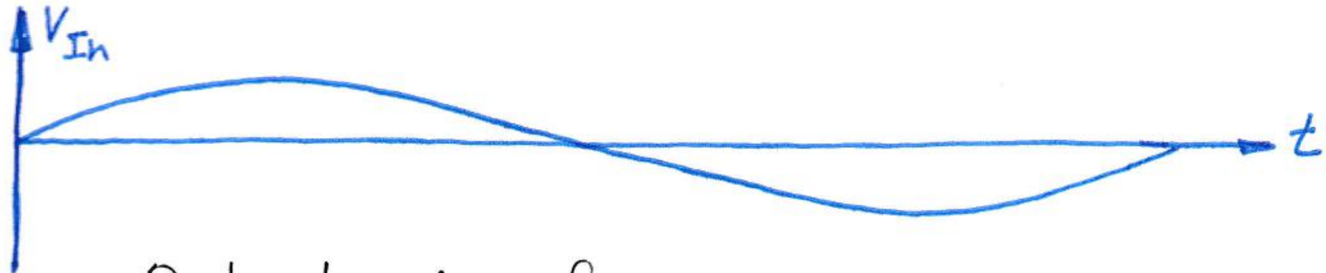
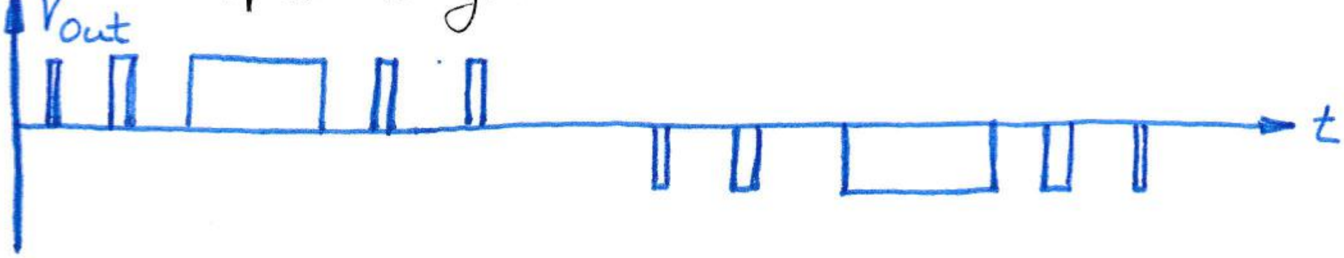
ITE Exam-02 BJTs & BJT circuits
Spring Semester 2024

Problem 1 Class-D amplifier

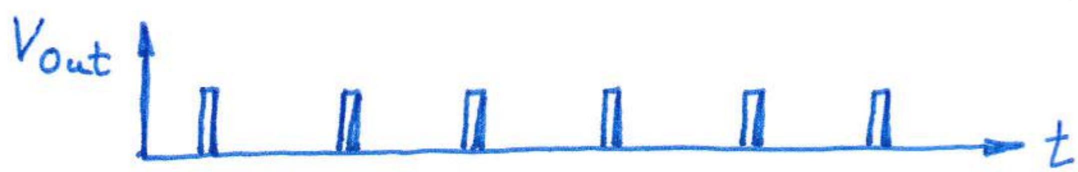
(a) Input signal:



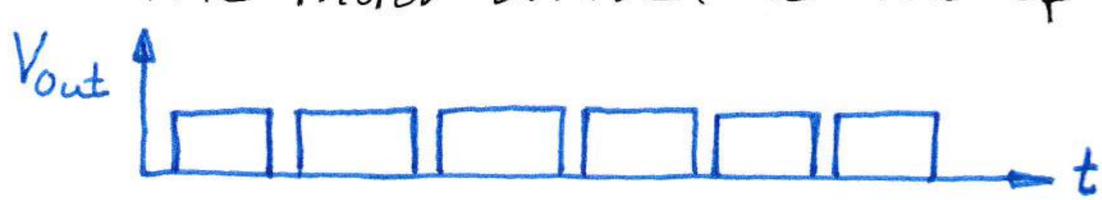
Output signal:



(b) Electric motor driven at 10% of power



Electric motor driven at 90% of power

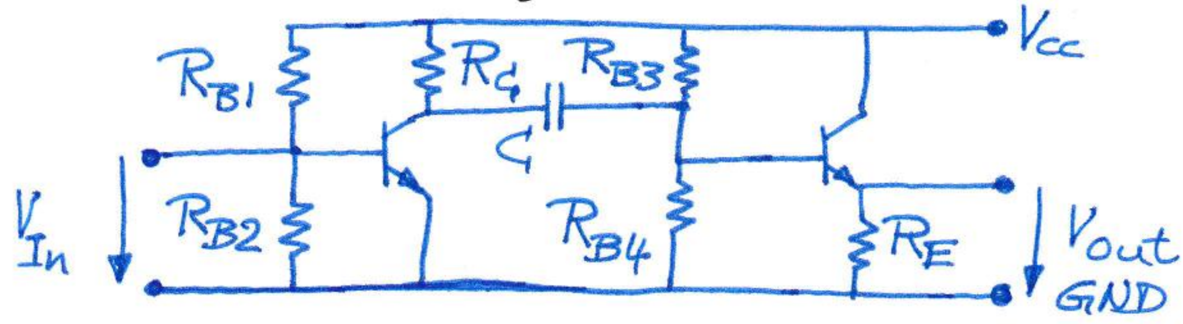


(c) A Class-D amplifier is an ON / OFF amplifier. $R_{ON} = 0\Omega$ $R_{OFF} = \infty\Omega$

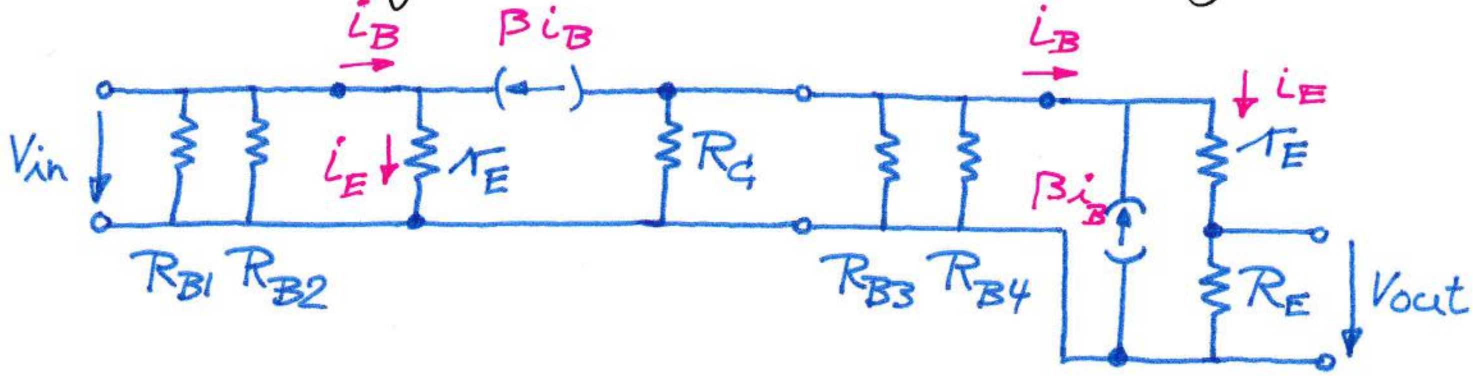
The amplifier does not consume any power. This is a marked advantage.

Problem 2 Two-stage tranistor amplifier

(a) Circuit diagram ($V_{cc} = 10V$ $\beta = 100$)



(b) Small-signal AC circuit diagram



(c) Output impedance of 2nd stage

$$R_{out} = R_E \,||\, (r_E + \underbrace{(R_{B3} \,||\, R_{B4})}_{\gg R_E}) \approx \underline{\underline{R_E}}$$

(d) I choose: $\underline{\underline{R_E = 100\Omega}}$

If the DC operating point is in the middle of the load line, then $\underline{\underline{V_{CE} = 5V}}$.

$\Rightarrow V_{RE} = 5V$ $\quad \underline{\underline{I_{RE}}} = \frac{V_{RE}}{R_E} = \frac{5V}{100\Omega} = \underline{\underline{50mA}}$

$\Rightarrow \underline{I_E} = I_{RE} = \underline{50\,mA}$

(e) Base voltage $= \underline{V_B} = V_{RE} + 0.7V = 5V + 0.7V = \underline{5.7V}$

Base current: $I_C = \beta I_B$

$i_c = \beta i_B \qquad i_E = i_c + i_B = \beta i_B + i_B = (\beta+1) i_B$

$$\Rightarrow \underline{I_B} = \frac{I_E}{\beta+1} = \frac{50mA}{101} \approx \underline{0.5\,mA}$$

(f) Current through base voltage divider should be much greater than the base current. I choose a current of 5mA. ($5mA \gg 0.5mA$)

