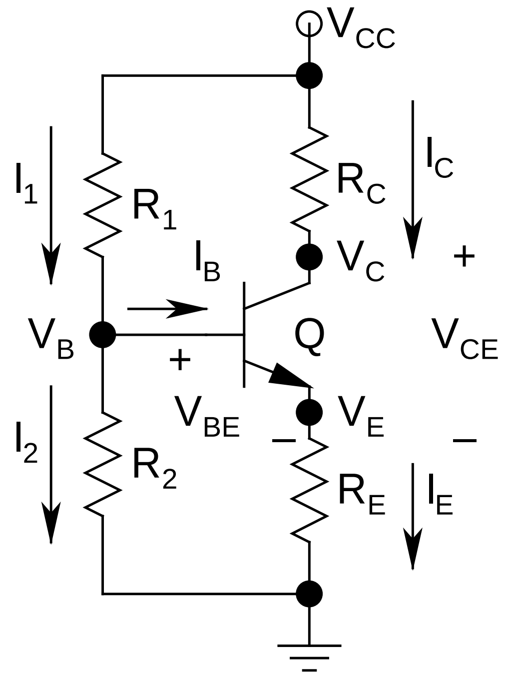
- ***Voltage Divider (or 4-Resistor) Bias***:
  - ***The best***: ***Extremely robust and versatile***
  - If properly designed, ***almost β independent***
  - If $I_1 \geq 10I_B$, $I_1 \approx I_2$

$$\Rightarrow V_B \simeq \frac{R_2}{R_1 + R_2} V_{CC}$$

$$\Rightarrow V_E = V_B - V_{BE} \text{ and } I_C \simeq I_E = V_E / R_E$$



- ***Example***: Let $V_{CC} = 5$ V, $R_1 = 40$ kΩ, $R_2 = 10$ kΩ, $R_C = 2$ kΩ, and $R_E = 300$ Ω
  - ***Quick estimate***: Assume $\beta \geq 100$

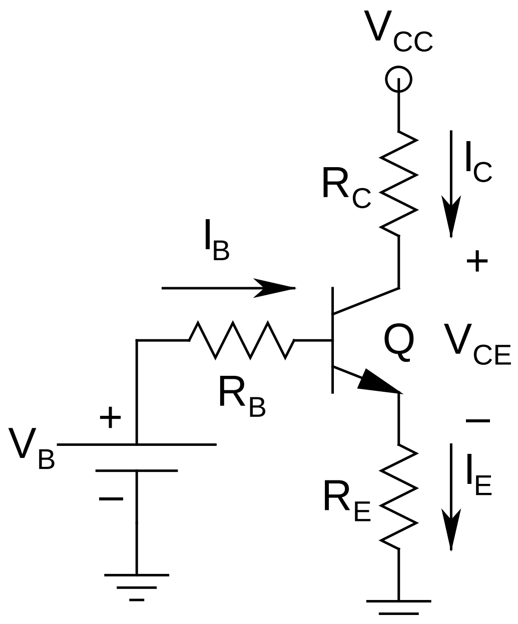
    $\Rightarrow V_B = 1$V, $V_E = 0.3$ V, $I_C \approx I_E = 1$ mA, $V_{CE} = 2.7$ V, and $P_D = 5.5$ mW

    $\Rightarrow$ Done! Piece of cake, isn't it?
  - $I_1 = 100$ μA and $I_B \leq 10$ μA (for $\beta \geq 100$): Assumption of $I_1 \geq 10I_B$ validated
  - Actually, ***as I_1 and β go down***, this ***analysis becomes more and more inaccurate***!

- ***Exact Analysis***:
  - ***Sufficiently more complicated***
  - ***Open the base lead*** and ***Thevenize the left branch***

$$\Rightarrow V_B = \frac{R_2}{R_1 + R_2} V_{CC} = 1\ \text{V}$$

$$R_B = R_1 \,||\, R_2 = 8\ \text{k}\Omega$$



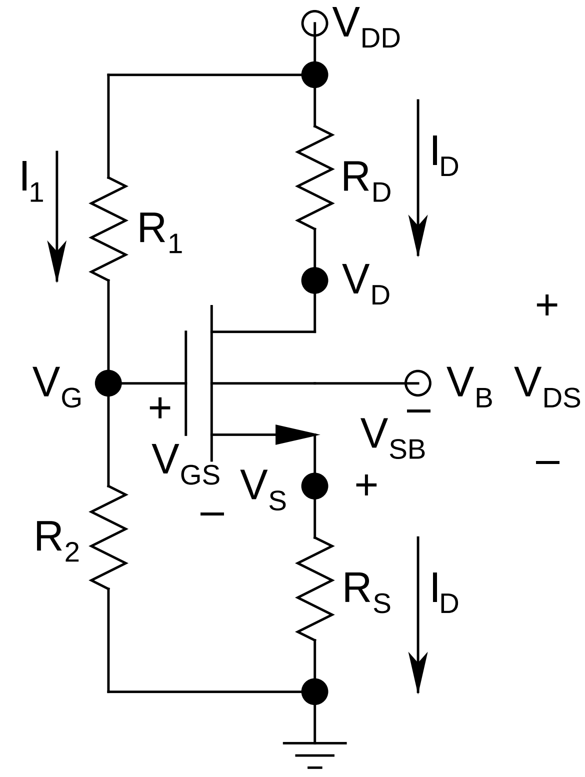
  - Also, $V_B = I_B R_B + V_{BE} + I_E R_E$

$$\Rightarrow I_B = \frac{V_B - V_{BE}}{R_B + (\beta + 1) R_E}$$

- Gives:
  - I_B = 7.83 μA, I_C = 0.78 mA, and V_{CE} = 3.2 V for β = 100 (***quite off from quick estimate***!)
  - I_B = 3.6 μA, I_C = 0.9 mA, and V_{CE} = 2.93 V for β = 250 (***within ±10% error band***)
- Thus, ***as β↑***, ***accuracy of quick estimate↑***
- Also, ***as*** R_B***↓***, ***accuracy↑***
- ***R_B should not be too small***, ***since*** P_D***↑↑***
- Thus, there are ***various design constraints***

Discrete Stage Biasing: MOSFET

- ***Almost universally biased using 4-Resistor Bias***
- ***Significantly more complicated than BJT biasing, since there is no quick estimate***
- ***Also, body effect and CLM complicate matters***



- ***No I_G*** $\Rightarrow$ ***R_1-R_2 combination provides a perfect voltage division***

$$\Rightarrow V_G = \frac{R_2}{R_1 + R_2} V_{DD}$$

- $V_S = I_D R_S$ and $V_D = V_{DD} - I_D R_D$

$$\Rightarrow I_D = \frac{k_N}{2}\left(V_G - I_D R_S - V_{TN}\right)^2 \times \left(1 + \lambda\left[V_{DD} - I_D\left(R_S + R_D\right)\right]\right)$$