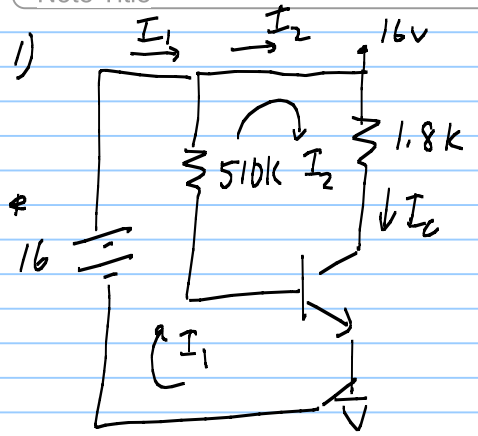
Chpt 4 # 1, 3, 4, 5, 6, 8, 15, 21, 24, 27, 33

Note Title 10/8/2012

1)



* Add V source on left of circuit

loop 1: $16 - 510k\,I_1 - 0.7 + 510k\,I_2 = 0$

loop 2: SPECIAL!

use $I_C = \beta I_B$ $\quad I_C = I_2$ $\quad I_B = I_1 - I_2$ $\quad \beta = 120$

$I_2 = \beta (I_1 - I_2)$

$I_2 + \beta I_2 = \beta I_1$

$I_2 (1 + \beta) = \beta I_1$

$I_2 = \frac{120 I_1}{121} = 0.99174 I_1$ put in loop 1

$16 - 0.7 = 510k (I_1 - I_2) = 510k (I_1 - 0.99174 I_1)$

$15.3 = 510k (1 - 0.99174) I_1$

$I_1 = \frac{15.3V}{4.214876k} = 3.63mA$

$I_2 = \frac{120}{121} \cdot 3.63\mu A = 3.6mA$

a) $I_{B_Q} = I_1 - I_2$

$= 3.63mA - 3.6mA$

$= 30\mu A$

b) $I_{C_Q} = I_2 = 3.6mA$

c) V_{CE_Q}

KVL Equation around outside of circuit

$16 - I_C (1.8k) - V_{CE_Q} = 0$

$V_{CE_Q} = 16 - (3.6mA)(1.8k) = 9.52V$

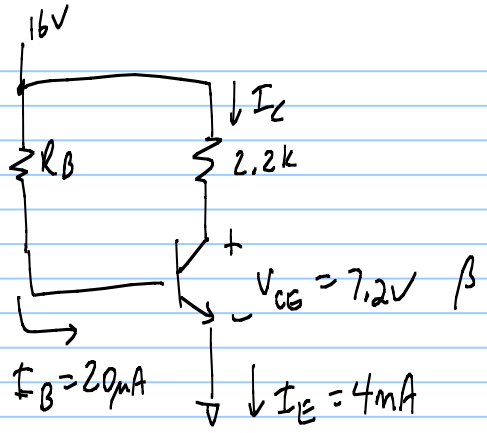
d) V_{C_Q}.

$V_{CE_Q} = V_C - V_E$ since $V_E = 0V$ $\quad V_{C_Q} = V_{CE_Q} = 9.52V$

e) $V_B = 0.7V$

f) $V_E = 0V$

3)



$\frac{I_E}{I_B} = \beta + 1$

c) $\beta = \frac{4mA}{20\mu A} - 1 = 199 = \beta$

a) $I_C \cong I_E = 4mA$.

