College of Applied Sciences / Hit

University of Anbar

Laboratory Experiments

Bioelectronics

Experiment No. 4

Second Stage

Department of Medical Physics

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Week 7:
Experiment 5 : Clipper And Clamper Circuits

OBJECTIVES:

- The purpose of this experiment is to study the use of diodes in wave-shaping (clipper) circuits and in level-shifting (clamper) circuits.

Test Standard : IEEE 503-1978

PRE-LAB:

The circuits to be tested and simulated are several clipper circuits and a clamper circuit. The clippers use a diode, resistor, and voltage source in different orientations in a circuit. You should be familiar with the basic operation of clipper and clamper circuits as discussed in the lecture. You should be able to produce the output wave shapes for the circuits below. You have to simulate the circuits shown below in the Figures.

You will need to compare your measured circuits with the simulated circuits.

THEORY:

It is frequently necessary to modify the shape of various waveforms for use in instrumentation, controls, computation, and communications. Wave shaping is often achieved by relatively simple combinations of diodes, resistors, and voltage sources. Such circuits are called clippers, limiters, amplitude selectors, or slicers. Clipper circuits are primarily used to prevent a waveform from exceeding a particular limit, either positive or negative. For example, one may need to limit a power supply's output voltage so it does not exceed +5 V. The most widely used wave shaping circuit is the rectifier, which you have previously studied.

Diode Clampers add or shift a dc level to an ac signal, and are sometimes known as dc restorers. For example, if we have a clock signal that swings between 0V and 5V but our application requires a clock signal from -5V to 0V, we can provide the proper DC offset by using a passive Clamper circuit. For the clamping circuit to work properly the pulse width should be less than the RC time constant (τ) of the circuit, by a factor of 5 approximately. Because of the time constant requirement the voltage across the capacitor can not change significantly during the pulse width, and after a short transient period the voltage across the capacitor reaches a steady state offset value.

The output voltage is simply the input voltage shifted by this steady state offset. Also, observe that the peak-to-peak output voltage is equal to the peak-to-peak input voltage. Because the voltage across the capacitor can not change instantaneously and the full change of voltage on the input side of the capacitor will likewise be seen on the output side of the capacitor.

PROCEDURE:

PART-A Diode Clipper circuits

A-1 Positive Clipper

1. Construct the circuit shown in Figure 1.a by using ***1N4007 Si*** diode.
2. Switch ON the Oscilloscope.
3. Switch ON the Function Generator and set the voltage (V_S) to ***8V$_{p\text{-}p}$***, ***100Hz***, sinusoidal.
4. Use the Oscilloscope to measure and record V_S from CH1 and V_O from CH2. Sketch the Oscilloscope screen. (*Note: set the input coupling switch of the Oscilloscope to the DC coupling mode*).
5. Switch OFF the Function Generator, and insert the DC power supply as shown in Figure 1.b.
6. Switch ON the DC power supply and the Function Generator, and set the DC voltage to 2V. Then repeat step 4.
7. When finished, switch OFF the DC power supply and the Function Generator.

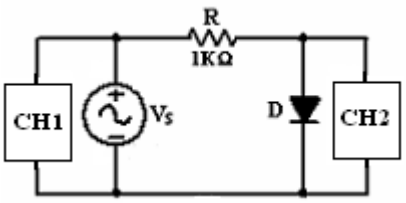

Figure 1.a

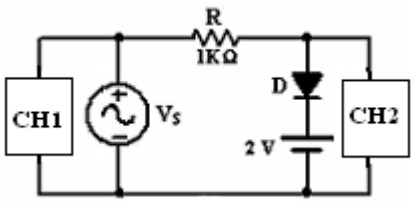

Figure 1.b

8. If you want to draw the resistor voltage waveform (Rectified Signal):
    a. What are the changes you had to do in the circuit shown in Figure 1.a?
    b. Draw the circuit again and show the locations of the Oscilloscope channels terminals. Explain.
    c. Sketch the output waveform in this case.

A-2 Negative Clipper

1- Construct the circuit shown in Figure 2.a by reversing the diode of the previous circuit.
2- Use the Oscilloscope to measure and record V_S from CH1 and V_O from CH2. Sketch the Oscilloscope screen on the respective grids in Table 2. (*Note: set the input coupling switch of the Oscilloscope to the DC coupling mode*).
3- Switch OFF the Function Generator, and insert the DC power supply as shown in Figure 2.b.

