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EPE 2165—Analog Electronics

EXERCISE #—3: MOSFET CIRCUITS

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Section 6.1: Device Structure and Physical Operation

6.1

For an *npn* BJT operating in the active region, find the following:

(a) The change in the base-emitter voltage v_{BE} if the current i_C is doubled.

(b) The change in the base-emitter voltage v_{BE} if the current i_C is increased by a factor of 10.

(c) The percentage change in i_C corresponding to changes in v_{BE} of $+0.5\,\text{mV}$, $-0.5\,\text{mV}$, $+1\,\text{mV}$, $-1\,\text{mV}$, $+2\,\text{mV}$, $-2\,\text{mV}$, $+5\,\text{mV}$, $-5\,\text{mV}$, $+10\,\text{mV}$, and $-10\,\text{mV}$. Present the results in a table and comment.

(d) The values of α and β if at $i_C = 1\,\text{mA}$ the base current i_B is measured as 12.5 μA. What is the corresponding value of emitter current?

(e) The saturation current I_S if at $i_C = 1\,\text{mA}$ the base-emitter voltage $v_{BE} = 675\,\text{mV}$.

(f) The base-emitter voltage that results if two identical transistors are connected in parallel and the total collector current in the parallel combination is 1 mA.

Section 6.2: Current–Voltage Characteristics

6.2

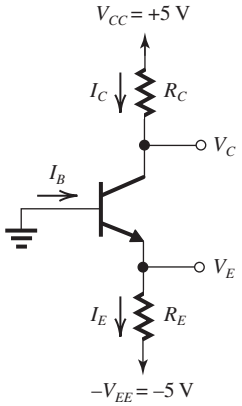


Figure 6.2.1

The BJT in the circuit in Fig. 6.2.1 has $\beta = 100$. Resistance R_E is $5\,\text{k}\Omega$. The voltages V_E and V_C are measured and found to be $-0.68\,\text{V}$ and $+1.58\,\text{V}$, respectively.

(a) In what mode is the BJT operating?

(b) Find I_E, I_B, and I_C.

(c) What must R_C be?

(d) Redesign the circuit to obtain a collector current of 2 mA and a collector voltage $V_C = +1\,\text{V}$. What are the new values of R_E and R_C?

6.3

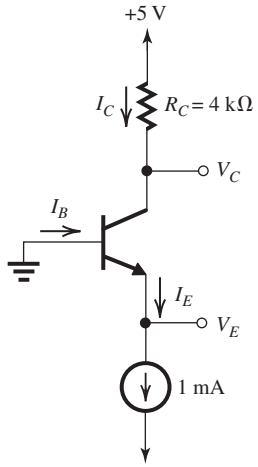


Figure 6.3.1

The BJT in the circuit of Fig. 6.3.1 is specified to have $I_S = 10^{-15}$ A and β in the range 50 to 200. Find the expected range of I_E, α, I_C, V_C, I_B, V_{BE}, and V_E. Comment on the results obtained.

6.4

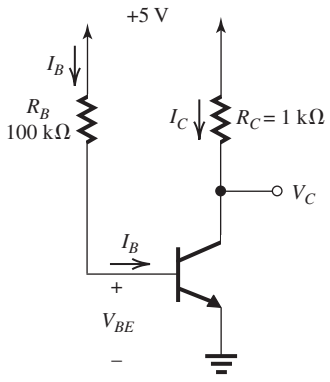


Figure 6.4.1

The transistor in the circuit in Fig. 6.4.1 is specified to have β in the range 50 to 200. Assuming that V_{BE} remains in the vicinity of 0.7 V, find the range of I_B, I_C, and V_C. Comment on the results obtained.

