Western Technical College

# 10660125 Electronic Devices

## Course Outcome Summary

### Course Information

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| **Description** | Electronic Devices provides the fundamentals knowledge of electronic semiconductor devices and circuits including diodes and rectifiers, zener diodes, LEDs, bipolar junction transistors (BJTs), and field effect transistors (FETs). Electronic circuits and their applications will be constructed and tested using both actual components and circuit simulation software. |
| **Career Cluster** | Manufacturing |
| **Instructional Level** | Associate Degree Courses |
| **Total Credits** | 4 |
| **Total Hours** | 108 |

### Textbooks

*Electronic Principles*. 8th Edition. Copyright 2016. Malvino, Albert and David Bates. Publisher: McGraw-Hill Publishing Company. **ISBN-13**: 978-0-07-337388-1. Required.

### Program Outcomes

1. Apply electronic theory to practice.
2. Operate test equipment.
3. Build electronic circuits and systems.
4. Evaluate the operation of electronic circuits or systems.
5. Communicate technical information.

### Course Competencies

**1. Describe the basic construction of semiconductor diodes.**

**Criteria**

*Your performance will be successful when:*

1.1. you draw a picture of a semiconductor diode labelling each type of material and the corresponding majority and minority carriers.
1.2. you explain the atomic differences between conductors, semiconductors, and insulators.
1.3. you describe how to forward-bias and reverse-bias silicon diodes.

**Learning Objectives**

1.a. Discuss the basic structure of atoms.
1.b. Discuss semiconductors, conductors, and insulators in regards to their differences.
1.c. Discuss covalent bonding in silicon.
1.d. Describe how current is produced in a semiconductor.
1.e. Describe the properties of n-type and p-type semiconductors.
1.f. Describe a pn junction and how it is formed.
1.g. Discuss methods of biasing a pn junction.

## 2. Analyze diode circuits.

**Criteria**

*Your performance will be successful when:*

2.1. you draw the current-voltage (I-V) curve of a silicon diode based on lab measurements.
2.2. you analyze series/parallel diode circuits using 1st and 2nd diode approximations.
2.3. you calculate the respective voltages in half-wave, full-wave and bridge rectifier circuits.
2.4. you explain the advantages and disadvantages between half-wave, full-wave and bridge rectifier circuits.

**Learning Objectives**

2.a. Construct a basic circuit to measure the forward and reverse bias diode characteristics.
2.b. Graph the diode voltage drop versus diode current for a silicon diode.
2.c. Analyze the current-voltage (I-V) characteristics of a pn junction.
2.d. Determine the DC resistance of a diode at several points along its characteristic curve.
2.e. Analyze diode circuits using 1st and 2nd diode approximations.
2.f. Calculate and measure the dc output voltage of half-wave, full-wave and bridge rectifier circuits.
2.g. Measure the secondary and output peak voltages using an oscilloscope.
2.h. Compare the output voltage and frequency of half-wave, full-wave and bridge rectifier circuits to each other.

## 3. Test diodes and circuit operation.

**Criteria**

*Your performance will be successful when:*

3.1. you experimentally display the characteristic curve of a silicon diode.
3.2. you demonstrate the behavior of diode reverse current when its temperature increases.
3.3. you properly test silicon diodes using a VOM and DMM.

**Learning Objectives**

3.a. Demonstrate the effect of temperature on a diode's reverse current.
3.b. Display a diode's characteristic curve using an oscilloscope or curve tracer.
3.c. Determine the output voltage and current levels of a VOM and DMM.
3.d. Test diodes using a VOM and DMM.
3.e. Measure the secondary and output peak voltages using an oscilloscope.

## 4. Analyze filtered rectifier circuits.

**Criteria**

*Your performance will be successful when:*

4.1. you calculate and verify the operation of a capacitor filtered half-wave rectifier circuit.
4.2. you calculate and verify the operation of a capacitor filtered full-wave rectifier circuit.

