CND 101 - LAB [6]

Zener Diode and BJT Transistor

Student name: Karim Mahmoud Kamal Mohamed

Student ID: V23010174

Section #: 16

Submitted to TA: Mariam Mamdouh

Date: 5/11/2023

ZENER DIODE CHARACTERISTICS

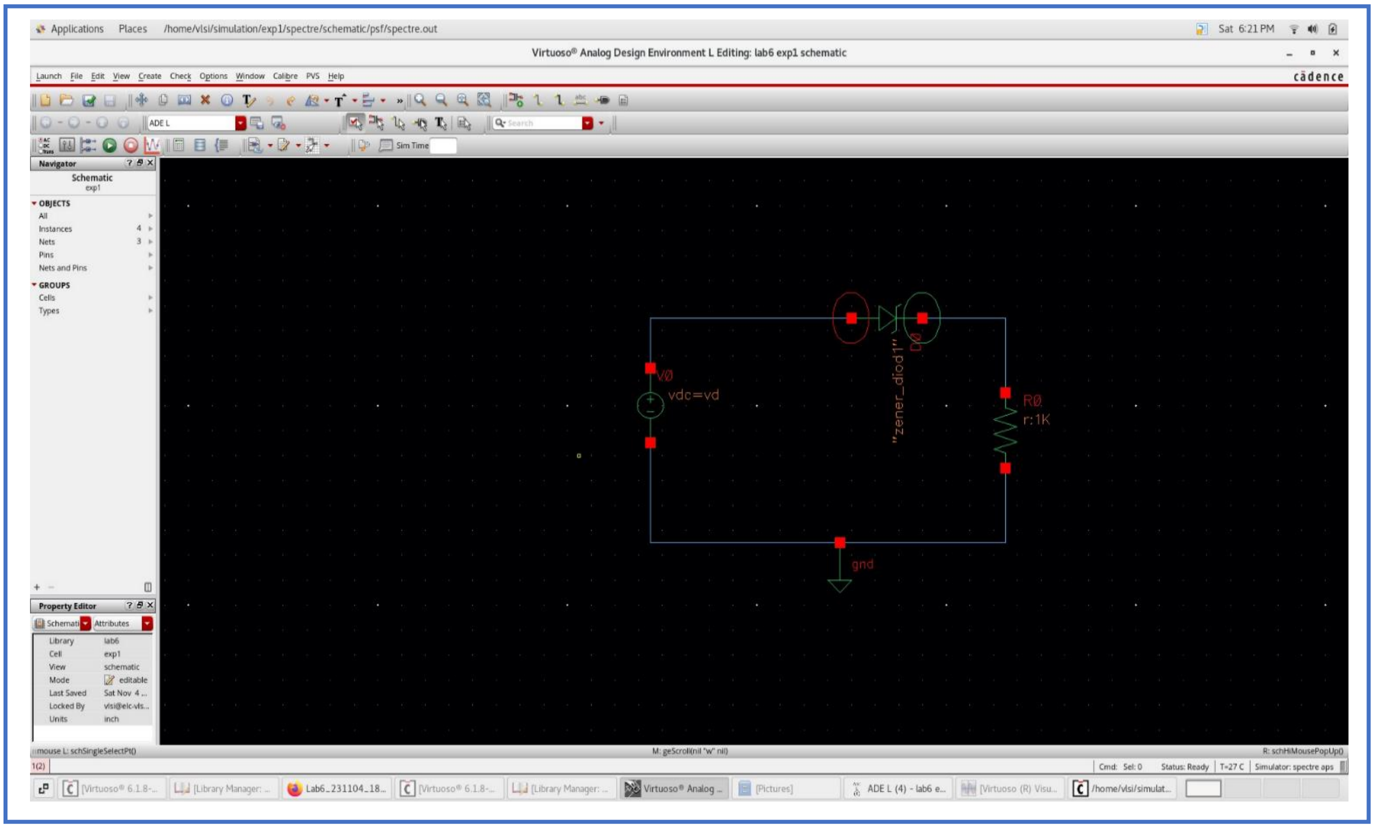

Figure 1 schematic of Zener diode circuit.

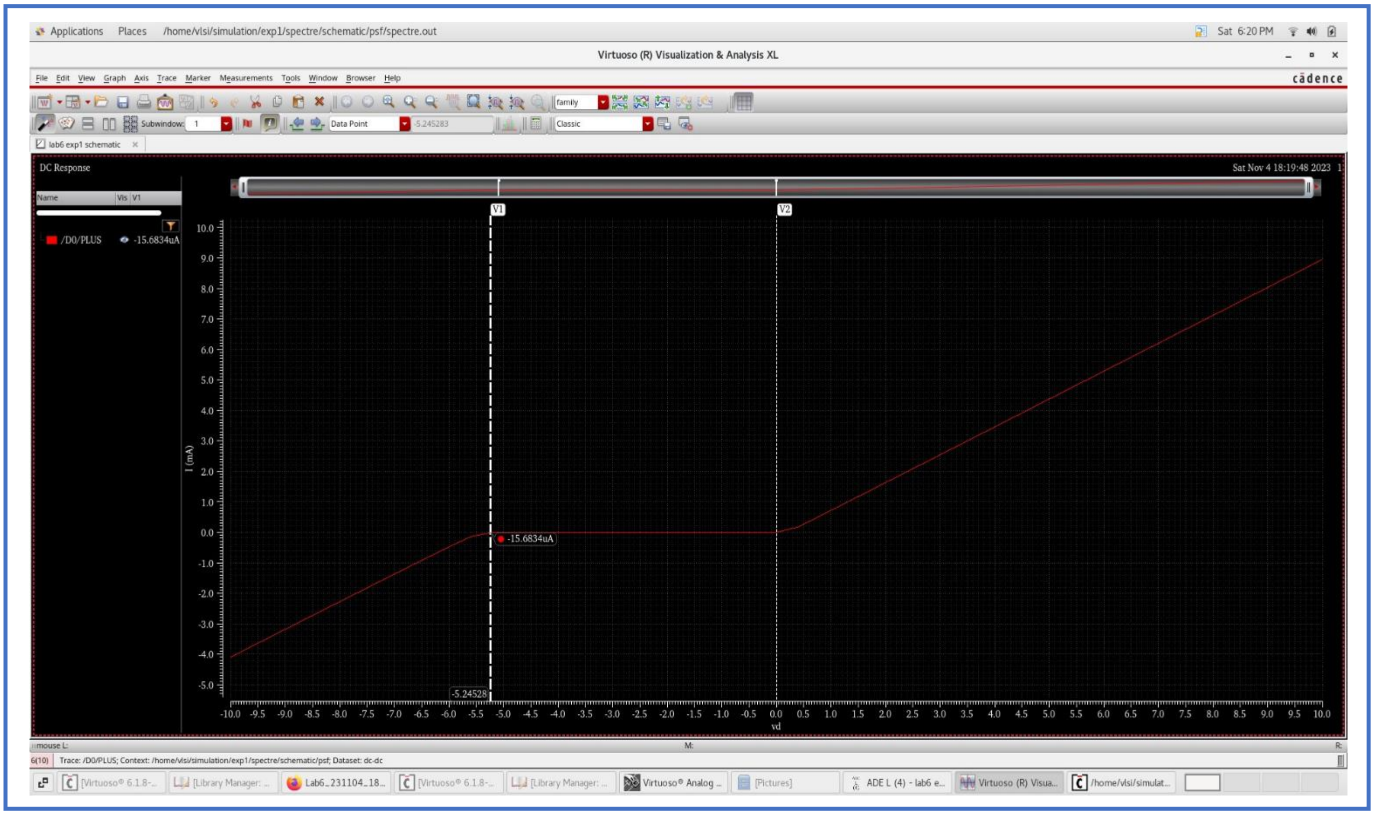

Figure 2 DC analysis shows I-V characteristics of Zener diode.

