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ABSTRACT

The general objective, recommended text, and specific objectives of a course titled "Electronic Fundamentals," as offered at St. Lawrence College of Applied Arts and Technology, are provided. The general objective of the course is "to acquire an understanding of diodes, transistors, and tubes, and so be able to analyze the operation of single stages of amplification and diode circuits." (DB)

COURSE OBJECTIVES:
ELECTRONIC FUNDAMENTALS
EL16

Prepared by
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for

ST. LAWRENCE COLLEGE OF APPLIED ARTS AND TECHNOLOGY
KINGSTON, ONTARIO

Kingston
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ST. LAWRENCE COLLEGE OF APPLIED ARTS & TECHNOLOGY - Kingston Campus

COURSE OBJECTIVES D. Wilson	EL16	Electronic Fundamentals -- 1973/74

General Objective: To acquire an understanding of Diodes, transistors and tubes, and so be able to analyze the operation of single stages of amplification and diode circuits.

This basic course will be a firm foundation for students intending to proceed further in the study of electronics. Instruction will include practical experimentation to clarify theoretical concepts.

Recommended Text: Malvino, P.M., Transistor Circuit Approximations, N.Y., McGraw-Hill, 1968, zl-404p.

(A) Specific Objectives:

1) Sketch a diagram which illustrates the pair-bonding structure of Ge and Si crystal, considering only core and outer shell electrons.

2) State the relationship between temperature and conductivity of intrinsic semiconductor and explain why, at the same temperature, the germanium crystal conducts more heavily than the silicon.

3) Describe the generation and the movement of "holes" within intrinsic semiconductors.

4) Given a block of semiconductor material having a DC potential applied between two faces, determine the direction of current, electron drift and hole drift, through the block.

5) Sketch a diagram illustrating the effect upon the pair-bonding structure, of the controlled introduction of 3 and 5 valency impurity atoms, into intrinsic semiconductor material.

6) Describe the distinguishing characteristics of P and N type materials.

7) Given a block of P type and a block of N type material, having separate sources of D.C. potential, applied across opposite faces, determine the directions of conventional current, holes, electrons, majority and minority carriers.

8) Be able to name the majority carriers in a given extrinsic semiconductor.

9) Sketch a diagram which illustrates the disposition and polarity of immobile atoms and majority carriers, at the instant of PN junction formation.

10. Describe the formation of the depletion zone and explain barrier potential, through consideration of the movement of charge carriers on PN junction formation.

11. Be able to recall that the approximate barrier potentials for silicon and germanium semiconductor material at room temperature are respectively 0.7 and 0.3 volts.

12. With reference to a circuit in which PN junction is connected across a potential source, describe the current flow, movement of electrons, holes, majority and minority carriers and effect upon depletion zone, when the source is connected in both possible polarities.

13. Given a schematic symbol of a diode, state under what applied polarity the diode would be forward and reverse biased.

14. Identify which parts of a diode symbol represent P and N type materials.

15. Sketch typical solid state diode characteristics showing breakdown, knee, voltage, reverse and forward parts.

16. Given diode specifications calculate breakdown operational limits.

17. Be able to state the approximate value of knee voltages for germanium and silicon diodes.

18. If a diode is in reverse bias breakdown region describe how current carriers are being produced.

(B) Specific Objectives

Large Signal Operation -

1. Distinguish between large and small signal operation.

2. Recall three important characteristics of an ideal diode.

3. Be able to sketch the characteristic curve of an ideal diode.

4. Sketch the characteristic curve representing the second approximation of a real diode.

5. Draw the equivalent circuit describing the second approximation of a real diode.

6. Given values, sketch the output wave-forms of rectifier and clipping circuits, using the second approximation of a real diode.

7. Draw the equivalent circuit describing the third approximation of a real diode.

8. Sketch the characteristic curve representing the third approximation of a real diode.

9. Given diode specifications calculate diode bulk resistance.

10. Given half wave rectifiers and clipping circuits with fixed bias working into resistive loads, be able to sketch the output waveforms and state voltage levels.