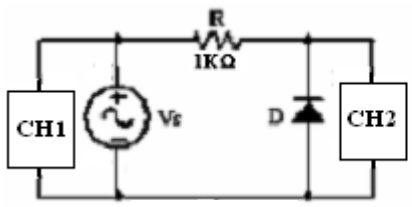

Figure 2.a

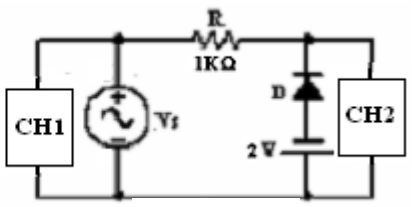

Figure 2.b

4- Switch ON the DC power supply and the Function Generator, and set the DC voltage to 2V. Then repeat step 2.
5- When finished, switch OFF the DC power supply and the Function Generator.
6- Explain the effects of using a diode that is not ideal.

PART-B Diode Clamper circuits

B1- Positive Clamper

1- Construct the circuit shown in Figure 3.
2- Use the Oscilloscope to measure and record V_S from CH1 and V_O from CH2. Sketch the Oscilloscope screen. (*Note: set the input coupling switch of the Oscilloscope to the DC coupling mode*).
3- When finished, switch OFF the Function Generator.

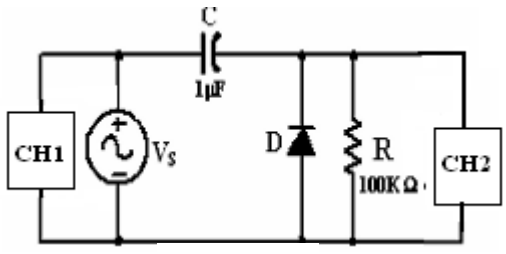

Figure 3

4- What happen when using clamping circuit to drive low load impedance? Does the circuit still work as clamper? Explain.

B-2 Negative Clamper

1- Construct the circuit shown in Figure 4.
2- Use the Oscilloscope to measure and record V_S from CH1 and V_O from CH2. Sketch the Oscilloscope screen.
3- When finished, switch OFF the instruments.

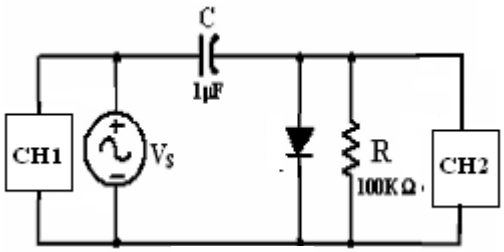

Figure 4

Week 8 and Week 9:

Experiment 6: Bipolar Junction Transistor Characteristics

OBJECTIVES:

- To investigate the DC behavior of BJT.
- To understand the transistor DC biasing circuit.
- To identify the characteristics of a BJT transistors in different regions of operations.

Test Standard : IEEE C62.42

PRE-LAB:

- By using the data sheet of the **BC140** transistor, look up to the following:
  - Pin out configuration package (Bottom View)
  - Minimum h_{FE} (β) _____ .
  - Maximum h_{FE} (β) _____ .
  - V_{CE} (max) _____ V .
  - I_C (max) _____ V .
  - Total maximum power dissipation _____ mW .
  - Semiconductor material and the type of transistor _____
  - The complementary transistor of the **BC140** is _____
- What is the difference between a BC140 BJT and its complementary transistor.
- Build the circuit in the experiment using the MULTISIM simulation package, to obtain the expected results and graphs.

THEORY:

The Bipolar Transistor essentially consists of a pair of PN-Junction diodes that are joined back-to-back. They can be found anywhere and used in many electronic circuit applications such as in sensors, amplifiers, OP-AMPs, oscillators and digital logic gates. The PC computer contains around a hundred million transistors; or more!

There are all sorts, shapes, and sizes of transistors. In this lab we will only consider one basic general purpose type, the bipolar junction transistor. This transistor comes in two constructions called PNP and NPN. For the following experiments you will use the **BD140 Si**, NPN transistors.

