

Semester V

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	BEC23301T	Digital Signal Processing	2	1	0	3	40	60
T	2.	PCC	BEC23302T	Microcontroller and Embedded Systems	3	0	0	3	40	60
T	3.	PCC	BEC23303T	Digital Communication	2	1	0	3	40	60
T	4.	PCC	BEC23304T	Electromagnetic Waves	2	1	0	3	40	60
T	5.	OE	BEC23330T	VLSI design/ Mechatronics / Robotics and Control	3	0	0	3	40	60
T	6.	HM	BME24111T	HSM 4: Entrepreneurship and startup	3	0	0	3	40	60
PRACTICAL										
P	7.	PCC	BEC23301P	Digital Signal Processing Lab	0	0	2	1	50	50
P	8.	PCC	BEC23302P	Microcontroller and Embedded Systems Lab	0	0	2	1	50	50
P	9.	PCC	BEC23303P	Digital Communication Lab	0	0	2	1	50	50
P	10		BEC23306	Internship	0	0	0	1		100
Total					15	3	6	22	390	510

BEC23301T	Digital Signal Processing	2L:1T:0P	3 Credits
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Pre-requisites: Signals and Systems

Course Outcomes:

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

CO1: Understand discrete time signals. (Understanding)

CO2: Apply Discrete Fourier Transform and appreciate the importance of Fast Fourier Transform (Apply)

CO3: Design IIR and FIR filters. (Design)

CO4: Apply signal processing algorithms for real time applications. (applying)

Course Contents:

<i>MODULE</i>	<i>CONTENT</i>	<i>No. of CLASSES</i>
<i>MODULE 1</i>	What is DSP? Discrete time signals: Sequences; representation of signals on orthogonal basis; Sampling and reconstruction of signals, Discrete time systems: Definition, Impulse response, FIR and IIR systems, recursive and non-recursive systems. Z- Transform.	<i>10</i>
<i>MODULE 2</i>	Realization of Digital Systems: Recursive and non-recursive structures, block diagram and signal flow graphs. Cascade and parallel realizations.	<i>12</i>
<i>MODULE 3</i>	Discrete Fourier Transform (DFT), Linear and Circular convolution, Fast Fourier Transform Algorithm	<i>10</i>
<i>MODULE 4</i>	Design of FIR Digital filters: Window method, Park-McClellan's method. Design of IIR Digital Filters: Butterworth, Chebyshev, and Elliptic Approximations; Low pass, Band pass, Band stop and High pass filters.	<i>8</i>
<i>MODULE 5</i>	Finite word length effects in digital filter design, Quantization effects. Introduction to multirate signal processing. State variable analysis.	<i>5</i>

Text/Reference Books:

1. S.K. Mitra, Digital Signal Processing: A computer-based approach. TMH
2. A.V. Oppenheim and Schaffer, Discrete Time Signal Processing, Prentice Hall, 1989.
3. John G. Proakis and D.G. Manolakis, Digital Signal Processing: Principles, Algorithms and Applications, Prentice Hall, 1997.
4. L.R. Rabiner and B. Gold, Theory and Application of Digital Signal Processing, Prentice Hall, 1992.
5. J.R. Johnson, Introduction to Digital Signal Processing, Prentice Hall, 1992.

BEC23302T	Microcontroller and Embedded Systems	3L:0T:0P	3 Credits
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Pre-requisites: Digital Electronics, Microprocessor

Course outcomes:

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

1. Explain the architecture of microcontroller (Understanding)
2. Develop programs for various microcontrollers with and without peripherals. (Creating)
3. Explain advanced concepts of Embedded System Architecture (Understanding)
4. Design and apply systems for various embedded applications. (Creating, Applying)

