CIRCUIT ANALYSIS FOR ANALOG DESIGNERS

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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 to cover topics in circuit analysis that an analog designer uses on a daily basis. After a refresher and building background in linear-time invariant networks, it introduces aspiring analog designers to more advanced topics like inter-reciprocal networks, analog filters, noise analysis of circuits, transmission lines and distributed circuits, and the analysis of circuits with weak nonlinearities. Another important topic, which is not covered in this course due to paucity of time, is that of the study of time-varying circuits. This topic is covered in the course ``Introduction to Time-Varying Electrical Networks'', also on NPTEL

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. Prof.Pavan is the recipient of several awards, including the IEEE Circuits and Systems Society Darlington Best Paper Award and the Shanti Swarup Bhatnagar Award. He is the author of Understanding Delta-Sigma Data Converters (second edition), with Richard Schreier and Gabor Temes. Prof.Pavan has served as the Editor-in-Chief of the IEEE Transactions on Circuits and Systems:Part I -Regular Papers, and on the technical program committee of the International Solid State Circuits Conference. He has been a Distinguished Lecturer of the Solid-State Circuits and Circuits and Systems Societies. He is a fellow of the Indian National Academy of Engineering, and an IEEE fellow.

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 (cntd), its use to prove reciprocity in bilatera

Week 2: Reciprocity in networks with controlled sources (contd), inter-reciprocal networks Modified Nodal Analysis (MNA) formulation to write network equations

Week 3: MNA formulation (contd), MNA stamps of circuit elements, Reciprocity and inter-reciprocity revisited Reciprocity and inter-reciprocity (contd), the adjoint network. Introduction to analog filtering, the Butterworth approximation

Week 4: Butterworth filters (continued), opamp-RC realization of filters Biquadratic sections using opamp-RC integrators, frequency and impedance scaling

Week 5: Cascade of biquads realization of high-order filters, dynamic-range scaling Effect of non-ideal opamps on integrator behaviour Q-enhancement in biquads due to finite opamp gain-bandwidth product

Week 6: Transconductance-capacitance filters, Introduction to noise in electronic circuits Noise in RLC circuits, Nyquist's theorem, Bode's Noise Theorem

Week 7: 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 8: Introduction to distributed networks, the ideal transmission line and Telegrapher's equations Transmission line circuit analysis, the reflection coefficient, open- and short-circuited lines

Week 9: The Smith chart (introduction), the need for scattering parameters Scattering matrices of

simple elements Scattering matrices properties, measurement of a one-port

Week 10**:** Scattering matrices (contd), the vector network analyzer, principle behind calibration. Weak nonlinearity in electronic circuits, harmonic distortion, HD2 and IM2

Week 11**:** Harmonic distortion (contd), third-order distortion and intermodulation Analysis of weak nonlinearities in circuits using the method of current injection Method of current-injection (contd), application to analysis of distortion in a negative feedback system

Week 12**:** Course summary and recap