$V_{CC} = I_C(2.2k) + 7.2 = (4mA)(2.2k) + 7.2$

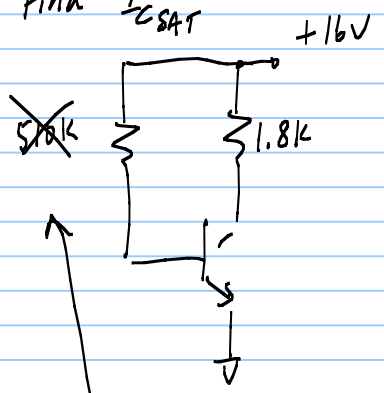
b) $V_{CC} = 16V$.

d) $V_{CC} = I_B R_B + 0.7$

$R_B = \frac{V_{CC} - 0.7}{I_B} = \frac{16 - 0.7}{20\mu A} = 765k\Omega$

$R_B = 765k\Omega$

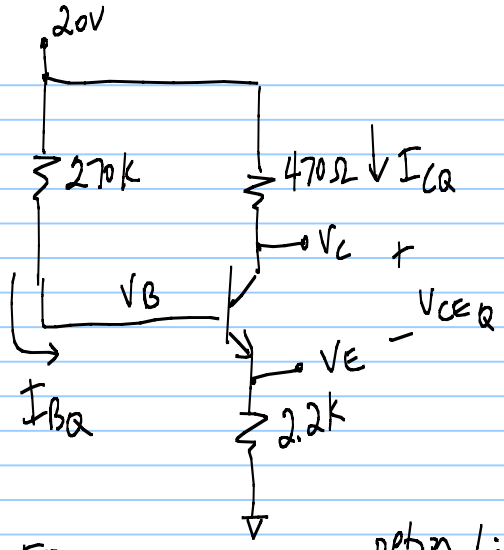
4) Find $I_{C_{SAT}}$

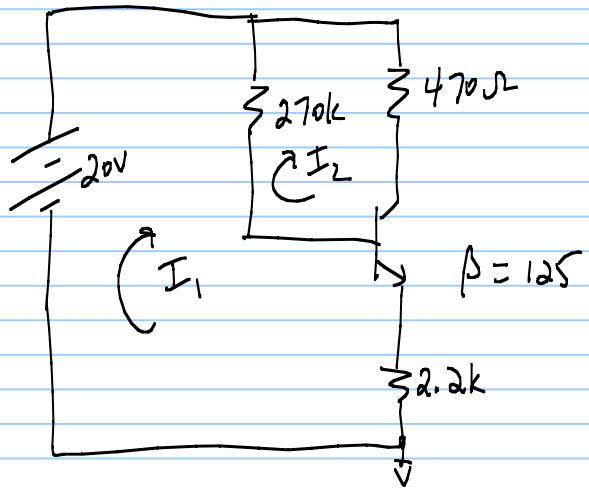


$I_{C_{SAT}} = \frac{16}{1.8k} = 8.89mA$, max current that can flow

(would require new R_B)

8)





option 2: EQ

$$I_B = \frac{V_{CC} - V_{BE}}{R_B + (\beta+1) R_E}$$

$$= \frac{20 - 0.7}{270k + (126)(2.2k)}$$

$I_{BQ} = 35.3\,\mu A$

$I_C = \beta I_B = 4.409\,mA = I_{CQ}$

option 1: MESH

#1 $20 - 270k I_1 + 270k I_2 - 0.7 - 2.2k I_1 = 0$

#2 NO LOOP! $I_C = \beta I_B$

$I_2 = \beta (I_1 - I_2)$

$I_2 + \beta I_2 = \beta I_1$

$I_2 (1 + \beta) = \beta I_1$

#1 $19.3 = 270k I_1 + 2.2k I_1 - 270k I_2$

put in #2

$19.3 = 272.2 I_1 - 270k I_2$

$19.3 = 272.2k I_1 - \frac{270k \beta I_1}{\beta + 1}$

$19.3 = 272.2k I_1 - 267.857k I_1$

$19.3 = 4.343k I_1 \qquad I_1 = 4.44\,mA$

$I_C = I_2 = \frac{(125) 4.44mA}{126} = 4.409mA = I_{CQ}$

$I_B = \frac{I_C}{\beta} = 35.3\,\mu A = I_{BQ}$

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remaining the same method 1 or method 2

