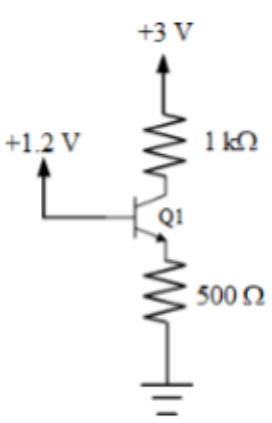
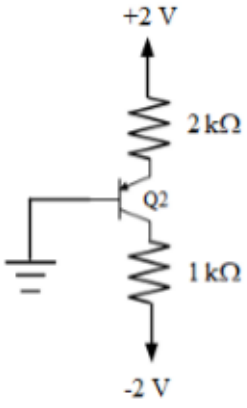
EE 315

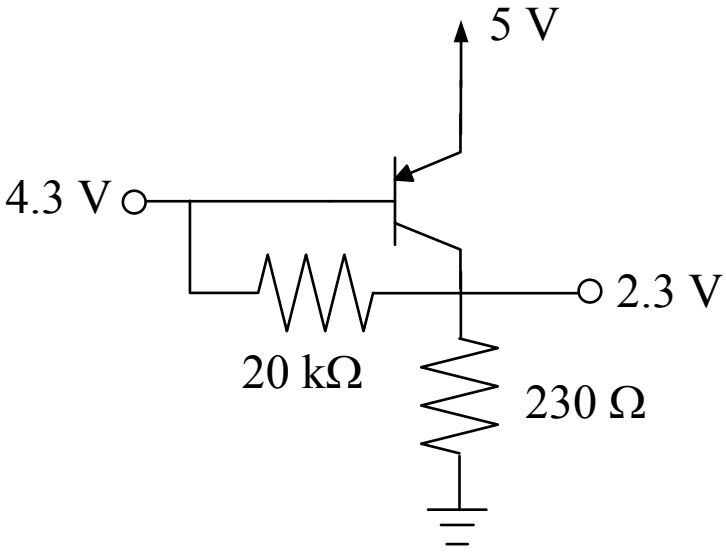
Practice Problems Module 5

1. For an npn BJT, the voltage v_{BE}=0.74 V for i_C=9.5mA. What i_C for v_{BE}=0.714 V?
2. For a given BJT, i_B=0.010mA and i_C=0.6mA. What are I_S, β, α, and i_E?
3. A BJT has $I_S=5\times10^{-15}$ A and β fall in the range of 50 to 500. If the BJT operates in the active mode with v_{BE} = 0.64V, find the expected range of the collector, base, and emitter currents.
4. For Q_1 and Q_2 below, find the collector, base, and emitter currents for β=50 and $|V_{BE}|$=0.8V. What is the mode of operation for each circuit?





5. For the pnp transistor circuit below, find I_C and β.



6. For the following transistor, find the collector, base, and emitter currents and the collector and emitter voltages for the case where β=100 and β being very large. Assume V_{BE}=0.7 V. Do this for each of the following base voltages: V_B=0 V, V_B=1 V, and V_B=2 V.

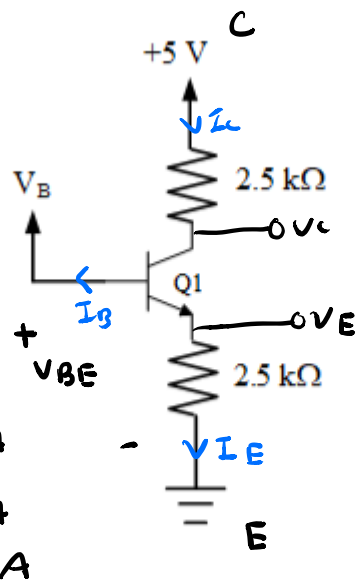
$V_{BE} = 0.7v$ $\alpha = \frac{100}{101} = .99$

$V_E = -0.7v = 0.3v = 1.3v$

$I_E = -.28mA = .12mA = .52mA$

$I_C = -0.27mA$
$= 0.12mA$
$= .515mA$

$I_B = -2.7mA$
$= 1.2mA$
$= 5.1mA$



I_C
I_B
I_E
V_C
V_E
} ?

