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Intro to Electronics HW5

1. A bipolar junction transistors (BJT) is characterized by various quantities, for example the thermal voltage (Vt), alpha (α), beta (β), and the BE threshold voltage (Vth).
    a. Describe the meaning of each of these quantities and give (approximate) associated numerical values.

Vt kTq, Voltage between p and n junctions due to temperature, 26mV
α CE current amplification, IC=αIE, α~<1, α~=0.99
β CB current amplification IC=βIB a/(1-a), β>>1, β~=100
Vth pn junction turn on voltage, Vth~=0.7V

    b. Which one of these quantities is best suited to help us understand the physical operation of a BJT? Explain your answer.

Vth, it helps us understand the pn junctions that the BJT is made of

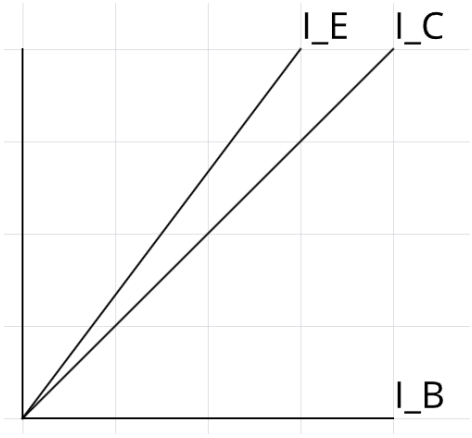
    c. Which one of these quantities is most relevant in the practice of BJTs? Explain your answer.

β, it is what is often how we amplify our signal

    d. Which of these quantities depends strongly on a geometrical dimension (thickness of the base layer) of the BJT? Explain your answer.

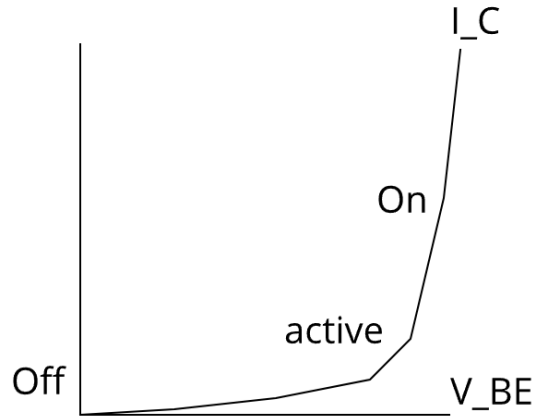
α and β, amplification increases with a thinner base layer

2. This problem relates to a bipolar junction transistor (BJT).
    a. Draw the IE-versus-IB characteristic (IE vertical axis (ordinate) and IB horizontal axis (abscissa)) of a generic BJT. In the same diagram, draw the IC -versus-IB characteristic of a BJT. Explain the characteristic.



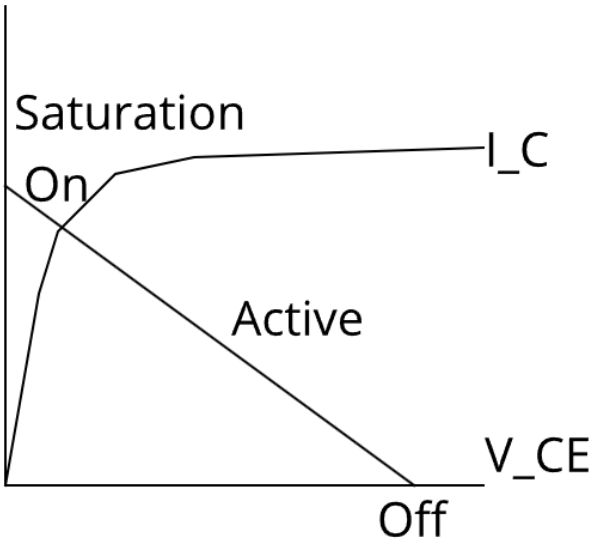
IC=beta * IB
IE=IB+IC=(beta+1) * IB

    b. Draw the IC -versus-VBE characteristic of a BJT. In the drawing, show the BJT's forward active region (ON region) and cutoff region (OFF region). Explain the characteristic.

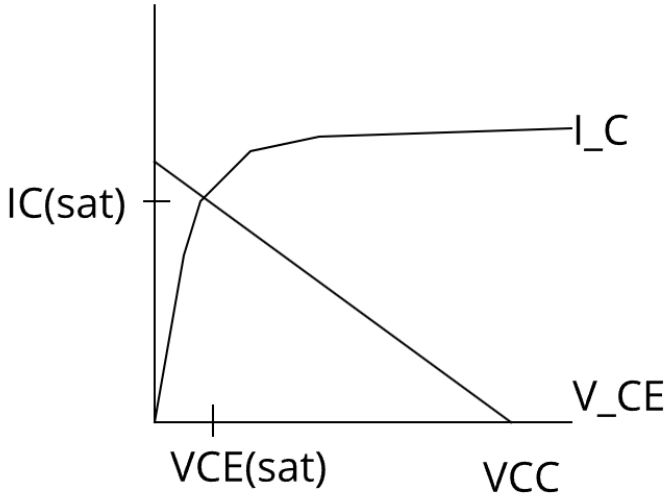


There's a diode like characteristic where once VBE hits a threshold, IC is allowed to flow with little resistance.

    c. Draw the output characteristic IC -versus-VCE of a BJT. In the drawing, show the BJT's forward active region (ON region), cutoff region (OFF region), and saturation region.

