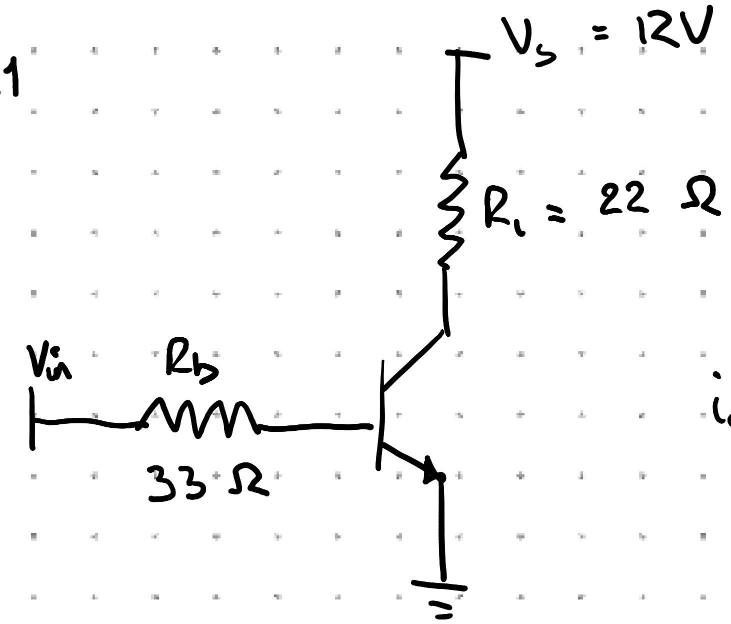
Chapter 1: Transistors

1.1



$\beta = 25$

$V_{ce(sat)} = 0{,}2V$

$V_{in} = 3.3V$

$$i_c = i_L = \frac{12 - 0{,}2}{22}$$

$$= 0{,}536\ A$$

$$i_b = \frac{3.3 - 0{,}7}{33}$$

$$= 0{,}0788\ A$$

Max current that can be supplied by $\beta = 25$:

$$i_{c(max)} = \beta \cdot i_b$$

$$= 25 \cdot 0{,}0788$$

$$= 1{,}97\ A \quad (\gg 0{,}536\ A \ \therefore \text{saturated})$$

$$\beta_{eff} = \frac{i_c}{i_b} = \frac{0{,}536}{0{,}0788}$$

$$= 6{,}80$$

→ The load limits i_c here

1.2 Same circuit but $R_L = 5\Omega$

$$i_c = \frac{12 - 0{,}2}{5} = 2{,}36\,A \quad \text{(if saturated)}$$

$$i_b = 0{,}0788$$

Max current that can be supplied by $\beta = 25$:

$$i_{c(max)} = 1{,}97\ A$$

As $2{,}36\ A > 1{,}97\ A$ Transistor cannot reach saturation

$\therefore \beta_{eff} = 25$

and $i_c = 1{,}97\ A$

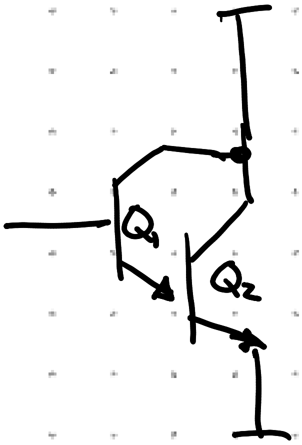
(limited by the transistor β & i_b)

