1 Introduction - Prelab

1.1 Biasing of Bipolar Junction Transistor

1. **Calculations**

$V_{R1} + V_B = 20\,V$

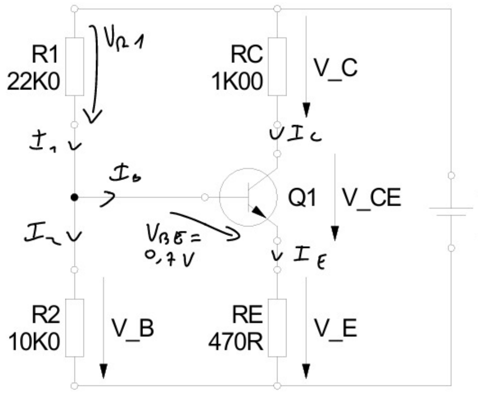
$I_C = 150\, I_B$

$I_E = I_C + I_B$

$V_B = 20 \cdot \frac{R_2}{R_2 + R_1} = 6{,}23\,V$

$V_E = V_B - V_{BE} = 5{,}55\,V$

$I_E = \frac{V_E}{R_E} = 11{,}8\,mA$



$\begin{cases} I_C = 150\, I_B \\ I_C + I_B = 11{,}8\,mA \end{cases}$

$151\, I_B = 11{,}8\,mA \rightarrow I_B = 78{,}1\,\mu A$

$I_C = 150\, I_B \rightarrow 11{,}72\,mA$

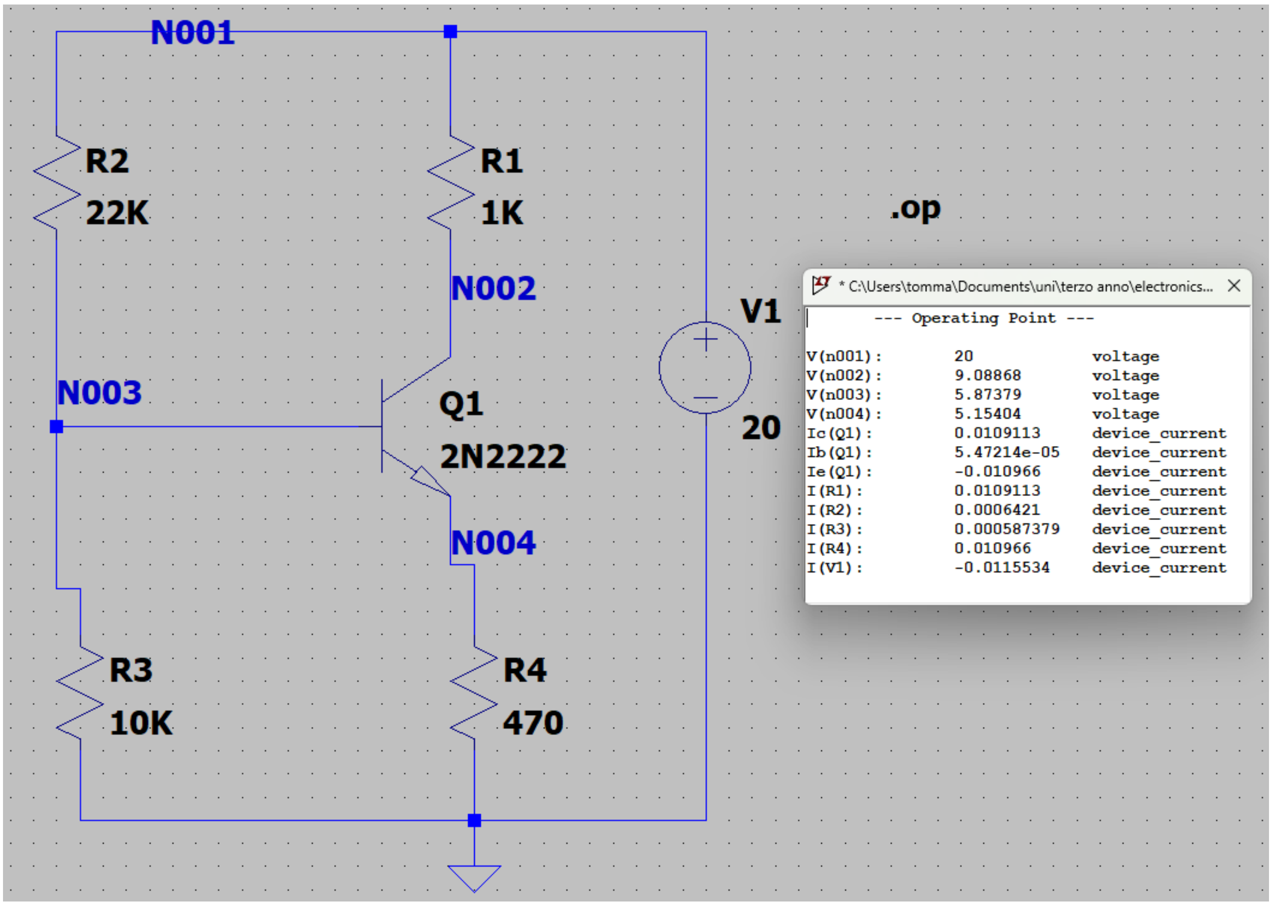
$V_C = I_C R_C = 11{,}72\,V$

$V_{CE} = V_{CC} - V_C - V_E = 2{,}73\,V$

$\beta = 150$ and $V_{BE} = 0.7\,\mathrm{V}$

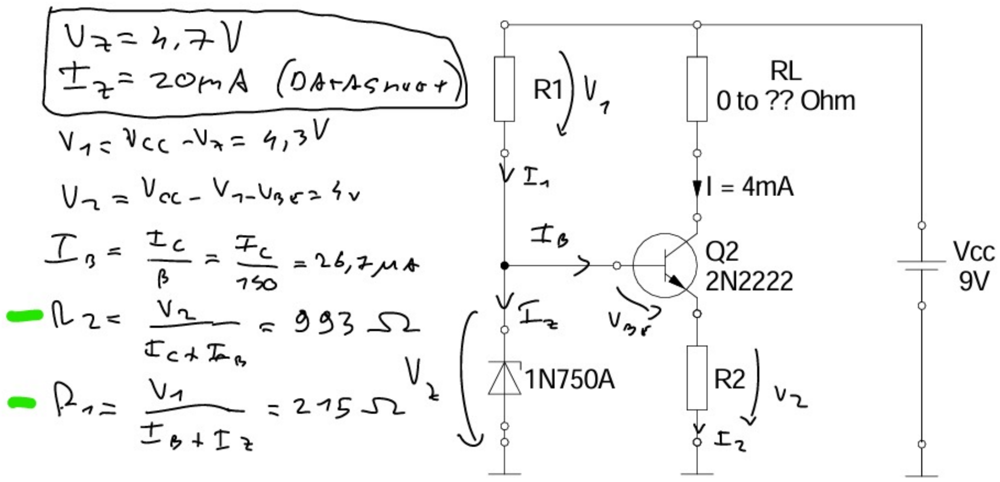
1. (a) Calculate V_B, V_E, V_{CE}, and V_C.
   (b) Calculate I_B, I_E, and I_C.

