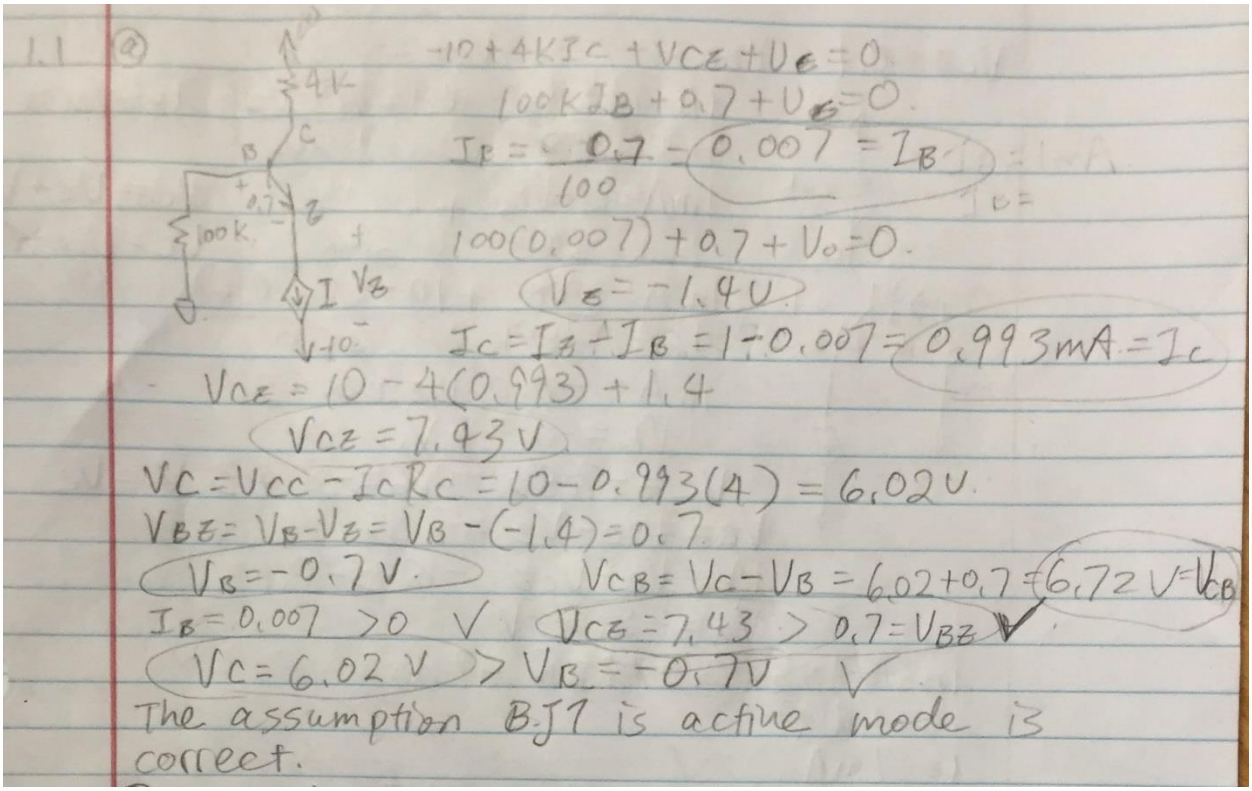
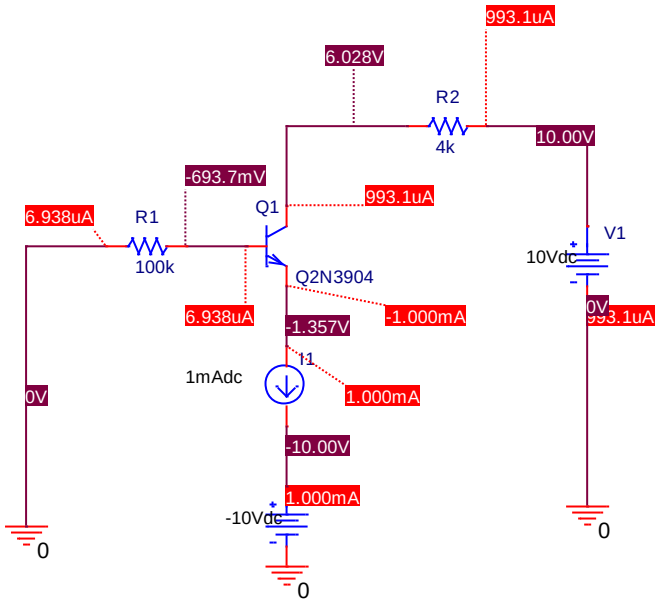
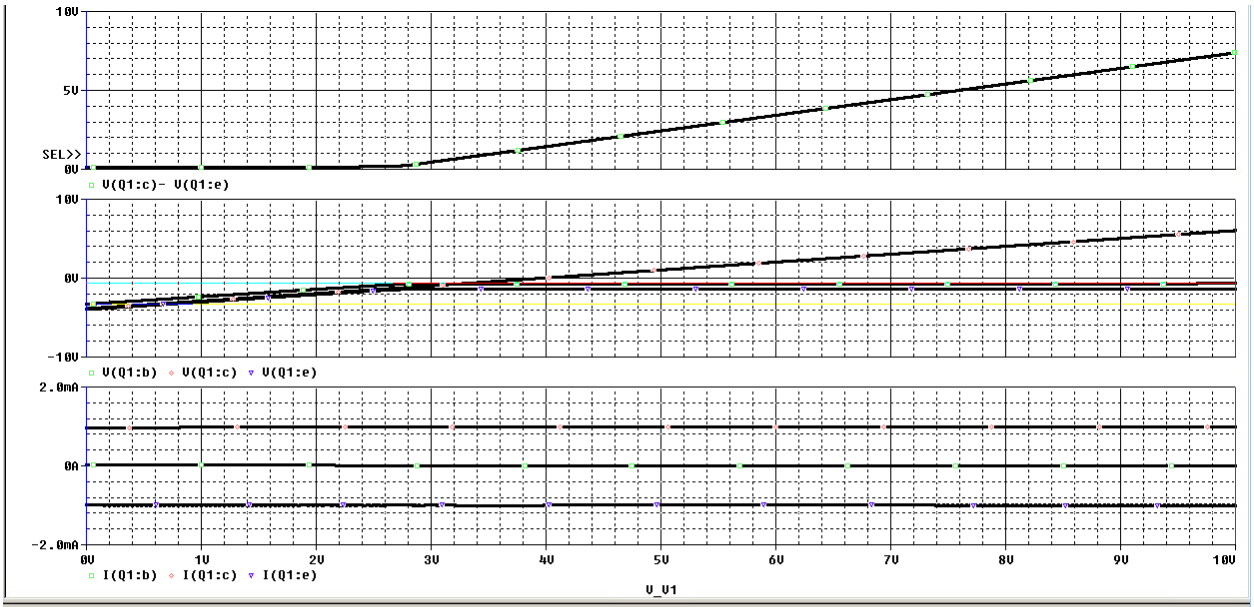
Rong Zheng

Homework 3



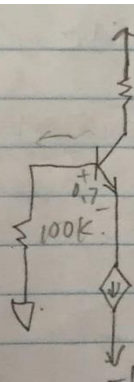




	I(Q1:b)	6.9382u	33.060u	-26.122u		693.755m	3.3060	33.060u	6.9382u	19.999u
	I(Q1:c)	993.064u	966.940u	26.124u		694.741m	3.3069	993.064u	966.940u	980.002u
	I(Q1:e)	-1.0000m	-1.0000m	-2.3282n		692.748m	3.3050	-1.0000m	-1.0000m	-1.0000m
	CURSOR 1,2	V(Q1:b)	-693.748m	-3.3060	2.6122		0.000	0.000	-693.748m	-3.3060	-1.9999
		V(Q1:c)	6.0178	-3.8678	9.886		6.7115	-561.811m	6.0178	-3.8678	1.0750
		V(Q1:e)	-1.3571	-3.9725	2.6153		-663.396m	-666.520m	-1.3571	-3.9725	-2.6648
		V(Q1:c)- V(Q1:e)	7.3749	104.709m	7.2702		8.0686	3.4107	7.3749	104.709m	3.7398

t a measurement value | X=0.73 Y=0.000787 | V_V1 = 10 | 100%

(b)



$-10+20KI_C+V_{CE}+V_E=0.$

$100kI_B+0.7+V_E=0.$

$I_B=\frac{0.7}{100}=0.007V.$

$100(0.007)+0.7+V_E=0$

$V_E=-1.4$

$I_C=I_E-I_B=1-0.007=0.993mA.$

$V_{CE}=10-20(0.993)+1.4=0.$

$V_{CE}=-8.46V < 0.7V=V_{BE}$ X

$V_C=V_{CC}-I_CR_C=10-0.993(20)=-9.86V.$

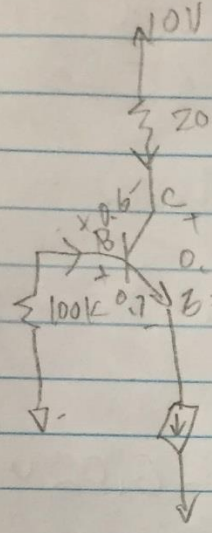
$V_B=0.7-1.4=-0.7V.$ X

$V_{CE}=-8.46V < V_{BE}=0.7V$ X $V_C=-9.86 < V_B=-0.7V$ X

The assumption BJT is active mode is not correct.

Now assume BJT is in saturation mode

$V_{CE} = 0.1$ $V_{BE} = 0.7$ $V_{CB} = -0.6\,V$.



$i_B = \frac{0 - V_B}{100}$ $i_C = \frac{10 - V_C}{20K}$ $i_E = 1mA$.