MODULE	CONTENT	No. of CLASSES
MODULE 1	Overview of various available Microcontrollers, Microcontrollers 8051 Architecture, Memory organization, Addressing modes of 8051, Instruction Set, Assembler directives.	6
MODULE 2	Timers/Counters and programming, Serial port and programming, Interrupts and Interrupt control Power Saving modes.	8
MODULE 3	Embedded C-programming concepts: Data types, Modifiers, Qualifiers, Functions, Macros, Interrupt service routines Embedded C programming for 8051 (Timers/Counters, Serial port and Interrupts).	4
MODULE 4	Display interfacing: 7-segment LED display, 16x2 generic alphanumeric LCD display, Keyboard interfacing, 4x4 matrix keyboard, Analog devices interfacing: 8-bit ADC, 8-bit DAC, temperature sensor (LM35) Motor interfacing- Relay, DC motor (speed control using PWM), Stepper motor and Servo motor	8
MODULE 5	Introduction to Embedded Systems, The build process for embedded systems - Structural units in Embedded processor, selection of processor & memory devices - DMA – Memory management methods - Timer and Counting devices, Watchdog Timer, Real Time Clock. Embedded Networking: Introduction, I/O Device Ports & Buses– Serial Bus communication protocols – RS232 standard – RS422 – RS485 – CAN Bus -Serial Peripheral Interface (SPI) – Inter Integrated Circuits (I2C).	8
MODULE 6	Embedded Product Development Life Cycle, Modelling of EDLC; issues in Hardware-software Co-design, Data Flow Graph, state machine model, Sequential Program Model, concurrent Model, object oriented Model.	5
MODULE 7	RTOS Based Embedded System Design: Introduction to basic concepts of RTOS- Task, process & threads, interrupt routines in RTOS, Multiprocessing and Multitasking, Preemptive and non preemptive scheduling.	4

Text/Reference Books:

1. D A Patterson and J H Hennessy, "Computer Organization and Design The hardware and software interface. Morgan Kaufman Publishers.
2. Kenneth J. Ayala, The 8051 Microcontroller, Penram International Publishing, 1996
3. J.W. Valvano, "Embedded Microcomputer System: Real Time Interfacing", Brooks/Cole, 2000.
4. Jack Ganssle, "The Art of Designing Embedded Systems", Newnes, 1999.
5. V.K. Madisetti, "VLSI Digital Signal Processing", IEEE Press (NY, USA), 1995.
6. David Simon, "An Embedded Software Primer", Addison Wesley, 2000.

BEC23303T	DIGITAL COMMUNICATION	3L:0T:0P	3 Credits
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Pre-requisites: *Digital Electronics, Analog Communication, Signal and System*

Course outcomes:

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

CO1 Understand the importance of waveform coding techniques (Understanding)

CO2 Apply Bandpass digital modulation techniques for bit error rate, bandwidth and power requirements. (Applying)

CO3 Understand the concept of information rate and channel capacity. (Understanding)

Course Contents:

MODULE	CONTENT	No. of CLASSES
MODULE 1	Digital Modulation Techniques: Difference between digital and analog communication, basic block diagram of digital communication system. Phase shift Keying techniques using coherent detection: generation, detection and error probabilities of BPSK and QPSK, M-ary PSK, M-ary QAM. Frequency shift keying techniques using Coherent detection: BFSK generation, detection and error probability. Non coherent orthogonal modulation techniques: BFSK, DPSK Symbol representation, Block diagrams treatment of Transmitter and Receiver, Probability of error (without derivation of probability of error equation).	10
MODULE 2	Signaling over AWGN Channels -Introduction, Geometric representation of signals, Gram- Schmidt Orthogonalization procedure, Conversion of the continuous AWGN channel into a vector channel (without statistical characterization), Optimum receivers using coherent detection: ML Decoding, Correlation receiver, matched filter receiver.	6
MODULE 3	Elements of Detection Theory, Optimum detection of signals in noise, Coherent communication with waveforms- Probability of Error evaluations. Baseband Pulse Transmission- Inter Symbol Interference and Nyquist criterion. Design of band limited signals for zero ISI-The Nyquist Criterion (statement only), Design of band limited signals with controlled ISI-Partial Response signals, Probability of error for detection of Digital PAM: Symbol-by-Symbol detection of data with controlled ISI.	6
MODULE 4	Introduction to Information Theory: Measure of information, Average information content of symbols in long independent sequences. Source Coding: Encoding of the Source Output, Shannon's Encoding Algorithm, Shannon-Fano Encoding Algorithm, Huffman coding. Error Control Coding: Introduction, Examples of Error control coding, methods of Controlling Errors, Types of Errors, types of Codes.	8