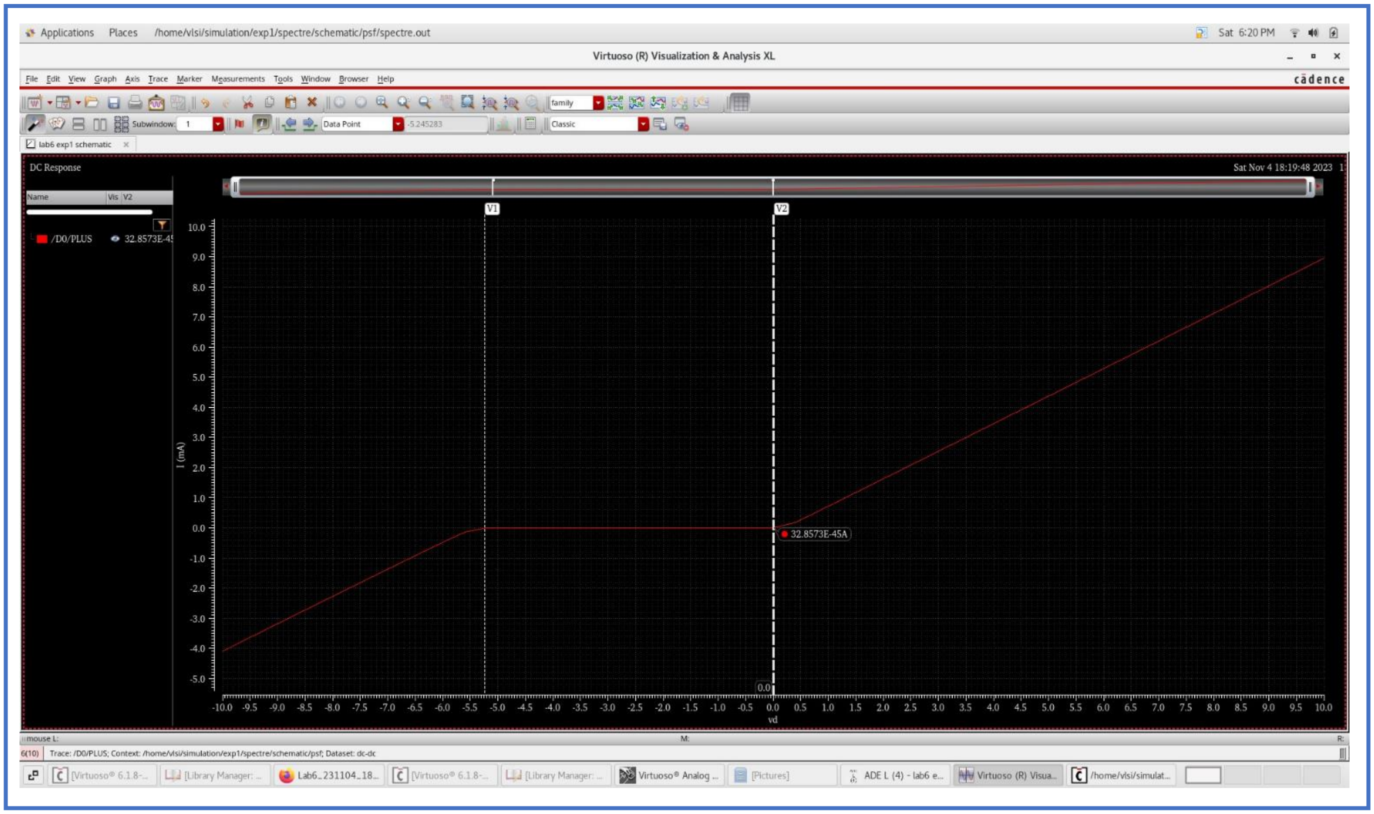

Figure 3 DC analysis shows I-V characteristics of Zener diode.

Comments

In the figure above, Zener diodes have three distinct regions of operation:

<u>Forward Bias Region:</u>

When a positive voltage is applied to the positive terminal of the diode, and a negative voltage is applied to the negative terminal of the Zener diode, it acts as a simple diode and allows current to pass (when Vin > 0.7V).

<u>Reverse Bias Region:</u>

When the voltage applied to the diode ranges from 0V to 5.24V, the diode is in a reverse bias region, and no current flows through it (current is zero).

<u>Breakdown Region:</u>

When a positive voltage is applied to the negative terminal of the diode, and a negative voltage is applied to the positive terminal of the Zener diode, it allows current to flow in the opposite direction when the voltage is less than -5.24V.

ZENER DIODE AS A REGULATOR

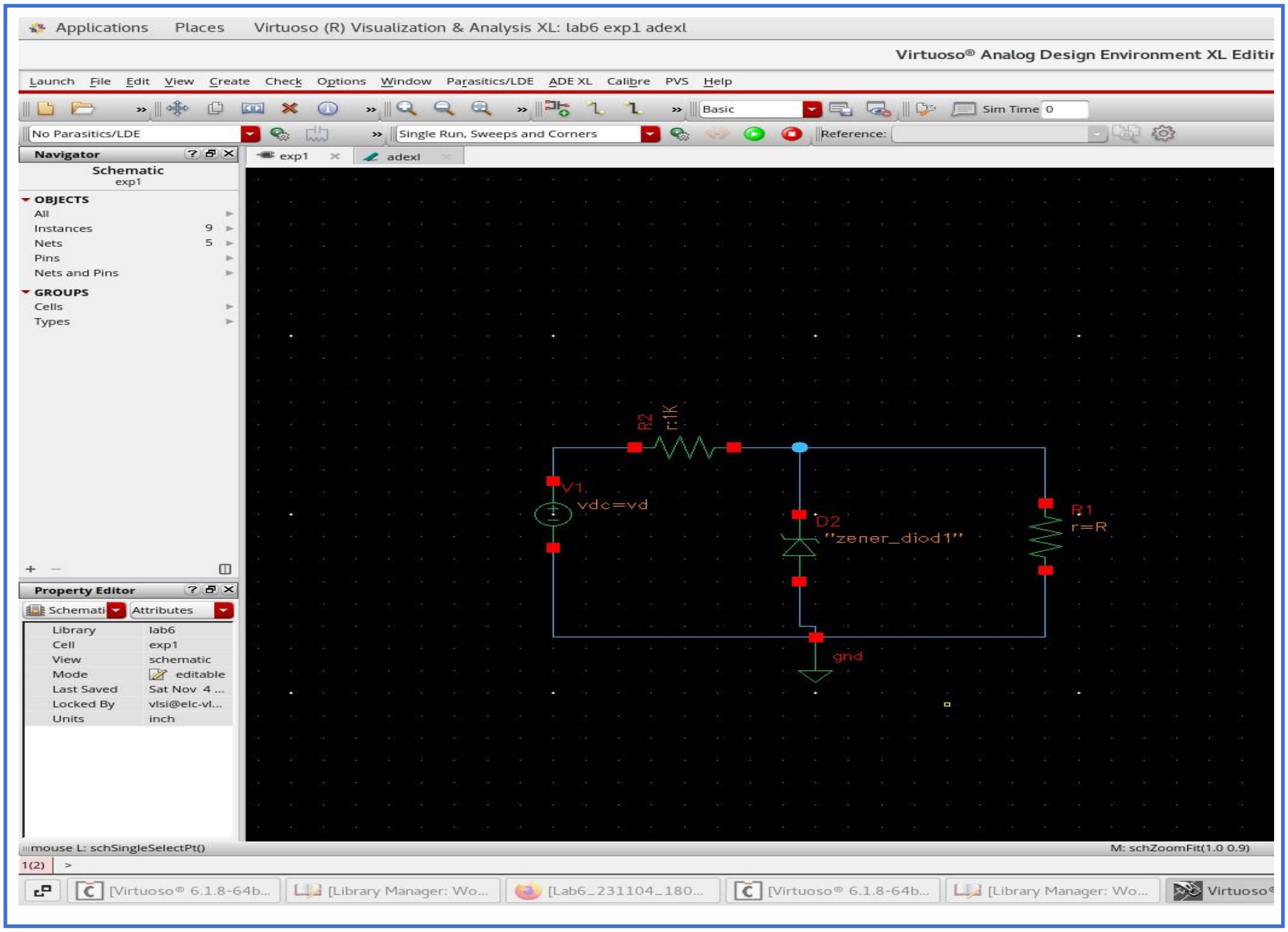

Figure 4 circuit implementation of voltage regulator using Zener diode.

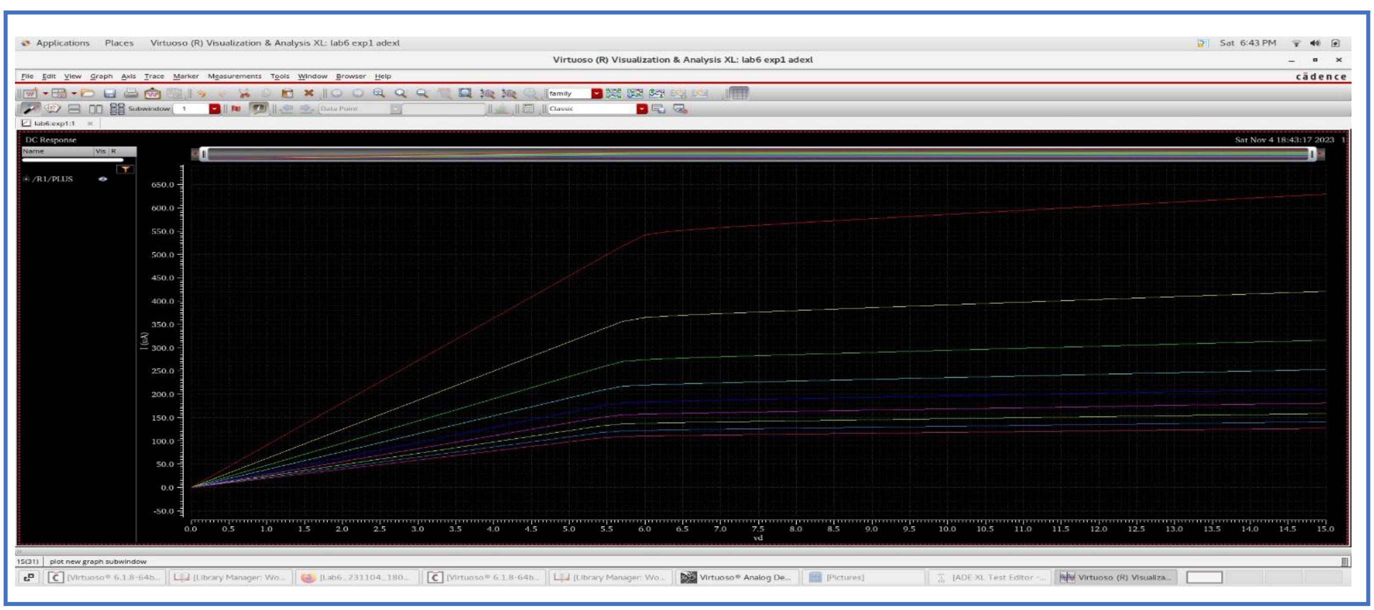

Figure 5 voltage regulator output from Zener diode circuit on resistive load from 10k to 50k using step 5k.

