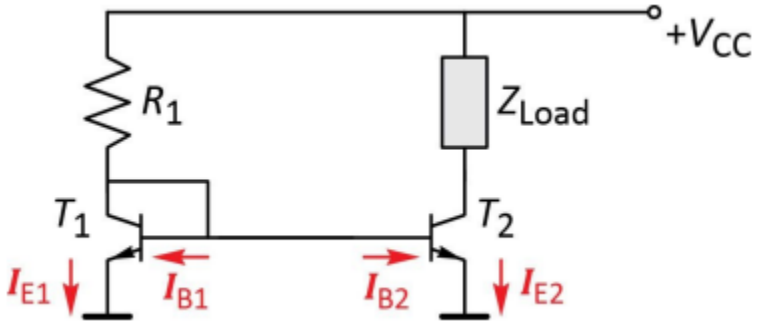
Hayden Fuller
Intro to Electronics HW8

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 β1 = β2 = β = 100.



   a. (a) Determine the voltage across R1 (symbolic expression).

V(R1)=VCC-VBE=I(R1)*R1=(IC1+IB1+IB2)*R1

   b. (b) Determine the current through R1 . Determine I E1 (symbolic expressions).

I(R1)=(VCC-VBE)/R1=IC1+IB1+IB2=IB*(B+2)
IE1=IB1+IC1=(B+1)*IB

   c. (c) Determine IB1 . Determine I C1 (symbolic expressions).

   d. (d) Is IB2 = IB1? Is I E2 = I E1? Is I C2 = I C1? Justify your answers.

Yes, they’re all coming from the same node and go to the same node across identical components.

   e. (e) The load is an unknown quantity. Give the current through the load (symbolic expression).

Iload=IC2=B*IB2=B*IB1=IR1

   f. (f) Explain why the circuit is called a “current-mirror circuit”.

The current through the load is a mirror of the current flowing through the resistor

   g. (g) Can ZLoad be zero? Justify your answer.

Yes, only and only the mirrored current will flow.

   h. (h) Can ZLoad be infinite? Justify your answer.

No, as the transistors are unable to push the current needed through an infinite load

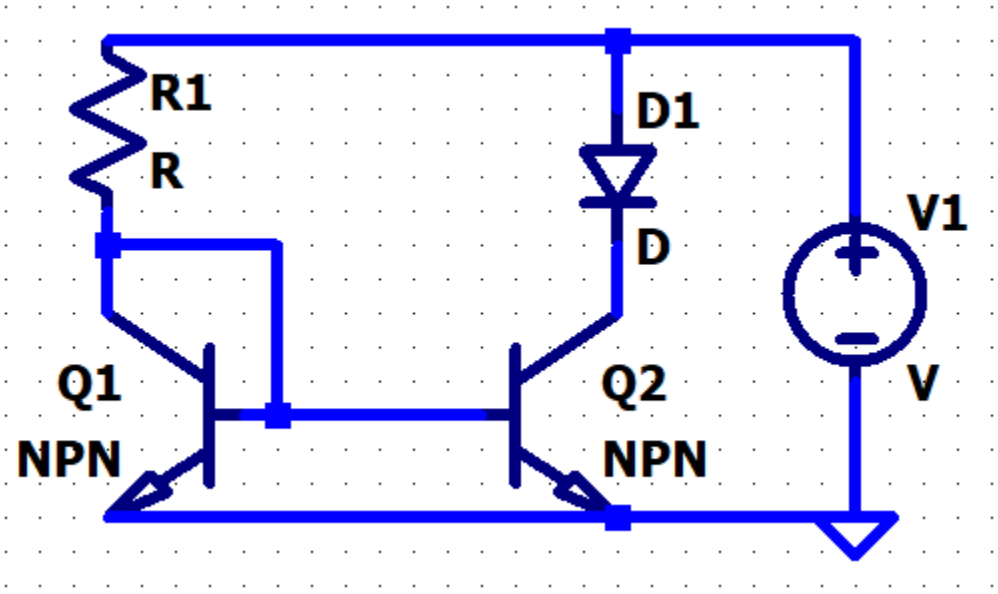
   i. (i) What is the upper limit for ZLoad for the circuit to work properly?

