Lab 6

Zener Diode and BJT Transistor

Introduction:

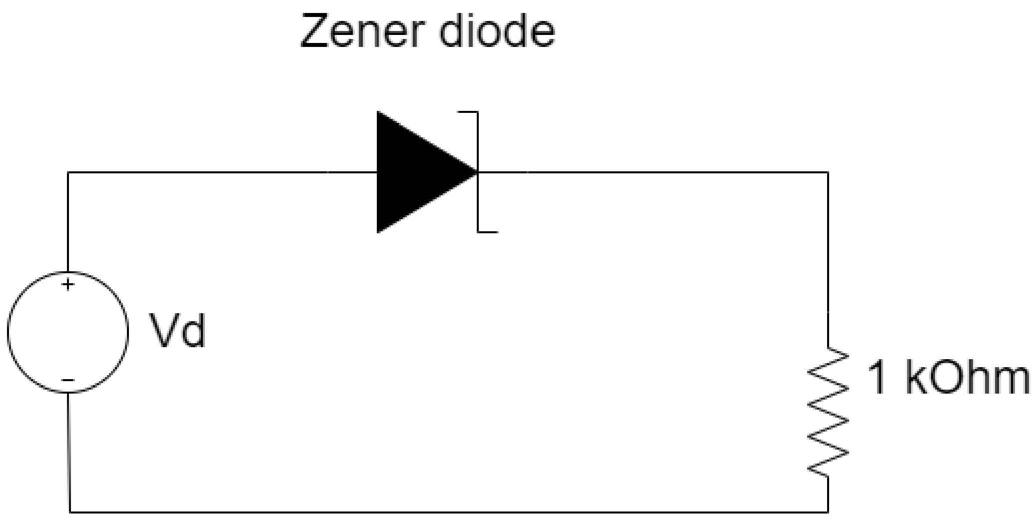
A diode is an electrical device that allows current to move through it in one direction with far greater ease than in the other. When placed in a simple battery-lamp circuit, the diode will either allow or prevent current through the lamp, depending on the polarity of the applied voltage.

A- ZENER DIODE CHARACTERISTICS

A Zener diode is a silicon semiconductor device that allows current to flow in either direction.

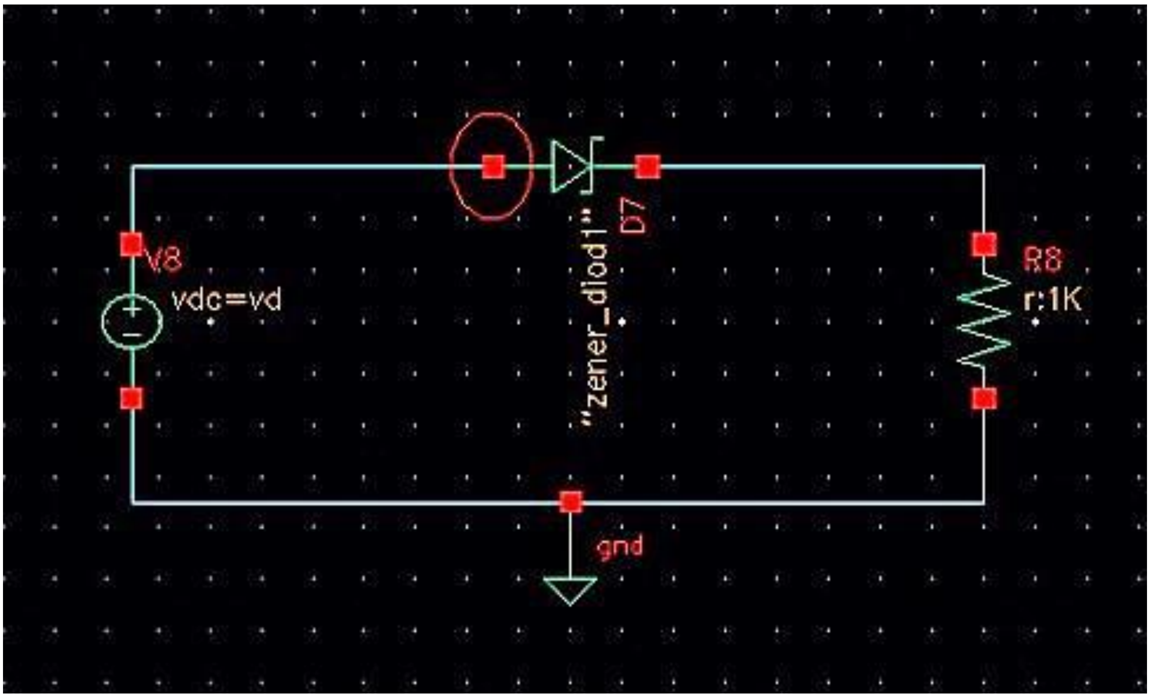
I. Experiment:

- You are required to simulate this circuit to plot I-V characteristics of Zener diode.

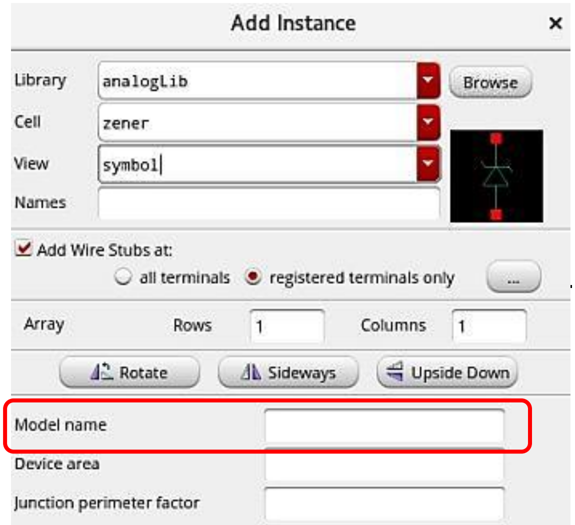


II. Simulation procedures:

- Draw SCHEMATIC:



- For the zener diode just repeat the step to the add instance because here is the difference. YOU WANT FIND THE ZENER DIODE ON THE TECHNOLOGY UMC.
- To solve this problem just grab the Zener diode from analoglib.



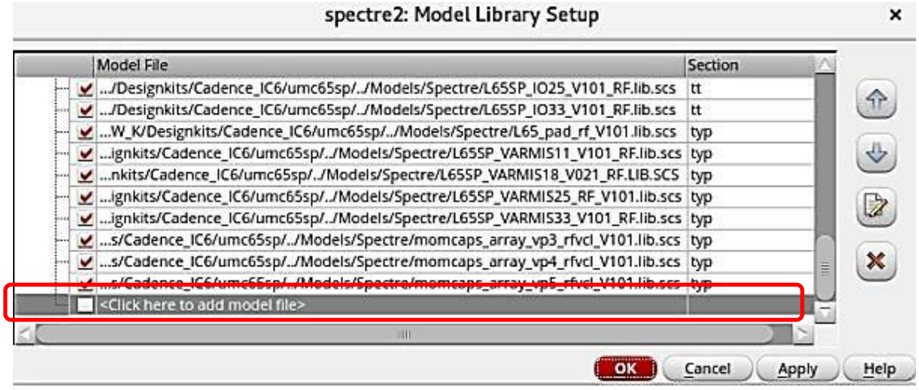
NO SPICE MODEL == EMPTY SYMBOL

- To solve this another problem you will have to **create your own Zener diode spice model**.
- Open terminal and type $cat>filename.scs
- Copy the following spice code:

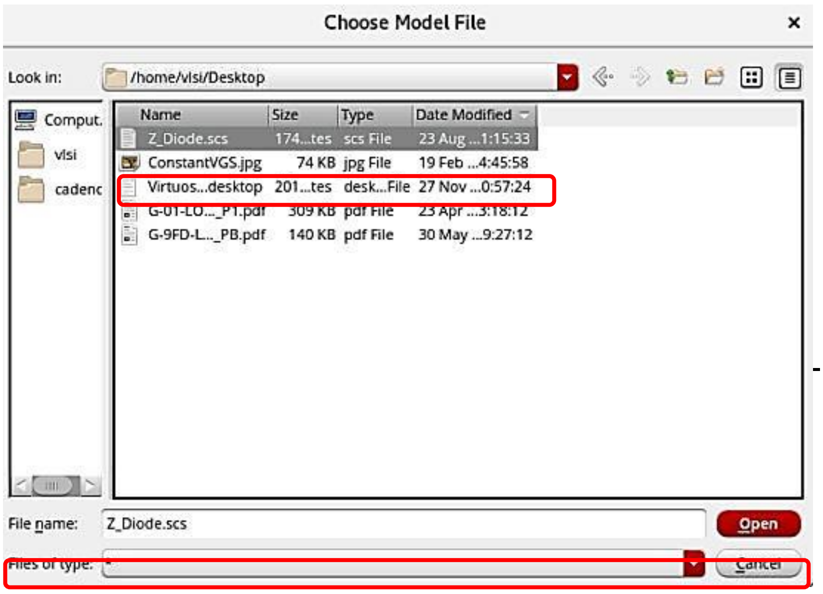
```
simulator lang = spice
.model zener_diod1 d
+ bv = 5.5
+ cj = 9.353E-14
+ level=1
+ is=1e-20 n=0.2118 ibv=1e-3
+ rs=91.5316 tcv=-1.600e-03 eg=0.1 xti=0
+ mj=0.3552 pb=0.8144
```

- Now copy the Model Zener_diod1 to the Model Name Section. Just select the diode and **press Q** from your keyboard.