Comments

When the input voltage (Vin) is applied to the circuit, current flows through the series resistor (R) and the Zener diode. The Zener diode operates in the reverse breakdown region, maintaining a nearly constant voltage across its terminals, regardless of the current flowing through it. If we increase the resistance value, the curve shifts downward. This is because according to Ohm's law ($I = V/R$), as the output voltage across the load resistance is constant, an increase in resistance (R) will lead to a decrease in current (I).

Bipolar Junction Transistors

a. Active-mode operation

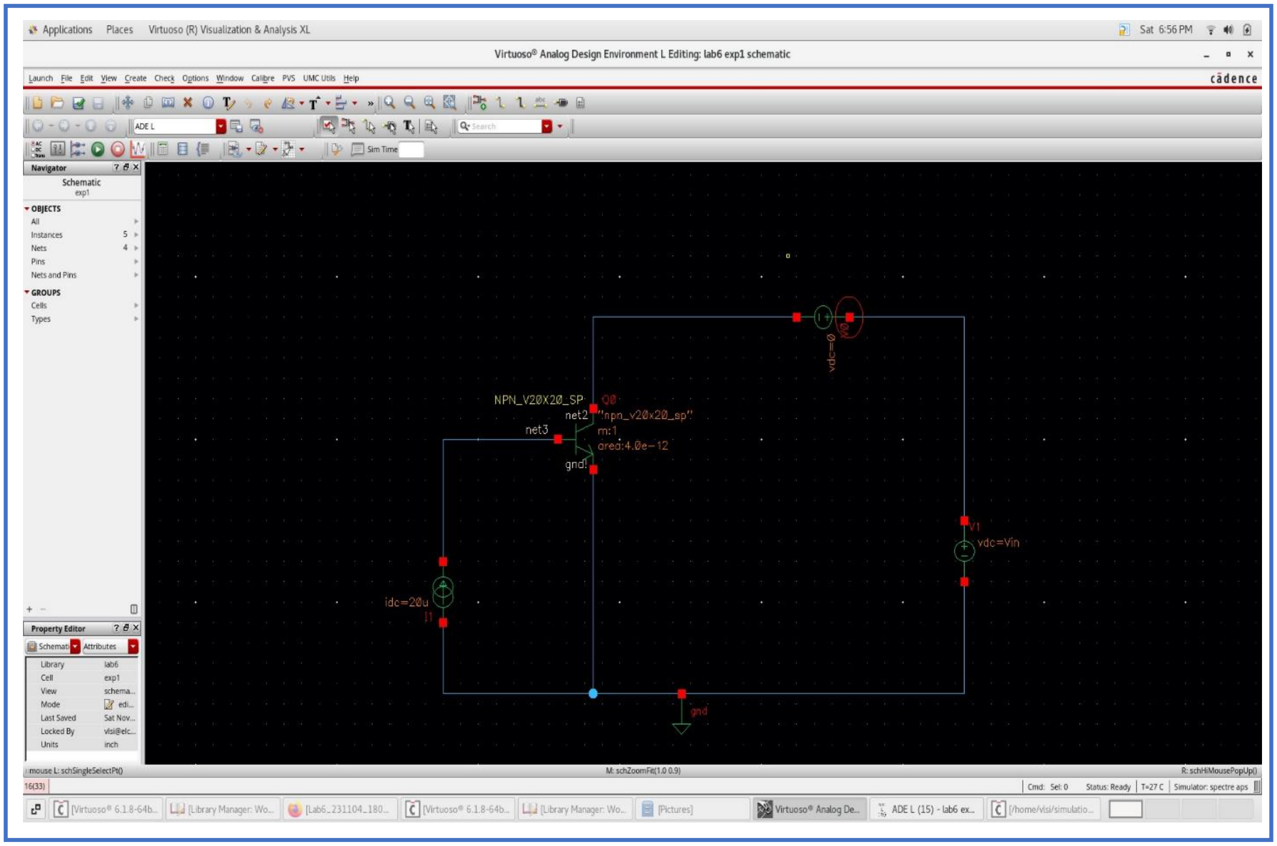

Figure 6 circuit schematic of bipolar junction transistor.

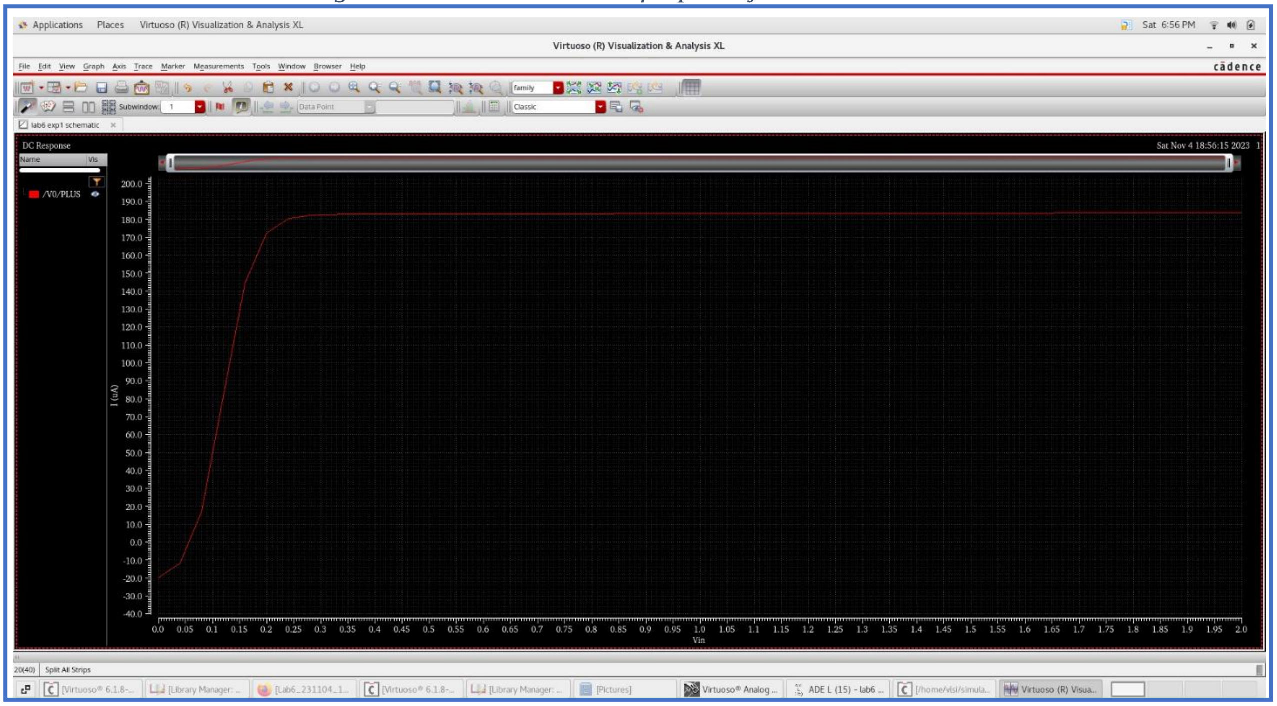

Figure 7 I-v characteristics of bipolar transistor circuit.

Comments

In the figure above, when the voltage value is less than 0.2V (VCE sat), the BJT (Bipolar Junction Transistor) will be in saturation mode, which is considered the linear region. However, when the voltage value exceeds 0.2V (VCE sat), the transistor will enter the active mode region. This active mode is typically used for amplification purposes, and in this region, the current remains relatively constant.