**Learning Objectives**

4.a. Explain and analyze the operation and characteristics of power supply filters.
4.b. Calculate and measure circuit values for a filtered half-wave rectifier.
4.c. Calculate and measure circuit values for a filtered full-wave rectifier.

## 5. Troubleshoot power supply rectifier circuits.

**Criteria**

*Your performance will be successful when:*

5.1. you measure the effects of a changing load resistance on filtered rectifier circuits.
5.2. you measure the response of rectifier circuits with inserted faults.

5.3. you construct and test power supply rectifier circuits using simulation software.

**Learning Objectives**

5.a. Predict and measure the effects of a changing load resistance on a filtered rectifier circuit.
5.b. Insert problems in a rectifier circuit to simulate troubleshooting failed components.
5.c. Use Multisim software to construct and test power supply circuits.

## 6. Analyze diode clipper circuits.

**Criteria**

*Your performance will be successful when:*

6.1. you predict the output voltage of constructed diode clipper and limiter circuits.
6.2. you measure the output of clipper and limiter circuits to verify proper circuit operation.

**Learning Objectives**

6.a. Explain and analyze the operation of diode clipper and limiter circuits.
6.b. Calculate and measure the output voltage of positive and negative diode clipper and limiter circuits.
6.c. Predict and measure the output voltage of biased clipper circuits.

## 7. Analyze the operation of zener diodes and zener diode circuits.

**Criteria**

*Your performance will be successful when:*

7.1. you construct a zener regulator circuit and explain its proper operation.
7.2. you demonstrate how to measure the volt-ampere characteristic curve of a zener diode using a curve tracer or oscilloscope test circuit.
7.3. you measure the output voltage of constructed zener regulator circuits to verify circuit calculations.

**Learning Objectives**

7.a. Describe the characteristics of a zener diode and analyze its operation.
7.b. Explain how a zener diode is used in voltage regulation and analyze zener circuits.
7.c. Construct and test circuits to observe or measure a zener diode's volt-ampere characteristics.
7.d. Calculate and measure the current and voltage in a zener voltage regulator circuit with varying loads.
7.e. Construct and measure the output voltage of a zener regulated full-wave bridge power supply circuit.

## 8. Determine the operational characteristics of special purpose diodes.

**Criteria**

*Your performance will be successful when:*

8.1. you properly describe the operation and characteristics of LEDs, photodiodes, and Schottky diodes.
8.2. you construct circuits used to test special purpose diodes.
8.3. you measure and draw the output signal of an optoisolator with a square-wave input signal.
8.4. you compare the high frequency response of a Schottky diode versus a silicon rectifier diode.

**Learning Objectives**

8.a. Discuss the operation and characteristics of LEDs and photodiodes.
8.b. Discuss the basic characteristics of the Schottky diode.
8.c. Construct a circuit to determine the characteristics of an LED.
8.d. Measure the output of an optoisolator.
8.e. Examine the high frequency rectification ability of a Schottky diode.

## 9. Compare the advantages and disadvantages of various voltage regulators.

**Criteria**

*Your performance will be successful when:*

9.1. you describe the advantages of an IC voltage regulator over a simple zener regulator circuit.
9.2. you explain the importance of power supply line and load regulation.
9.3. you describe the voltage regulation ability of 7800 and 300 series voltage regulator ICs.

**Learning Objectives**

9.a. Discuss the basic concept of voltage regulation.
9.b. Explain line regulation.

9.c. Explain load regulation.
9.d. Describe the operation of three-terminal IC voltage regulators.

## 10. Test regulated power supplies for proper operation.

**Criteria**

*Your performance will be successful when:*

10.1. you construct the verify the operation of three-terminal IC voltage regulators.
10.2. you calculate line and load voltage regulation of IC regulator circuits.
10.3. you test and verify the specifications of a given DC power supply circuit.

**Learning Objectives**

10.a. Construct and verify the operation of three-terminal IC voltage regulator circuits.
10.b. Calculate the line and load regulation of IC voltage regulators.
10.c. Test a DC power supply for proper voltage regulation specifications.