ZloadMax=(VCC-VBE)/IR1

   j. (j) Assume the following values: VCC = 10 V; R1 = 500 Ω. Determine I C1 (numerical value).

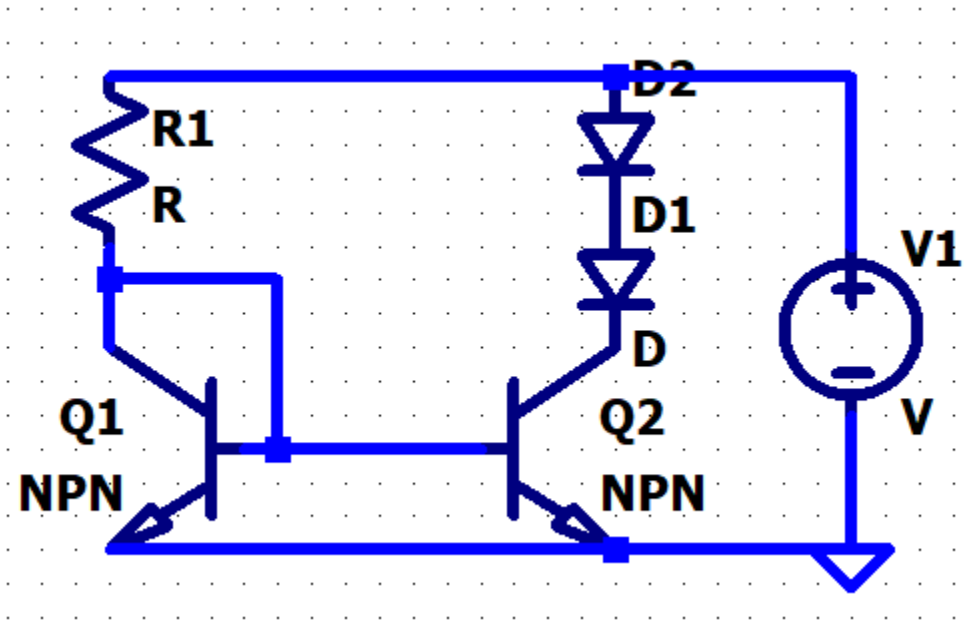
VR1=10-.7=9.3V
IR1=18.6mA
IR1=IC1+IB1+IB2=1.02 IC1
IC1=18.6/1.02=18.24mA

k. (k) Assume that the load is an LED (diode). Sketch the load circuit diagram. Determine the current through the diode (numerical value).



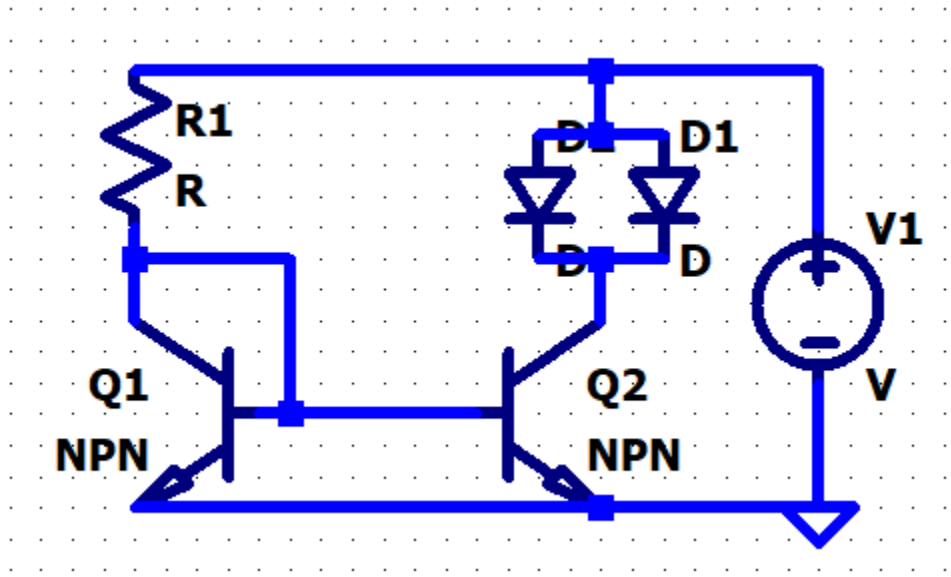
18.6mA

l. (l) Assume that the load is two LEDs in series. Sketch the load circuit diagram. Determine the current through each diode (numerical value).