LTSpice simulation



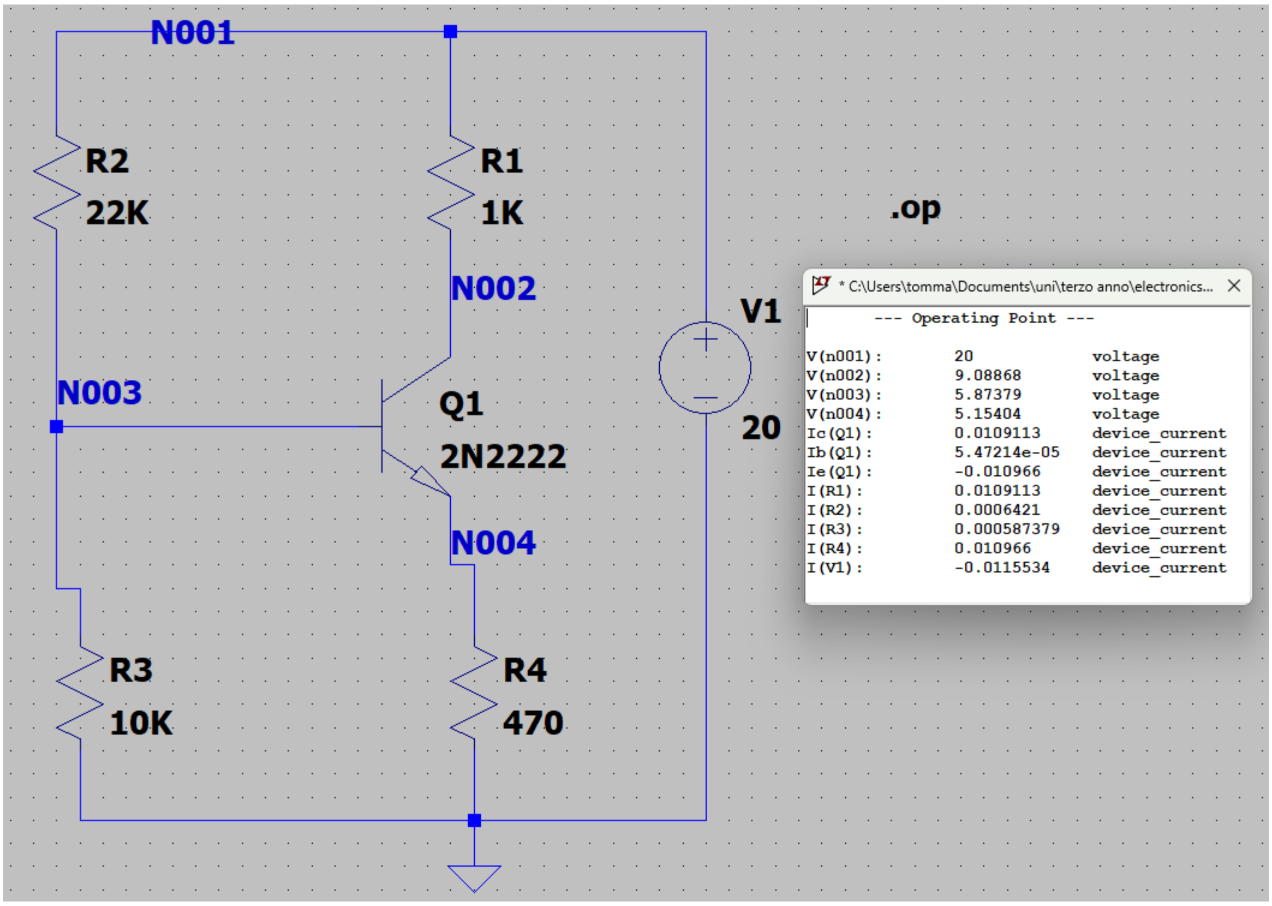
1.2 Constant Current Source

1. **Calculations and simulation on LTSpice**



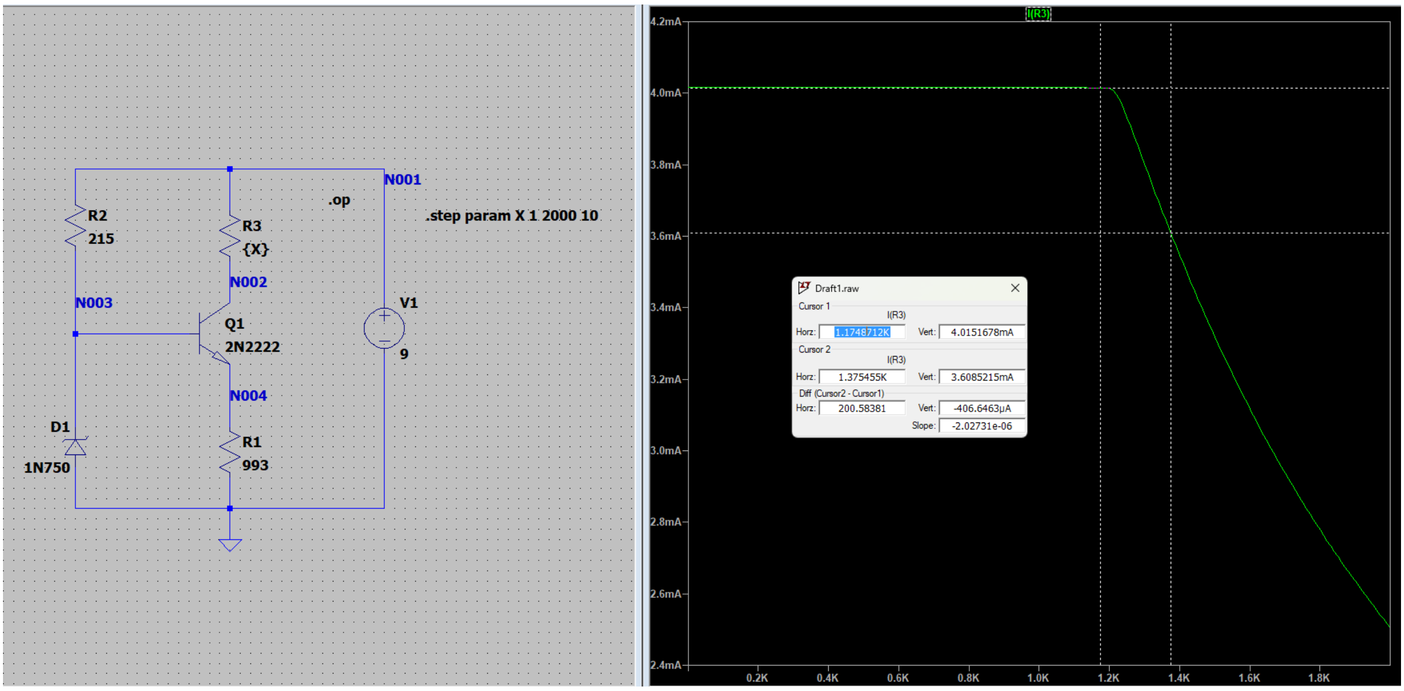
$V_{BE} = 0.7V$

2. R1 = 215Ω, R2 = 993Ω



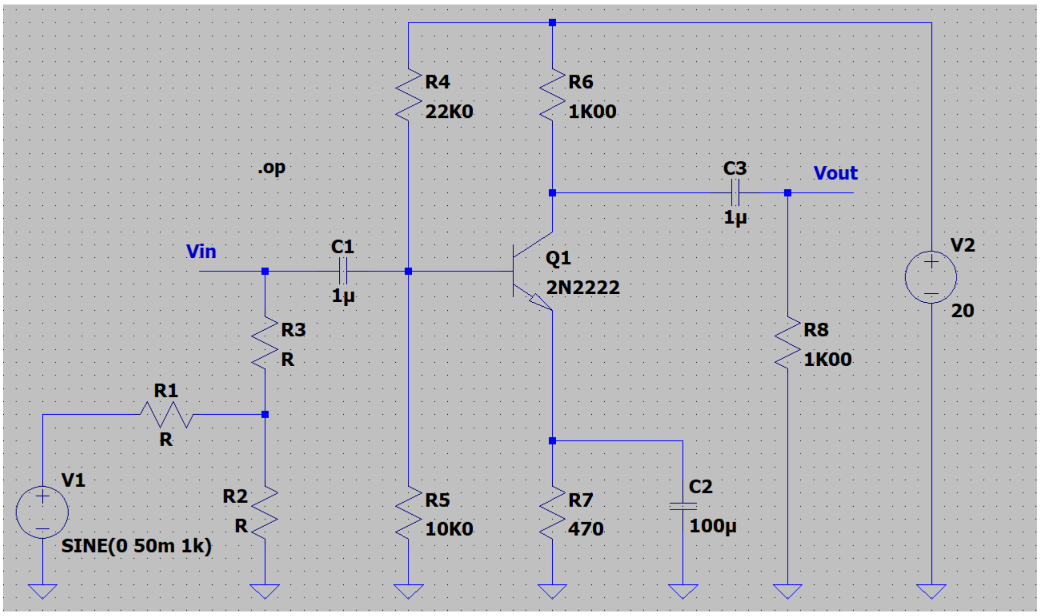
3. To have a constant current V_{CE} has to be higher than 0.3V (from 2N2222 datasheet) to stay in active mode. So the condition for RL is $V_{RL} < V_{CC} - 0.3V - V_2 = V_{RL} < 4.7V$ so R_L must be lower than $\frac{4.7}{0.004} = 1175\ \Omega$.