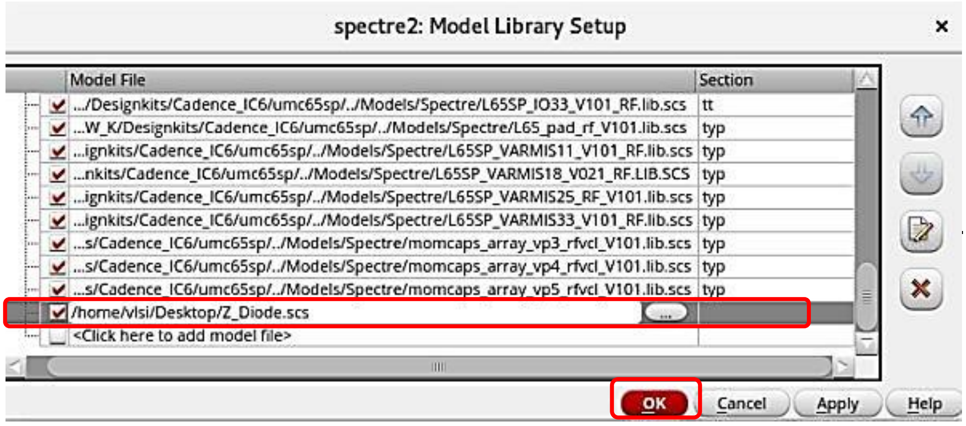
- Now Open the ADEL again as before but **now we need to add the Spice file to its library**.
  - You can do this by choosing: **Setup >> Model Libraries**. A new window will open:



- **Now add your Spice file**

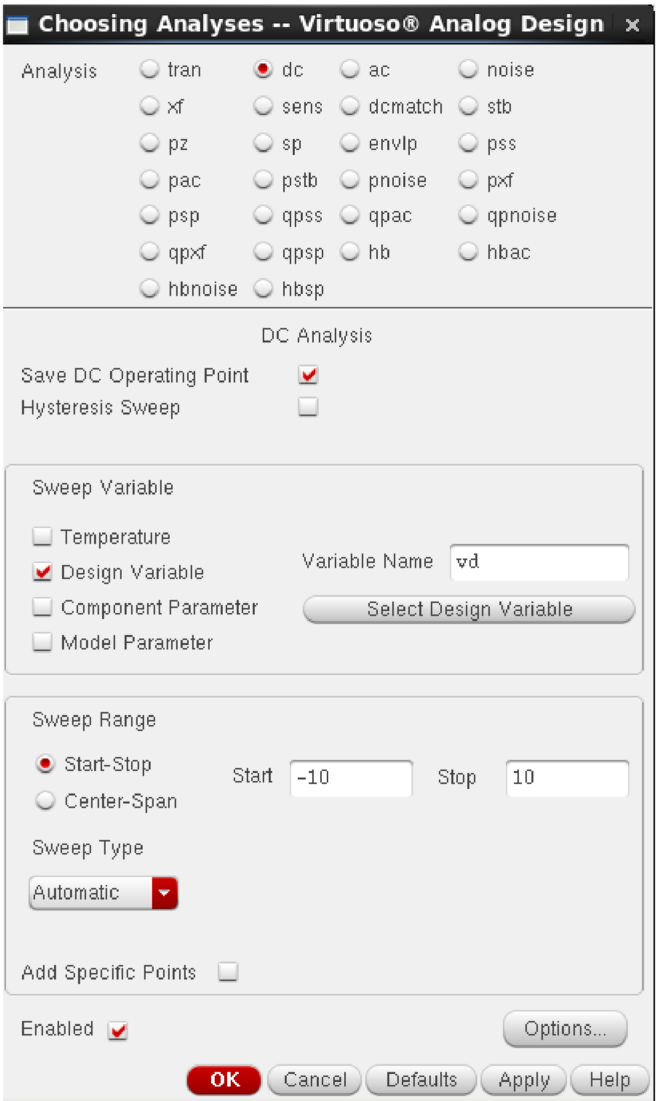


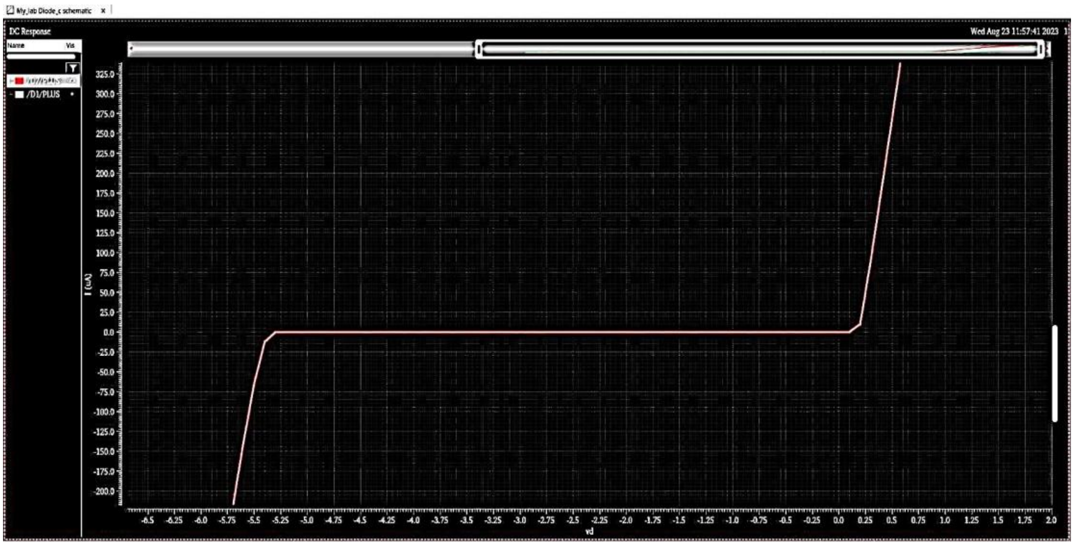
Now click **OK** for it to be **ADDED.**



Note: You have to add spice file of Zener in each cell

9. Now to show its characteristics just apply dc analysis and sweep on the input value between ranges (-10,10).

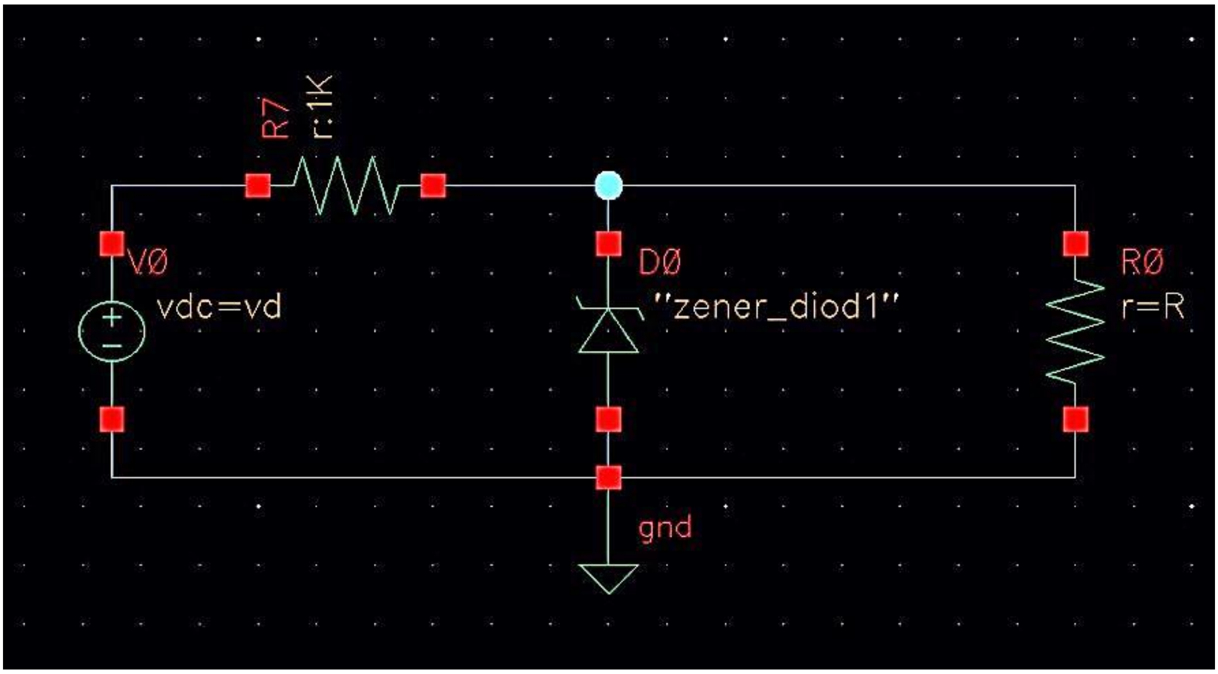




10-Get the break up and down voltage of Zener diode from output curve.