$1mA = \frac{0 - V_B}{100} + \frac{10 - V_C}{20K}$ $V_{CB} = V_C - V_B$

$V_C = V_B - 0.6$

$1mA = \frac{-V_B}{100K} + \frac{10 - (V_B - 0.6)}{20K}$

$1mA = -0.06V_B + 0.53$

$V_B = -7.83\,V$

$V_C = -7.83 - 0.6 = -8.43\,V = V_C$

$V_{CE} = V_C - V_E$

$V_E = V_C - V_{CE} = -8.43 - 0.1$

$V_E = -8.53\,V$

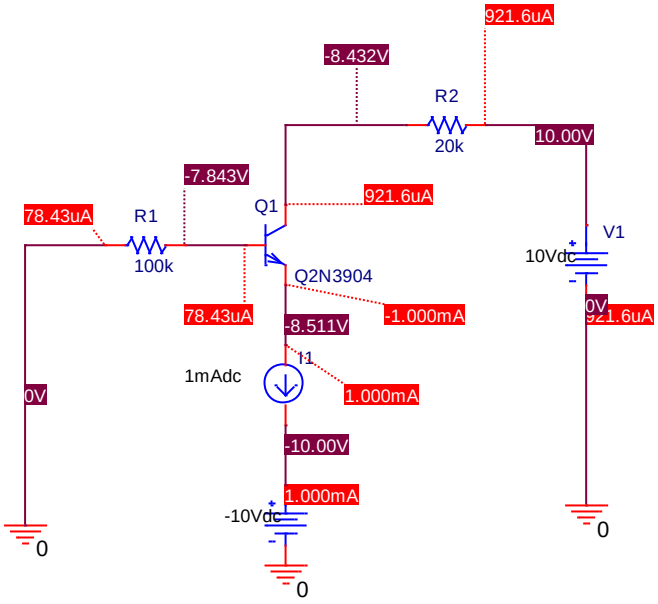
$i_B = \frac{0 - (-7.83)}{100} = 0.0783\,mA = i_B$ > 0 ✓

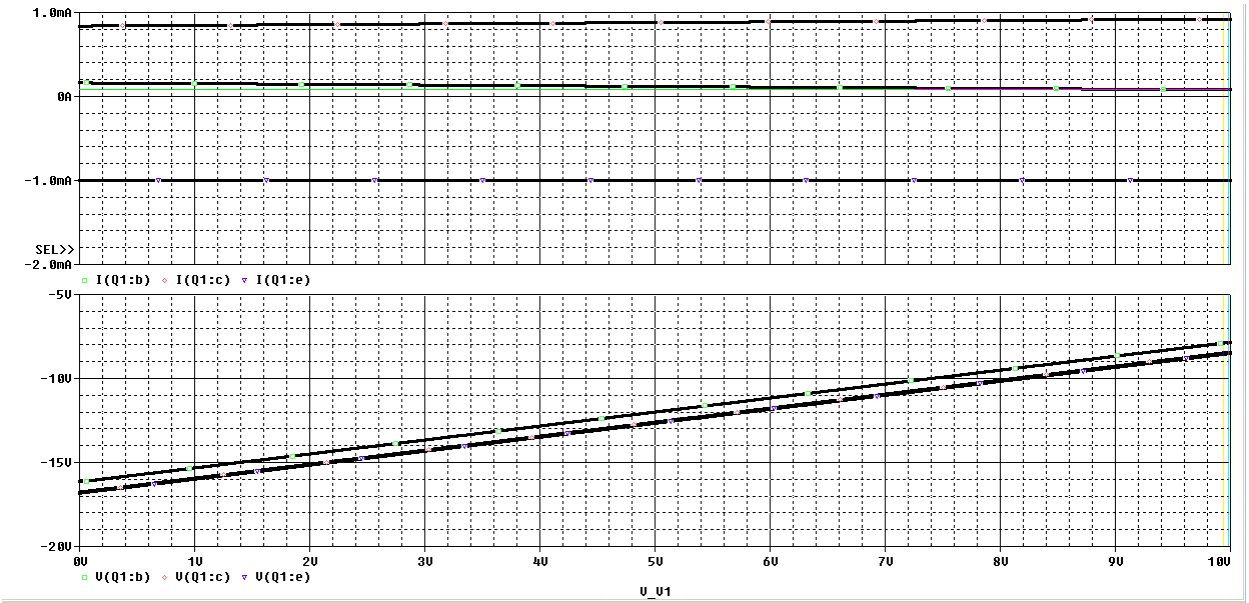
$i_E = 1mA$ > 0 ✓

$i_C = 1mA - 0.0783mA = 0.9217\,mA = i_C$ > 0 ✓

$i_C = 0.9217mA < \beta i_B = 7.83mA$ ✓

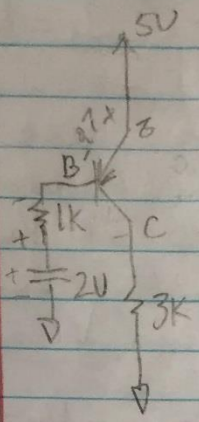
The assumption of BJT in saturation is correct.





	X Values	9.983	9.939	43.478m		Y1 - Y1(Cursor1)	Y2 - Y2(Cursor2)	Max Y	Min Y	Avg Y
	V(Q1:b)	-7.8593	-7.8933	33.952m		-7.8594	-7.8934	-7.8593	-7.8933	-7.8763
	V(Q1:c)	-8.4481	-8.4822	34.079m		-8.4482	-8.4823	-8.4481	-8.4822	-8.4652
	V(Q1:e)	-8.5272	-8.5611	33.962m		-8.5272	-8.5612	-8.5272	-8.5611	-8.5441
CURSOR 1,2	I(Q1:b)	78.583u	78.939u	-355.682n		0.000	0.000	78.939u	78.583u	78.761u
	I(Q1:c)	921.388u	921.057u	330.899n		842.804u	842.118u	921.388u	921.057u	921.222u
	I(Q1:e)	-1.0000m	-1.0000m	3.5005n		-1.0786m	-1.0789m	-1.0000m	-1.0000m	-1.0000m

1.2



Assume active.

$-5 - V_{EC} + 3i_C = 0$. $V_{EB} = 0.7$

$5 - V_{EB} + 1K\, i_B = 2$ $i =$

$5 - 0.7 + 1K\, i_B = 2$

$i_B = -2.3\ mA < 0$ ✗

$i_B R_B = 2 - V_B$ $V_E - V_B = 0.7$

$-2.3(1) = 2 - V_B$ $V_B - 4.3 = 0.7$

$V_B = 4.3V$ $V_E = 5$

$i_C = \beta i_B = 100(-2.3) = -230\ mA$

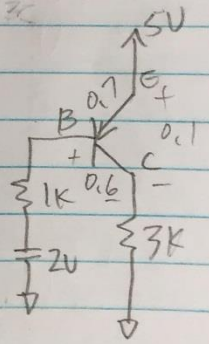
$-5 - V_{EC} + 3(-230) = 0$

$V_{EC} = -695V < 0.7 = V_{EB}$ ✗

The assumption BJT is active doesn't make any sense.

② Assume saturation. KVL

$V_{EC} = 0.1V$ $V_{EB} = 0.7V$ $V_{BC} = 0.6V$



$5 - V_{EC} - 3i_C = 0$. V_C $i = \frac{5V}{R}$

$5 - 0.1 - 3i_C = 0$. 3K

$i_C = 1.63\ mA$

$I_B = \frac{V_B - 2}{1K}$ $I_C = \frac{V_C - 0}{3}$ $I_E = I_B + I_C$

$V_C = 3(1.63) = 4.89V = V_C$

$V_{EC} = 0.1 = V_E - V_C = V_E - 4.89$

$V_E = 4.99V$

$V_{EB} = V_E - V_B = 4.99 - V_B = 0.7$

$V_B = 4.29$

$I_B = \frac{4.29 - 2}{1K} = 2.29\ mA = I_B > 0$ ✓

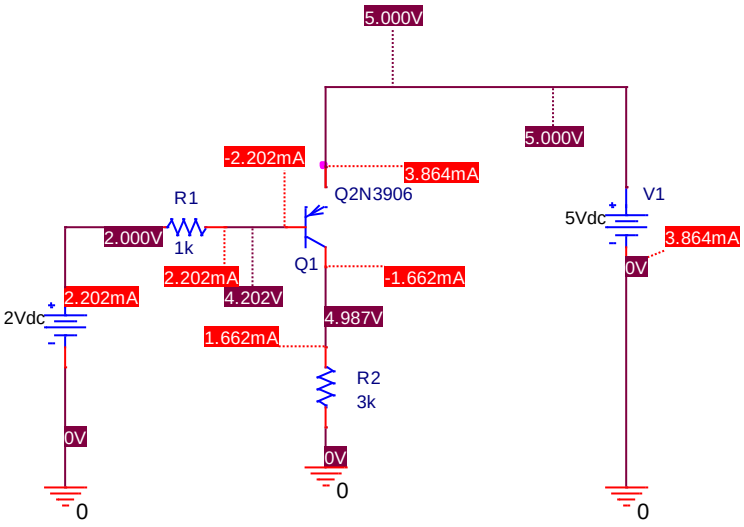
$I_C = 1.63\ mA > 0$ ✓

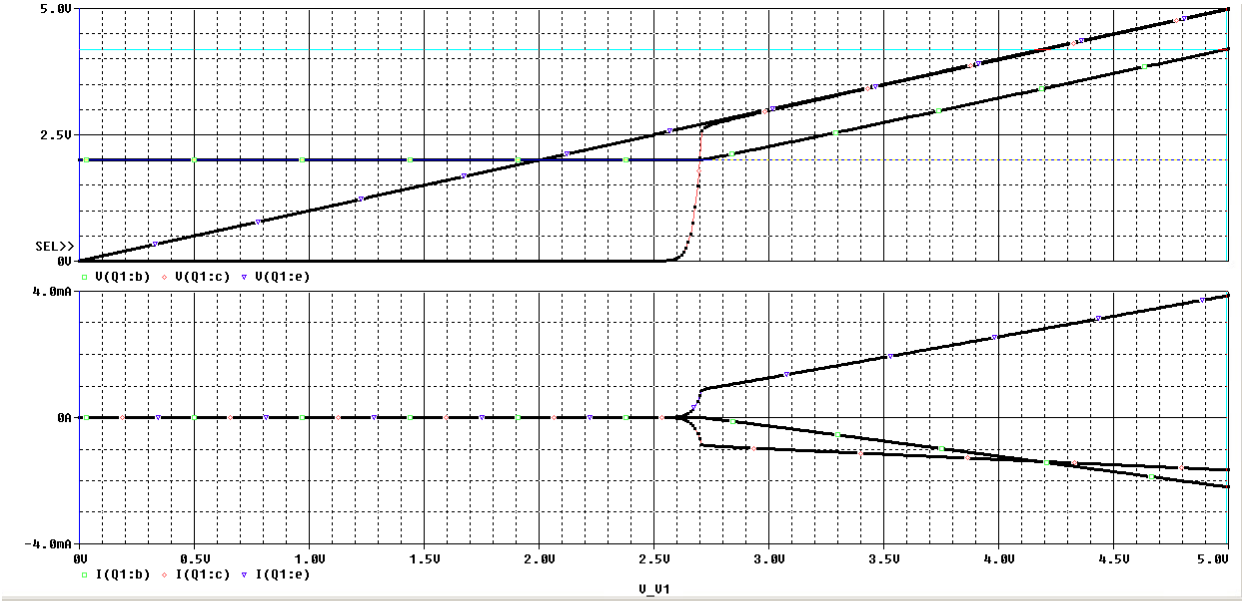
$I_E = I_C + I_B = 1.63 + 2.29 = 3.92\ mA = I_E > 0$ ✓

$i_C < \beta i_B$.

