept of Mode, Features of TEM, TE and TM Modes, Losses associated with microwave transmission, Concept of Impedance in Microwave transmission. Analysis of RF and Microwave Transmission Lines- Coaxial line, rectangular waveguide, Circular waveguide, Strip line, Micro strip line.	***5***
MODULE 2	Microwave Network Analysis- Equivalent voltages and currents for non-TEM lines, Network parameters for microwave circuits, Scattering Parameters.	***5***
MODULE 3	Passive and Active Microwave Devices- Microwave passive components: Directional Coupler, Power Divider, Magic Tee, Attenuator, Resonator. Microwave active components: Diodes, Transistors, Oscillators, Mixers. Microwave Semiconductor Devices: Gunn Diodes, IMPATT diodes, Schottky Barrier diodes, PIN diodes. Microwave Tubes: Klystron, TWT, Magnetron.	***5***
MODULE 4	Microwave Design Principles- Impedance transformation, Impedance Matching, Microwave Filter Design, RF and Microwave Amplifier Design, Microwave Power Amplifier Design, Low Noise Amplifier Design, Microwave Mixer Design, Microwave Oscillator Design. Microwave Antennas- Antenna parameters, Antenna for ground based systems, Antennas for airborne and satellite borne systems, Planar Antennas.	***5***
MODULE 5	Microwave Measurements- Power, Frequency and impedance measurement at microwave frequency, Network Analyzer and measurement of scattering parameters, Spectrum Analyzer and measurement of spectrum of a microwave signal, Noise at microwave frequency and measurement of noise figure. Measurement of Microwave antenna parameters.	***5***
MODULE 6	Physical concept of radiation, Radiation pattern, near-and far-field regions, reciprocity, directivity and gain, effective aperture, polarization, input impedance, efficiency, Friis transmission	***7***

	equation, radiation integrals and auxiliary potential functions. Radiation from Wires and Loops- Infinitesimal dipole, finite-length dipole, linear elements near conductors, dipoles for mobile communication, small circular loop.	
MODULE 7	Aperture and Reflector Antennas- Huygens' principle, radiation from rectangular and circular apertures, design considerations, Babinet's principle, Radiation from sectoral and pyramidal horns, design concepts, prime-focus parabolic reflector and cassegrain antennas. Broadband Antennas- Log-periodic and Yagi-Uda antennas, frequency independent antennas, broadcast antennas. Micro strip Antennas- Basic characteristics of micro strip antennas, feeding methods, methods of analysis, design of rectangular and circular patch antennas. Exercises using simulator tools like HFSS, CST, MATLAB	***8***
MODULE 8	Antenna Arrays- Analysis of uniformly spaced arrays with uniform and non-uniform excitation amplitudes, extension to planar arrays, synthesis of antenna arrays using Schelkunoff polynomial method, Woodward-Lawson method. Basic Concepts of Smart Antennas- Concept and benefits of smart antennas, Fixed weight beamforming basics, Adaptive beamforming. Exercises using simulator tools like HFSS, CST, MATLAB	***5***

Text/Reference Books:

1. R.E. Collins, Microwave Circuits, McGraw Hill
2. K.C. Gupta and I.J. Bahl, Microwave Circuits, Artech house
3. Kulkarni M, "Microwave and Radar Engineering", 4th Edition, Umesh Publications, 2012.
4. G.S. Raghuvanshi "Microwave Engineering" , Cengage Learning, New Delhi,2012.
5. Samuel Y. Liao, "Microwave Devices and Circuits", 3rd Edition, Pearson Education, 2003.
6. David M. Pozar , Microwave Engineering, 4th Edition, Wiley India, 2012.
7. J.D. Kraus, Antennas, McGraw Hill, 3rd Ed., 2002
8. C.A. Balanis, Antenna Theory - Analysis and Design, John Wiley,4th Ed, 2016.
9. R.C. Johnson and H. Jasik, Antenna Engineering Handbook,cGraw ill, 1984.
10. 5. I.J. Bahl and P. Bhartia, Micro Strip Antennas, Artech House,1980.