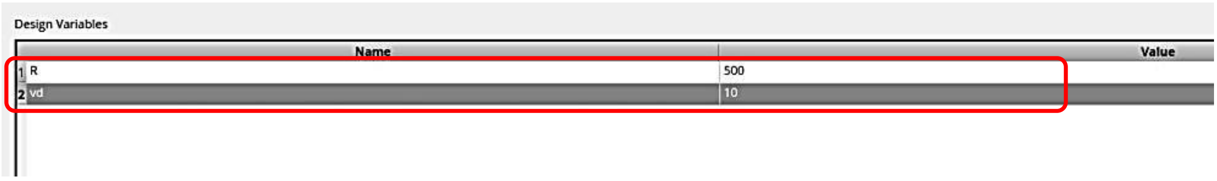
B-ZENER DIODE AS A REGULATOR

SCHEMATIC:

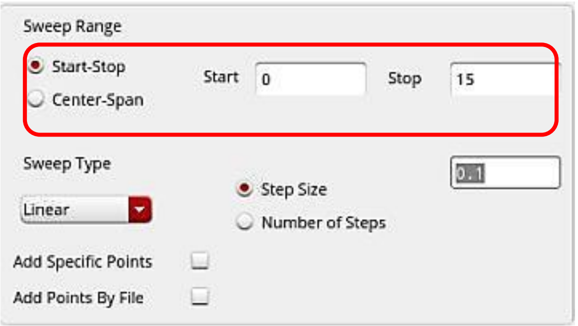


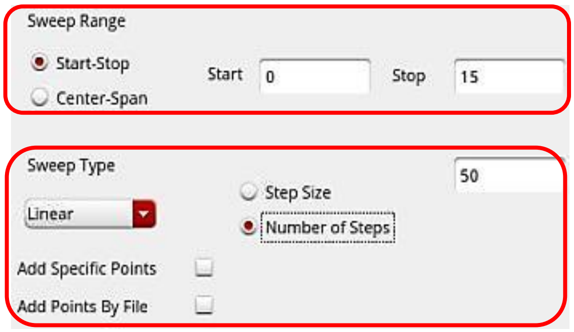
- **For the Resistor change its value to a variable R so we could SWEEP it.**

- To vary the value of R first add it to Design Variables as we did before. Now assign a value to it as we did before.



- Now add the Dc sweep Analysis for vd but this time it won't be automatic.

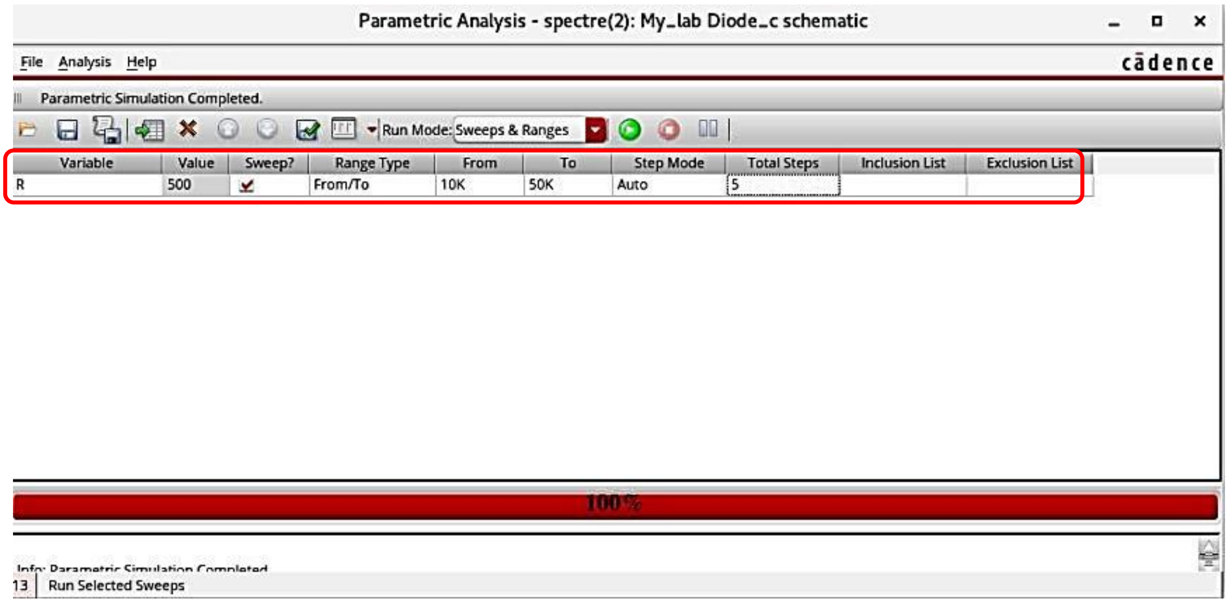




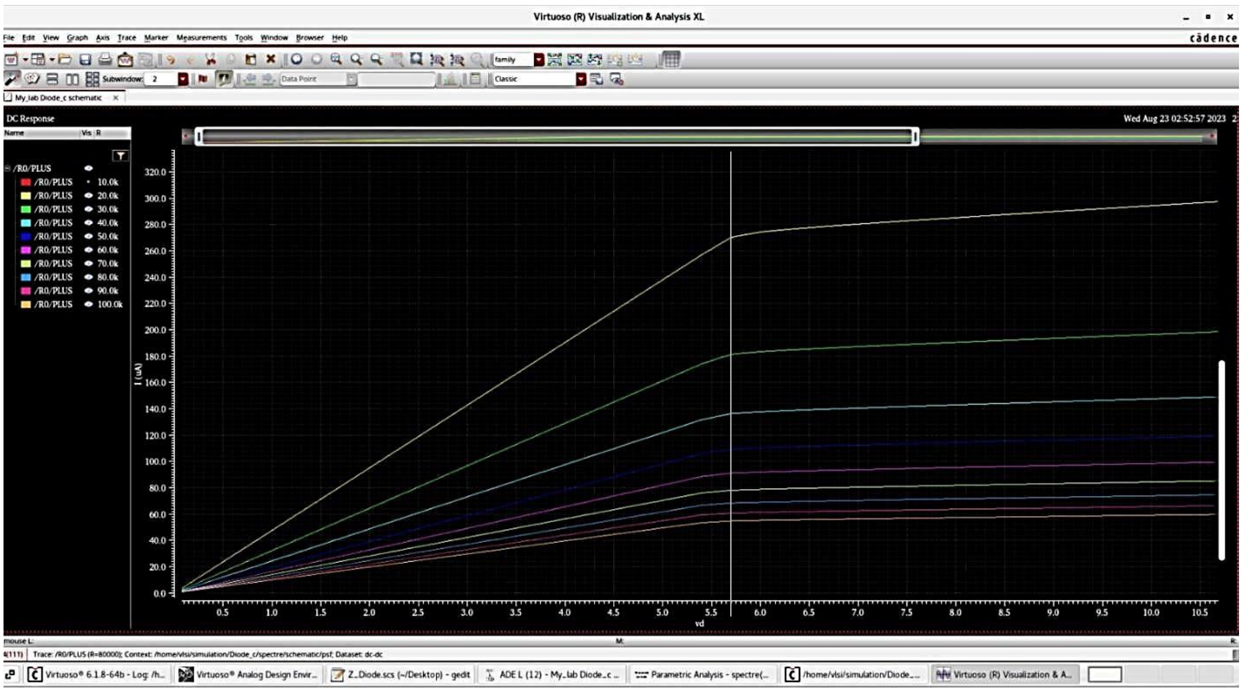
- Add the output as we did before **but this time choose any of the resistor nodes.**
- Now to vary the resistance R you will need to open the parametric analysis. Just choose:

  Tools >> Parametric Analysis...

CENTER OF NANOELECTRONICS & DEVICES



Now click the green button to start simulation .



