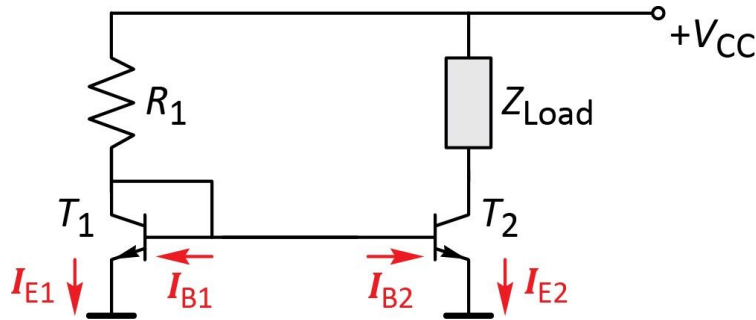


## Homework 08

1. **Current mirror:** This problem concerns a circuit that is generally known as a “current mirror.” The current mirror circuit diagram is shown below. The two Si transistors are identical with  $\beta_1 = \beta_2 = \beta = 100$ .



- Determine the voltage across  $R_1$  (symbolic expression).
  - Determine the current through  $R_1$ . Determine  $I_{E1}$  (symbolic expressions).
  - Determine  $I_{B1}$ . Determine  $I_{C1}$  (symbolic expressions).
  - Is  $I_{B2} = I_{B1}$ ? Is  $I_{E2} = I_{E1}$ ? Is  $I_{C2} = I_{C1}$ ? Justify your answers.
  - The load is an unknown quantity. Give the current through the load (symbolic expression).
  - Explain why the circuit is called a “current-mirror circuit”.
  - Can  $Z_{Load}$  be zero? Justify your answer.
  - Can  $Z_{Load}$  be infinite? Justify your answer.
  - What is the upper limit for  $Z_{Load}$  for the circuit to work properly?
  - Assume the following values:  $V_{CC} = 10\text{ V}$ ;  $R_1 = 500\ \Omega$ . Determine  $I_{C1}$  (numerical value).
  - Assume that the load is an LED (diode). Sketch the load circuit diagram. Determine the current through the diode (numerical value).
  - Assume that the load is two LEDs in series. Sketch the load circuit diagram. Determine the current through each diode (numerical value).
  - Assume that the load is two identical LEDs in parallel. Sketch the load circuit diagram. Determine the current through each diode (numerical value).
  - Is there a feature of the “current-mirror circuit” that we can appreciate?
2. **SRAM (static random access memory):** This problem concerns the design of a 4-resistor 2-transistor (BJT) SRAM cell (flip-flop) having a supply voltage of  $V_{CC} = 5.0\text{ V}$ . Assume that the BJT’s CE saturation voltage ( $V_{CE,sat}$ ) in the **ON** state is  $0.2\text{ V}$ . Assume that the current amplification of the transistors is  $\beta = 50$ .
- Draw the circuit diagram.
  - Choose one of the two stable states of the flip-flop, and indicate all circuit elements that consume power. Circle these circuit elements.

- (c) Write an equation for the power consumed by each of these circuit elements (circled under the previous question). Sum up all these powers (summands) to obtain the total power consumed by the circuit. Which of these summands represents the greatest power? Give the approximate power consumed by the circuit by writing an equation that has just the dominant summand.
- (d) Design a 4-resistor 2-transistor SRAM circuit in which the dominant power-consuming circuit element consumes a power of about  $1\ \mu\text{W}$ . What is the collector current? Suggest numerical values for the resistances of all four resistors.
- (e) What would be the power consumed by a 1 Gbit SRAM circuit using the memory cell you just designed? Do you have any comments on the result?