EE 332/532 LABORATORY I

Diode Characteristics

Prelab:

1. Familiarize yourself with data sheets for the lN4001 p-n junction diode, the MBR340 Schottky barrier diode, and an LED diode.
2. Design a circuit for measuring the I_D-V_D diode forward characteristics for I_D □5 15 mA. Use an adjustable power supply whose voltage Vs can be varied in the range from 0 to 20 V.
3. Determine the small-signal model of a p-n junction diode and Schottky diode at I_D □1 mA and 4 mA. Compare the small-signal resistance at two dc currents.
4. Using the data sheets for the p-n junction diode:
   a) Determine the maximum forward current and the maximum reverse voltage.
   b) Find a large-signal constant-voltage-drop model.
   c) Find a large-signal constant-voltage-drop/constant-forward-resistance model for the diode current 1 mA □ I_D □ 1 A.
5. Repeat step 4 for the MBR340 Schottky barrier diode and LED diode. Compare the large-signal models for the p-n junction diode, the Schottky diode, and the LED diode.

Experiments:

1. p-n Junction Diode (Fig. 1-a)
   a) Measure and plot the I_D - V_D forward characteristics for the IN4001 diode up to 12 mA.
   b) Measure the small-signal resistance r_d at I_D = 1 mA and I_D = 4 mA.
2. Light-Emitting Diode (LED) (Fig. 1-b)
   a) Connect in series a DC power supply, a 100 □ (current-limiting) resistor, and a red LED.
   b) Adjust the supply voltage until the first "visible light" is noticed. Measure the 'firing level" of I_D and V_D
   c) Increase the supply voltage until 'good brightness' is reached. Measure I_D and V_D at the bright light.
3. Schottky Diode

Repeat the Experiment 1 for the MBR340 Schottky diode.

Postlab:

Submit a written report.

1. Sketch the I_D - V_D characteristics and calculate the small-signal resistance at I_D = 1 and 4 mA for the IN4001 diode from the slope of the I_D –V curve. Compare this small-signal resistance to the one found in prelab and to the measured values.
2. Sketch the I_D - V_D characteristics and calculate the smah-signal resistance at I_D = 1 and 4 mA for the Schottky diode from the slope of the ID-VD curve. Compare this small-signal resistance to the one found in prelab and to the measured values.
3. Compare the forward voltage drop for p-n junction diode, Schottky diode, and the LED.

Circuit Schematics:

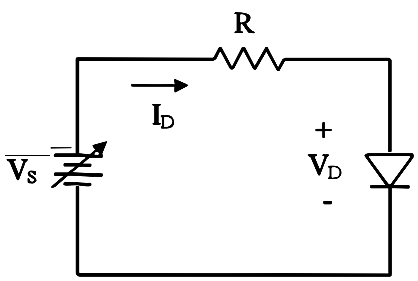


Figure 1-a: Diode Test Circuit.

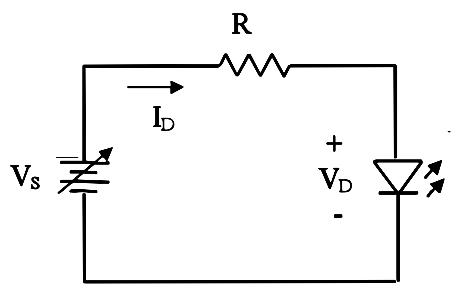


Figure 1-b: LED Test Circuit.

Testing a diode with an Ohm-meter:

To verify if a diode is good or failed, measure a DC forward resistance (use 1 k range) and a DC reverse resistance. A good diode will have a low forward resistance and a very large DC reverse resistance. Ratio of the reverse to forward resistances should be at least 1000:1.

