



INTRODUCTION TO TIME-VARYING ELECTRICAL NETWORKS

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TYPE OF COURSE

: New | Elective | PG

COURSE DURATION

: 12 weeks (18 Jan'21 - 9 Apr'21)

EXAM DATE

: 25 Apr 2021

PRE-REQUISITES : Engineering mathematics, a basic course on electric network analysis at the UG level, signals and systems.

INTENDED AUDIENCE : M.Tech/M.S/Ph.D students, advanced undergraduates

INDUSTRIES APPLICABLE TO : Companies engaged in analog, mixed-signal and RF design

COURSE OUTLINE :

The course is intended as a gentle introduction for analog, mixed-signal and RF circuit designers to the area of time-varying circuits and systems. The pre-requisites are minimal. After a refresher and building background in linear-time invariant networks, it introduces linear time-varying (LTV) and linear periodically time-varying (LPTV) circuits. The applications of the theory are illustrated with practical examples.

ABOUT INSTRUCTOR :

Prof. Shanthi Pavan obtained the B.Tech degree in Electronics and Communication Engg from the Indian Institute of Technology, Madras in 1995 and the doctoral degree from Columbia University, New York in 1999. Since 2002, he has been with IIT-Madras, where he is now a Chair Professor of Electrical Engineering. His research interests are in the areas of high speed analog circuit design and signal processing.

COURSE PLAN :

Week 1: Motivation for the topics covered in the course, review of linearity and time-variance; Review of electrical network basics, incidence matrix, Tellegen's theorem; Tellegen's theorem (contd), its use to prove reciprocity in bilateral networks, reciprocity in networks with controlled sources

Week 2: Reciprocity in networks with controlled sources (contd), inter-reciprocal networks; Modified Nodal Analysis (MNA) formulation to write network equations; MNA formulation (contd), MNA stamps of circuit elements, Reciprocity and inter-reciprocity revisited

Week 3: Reciprocity and inter-reciprocity (contd), the adjoint network.; Introduction to noise in electronic circuits; Noise in RLC circuits, Nyquist's theorem, Bode's Noise Theorem

Week 4: Bode's noise theorem (contd), input referred noise sources in networks; Input-referred noise sources (contd) - equivalent noise voltage and current sources; Equivalent noise sources, noise factor

Week 5: Need to study time-varying circuits and systems; Linear time-varying (LTV) system basics; Linear Periodically Time-Varying (LPTV) systems basics

Week 6: Harmonic transfer functions, the Zadeh expansion; MNA equations in LPTV networks with Harmonic transfer matrices; LPTV circuit example : the sampling mixer

Week 7: Impedance and admittance in LPTV networks, Norton and Thevenin equivalents; The N-path principle; N-path circuits (contd) - the time-interleaved ADC

Week 8: N-path circuits (contd) - the multiphase dc-dc converter, introduction to the N-path filter; N-path filters (contd) - input impedance and gain; N-path filters (contd)

Week 9: Reciprocity and inter-reciprocity in LPTV networks - time-reversal to generate the adjoint; Inter-reciprocity (contd), transfer-function theorem; Inter-reciprocity (contd), the frequency-reversal theorem

Week 10: Inter-reciprocal signal-flow graphs. Example : chopped amplifiers; Chopped-amplifiers with sinusoidal and square-wave modulation; Adjoint networks - the switched-RC kernel example; time-domain implications of adjoint networks

Week 11: Time-domain implications of the adjoint - example of a switched-RC network. Sampled LPTV networks; Equivalent LTI filter of a sampled LPTV system; derivation of the equivalent impulse response, switched-RC network example; Cont. time delta-sigma as a sampled LPTV system

Week 12: Response of LPTV systems to modulated inputs; equivalent LTI filter; Introduction to noise in LPTV networks, noise in switched-RLC networks, the Bode noise theorem applied to LPTV networks; Course summary and recap