$$\therefore V_L = i_c \cdot R_L$$
$$= 1{,}97 \cdot 5$$
$$= 9{,}85\ V$$

and $\therefore$ $V_{ce} = 12 - 9{,}85$

$$= 2{,}15\ V$$

1.3



$i_c = \beta i_b$

$i_e = i_b + i_c$

$i_{e_1} = i_{b_1} + \beta_1 \cdot i_{b_1}$

$= (\beta_1 + 1) i_{b_1} \quad = i_{b_2}$

$i_{c_{total}} = i_{c_1} + i_{c_2}$

$i_{c_1} = \beta_1 i_{b_1}$

$i_{c_2} = \beta_2 i_{b_2} = \beta_2 (\beta_1 + 1) i_{b_1}$

$\therefore i_{c_{total}} = \beta_1 i_{b_1} + \beta_2 (\beta_1 + 1) i_{b_1}$

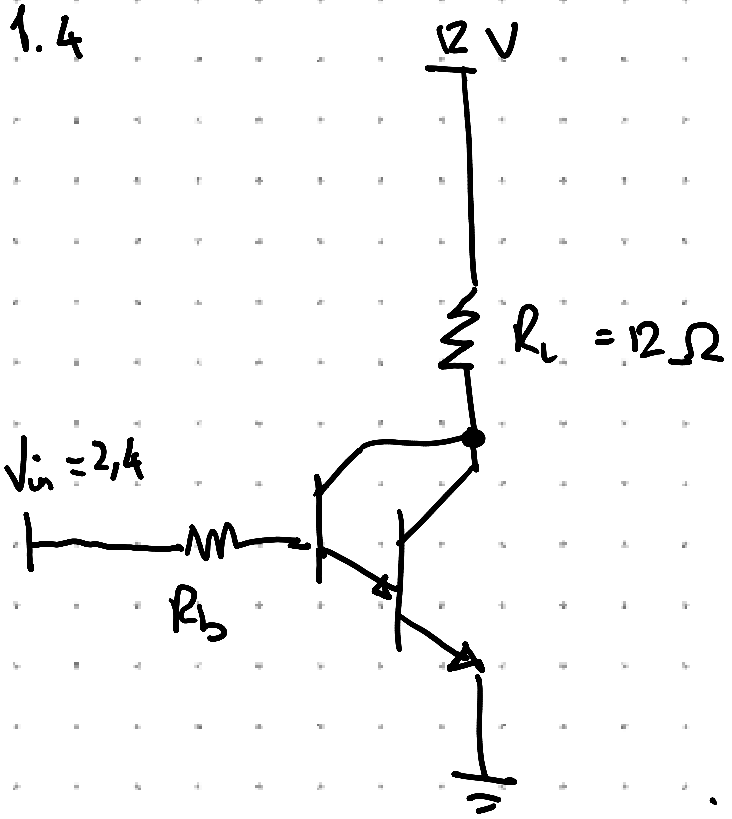
$= (\beta_1 + \beta_2 \beta_1 + \beta_2) i_{b_1}$

$$\beta_{total} = \frac{i_{c_{total}}}{i_{b_1}} = \beta_1 + \beta_2 \beta_1 + \beta_2$$

$= \beta_1 (\beta_2 + 1) + \beta_2$

As $\beta_x \gg 1$ $\quad \beta_{total} \rightarrow \beta_2 \beta_1$

1.4



$\beta > 1000$

for saturation, $V_{CE_{sat}} = 0{,}2\,V$

$\therefore i_{c(sat)} = \frac{12 - 0{,}2}{12}$

$= 0{,}983\ A$

$i_b > \frac{i_c}{\beta_{min}}$

$> \frac{0{,}983}{1000}$

$> 0{,}983\ mA$

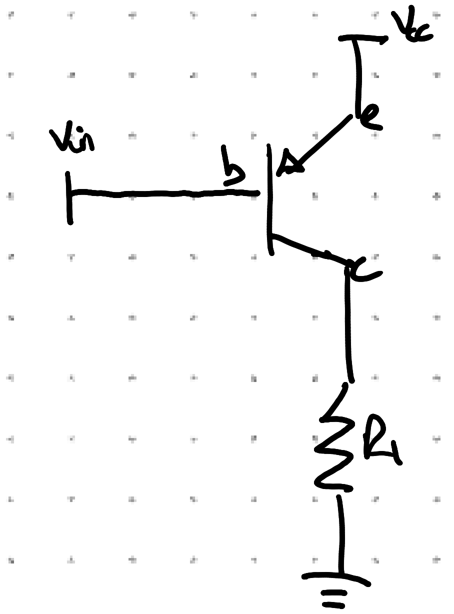
$i_b > \frac{V_{in} - 1{,}4}{R_b}$

$R_b < \frac{2{,}4 - 1{,}4}{0{,}000983}$

$R_b < 1017\ \Omega$

$\therefore$ choose $R_b = 560\,\Omega$ (E12)

1.5



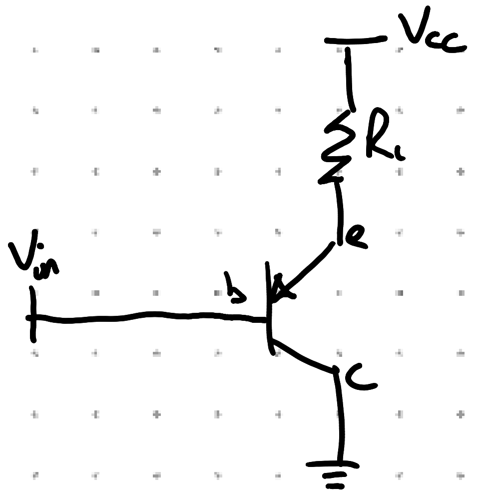
<u>Ground connected load</u> without R_b

When $V_{in} = 0\,V$ there

is a short from V_{cc} to GND

through the b-e junction.

→ Need R_b to prevent short.