EE 332/532 LABORATORY II

Diode Applications

Prelab:

1. Design a circuit for measuring the I_D-V_D reverse characteristic of the IN52318 Zener diode for -10 mA $\leq I_D \leq$ 0.
2. Design a transformer center-tapped rectifier such that V_{DC} = 19.4 V, P_o = 0.24W, and the peak-to-peak ripple voltage $V_r \leq$ 0.6 V. The rms value of the voltage across each secondary of the transformer is $V_{sec(rms)}$ = 14. V at f = 60 Hz.
3. Design a Zener diode regulator to regulate the output voltage of the rectifier designed in prelab 2 such that V_o = 5.1 V and I_L = 10 mA.

Experiments:

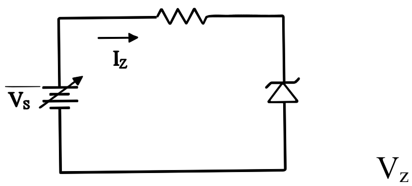
1. Measure and plot the I_D-V_D reverse characteristics for the IN52318 Zener diode (Fig. 2-a).
2. Build and test the transformer center-tapped rectifier (Fig. 2-b) designed in prelab 2. Measure the V_{DC}, I_L, and V_r.
3. Build and test the regulated power supply (Fig. 2-c) consisting of the filter capacitor, the transformer center-tapped rectifier, and the Zener diode regulator designed in prelab 3. Measure the V_o and I_L. Also, measure and compare the ripple voltage across the rectifier filter capacitor and the ripple voltage at the output of the regulator.
4. Measure the DC output voltage Vo versus the load current I_L = 0 to 10 mA (Fig. 2-c).
5. Reverse both diodes and the electrolytic capacitor and measure the output voltage.

Postlab:

Submit a written report.

1. Sketch the DC output voltage Vo versus the load current I_L = 0 to 10 mA from Exp. 4.
2. Calculate the load regulation of the power supply ——— where V_{NL} is the output voltage at no load, and V_{FL} is the output voltage at full load.
3. Explain why the Zener diode regulator reduces the ripple voltage.

Circuit Schematics:



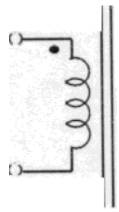


Figure 2-a: Zener Test Circuit.

Figure 2-b: Transformer Center-Tapped Rectifier.

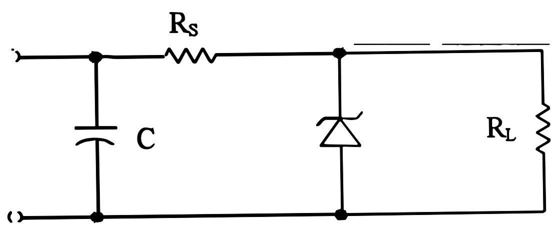


Figure 2-c: Zener Regulator Circuit.

EE 332/532 LABORATORY III

MOSFET Characteristics and Biasing

Prelab:

1. Familiarize yourselves with data sheets for the 2N7000 MOSFET.
2. Design a circuit for biasing the enhancement n-channel 2N7000 MOSFET employing the voltage-divider bias to meet the following specifications:
   a) V_{DD} = 16 V.
   b) Set the operating Q-point at I_D = 4 mA and V_{DS} = 8 V.
   c) Current through the voltage divider I_{VD} □ 20 uA, which is the current flowing through R_1 and R_2.
3. Draw the DC load line for the specified case and label the slope and the crossing points.
4. Calculate g_m and r_o, at I_D = 1 mA and 4 mA assuming V_A = -50 V. How does the drain current affect g_m and r_o?

Experiments:

1. Measure and plot the I_D-V_{GS} and I_D-V_{VS} characteristics of the 2N7000 MOSFET for V_{GS}□2.25V and V_{DS}□10 V using the test circuit shown in Fig. 3-b. Measure the threshold voltage V_t of the MOSFET. Enter the collected data in the data table
2. Observe and record the output characteristics of the MOSFET on the curve tracer.
3. Build and test the circuit for biasing the MOSFET designed in prelab 2 (Fig. 3-a). Measure V_S, V_G, V_D, V_{GS}, V_{DS}, V_{DG}, and I_D. Adjust the component values so that the given specifications are met

Postlab:

Submit a written report.

