GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering
Level: UG
Branch: Power Electronics
Subject Code: BE05024061
Subject Name: Signals and Systems

w.e.f. Academic Year:	2024-25
Semester:	5
Category of the Course:	Professional Elective Course - 2

Prerequisite:	**Mathematics, Laplace Transformation**
Rationale:	Signals and Systems establishes the fundamental concepts needed to understand how real-world signals are represented, analyzed, and processed. Through topics such as LTI system behavior, convolution, sampling, and transform techniques, the course forms the core analytical base required for advanced Digital Signal Processing (DSP), enabling further study in digital filtering, spectral analysis, and real-time signal applications. Additionally, the subject strengthens the understanding of dynamic system response, stability, and frequency-domain behavior—concepts that are essential in Power Electronics for analyzing switching waveforms, designing control loops, and interpreting converter behavior. Thus, this course serves as a foundational bridge supporting both DSP and Power Electronics domains.

Course Outcomes:

Sr.No.	CO statement	Marks% weightage
CO-1	Classify continuous time and discrete time signals and systems based on their fundamental properties.	25
CO-2	Determine the response of LTI systems using convolution and system equations in the time domain.	25
CO-3	Apply Fourier Series and Fourier Transform techniques to analyze signals in the frequency domain.	20
CO-4	Use Laplace and Z Transforms to evaluate system characteristics and solve system equations.	20
CO-5	Explain sampling, aliasing, and reconstruction concepts that form the basis of Digital Signal Processing.	10

Teaching and Examination Scheme:

Teaching / Learning Scheme (in Hours per semester)					Total Credits	Assessment Pattern and Marks					Total Marks
						Theory		Tutorial / Practical			
L	T	P	PBL *	Total no of hours per semester		ESE (E)	PA / CA (M)	PA/CA (I)	PBL (I)	ESE (V)	
45	0	30	15	90	3	70	30	20	30	50	200

**** Problem-Based Learning (PBL) aims to accommodate learning beyond the syllabus as per clause 9.4 of NBA manual.***

Where L = Lecture, T= Tutorial, P= Practical, TW/SL = Term-Work / Self-Learning, TH = Total Hours, ESE = End Semester Examination, PA = Progressive Assessment.

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Content:

Sr. No.	Content	Total Hrs
1	**Introduction to Signals** Definition of signal; CT and DT signals, Classification: periodic/aperiodic, energy/power, even/odd, Basic signals: step, impulse, ramp, exponentials, sinusoids, Signal operations: shifting, scaling, folding, time inversionSampling, quantization & discretization, Applications in sensor signals and digital acquisition	7
2	**Introduction to Systems** Definition and representation of CT and DT systems, System properties: linearity, time invariance, memory, stability, causality, Impulse response and system characterization, Convolution integral and convolution sum, Block-diagram representations of CT-LTI & DT-LTI systems	8
3	**Time-Domain Analysis of CT and DT Systems** Convolution integral (CT) and convolution sum (DT), Causal and non-causal LTI system responses, Interconnection of LTI systems (cascade/parallel/feedback), Review of Laplace concepts relevant to time-domain analysis, FIR vs IIR conceptual introduction	7
4	**Fourier Analysis of CT and DT Signals:** Fourier Series:Representation of periodic signals, Line spectra, harmonic content, Power and energy spectral interpretations Fourier Transform (CTFT & DTFT): Fourier Transform of aperiodic signals, Properties, time/frequency scaling, modulation, convolution, Relationship between Laplace and Fourier Transform, Introduction to DTFT and its properties Conceptual introduction to DFT (as precursor to DSP)	10
5	**Laplace Transform and Z-Transform:** Laplace Transform: ROC, properties, inverse LT, Solving differential and integro-differential equations, Transfer function and system stability Z-Transform: Definition, ROC, inverse ZT, Properties of Z-Transform, Solving linear difference equations, Pole-zero plots and system stability	9
6	**Sampling, Reconstruction & DSP Foundations** Ideal and practical sampling, Nyquist criterion & aliasing, Reconstruction using ideal and practical filters, Introduction to discrete-time signal processing chain, Real-world applications (audio, ECG, communication)	4
	TOTAL	**45**

Suggested Specification table with Marks(Theory):

Distribution ofTheoryMarks					
RLevel	ULevel	ALevel	NLevel	ELevel	CLevel
15	30	30	15	10	-

R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate; C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers.Theactual distribution of marks in the question paper may vary slightly from the above table.