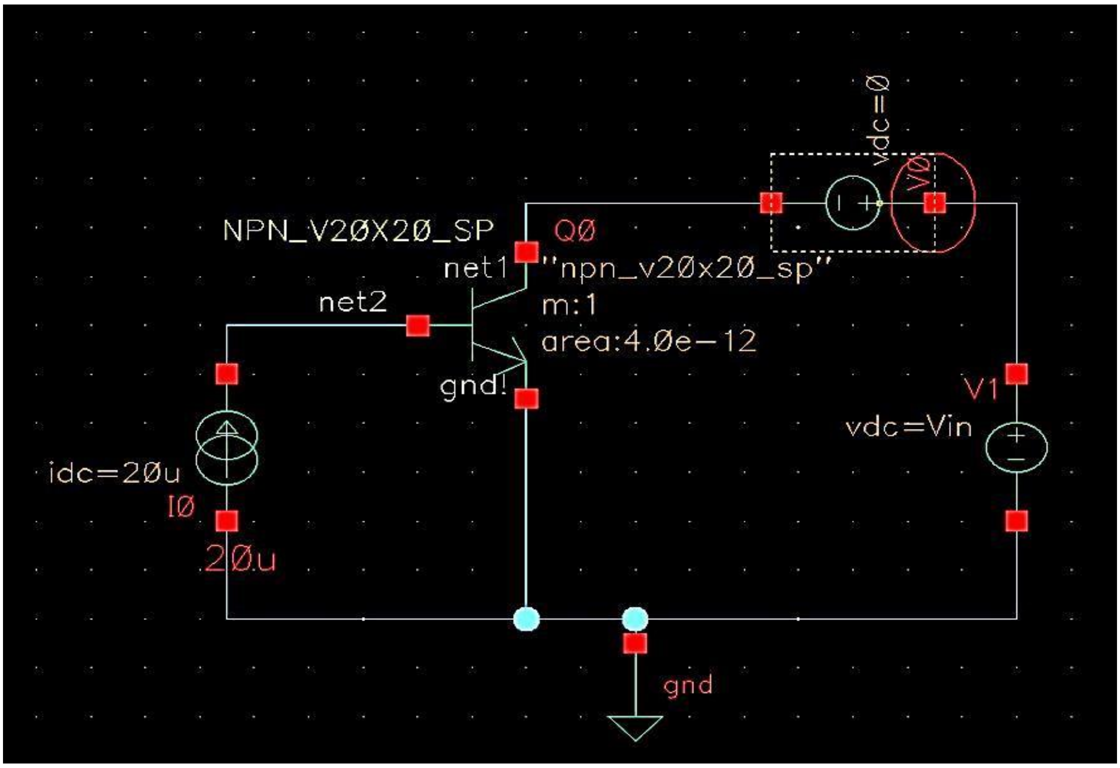
B-Bipolar Junction Transistors

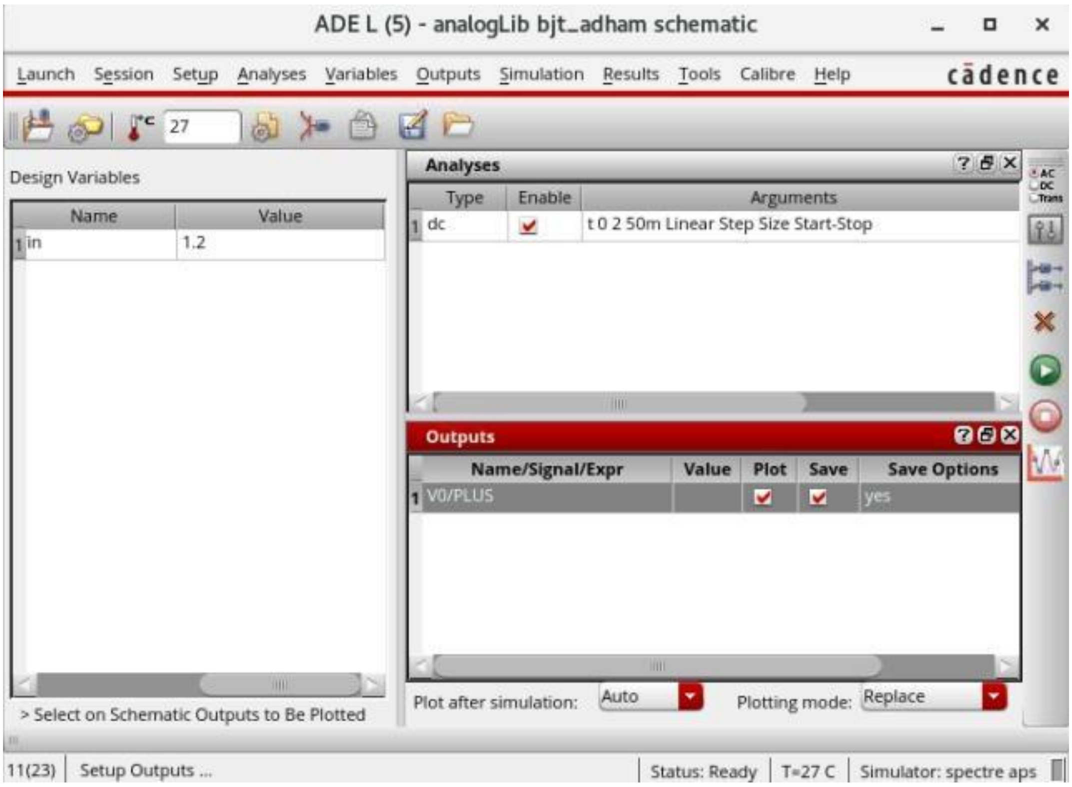
Introduction

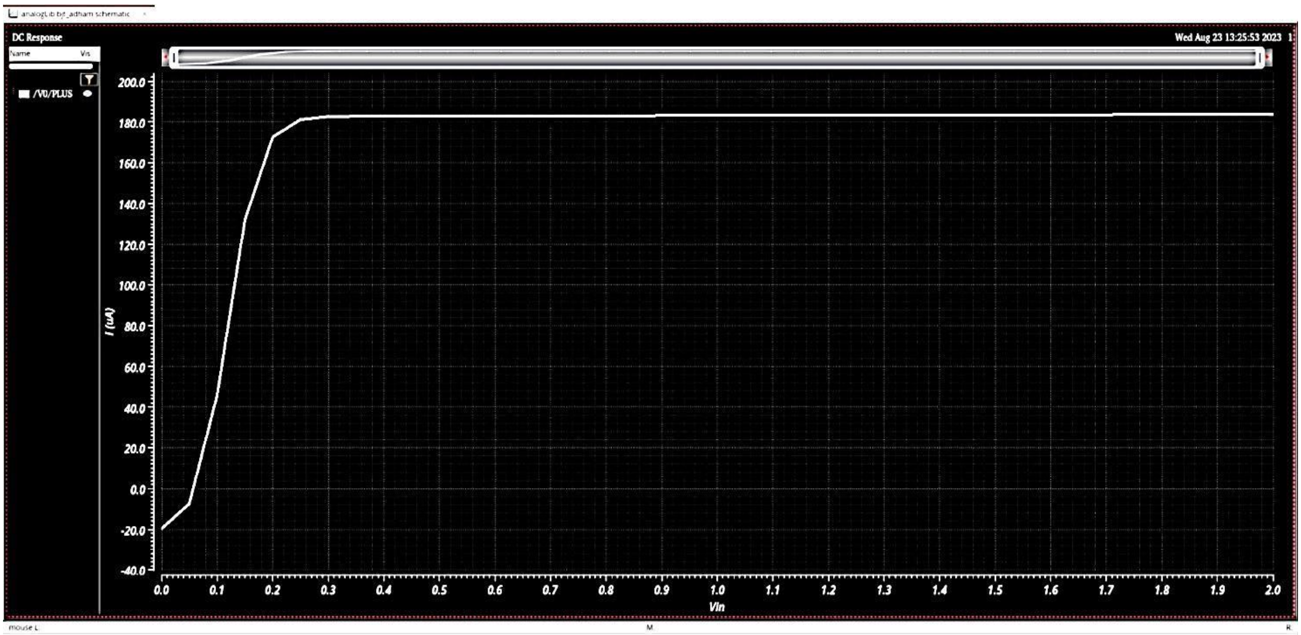
Bipolar transistors work as current-controlled current regulators. In other words, transistors restrict the amount of current passed according to a smaller, controlling current.

1. Active-mode operation

Set the current source (Idc) at a constant value of 20 µA, then vary the voltage source (V1) over a range of 0 to 2 volts and monitor how much current goes through it.