$1.63 < 100(2.29) = 229$ ✓

The assumption BJT is in saturation is correct.





		X Values	4.9900	0.000	4.9900		Y1 - Y1(Cursor1)	Y2 - Y2(Cursor2)	Max Y	Min Y	Avg Y
		I(Q1:b)	-2.1922m	413.208f	-2.1922m		-4.1944	-2.0000	413.208f	-2.1922m	-1.0961m
		I(Q1:c)	-1.6588m	-402.132f	-1.6588m		-4.1938	-2.0000	-402.132f	-1.6588m	-829.417u
		I(Q1:e)	3.8510m	-11.076f	3.8510m		-4.1883	-2.0000	3.8510m	-11.076f	1.9255m
	CURSOR 1,2	V(Q1:b)	4.1922	2.0000	2.1922		0.000	0.000	4.1922	2.0000	3.0961
		V(Q1:c)	4.9765	1.2064n	4.9765		784.347m	-2.0000	4.9765	1.2064n	2.4883
		V(Q1:e)	4.9900	0.000	4.9900		797.835m	-2.0000	4.9900	0.000	2.4950

(c) To make active, $V_{EC} > 0.7$ $\quad$ $I_C = 1mA$

$V_{BC} > 0$. $\quad$ $I_E = I_C + I_B$

$5 - V_{EC} - I_C R_C = 0$. $\quad$ $V_{EB} = 0.7$

$5 - V_{EC} = V_C$ $\quad$ Assume $V_{BC} = 0.1$

$5 - V_{EB} - R_B I_B - 2 = 0$ $\quad$ $V_B - V_C = 0.1$

$I_B = 1.01\,mA$ $\quad$ $4.3 - V_C = 0.1$

$V_C = 4.2$

$V_B = 5V$

$V_{EB} = V_E - V_B = 0.7$

$V_B = 4.3V$ ✓

$i_C = \beta i_B$

$1mA = 100\, i_B$

$i_B = 0.01\,mA$, > 0 ✓

$5 - 0.7 - I_B R_B - 2 = 0$

$2.3 = I_B R_B = 0.01 R_B$

$R_B = 230\,K\Omega$

$2 + i_B R_B - 0.1 - i_C R_C = 0$

$2 + (0.01)(230) - 0.1 = i_C R_C$

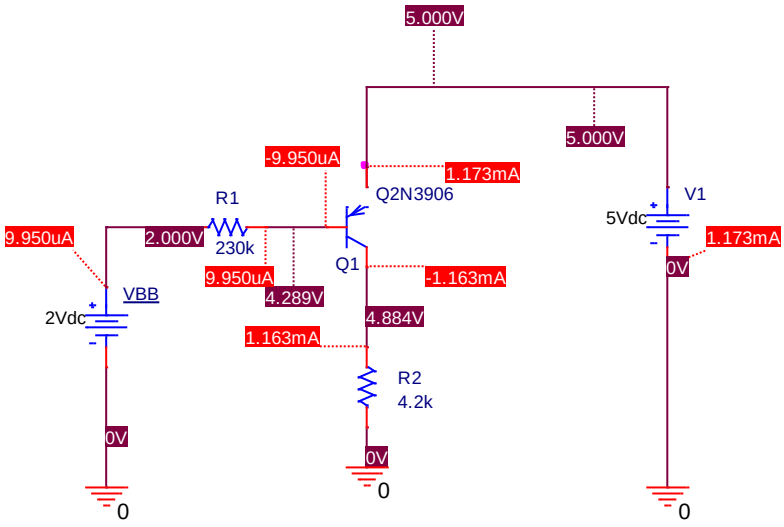
$4.2\,K\Omega = R_C$ ✓

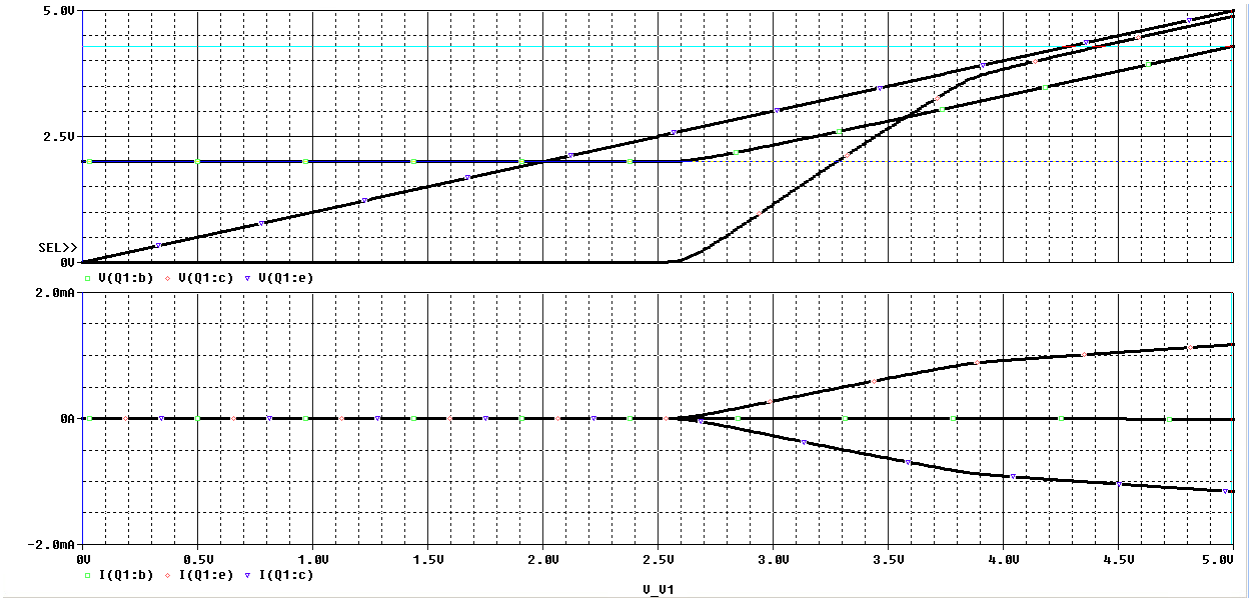
$V_C = 4.2V$

$V_{EC} = V_E - V_C = 5 - 4.2 = 0.8 > V_{EC} = 0.7$ ✓

$V_{BC} = V_B - V_C = 4.3 - 4.2 = 0.1 > 0$ ✓

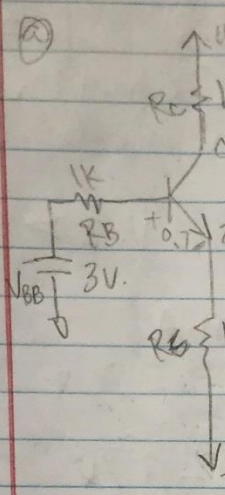
The BJT is in active mode. Just change R_B is not enough to make $I_C \approx 1mA$. We also need to find a new R_C. The assumption $V_{BC} = 0.1 \approx 0$ made BJT around borderline between active and saturation modes.





	I(Q1:b)	-9.907u	413.208f	-9.907u		-4.2787	-2.0000	413.208f	-9.907u	-4.9536u
	I(Q1:e)	1.1703m	-11.076f	1.1703m		-4.2775	-2.0000	1.1703m	-11.076f	585.132u
	I(Q1:c)	-1.1604m	-402.132f	-1.1604m		-4.2798	-2.0000	-402.132f	-1.1604m	-580.178u
CURSOR 1,2	V(Q1:b)	4.2787	2.0000	2.2787		0.000	0.000	4.2787	2.0000	3.1393
	V(Q1:c)	4.8735	1.6890n	4.8735		594.825m	-2.0000	4.8735	1.6890n	2.4368
	V(Q1:e)	4.9900	0.000	4.9900		711.334m	-2.0000	4.9900	0.000	2.4950

1.3 (a)



Assume active

$-10+1K i_C + V_{CE} + i_E R_E = 0$

$-3+1K I_B + 0.7 + I_E R_E = 0$

~~$-3+1K I_B + 0.7 + (-10.7mA)(1K) = 0$~~

$V_E = -10 - I_E R_E$

$V_E = -10 - (-10.7)$ $V_E = 0.7V$

$I_E = \frac{-10-0.7}{1K} = -10.7mA = I_E$ $\beta = 100 = I_C/I_B$

$I_C = 100 I_B$

$I_E = I_B + I_C = 101 I_B$

$I_B = \frac{-10.7}{101} = -0.1059mA < 0$ ✗

$I_C = 100(-0.1059) = -10.59mA$.

$-10 - 1K(10.59) - V_{CE} - (10.7)(1K) = 0$

$V_{CE} = -11.29V < 0.7 = V_{BE}$ ✗

The assumption is wrong. The BJT is not in active mode. $V_E = 0.7$, note that $V_{BE} = 0.7V$, this will give $V_B \cong 0$, which doesn't make sense.

(b) Assume saturation mode.

$V_{CE} = 0.1$ $V_{BE} = 0.7V$ $V_{CB} = 0.6V$.

$i_B = \frac{3-V_B}{1K}$ $i_C = \frac{10-V_C}{1K}$ $i_E = \frac{V_E+10}{1K}$.

$\frac{3-V_B}{1} + \frac{10-V_C}{1} = \frac{V_E+10}{1}$

$V_{CE} = V_C - V_E = 0.1V$ $V_C = V_E + 0.1$

$V_{BE} = V_B - V_E = 0.7V$ $V_B = V_E + 0.7$

$\frac{3-(V_E+0.7)}{1} + \frac{10-(V_E+0.1)}{1} = \frac{V_E+10}{1}$

$3 - V_E - 0.7 + 10 - V_E - 0.1 = V_E + 10$.