1. Plot I_D-V_{GS} and I_D-V_{DS} characteristics of the 2N7000 MOSFET and determine g_m and r_o, at I_D=4 mA from the slope of the measured characteristics.
2. Compare the theoretical and measured results, i.e., V_S, V_G, V_D, V_{GS}, $V_{DS,}$ V_{DG} and I_D
3. Compare I_D-V_{DS} curves obtained from curve tracer and measured point by point.

4. Give conclusions drawn from the experiments.

Circuit Schematics:

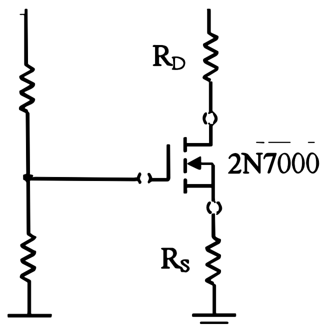


Figure 3-a: Voltage-Divider Self- Bias.

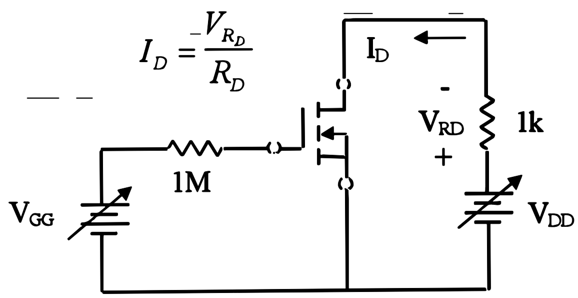


Figure 3-b: MOSFET Test Circuit.

Data Table: Measure and record I_D at the corresponding V_{GS} and V_{DS}.

	V_{DS}										
V_{GS}	0.1V	0.2V	0.3V	0.4V	0.5V	1.0V	2.0V	4.0V	6.0V	8.0V	10.0V
2.25V											
2.00V											
1.75V											
1.50V											

EE 332/532 LABORATORY IV

MOSFET Common-Source Amplifier

Prelab:

1. Design a common-source amplifier with the following specifications:

   a) $|A_V| \geq 12$ b) $V_{am} \geq 2V$ @ f = 1 kHz c) $R_{in} \geq 500\ k\Omega$

   d) $R_o < 1\ k\Omega$ e) $R_L = 10\ k\Omega$ f) $R_{GEN} = 1k\Omega$

   g) $12\ V \leq V_{DD} \leq 18\ V$ h) Reactances of the coupling and by-pass capacitors to be less than 10 Ω at 1 k Hz.

2. Draw the dc and ac load lines for the designed amplifier.

Experiments:

1. Build and test the amplifier designed in prelab 1. Measure I_D, V_{GS}, V_{DS}, Ri and R_o. Adjust the component values so that the specifications are met
2. Measure the maximum output voltage amplitude $V_{om(max)}$ without distortion.

Figure **4:** Common-Source Amplifier.

Postlab:

1. Compare the theoretical and measured results, i.e., I_D, V_{GS}, V_{DS}, A_v, R_o, R_{in} and $V_{om(max)}$.
2. Give conclusions drawn from the experiments.

EE 332/532 LABORATORY V

BJT Characteristics and Biasing

Prelab:

1. Familiarize yourselves with data sheets for the 2N3904 BJT.
2. Design a circuit for biasing the npn 2N3904 BJT employing the voltage-divider bias to meet the following specifications:
   a) V_{cc} = 12 V.
   b) Set the operating Q-point at I_c = 1 mA and V_{CE} = 6 V.
3. Draw the DC load line for the specified case.
4. Calculate g_m, $r_{□}$, and r at I_C = 1 mA and 4 mA assuming V_A = -100 V.

Experiments:

1. Measure and plot I_C-V_{BE} and I_C-V_{CE} characteristics of the 2N3904 BJT for and V_{BE} □ 10 V using the test circuit shown in Figure 5-b. Enter the collected data in the data table provided, then use that data to plot the characteristic curves.
2. Observe and record the output characteristics of the BJT on the curve tracer.
3. Build and test the circuit for biasing the BJT designed in prelab 2. Measure V_E, V_B, V_C, $V_{BE,}$ V_{CE}, V_{CE} and I_C. Adjust the component values so that the given specifications are met.