ADE L (5) - analogLib bjt_adham schematic
Launch Session Setup Analyses Variables Outputs Simulation Results Tools Calibre Help
cādence
27
Design Variables
Name Value
1 in 1.2
Analyses
Type Enable Arguments
1 dc t 0 2 50m Linear Step Size Start-Stop
Outputs
Name/Signal/Expr Value Plot Save Save Options
1 V0/PLUS yes
Plot after simulation: Auto
Plotting mode: Replace
> Select on Schematic Outputs to Be Plotted
11(23) Setup Outputs ...
Status: Ready T=27 C Simulator: spectre aps


DC Response
/V0/PLUS
Wed Aug 23 13:25:53 2023
I (uA)
200.0
180.0
160.0
140.0
120.0
100.0
80.0
60.0
40.0
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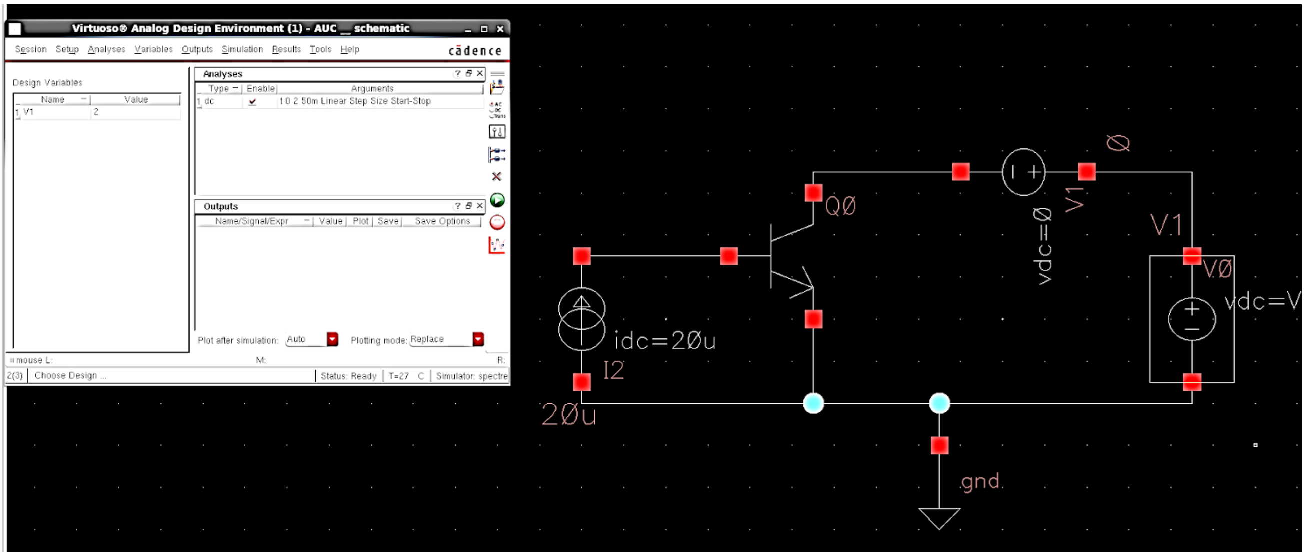
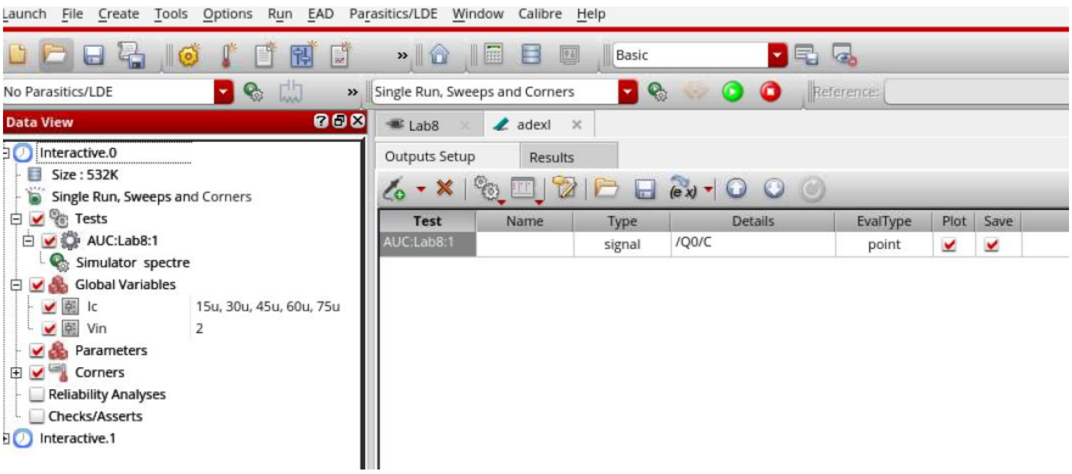
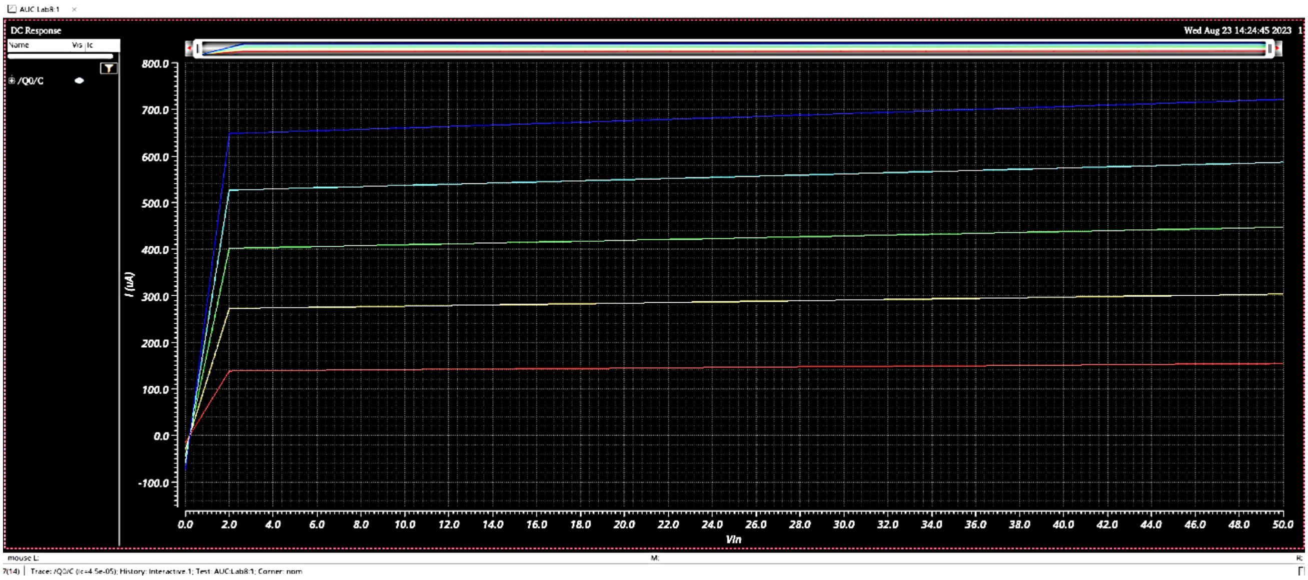
0.0
-20.0
-40.0
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0
Vin



