1. (10 points) FoEE 7.27

7.27 For the circuit shown in Fig. P7.27, suppose that $R_B = 230\ k\Omega$, $R_{E1} = 400\ \Omega$, $R_{E2} = 0\ \Omega$, $R_C = 100\ \Omega$, and $V_{CC} = 6$ V. Given that the BJTs have $\beta = 100$, verify that the transistors are in the active region by finding i_{C1}, v_{CE1}, i_{C2}, and v_{CE2}.

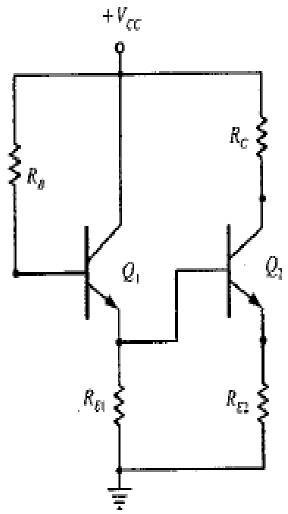
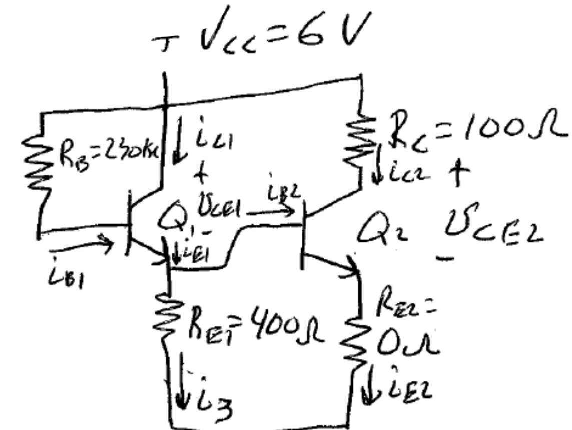


Fig. P7.27

$\beta = 100$



If we are asked to verify that the transistors are on, then we can assume on and confirm that there are no contradictions.

If Q_1 & Q_2 are on: $v_{BE_1} = 0.7V$, $v_{BE2} = 0.7V$

$i_{c1} = \beta i_{B1} = 100 i_{B1}$ and $i_{c2} = 100 i_{B2}$

so, KVL: $6 = 230K(i_{B1}) + v_{BE1} + v_{BE2} + i_{E2}R_{E2}$

$6 = 230{,}000\, i_{B1} + 1.4$

$\therefore i_{B1} = 20\,\mu A.$

$i_{c1} = 100 i_{B1}$ $\therefore \boxed{i_{c1} = 2\,mA}$

$i_{B2} = i_{E1} - i_3$ $\qquad i_3 = \dfrac{v_{BE2}}{400\Omega} = \dfrac{0.7}{400} A$

$i_{E1} = i_{B1} + i_{c1} = 2.02\,mA$

$\therefore i_{B2} = 2.02\,mA - 1.75\,mA = 270\,\mu A$

$\therefore \boxed{i_{c2} = 100 \cdot 27\mu A = 27\,mA}$

By KVL: $\boxed{v_{CE1} = 6 - v_{BE2} = 5.3V}$

By KVL: $\boxed{v_{E2} = 6 - i_{c2}(R_c) = 3.3V}$

2. (10 points) FoEE 7.91

7.91 The RTL circuit shown in Fig. P7.91 is a NAND gate. The low voltage is 0.4 V and the high voltage is 1.2 V. Determine whether each transistor is OFF or ON, and find the minimum values of h_{FE} for (a) $v_1 = v_2 = 0.4$ V; (b) $v_1 = 0.4$ V, $v_2 = 1.2$ V; (c) $v_1 = 1.2$ V, $v_2 = 0.4$ V; and (d) $v_1 = v_2 = 1.2$ V.

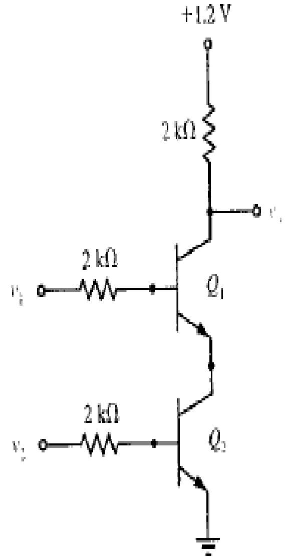
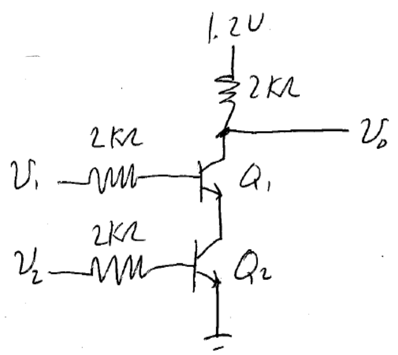