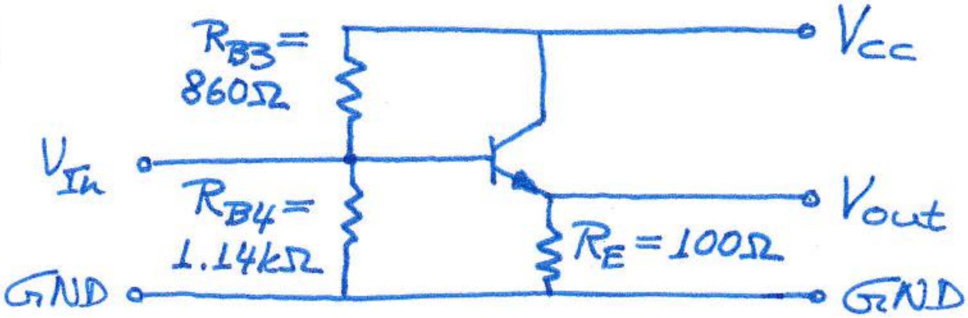
$$\Rightarrow \underline{R_{B3} + R_{B4}} = \frac{V_{CC}}{5mA} = \frac{10V}{5mA} = \underline{2\,k\Omega}$$

Voltage divider $\frac{R_{B4}}{R_{B3}+R_{B4}} \times 10V = 5.7V \; (= V_B)$

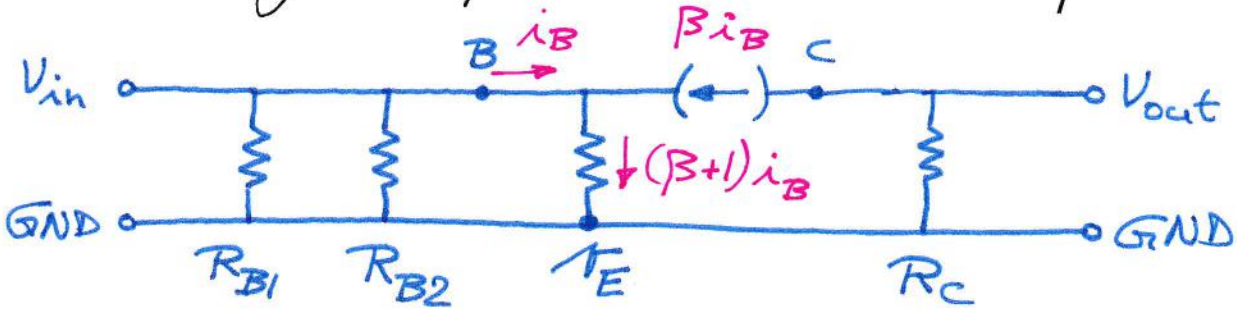
$$\Rightarrow \underline{R_{B4}} = \frac{5.7V}{10V} \times 2k\Omega = \underline{1.14\,k\Omega}$$

$$\Rightarrow \underline{R_{B3}} = 2k\Omega - R_{B4} = 2k\Omega - 1.14k\Omega = \underline{0.86k\Omega}$$

(g)



(h) Small-signal equivalent circuit of 1st stage:



Voltage amplification

$$V_{out} = -\beta\, i_B R_C,$$

$$V_{in} \approx (i_B + \beta i_B) r_E$$

$$\Rightarrow \underline{\underline{A_{Voc}}} = \frac{V_{out}}{V_{in}} \approx \underline{\underline{R_C / r_E}}$$

(i) $R_C = 200\Omega \qquad A_{Voc} = 20$

$$\Rightarrow r_E = \frac{R_C}{A_{Voc}} = \frac{200\Omega}{20} = \underline{\underline{10\Omega}}$$

$$\Rightarrow \text{Recall: } r_E = \frac{V_t}{I_E} = \frac{26mV}{I_E}$$

$$\Rightarrow \underline{\underline{I_E}} = \frac{V_t}{r_E} = \frac{26mV}{10\Omega} = \underline{\underline{2.6\,mA}}$$

(j) Base voltage $= V_B = V_{BE} = 0.7V$

Base current $= I_B = \frac{I_E}{\beta+1} = \frac{2.6mA}{101} \approx 26\mu A$

(k) Current through base voltage divider should be much greater than I_B

I choose $I_{RB} = 10 \times I_B = 10 \times 26\mu A = 260\mu A$

$$R_{B1} + R_{B2} = \frac{V_{cc}}{I_{RB}} = \frac{10V}{260\mu A} = 38.5\,k\Omega$$

Voltage divider eqn.:

$$\frac{R_{B2}}{R_{B1}+R_{B2}} V_{cc} = 0.7V \quad (= V_B)$$

$$\Rightarrow R_{B2} = \frac{0.7V}{V_{cc}}(R_{B1}+R_{B2}) = \frac{0.7V}{10V} 38.5k\Omega = 2.7k\Omega$$

$$\Rightarrow R_{B1} = (R_{B1}+R_{B2}) - R_{B2} = 38.5k\Omega - 2.7k\Omega$$

$$= 35.8\,k\Omega$$

Problem 3

(a) False. A BJT common-emitter amplifier has a relatively low input impedance (not close to ∞).

(b) False. A DC blocking capacitor constitutes a high-frequency pass filter.