Supply connected load without R_b

is fine as when $V_{in} = 0V$,

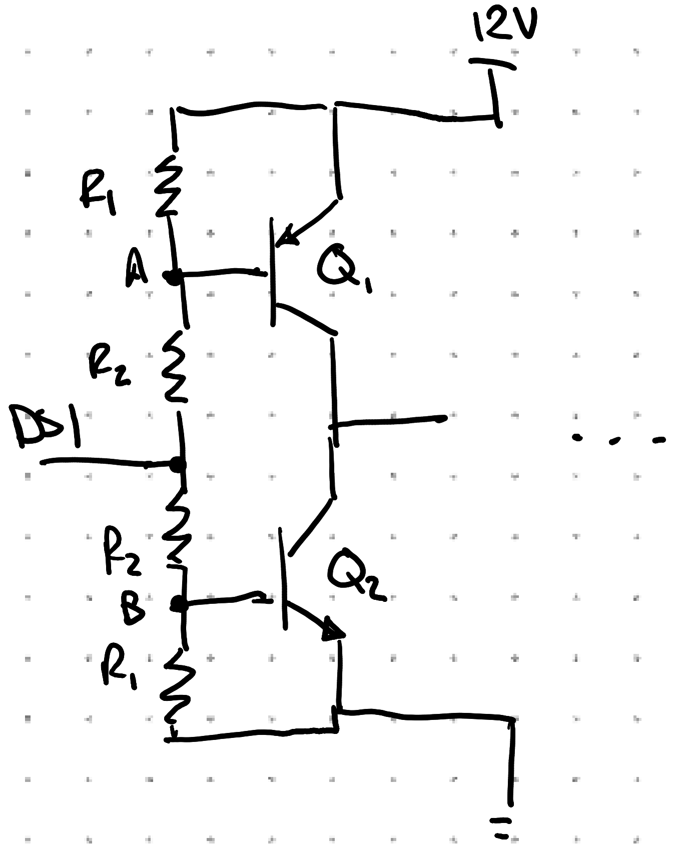
R_L itself limits the current

through b-e, preventing the

short

1.6 Without the resistors to the bases, when DS1 or DS2 is low (V- or GND) the top transistors would short circuit through b-e. When DS1 or DS2 is high (V+) the bottom transistors would short through b-e.

1.7



$\beta = 1000$

$R_1 = 180\ \Omega$
$R_2 = 1\ k\Omega$

When DS1 = 12 V : $V_A = 12V \quad \therefore Q_1$ OFF

$$V_B = 12 \cdot \frac{R_1}{R_1 + R_2}$$

$$= 12 \cdot \frac{180}{1180} = 1,83\ V$$

$\therefore Q_2$ ON

When DS1 = 0V : $V_A = 12 \cdot \frac{1000}{1180}$

$= 10.17\ V \quad \therefore Q_1$ ON

$V_B = 0V \quad \therefore Q_2$ OFF

When DS1 = 6 V: $V_B = 6 \cdot \frac{180}{1180}$

$= 0,915 \text{ V}$ ∴ Q_2 OFF

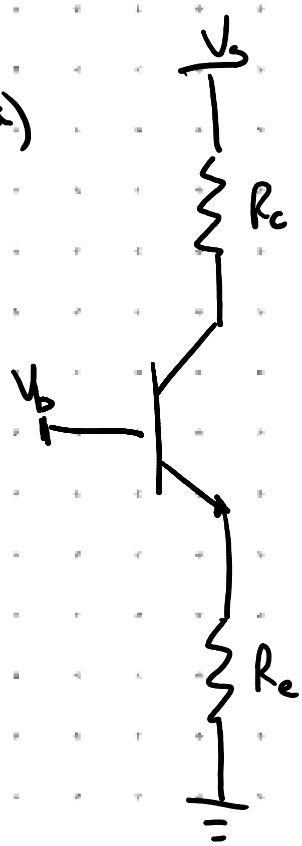
$V_A = 6 + (12-6) \cdot \frac{1000}{1180}$

$= 11,08 \text{ V}$

∴ Q_1 OFF

1,8

a)



$V_e = V_b - 0,7$

$i_e = \frac{V_e}{R_e} = \frac{V_b - 0,7}{R_e}$

$i_c = \left(\frac{\beta}{\beta+1}\right) i_e$

∴ $i_c = \left(\frac{\beta}{\beta+1}\right)\left(\frac{V_b - 0,7}{R_e}\right)$

and $i_c = \frac{V_s - V_c}{R_c}$

∴ $V_s - V_c = R_c \left(\frac{\beta}{\beta+1}\right)\left(\frac{V_b - 0,7}{R_e}\right)$

∴ $\frac{V_s - V_c}{V_b - 0,7} = \frac{R_c}{R_e} \cdot \frac{\beta}{\beta+1}$