6.5

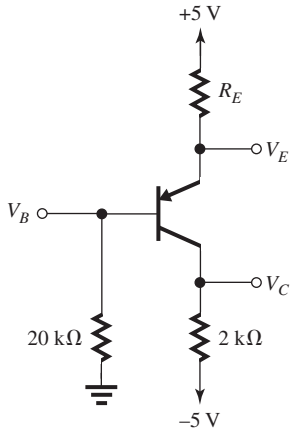


Figure 6.5.1

The *pnp* transistor utilized in the circuit in Fig. 6.5.1 exhibits a voltage $V_{EB} = 0.7$ V when the collector current $I_C = 1$ mA. The voltages at the base and collector are measured and found to be $V_B = +0.5$ V and $V_C = -1$ V. What must the transistor β and the resistance R_E be?

6.6

An *npn* transistor for which $V_A = 100$ V has V_{BE} adjusted to provide a collector current of 1 mA at $V_{CE} = 1$ V.

(a) What is the value of r_o at the operating point specified, that is, at $I_C = 1$ mA and $V_{CE} = 1$ V?

(b) If V_{CE} is increased by 10 V, what does I_C become?

(c) If, at $V_{CE} = 1$ V, V_{BE} is adjusted to obtain $I_C = 0.1$ mA, what does r_o become? Now, if V_{CE} is increased by 10 V, what does I_C become?

Section 6.3: BJT Circuits at DC

6.7

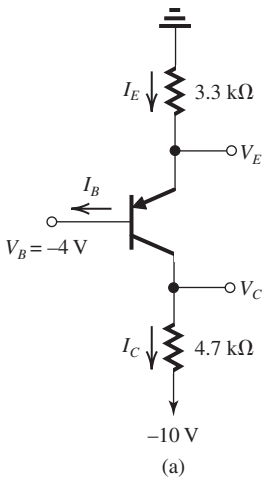
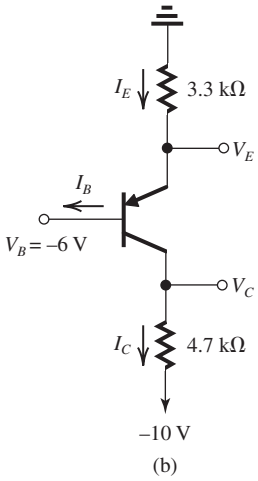
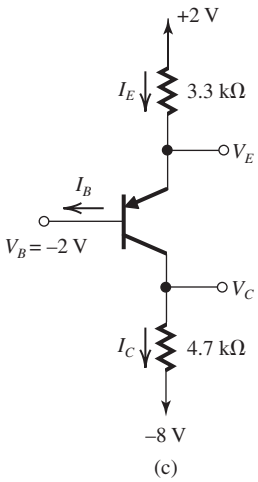


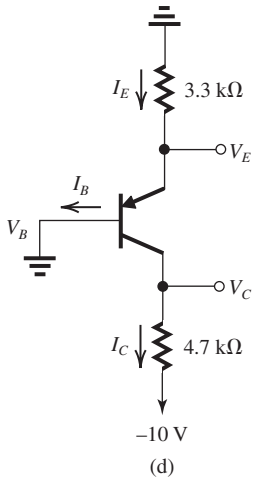
Figure 6.7.1 ***continues***



(b)

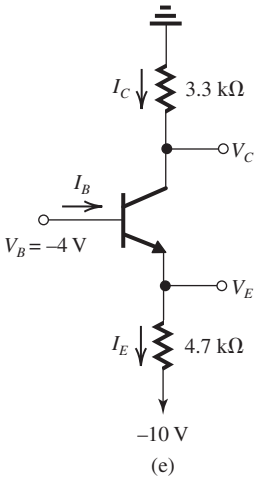


(c)

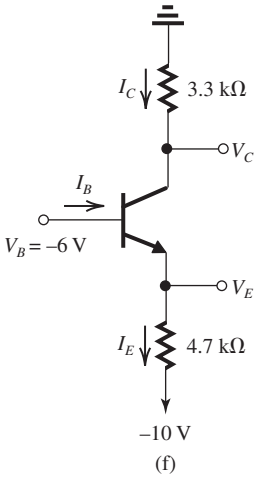


(d)

Figure 6.7.1 ***continued***



(e)



(f)

Figure 6.7.1 ***continued***

For the circuits in Fig. 6.7.1, find node voltages, V_E and V_C, and branch currents, I_E, I_C, and I_B. Use $|V_{BE}| = 0.7$ V for a conducting transistor, and $\beta = 50$.

