Lesson Objectives by Chapter

EE241
Spring 2009
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A student in EE241 should be able to…

Chapter 1

- Distinguish between analog and digital systems.
- Define "integrated circuit."
- Describe the voltage amplifier model.
- Apply the model to solve for voltages and currents in both single and cascaded amplifier circuits.
- Distinguish between open-circuit voltage gain, A_{voc}, voltage gain including the load, A_v, and voltage gain including the load and source resistance, A_{vs}, in amplifier circuits.
- Given voltages and currents for an amplifier circuit, calculate input power, source power, output power, dissipated power, and the power efficiency.
- Represent voltage, power and current gain in decibels.
- Describe the current amplifier, transconductance amplifier and transresistance amplifier models, and apply these models to solve for voltages and currents in amplifier circuits.
- List the ideal input and output resistances for all four amplifier types.
- Define "Amplifier Frequency Response."
- Given the frequency response for an amplifier and an input signal, determine the output signal.
- Distinguish between AC- and DC-coupling, and show how capacitors are used in AC coupled amplifiers.
- Describe what is meant by differential and common-mode input in a circuit with two input sources, and distinguish between differential and common-mode gain.
- Define "Common Mode Rejection Ratio"

Chapter 2

- List the characteristics of an ideal operational amplifier.
- Describe how negative feedback leads to the "summing point constraint."
- Given any amplifier circuit, derive the equation for the output as a function of the input and circuit components using the summing point constraint.

- Draw an inverting amplifier circuit and derive its gain (assuming an ideal op-amp).
- Draw a summing amplifier circuit and derive its output voltage expression (assuming an ideal op-amp).
- Draw a voltage follower circuit and derive its gain (assuming an ideal op –amp).
- Draw a non-inverting amplifier circuit and derive its gain (assuming an ideal op-amp).
- Design inverting, summing, and non-inverting amplifiers to meet specifications.
- Distinguish between open-loop and closed-loop gain.
- Derive gain expressions for real op-amp circuits including the effects of finite open-loop gain and input resistance, and non-zero output resistance.
- Draw a comparator circuit and describe its operation.
- Design a comparator circuit to meet a specified need.
- Given an op-amp circuit employing positive feedback, such as a Schmitt trigger, determine the voltage transfer characteristic.
- List the range of discrete resistor values suitable for op-amp circuits and describe why resistances lower and greater than this range are undesirable.
- Describe what is meant by the gain-bandwidth trade-off.
- Define unity gain bandwidth.
- Describe how output voltage swing limits, current limits and slew rate limits affect op-amp circuits.
- Given key op-amp parameters, determine the operation limits before distortion occurs.
- Describe what is meant by offset voltage, offset current and bias current.
- Given the datasheets for an op-amp, identify figures of merit such as unity gain bandwidth, output voltage swing, output current limits, slew rate, input resistance, output resistance, offset voltage, offset current and bias current.
- Draw an integrator circuit and derive its gain (assuming an ideal op-amp).
- Draw a differentiator circuit and derive its gain (assuming an ideal op-amp).
- Design an integrator or differentiator circuit to meet a specification.

Chapter 3

- Draw the symbol for a diode, note the conventional voltage polarity and current direction, and sketch a plot of its current-voltage relationship.
- Name the three operation regions for a diode.
- Draw the symbol for a zener diode and describe how zener diodes are typically used.
- Apply load-line analysis to determine the operating point for a simple circuit with a non-linear element such as a diode.