The DMMs in the lab have a separate function for PN-junction testing. In diode test, the DMM outputs a constant current of about **1 mA** and it measures the voltage between the two leads without computing the resistance. The measured voltage is the threshold voltage (V_γ; *i.e.* ***(0.5 - 0.65)*** *V for* ***Si****, typically less than the normal drop*

of 0.7 V) of the PN-junction for a 1 mA current, if the PN-junction is forward biased. If the PN-junction is reverse biased, then the DMM cannot force 1 mA of current to pass through the PN-junction and the voltage across the PN-junction rises up to the upper range limit of the DMM, usually about (1.5 to 3.0) Volts. Some meters give an over-limit (**.OL, 1.,** or **2** to **3V**) indication. Using the DMMs diode function is one way to perform the transistor test, and it gives understandable information about the typical PN-junction voltages of the BJT.

The operation of the BJT transistors is very strongly affected by heat, which is usually generated internally due to power dissipation. It is advisable, therefore, to limit transistor heating in this experiment by starting data runs with maximum current and voltage, when the transistor is still cool, and then progressively reducing the current. (*Note: Transistor currents change due to heating effects even when supply voltages are kept constant*).

PROCEDURE:

Part-A Current-Voltage Characteristics of a CE BJT

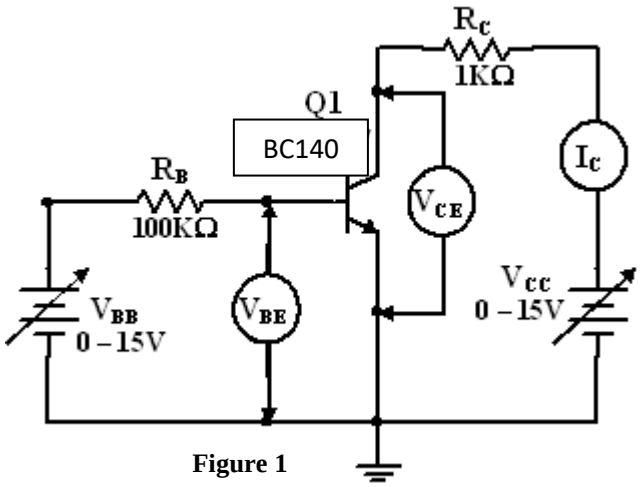

Figure 1

1- Construct the circuit shown in Figure 1. By using the **BC140 BJT**. (*Make sure the transistor is connected with the correct polarity)*.
2- Set the DC power supplies output to zero volt, then switch the supply ON.
3- Adjust the DC power supply of $\mathbf{V_{CC}}$ according to Table 1.
4- Adjust the DC power supply V_{BB} to obtain the approximate values according to Table 1.
5- Use the voltmeter to **measure** $\mathbf{V_{BE}}$, $\mathbf{V_{CE}}$ and $\mathbf{I_C}$ and **calculate** $\mathbf{I_B}$ and, and record the readings in Table 1.
6- Repeat steps 4 and 5 for all values of $\mathbf{V_{BB}}$.
7- Repeat steps 3 to 6.

8- When finished, set the **V_{BB}** and **V_{CC}** to ***0.0V***. Then switch OFF the DC power supplies.
9- From your data in Table 1, plot the experimental output collector characteristics (I_C vs. V_{CE}) at V_{BB}= 4 volt. On the same graph:

   a) Draw the load line.
   b) Determine the Q-point (Operating Point).
   c) Determine the 4 regions of operations.

10- From your data in Table 1, plot the input characteristics (I_B vs. V_{BE}) at V_{CC}= 15V.
11- From the experimental results calculate the average β_{DC} (h_{FE}). For what significant reasons is the experimental β different from the manufacturer's specified value?
12- From the above β, calculate the corresponding alpha α.
13- On the basis of the measurements you made, what material is the transistor made of? How did you arrive at this conclusion?
14- Explain how the **Common Emitter (CE)** characteristics would be different if β were increased?
15- Explain how the **CE** output characteristics (V_{CE}, I_C) would be affected by a decrease in temperature.
16- Draw (I_C ***vs.*** I_B), and (V_{CE} ***vs.*** I_B) when V_{CC} = 15 volt.

