

CIRCUIT THEORY II

METU EE202 - FALL 2026

Instructor: Emre Tuna; E113

Web: <http://users.metu.edu.tr/etuna/ee202/>

Scope: This course aims to cover some of the standard methods used in the formulation and analysis of linear time-invariant (LTI) circuits with special emphasis on the networks operating in the sinusoidal steady state.

Reference Texts:

- *Fundamentals of Electrical Circuits*. C.K. Alexander and M.N.O. Sadiku. McGraw-Hill, 2016.
- *Linear and Nonlinear Circuits*. L.O. Chua, C.A. Desoer, and E.S. Kuh. McGraw-Hill, 1987.

Grading: There will be two midterm exams (30% each) and a final exam (40%).

Tentative course outline:

I. *Coupled Inductors*

- LTI coupled inductors; power and energy; passivity; initial condition models; series and parallel connections of branches; equivalent models.
- Analysis of simple circuits with LTI coupled inductors.

II. *State Equation*

- State-space formulation of dynamic circuits.
- Complex frequency; complex exponential function.
- Natural frequencies; bounded/unbounded responses; mode excitation.
- Particular solutions for complex exponential inputs; phasors; KVL and KCL in phasor domain; phasor domain elements; impedance and admittance; phasor domain circuits.
- State transition matrix; zero-input and zero-state solutions.

III. *Analysis of LTI Dynamic Circuits*

- Laplace transformation; real rational functions; poles and zeros; partial fraction expansion.
- Solution to state equation by Laplace transformation.
- Node, modified node, and mesh analyses.

IV. *Sinusoidal Steady-State (SSS) Analysis*

- Periodic functions; average and effective values.

- Responses of LTI dynamic circuits to sinusoidal excitations; transient/steady-state responses.
- Analysis of phasor domain circuits; phasor diagrams.
- Passive one-ports; resistive, inductive, and capacitive one-ports.
- Superposition in the SSS.
- Instantaneous, average, complex, real, reactive, and apparent powers; power factor; conservation of power.
- Power calculations in the SSS; superposition in power calculations.
- Power factor correction.
- Maximum power transfer.

V. *Balanced Three-Phase Circuits*

- Three-phase voltage sources and loads; Y and Δ connections.
- Analysis of balanced three-phase circuits; phasor diagrams.
- Power calculations.

VI. *Complex Frequency Domain Analysis*

- Complex frequency domain voltages and currents; KVL and KCL in complex frequency domain; complex frequency domain elements; impedance and admittance; complex frequency domain circuits.
- Analysis of complex frequency domain circuits.
- Transfer functions; impulse response and convolution integral; step response; SSS response.
- Two-port circuits; impedance, admittance, hybrid, and chain representations.

VII. *Frequency Response*

- Frequency response functions; magnitude and phase characteristics.
- First order lowpass, highpass, and allpass passive LC filters; second order lowpass, highpass, bandpass, and bandstop passive LC filters; active RC filters.
- Parallel and series resonance; resonant frequency, quality factor, resonant circuits with finite-Q capacitors and inductors.
- Magnitude and frequency scalings.
- Bode plots.