MODULE 5	Linear Block Codes: Matrix description of Linear Block Codes, Error Detection & Correction capabilities of Linear Block Codes, Single error correction Hamming code, Table lookup Decoding using Standard Array. Convolution codes: Convolution Encoder, Time domain approach, Transform domain approach, Code Tree, Trellis and State Diagram.	8
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Text/Reference Books:

1. B.P.Lathi,Zhi Ding “Modern Digital and Analog Communication”, Oxford, 4th Edition,2011
2. Haykin S., "Communications Systems", John Wiley and Sons, 2001.
3. Proakis J. G. and Salehi M., "Communication Systems Engineering", Pearson Education, 2002.
4. Taub H. and Schilling D.L., "Principles of Communication Systems",Tata McGraw Hill, 2001.
5. Proakis J.G., ``Digital Communications", 4th Edition, McGraw Hill, 2000.
6. R. Anand, Communication Systems, Khanna Book Publishing Company, 2011.

BEC23304T	ELECTROMAGNETIC WAVES	3L:0T:0P	3 Credits
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Pre-requisites: *Signal and System, Calculus, Differentiation*

Course outcomes:

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

CO 1 *Understand the the importance of transmission lines and analyze transmission line problems (Understanding, Analyzing)*

CO 2 *Apply Maxwell's equations to understand propagation of electromagnetic waves in unbound medium and across media interfaces (Applying)*

CO 3 *Analyzing electromagnetic wave propagation in rectangular metallic waveguides and resonators. (Analyzing)*

CO 4 *Understand antenna characteristics, and design linear antennas and their arrays. (Creating)*

Course Contents:

MODULE	CONTENT	No. of CLASSES
MODULE 1	Transmission Lines- Equations of Voltage and Current on TX line, Propagation constant, Characteristic impedance and reflection coefficient, Impedance Transformation, Loss-less and Low Loss Transmission line and VSWR, Power transfer on TX line, Smith Chart, Admittance Smith Chart, Applications of transmission lines, Impedance Matching, Lossy transmission line, Problems on Transmission line, Types of transmission line.	10
MODULE 2	Maxwell's Equations- Basics of Vectors, Vector calculus, Basic laws of Electromagnetics, Maxwell's Equations, Boundary conditions at Media Interface.	6
MODULE 3	Uniform Plane Wave- Uniform plane wave, Propagation of wave, Wave polarization, Wave propagation in conducting medium, Wave propagation and phase velocity, Power flow and Poynting vector, Surface current and power loss in a conductor OS transistor.	6
MODULE 4	Plane Waves at a Media Interface- Plane wave in arbitrary direction, Plane wave at dielectric interface, Reflection and refraction at media interface, Total internal reflection, Polarization at media interface, Reflection from a conducting boundary.	8
MODULE 5	Waveguides- Parallel plane waveguide, Wave propagation in parallel plane waveguide, Analysis of waveguide general approach, rectangular waveguide, Modal propagation in rectangular waveguide, Surface currents on the waveguide walls, Field visualization and Attenuation in waveguide, Attenuation in waveguide continued.	8
MODULE 6	Radiation- Solution for potential function, Radiation from the Hertz dipole, Power radiated by hertz, dipole, thin linear antenna, Radiation Parameters of antenna, receiving antenna, Monopole and Dipole antenna, Fourier transform relation between current and radiation pattern. MATLAB, HFSS, CST simulations	7

Text/Reference Books:

1. R.K. Shevgaonkar, „Electromagnetic Waves, Tata McGraw Hill India, 2005
2. M.N.O. Sadiku, Principles of Electromagnetics, Oxford University Press, 6th Edition, 2016
3. R.L. Yadav, Electromagnetic Fields and Waves, Khanna Book Publishing, 2021
4. E.C. Jordan & K.G. Balmain, Electromagnetic waves & Radiating Systems, Prentice Hall, India
5. Narayana Rao, N: Engineering Electromagnetics, 3rd ed., Prentice Hall, 1997.
6. David Cheng, Electromagnetics, Prentice Hall

BEC23305T	VLSI design	3L:0T:0P	3 Credits
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Pre-requisites: Semiconductor Devices, Analog Circuit

Course outcomes:

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

CO 1 Understand the models of MOS transistors and its use in circuit simulations (Understanding)

CO 2: Evaluate the use of various delay models and optimize the CMOS circuit delay (Evaluation)

CO 3: Apply and analyze various CMOS combinational and sequential circuits, data path and memory subsystems. (Applying and analyzing)

CO 4: Understand the effects of interconnects on the circuit performance. (Understanding)

Course Contents:

MODULE	CONTENT	No. of CLASSES
MODULE 1	Introduction to VLSI; CMOS Logic: Combinational and sequential circuits, CMOS fabrication and layouts, Layout representations, Stick diagrams, Design partitioning, Logic design, Circuit design, Physical design, Design verification, fabrication, packaging and testing, Design Flow. Modeling of MOS transistor, Capacitance voltage characteristics, non-ideal effects DC transfer characteristics, MOS Inverter, MOS Transistor Switches, CMOS Logic design, Circuit and System Representations, Design Equations, Static Load MOS Inverters, Transistor Sizing, Static and Switching Characteristics; Body Effect, Noise Margin;	12
MODULE 2	Delay and Power Transient Response, RC Delay Model, Effective Resistance, Gate and Diffusion Capacitance, Equivalent RC Circuits, Transient Response, Elmore Delay, Layout Dependence of Capacitance, Determining Effective Resistance, Linear Delay Model Logical Effort, Parasitic Delay, Delay in a Logic Gate, Drive, Extracting Logical Effort from Datasheets, Limitations to the Linear Delay Model, Logical Effort of Paths, Delay in Multistage Logic Networks, Choosing the Best Number of Stages, Sources of power dissipation, dynamic power, static power, Wire Geometry, Example of Metal Stacks, Interconnect Modelling, Resistance, Capacitance Inductance, Skin Effect, Temperature Dependence, Interconnect Impact, Delay, Energy, Crosstalk, Inductive Effects,	10
MODULE 3	Circuit Design Circuit Families, Static CMOS, Ratioed Circuits, Cascode Voltage Switch Logic, Dynamic Circuits, Pass-Transistor Circuits, Sequencing Static Circuits, Sequencing Methods, Max-Delay Constraints, Min-Delay Constraints, Time Borrowing, Clock Skew, Circuit Design of Latches and Flip-Flops, Conventional CMOS Latches, Conventional CMOS Flip-Flops, Pulsed Latches, Resettable Latches and Flip-Flops, Enabled Latches and Flip-Flops, Incorporating Logic into Latches	8
MODULE 4	Subsystems Design Adders, zero one detectors, comparators, counters, Memory subsystems SRAM, Read and write operation, DRAM, sense amplifiers	5

Text/Reference Books:

1. N.H.E. Weste and D.M. Harris, CMOS VLSI design: A Circuits and Systems Perspective, 4th Edition, Pearson Education India, 2011.