NOTE:

$$I_B = (V_{BB} - V_{BE})/R_B$$

$$\beta_{DC} = I_c/I_B$$

Table 3:

$V_{CC}\Downarrow$	V_{BB}(V)	6.0	4.0	2.0	0.0
V_{CC} = 15V	V_{CE}(V)				
	I_C(mA)				
	V_{BE}(V)				
	I_B^*(μA)				
	β_{DC}^*				
V_{CC}= 12V	V_{CE}(V)				
	I_C(mA)				
	V_{BE}(V)				
	I_B^*(μA)				
	β_{DC}^*				
V_{CC} = 9 V	V_{CE}(V)				
	I_C(mA)				
	V_{BE}(V)				
	I_B^*(μA)				
	β_{DC}^*				
V_{CC} = 6 V	V_{CE}(V)				
	I_C(mA)				
	V_{BE}(V)				
	I_B^*(μA)				
	β_{DC}^*				
V_{CC} = 4 V	V_{CE}(V)				
	I_C(mA)				
	V_{BE}(V)				
	I_B^*(μA)				
	β_{DC}^*				
V_{CC} = 2 V	V_{CE}(V)				
	I_C(mA)				
	V_{BE}(V)				
	I_B^*(μA)				
	β_{DC}^*				
V_{CC} = 0 V	V_{CE}(V)				
	I_C(mA)				
	V_{BE}(V)				
	I_B^*(μA)				
	β_{DC}^*				

Week 10 and Week 11:

Experiment 7： Transistor AC Amplifiers

(This experiment would be for two weeks so that the lab can be synchronized with the lecture)

OBJECTIVES:

- To study AC transistor amplifiers
- Design and Conduct a Common-Emitter Amplifier circuit to illustrate how the voltage gain of a CE bipolar transistor circuit can be changed by using the Emitter Bypass capacitor.
- Understand the concept "Q-point determines the relationship between the input wave shape and the output wave shape".
- The gain of the CE amplifier is a function of the transistor used in the circuit, the values of the resistors, and the presence of an emitter bypass capacitor. The CE amplifier with capacitor-bypassed emitter resistance shows good gain stability to variations in transistor β.
- **Test Standard : IEEE C62.42**

PRE-LAB:

- You should be familiar with the dc analysis techniques needed to find the Q-point of a common-emitter circuit.
- All the preparation parts must be computed before the experiments part. Consider the circuit of Fig. 1.

Let V_{CC} = 12 V, R_C = 6.2 kΩ, R_E = 1.8 kΩ, and R_L = 2.2 kΩ.

- Calculate values of R_1, R_2 so that $I_{CQ} \approx 1$ mA and for good bias stability (or $R_{BB} = 0.1\times(\beta+1)\times R_E$).
- Compute the Q-point and the maximum unclipped output voltage with C_E included (C_E = 100μF).
- Repeat 2 if capacitor C_E is removed.
- With R_C, R_E and R_L the same as what used in 1), re-calculate R_1 and R_2 so that the operating point is at the center of the AC load line. Re-calculate the maximum unclipped output with C_E included (C_E = 100 μF).
- Repeat 4 with the bypass capacitor C_E removed.
- Change the value of R_C to 3.2 kΩ and re-calculate the DC operating point I_{CQ}. What do you notice?

You may find the following equations useful:

$$I_{CQ} \approx \frac{V_{BB} - V_{BE(on)}}{R_E + \frac{R_{BB}}{\beta}}, V_{BB} = \frac{V_{CC} \times R_2}{R_1 + R_2}, R_{BB} = \frac{R_1 \times R_2}{R_1 + R_2}, V_{BE(on)} \approx 0.7V$$

- Simulate all the circuits in the experiment sheet using the MULTISIM simulation package, to verify your results and graphs.

Background Information:

A typical common emitter amplifier stage is shown in the Figure 1. The placement of the Q-point on the AC load line determines the maximum symmetrical AC component in the collector voltage and current.

With an arbitrary location of the Q-point on the AC load line, the maximum unclipped voltage or current will occur first on either the positive or the negative cycles of the AC waveform, and as the input is increased, the output will eventually be clipped on both cycles. The maximum unclipped output can be optimized (maximized) placing the Q-point at the center of the AC load line.

