Bipolar Junction Transistors

Introduction

PHY2003 does not require a knowledge of the semiconductor physics underlying *how* transistors work, they are treated as nonlinear three-terminal devices. Figure 1 defines the current conventions used in PHY2003. The rules-of-thumb for analysing bipolar junction transistor (BJT) circuits at low-frequencies are:

$$\begin{aligned} &\text{NPN:} \quad V_C > V_B = V_E + 0.6\ \text{V} \\ &\text{PNP:} \quad V_C < V_B = V_E - 0.6\ \text{V} \end{aligned} \tag{9.1}$$

$$\text{if} \left\{ \begin{aligned} &\text{NPN:} \quad V_B < V_E + 0.6\ \text{V} \\ &\text{PNP:} \quad V_B > V_E - 0.6\ \text{V} \end{aligned} \right\} \text{then } I_C = 0 \text{ else } I_C = h_{FE} I_B \tag{9.2}$$

$$\text{typically } 50 < h_{FE} < 500 \quad \text{therefore} \quad I_E \approx -I_C. \tag{9.3}$$

Required Reading

Bipolar Transistors – Storey (1998) §7.1–7.7 pp. 234–295 / (2006) §8.1–8.8 pp. 221–284.
Another source of the required information are the WWW references listed under:
<http://newton.ex.ac.uk/teaching/CDHW/Electronics2/ElectronicsResources.html#xistors>

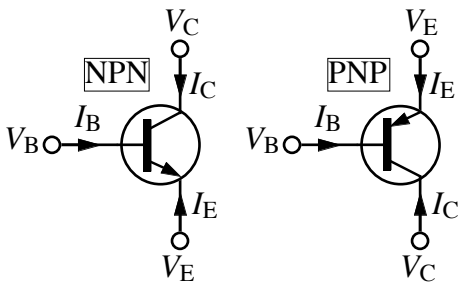
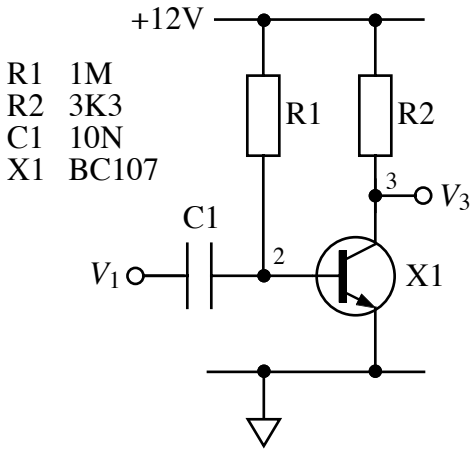
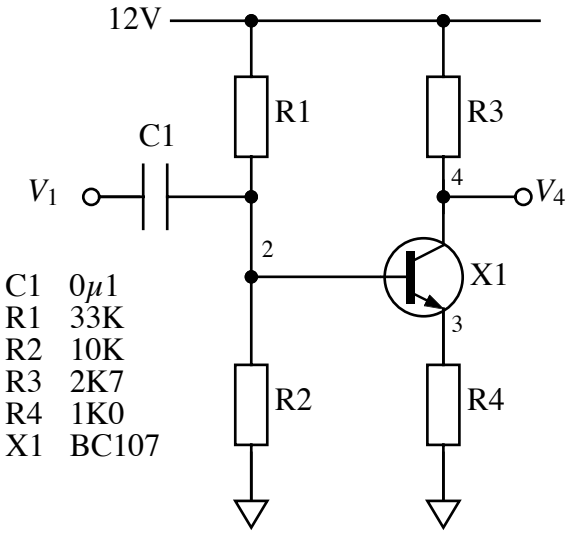


Figure 9.1 Current conventions



Circuit 9.1 Common Emitter Amplifier



Circuit 9.2 Series Feedback Amplifier

Exercise 9.1 Analyse circuit 9.1 using typical values from the BC107 datasheet and find:

(a) the quiescent voltage at node 3,

(b) the DC impedance of node 2 and hence the low-frequency –3 dB point

(c) the small-signal voltage gain v_3/v_1 at 1 kHz and 10 kHz.

Answers: (a) 6.4 V (assuming HFE = 150) (b) 2.2 kΩ, 7.2 kHz (c) –60 and –400

Exercise 9.2 Analyse circuit 9.2 using typical values from the BC107 datasheet and find:

(a) the quiescent voltage at node 3

(b) the quiescent voltage at node 4

(c) the small-signal gain v_4/v_1 at 1kHz

Answers: (a) 2.1 V (b) 6.3 V (b) –60 and –400 (c) $v_4/v_1 = -2.7$
