Middle East Technical University
Department of Electrical and Electronics Engineering

EE201: Circuit Theory I
Fall 2020

Course Outline

I. **Basic Concepts (8 Hrs.)**

1. Introduction
   - Electrical components/devices and electric circuits; circuit variables.
   - Analysis and design. Modeling, model elements and model circuits.
2. Lumped Elements and Lumped Circuits
   - Current, Kirchhoff's Current Law (KCL), current equations.
   - Voltage, Kirchhoff's Voltage Law (KVL), voltage equations.
   - Terminal equations, schematic representations.
3. Interconnection Equations
   - Branch voltage and branch current, power and energy.
   - Circuit gaphs, circuit matrices.
   - Independent current and independent voltage equations.
   - Tellegen's Theorem. Duality.
4. Branch Relations
   - Linear/nonlinear and time-invariant/time-varying relations.
   - One-port and multi-port circuits.
5. Basic Lumped Elements
   - Waveforms. Independent voltage and independent current sources.
   - Resistors, capacitors, inductors.
   - Dependent sources, ideal transformers, coupled inductors.
   - Classification of elements: resistive/dynamic, linear/nonlinear, time-invariant/time-varying, passive/active elements.
6. Circuit Analysis
   - Classification of circuits: resistive/dynamic, linear/nonlinear, time-invariant/time-varying, passive/active circuits.
   - Formulation of circuits: inputs, outputs, formulation variables; formulation and output equations.
   - Solution of formulation equations.

II. **Linear Time-Invariant Resistive Circuits (12 Hrs.)**

1. Linear Time-Invariant (LTI) Resistive Elements
   - LTI resistors; series and parallel connections; delta-wye transformation.

- LTI dependent sources.
- Ideal transformers.

2. Analysis Methods
   - Node, modified node and mesh analysis methods.
   - Linearity and time-invariance; superposition.
3. One-Port Circuits
   - Input resistances of LTI one-ports.
   - Thevenin/Norton equivalent circuits.
   - Maximum power transfer.
4. Two-Port Circuits
   - Resistance, conductance, hybrid and chain parameters.
   - Reciprocity.
5. Symmetric Circuits

III. **Time-Varying and Nonlinear Resistive Circuits (4 Hrs.)**

1. Linear Time-Varying Resistive Elements and Circuits
2. Nonlinear Resistive Elements and Circuits
   - Analysis of resistive circuits with a single nonlinear resistor; load line.
   - Small-signal analysis
3. Piecewise-Linear Resistive Circuits
   - Analysis and design of one-ports made of ideal diodes, constant sources and LTI passive resistors.

IV. **Operational Amplifier Circuits (8 Hrs.)**

1. Operational Amplifiers
   - Finite-gain/infinite-gain ideal operational amplifier (op-amp) models.
2. Basic Op-Amp Circuits
   - Buffer circuit; inverting and noninverting amplifiers.
   - Feedback, stability.
   - Summing and difference amplifiers.
3. More Realistic Op-Amp Models
   - Input and output resistances; common-mode-rejection-ratio.
4. Miscellaneous Resistive Op-Amp Circuits
   - Circuits with one or more op-amps, with or without nonlinear resistors.

V. **Dynamic Elements (6 Hrs.)**

1. Ramp, Step, and Impulse Functions
2. Capacitors
   - LTI capacitors; initial condition models; series and parallel connections; delta-wye transformation.
   - Simple circuits made of LTI passive capacitors, independent sources and/or switches.
   - Time-varying and nonlinear capacitors.

3. Inductors

VI. **First Order Circuits (12 Hrs.)**

1. First Order Linear Differential Equations with Constant Coefficients
   - Homogeneous solution; exponential function; bounded/unbounded solutions.
   - Particular solution.
   - Complete solution.
   - Zero-input and zero-state solutions.
   - Linearity and time-invariance of solutions.
   - Convolution integral.
2. Simple LTI RC Circuit
   - State variable, state equation.
   - Natural response; natural frequency, bounded/unbounded responses.
   - Forced response; responses to constant and sinusoidal excitations.
   - Transient and steady-state responses.
   - Step, pulse, ramp, and impulse responses.
3. Simple LTI RL Circuit
4. Analysis of Miscellaneous LTI First Order Circuits
   - Circuits with one or more dynamic elements, with or without switches.
5. Piecewise-Linear First Order Circuits
6. Time-Varying and Nonlinear First Order Circuits

VII. **Simple Second Order Circuits (6 Hrs.)**

1. Second Order Linear Differential Equations with Constant Coefficients
   - Homogeneous solution; bounded/unbounded solutions; overdamped, critically damped, underdamped and lossless cases.
   - Particular solution.
   - Complete solution.
   - Zero-input and zero-state solutions.
   - Linearity and time-invariance of solutions.
   - Convolution integral.
2. Parallel LTI RLC Circuit
   - State variables, state equation, second order differential equation formulation.
   - Natural response; natural frequencies, bounded/unbounded responses.
   - Forced response; responses to constant and sinusoidal excitations.
   - Transient and steady-state responses.
   - Step and impulse responses.
3. Series LTI RLC Circuit
4. Miscellaneous Simple Second Order Circuits