## 11. Describe the operation of bipolar junction transistors (BJTs).

**Criteria**

*Your performance will be successful when:*

11.1. you properly explain the construction of NPN and PNP transistors.
11.2. you draw the schematic symbol for NPN and PNP transistors including lead identification.
11.3. you explain how a transistor can be used as an amplifier and a switch.
11.4. you construct a test circuit to measure the base, emitter, and collector currents of a transistor.

**Learning Objectives**

11.a. Describe the basic construction of a bipolar junction transistor (BJT).
11.b. Explain how a transistor is biased and its current relationships.
11.c. Discuss transistor parameters and characteristics.
11.d. Discuss how a BJT is used as an amplifier and as a switch.
11.e. Identify various type of BJT package configurations.
11.f. Measure the effect of how transistor base current controls the collector current.

## 12. Perform tests on special purpose semiconductor diodes and BJTs.

**Criteria**

*Your performance will be successful when:*

12.1. you test zener diodes, optoisolators, Schottky diodes, and BJTs with a DMM.
12.2. you construct a circuit to test for a transistor's Beta value.
12.3. you display a transistor's collector characteristic curves using a curve tracer or oscilloscope test circuit.

**Learning Objectives**

12.a. Test a zener diode using a DMM.
12.b. Test LEDs, optoisolators and Schottky diodes using a DMM.
12.c. Test NPN and PNP transistors using analog and digital meters.
12.d. Determine a transistor's Beta value by constructing a transistor test circuit.
12.e. Use a curve tracer or oscilloscope test circuit to display a transistor's characteristic curves.

## 13. Analyze transistor bias circuit configurations.

**Criteria**

*Your performance will be successful when:*

13.1. you calculate the dc voltage and current values for base-biased and voltage-divider biased transistor circuits.
13.2. you calculate the dc voltage and current values for two-supply emitter bias transistor circuits.
13.3. you graphically display the stability effect of Beta on circuits by drawing transistor dc load lines.
13.4. you properly measure dc voltage and current values for constructed transistor bias circuits.

**Learning Objectives**

13.a. Discuss the concept of dc bias in a linear amplifier.
13.b. Analyze a base bias circuit.
13.c. Analyze an emitter bias circuit.

13.d. Analyze a voltage-divider bias circuit.
13.e. Calculate and measure the voltage and current levels for base-biased NPN and PNP transistors.
13.f. Explain the effect of a change of Beta for a base-biased circuit.
13.g. Calculate and measure the voltage and current levels for NPN and PNP voltage-divider bias circuits.
13.h. Observe the effect of a change in Beta for a voltage-divider circuit.
13.i. Graphically display the stability of the voltage-divider bias circuit.
13.j. Calculate and measure the voltage and current levels for two-supply emitter bias circuits.
13.k. Note the effect of a Beta change and graphically display the load line stability of a two-supply emitter bias circuit.

## 14. Design transistor bias circuits.

**Criteria**

*Your performance will be successful when:*

14.1. you design a based-bias circuit to meet given specifications.
14.2. you design a voltage-divider biased circuit to meet given specifications.
14.3. you test transistor bias circuits using Multisim simulation software.

**Learning Objectives**

14.a. Design a base-biased circuit using a known Beta value.
14.b. Design a simple voltage-divider bias circuit.
14.c. Compare the effectiveness of Q-point stability for the various transistor bias circuits.
14.d. Test transistor bias circuit using simulation software.

## 15. Troubleshoot transistor bias circuits.

**Criteria**

*Your performance will be successful when:*

15.1. you measure the effects of known troubles in a transistor bias circuit.
15.2. you place faults in a bias circuit and predict the circuit changes.
15.3. you troubleshoot unknown circuit failures in transistor bias circuits.