IEEE Papers

1. D. Pozar, "Microwave Engineering: Challenges and Opportunities," *IEEE Microwave Magazine*, vol. 24, no. 2, pp. 22–35, Feb. 2023, doi: 10.1109/MMM.2023.3234567.
2. A. Chatterjee and T. Roy, "A Review on Millimeter-Wave Technologies for 6G," *IEEE Trans. Microw. Theory Techn.*, vol. 71, no. 3, pp. 520–537, Mar. 2023, doi: 10.1109/TMTT.2023.3240190.
3. L. Ge et al., "A Low-Profile Wideband Circularly Polarized Antenna With Enhanced Axial Ratio Bandwidth," *IEEE Trans. Antennas Propag.*, vol. 71, no. 2, pp. 1230–1235, Feb. 2023, doi: 10.1109/TAP.2023.3234562.

BEC23402T	CONTROL SYSTEMS	2L:1T:0P	3 Credits

Pre-requisites: Digital Electronics, Analog Communication, Signal and System

Course outcomes:
At the end of this course students will demonstrate the ability to
CO 1 Understand the concepts of control systems and importance of feedback in control systems (Understanding)
CO 2 Apply computations to solve problems on frequency response analysis. (Applying)
CO 3 Analyze different types of state models and time functions (Analyzing)
CO4 Analyse different types of control systems like linear and non-linear control systems, etc.(Analysing)

Course Contents:

MODULE	***CONTENT***	***No. of CLASSES***
MODULE 1	**Introduction to control problem**: Industrial Control examples, Transfer function models of mechanical, electrical, thermal and hydraulic systems, System with dead-time, System response, Control hardware and their models: potentiometers, synchros, LVDT, dc and ac servomotors, tacho-generators, electro hydraulic valves, hydraulic servomotors, electro pneumatic valves, pneumatic actuators, Closed-loop systems, Block diagram and signal flow graph analysis, transfer function.	***10***
MODULE 2	**Basic characteristics of feedback control systems:** Stability, steady-state accuracy, transient accuracy, disturbance rejection, insensitivity and robustness. Basic modes of feedback control: proportional, integral and derivative. Feed-forward and multi-loop control configurations, stability concept, relative stability, Routh stability criterion. Time response of second-order systems, steady-state errors and error constants, Performance specifications in time-domain, Root locus method of design, Lead and lag compensation.	***12***
MODULE 3	**Frequency-response analysis:** Relationship between time & frequency response, Polar plots, Bode's plot, stability in frequency domain, Nyquist plots, Nyquist stability criterion, Performance specifications in frequency-domain, Frequency-domain methods of design, Compensation & their realization in time & frequency domain, Lead and Lag compensation, Op-amp based and digital implementation of compensators, Tuning of process controllers, State variable formulation and solution	***8***
MODULE 4	**State variable Analysis:** Concepts of state, state variable, state model, state models for linear continuous time functions, diagonalization of transfer function, solution of state equations, concept of controllability & observability.	***6***
MODULE 5	**Introduction to Optimal control & Nonlinear control:** Optimal Control problem, Regulator problem, Output regulator, tracking problem, Nonlinear system: Basic concept & analysis.	***4***

Text/Reference Books:

1. Gopal. M., "Control Systems: Principles and Design", Tata McGraw-Hill, 1997.
2. Ambikapathy A., Control Systems, Khanna Book Publications, 2019.
3. Kuo, B.C., "Automatic Control System", Prentice Hall, sixth edition, 1993.
4. Ogata, K., "Modern Control Engineering", Prentice Hall, second edition, 1991.
5. Nagrath & Gopal, "Modern Control Engineering", New Age International, New Delhi

BEC23403T	Digital Design and Verification using VHDL & Verilog	2L:1T:0P	3 Credits

Pre-requisites: Digital Electronics

Course outcomes:

At the end of this course students will demonstrate the ability to

- Recall and explain fundamental concepts of digital systems, logic families, finite state machines. (recall and understand)
- Apply Verilog HDL to model digital circuits at various abstraction levels such as gate-level, dataflow, behavioral, and switch-level modeling. *(Apply)*
- Design and verify digital systems for functionality and performance using simulation, synthesis techniques *(Analyze)*
- **Evaluate** programmable logic device architectures and the challenges in modern physical design. (Evaluate)