$12.2 = 3V_E + 10$.

$V_E = 0.733V$

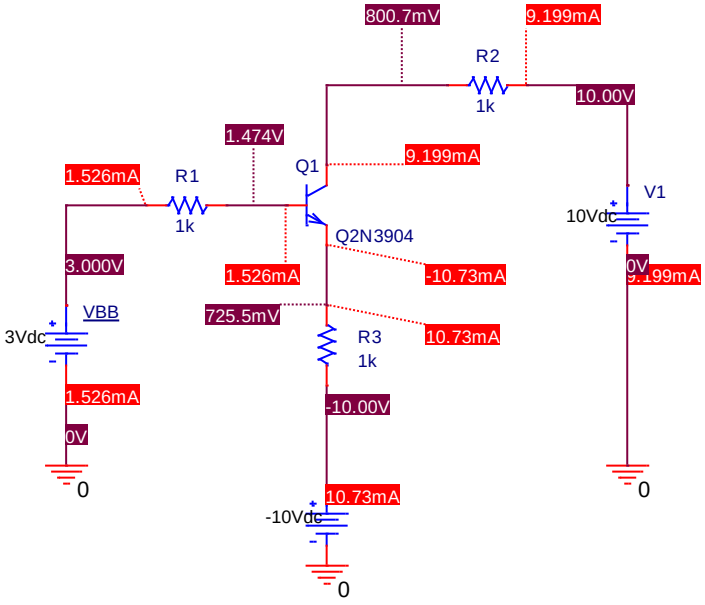
$V_B = 0.733 + 0.7 = 1.4V = V_B$

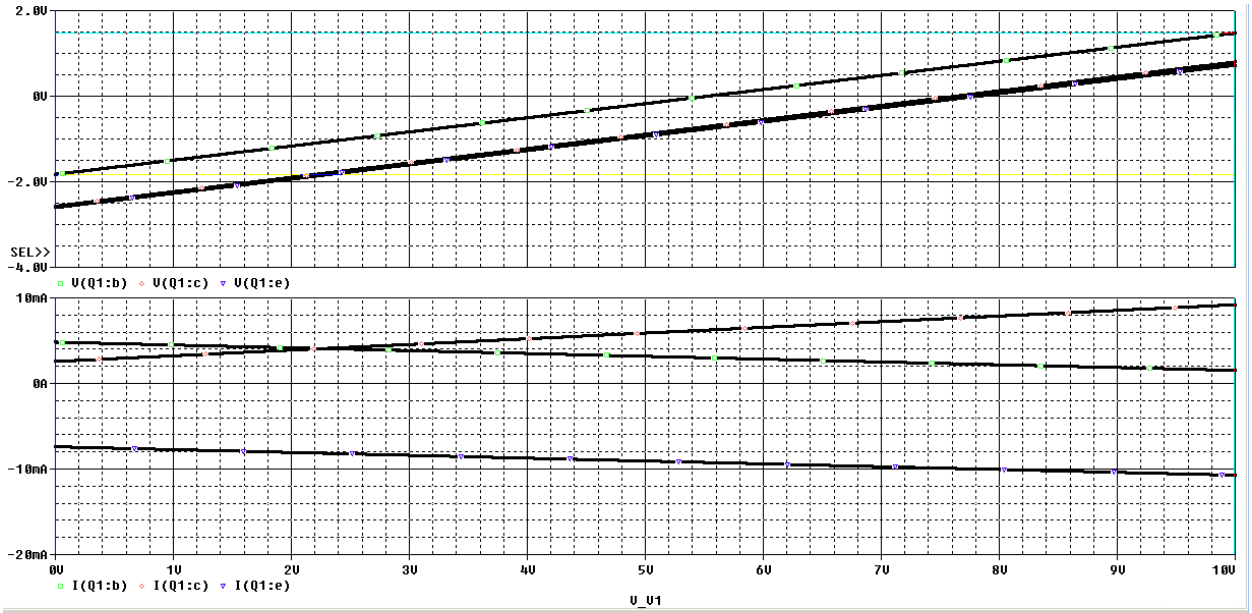
$V_C = 0.833V$

$i_C = 9.167\text{mA} > 0$ ✓ $i_B = 1.6\text{mA} > 0$ ✓ $i_E = 10.73\text{mA} > 0$ ✓

$i_C = 9.167\text{mA} < \beta(i_B) = 100(1.6\text{mA})$ ✓

The assumption of saturation mode is correct.





	I(Q1:b)	1.5295m	4.8262m	-3.2967m		-1.4690	1.8310	4.8262m	1.5295m	3.1778m
	I(Q1:c)	9.1927m	2.5697m	6.6231m		-1.4613	1.8287	9.1927m	2.5697m	5.8812m
	I(Q1:e)	-10.722m	-7.3958m	-3.3264m		-1.4813	1.8188	-7.3958m	-10.722m	-9.0590m
CURSOR 1,2	V(Q1:b)	1.4705	-1.8262	3.2967		0.000	0.000	1.4705	-1.8262	-177.823m
	V(Q1:c)	797.262m	-2.5697	3.3669		-673.263m	-743.488m	797.262m	-2.5697	-886.199m
	V(Q1:e)	722.214m	-2.6042	3.3264		-748.310m	-778.000m	722.214m	-2.6042	-940.978m

c) To active mode, $V_{BE} = 0,7\ V$ $V_{CE} > 0,7V$.

$I_C = 2mA$.

$\beta = 100 = I_C / I_B$ $I_C = 100\, I_B = 2mA$.

$I_B = 0,02\ mA$. > 0 V.

$I_E = I_B + I_C = 2,02\ mA = I_E$

$V_{CE} = V_C - V_E$ $V_{BE} = V_B - V_E = 0,7V$.

$i_B R_B = 3 - V_B$ $i_C R_C = 10 - V_C$ $i_E R_E = V_E + 0$

$V_{BE} = (3 - i_B R_B) - (i_E R_E - 10)$

$0,7 = (3 - (0,02) R_B) - (2,02) R_E - 10)$

$0,7 = 3 - 0,02 R_B - 2,02 R_E + 10$.

$-12,3 = -0,02 R_B - 2,02 R_E$.

$12,3 = 0,02 R_B + 2,02 R_E$.

$615 = R_B + 101 R_E$

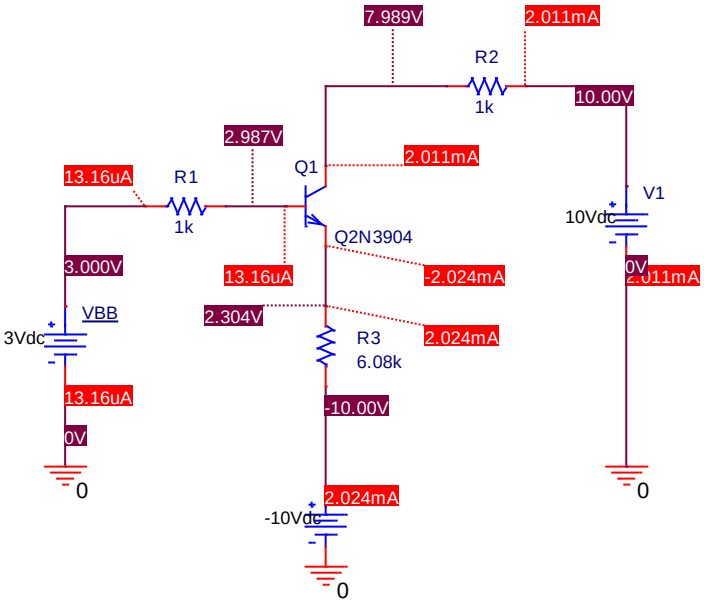
$R_B = 1K$ $R_E = 6,08K$

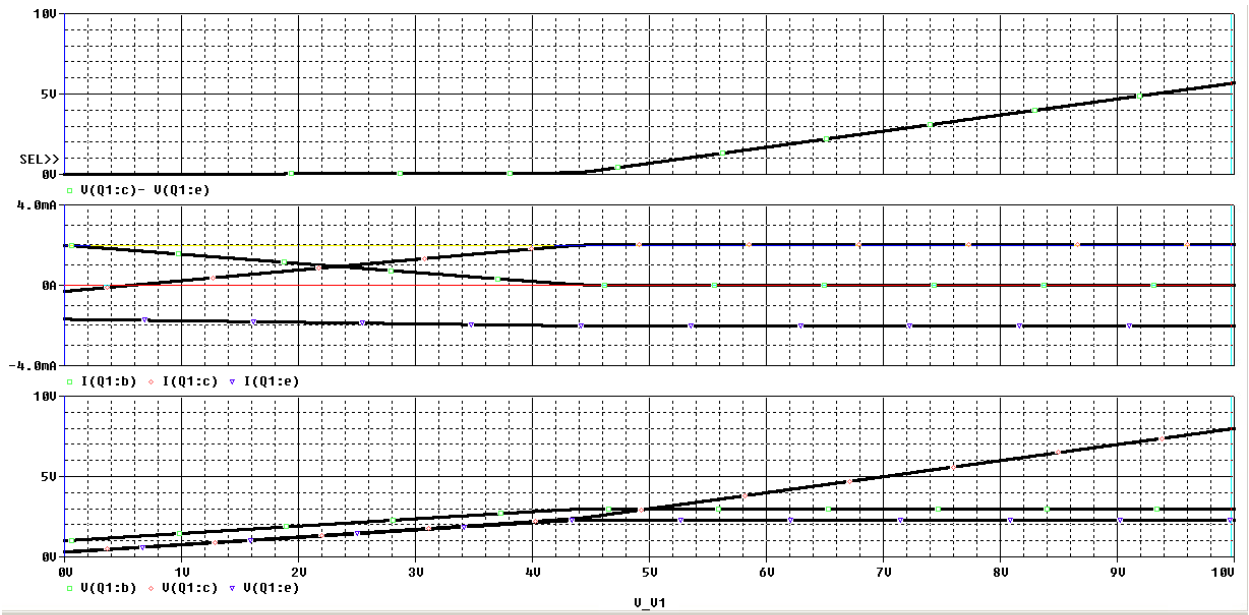
$V_B = 3 - 0,02(1) = 2,98$.

