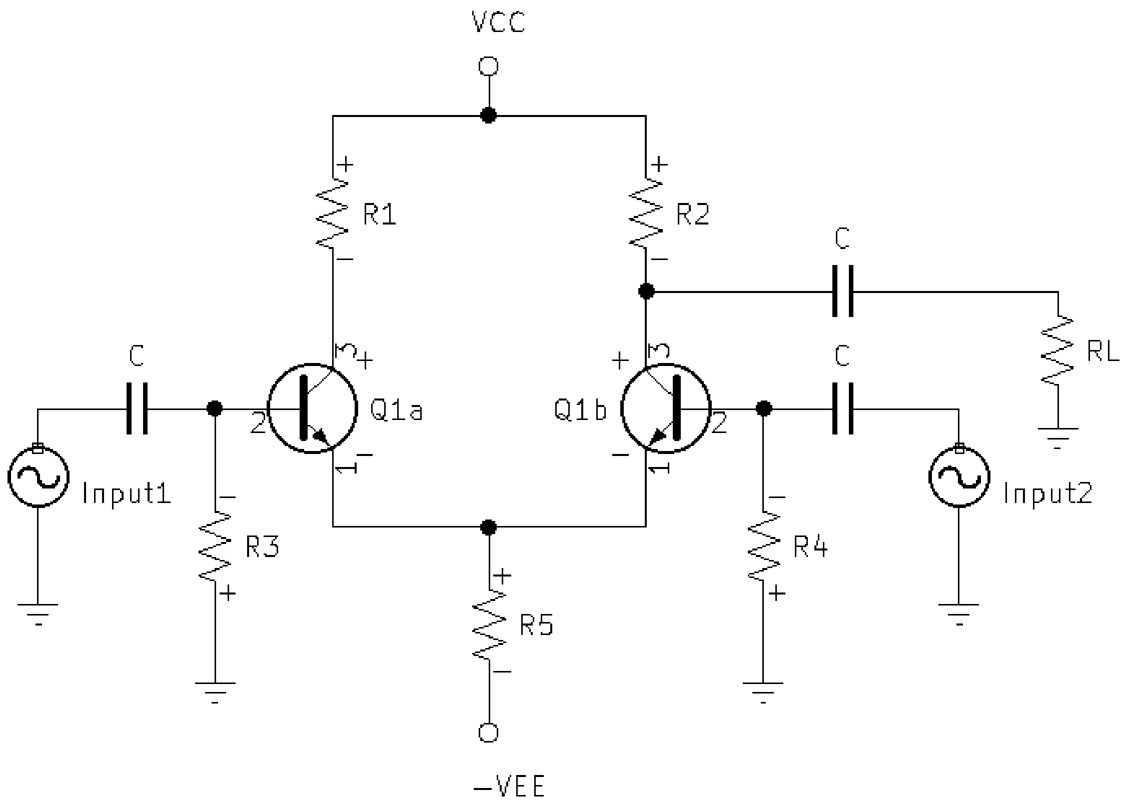
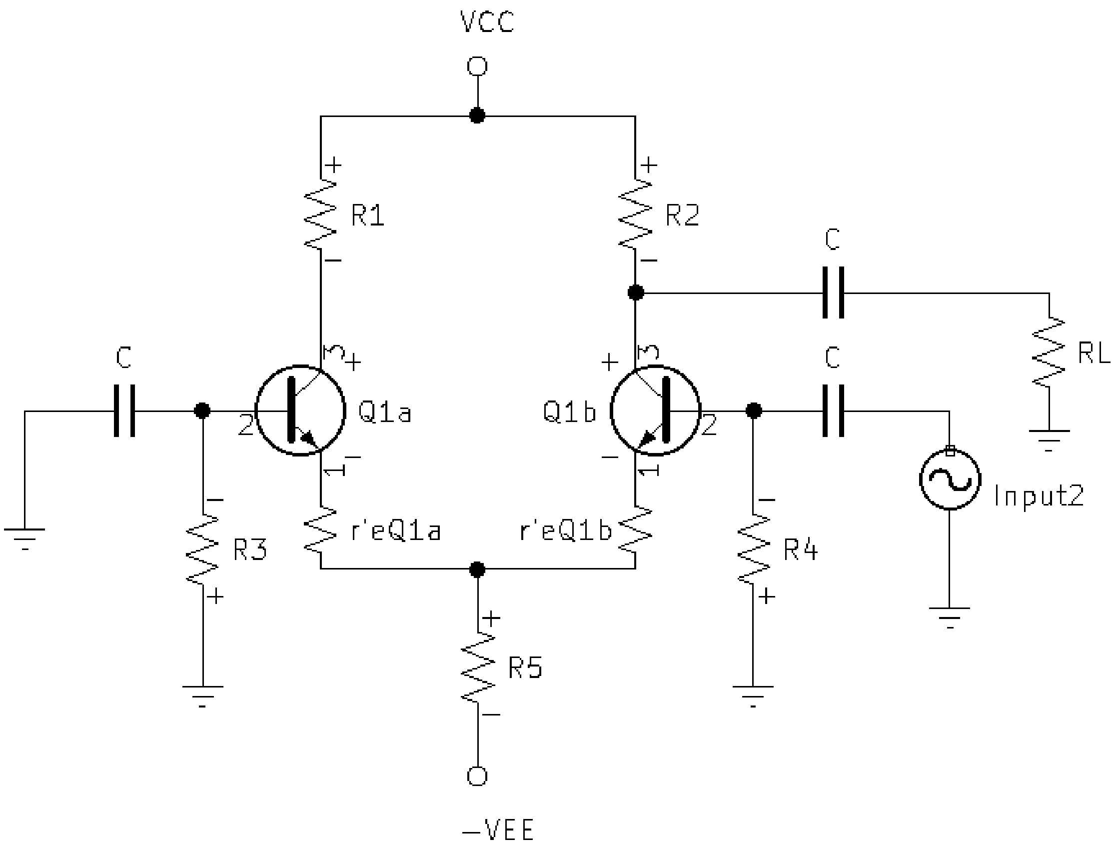


