

# LAB04 extras

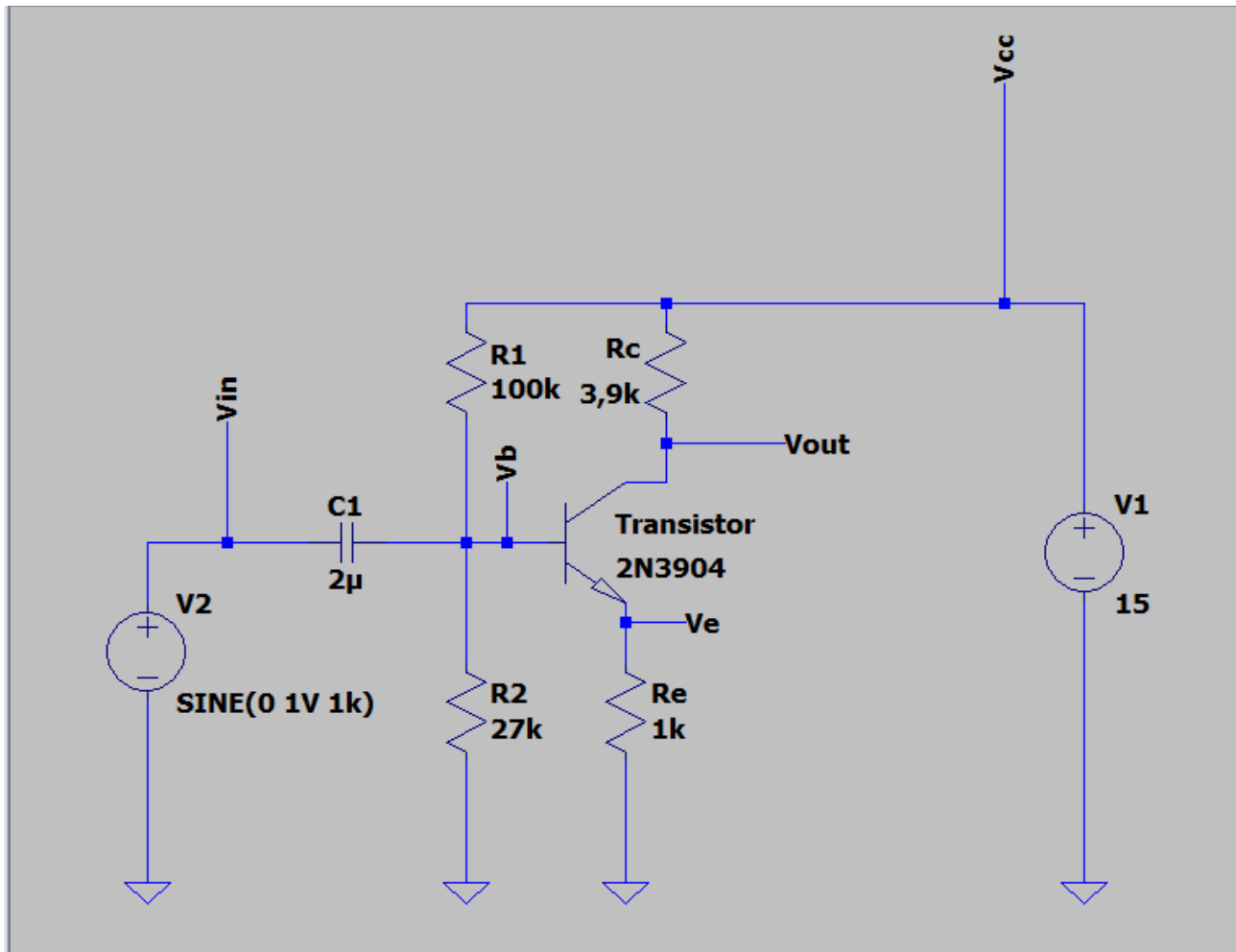
## Task 1:

nPn

Components:

- V1 +15 VDC
- Re 1k ohm
- Rc 3,9k ohm
- R1 100k ohm
- R2 27k
- C1 2uF
- nPn 2N3904
- Rb 10k ohm
- V2 Sine
  - Amplitude 1V
  - Offset 0V
  - Frequency 1k Hz

Circuit:



Calculations:

$$R_{th}(R_b) = R1 \cdot R2 / (R1 + R2) \Rightarrow 100k \text{ ohm} \cdot 27k \text{ ohm} / (100k \text{ ohm} + 27k \text{ ohm}) = 21\,259,8 \text{ ohm}$$

$$V_{th}(V_b) = (R2 / (R1 + R2)) \cdot V_{cc} \Rightarrow (27k \text{ ohm} / (100k \text{ ohm} + 27k \text{ ohm})) \cdot 15 \text{ VDC} = 3.188 \text{ VDC}$$

$$I_b = V_{th} / R_{th} \Rightarrow 3.188 \text{ V} / 21\,259,8k \text{ ohm} = 149,954 \text{ uA}$$

$$I_e = V_{th} - V_{be} / (R_e + R_{th} / \beta) \Rightarrow (3.188 \text{ VDC} - 0,7 \text{ V}) / (1k \text{ ohm} + 21\,259,8k \text{ ohm} / 100) = 2,052 \text{ mA}$$

$$I_c = I_e \Rightarrow 2,052 \text{ mA}$$

$$V_e = I_e \cdot R_e \Rightarrow 2,052 \text{ mA} \cdot 1k \text{ ohm} = 2,052 \text{ V}$$

$$V_b = V_e + 0,7 \text{ V} \Rightarrow 2,052 \text{ V} + 0,7 \text{ V} = 2,752 \text{ V}$$

$$V_{out} = V_{cc} - I_c \cdot R_c \Rightarrow 15 \text{ VDC} - 2,052 \text{ mA} \cdot 3,9k \text{ ohm} = 6,99 \text{ V}$$

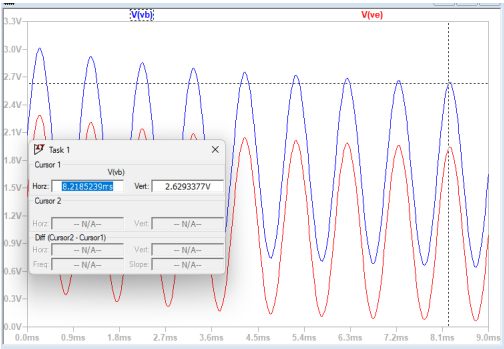
$$V_{ce} = V_c - V_e \Rightarrow 6,99 \text{ V} - 2,052 \text{ V} = 4,945 \text{ V}$$

$$A_v = V_c / V_b \Rightarrow 6,99 \text{ V} / 2,752 \text{ V} = 2,5\text{-kertainen (AC voltage gain between base and collector.)}$$

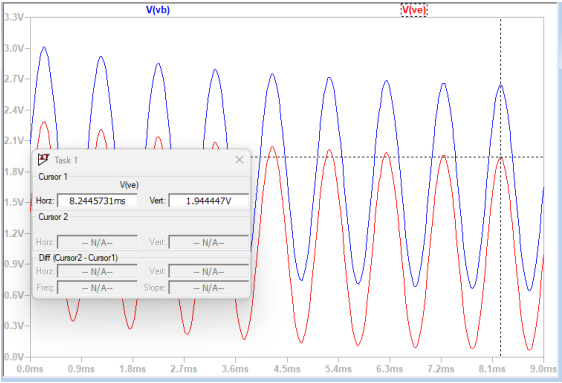
$$A_v = 25 \text{ mV} / I_e, \text{ The } 25 \text{ mV value is typically used as a rough approximation for the thermal voltage (} V_t \text{) at room temperature (} 25^\circ\text{C) in small-signal models of transistors.} \Rightarrow 25 \text{ mV} / 2,052 \text{ mA} = 12,83 \text{ ohm}$$