loop around outside

$20 - (470) I_C - V_{CEQ} - (2.2k) I_C = 0$

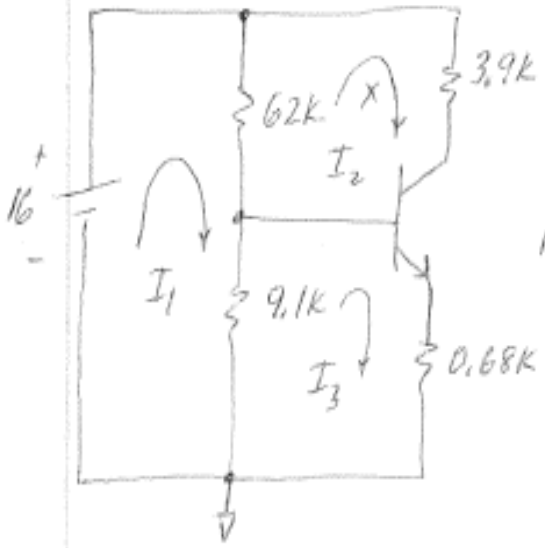
$V_{CEQ} = 8.23V$

$V_E = (2.2k) I_C = 9.7V = V_E$

$V_C = V_{CEQ} + V_E = 17.93V = V_C$

$V_B = V_E + V_{BE} = 10.4V = V_B$

15)



$\beta = 80$

replace loop #2

$I_2 = \beta(I_3 - I_2)$

$(\beta+1)I_2 - \beta I_3 = 0$

$16 = (62k + 9.1k)I_1 - (62k)I_2 - (9.1k)I_3$

$-0.7 = -(9.1k)I_1 + (9.1k + 0.68k)I_3$

$16 = (71.1k)I_1 - (62k)I_2 - (9.1k)I_3$

$0 = +(81)I_2 - (80)I_3$

$-0.7 = -(9.1k)I_1 + (9.78k)I_3$

$I_1 = 1.939\ mA$

$I_2 = 1.711\ mA$

$I_3 = 1.732\ mA$

a) $I_{BQ} = I_3 - I_2 = 21\mu A$

b) $I_{CQ} = 1.711\ mA$

c) $V_{CEQ} = 16 - (3.9k)I_2 - (0.68k)I_3$

$= 8.15V$

d) $V_C = 16 - (3.9k)I_2 = 9.33V$

e) $V_E = (0.68k)I_3 = 1.178V$

f) $V_B = V_E + 0.7 = 1.878V$

Alternatively. I_B can be found using equations in the text.

$R_{TH} = R_1 // R_2 = 62k // 9.1k = 7.9351k\Omega$

$E_{TH} = (R_2/R_1+R_2)V_{CC} = (9.1k/9.1k+62k)16$

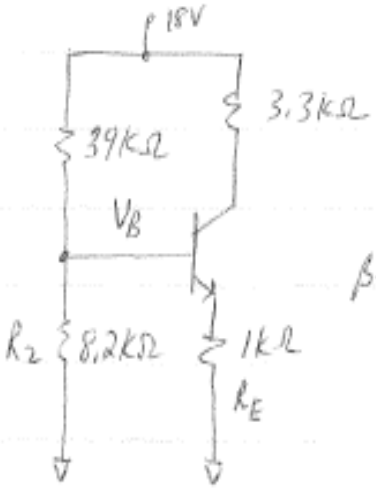
$= 2.0478V$

$I_B = \dfrac{E_{TH} - V_{BE}}{R_{TH} + (1+\beta)R_E} = \dfrac{2.0478 - 0.7}{7.9351k + (80+1)0.68k} = 21.39\mu A$ – similar to $21\mu A$ above.

(b–f above the same)

21)

IF $\beta R_E \geq 10 R_2$ approx. approach can be used.