Postlab:

Submit a written report.

1. Plot I_C-V_{BE} characteristics of the 2N3904 BJT. Determine g_m and r_0 at I_C = 4 mA from the slope of the measured characteristics. Compare g_m and r_0 at I_C = 4 mA which were determined from the slope of the measured characteristics to the calculated values arrived in prelab.
2. Compare the theoretical and measured results for V_E, V_B, V_C, V_{BE}, V_{CB}, V_{CE}, and I_C.
3. Compare I_C-V_{CE} curves obtained from curve tracer and measured point-by-point

Testing a BJT with an Ohm-meter:

a) Connect the positive lead of an ohm-meter to the base of an npn transistor and the negative lead to the collector and then to the emitter to measure the dc forward resistance of the junctions. Both of these resistances must be low for a good transistor.

b) Connect the negative lead of an ohm-meter to the base of an npn transistor and the positive lead to the collector and then to the emitter to measure the dc reverse resistance of the junctions. Both of these resistances must be very high for a good transistor. Ratio of the reverse to forward resistance should be greater than 1000:1.

Circuit Schematics:

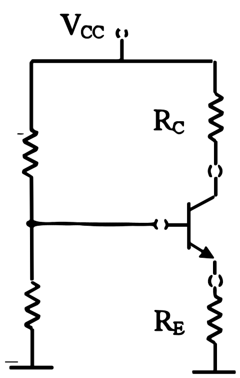


Figure 5-a: Voltage-Divider bias of BJT.

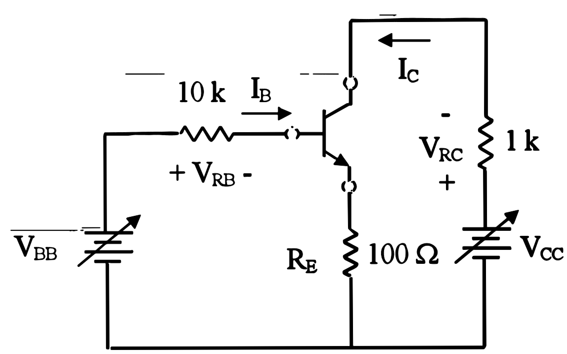


Figure 5-b: Test Circuit for the BJT.

Data Table: Measure and record Ic at the corresponding I_B and V_{CE}.

	V_{CE}						
I_B	0.5V	1.0V	2.0V	4.0V	6.0V	8.0V	10.0V
50 µA							
40 µA							
30 µA							
20 µA							
10 µA							
5 µA							

EE 332/532 LABORATORY VI

Common-Collector Amplifier

Prelab:

1. Design a common-collector amplifier using the 2N3904 BJT to meet the following specifications:

a)	$A_v \geq 0.90$	b)	$V_{om} \geq 1$ V @ f = kHz	c)	$R_{in} \geq 15$ kΩ
d)	$R_o \leq 25$Ω	e)	$R_l = 1$ kΩ	f)	$R_S = 1$ kΩ
g)	$6 \text{ V} \leq V_{CC} \leq 10 \text{ V}$	h)	Reactances of the coupling capacitors are to be less than 10 Ω at 1 KHz.		

2. Draw the dc and ac load lines for the designed amplifier.

Experiments:

1. Build and test the amplifier designed in prelab 1. Measure I_C, V_{CE}, Av, R_o and R_{in}. Adjust the component values so that the specifications are met.
2. Measure $V_{om(max)}$ without distortion.

Figure 6: Common-Collector Amplifier.

Postlab:

Submit a written report.

1. Compare the small-signal models of MOSFETs and BJTs.
2. Compare the theoretical and measured results for V_{CE}, I_C, A_v, R_o, and R_{in}.
3. Give conclusions drawn from the experiments.