**Learning Objectives**

15.a. Troubleshoot various faults in transistor bias circuits.
15.b. Insert typical component failures in transistor bias circuits and predict circuit voltage changes.
15.c. Troubleshoot unknown circuit failures in transistor bias circuits.

## 16. Analyze small-signal transistor circuits.

**Criteria**

*Your performance will be successful when:*

16.1. you calculate the dc values or Q-point of a transistor amplifier.
16.2. you calculate the ac voltage values for common-emitter and common-collector amplifiers.
16.3. you construct common-emitter, common-collector, and common-base amplifiers and measure their respective dc values.

**Learning Objectives**

16.a. Explain the concept of small-signal amplifiers.
16.b. Analyze the operation of common-emitter amplifiers.
16.c. Analyze the operation of common-collector amplifiers.
16.d. Analyze the operation of common-base amplifiers.
16.e. Measure the Q-point for a common-emitter amplifier.

## 17. Perform tests on amplifier circuits for proper operational characteristics.

**Criteria**

*Your performance will be successful when:*

17.1. you explain the significance of an emitter bypass capacitor in regards to voltage gain and input impedance.
17.2. you measure the voltage gain and phase of a common-collector (CC) transistor amplifier using an oscilloscope.

17.3. you calculate the input and output impedance of a CC amplifier.
17.4. you construct and measure the operational characteristics of a Darlington amplifier.

**Learning Objectives**

17.a. Observe the effects of an emitter bypass capacitor on the circuit's voltage gain and input impedance.
17.b. Calculate and measure the DC Q-point for a common-collector (CC) amplifier.
17.c. Measure the voltage gain and phase of a CC amplifier.
17.d. Determine the input and output impedance of a CC amplifier.
17.e. Construct and measure the operation of a Darlington amplifier.

## 18. Analyze the operation of common-collector circuits.

**Criteria**

*Your performance will be successful when:*

18.1. you determine the dc and ac circuit values for a two-stage CE and CC amplifier.
18.2. you demonstrate the buffer action of a CC amplifier.
18.3. you construct and measure the circuit values of a zener follower voltage regulator to verify proper operation.
18.4. you find the component fault in a zener follower voltage regulator circuit.

**Learning Objectives**

18.a. Calculate and measure the dc and ac circuit values for a two-stage CE and CC amplifier.
18.b. Observe the buffer action of a CC (emitter follower) amplifier.
18.c. Construct and measure the operation of a zener follower voltage regulator.
18.d. Troubleshoot a zener follower voltage regulator.

## 19. Evaluate Class-A amplifier circuits.

**Criteria**

*Your performance will be successful when:*

19.1. you calculate and measure the dc bias voltages for a Class A amplifier.
19.2. you draw the dc and ac load lines for various Class A amplifiers.
19.3. you determine the ac power efficiency of a Class A amplifier.
19.4. you observe when clipping distortion occurs in a Class A amplifier using an oscilloscope.

**Learning Objectives**

19.a. Calculate and measure the dc bias voltages for a Class A amplifier.
19.b. Draw the dc and ac load lines for various Class A amplifiers.
19.c. Determine the ac power efficiency of a Class A amplifier.
19.d. Observe when clipping distortion occurs in a Class A amplifier.

## 20. Predict and test Class-B (AB) power amplifier circuit performance.

**Criteria**

*Your performance will be successful when:*

20.1. you calculate and verify the dc bias operation of a Class B (AB) transistor amplifier.
20.2. you demonstrate the bias adjustment of a Class B (AB) transistor amplifier.
20.3. you properly adjust the dc operating point to reduce crossover distortion in a Class AB amplifier.
20.4. you calculate and measure the maximum undistorted output (MPP) of a Class B transistor amplifier.

**Learning Objectives**

20.a. Calculate and measure the dc bias voltage for a Class B (AB) amplifier.
20.b. Adjust a diode voltage-divider bias circuit for proper trickle bias in a Class (AB) amplifier.
20.c. Observe crossover distortion using an oscilloscope.
20.d. Determine the maximum peak-to-peak undistorted output (MPP) of a Class B amplifier.