D6.8

For the circuits in Fig. 6.7.1(a) and (b), find emitter and collector resistors (to replace the present ones) such that $I_E = 0.5$ mA and $V_{BC} = 0$ V for $\alpha = 1$.

D6.9

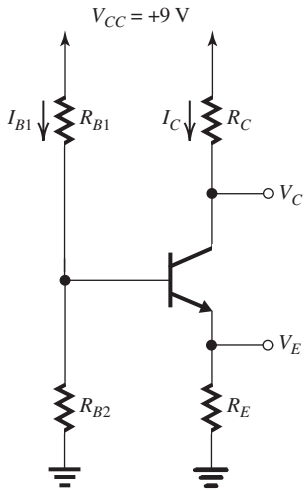


Figure 6.9.1

Design the circuit in Fig. 6.9.1 to operate the transistor at $I_C = 1$ mA, $V_C = +5$ V, $V_E = +3$ V, and $I_{B1} = 0.1$ mA. Assume $V_{BE} = 0.7$ V and $\beta = 100$.

D6.10

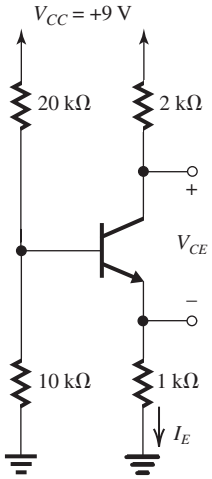


Figure 6.10.1

For the circuit shown in Fig. 6.10.1, find I_E and V_{CE} for $V_{BE} = 0.7$ V and (a) $\beta = \infty$, (b) $\beta = 100$, and (c) $\beta = 10$.

6.11

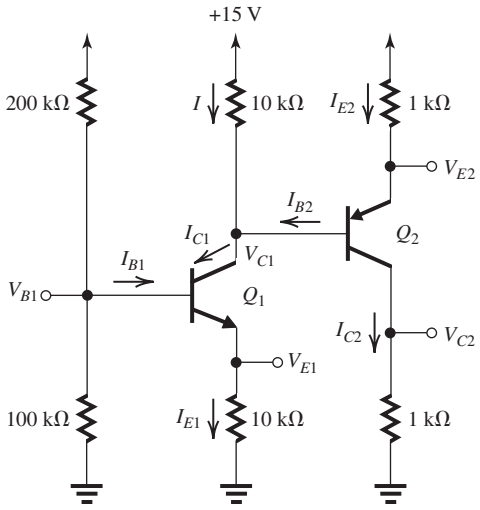


Figure 6.11.1

For the circuit shown in Fig. 6.11.1, find the values of all labeled currents and voltages for the two cases: (a) $\beta = \infty$ and (b) $\beta = 100$. Assume $V_{BE1} = V_{EB2} = 0.7$ V.

6.12

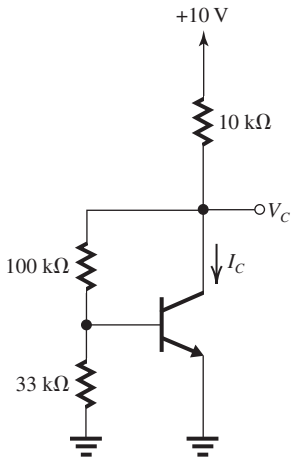


Figure 6.12.1

For the circuit in Fig. 6.12.1, the BJT has $V_{BE} = 0.7$ V and $\beta = 50$. Find I_C and V_C.