$V_E = 2,02(6,08) - 10 = 2,28V$.

$V_C = 10 - 1(2) = 8V$.

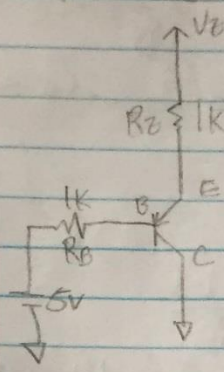
$V_{CE} = V_C - V_E = 8 - 2,28 = 5,72 > 0,7 = V_{BE}$ V.





	V(Q1:b)	2.9868	1.0018	1.9851		2.9868	0.9998	2.9868	1.0018	1.9943
	V(Q1:c)	7.9594	306.413m	7.6530		7.9594	304.415m	7.9594	306.413m	4.1329
	V(Q1:e)	2.3043	286.205m	2.0181		2.3043	284.207m	2.3043	286.205m	1.2952
CURSOR 1,2	I(Q1:b)	13.149u	1.9982m	-1.9851m		0.000	0.000	1.9982m	13.149u	1.0057m
	I(Q1:c)	2.0086m	-306.415u	2.3150m		1.9954m	-2.3046m	2.0086m	-306.415u	851.080u
	I(Q1:e)	-2.0217m	-1.6918m	-329.914u		-2.0349m	-3.6900m	-1.6918m	-2.0217m	-1.8568m
	V(Q1:c)- V(Q1:e)	5.6552	20.208m	5.6349		5.6551	18.210m	5.6552	20.208m	2.8377

1.4) @ Assume active.



$V_{EB}=0.7$ $\quad i_C=\beta i_B=100 i_B$

$i_E R_E = 3 - V_E$ $\quad i_E = 101 i_B$

$i_B R_B = 5 - V_B$

$i_C R_C = V_C$

$V_{EB} = 0.7 = V_E - V_B = 3 - i_E R_E - 5 + i_B R_B$

$0.7 = -2 - (101 i_B)(1) + i_B(1)$

$2.7 = -100 i_B$

$i_B = -0.027\,mA < 0$ ✗

$i_C = 100(-0.027) = -2.7\,mA$

$i_E = -2.727\,mA$

$3 - (1)(-2.727) - V_{EC} = 0$

$V_{EC} = -5.727\,V < 0.7 = V_{EB}$ ✗

The assumption BJT active mode is wrong.

Assume saturation.

$V_{EC}=0.1V$ $\quad V_{EB}=0.7V$ $\quad V_{BC}=0.6V$.

$i_B R_B = 5 - V_B$ $\quad i_C R_C = V_C$ $\quad i_E R_E = 3 - V_E$.

$V_{BC} = V_B - V_C = 0.6V$

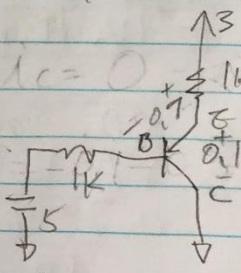
$V_{EB} = V_E - V_B = 0.7V$

$V_{EC} = V_E - V_C = 0.1V$

$V_C = 0$

$V_B = 0.6V$ $\quad V_{EB} = -0.5 < 0.7$

$V_E = 0.1V$



$i_B = 4.4\,mA > 0$ ✓ $\quad i_C = 0$ ✗ $\quad i_E = 3.1\,mA$ ✓

$V_{EB}=-0.5$, $I_C=0$ made assumption of saturation mode false.

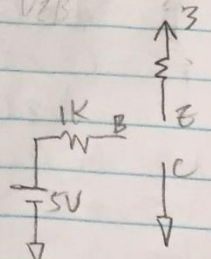
Assume cut off.

$i_B = 0$ $\quad i_C = 0$ $\quad i_E = 0$

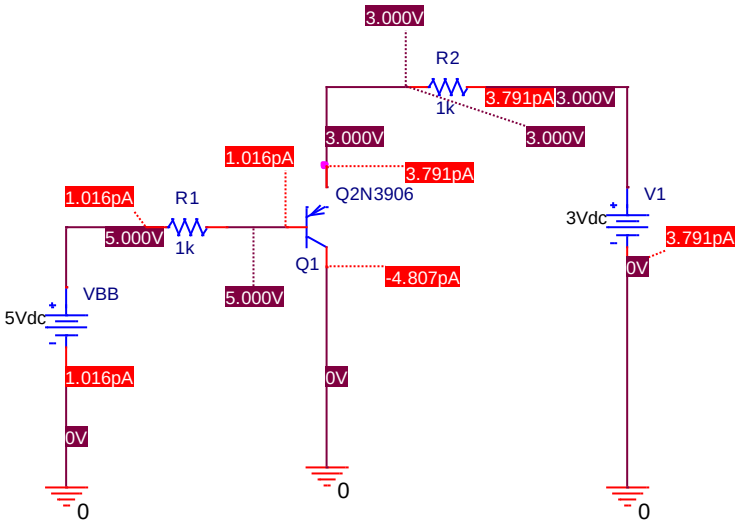
$V_C = 0V$ $\quad V_E < V_B$ ✓

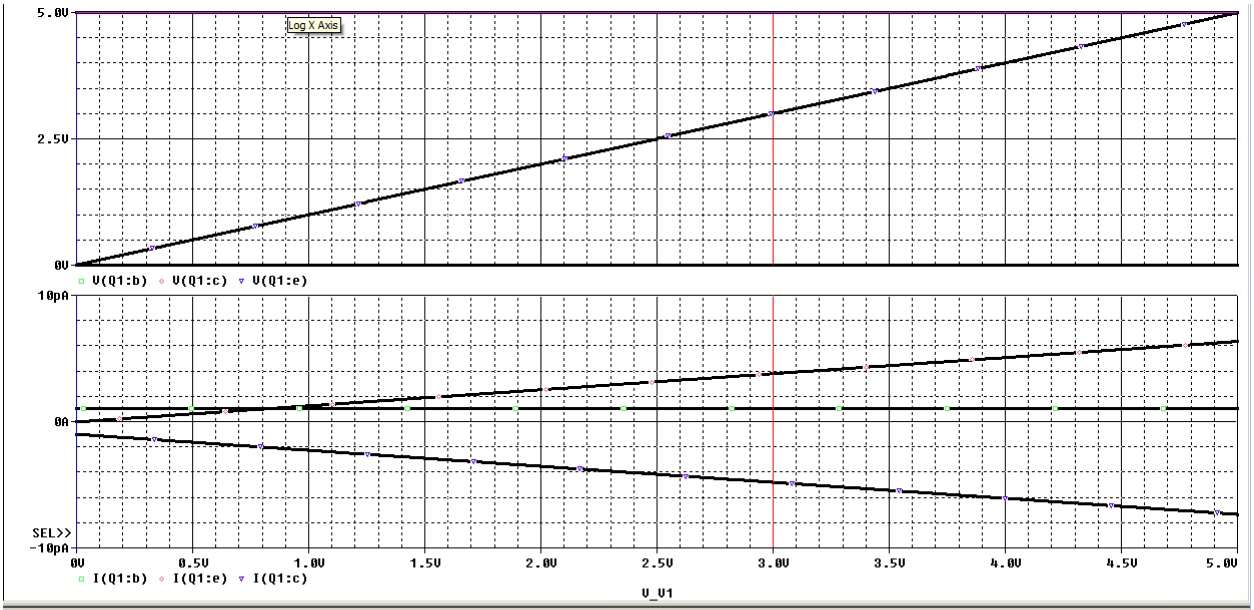
$V_E = 3V$ $\quad V_{EB} = -2 < 0$ ✓

$V_B = 5V$ $\quad V_{CB} = -5 < 0$ ✓



The assumption cut off mode is correct.





		X Values	3.0000	0.000	3.0000		Y1 - Y1(Cursor1)	Y2 - Y2(Cursor2)	Max Y	Min Y	Avg Y
	I(Q1:b)	1.0160p	1.0326p	-16.602f		-5.0000	-5.0000	1.0326p	1.0160p	1.0243p	
	I(Q1:e)	3.7911p	-27.678f	3.8187p		-5.0000	-5.0000	3.7911p	-27.678f	1.8817p	
	I(Q1:c)	-4.8070p	-1.0049p	-3.8021p		-5.0000	-5.0000	-1.0049p	-4.8070p	-2.9060p	
CURSOR 1,2	V(Q1:b)	5.0000	5.0000	17.001p		0.000	0.000	5.0000	5.0000	5.0000	
	V(Q1:c)	0.000	0.000	0.000		-5.0000	-5.0000	0.000	0.000	0.000	
	V(Q1:e)	3.0000	27.678p	3.0000		-2.0000	-5.0000	3.0000	27.678p	1.5000	

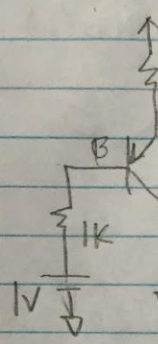
(b) Make it active. Lower V_{BB} or increase R_b

$V_{EB} = 0.7V$ $i_C = \beta i_B$ $i_E = i_C + i_B$

$i_E = 101 i_B$ $i_C = 100 i_B$

$V_{BC} > 0$ $V_{EC} > 0.7$

Lower $V_{BB} \rightarrow 1V$.