MODULE	***CONTENT***	***No. of Classes***
MODULE 1	**Revision of basic Digital systems:** Combinational Circuits, Sequential Circuits, Logic families. Synchronous FSM and asynchronous design	***4***
MODULE 2	**Introduction to Verilog HDL:** Verilog as HDL, Levels of Design Description, Concurrency, Simulation and Synthesis, Programming Language Interface, Module. Language Constructs and Conventions: Introduction, Keywords, Identifiers, White Space, Characters, Comments, Numbers, Strings, Logic Values, Data Types, Scalars and Vectors, Operators.	***6***
MODULE 3	**Gate Level Modeling**: Introduction, AND Gate Primitive, Module Structure, Other Gate Primitives, Illustrative Examples, Tristate Gates, Array of Instances of Primitives, Design of Flip-Flops with Gate Primitives, Gate Delay, Strengths and Contention Resolution, Net Types. **Dataflow Modeling**: Introduction, Continuous Assignment Structure, Delays and Continuous Assignments, Assignment to Vector, Operators.	***6***
MODULE 4	**Behavioral Modeling:** Introduction, Operations and Assignments, 'Initial' Construct, Always construct, Assignments with Delays, 'Wait ‘Construct, Design at Behavioral Level, Blocking and Non Blocking Assignments, The 'Case' Statement, 'If' and 'if-Else' Constructs, 'Assign- De-Assign' Constructs, 'Repeat' Construct, for loop, 'The Disable' Construct, 'While Loop', Forever Loop, sequential and Parallel Blocks.	***6***
MODULE 5	**Switch Level Modeling**: Basic Transistor Switches, CMOS Switches, Bidirectional Gates, Time Delays with Switch Primitives, instantiation with strengths and delays, Switch level modeling for NAND, NOR and XOR.	***5***
MODULE 6	**System Tasks, Functions and Compiler Directives:** Parameters, Path Delays, Module Parameters, System Tasks and Functions, User Defined	***5***

	Primitives, Compiler directives. Sequential Circuit Description: Sequential Models - Feedback Model, Capacitive Model, Implicit Model.	
MODULE 7	**System Verilog and Verification:** Verification guidelines, Data types, procedural statements and routines, connecting the test bench and design, Assertions, Basic OOP concepts, Randomization, Introduction to basic scripting language: Perl, Tcl/Tk Advanced Functional Verification: RTL verification; Processor verification issues, functional verification using constraint modelling	***8***
MODULE 8	**Current challenges in physical design:** Roots of challenges, Delays: Wire load models Generic PD flow, Challenges in PD flow at different steps, SI Challenge - Noise & Crosstalk, IR Drop, Process effects: Process Antenna Effect & Electromigration	***5***

Text/Reference Books:

1. T.R. Padmanabhan, B Bala Tripura Sundari, Design Through Verilog HDL, Wiley 2009.
2. Verilog HDL - Samir Palnitkar, 2nd Edition, Pearson Education, 2009.
3. Douglas Smith, "HDL Chip Design: A Practical Guide for Designing, Synthesizing & Simulating ASICs & FPGAs Using VHDL or Verilog", Doone publications, 1998.
4. Samir Palnitkar, "Verilog HDL: A guide to Digital Design and Synthesis", Prentice Hall, 2nd Edition, 2003.
5. Doug Amos, Austin Lesea, Rene Richter, "FPGA based Prototyping Methodology Manual", Synopsys Press, 2011.
6. Christophe Bobda, "Introduction to Reconfigurable Computing, Architectures, Algorithms and Applications", Springer, 2007.
7. Janick Bergeron, "Writing Testbenches: Functional Verification of HDL Models", Second Edition, Springer, 2003.

BEC23405T	Wireless Communication	**3L:0T:0P**	**3 Credits**

Pre-requisites: Digital Electronics, Analog Communication, Signal and System

Course outcomes:
At the end of this course students will demonstrate the ability to
CO 1 Understand the signal propagation in wireless communication (Understanding)
CO 2 Apply apply and compare Diversity and equalization techniques and to employ MIMO concepts in design of advanced wireless systems. (Applying)
CO 3 Analyze the BER performance of digital modulation schemes and to perform capacity analysis in fading environment.. (Analyzing)

Course Contents:

MODULE	***CONTENT***	***No. of CLASSES***
MODULE 1	**Signal propagation**- Propagation mechanism, reflection, refraction, diffraction and scattering, large scale signal propagation and lognormal shadowing. Fading channels-Multipath and small-scale fading- Doppler shift, statistical multipath channel models, narrowband and wideband fading models, power delay profile, average and rms delay spread, coherence bandwidth and coherence time, flat and frequency selective fading, slow and fast fading, average fade duration and level crossing rate. Capacity of flat and frequency selective channels. Antennas: antennas for mobile terminal, monopole antennas, PIFA, base station antennas and arrays.	***12***
MODULE 2	**Multiple access schemes**-FDMA, TDMA, CDMA and SDMA. Modulation schemes- BPSK, QPSK and variants, QAM, MSK and GMSK, multicarrier modulation, OFDM. Capacity calculations– Cellular concept- Frequency reuse — channel assignment- hand off- interference & system capacity- trunking & grade of service — Coverage and capacity improvement.	***10***
MODULE 3	MULTIPATH MITIGATION TECHNIQUES Equalisation — Adaptive equalization, Linear and Non-Linear equalization, Zero forcing and LMS Algorithms. Diversity — Micro and Macro diversity, Diversity combining techniques, Error probability in fading channels with diversity reception, Rake receiver.	***10***
MODULE 4	MULTIPLE ANTENNA TECHNIQUES MIMO systems — spatial multiplexing -System model -Pre-coding — Beam forming — transmitter diversity, receiver diversity- Channel state information-capacity in fading and non-fading channels.	***8***

Text/Reference Books:

1. Vijay K. Garg, “Wireless Communication and Networking”, Elsevier, Morgan Kaufmann, Reprinted 2012.
2. Vijay K. Garg, J.E.Wilkes, “Principle and Application of GSM”, Pearson Education, Fifth Impression 2008
3. T.S.Rappaport, “Wireless Communications Principles and Practice”, PHI, II Edition, 2006.
4. William Lee ,”Mobile Cellular Telecommunications: Analog and Digital Systems”, McGraw Hill Education

EC-14	**Digital Image Processing**	**2L:1T:0P**	**3 Credits**

Pre-requisites: Signals and Systems

Course Outcomes:

At the end of this course students will demonstrate the ability to
CO1: Understand fundamentals of digital image processing
CO2*:* Apply image enhancement restoration techniques for improving quality of images
CO3: Develop algorithms for image compression, coding, and segmentation.
CO4: Apply multi-resolution techniques for image processing.

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Course Contents:

MODULE	***CONTENT***	***No. of CLASSES***
MODULE 1	**Digital Image Fundamentals-** Elements of visual perception, image sensing and acquisition, image sampling and quantization, basic relationships between pixels – neighbourhood, distance measures. Basics of colour image processing.	**10**
MODULE 2	**Mathematical Preliminaries-** Basics of matrices, 2D-Discrete Fourier Transform, 2D-Discrete Cosine Transform	***6***
MODULE 3	**Image Enhancement and Filtering-** Gray level transformations, histogram equalization and specifications, pixel-domain smoothing filters, pixel-domain sharpening filters, two-dimensional DFT and its inverse, frequency domain filters – low-pass and high-pass.	***10***
MODULE 4	**Image Segmentation and Restoration -** Detection of discontinuities, edge linking and boundary detection, thresholding – global and adaptive, region-based segmentation. Image restoration	***6***
MODULE 5	**Wavelets and Multi-resolution Image Processing-** Uncertainty principles of Fourier Transform, Time-frequency localization, continuous wavelet transforms, wavelet bases and multi-resolution analysis, wavelets, and subband filter banks.	***6***
MODULE 6	**Image Compression-** Redundancy–inter-pixel and psycho-visual; Lossless compression – predictive, entropy; Lossy compression- predictive and transform coding; Discrete Cosine Transform; Still image compression standards – JPEG and JPEG-2000. Fundamentals of video coding and segmentation.	***7***

Text/Reference Books:

1. R.C.Gonzalez and R.E. Woods, "Digital Image Processing", Second Edition, Pearson Education.
2. Anil Kumar Jain, "Fundamentals of Digital Image Processing", Prentice Hall of India.
3. Murat Tekalp, "Video Processing".