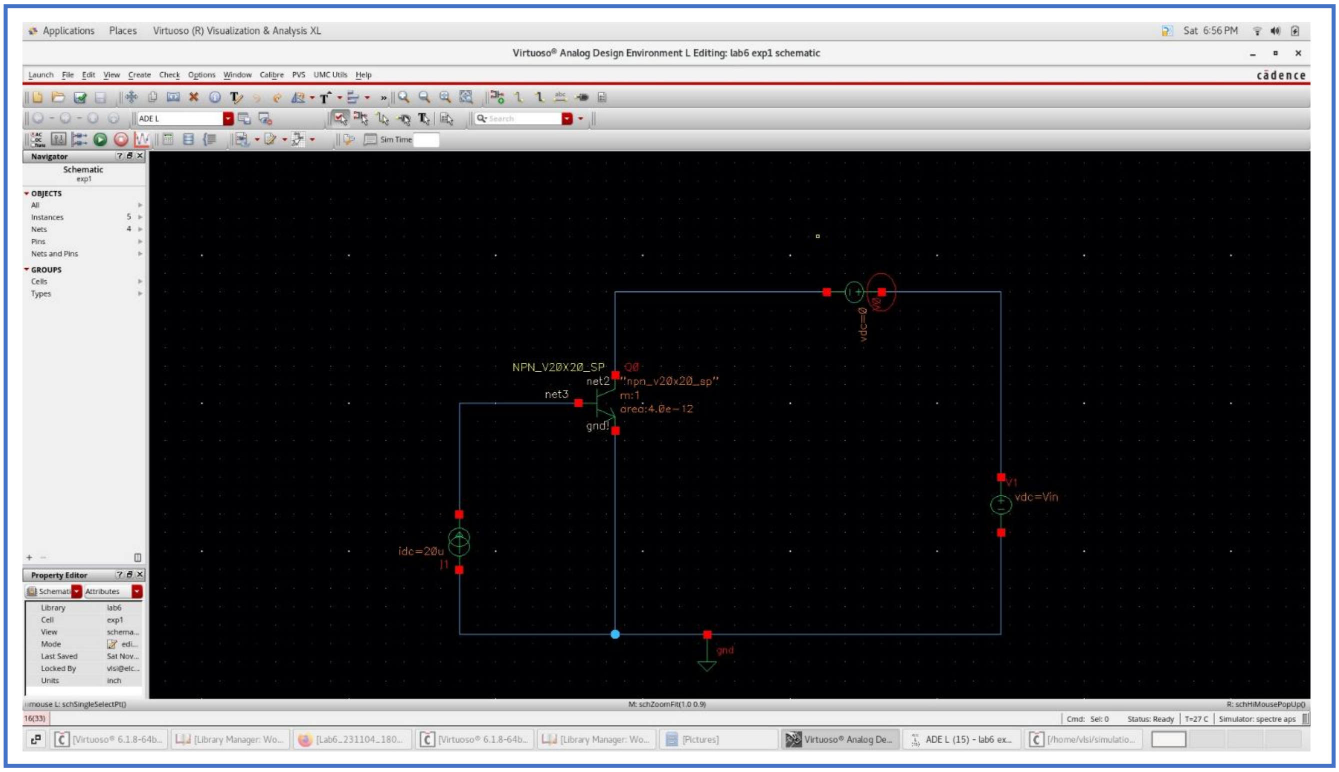

Figure 8 circuit schematic pf bipolar junction transistor with voltage source value of vin to get I-V characteristics of bjt for different values of IC.

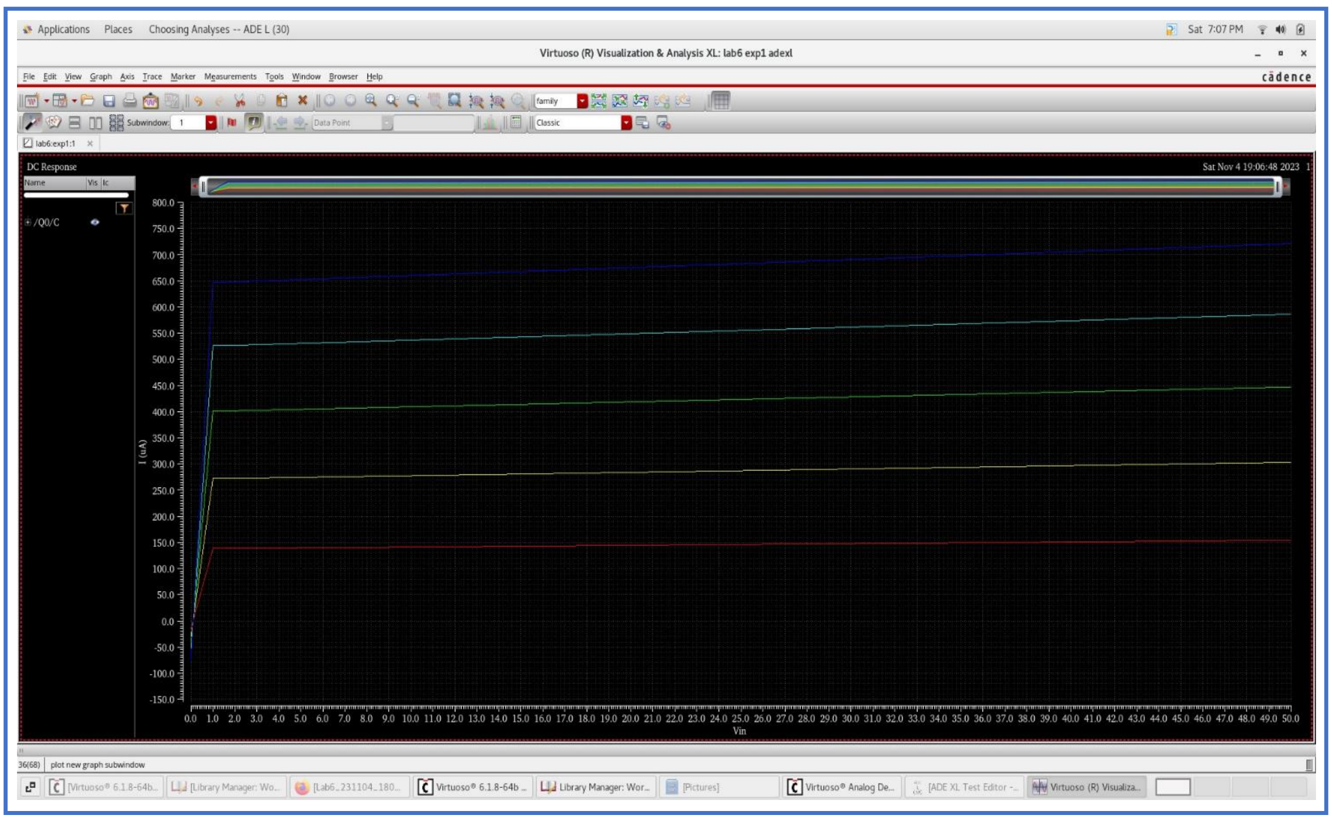

Figure 9 I-V characteristics of different values of biasing currents IC from 15uA to 75uA using 15uA step.

Comments

In the figure above, when I increased the collector current (IC) that I use to bias the circuit, the curve shifted upward. This shift is observed because when we increase the IC current source value, we also increase the base current (IB) since IC (collector current) is equal to β (the transistor's current gain) multiplied by IB. Consequently, the output current value increases, as shown in the figure.

b. Common emitter amplifier

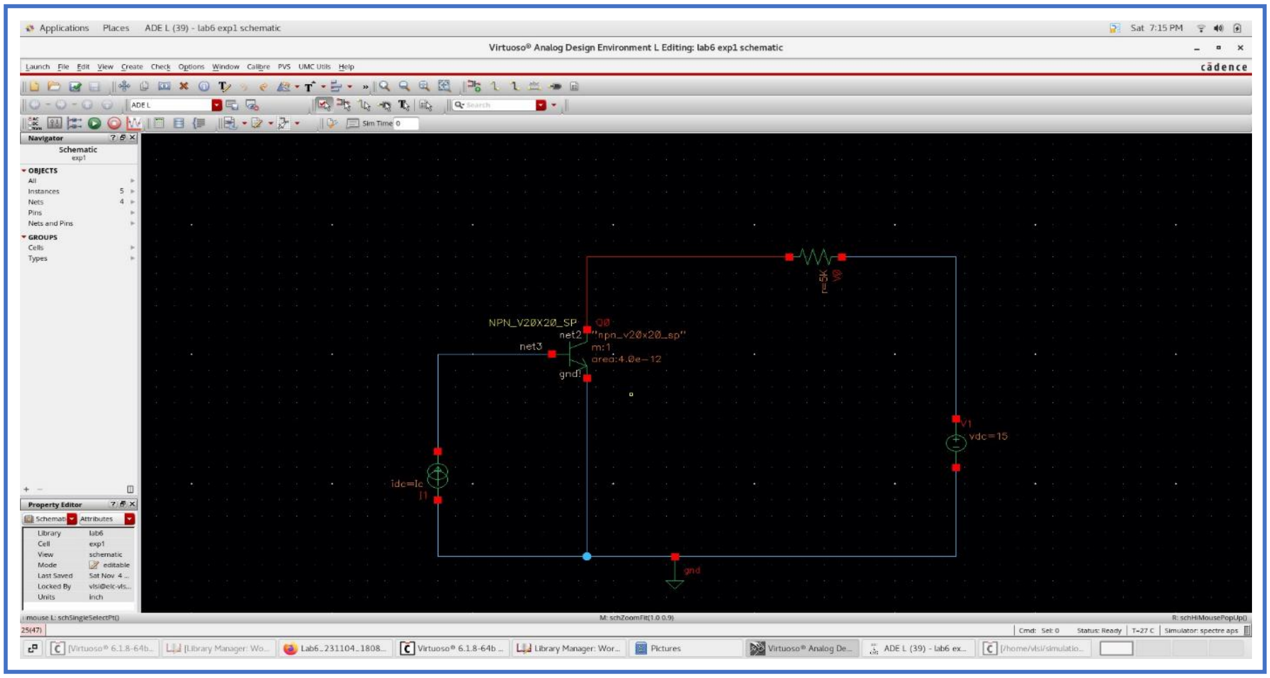

Figure 10 common emitter amplifier circuit.