$i_E = \frac{3 - V_E}{R_E}$ $i_B = \frac{1 - V_B}{R_B}$

$V_{BB} = V_E - V_B = 3 - i_E R_E - 1 + i_B R_B = 0.7$

$1 - 0.7 = 2 - 101 i_B$

$i_B = 0.0127 mA > 0$

$i_C = 1.27 mA$

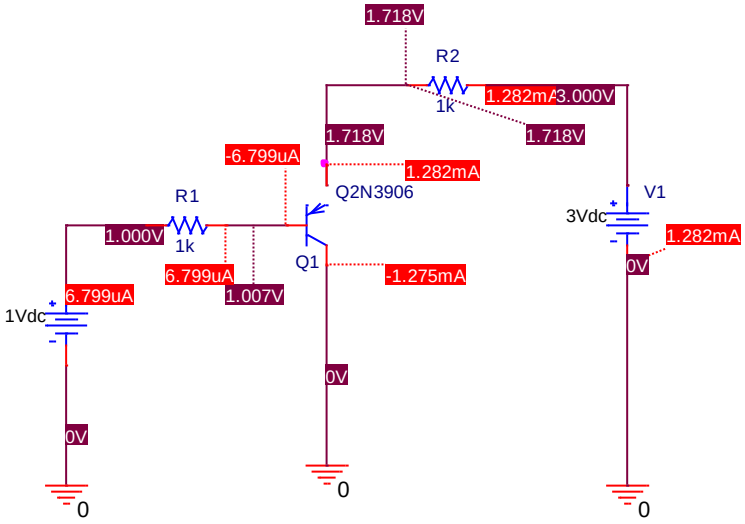
$i_E = 1.28 mA$

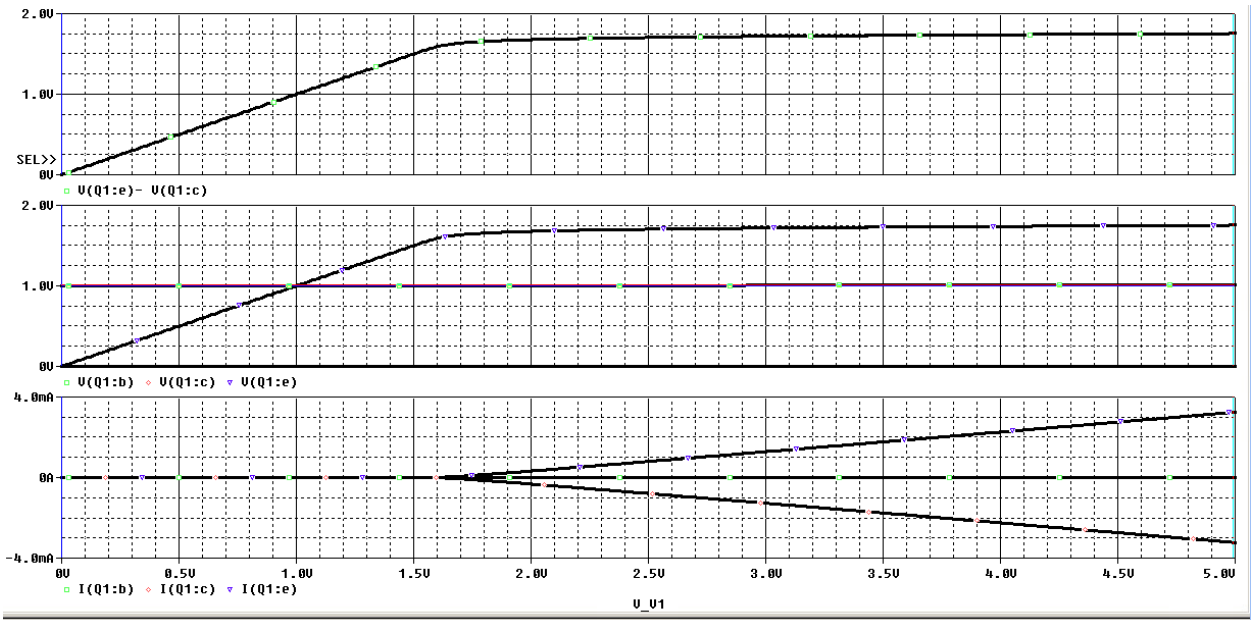
$V_E = 1.7V$ $V_B = 0.9871V$

$V_C = 0$ $V_{EC} = V_E - V_C = 1.7 > 0.7$ ✓

$V_{BC} = V_B - V_C = 0.9871 > 0.7$ ✓

- The BJT is in active mode by just lower V_{BB} to 1V. It is not necessary to increase R_B.





	I(Q1:b)	-17.533u	206.749f	-17.533u		-1.0176	-1.0000	206.749f	-17.533u	-8.7666u
	I(Q1:c)	-3.2166m	-201.219f	-3.2166m		-1.0208	-1.0000	-201.219f	-3.2166m	-1.6083m
	I(Q1:e)	3.2341m	-5.5301f	3.2341m		-1.0143	-1.0000	3.2341m	-5.5301f	1.6171m
CURSOR 1,2	V(Q1:b)	1.0176	1.0000	17.547m		0.000	0.000	1.0176	1.0000	1.0088
	V(Q1:c)	0.000	0.000	0.000		-1.0176	-1.0000	0.000	0.000	0.000
	V(Q1:e)	1.7533	5.5418p	1.7533		735.790m	-1.0000	1.7533	5.5418p	876.669m
	V(Q1:e)- V(Q1:c)	1.7533	5.5418p	1.7533		735.790m	-1.0000	1.7533	5.5418p	876.669m

* If $V_{BB} < 0$. Assume $V_{BB} = -1$. Assume active.

$V_{BE} = 0.7 = V_B - V_E = 3 - i_B R_E - (-1) + i_B R_B$

$0.7 = 4 - 10 i_B$ $\quad i_C = 3.267V$

$i_B = 0.03267 > 0$ $\quad i_E = 3.29967 V.$

$i_E = \frac{3 - V_B}{R_E}$ $\quad i_B = \frac{-1 - V_B}{R_B}$

$3 - i_E R_E - V_{EC} = 0$

$3 - (3.29967)(1) = V_{EC}$

$V_{EC} = -0.29967 < 0.7 = V_{EB}$ ✗

Not in active mode when $V_{BB} < 0$.

Assume saturation mode.

$V_{EB} = 0.7$ $\quad V_{EC} = 0.1$ $\quad V_E - V_B = 0.7$ $\quad V_B - V_C = 0.1$

$3 - i_E R_E - V_{EC} = 0$ $\quad i_E = 2.9 mA$

$I_B = \frac{V_B + 1}{1}$ $\quad I_E = \frac{3 - V_E}{1}$ $\quad I_C = \frac{V_C}{R}$ $\quad I_E = I_C + I_B$

$I_B = \frac{V_B + 1}{1} = 0.4 mA$ $\quad V_B = V_E - 0.7$

$I_E = 2.9 mA$

$I_C = I_E - I_B = 2.9 - 0.4 = 2.5 mA$

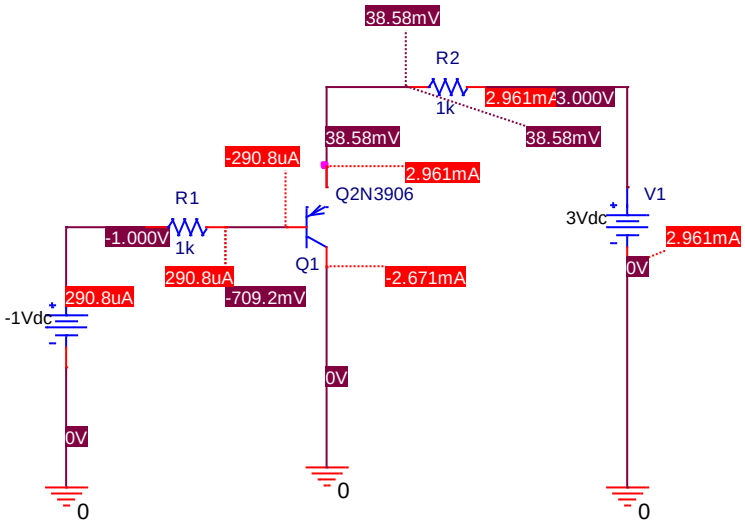
$V_E = V_B + V_{EB} =$

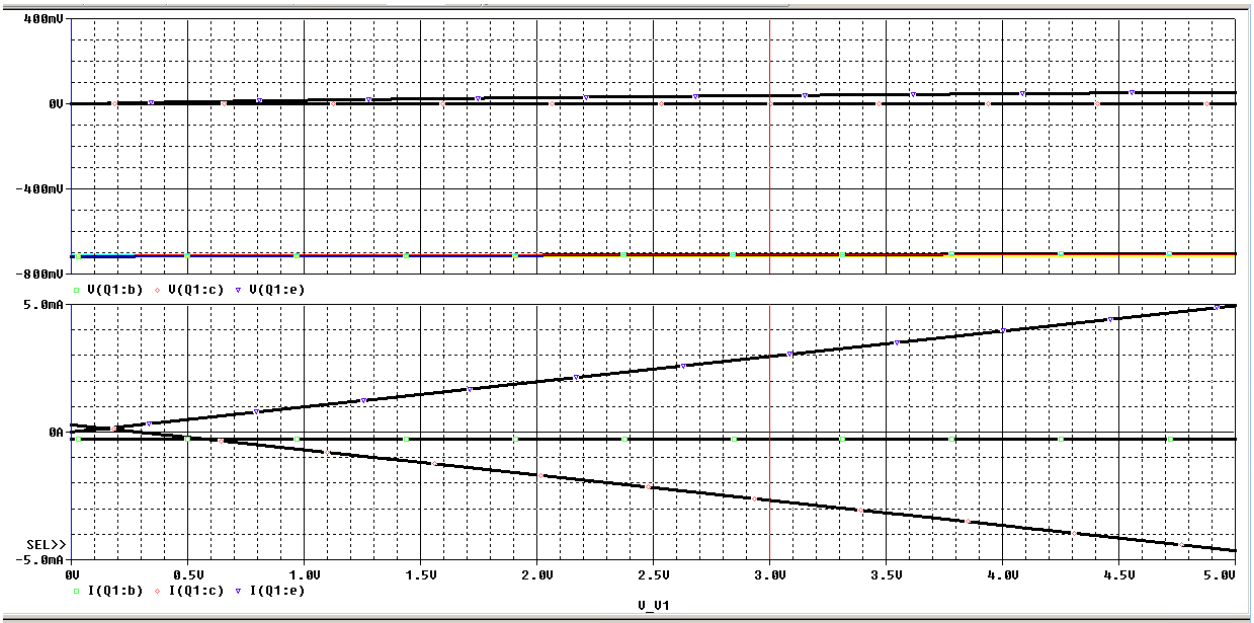
$3 - V_E = i_E R_E = 2.9(1)$

$V_E = 0.1 V$ $\quad V_C \cong 0 V$

$V_B = 0.6 V$

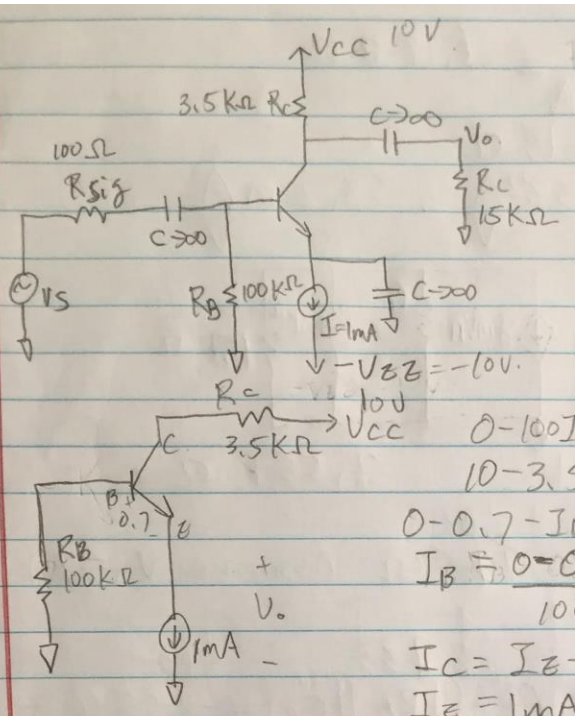
The BJT is in saturation mode if V_{BB} become negative.