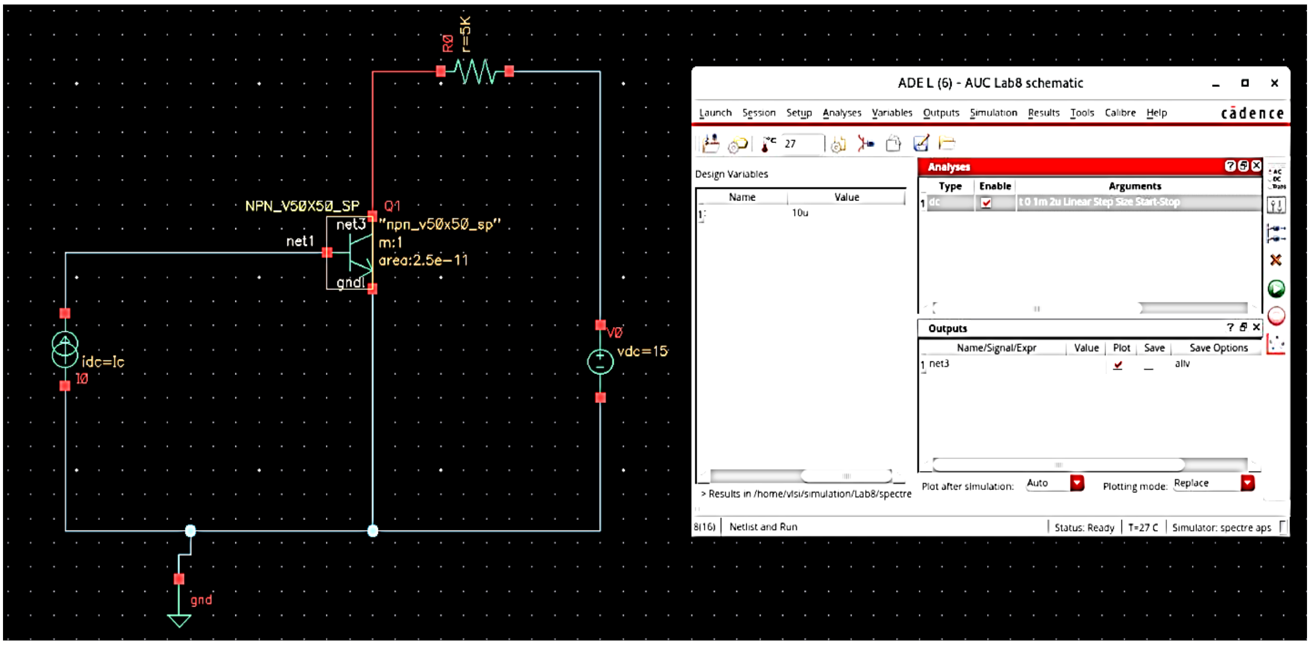


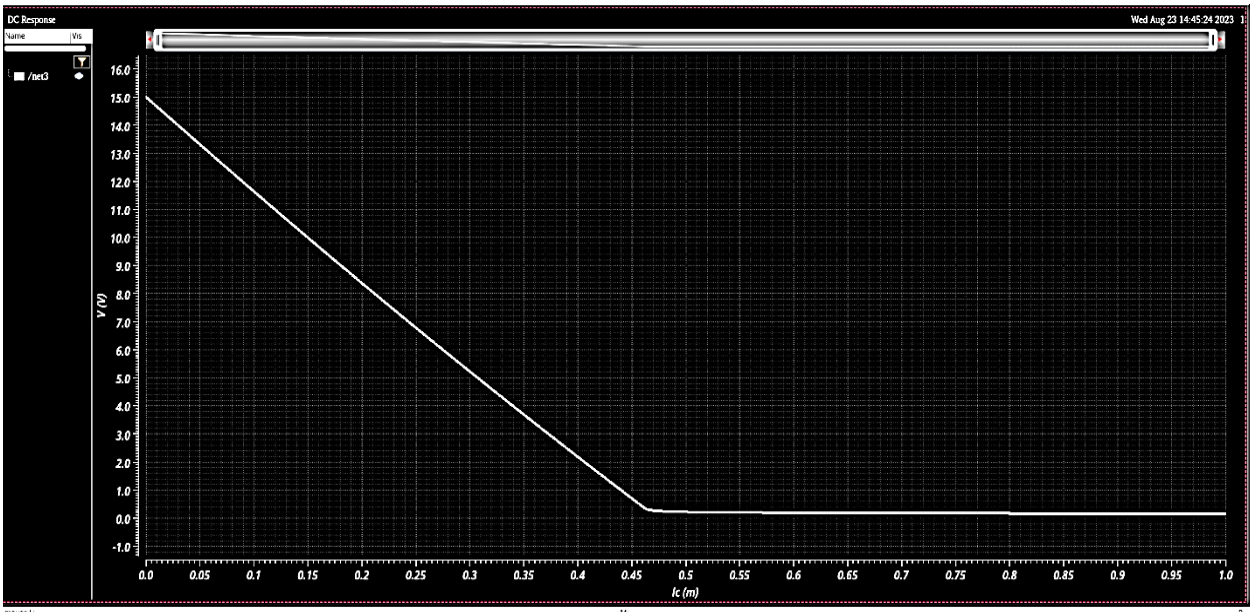
if we increase the controlling (Idc) current from 20 μA to 75 μA, once again sweeping the battery (V1) voltage from 0 to 50 volts and graphing the collector current in Figure below.



2. <u>The common-emitter amplifier</u>

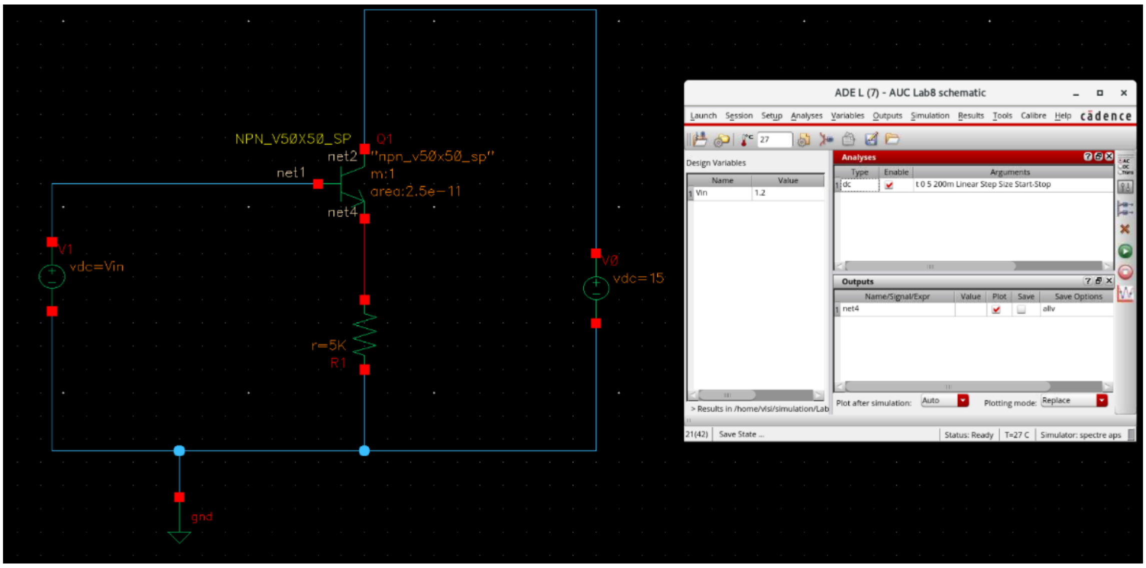
The input and output signals both share a connection to the emitter.



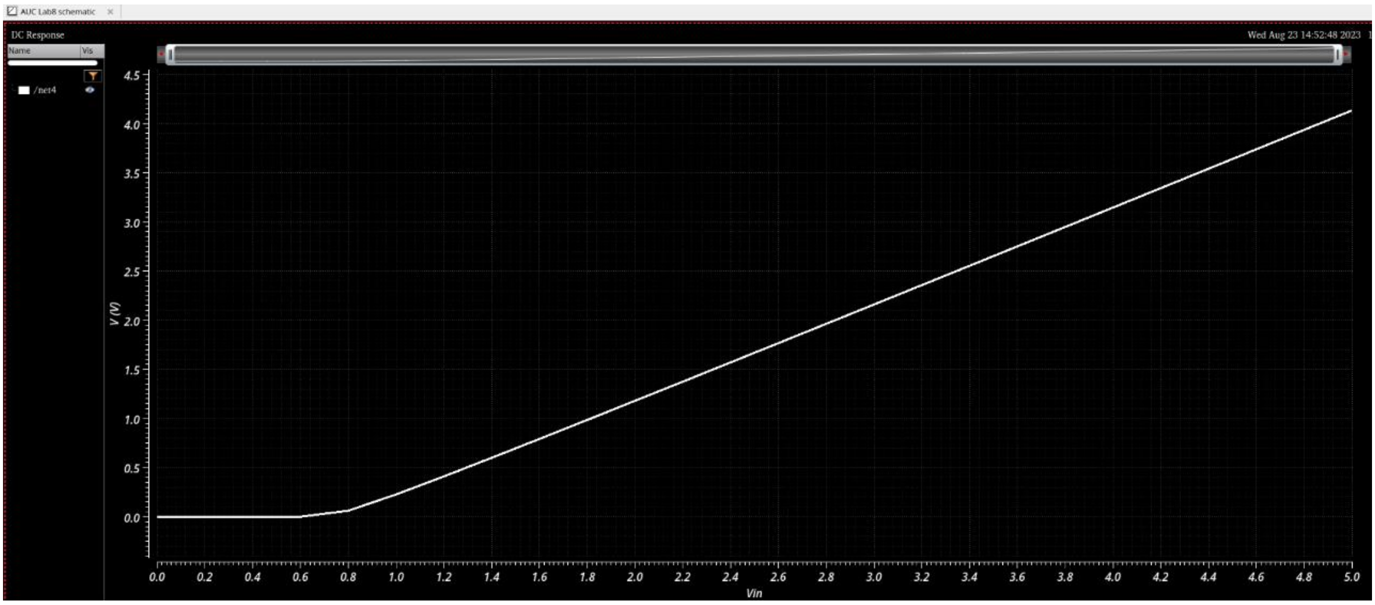


At the beginning of the simulation in the figure above where the current source is outputting zero current, the transistor is in cutoff mode and the full 15 volts from the battery is shown at the amplifier output. As the current begins to increase, the output voltage proportionally decreases, until the transistor reaches saturation at 30 µA of base current (3 mA of collector current). Notice how the output voltage trace on the graph is perfectly linear until the point of saturation, where it never quite reaches zero.