Fig. P7.91



Low V = 0.4 V
High V = 1.2 V

a) By looking at V_1, V_2 we know Q_2 is off.
$V_1 = V_2 = 0.4V$ V_{BE2} isn't high enough to turn it on.
$\therefore\ i_{B2} = 0,\ i_{C2} = 0.$
If $i_{C2} = 0$ $i_{E1} = 0.$
$V_{BE1} < 0.5V$ so Q_1 is off.
No current flows, so, $V_o = 1.2V.$

b) $V_1 = 0.4V$, $V_2 = 1.2V$
Here, Q_2 is on since $V_2 > 0.5V$.
$i_{B2} = \frac{V_2 - V_{BE2}}{2K} = 0.2mA$
Since $V_1 < 0.5$, Q_1 is OFF ... so, $i_{B1} = 0, i_{C1} = 0$
$i_{C1} = i_{E1} = i_{C2} = 0A.$
Since $h_{FE2} = \frac{i_{C2}}{i_{B2}} = \frac{0}{2mA} = 0.$
$V_o = 1.2V$

c) $V_1 = 1.2V$, $V_2 = 0.4V$. $V_{BE2} < 0.5 \therefore$ Q_2 is off
So, $i_{B2} = i_{C2} = 0$
If Q_1 is ON, so $i_{B1} > 0A$ $i_{E2} = i_{E2} = i_{B2} + i_{C2}$
this is $> 0A$.
So, Q_1 is off.
$\therefore\ V_o = 1.2V$

d) $V_1 = V_2 = 1.2V$. So, assume both Q_1 & Q_2 are on.
$i_{B2} = \frac{V_2 - V_{BE2}}{2K} = 0.2mA$
$i_{B1} = \frac{V_1 - (V_{BE1} + V_{CE2})}{2K} = 0.1mA$
$\boxed{V_o = V_{CE1} + V_{CE2} = 0.4V.}$
$i_{C1} = \frac{1.2 - 0.4}{2K} = 0.4mA.$
Also, $i_{C2} = i_{B1} + i_{C1} = 0.1mA + 0.4mA$
$= 0.5mA$
$\boxed{h_{FE1} \geq \frac{i_{C1}}{i_{B1}} = 4 \quad h_{FE2} \geq \frac{i_{C2}}{i_{B2}} = 2.5}$

3. (10 points) FoEE 8.11

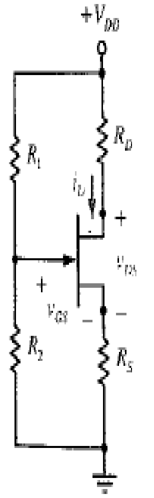
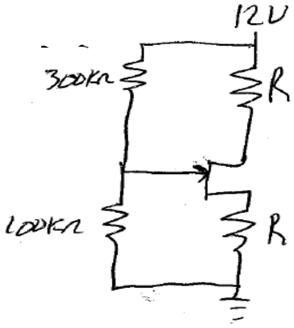
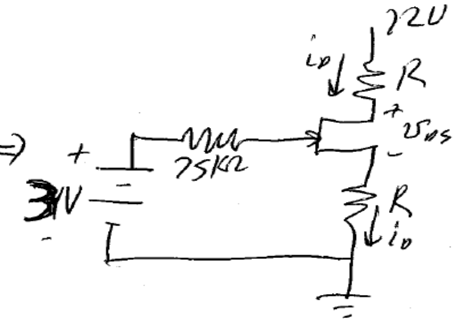


Fig. P8.10

8.11 For the circuit shown in Fig. P8.10, the JFET has $I_{DSS} = 12$ mA and $V_p = -4$ V. Given that $R_1 = 300$ kΩ, $R_2 = 100$ kΩ, $R_D = R_S = R$, $V_{DD} = 12$ V, and $v_{DS} = 6$ V, determine (a) v_{GS}, (b) i_D, and (c) R. (*Hint:* Use Thévenin's theorem.)





a) $V_{DS} = 6V$ By KVL, $12 = R i_D + v_{DS} + R i_D$
$= 2R i_D + 6$
$\therefore R i_D = 3$
By KVL: $3 = 75K(i_G) + v_{GS} + R i_D$
$= 0 + v_{GS} + R i_D$
$\therefore \underline{v_{GS} = 0\,V}$

b) $v_{DS} = 6V > V_{GS} - V_P = 4V$ JFET is active.
So $\underline{i_D = I_{DSS}\left(1 - \frac{v_{GS}}{V_P}\right)^2 = I_{DSS} = 12\,mA.}$

c) From (a) $R i_D = 3$ so, $\underline{\frac{3}{i_D} = R_D = 250\,\Omega}$

4. (0 points) FoEE 7.13

7.13 The BJT in the circuit shown in Fig. P7.10 has $\beta = 100$. Suppose that $R_1 = 60$ kΩ, $R_2 = 30$ kΩ, and $V_{CC} = 6$ V. Find R_E and R_C such that the transistor is biased in the active region at $i_C = 2$ mA and $v_{CE} = 2.1$ V.