	X Values	3.0000	0.000	3.0000		Y1 - Y1(Cursor1)	Y2 - Y2(Cursor2)	Max Y	Min Y	Avg Y
	I(Q1:b)	-290.768u	-282.581u	-8.1872u		708.931m	717.136m	-282.581u	-290.768u	-286.675u
	I(Q1:c)	-2.6691m	281.743u	-2.9509m		706.553m	717.701m	281.743u	-2.6691m	-1.1937m
	I(Q1:e)	2.9599m	838.445n	2.9591m		712.182m	717.420m	2.9599m	838.445n	1.4804m
CURSOR 1,2	V(Q1:b)	-709.222m	-717.419m	8.1971m		0.000	0.000	-709.222m	-717.419m	-713.320m
	V(Q1:c)	0.000	0.000	0.000		709.222m	717.419m	0.000	0.000	0.000
	V(Q1:e)	38.580m	-838.480u	39.418m		747.801m	716.580m	38.580m	-838.480u	18.871m

2.1



Ic, VCE
re, r, gm, ro
small signal diagram
input resistance Rin
Voltage gain $A_V = \frac{V_o}{V_s}$

$0 - 100I_B - 0.7 - V_o = 0$

$10 - 3.5I_C - V_{CE} - V_o = 0$

$0 - 0.7 - I_B R_B = 0$

$I_B \approx \frac{0 - 0.7}{100} = 0.007\text{mA}$

$I_C = I_E - I_B = 0.993\text{mA}$

$I_E = 1\text{mA}$

$-100(0.007) - 0.7 = V_o$

$-1.4V = V_o$

$V_{CE} = 10 - 3.5(0.993) + 1.4 = 0$

$V_{CE} = 7.9245V$

$V_C = V_{CC} - I_C R_C = 10 - 0.993(3.5)$

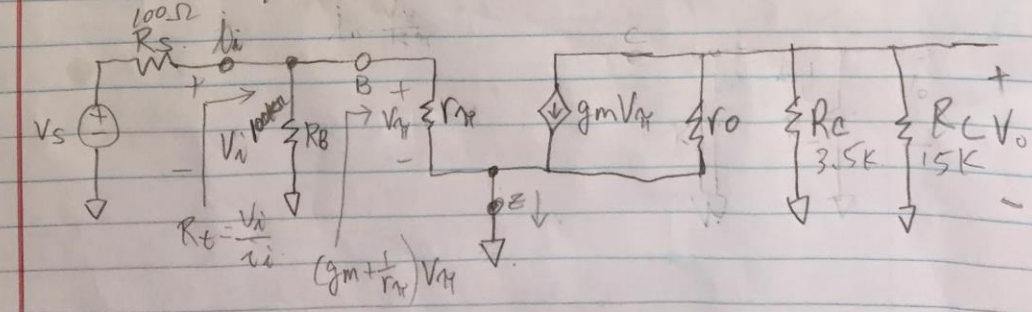
$V_C = 6.5245V$

$V_{CE} = V_C - V_E = 6.5245 - V_E = 7.9245$

$V_E = -1.4$

$V_{BE} = V_B - V_E = V_B - (-1.4) = 0.7$

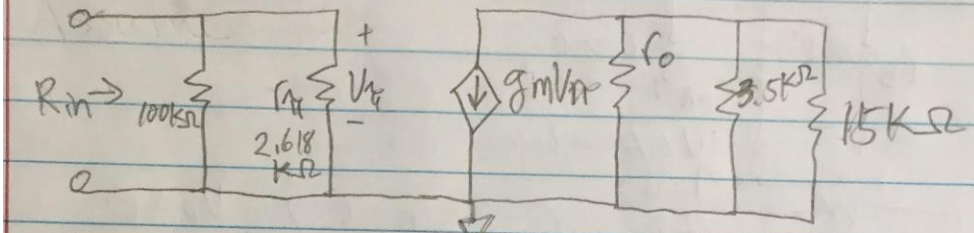
$V_B = -0.7\,V$



$r_e = \frac{V_T}{I_C} = \frac{26\,mV}{0.993\,mA} = 26.18\,\Omega$

$r_\pi = \beta r_e = 2618\,\Omega$

$g_m = \frac{1}{r_e} = 0.0382\frac{A}{V} = 38.2\,m\frac{A}{V}$

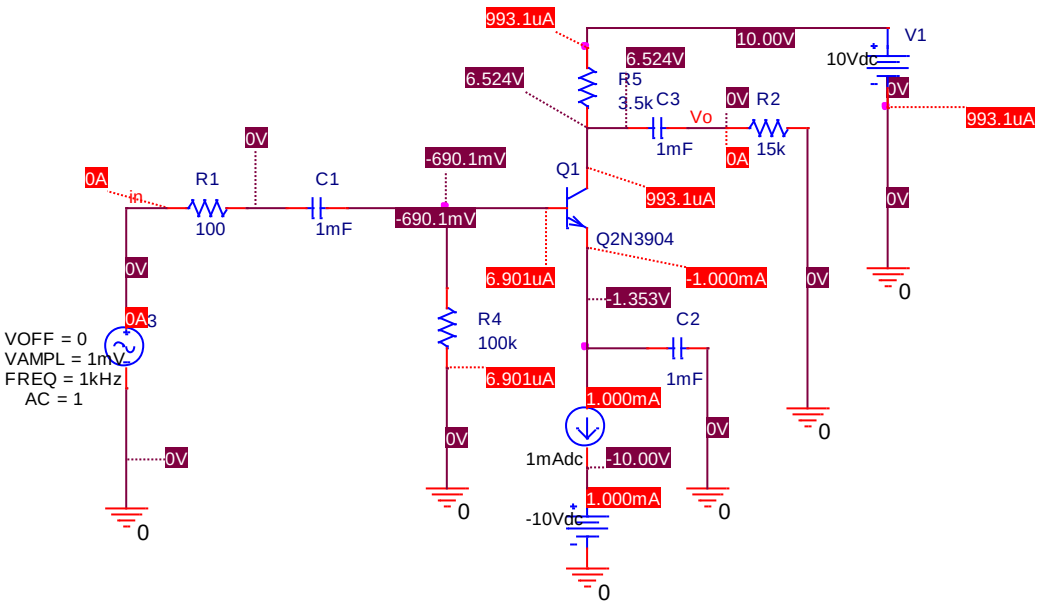


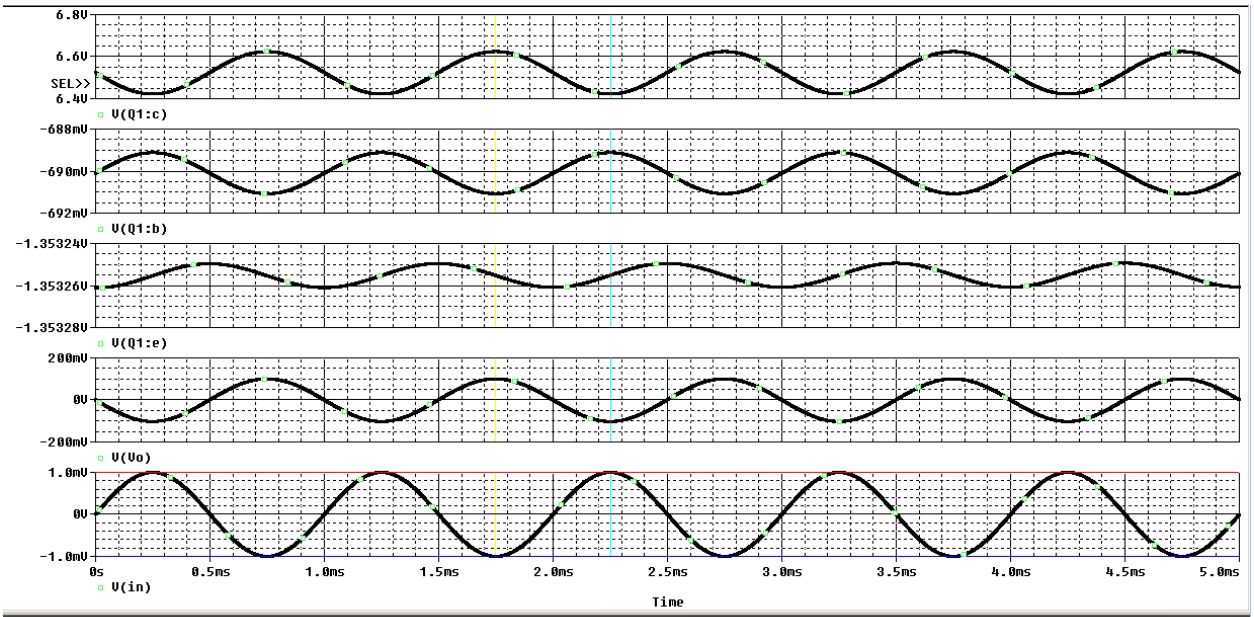
$R_{in} = R_B \| r_\pi = \frac{1}{\frac{1}{100} + \frac{1}{2.618}} = 2.55\,k\Omega$

$r_o = \frac{V_A}{I_C} = \frac{74}{0.993} = 74.5\,k\Omega$ Assume $V_A = 74V$.