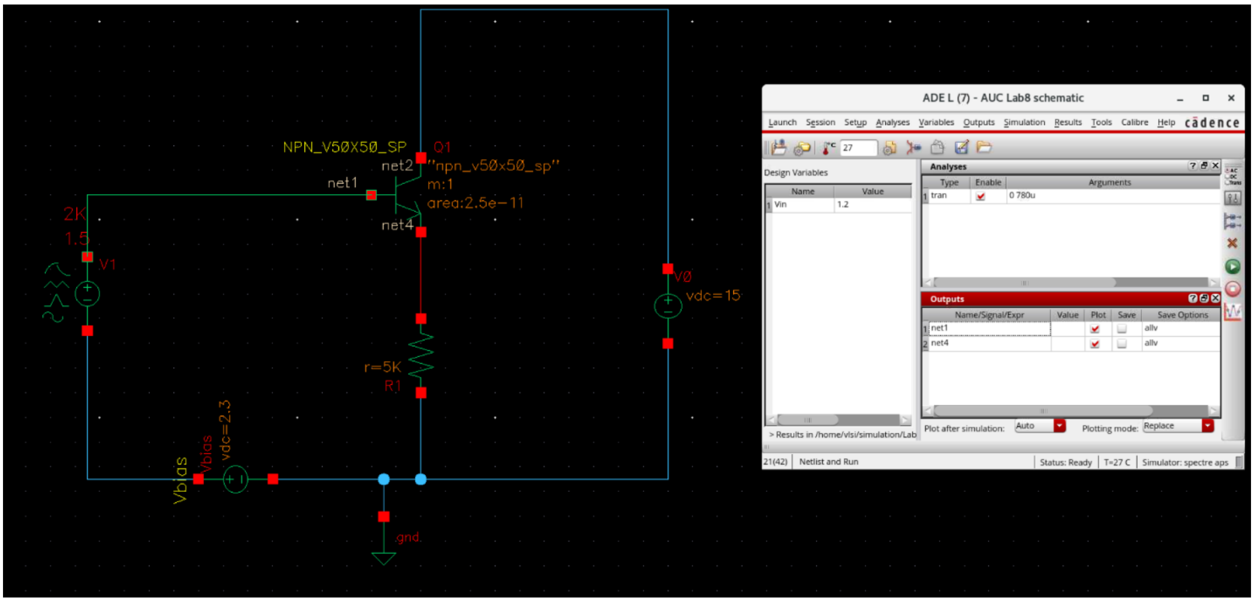
3. The common-collector amplifier



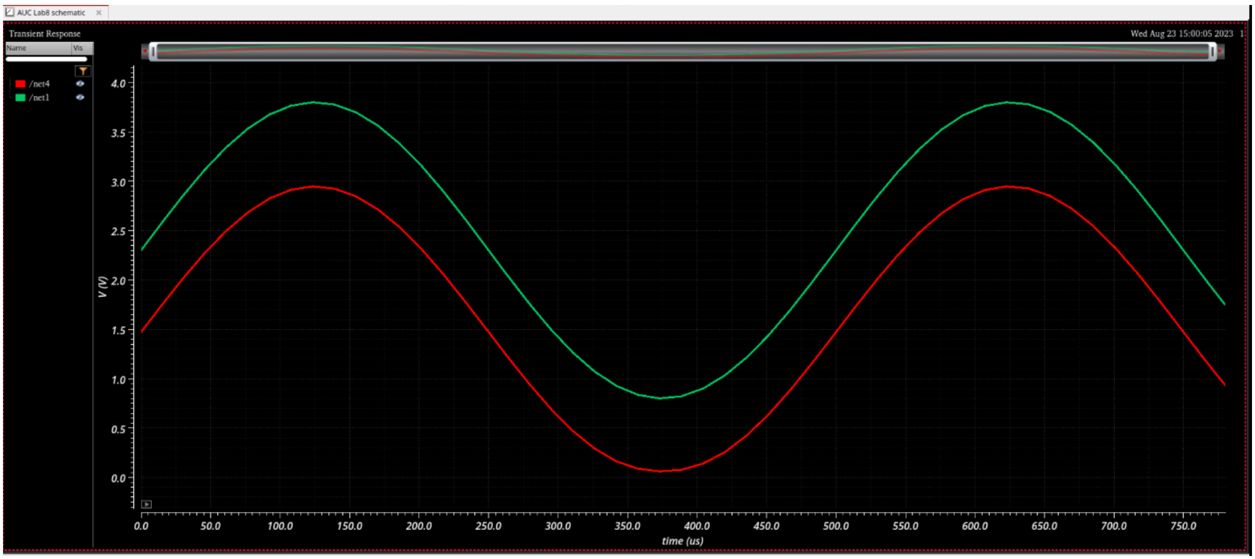
Unlike the common-emitter amplifier from the previous section, the common-collector produces an output voltage *direct* rather than *inverse* proportion to the rising input voltage. This amplifier has a voltage gain of almost unity (1), or 0 dB. This holds true for transistors of any β value, and for load resistors of any resistance value.



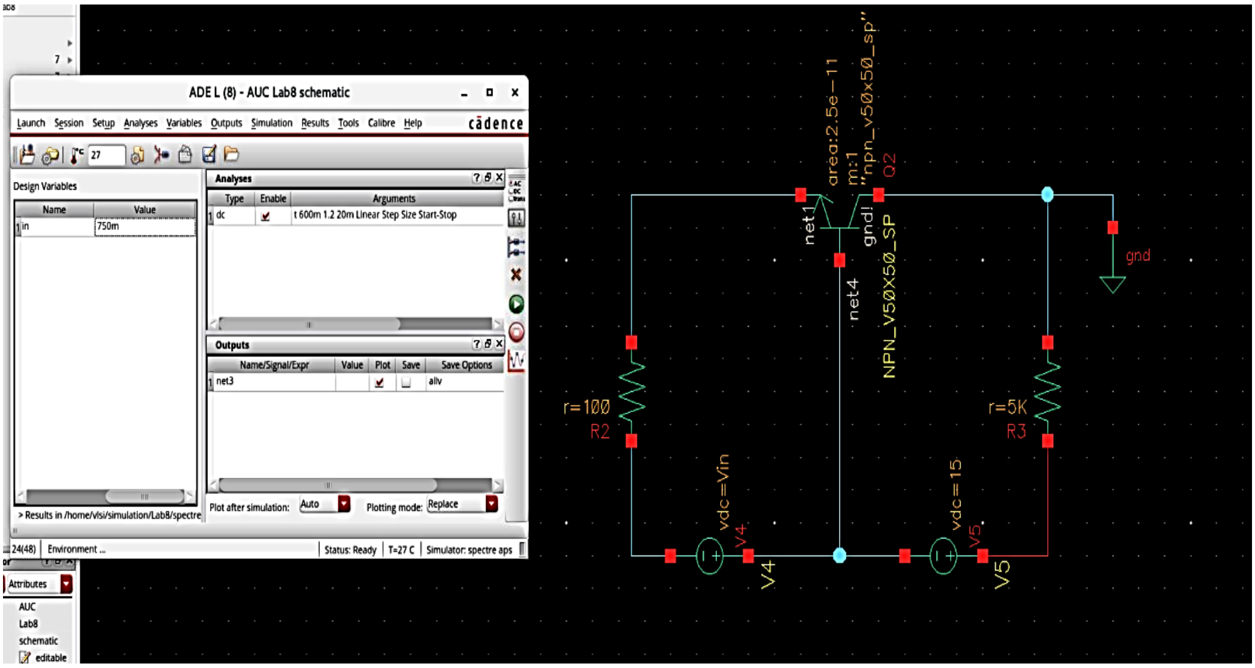
The common-collector amplifier circuit is also known as the *voltage-follower*



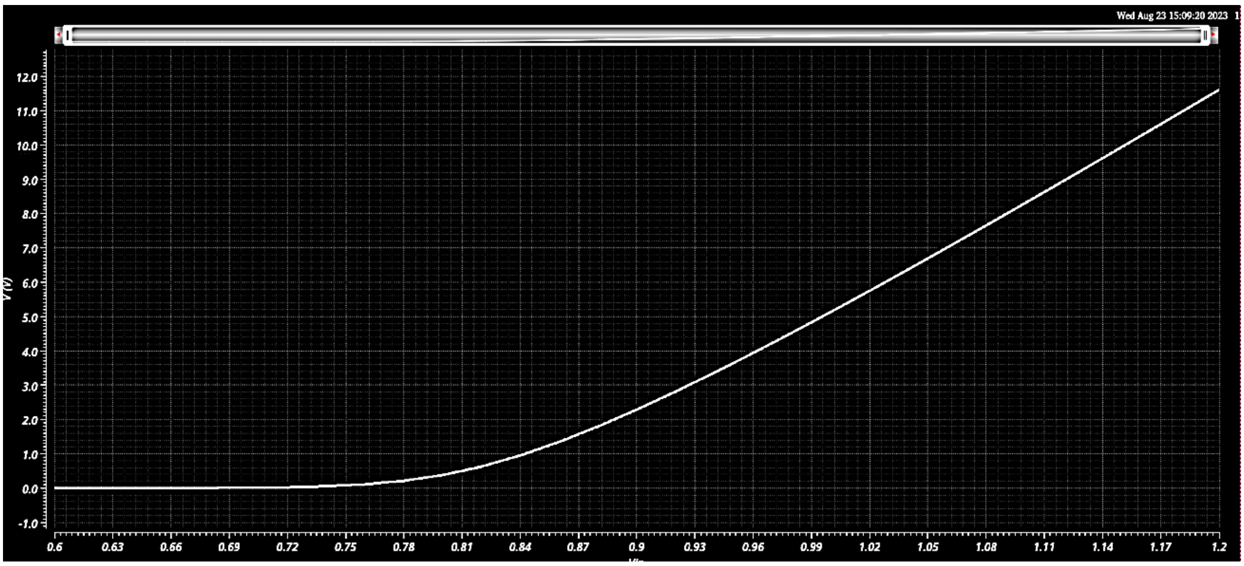
A DC voltage must be added to the AC input signal to keep the transistor in its active mode during the entire cycle. The results of the simulation in Figure below shows that the output follows the input. The output is the same peak-to-peak amplitude as the input. Though, the DC level is shifted downward by one VBE diode drop.



