

ECU204 SIGNALS AND SYSTEMS

Pre-requisites: Electric circuit theory, Calculus, Linear algebra

1 General Notions: (3 Hours)

Examples of physical systems: Biological systems, Mechanical (dynamical) systems (e.g. Automobile damping system, Market as a dynamical system, Communication system and so on); State of a physical system, measurement of the state of a physical system, Define Signal¹; Energy and its manifestations - basic notion of transducers, transducers as a probe².

2(a) Classes of Signals: (3 Hours)

Sinusoidal signals, periodic signals, bounded signals, Energy limited signals, Duration limited signals.

2(b) Signal space concepts (finite dimensional vector spaces): (7 Hours)

Signal as a point in the space, orthogonality, projection and inner product, Revisit the notion of root mean square value of a signal, relate to the notion of length (distance) in signal space; bring the idea of norm; construct norm from inner product; Introduce series representation of a point in finite dimensional signal space; Recall the notion of convergence, Develop the ideas of Cauchy sequence and completeness, Introduce Hilbert space. Next introduce the Fourier series representation of a periodic signal.

2(c) Fourier transform: (5 Hours)

Introduce the notion of mappings; Develop the general idea of integral transforms, Introduce the complex exponential as the eigenfunction of the second order differential operator (use the notion of a dynamical system), Develop the idea behind Fourier transform; Introduce square integrability (finite energy) as a sufficient condition for the existence of Fourier transform of a signal.

3(a) Linear time-invariant continuous-time systems: (9 Hours)

Input/output description, Linearity and time-invariance, Dirac Delta (as the limit of a sequence of functions), Impulse response, Causality, Convolution, Steady state and transient analysis: Revisit Fourier transform, Establish the need for Laplace transform, Revisit Laplace transform; Transfer function and frequency response, Poles, zeros and system response, Introduce the concept of feedback systems and its elementary analysis, Introduce the notion of stability.

¹As a quantity which in some manner conveys information about the state of a physical system.

²That converts one set of physical quantities to another set of physical quantities amenable to subsequent processing.

3(b) Representation of signals: (6 Hours)

Distinguish energy signals and power signals; Lowpass, bandpass and quadrature representations; Real and Complex signals, Introduce the notion of Hilbert transform to generate complex signals.

4 Linear shift-invariant discrete-time Systems and Signals: (9 Hours)

Sampling theory, Lowpass and bandpass cases, Sampling from the perspective of signal approximation, Laurent series and the z -transform, Inverse z -transform, Relation between Laplace transform and the z -transform, Input-output description of a discrete-time system, Causality, Transient and steady-state analysis.

Text books

1. B. P. Lathi, *Linear Systems and Signals*, Oxford University Press, 2002.
2. Alan V. Oppenheim, Alan S. Willsky, Ian T. Young, *Signals and Systems*, Prentice Hall of India, New Delhi, 1994.

Reference books

1. Chi-Tsong Chen, *Analog and Digital Control System Design*, Saunders College Publishing/Harcourt Brace Jovanovich College Publishers, NY, 1993.
2. David K. Cheng, *Analysis of Linear Systems*, Narosa Publishing House, New Delhi, 1995.
3. Douglas K. Lindner, *Introduction to Signals and Systems*, McGraw-Hill International Edition, 1999.
4. William H. Hayt Jr., Jack E. Kemmerly, *Engineering Circuit Analysis*, McGraw-Hill International, 5th edition, New York, 1993.
5. David F. Tuttle, Jr., *Circuits*, McGraw-Hill International Student Edition, Singapore, 1977.
6. A. Papoulis, *Fourier Integral and its applications*, McGraw-Hill International, New York, 1962.
7. A. Papoulis, *Systems and Transforms with Applications in Optics*, McGraw-Hill International Edition, New York, 1968.
8. Gilbert Strang, *Linear Algebra and its Applications*, 3rd edn., Brooks/Cole, US, 1998.
9. Erwin Kreyszig, *Introductory Functional Analysis with Applications*, John Wiley & Sons, 1989.