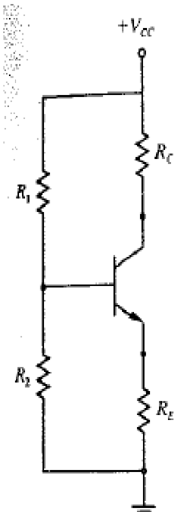
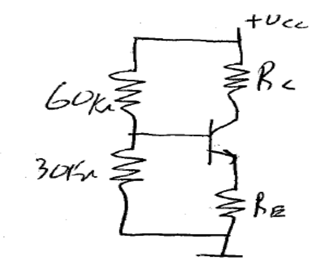
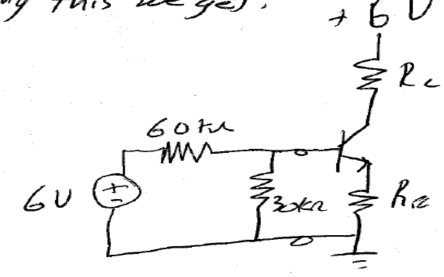


Fig. P7.10

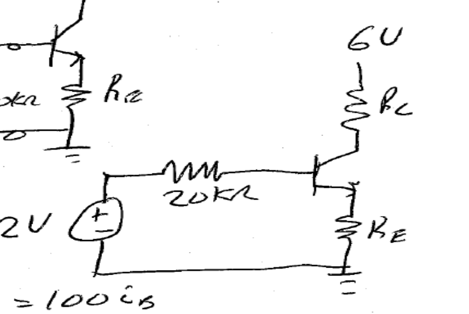


$i_c = 2\,mA$ $v_{CE} = 2.1\,V$
$\beta = 100$

Redrawing this we get:



Using Thevenin, we get



if $i_c = 2\,mA$ $i_c = \beta i_B = 100 i_B$
So, $i_B = 20\mu A$
$\underline{\text{By KVL}}$: $2 = 20k(i_B) + v_{BE} + R_E(i_B + i_c)$
$2 = 20{,}000(20\mu A) + 0.7 + R_E(101 \cdot 20\mu A)$
$R_E = 446\,\Omega$

KVL again ⇒ $i_c R_c + v_{CE} + i_E R_E = 6$ ⇒ $R_c = 1.5\,K\Omega$

5. (0 points) FoEE 8.33

8.33 For the circuit given in Fig. P8.32, the enhancement MOSFET has $K = 0.25\ \mathrm{mA/V^2}$ and $V_t = 2$ V. Given that $R_S = 0\ \Omega$ and $V_{DD} = 16$ V, determine the value of R_D for which the enhancement MOSFET will operate on the border between the active and the ohmic regions when V_{GG} is (a) 4 V and (b) 10 V.

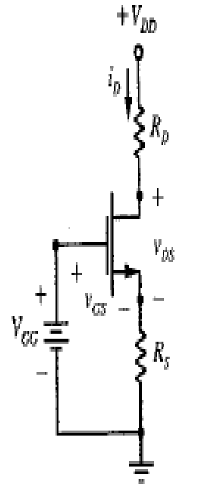
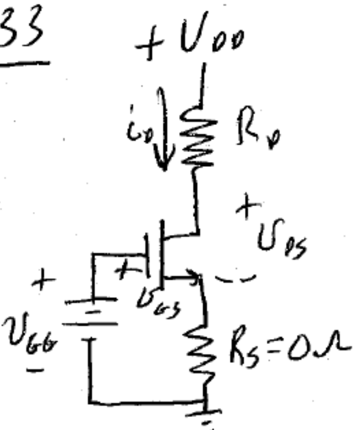


Fig. P8.32

5) FoEE 8.33



Given: $K = 0.25\ \mathrm{mA/V^2}$
$V_t = 2V$
$V_{DD} = 16V$

At the border $v_{DS} = v_{GS} - V_t$

In (a) $V_{GG} = 4V$, so $v_{GS} = 4V$, so $v_{DS} = 2V$

using $i_D = K(v_{GS} - v_t)^2 = 1\,mA$

By KVL: $16 = R_D i_D + v_{DS} = R_D(1mA) + 2$

$\therefore \boxed{R_D = 14\,K\Omega}$

In (b) $v_{GG} = 10V$, so $v_{GS} = 10V$, so $v_{DS} = 8V$

Again $i_D = K(v_{GS} - v_t)^2 = 16mA$ By KVL we find $\boxed{R_D = 500\Omega}$