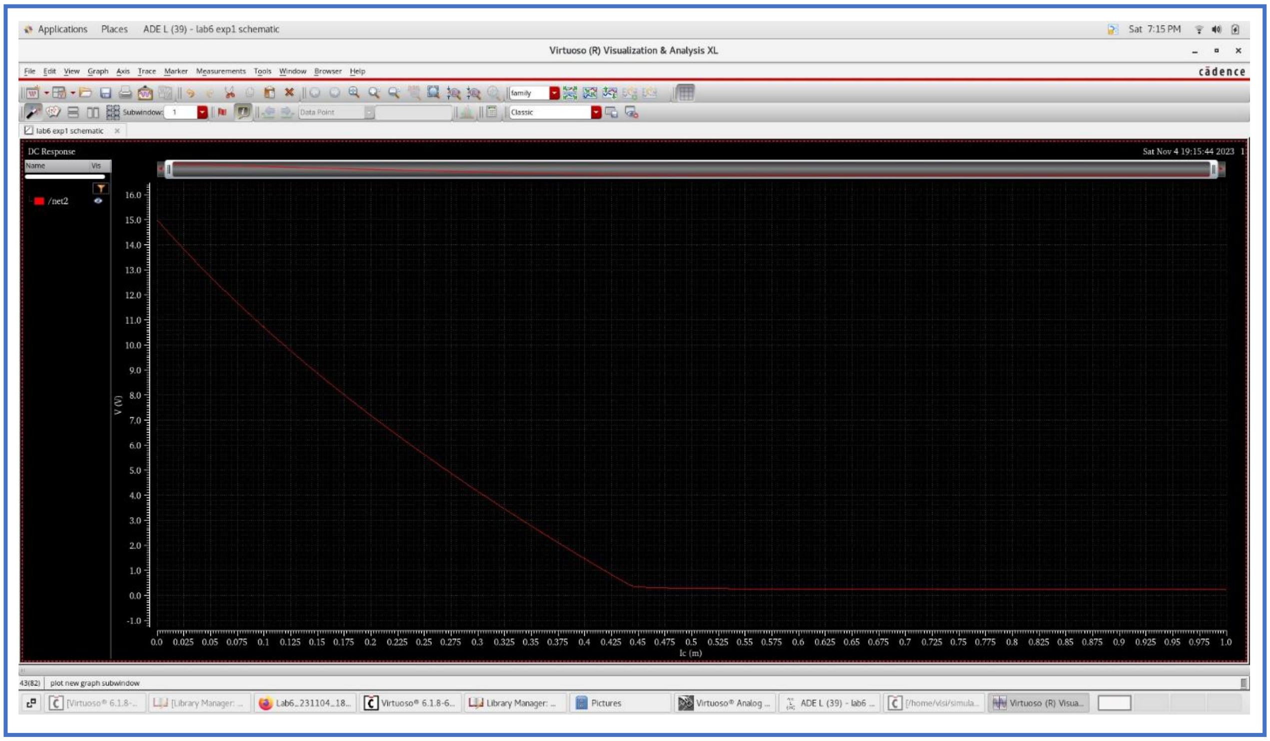

Figure 11 I-V characteristics of common Emitter amplifier.

Comments

As depicted in the figure above, when the current source value increases, the collector voltage experiences an exponential decrease until it reaches 0.7V and stabilizes. This occurs because the increase in base current (IB) leads to an increase in collector current (IC), causing a voltage drop across the resistor. Given the 15V source, this drop in voltage at the collector node continues until it reaches 0.7V, which is the minimum voltage required to turn the transistor on.

c. Common collector amplifier

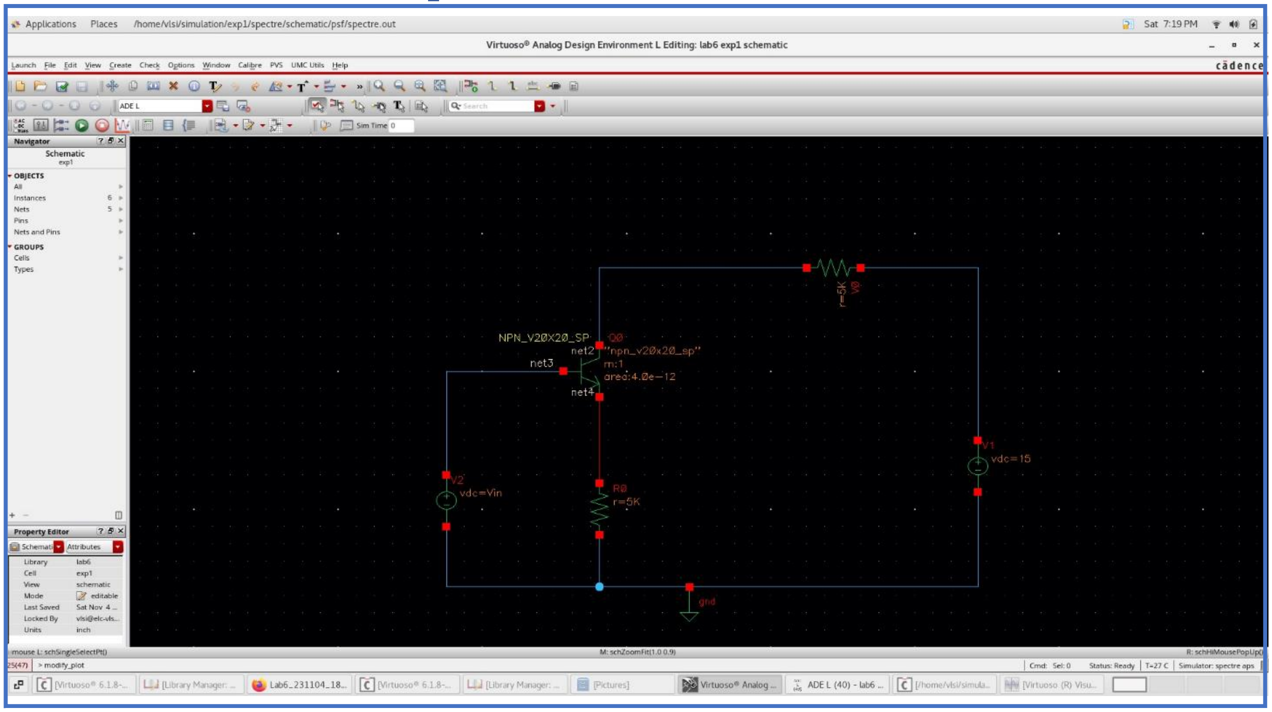

Figure 12 common collector amplifier schematic.

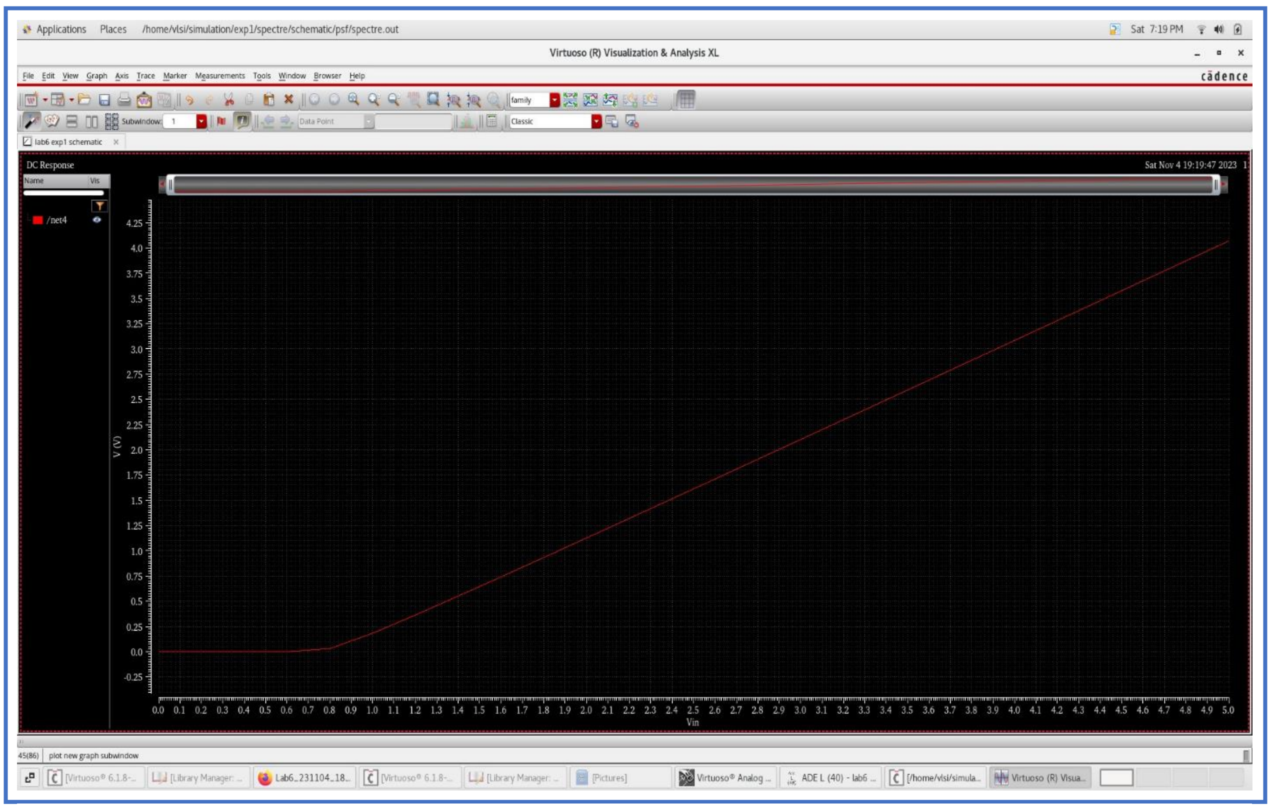

Figure 13 I-V characteristics of common collector amplifier.