$I_C = \frac{5 - V_C}{2.5}$

$V_B = 0 = 1 = 2$

$I_E = -.28mA$
$= .12mA$
$= .52mA$

$V_E = 0 - .7 = -0.7v$
$V_E = 1 - .7 = 0.3v$
$V_E = 2 - 0.7 = 1.3v$

$I_E = \frac{-0.7 - 0}{2.5k\Omega}$ $I_E = \frac{0.3 - 0}{2.5k\Omega}$ $I_E = \frac{1.3 - 0}{2.5k\Omega}$

$I_C = \alpha I_E = (.99)(-.28) = (.99)(.12) = (.99)(.52)$

$I_B = \frac{-.27mA}{100}$ $I_B = \frac{.12}{100}$ $I_B = \frac{.515}{100}$

$I_C = \frac{5 - V_C}{25k\Omega}$ $(2.5E3)($

1. For an npn BJT, the voltage v_{BE}=0.74 V for i_C=9.5mA. What i_C for v_{BE}=0.714 V?

$V_{BE} = 0.74\ v$ $\quad$ $i_C = 9.5mA$ $\quad$ $V_{BE} = 0.714\ v$ $\quad$ $i_C = ?$

$$V_{BE2} - V_{BE1} = V_T \ln\left(\frac{i_{C2}}{i_{C1}}\right)$$

$$0.714 - 0.74 = .025 \ln\left(\frac{i_{C2}}{9.5}\right)$$

$$-1.04 = \ln\left(\frac{i_{C2}}{9.5}\right)$$

$$X = \frac{9.5}{e^{1.04}}; \quad X = 3.36\,mA$$

Metric Prefix	Symbol	Multiplier (Traditional Notation)	Exponential	Description
Yotta	Y	1,000,000,000,000,000,000,000,000	10^{24}	Septillion
Zetta	Z	1,000,000,000,000,000,000,000	10^{21}	Sextillion
Exa	E	1,000,000,000,000,000,000	10^{18}	Quintillion
Peta	P	1,000,000,000,000,000	10^{15}	Quadrillion
Tera	T	1,000,000,000,000	10^{12}	Trillion
Giga	G	1,000,000,000	10^{9}	Billion
Mega	M	1,000,000	10^{6}	Million
kilo	k	1,000	10^{3}	Thousand
hecto	h	100	10^{2}	Hundred
deca	da	10	10^{1}	Ten
base	b	1	10^{0}	One
deci	d	1/10	10^{-1}	Tenth
centi	c	1/100	10^{-2}	Hundredth
milli	m	1/1,000	10^{-3}	Thousandth
micro	μ	1/1,000,000	10^{-6}	Millionth
nano	n	1/1,000,000,000	10^{-9}	Billionth
pico	p	1/1,000,000,000,000	10^{-12}	Trillionth
femto	f	1/1,000,000,000,000,000	10^{-15}	Quadrillionth
atto	a	1/1,000,000,000,000,000,000	10^{-18}	Quintillionth
zepto	z	1/1,000,000,000,000,000,000,000	10^{-21}	Sextillionth
yocto	y	1/1,000,000,000,000,000,000,000,000	10^{-24}	Septillionth

2. For a given BJT, i_B=0.010mA and i_C=0.6mA. What are Is, β, α, and i_E?

$i_B = 0.010mA$ $\quad$ $\beta = 60$

$i_C = 0.6\,mA$ $\quad$ $\alpha = .984$

$i_E? = 0.61\,mA$

$$i_B = \frac{i_C}{\beta} \qquad \beta = \frac{\alpha}{\alpha - 1} \qquad \alpha = \frac{\beta}{\beta - 1}$$

$i_E = i_B = i_C$

$i_E = i_B + i_C$

$$i_E = .010 + .6 = 0.61mA$$

$$\beta = \frac{0.6}{.010} = 60$$

$$\alpha = \frac{60}{61} = .984$$

3. A BJT has $I_S=5\times10^{-15}$ A and β fall in the range of 50 to 500. If the BJT operates in the active mode with v_{BE} = 0.64V, find the expected range of the collector, base, and emitter currents.

$I_S = 5E\text{-}15$

$50 \le \beta \le 500$

Active mode ; $V_{BE} = 0.64\,V$

i_C, i_B, i_E } ranges ?

$I_C = I_S \exp\left(V_{BE}/V_T\right)$

$i_B = \frac{i_C}{\beta}$ $\beta = \frac{\alpha}{\alpha - 1}$ $\alpha = \frac{\beta}{\beta+1}$

$i_E = i_B + i_C$

$I_C = 5E\text{-}15 \exp\left(\frac{0.64}{.025}\right) = .000656$ $0.656\,mA$

$i_B = \frac{i_C}{\beta} \Rightarrow \frac{.656E\text{-}4}{50}$ or $\frac{.656E\text{-}4}{500}$