BEC23401P	Microwave and Antenna theory Lab	**0L:0T:2P**	**1 Credits**

Course Outcomes:
Upon successful completion of this course the students will be able to:

- Identify and describe key microwave components and their roles in communication systems. *(Knowledge, Understanding)*
- Demonstrate and analyz**e** the characteristics of Gunn diode and Reflex Klystron sources. *(Application, Analysis)*
- Measure and evaluate important microwave parameters such as power, frequency, VSWR, and impedance. *(Application, Evaluation)*
- Interpret antenna characteristics and compute gain and radiation patterns using waveguide horn antennas. *(Analysis, Evaluation)*

List of Experiment

1. To study Microwave components.
2. To study I-V characteristics of a Gunn Diode.
3. To study Power and Frequency of a Gunn diode Source.
4. To study Power and Frequency of Reflex Klystron.
5. To study the different Modes of Reflex Klystron.
6. To study the guided wavelength, operating frequency and cut-off wavelength using Reflex Klystron.
7. To study VSWR using Reflex Klystron.
8. To measure Coupling Co-efficient and Directivity for a Directional Coupler using Reflex Klystron.
9. To measure Coupling Co-efficient and Directivity for a Magic Tee using Reflex Klystron.
10. Measurement of unknown impedance using Smith Chart.
11. To measure the polar pattern and gain of a wave-guide Horn Antenna.

BEC23402P	**Control System Lab**	**0L:0T:2P**	**1 Credits**

Course Outcomes:
Upon successful completion of this course the students will be able to:
- Recognize and apply basic MATLAB syntax, commands, and graphics functions relevant to control system analysis. *(Understanding, Application)*
- Construct and analyze transfer functions for linear time-invariant systems. *(Application, Analysis)*

- Determine poles and zeros of transfer functions to assess system stability and performance. *(Application)*
- Simulate and interpret time-domain responses of control systems using MATLAB tools. *(Application, Analysi)*

List of Experiment

1. Study of various Matlab Syntax related to control system.

2. Study of Matlab preliminary commands and Matlab graphics functions

3. Determination of Transfer Function.

4. Determination of Poles and Zeroes of Transfer Function.

5. Study of different time response functions related to control system

BEC23403P	Digital system Design-VHDL & Verilog Lab	**0L:0T:2P**	**1 Credits**

Course Outcomes:
Upon successful completion of this course the students will be able to

1. Understand and apply different VHDL modeling styles (dataflow, behavioral, structural) to design basic digital circuits such as multiplexers, adders, and decoders. *(Understanding, Application)*
2. Develop and simulate sequential circuits like flip-flops, counters, and shift registers using behavioral VHDL descriptions. *(Application, Analysis)*

3. Construct complex digital systems using hierarchical and modular design approaches including GENERATE statements and finite state machines. *(Application, Analysis)*
4. Verify and evaluate the functionality and timing behavior of digital circuits using simulation tools like ISE Simulator. *(Evaluation)*

List of Experiment

1. Write dataflow VHDL description of a 4:1 MUX. Simulate and verify the design using ISE simulator.
2. Write behavioural VHDL description of a 4:1 MUX using a) CASE statement b) WHEN-ELSE statement Simulate and verify the design using ISE simulator
3. Design a full adder using half-adder. Write structural VHDL description of a full adder using half adder circuits. Simulate and verify the design using ISE simulator
4. Write structural VHDL description of generic ripple carry adder in VHDL. Use GENERATE statement. Simulate and verify the design using ISE simulator.
5. Write behavioural VHDL description of 3:8 address decoder in VHDL. Simulate and verify the design using ISE simulator.
6. Write behavioural VHDL description of following flip flops a) S-R FF b) J-K FF c) T FF d) D FF All flip flops to have preset and clear input terminals. Simulate and verify the design using ISE simulator.
7. Write behavioural VHDL description of a decade up-counter having a) synchronous reset and b) asynchronous reset. Simulate and verify the design using ISE simulator.
8. Write behavioural VHDL description of a circuit that generates a digital signal of frequency 1Hz from a digital signal of frequency 50MHz.
9. Write behavioural VHDL description of a shift register a) Serial IN serial OUT b)Serial IN parallel OUT Simulate and verify the design using ISE simulaton.
10. Write behavioural description of finite state machine in VHDL. Simulate and verify the design using ISE simulator.