The Signals and Systems course supports the UN SDGs by directly contributing to SDGs 3, 4, and 9 through core signal analysis concepts, and indirectly supporting SDGs 7, 8, 11, 12, and 13 via applications in energy systems, industry, smart cities, efficient computation, and environmental monitoring.

SDG 3	Good Health and Well-being – Related directly Topics like sampling, Fourier analysis, and DSP enable processing of biomedical signals such as ECG and EEG. Accurate signal interpretation supports diagnostics, monitoring, and preventive healthcare systems.
SDG 4	Quality Education - Related directly Fundamental concepts like signals, systems, transforms, and convolution build core analytical and problem-solving skills in engineering education. The syllabus promotes computational learning using tools like MATLAB, enhancing modern technical competencies.
SDG 7	Affordable & Clean Energy - Related indirectly Signal analysis techniques are applied in power systems for monitoring, fault detection, and smart grid optimization.Fourier and Laplace methods help analyze harmonics and improve energy efficiency.
SDG 8	Decent Work and Economic Growth - Related indirectly Skills in signal processing and system modeling are essential in industries like telecommunications, automation, and AI. The syllabus prepares students for high-demand technical roles, boosting employability and innovation.
SDG 9	Industry, Innovation & Infrastructure - Related directly Core concepts such as LTI systems, convolution, and transforms underpin communication systems, control systems, and digital infrastructure. These enable development of modern technologies like IoT, wireless networks, and embedded systems.
SDG 11	Sustainable Cities & Communities - Related indirectly Signal processing is used in smart city applications such as traffic monitoring, environmental sensing, and public safety systems. Efficient data acquisition and processing improve urban infrastructure management.
SDG12	Responsible Consumption & Production - Related indirectly Efficient signal processing algorithms reduce computational load and energy consumption in electronic systems. Optimized system design minimizes resource usage in digital devices.
SDG 13	Climate Action - Related indirectly Signal analysis techniques help in environmental monitoring (e.g., air quality, seismic signals, climate data).Data-driven insights support climate modeling and disaster prediction systems.

Reference Books:

1. Linear Systems and Signals by B.P.Lathi, Oxford University Press
2. Signals and Systems by Alan V. Oppenheim, Alan S. Wilsky and Nawab, Prentice Hall
3. Signals and Systems by Simon Haykin and Bary Van Veen, Wiley- India Publications
4. Signal and Systems by Anand Kumar, 3rd Edition, PHI
5. Signals and Systems by K. Gopalan, Cengage Learning (India Edition)
6. Signals and Systems by Michal J. Roberts and Govind Sharma, Tata Mc-Graw Hill Publications

List of Experiments: Suggested Experiment

1. To Study Basic Signal Generation & Operations
   - Generate CT/DT signals in MATLAB

- Signal transformations
- Energy & power computations

2. To study Convolution and LTI System Response
   - Convolution (manual + built in functions)
   - Impulse and step response
3. To study Fourier Series & Fourier Transform
   - FS computation and spectrum plotting
   - CTFT / DTFT analysis
4. To study Laplace and Z Transform Analysis
   - Symbolic transforms
   - Pole zero plots and ROC visualization
5. To study Sampling & Reconstruction
   - Demonstration of aliasing
   - Ideal and practical reconstruction filters
6. Mini Project