11. Given input and load conditions and diode specifications, sketch output waveforms and give values, for simple half-wave rectifiers.

12. Calculate reverse resistance and currents for diodes working under reverse bias conditions.

Small Signal Operation --

13. Using the principle of superposition, draw the a-c and d-c equivalent circuits for a given two loop diagram, and sketch the voltage waveforms for signals appearing across given points on the diagram.

14. Be able to recall the approximate formula which describes the junction resistance of an ideal diode.

15. Given diode specifications, be able to calculate junction resistance, bulk resistance, a-c resistance, for various operating conditions in forward bias.

16. Given a circuit diagram consisting of separate a-c and d-c sources applied across a diode, be able to draw the a-c and d-c equivalent circuits.

17. Applying the principle of superposition, be able to sketch and give values to the approximate voltage signal across the diode.

(C) Transistor Basic Concepts

1. Describe the construction, (with diagram) of an alloy junction transistor showing emitter, collector and base connections, P and N regions and the relative thicknesses of base collector and emitter regions.

2. Be able to distinguish between the symbolic symbols for PNP and NPN transistors and correctly label the base, emitter and collector regions.

3. Given a schematic symbol of a PNP and NPN transistor showing biasing, be able to recognize the forward and reversed biased junctions and describe the direction of forward and reverse currents.

4. Describe the biasing conditions of PNP and NPN transistors necessary for use as amplifying devices. (Normal conditions).

5. Sketch an idealized block structure which shows the external currents, carrier movement in transistors, bias for normal operation, and explain qualitatively the carrier movement which occurs.

6. State the relationship between I_b, I_c, and I_e, and define the quantity alpha.

7. Correctly identify and use the symbolic abbreviations for d.c., a.c., and instantaneous values of electronic quantities.

(D) Common Base Amplifier

1. Be able to explain the shape of a family of collector characteristic curves, with reference to operation under normal bias conditions.

2. State two key assumptions underlying consideration of the transistor as an ideal device.

3. Given an ideal transistor in a common-base (CB) configuration connected in a circuit with emitter and collector sources and resistors, be able to calculate steady-state values of current and voltage, and calculate resistance values to achieve specific steady-state conditions.

4. Draw d.c. and a.c. equivalent circuits for transistors in common-base configuration.

5. Given steady-state conditions be able to calculate emitter junction resistance r_e.

6. Given a CB circuit consisting of emitter and collector bias, source resistors, load resistor and a.c. signal source, be able to calculate output values.

7. From given values of circuit components be able to calculate voltage gain of a CB circuit with consideration to ideal conditions.

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5. Given steady-state conditions be able to calculate emitter junction resistance r_e.

6. Given a CB circuit consisting of emitter and collector bias, source resistors, load resistor and a.c. signal source, be able to calculate output values.

7. From given values of circuit components be able to calculate voltage given of a CB circuit with consideration to ideal conditions.

(E) Common Emitter Amplifier

1. Be able to explain the shape of collector characteristic curves for a transistor in the CE configuration.

2. Define the beta (or H_{FE}) of a transistor.

3. Distinguish between $beta_{dc}$ and $beta_{ac}$ (H_{FE} and H_{fe}).

4. Sketch a set of ideal characteristic curves (CE collector), and explain the significance of the resulting approximations.

5. Given an ideal transistor in CE with a single power source, base and load resistors, determine I_b, I_c, and V_c.

6. Given the circuit described in (5) select R_B to provide specific base currents.

7. Given the circuit described in (5) select R_B to provide specific values of V_c.

(F) Analysis and Design of Simple C.E. Amplifier

1. With reference to a set of collector curves and a load line, determine values for R_b and R_l to effect specific quiescent conditions.