Simulations

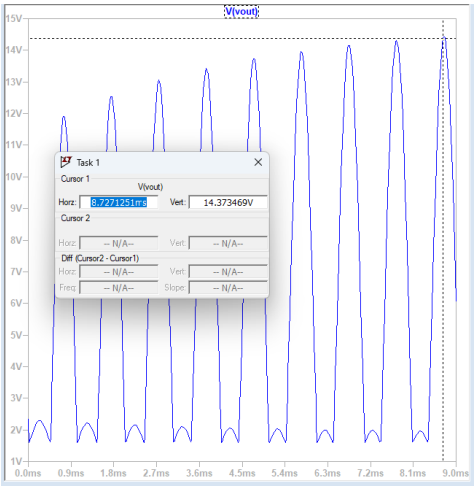
Vb



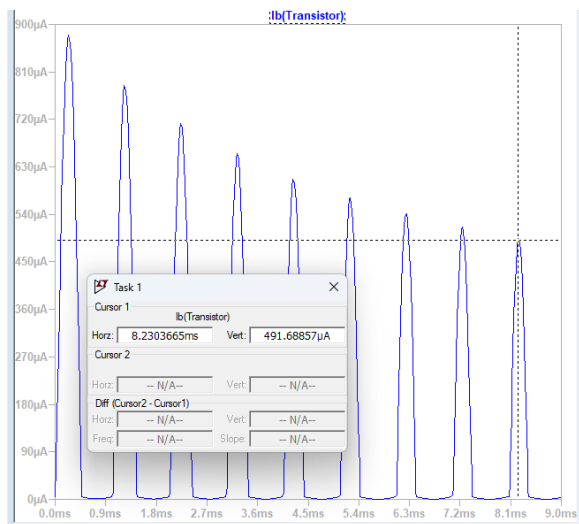
Ve



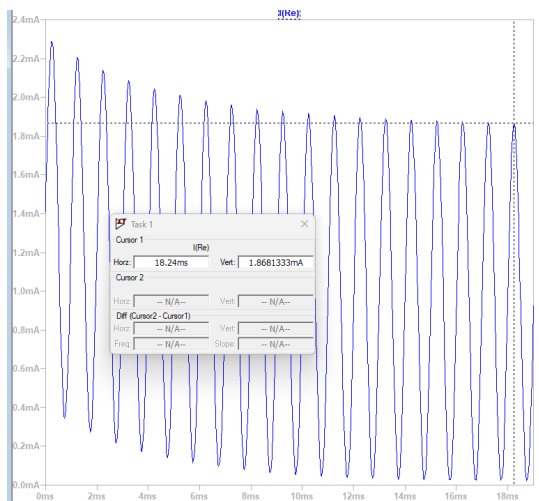
Vout



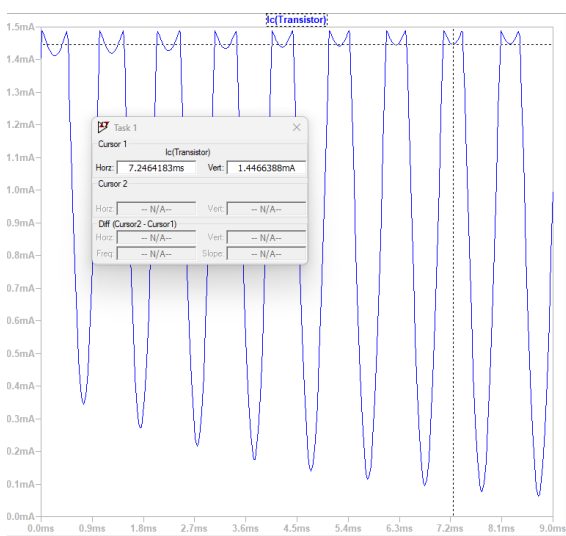
Ib



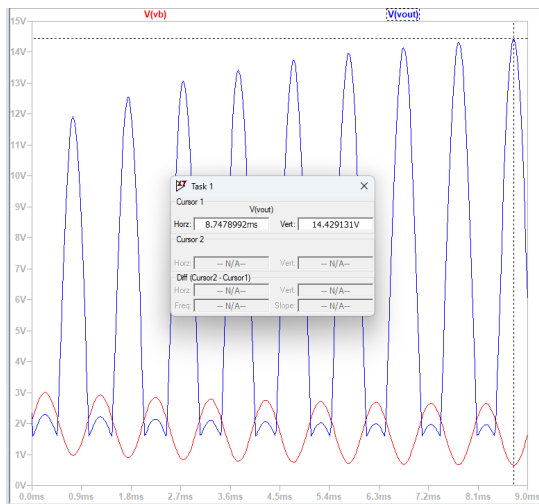
$I_e$



$I_c$



$A_v$  (AC gain)



### Conclusion:

Simulation data seems to correspond quite accurately calculations. Only visible difference is output  $V_{out}$ .  $V_{out}$  seems to be almost double in simulation.  $I_c$  and  $V_{out}$  shape also raises questions. Mostly why the two signals start to follow up collector signal when on the same level. (?)

Circuit seems to create considerable voltage gain which very small ( $\mu A$ ) current. In this sense, the circuit could be implemented physically for further testing.