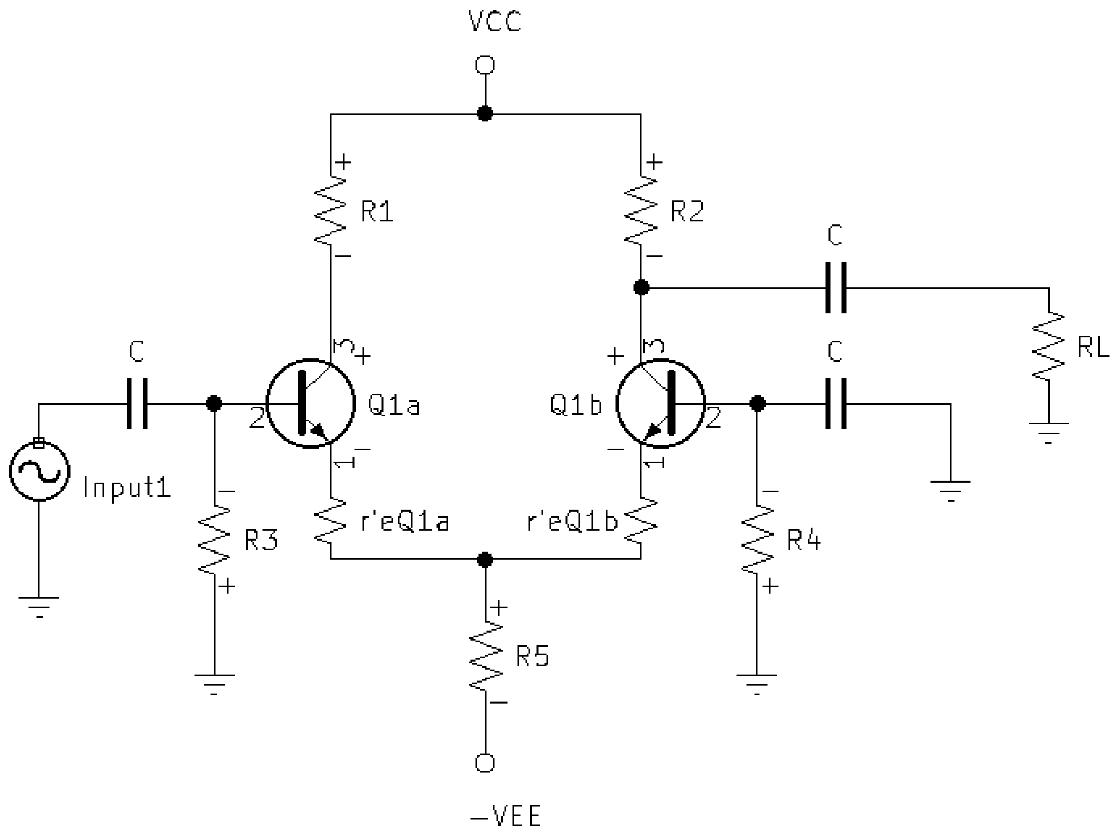
DC Biasing:

- R1 = R2 = RL
- R3 = R4
- VCC = $VEE(-1)$
- C value ≈ $10uF$ depending on low frequency response needs.
- $Beta_{Q1a} = Beta_{Q1b}$
- Optimize:
  - $V_{R1\&R2} = 45\%(VCC + VEE)$
  - $VCE_{Q1a\&Q1b} = 45\%(VCC + VEE)$
  - $V_{R5} = 10\%(VCC + VEE)$
    - $IR5 = 2IE$
  - $V_{R3\&R4} = VEE - VR5 - VBE$

Gain Calculations:



- Single-Ended Inverting Gain:
  - $\Delta v_{CE} = \frac{Vout}{Vin}$
  - $\Delta v_{CE} = \frac{IC(R2//RL)}{IB((r'eQ1a//R5)+r'eQ1b)(B+1)}$



- Single-Ended Non-Inverting Gain:
  - $\Delta v_{CC} = \frac{Vout}{Vin}$
    - $\Delta v_{CC} = \frac{IE(r'eQ1b//R5)}{IB((r'eQ1b//R5)+r'eQ1a)(B+1)}$
    - $\Delta v_{CC} \approx 0.5$
  - $\Delta v_{CB} = \frac{Vout}{Vin}$
    - $\Delta v_{CB} = \frac{IC(R2//RL)}{IE(r'eQ1b)}$
    - $\Delta v_{CB} \approx 2 \times \Delta v_{CE}$
  - $\Delta v_{CCCB} = \Delta v_{CC} \times \Delta v_{CB}$

- Double-Ended Gains:
  - $\Delta v_{Common\,mode} = \Delta v_{CCCB} - |\Delta v_{CE}|$
    - $\Delta v_{Common\,mode} \approx 0$
  - $\Delta v_{differential\,mode} = \Delta v_{CCCB} + |\Delta v_{CE}|$
    - $\Delta v_{differential\,mode} \approx 2 \times \Delta v_{CE}$
  - $Common\ Mode\ Rejection\ Ratio$:
    - $CMRR = 20Log(\frac{\Delta v_{Common\,mode}}{\Delta v_{differential\,mode}})$