- Describe the ideal diode model.
- Use the ideal diode model to determine voltages and currents in a circuit.
- Use the ideal diode with a 0.6V offset to determine voltages and currents in a circuit.
- Design a half-wave or full-wave rectifier.
- Design a half-wave or full-wave peak rectifier.
- Define peak inverse voltage, and use a PIV rating to determine the appropriate diode for a rectifier.
- Design a clipper circuit using diodes.
- Given a diode circuit, determine the voltage transfer characteristic.
- Given a voltage transfer characteristic and an input signal, determine the output signal.
- Analyze a voltage regulator to determine the minimum current and maximum power expected for the zener diode.
- Design a voltage regulator for a given source and load range.
- Define source regulation and load regulation.
- Given a simple circuit with a non-linear device, determine the small-signal resistance for a given Q point (or operating point) either graphically or from the device i-v relationship.
- Use the Shockley Equation to relate current and voltage for a diode.
- Determine the quiescent current and small-signal resistance for a diode in a simple circuit at room temperature, given the emission coefficient.
- Apply small-signal analysis to solve for voltages and currents in a simple diode circuit.
- Use small-signal analysis to calculate source and load regulation for a diode circuit.
- Given the datasheets for a diode, identify figures of merit such as peak inverse voltage, saturation current, emission coefficient and maximum power dissipation.
- Given the datasheets for a zener diode, identify figures of merit such as breakdown voltage, small-signal resistance, and maximum power dissipation.
- *Distinguish between intrinsic and extrinsic silicon.*
- *Describe what is meant by a "hole."*
- *Distinguish between donor- and acceptor-doped (i.e. n-type and p-type) silicon.*
- *Given a doping type and concentration, as well as the intrinsic electron concentration, determine the concentration of electrons and holes in a semiconductor.*
- *Describe the physics of a p-n junction diode.*

Items in italics are covered after the 6-wk exam.

Chapter 4

- Describe the physics of a bipolar junction transistor (BJT), including its operation in cutoff, active and saturation, and secondary effects such as the Early effect and breakdown.
- Sketch the input and output characteristics for a BJT, and identify the operation mode for the BJT in different regions of the plot.
- Use load-line analysis to determine bias point and AC gain for a common-emitter amplifier with the emitter tied to ground.
- Use load-line analysis to identify the amplitude of AC signal for which distortion would occur in a C-E amplifier.
- Describe the large-signal DC circuit models for the npn and pnp transistors in cutoff, active and saturation.
- Use the large-signal DC circuit models to analyze DC voltages and currents in a BJT circuit.
- Explain the advantage of adding a resistor in the emitter leg of a BJT bias circuit.
- Design a bias circuit for a discrete BJT amplifier given a power supply voltage and desired Q point, using the appropriate design "rules of thumb."
- Describe the small-signal equivalent circuit for a BJT.
- Use the small-signal equivalent circuit to analyze a BJT amplifier by finding gain, input resistance and output resistance.
- Given a bias point for a BJT amplifier, determine the largest possible output swing.
- Identify and describe the characteristics of a common-emitter amplifier and an emitter-follower amplifier.
- Describe how a BJT can be used as a switch.

Chapter 5

- Describe the structure and operation of an n-channel or p-channel enhancement-mode MOSFET, including its operation in cutoff, triode and saturation, and secondary effects such as channel-length modulation.
- Sketch the output characteristic for an NMOS transistor, and identify the operation mode for the transistor in different regions of the plot.
- Use load-line analysis to determine bias point and AC gain for a common-source amplifier with the source tied to ground.
- List the appropriate equations relating drain current to gate-to-source voltage and drain-to-source voltage for NMOS and PMOS transistors in cutoff, triode and saturation.
- Use the appropriate equations to analyze a DC MOSFET circuit.

Chapter 6

- State the truth table and Boolean expression for NOT, NAND, and NOR logic gates, and show how any combinatorial logic expression can be implemented with these gates.
- Given the voltage transfer characteristic of an inverter, determine V_{IL}, V_{IH}, V_{OL}, V_{OH} and the high and low noise margins.
- Define "fan-out."

- Distinguish between static and dynamic power dissipation.
- Define “propagation delay”
- Define “speed-power product”
- Describe the basic operation of a resistor-pull-up NMOS inverter.
- Design a resistor-pull-up NMOS inverter.
- Describe how R_D, W, L, and V_{DD} affect the static power dissipation and switching speed for a resistor-pull-up NMOS inverter.
- Sketch NMOS NOT, NAND & NOR gates.
- Design a circuit to implement a logic expression using NMOS NOT, NAND & NOR gates.
- Draw the circuit diagram of a CMOS inverter.