4. **Max R_L in LTSpice**



At 1275Ω the current is 4mA, at 1375Ω the current is 10% less (3.6mA).

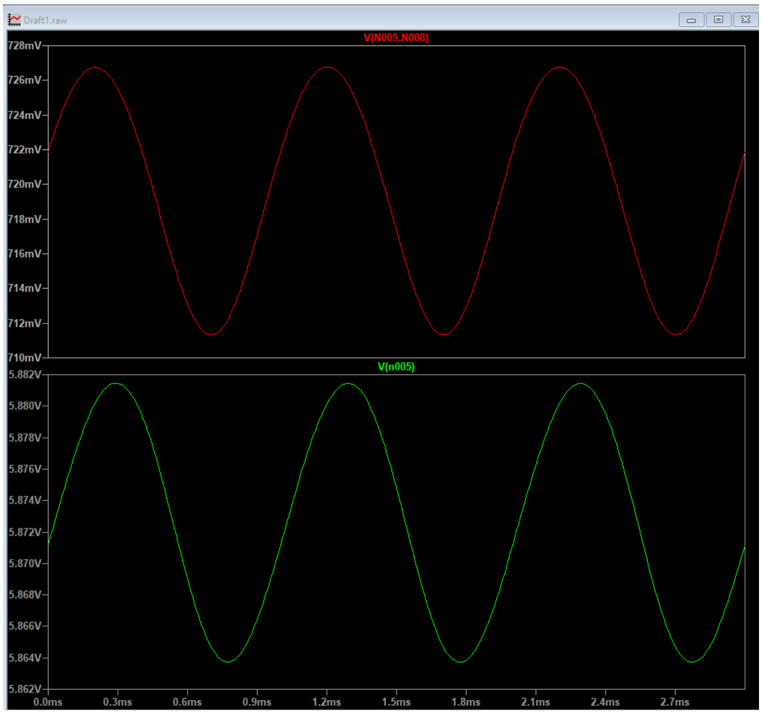
1.3 Amplifier circuit

1. 