4. The common-base amplifier

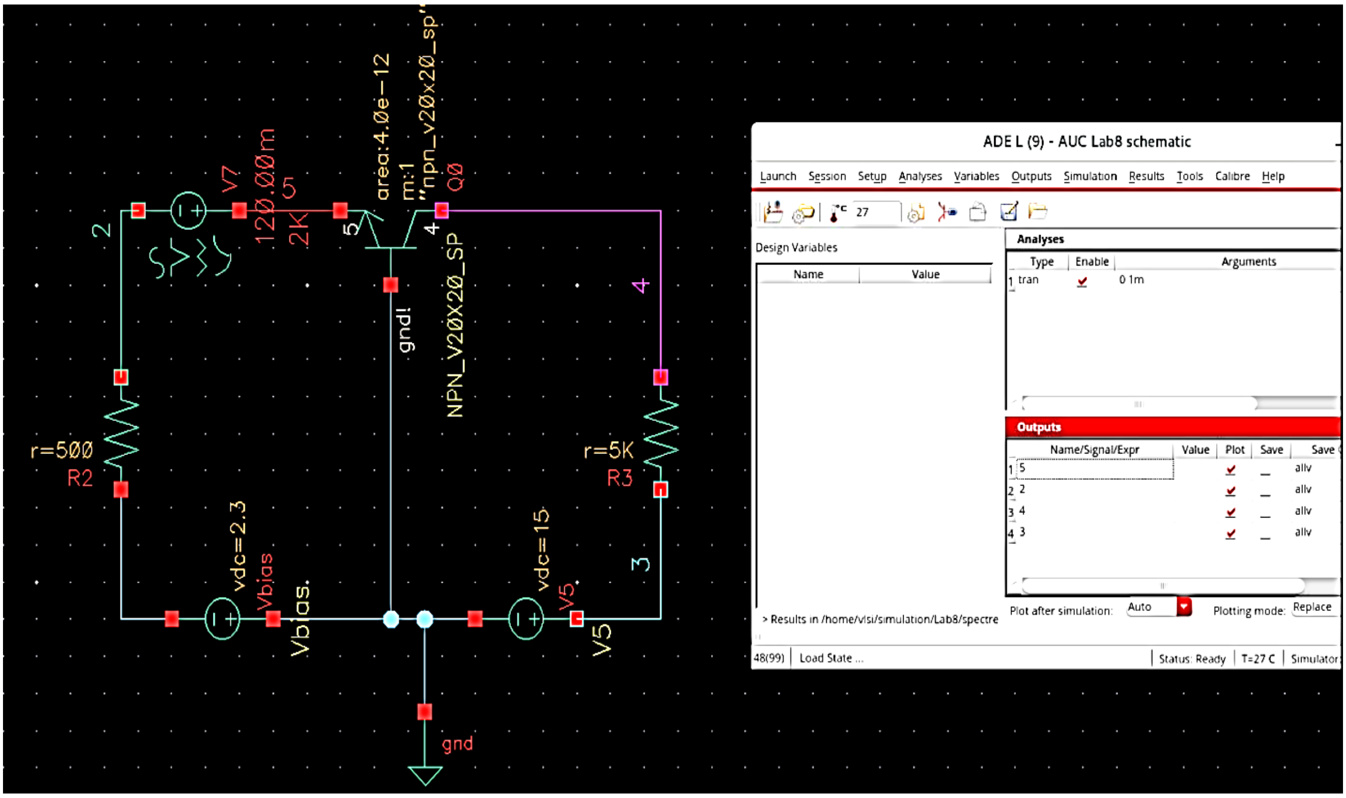


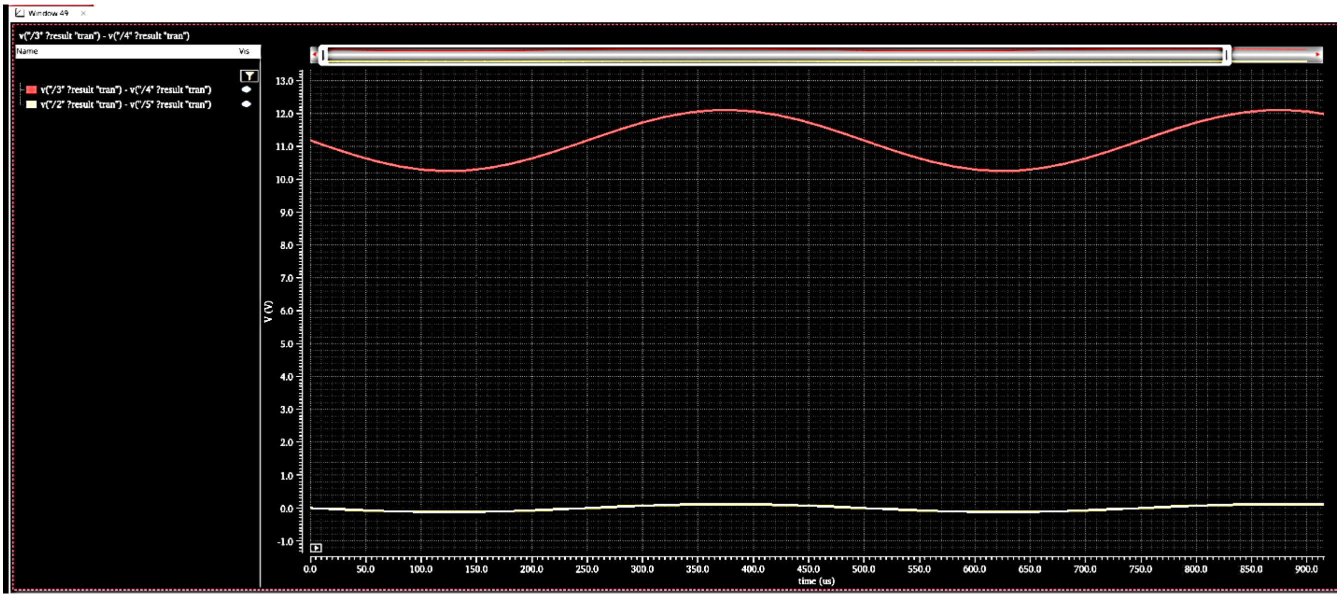
As we know, the emitter current is greater than any other current in the transistor, being the sum of base and collector currents. Because the input current exceeds all other currents in the circuit, including the output current, the current gain of this amplifier is less than 1. In other words, it attenuates current rather than amplifying it.



Notice in the figure above that the output voltage goes from practically nothing (cutoff) to 15.75 volts (saturation) with the input voltage being swept over a range of 0.6 volts to 1.2 volts. The output voltage plot doesn't show a rise until about 0.7 volts at the input and cuts off (flattens) at about 1.12 volts input. This represents a rather large voltage gain with an output voltage span of 15.75 volts and an input voltage span of only 0.42 volts: a gain ratio of 37.5, or 31.48 dB.

AC Input:





As we can see, the input and output waveforms in Figure below are in phase with each other. This tells us that the common-base amplifier is non-inverting with a high voltage gain.

Assignment 6

- Design a simple Series voltage regulator with BJT, Zener diode , resistance and load .
- Simulate the circuit below using cadence virtuoso.
- Try to run as same as steps of Zener regulator that we done before with mentioning your own comments.
- Compare between voltage regulator circuits(with bjt and with only zener) by advantages and dis advantages.

Bonus 6

- Design a **Transistor based Capacitance multiplier** with single transistor, capacitor, resistor, Ac source and putting load resistance =1kohm
- Record the output and input wave form with mention your comments
- Try to optimize your output curve

(load resistance not contained to design)