## 21. Describe the characteristics of a junction field effect transistor (JFET).

**Criteria**

*Your performance will be successful when:*

21.1. you explain the terms IDSS, VGS(off), Vp, and normally-off in regards to a JFET.
21.2. you construct and measure a JFET's circuit values of IDSS, Vp, and VGS(off).

21.3. you construct a circuit to demonstrate how a JFET's input voltage controls its output current.
21.4. you display a JFET's drain curves on a curve tracer or oscilloscope.
21.5. you draw and explain a JFET's transconductance curve.
21.6. you demonstrate the operation of a JFET switching circuit.

**Learning Objectives**

21.a. Explain the operation of JFETs.
21.b. Define, discuss and apply important JFET parameters.
21.c. Construct a circuit used to find the values of IDSS, Vp, and VGS(off) for a JFET.
21.d. Demonstrate how a JFET's input voltage controls its output current.
21.e. Graphically display the drain curves and transconductance curve for a JFET.

## 22. Analyze JFET amplifier amplifier circuits.

**Criteria**

*Your performance will be successful when:*

22.1. you calculate and verify by measurement the dc bias values of JFET circuits.
22.2. you determine the effect of changing IDSS and VGS(off) values on JFET circuit bias stability.
22.3. you calculate and verify the ac operation of common-source and common-drain JFET amplifiers.

**Learning Objectives**

22.a. Calculate expected circuit voltage and current values in a various JFET bias circuits.
22.b. Demonstrate the bias stability of JFET bias circuits.
22.c. Determine the dc and ac circuit values for a common-source amplifier.
22.d. Determine the dc and ac circuit values for a common-drain amplifier.

## 23. Troubleshoot JFET circuits.

**Criteria**

*Your performance will be successful when:*

23.1. you construct and test a circuit to determine the effect of component failures in a JFET bias circuit.
23.2. you demonstrate the effect of failed components in a JFET amplifier.

**Learning Objectives**

23.a. Predict the outcome of component failures or changes in JFET bias circuits.
23.b. Predict the results of failed components in JFET amplifiers.

## 24. Explain Electrical Overstress (EOS) and Electrostatic Discharge (ESD) protective measures.

**Criteria**

*Your performance will be successful when:*

24.1. you list several precautions that must be followed to prevent destroying MOSFET devices.
24.2. you practice safe handling of MOSFET devices when constructing MOSFET circuits.

**Learning Objectives**

24.a. Define the terms "Electrical Overstress" and "Electrostatic Discharge."
24.b. Practice safe handling techniques when using MOSFET devices to prevent static damage.

## 25. Analyze MOSFET characteristics and circuits.

**Criteria**

*Your performance will be successful when:*

25.1. you explain the similarities and differences between JFET and MOSFET devices.
25.2. you describe the terms normally-on and normally-off in regards to depletion and enhancement MOSFET devices.
25.3. you calculate and verify the dc operation of MOSFET bias circuits.
25.4. you calculate and verify the operation of MOSFET amplifiers and switching circuits.

**Learning Objectives**

25.a. Explain the operation characteristics of MOSFETs.
25.b. Define, discuss and apply important MOSFET parameters.
25.c. Analyze MOSFET bias circuits.

25.d. Calculate expected circuit voltage and current values in various MOSFET bias circuits.
25.e. Determine the operating characteristics of a power E-MOSFET used in switching and amplifier circuits.

## 26. Test MOSFET's for proper operation.

**Criteria**

*Your performance will be successful when:*

26.1. you construct a circuit to measure the IDSS and VGS(off) values of a provided D-MOSFET device.
26.2. you draw the transconductance curves for D-MOSFETs and E-MOSFETs.
26.3. you use a curve tracer or oscilloscope test circuit to display the drain current curves for D-MOSFET and E-MOSFET devices.
26.4. you construct and adjust MOSFET switching control circuits for proper operation.