Comments

In the figure provided, when Vin increases, initially, the transistor will be in cutoff mode until it reaches approximately 0.7V. At this point, the transistor will turn on, leading to an exponential increase in the emitter voltage. This increase in the emitter voltage is due to the corresponding increase in collector current, which, in turn, raises the voltage drop across the resistor connected to the emitter.

d. common-collector amplifier using Ac voltage source

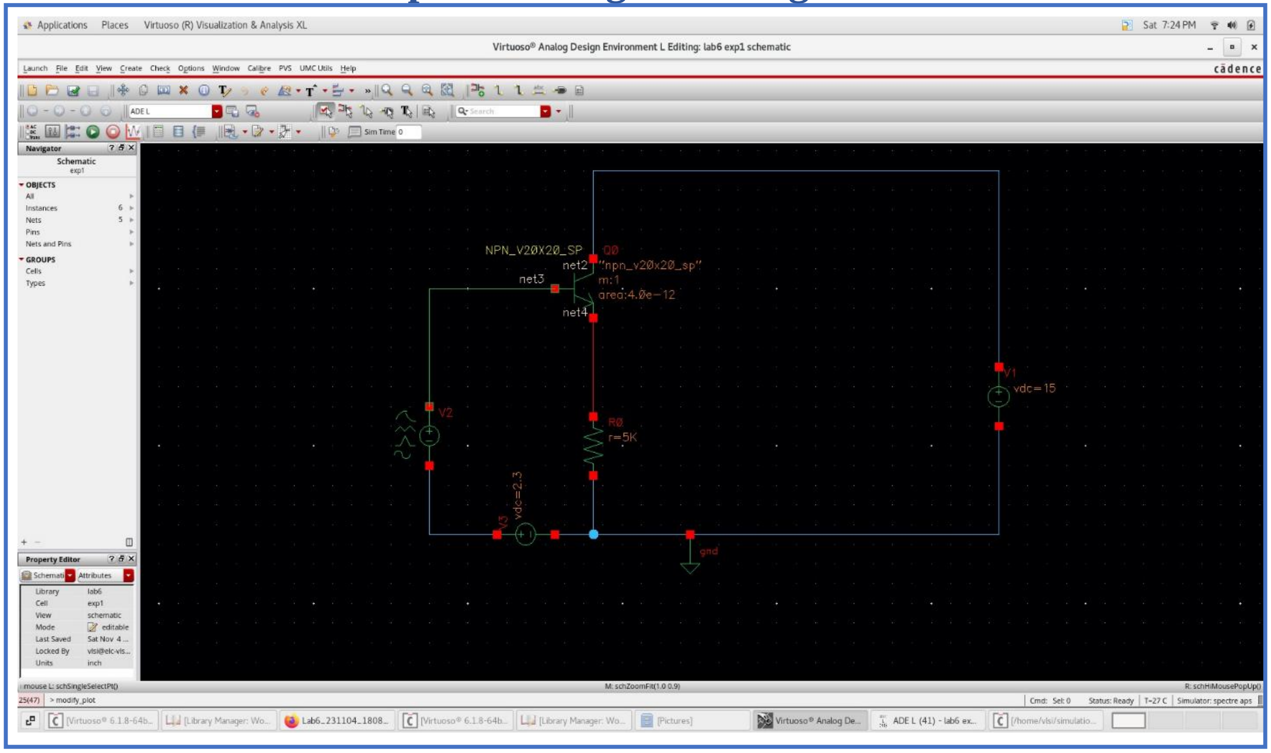

Figure 14 common collector amplifier circuit using AC source input.

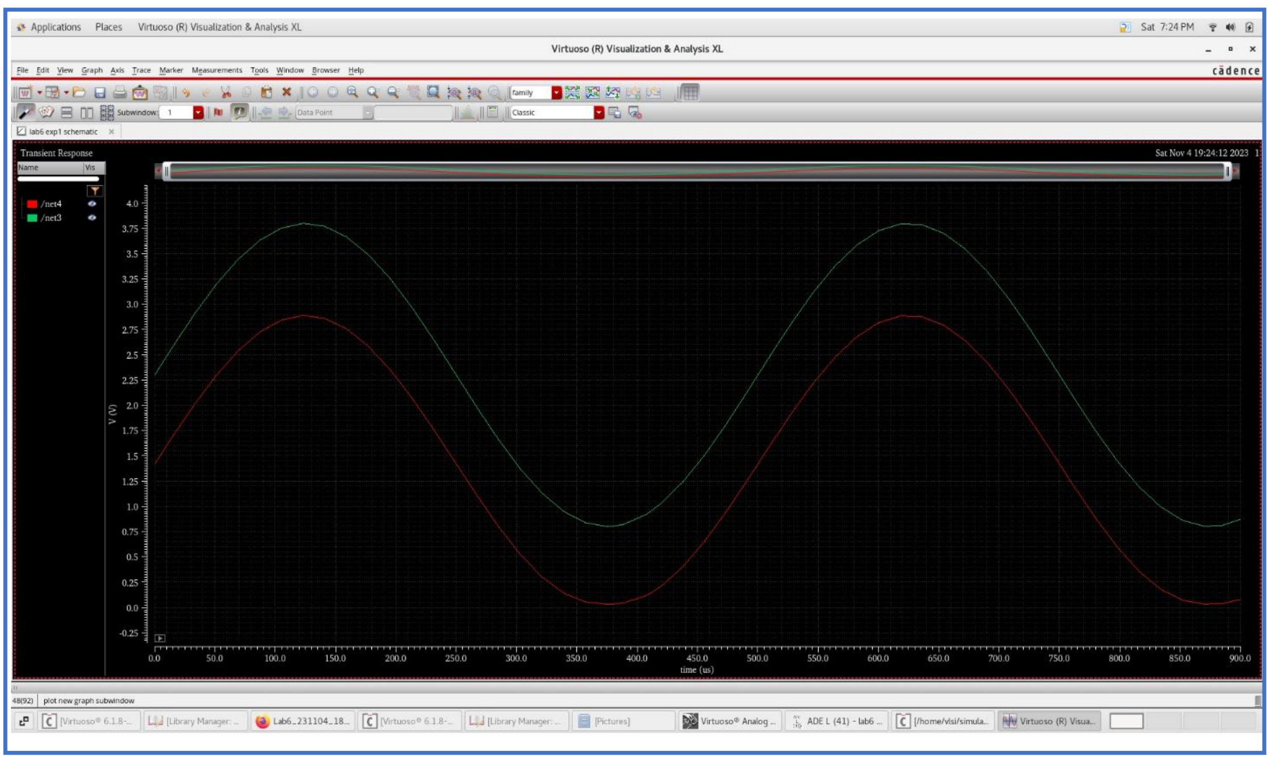

Figure 15 transient analysis of common collector amplifier circuit.

Comments

As depicted in the figure above, the voltage gain of the CC (Common Collector) amplifier is slightly less than unity. The voltage gain can be approximated as $Av \approx 1 - (RE / RL)$, where RE represents the emitter resistor, and RL is the load resistor connected to the collector. This voltage gain is less than unity due to the voltage divider effect between the emitter resistor and the load resistor. Consequently, the peak output voltage will be lower than the peak input voltage.

e. Common base amplifier

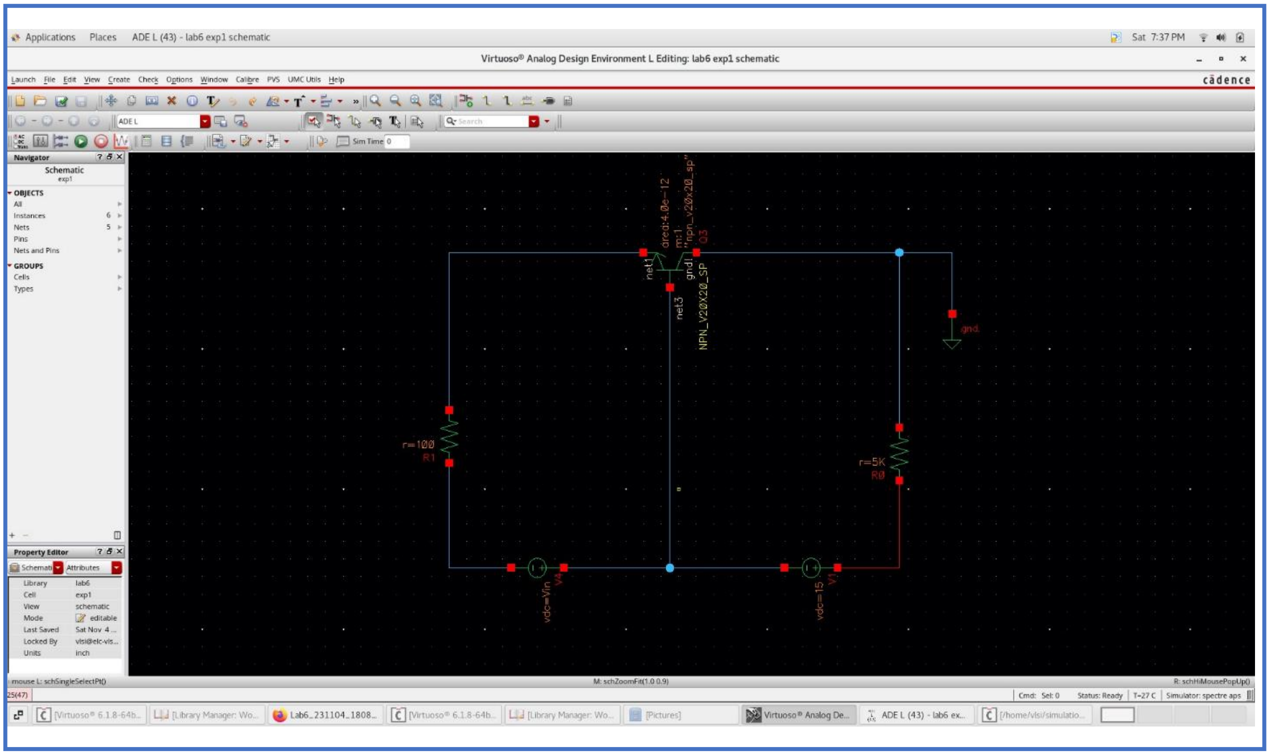

Figure 16 common base amplifier circuit.