Reference Books

1. C. Mead and L. Conway, Introduction to VLSI Systems, Addison Wesley, 1979.
2. S. M. Kang and Y. Leblebici, CMOS Digital Integrated Circuits : Analysis and Design, Third Edition, MH, 2002
3. J. M. Rabaey, A. P. Chandrakasan and B. Nikolic, Digital Integrated Circuits : A Design Perspective, Second Edition, PHI /Pearson, 2003.
4. J. P. Uyemura, CMOS Logic Circuit Design, Springer; 2001,.
5. J. P. Uyemura, Introduction to VLSI Circuits and System, Wiley, 2002.
6. R. J. Baker, H. W. Li and D. E. Boyce, CMOS Circuit Design, Layout and Simulation, PH, 1997

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BME24111T	ENTREPRENEURSHIP AND START-UPS	3L:0T:0P	3 Credits
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Pre-requisites: *Semiconductor Devices, Analog Circuit*

CO1: Identify and analyze entrepreneurial opportunities in mechanical engineering sectors

CO2: Apply mechanical design, prototyping, and innovation management principles to develop feasible products or services

CO3: Develop business models and conduct techno-economic feasibility studies for mechanical engineering ventures

CO4: Demonstrate financial literacy in budgeting, forecasting, funding acquisition, and regulatory compliance for technology-based start-ups

Course Contents:

MODULE	CONTENT	No. of CLASSES
MODULE 1	Technology Entrepreneurship and Opportunity Identification: Entrepreneurship in manufacturing, energy, mobility, and automation sectors; Design Thinking for mechanical engineering problem-solving; Opportunity identification: Market need vs. technology push, technology gap analysis; User-centric design thinking for engineers; Frugal innovation and Jugaad technologies in Indian context Case studies: Mechanical engineering start-ups (Ather Energy, GreyOrange Robotics, etc.)	9
MODULE 2	Product Development and Technology Commercialization: Product development lifecycle for mechanical products; Rapid prototyping: CAD/CAM, 3D printing, CNC processes; Design for Manufacturability (DFM) and Design for Assembly (DFA); Technology Readiness Levels (TRL) for engineering products; Intellectual Property Rights (IPR): Patents and design protection.	9
MODULE 3	Business Model Development and Techno-Economic Feasibility: Business Model Canvas for engineering ventures; Market analysis, segmentation and customer identification for technical products; Cost estimation, pricing, break-even analysis; Techno-economic feasibility case studies; Minimum Viable Product (MVP) for engineering products; Quality assurance and reliability in product design	9
MODULE 4	Funding Strategies and Financial Literacy Funding options: Bootstrapping, Angel Investors, VC, MSME loans, Start-up India, SIDBI, TDB schemes; Preparing project proposals for funding agencies and banks (PMEGP, CGTMSE, AICTE Start-up Policy grants); Basics of financial management: budgeting, forecasting, financial statements for engineering start-ups; Regulatory requirements: business registration, GST, factory acts, environmental clearances, quality standards (ISO, BIS)	9
MODULE 5	Regulatory, Quality, and Ethical Aspects for Mechanical Start-ups Business registration procedures for technology start-ups; Regulatory clearances and certifications (ISO, CE marking, BIS, etc.); Environmental and safety regulations for engineered products; Start-up India and MSME schemes: legal and procedural overview; Ethical considerations and professional responsibility for engineer-entrepreneurs	9

Text/Reference Books:

1. Byers, T., Dorf, R., & Nelson, A. (2014). Technology Ventures: From Idea to Enterprise. McGraw-Hill Education.
2. Ries, E. (2011). The Lean Startup. Crown Business.
3. Timmons, J.A., & Spinelli, S. (2019). New Venture Creation. McGraw-Hill.

Reference book (s)

1. Saini, V., & Bhardwaj, R. (2020). Entrepreneurship Development for Engineers. I.K. International Publishing House.
2. Kuratko, D.F. (2016). Entrepreneurship: Theory, Process, and Practice. Cengage Learning
3. Hishamuddin, M.S., & Hasan, M.F. (2019). Engineering Entrepreneurship. CRC Press

BEC23301P	Digital Signal Processing Lab	0L:0T:2P	1 Credits
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Course Outcomes:

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

CO1: Understand and generate standard discrete-time signals and perform basic signal operations using MATLAB. [Understand, Apply]

CO2: Implement and analyze linear and circular convolution, on discrete-time signals.[Apply, Analyze]

CO3: Compute and interpret the Discrete Fourier Transform (DFT) and its applications in frequency domain analysis of signals.[Analyze, Evaluate]

CO4: Design and evaluate FIR and IIR digital filters using MATLAB and analyze their frequency responses.[Apply, Evaluate]

CO5: Demonstrate practical DSP applications such as signal sampling using MATLAB. [Apply, Create]

List of Experiment

1. Basic Signal Generation and Plotting

- Generate and plot discrete-time signals: unit step, unit impulse, ramp, exponential, sinusoidal.
- MATLAB functions: stem(), plot(), linspace(), etc.