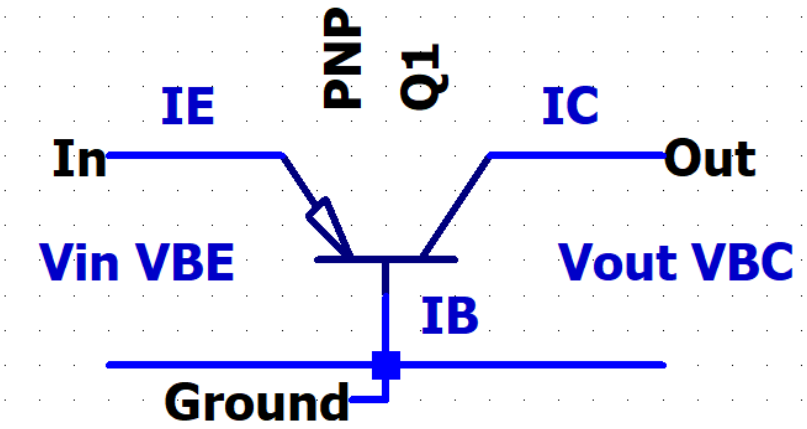


d. Sketch the IC -versus-VCE characteristic and indicate the saturation voltage.A typical value of the saturation voltage is 0.2 V. Can you give a quantitative justification of that typical value?

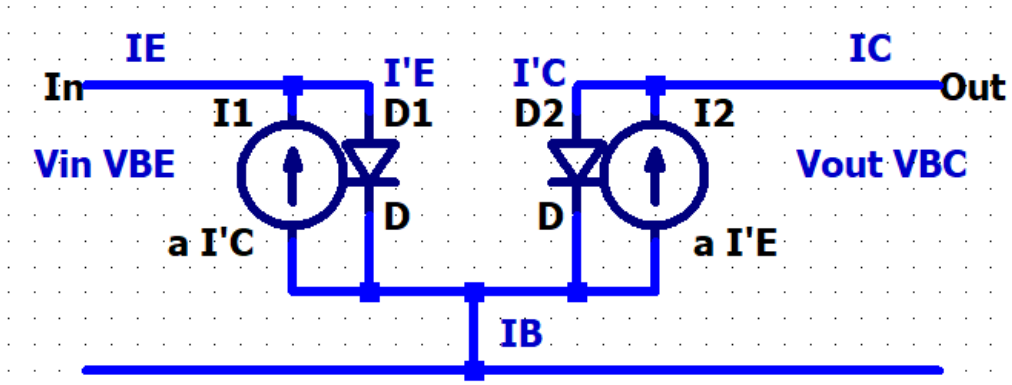


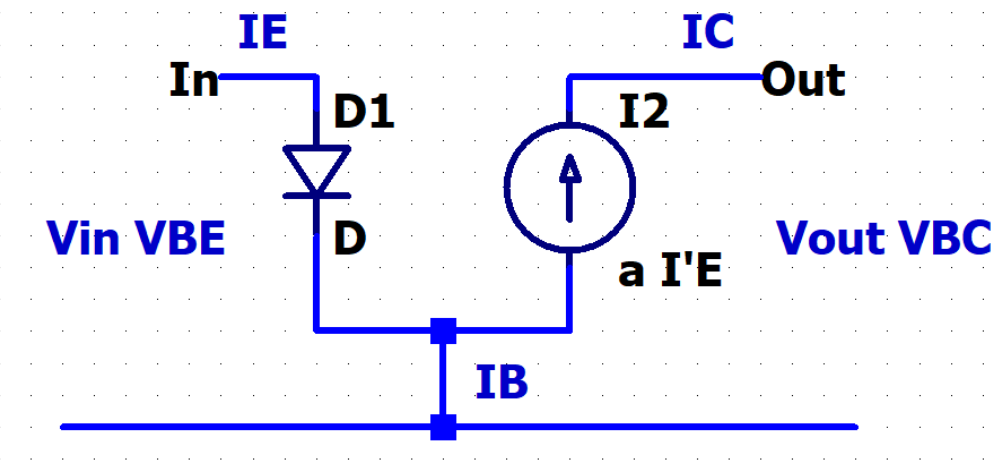
I won't lie, I've spent over an hour researching an equation for VCE(sat) or BJT knee voltage, I've found absolutely nothing. It's between 0.1V and 0.3V, often said to be 0.2V.

3. This problem relates to a bipolar junction transistor (BJT) having a current amplification α in common-base (common-B) configuration.
    a. Draw a common-B BJT amplifier circuit of a pnp BJT (without sources and without resistors). Label all input and output quantities.



    b. Draw the large-signal equivalent circuit of the transistor circuit (for the forward active operating regime); the equivalent circuit should not use the transistor circuit symbol. Define all quantities used in the equivalent circuit.

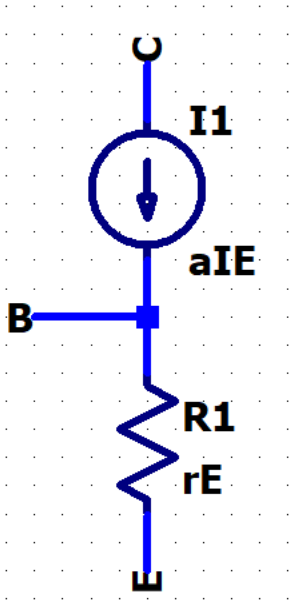




Vin=VBE, Voltage between the Base and Emitter

Vout=VBE, Voltage between Base and Collector
a * IE, output = amplification * input

c. Draw the AC small-signal equivalent circuit (for the forward active operating regime). Define all quantities used in the circuit.



rE = Vt / IE
IC = a * IE

d. Can you comment on the input resistance of the circuit? Do we generally prefer an amplifier having a small or large input resistance?

Smaller input resistances are preferred because that gives a more ideal source and higher amplification.