18.6mA

m. (m)Assume that the load is two identical LEDs in parallel. Sketch the load circuit diagram. Determine the current through each diode (numerical value).

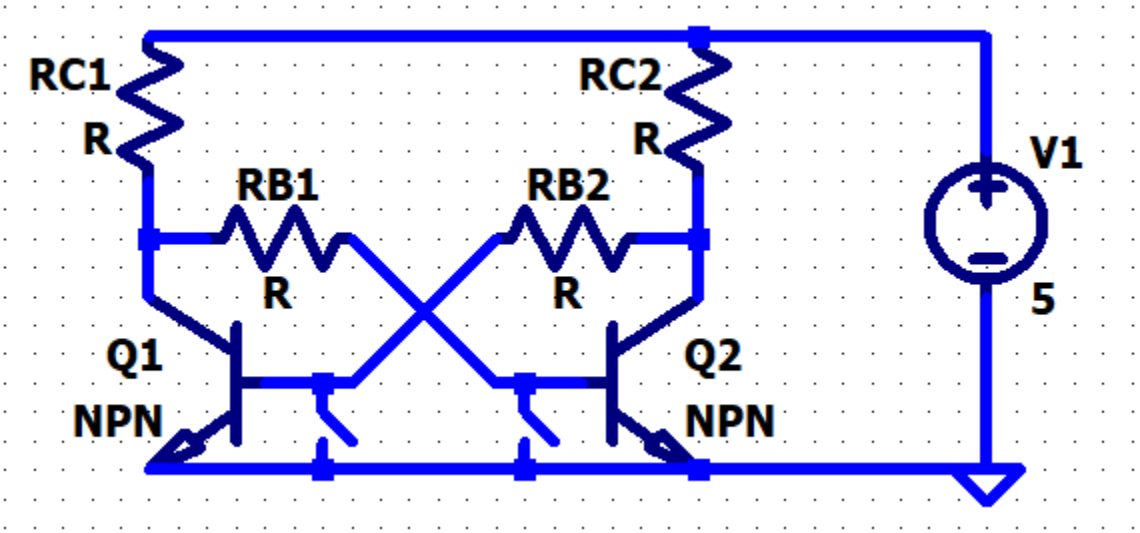


9.3mA

n. (n) Is there a feature of the “current-mirror circuit” that we can appreciate?

It acts as a constant current source, which is useful for current dependent devices like LEDs

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 VCC = 5.0 V. Assume that the BJT’s CE saturation voltage (VCE,sat) in the ON state is 0.2 V. Assume that the current amplification of the transistors is β = 50.
   a. (a) Draw the circuit diagram.



Note: RB>RC

b. (b) Choose one of the two stable states of the flip-flop, and indicate all circuit elements that consume power. Circle these circuit elements.

Q1 on
Consuming power: RC1, RC2, RB2, Q1
Not consuming power: RB1, Q2

c. (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.

IB1=(VCC-.7)/(RC2+RB2)
PRC2+PRB2=(VCC-.7)^2/(RC2+RB2)
PRC1=(50*IB1)^2 *RC1=2500 RC1 (VCC-.7)^2/(RC2+RB2)^2
PQ1=.7*(IB+IC)=.7*(51*IB)=35.7*(VCC-.7)/(RC2+RB2)
P=(VCC-.7)^2/(RC2+RB2) + 2500 RC1 (VCC-.7)^2/(RC2+RB2)^2 +
.7*(IB+IC)=.7*(51*IB)=35.7*(VCC-.7)/(RC2+RB2)
P~=VCC^2/RC

d. (d) Design a 4-resistor 2-transistor SRAM circuit in which the dominant power-consuming circuit element consumes a power of about 1 μW. What is the collector current? Suggest numerical values for the resistances of all four resistors.

VCC^2/RC=1uW
RC=1Meg*VCC^2
VCC=1
RC=1Meg
RB=10Meg
IC=50(VCC-.7)/(RC2+RB2)=1.3uA

e. (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?

1uW*1G=1kW, it takes a lot of power