2. Signal Operations

- Perform operations: time shifting, time reversal, time scaling, addition, multiplication.
- Observe changes graphically and analytically.

3. Convolution

- Linear convolution using MATLAB conv() function.
- Circular convolution using cconv() or via DFT and IDFT.

4. Discrete Fourier Transform (DFT) and Inverse DFT

- Compute and plot magnitude and phase of DFT.
- Use fft() and ifft() functions.

5. Frequency Analysis of Signals

- Analysis of frequency spectrum using DFT/FFT.
- Identify frequency components in composite signals.

6. Z-Transform and Region of Convergence (ROC)

7. FIR Filter Design

- Design low-pass, high-pass, band-pass FIR filters

8. IIR Filter Design

- Butterworth, Chebyshev Type I & II filter design

9. Filter Realization Structures

- Direct form I & II realization using difference equations.

10. Sampling and Reconstruction

- Demonstration of sampling theorem.
- Downsampling and upsampling using downsample() and upsample().

BEC23302P	Microcontroller and Embedded Systems Lab	0L:0T:2P	1 Credits
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Course Outcomes:

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

CO1: **Understand** the architecture, memory organization, and instruction set of the 8051 microcontroller

CO2: **Apply** Keil C programming skills to perform basic I/O operations and control tasks on 8051.

CO3: **Analyze** the use of timers, counters, interrupts, and serial communication in embedded design.

CO4: **Design and simulate** peripheral interfacing circuits (LEDs, switches, LCD, ADC, motors) using Proteus.

CO5: **Evaluate** the functionality and performance of embedded systems through simulation-based testing.

List of Experiment

1. LED blinking using delay loop
2. Switch controlled LED- Turn ON/OFF LED based on push button
3. Interface with 7-Segment Display – Count 0 to 9
4. 16x2 LCD Display Interface to display a message
5. Timer – based LED Blinking
6. External interrupt Demonstration – Toggle Led using INT0
7. Serial communication – Send data from 8051 to virtual terminal
8. Digital Clock using Timer and LCD
9. **ADC Interface Simulation** (e.g., ADC0804 with variable voltage input)
10. **DC Motor ON/OFF Control** using output pin and switch
11. **Stepper Motor Control** – Clockwise & anticlockwise
12. Sensor interfacing Simulation – LDR or IR based obstacle detector.

BEC23303P	Digital Communication Lab	0L:0T:2P	1 Credits
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Course Outcomes:

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

CO1: To understand the basic concepts of digital communication systems, including data formatting and sampling. (Understanding)

CO2: To demonstrate practical knowledge of modulation techniques such as PAM, ASK, FSK, and PSK using simulators and trainer kits. (Apply)

CO3: To analyze various digital modulation and demodulation techniques through experimental observation. (Analyze)

CO4: To study and interpret the working of advanced components such as pseudo-random code generators and time-division multiplexers. (Understand, analyze)

CO5: To develop basic skills in configuring, measuring, and simulating digital communication circuits. (Apply, Create)

List of Experiment

1. To study Data Format using Trainer kit.
2. To Study Pulse Amplitude Modulation (Flat top sampling) & Time Division Multiplexing using Trainer kit.
3. To study Pulse Code Modulation and Demodulation using Trainer kit.
4. Study of Pseudo-random Sync Code Generator using Trainer kit.
5. To study ASK modulation and demodulation.
6. To Study of Pulse amplitude modulation (Natural sampling).
7. To Study of PSK modulation using simulator.
8. To Study of PSK Demodulation using simulator.
9. To Study of FSK modulation using simulator.