$i_B = 13.1nA$ to $1.31nA$

$i_E = i_C + i_B$

$i_E = 13.1nA + .656mA$

$i_E = 13.1E\text{-}6 + .656E\text{-}3$

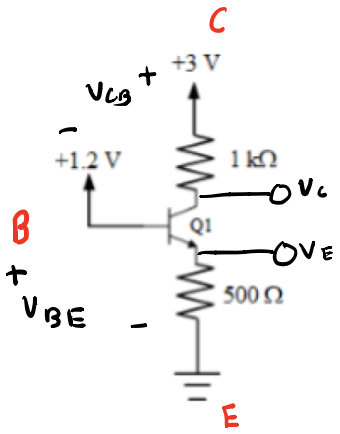
$i_E = .669mA$ to $.657mA$

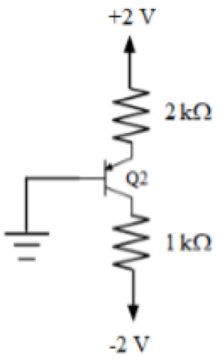
$i_E = 1.31nA + .656\,mA$

$i_E = 1.31E\text{-}6 + .656E\text{-}3$

4. For Q_1 and Q_2 below, find the collector, base, and emitter currents for $\beta=50$ and $|V_{BE}|=0.8V$. What is the mode of operation for each circuit?

$V = IR$





$V_B = 1.2v$

$V_E = 1.2 - 0.8 = 0.4v$

$\alpha = \frac{50}{51} = .98$

$V_{BE} > 0$

$V_{CB} = ?$

$i_E = \frac{0.4}{500} = 0.8mA$

$I_C = \alpha I_E$

$I_C = .98 \times .8mA = .784mA$

$I_B = i_E - i_C$

$I_B = .8 - .784$

$I_B = .02mA$

$I_C = \frac{3 - V_C}{1k\Omega}$

$.784 = 3 - V_C$

$I_E = .8mA$

$I_C = .784mA$

$I_B = .02mA$

$\beta = 50$

$\alpha = .98$

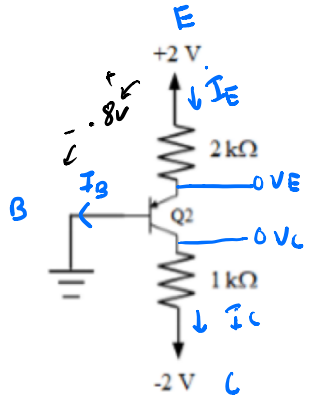
$V_B = 1.2v$

$V_E = 0.4v$

$V_C = 2.22v$

$V_C > V_B > V_E \Rightarrow$ Active

4. For Q_1 and Q_2 below, find the collector, base, and emitter currents for $\beta=50$ and $|V_{BE}|=0.8V$. What is the mode of operation for each circuit?



Answers

$\beta=50$ $V_B=0$ $I_E=.6mA$

$|V_{BE}|=.8v$ $V_E=.8v$ $i_C=.58mA$

$\alpha=.98$ $V_C=-1.42v$ $i_B=.02mA$

$V_C < V_B < V_E \rightarrow$ Active

Work

$V_E - V_B = .8v$

$I_E = \frac{2-.8v}{2k\Omega} = .6mA$

$\alpha = \frac{50}{51} = .98$

$i_C = .98(.6E-3)$

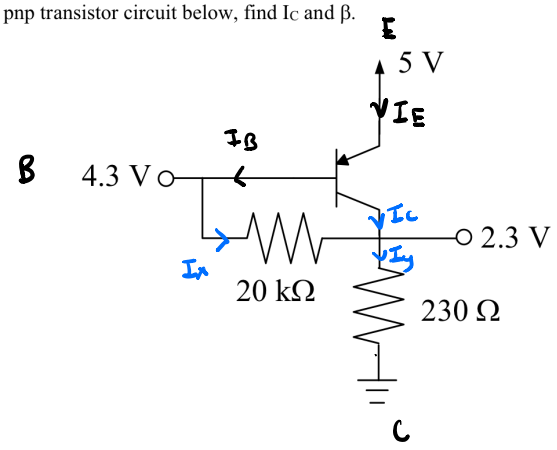
$i_B = i_E - i_C$

$i_B = .6-.58$

$I_C = \frac{V_C+2}{1000} \Rightarrow V_C+2=.58$

$V_C = -1.42v$

5. For the pnp transistor circuit below, find I_C and β.



$I_y = \frac{2.3-0}{230} = 10mA$

$I_x = \frac{4.3-2.3}{20000} = .1mA$

$I_C = I_y - I_x \quad I_B = .1mA$

$I_C = 10 - .1$

$I_C = 9.9mA$

$\beta = \frac{I_C}{I_B} \Rightarrow \frac{9.9}{0.1} = 99$

$\beta = 99$