$\beta = 120$

$(120)(1k) \geq 10(8.2k)$

$120k \geq 82k$ ✓ approx. may be used

$$V_B = \frac{8.2k}{39k + 8.2k}(18) = 3.127V$$

$$V_E = 3.127 - 0.7 = 2.427V$$

a) $I_E = 2.427/1k = 2.427\,mA \cong I_C$

b) $V_{CE} = 18 - (2.427\,mA)(3.3k + 1k) = 7.56V = V_{CE}$

c) $I_B = \frac{2.427}{120} = 20.2\,\mu A$

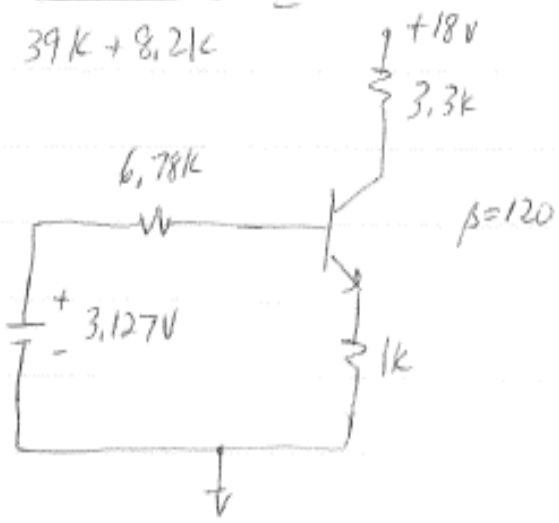
d) $V_E = 2.427V$

e) $V_B = 3.127V$

22) Repeat #21 using the exact (Thevenin) approach and compare to the approximate in 21.

$$V_{BB} = \frac{18(8.2k)}{8.2k + 39k} = 3.127V$$

$$R_{BB} = \frac{(39k)(8.2k)}{39k + 8.2k} = 6.78k\Omega$$



PROB #16

a) $I_{C_Q} = \frac{3.127 - 0.7}{1k + \frac{6.78k}{120}} = 2.297mA = I_C \lesssim 2.427mA$

b) $V_{CE} = 18 - (2.297mA)(4.3k) = 8.12V \longleftrightarrow 7.56V$

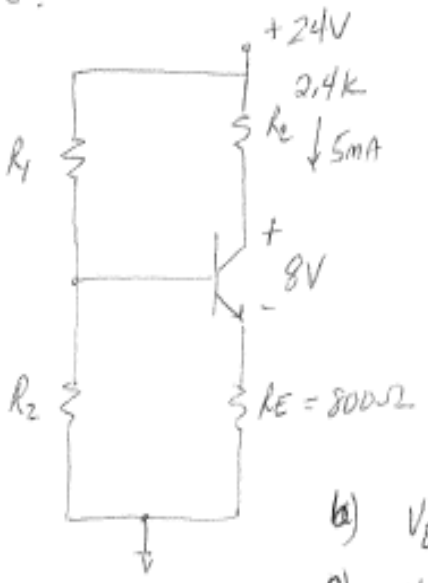
c) $I_B = \frac{2.297mA}{120} = 19.14\mu A \longleftrightarrow 20.2\mu A$

d) $V_E = (2.297mA)(1k) = 2.297k \longleftrightarrow 2.427V$

e) $V_B = 2.297 + 0.7 = 2.997V \longleftrightarrow 3.127V$

$\beta R_E > 10R_2$ was satisfied in #21. You can see approximate values are close but still not exact even with the condition met.

24) Using the characteristics of fig. 4.76, determine R_C and R_E for a voltage-divider network having a Q-point of $I_{CQ} = 5mA$ and $V_{CEQ} = 8V$. Use $V_{CC} = 24V$ and $R_C = 3R_E$.