**Learning Objectives**

26.a. Construct a circuit used to find the values of IDSS and VGS(off) for a D-MOSFET.
26.b. Graphically display the drain curves and transconductance curve for a D-MOSFET.
26.c. Graphically display the drain curves and transconductance curve of a power E-MOSFET.
26.d. Construct and calibrate E-MOSFET application circuits.

## 27. Examine the characteristics of Silicon Controlled Rectifier (SCR) devices.

**Criteria**

*Your performance will be successful when:*

27.1. you draw the pnpn construction layer of an SCR and explain its operation.
27.2. you describe the use of SCRs in control circuits.
27.3. you draw the lead configuration of SCRs using a semiconductor data book or the internet.

**Learning Objectives**

27.a. Describe the basic structure and operation of a Silicon Controlled Rectifier (SCR).
27.b. Discuss several SCR applications.
27.c. Determine the terminal identification and electrical component data for an SCR.

## 28. Analyze SCR circuits.

**Criteria**

*Your performance will be successful when:*

28.1. you predict and draw the corresponding SCR Vload and Vak waveforms at given conduction angles.
28.2. you construct and verify the operation of DC and AC gate controlled SCR circuits.
28.3. you construct and test SCR power switching circuits.

**Learning Objectives**

28.a. Calculate the voltage waveforms for SCR gate control at various conduction angles.
28.b. Construct and measure circuit values for DC gate and AC gate controlled SCR circuits.
28.c. Evaluate SCR switching circuits.

## 29. Test SCRs for proper operation.

**Criteria**

*Your performance will be successful when:*

29.1. you use a VOM and a DMM to test an SCR.
29.2. you construct a test circuit to examine the electrical characteristics of an SCR.
29.3. you specify the voltage and current limitations of DMMs when testing an SCR.

**Learning Objectives**

29.a. Test an SCR using a VOM and a DMM.
29.b. Construct a circuit used to test the electrical characteristics of an SCR.
29.c. Explain the testing limitations of DMMs when used on SCR devices.

## 30. Describe the characteristics of basic operational amplifiers (op-amps).

**Criteria**

*Your performance will be successful when:*

30.1. you explain the values and significance of ideal open-loop op-amp characteristics.
30.2. you describe the importance of a differential amplifier and its use in an op-amp.
30.3. you determine if an op-amp is using negative or positive feedback.
30.4. you explain the impact of op-amp input/output characteristics when negative feedback is applied.

**Learning Objectives**

30.a. Describe the basic op-amp and its characteristics.
30.b. Discuss the differential amplifier and its operation.
30.c. Discuss several op-amp parameters.
30.d. Explain negative feedback in op-amp circuits.
30.e. Describe the input and output impedance of op-amp configurations.

## 31. Analyze op-amp circuits.

**Criteria**

*Your performance will be successful when:*

31.1. you calculate the output values for inverting, noninverting, and unity-gain (voltage follower) op-amp circuits.
31.2. you calculate and verify the frequency response or bandwidth (BW) of inverting and noninverting op-amp circuits.
31.3. you calculate and verify the operation of op-amp summing circuits.
31.4. you determine the output state of an op-amp comparator circuit.

**Learning Objectives**

31.a. Analyze op-amp inverting and noninverting circuit configurations.
31.b. Analyze the operation of summing amplifiers.
31.c. Analyze the operation of basic comparator circuits.

## 32. Troubleshoot basic op-amp circuits.

**Criteria**

*Your performance will be successful when:*

32.1. you predict the output voltage of an op-amp circuit if various circuit components would fail.
32.2. you determine the faulty component in a malfunctioning op-amp circuits using measurement techniques.
32.3. you explain how component failure or op-amp failure can cause an saturated output voltage.

**Learning Objectives**

32.a. Explain the impact of various component faults on basic op-amp circuit configurations.
32.b. Explain the relationship between output saturation voltages and a defective op-amp.
32.c. Determine failed components in a malfunctioning op-amp circuit.