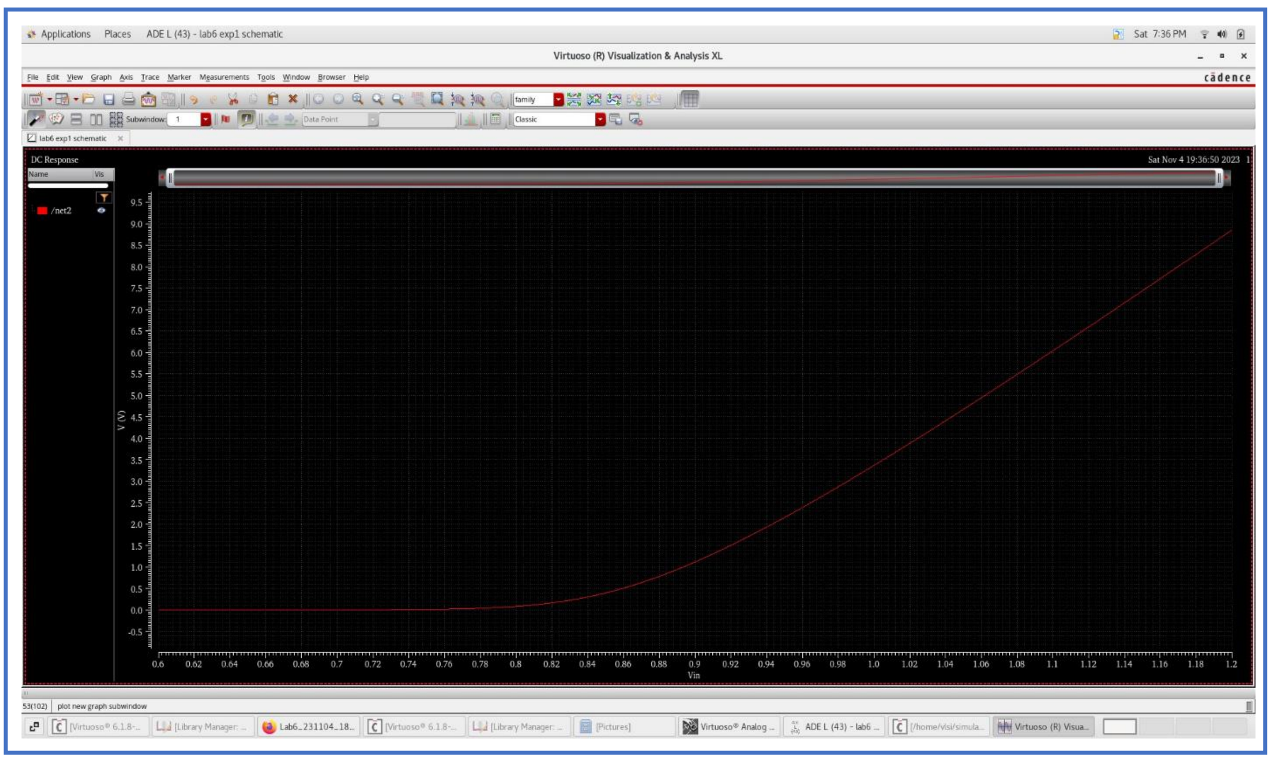

Figure 17 I-V characteristics of common base amplifier circuit.

Comments

In the figure provided, when Vin increases, initially, the transistor will be in cutoff mode until it reaches approximately 0.8V. At this point, the transistor will turn on, and as a result, the voltage will begin to increase exponentially. This increase in voltage is due to the corresponding increase in collector current, which leads to an increased voltage drop across the resistor connected to the collector.

f. Common base amplifier with Ac input signal

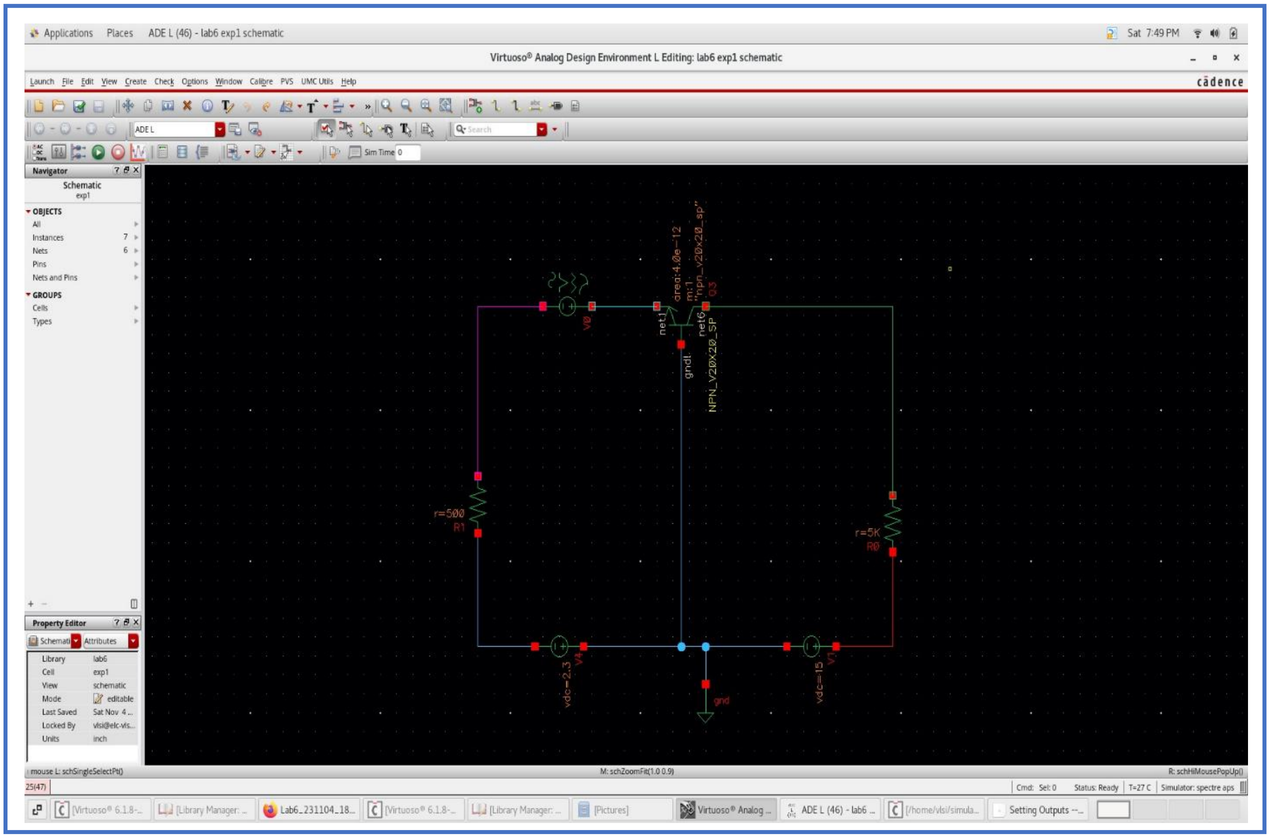

Figure 18 common base amplifier circuit using AC source input.