2. Describe the major limitation of the simple base biased CE amplifier.

3. Find the change in I_e caused by the replacement, within the same network, of transistors with different values of beta.

4. Draw the DC and AC equivalent circuits for transistors used in the CE configuration.

5. From the approximate formula $r_e = \frac{25\ mV}{I_e}$, derive the input resistance of a transistor in the CE configuration.

6. Derive the approximate formula which describes the voltage gain of a CE amplifier using simple base bias.

7. Calculate the stability factor.

8. Determine the current and power gain of transistors used in CE configuration with simple base bias.

(G) C.E. With Base Bias + Decoupled or Undecoupled Emitter Resistor

1. State the advantages to be derived from the inclusion of a decoupled emitter resistor in the CE configuration.

2. Determine the input resistance and quiescent conditions of a CE transistor amplifier with decoupled emitter resistor.

3. Determine the input resistance gain and quiescent conditions gain of a CE transistor amplifier with an undecoupled emitter resistor.

4. Describe the effect which the inclusion of an emitter resistor has upon stability and gain in a CE amplifier.

5. Calculate the stablility factor.

(H) C.E. With Emitter Resistor Plus Collector Feed-back

1. Given a circuit, determine input resistance, gain quiescent conditions and stability factor.

2. Given a loaded amplifier and signal source characteristics,

(I) C.E. With Potential Divider Bias

1. Given a circuit, determine input resistance, gain quiescent conditions and stability factor.

2. Given a loaded amplifier and signal source characteristics, calculate overall stage gain.

(J) Common Collector Amplifier

1. Given a CC circuit calculate input resistance and quiescent values.

(K) Tube Type Devices

1. Sketch the curves which describe the relative emission characteristics of tungsten, thoriated tungsten and oxide-coated cathodes.

2. Describe thermionic emission, secondary emission and high field emission.

3. Describe the general applications and the limitations of the three common cathode materials.

4. Sketch a typical indirectly heated cathode.

5. Sketch typical curves which describe the relative effects of various levels of operating cathode temperatures.

6. Explain the requirement of the maintenance of high vacuum in electron tubes.

7. Sketch typical diode forward characteristic curves.

8. Given diode characteristic curves, be able to calculate static resistance and dynamic resistance.

9. Compare the relative virtues and disadvantages of tubes and Semi-conductor associated with -

   a. Current handling capacity.
   b. PIV rating.
   c. Forward static resistance.
   d. Forward dynamic resistance.
   e. Size.
   f. Power dissipation.
   g. Reverse resistance.
   h. Radiation vulnerability.
   i. High Ambient temperature.

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(L) 1. Sketch one typical triode element assembly, showing relative positioning of the elements.

2. Describe how the potential of the grid may be used to control the plate current.

3. Given a circuit diagram, describe how a set of triode characteristic curves may be generated.

4. Sketch a set of typical triode plate characteristic curves.

5. Interpret a set of transfer characteristic curves.

6. Given a set of plate characteristic curves be able to establish the three dynamic coefficients of a triode, i.e. Amplification factor, (u), transconductance (g_m), and plate resistance (r_p).

7. Given any two dynamic coefficients be able to calculate the third.

8. Given a set of triode characteristics with load line superimposed, be able to design the simple cathode biased amplifier circuit.

9. Given a set of triode characteristic curves, be able to design a simple cathode biased amplifier circuit to obtain an approximate specified gain.

10. Given a triode amplifier circuit and a set of characteristic curves, be able to establish the quiescent conditions and the voltage gain.

11. Draw an a.c. equivalent circuit for a simple decoupled cathode biased triode amplifier and label with the appropriate references.

12. Using the equivalent circuit, develop an expression for voltage gain.

13. Given a set of triode characteristics and the maximum plate dissipation, superimpose a dissipation characteristic upon the curves.

14. Be able to use the dissipation characteristic as a limiting factor in the design of simple amplifier circuits.