Suggested List: Audio signal spectrum analysis, ECG processing basics, Image as a 2D signal, Simple digital filtering

Major Equipment:

PC With MATLAB, Python

List of Open-SourceSoftware:

1. OpeModellica
2. GNU Octave
3. Scilab

List of learning websites:

1. MIT OpenCourseWare (https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/)
2. NPTEL
3. Coursera
4. edX
5. Reputed Research Journal Website

List of suggested activities for Problem-based Learning (PBL):

Sr. No.	PBL Category	Name of the activity	No. of hours	Evaluation Criteria
1	Industry / Research Laboratory Visit	Industry/Research laboratory Visit	Visit = 5hrs, Report preparation = 5hrs Total = 10hrs	Based on the report submitted. Report should contain observations and calculations based on industry/ lab data.
2	Video-Based Learning	Technical Video-based learning related to the subject (MOOC/NPTEL Video)	Duration of video = 5hrs Report preparation = 5hrs Total = 10hrs	Report /presentation based on the video learning outcomes.
		Self-learning online	The minimum	Examination-based assessment

Sr. No.	PBL Category	Name of the activity	No. of hours	Evaluation Criteria
		course	duration of the course should be 10 hours.	at the end of the course. Based on the certificate produced.
		Annotated Video Explanation of Concept/Problem	10hrs (Preparation + Recording + Submission)	Based on the accuracy of explanation, clarity, and presentation style.
3	Assignment/ Technical Writing / Research Writing	Assignment writing. Numerical-basedassignment is preferable.	5 assignments of 2 hours each. Total = 10hrs	Based on the assignment submitted.
		Blog or Technical Article Writing	10hrs (Research – 6hrs, Writing – 4hrs)	Based on originality, technical content, references cited, and clarity of communication.
4	Complex Problem-Solvingtargeting relevant SDGs. / Mini Project	Complex problem solving	Maximum 2 problems. Study of the problem and solution finding, Total = 15 hrs	Based on the depth of the solution submitted.
5	Research Paper Review / Analysis	Discussion on a research paper based on a relevant subject (SCOPUS Index/any reputed Journal)	5 research paper = 20 hrs	Summarize research paper and the evaluation of critical parameters
6	Poster/ Chart/ Power point presentation	Poster/chart/power point preparation on technical topics	Duration = 6 hrs	Based on poster/chart preparation and presentation skills
7	MicroProject	Working/non-working model on technical topics	Working = 10hrsnon-working = 10hrs	Based on inter-department/external evaluation
8	Group Discussion / Quiz / Simulation	Group Discussion on emerging/trending technical topics based on the subject	Duration = 1 hrs each	Based on performance in group discussion, technical depth,knowledge etc.
		Online Technical Quizzes/Simulations	Multiple quizzes summing up to 10 hours	Based on quiz scores and the reflection report after each quiz.
9	Case Study Analysis / Seminar	Real-world case studies-based learning	Duration of data collection/study = 5hrs Report preparation = 5hrs Total = 10hrs	Based on an in-depth study, technical depth, data collected, fact-finding, etc.
10	Other	Patent Search and Innovation Gap Identification	10hrs (Search + Report)	Based on the number of relevant patents analyzed and the identification of innovation scope.

Note:

1. In alignment with Outcome-Based Education (OBE) and NBA accreditation requirements, the subject **Signals and Systems** incorporate;
   - Mini Project – 10 Marks
   - Micro Project – 5 Marks

These activities are incorporated as integral components of PBL. These activities are designed to foster experiential learning, encourage innovation, and strengthen problem-solving skills by engaging students in practical applications of power converter design, simulation, and analysis. The inclusion of PBL ensures that learners develop higher-order cognitive abilities mapped to Bloom's taxonomy, while simultaneously enhancing teamwork, communication, and research competencies essential for professional engineering practice.

2. The hours allocated to specific activities should be proportionate to the total number of PBL hours and marks.

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