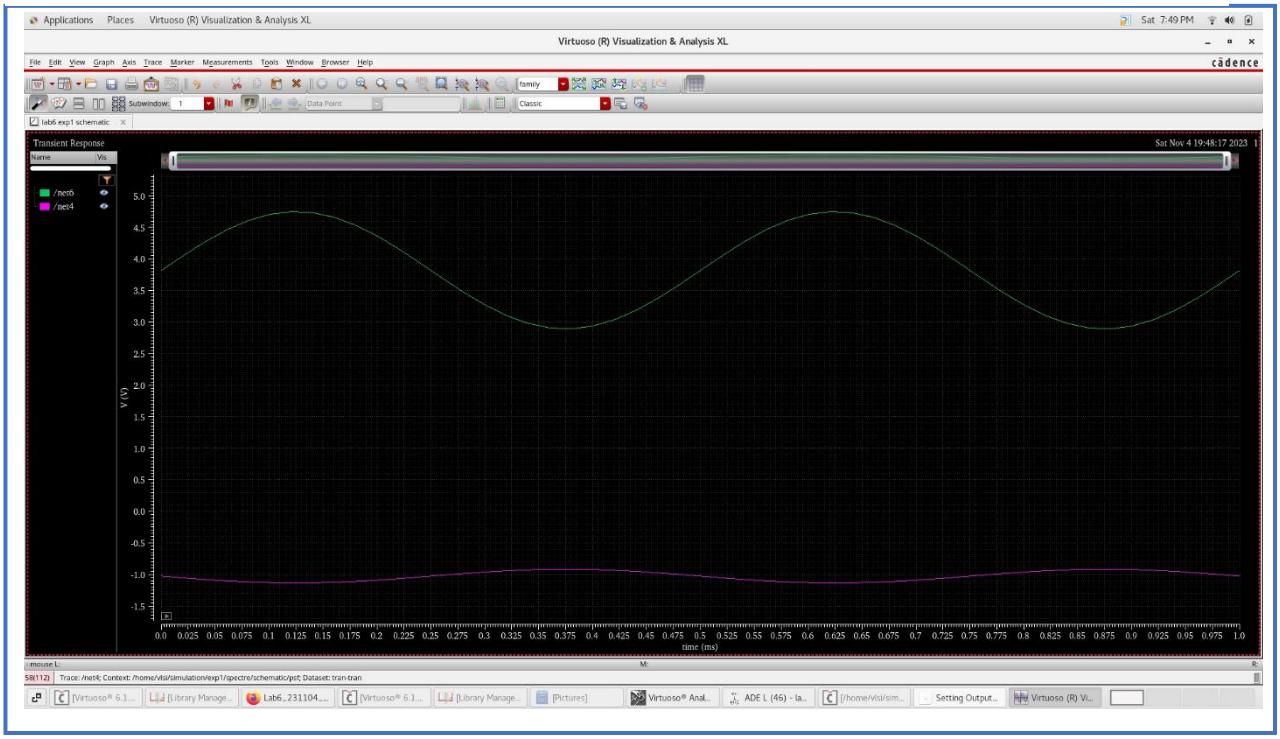

Figure 19 transient analysis of common base amplifier circuit.

Comments

n the figure above, the current gain (H) of a common base amplifier can be determined using the formula: H = IC / IB. Additionally, the voltage gain (Av) of a common base amplifier is calculated as Av = H * RL / RE, where RL represents the load resistance connected to the collector, and RE is the emitter resistance. It's important to note that, as shown in the figure, both the input and output are in phase. Therefore, the common base amplifier is a non-inverting amplifier.

Assignment 6

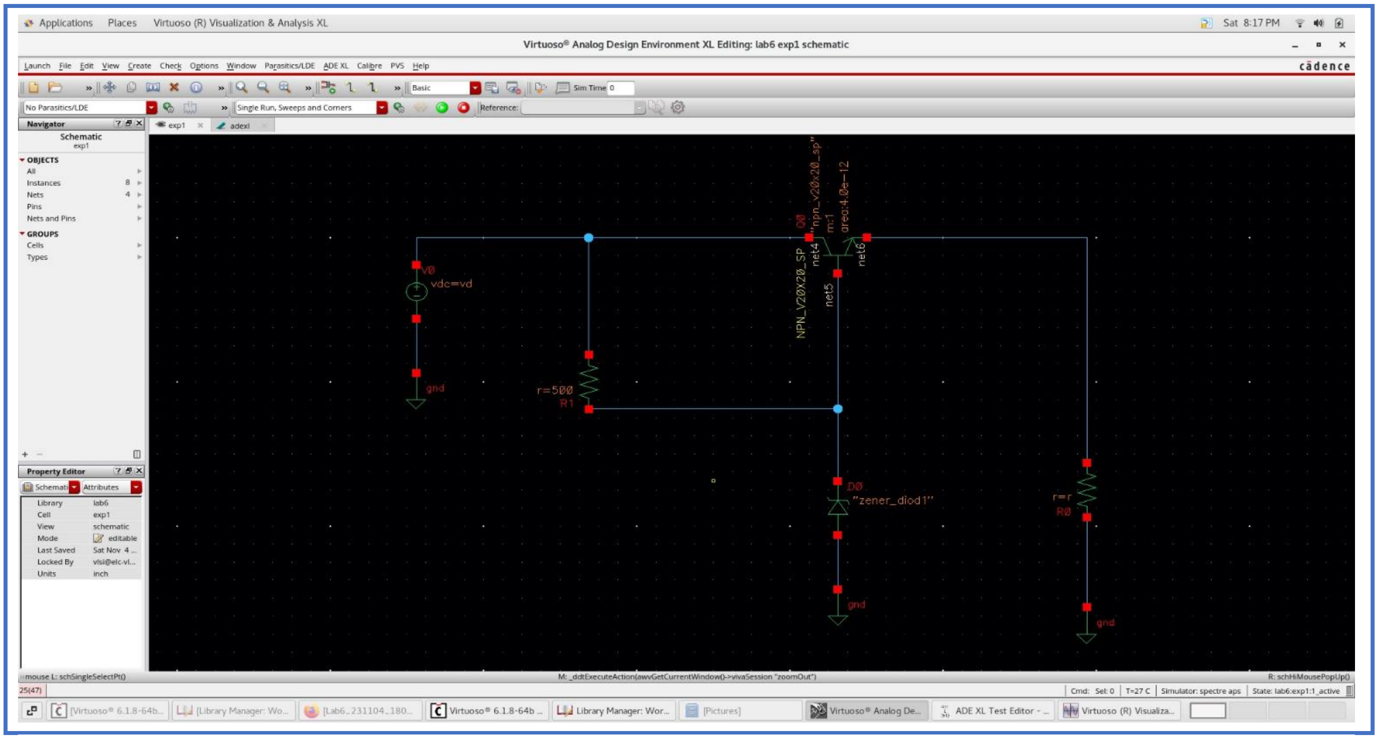

Figure 20 voltage regulator circuit using BJT, Zener diode , resistance and load .

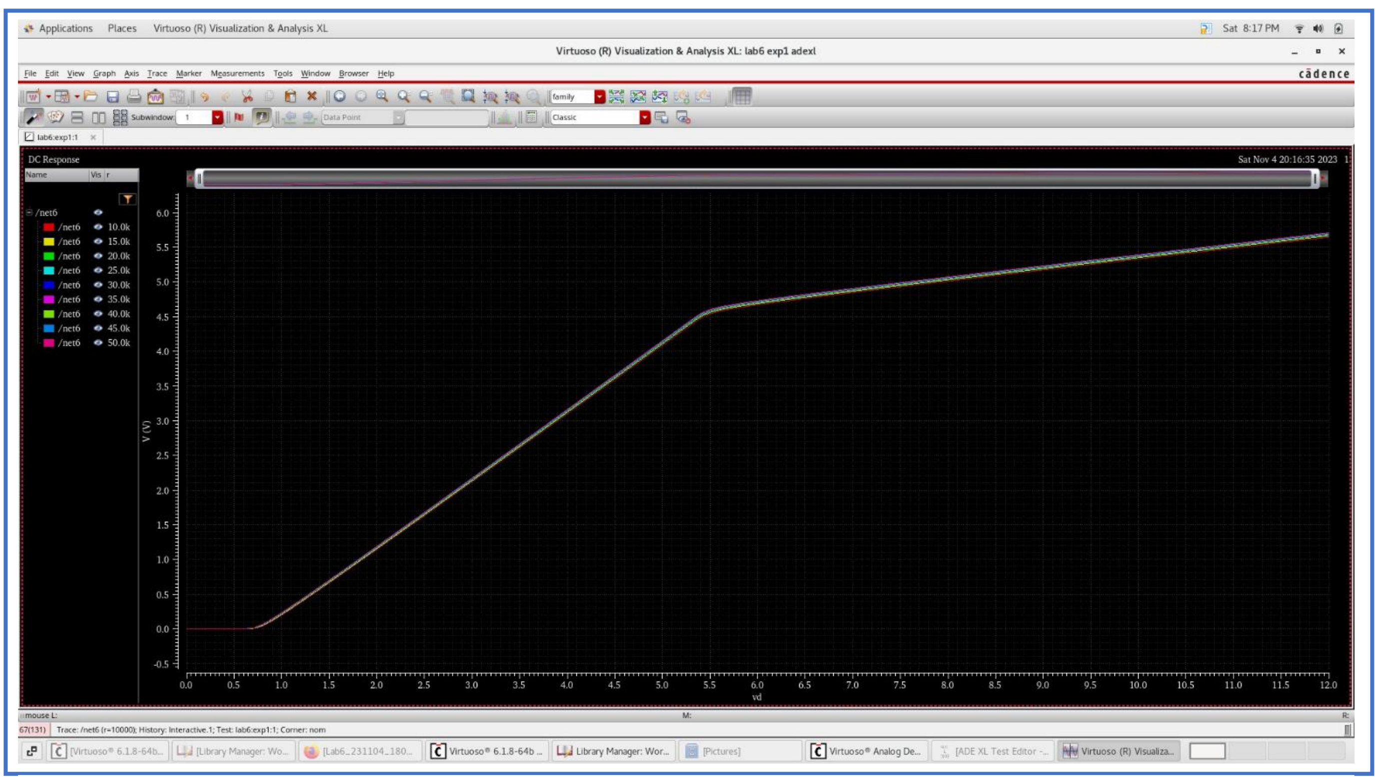

Figure 21 DC response of regulator circuit using different values of resistive load values from 15k to 75k using 15k step.

Comments

In the figure above, when the voltage applied to the circuit reaches around 5.5V, the Zener diode enters the breakdown region. Consequently, the voltage across the resistive load remains approximately constant. As depicted, when the resistive load value is increased, all the curves are identical to each other. This uniform behavior indicates that regardless of the resistive load value, the output voltage remains constant, which aligns with the desired operation of this circuit.