$24 = 5mA(R_C) + 8 + 5mA(R_E)$

$16 = 5mA(3R_E + R_E)$

$R_E = \frac{16}{(5mA)4} = 800\Omega$ //

$R_C = 3R_E = 2.4k$

b) $V_E = (800)(5mA) = 4V$

c) $V_B = 4.7V$

d) $4.7 = \frac{(24)R_2}{24k + R_2}$

$4.7(24k) + 4.7R_2 = 24R_2$

$\frac{4.7(24k)}{24 - 4.7} = R_2 = 5.84k\Omega$

e) $\beta = \frac{5mA}{39\mu A} = 128$ //

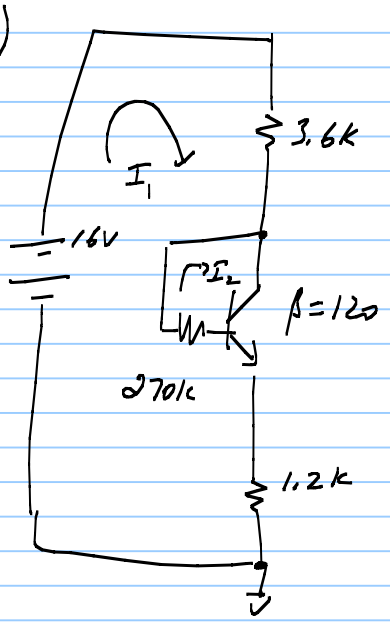
f) $\beta R_E \geq 10R_2$

$(128)(800) \geq 10(5.84k)$

$102.4k \geq 58.4k$

✓ assumption valid.

27)



no equations ∴

MESH still works

LOOP 1 : $16 - 3.6k\,I_1 - 270k\,I_1 + 270k\,I_2 - 0.7 - 1.2k\,I_1 = 0$

$15.3 = 274.8\,I_1 - 270k\,I_2$

LOOP 2 : NOT KVL! $I_C = \beta I_B$ $I_C = I_2$ $I_B = I_1 - I_2$

$I_2 = \beta(I_1 - I_2) = \beta I_1 - \beta I_2$

$I_2 + \beta I_2 = I_2(1+\beta) = \beta I_1$

$I_2 = \frac{120\,I_1}{121}$

$15.3 = 274.8k\,I_1 - \frac{270k\,(120)\,I_1}{121}$

$15.3 = 7.031k\,I_1$

$I_1 = 2.176mA$

$I_2 = \frac{120\,I_1}{121}$

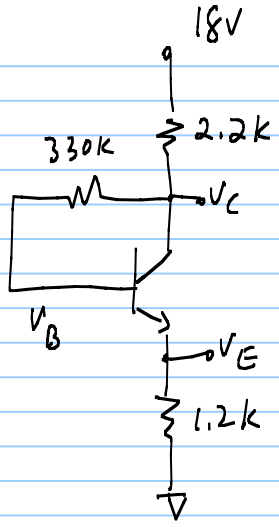
$I_2 = 2.158mA$

a) $I_B = I_1 - I_2 = 18.03\mu A$

b) $I_C = I_2 = 2.158mA$

c) $V_C = 16 - I_1(3.6k) = 8.166V$

33)



Given $V_B = 4V$

a) Find $V_E = V_B - 0.7 = 3.3V$

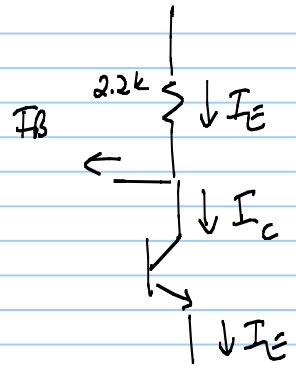
b) Find I_c.

use V_E to find I_E. $I_E = \frac{3.3V}{1.2k} = 2.75mA$

drop across 2.2k uses I_E

$V_{R_C} = (2.75mA)(2.2k) = 6.05V$

$V_C = 18 - 6.05V = 11.95V$



voltage across 330k used to find I_B

$I_B = \frac{V_C - V_B}{330k} = \frac{11.95 - 4V}{330k}$

$I_B = 24.09\mu A$

$I_C = I_E - I_B = \boxed{2.726mA}$

c) $\boxed{V_C = 11.95V}$

d) $V_{CE} = V_C - V_E = 11.95 - 3.3V = \boxed{8.65V = V_{CE}}$

e) $\boxed{I_B = 24.09\mu A}$

f) $\beta = \frac{2.726mA}{24.09\mu A} = \boxed{113.2 = \beta}$