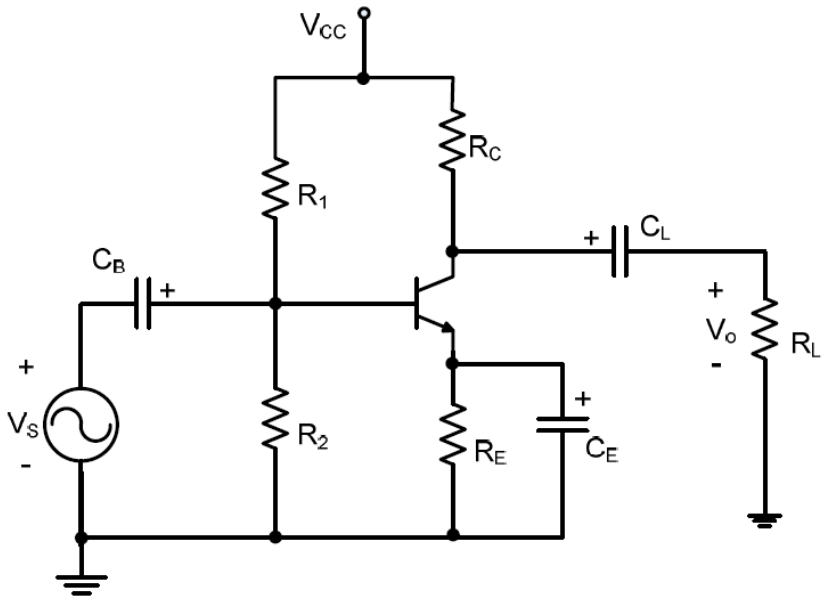

Figure 1: Common Emitter Amplifier

Common-Emitter Amplifier

The Common-Emitter (CE) amplifier is characterized by high voltage and current gains, A_v and A_i, respectively. The amplifier typically has a relatively high input resistance ***Zi*** (***1 to 10 kΩ***) and is generally used to drive medium to high resistive loads. The circuit for the common-emitter used in applications where a small voltage signal needs to be amplified to a large voltage signal. Since the amplifier cannot drive low resistive loads

R_L, usually it is cascaded with a Common-Collector (CC) (*some times called, emitter follower or buffer*) circuit that can act as a driver.

Common-Collector (Emitter follower) Amplifier

The common-collector amplifier (emitter-follower), is a unity voltage gain A_v and a high current gain A_i amplifier. The input resistance Zi for this type of amplifiers is usually (1 *to* $10\ k\Omega$) which is relatively high. Because the amplifier has unity voltage gain ($Av \cong 1$), it is useful as a buffer amplifier providing isolation between two circuits while providing driving capability for low resistive loads.

Experimental Procedure:

The purpose of the experiment is to verify the theoretical and simulation results. Use C_B = 1 µF, C_L = 1 µF, and C_E = 100 µF.

NOTE: Make sure capacitors are connected with the correct polarity.

1) Build the circuit in Fig.1 with the values you calculated in part (1) of the preparation. If necessary, re-adjust R_1, R_2 so that $I_{CQ} \approx 1$ mA.
2) Measure the maximum sinusoidal unclipped output. Set the input frequency to 5 kHz.
3) Repeat (2) with C_E removed.
4) Replace R_1, R_2 with the ones found in the pre-lab preparation part (4) and measure the new unclipped output.
5) Repeat (4) with C_E removed.
6) Change R_C to 3.2 kΩ and measure I_{CQ} after the change.

Report:

In your lab report, present experimental data and compare them with your expected results. Discuss any discrepancies, make comments, and write conclusions.

Your report will include the following information:

1. Laboratory partner.
2. Date and time data were taken.
3. The pre-laboratory results.
4. The experimental procedures.
5. All calculations or simulation results for each step.
6. All plots or waveforms for each step.
7. Short summary discussing what was observed for each of the steps given in experiment.
8. What you learned.

Notes:

1- You have to connect the circuit.

2- You have to change Vs. and record your results.

3- From your data you have to check V_{BE} and V_{BC} that verify the transistor is biased in the forward-active mode. Why is $V_{CE} = 7.5$ **V** a good choice?

4- You have to show all the steps and results. Also you have to write a report.