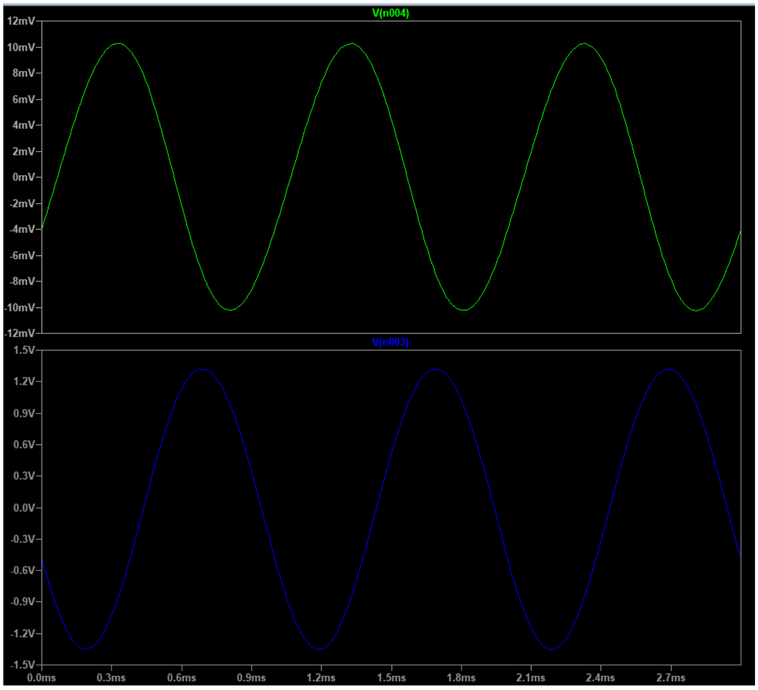
2. **DC operation point values**

$I_C = 0.011$ A, $I_B = 54.7$ uA
$V_B = 5.87$V, $V_E = 5.15$ V, $V_C = 9.09$V, $V_BE = 0.12$, $V_CE = 3.94$V

3. **Transient analysis at 50mV**



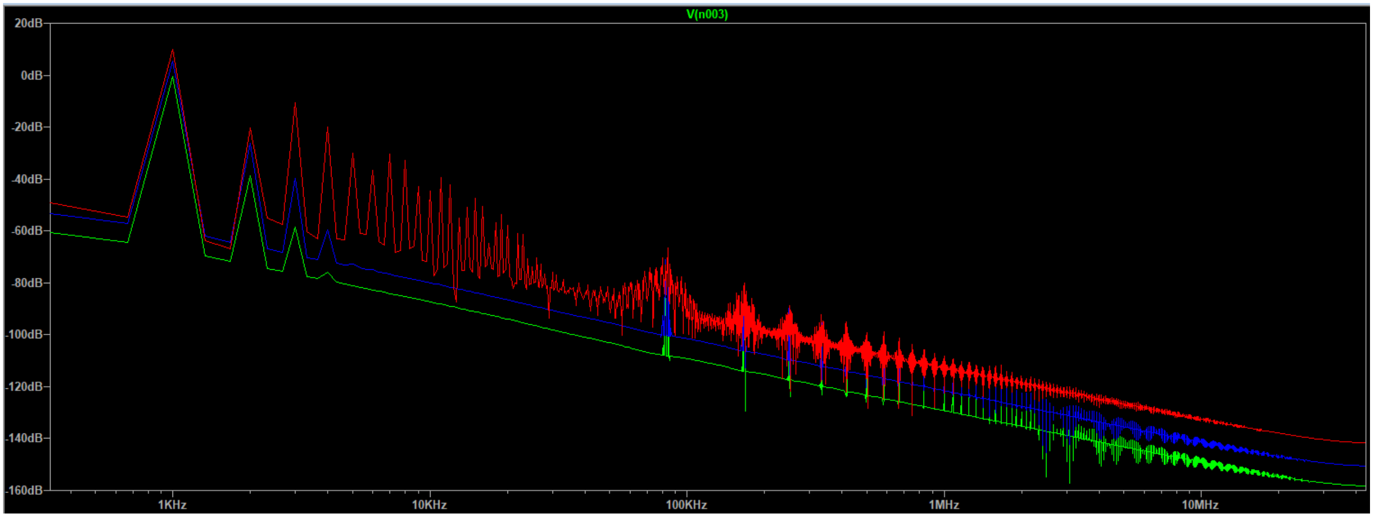
Green line: V_B: 17.7mV peak to peak, red line: V_{BE}: 15.4mV peak to peak.



Green line: V_i: 20.5mV peak to peak, blue line: V_o: 2.67V.

Gain: $\frac{V_o}{V_i} = 130$.

4. **Harmonic distortion analysis**



According to the FFT the harmonic distortion is similar between 50mV and 100mV as input amplitude and is much worse when using 200mV.

5. **AC analysis**