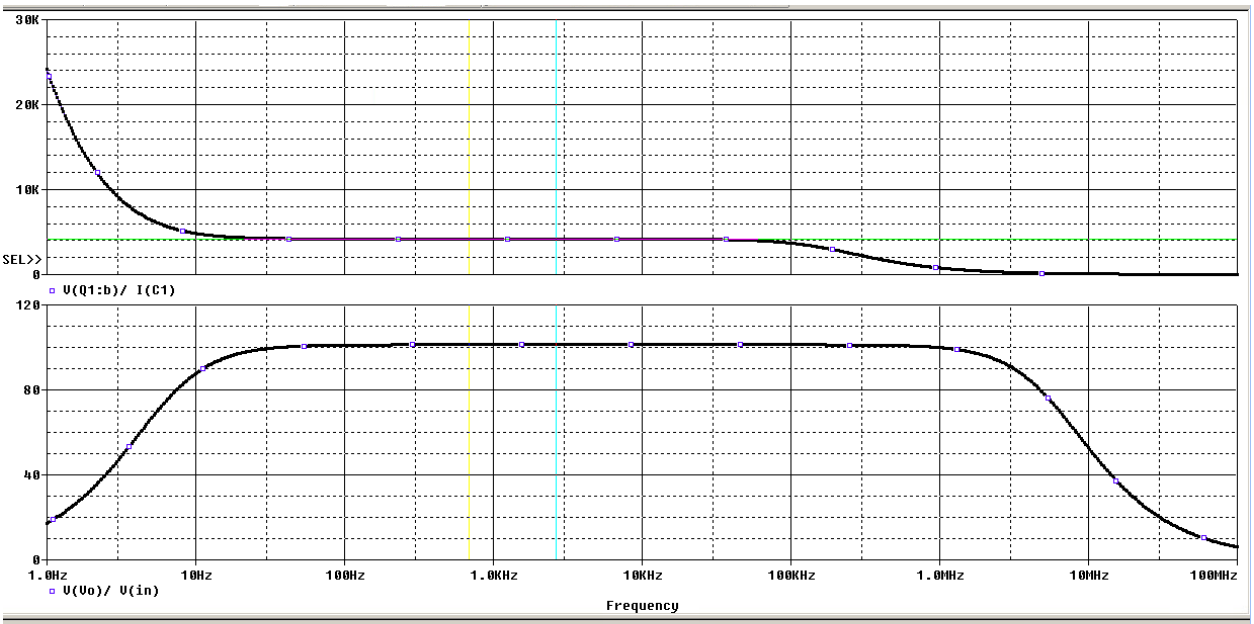
$A_V = -\frac{R_{in}}{R_{in}+R_s} g_m (R_C \| R_L \| r_o)$

$A_V = (0.9623)(38.2)(3) \cong -100.5$



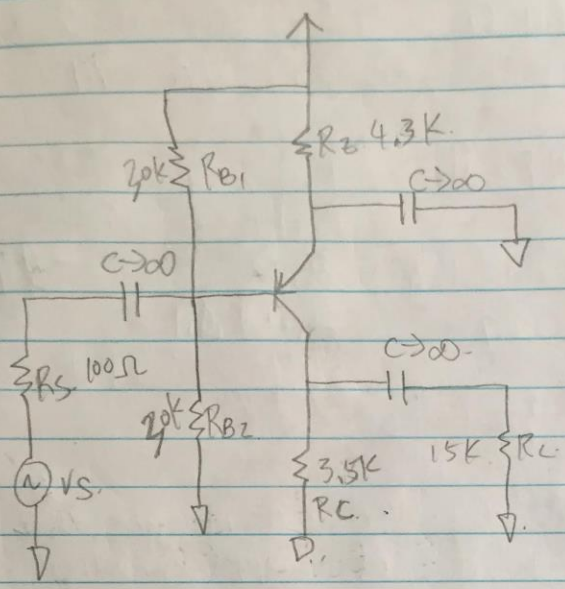


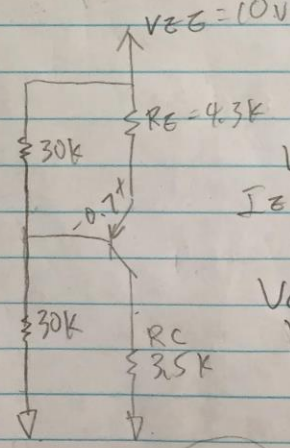
Trace Color	Trace Name	Y1	Y2	Y1 - Y2		Y1(Cursor1) - Y2(Cursor2)		1.9998m		
	X Values	2.2522m	1.7478m	504.348u		Y1 - Y1(Cursor1)	Y2 - Y2(Cursor2)	Max Y	Min Y	Avg Y
CURSOR 1,2	V(in)	0.9999m	-0.9999m	1.9998m		0.000	0.000	0.9999m	-0.9999m	1.1565n
	V(Vo)	-102.330m	100.134m	-202.464m		-103.330m	101.134m	100.134m	-102.330m	-1.0978m
	V(Q1:e)	-1.3533	-1.3533	98.309n		-1.3543	-1.3523	-1.3533	-1.3533	-1.3533
	V(Q1:b)	-689.125m	-691.078m	1.9534m		-690.125m	-690.078m	-689.125m	-691.078m	-690.102m
	V(Q1:c)	6.4218	6.6243	-202.464m		6.4208	6.6253	6.6243	6.4218	6.5231



Trace Color	Trace Name	Y1	Y2	Y1 - Y2		Y1(Cursor1) - Y2(Cursor2)		-522.950m		
	X Values	2.6410K	686.649	1.9544K		Y1 - Y1(Cursor1)	Y2 - Y2(Cursor2)	Max Y	Min Y	Avg Y
	V(Vo)/ V(in)	101.230	101.226	3.3063m		-4.0838K	-4.0844K	101.230	101.226	101.228
CURSOR 1,2	V(Q1:b)/ I(C1)	4.1851K	4.1856K	-522.950m		0.000	0.000	4.1856K	4.1851K	4.1853K

2.2





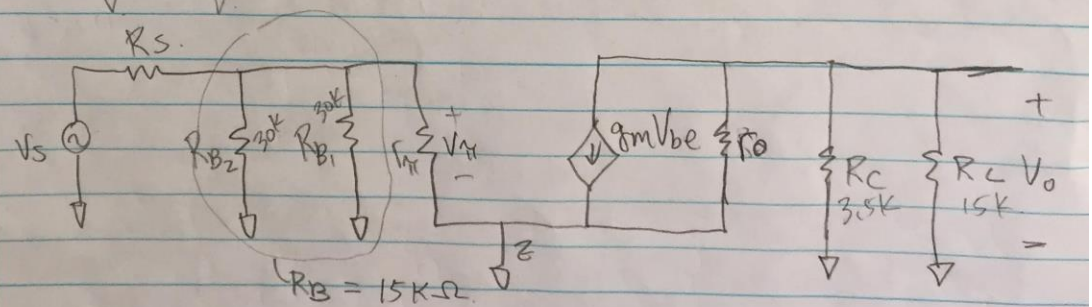
$$V_B \approx V_{BB} = V_{ee}\frac{R_{B1}}{R_{B2}+R_{B1}} = \frac{10(30)}{60} = 5$$

$$V_E = V_B + V_{BB} \cong 5 + 0.7 = 5.7V.$$

$$I_E = \frac{V_{ee} - V_E}{R_E} = \frac{10 - 5.7}{4.3} = 1mA \cong I_C$$

$$V_C = I_C R_C = 1(3.5) = 3.5V$$

$$V_{EC} = V_E - V_C = 5.7 - 3.5 = 2.2V$$



$$r_e = \frac{V_T}{I_C} = \frac{26}{1} = 26\Omega$$

$$g_m = 1/r_e = 0.0384 A/V = 38\ mA/V$$

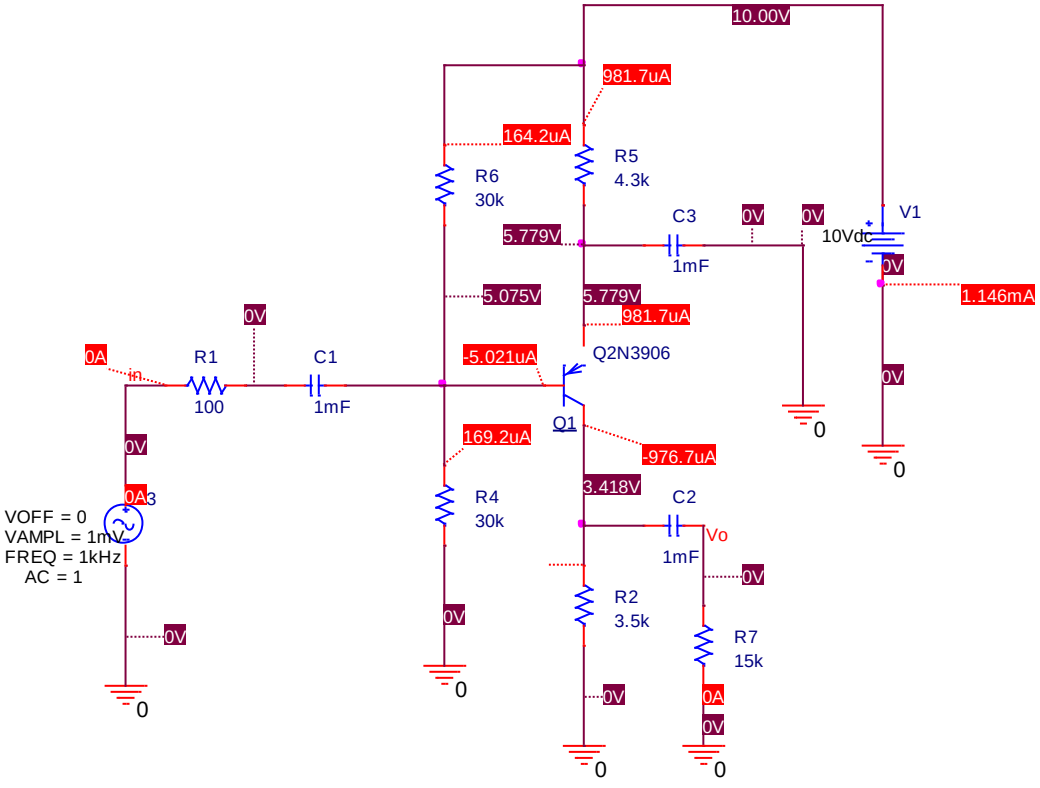
$r_\pi = 100 r_e = 2.6\,k\Omega$

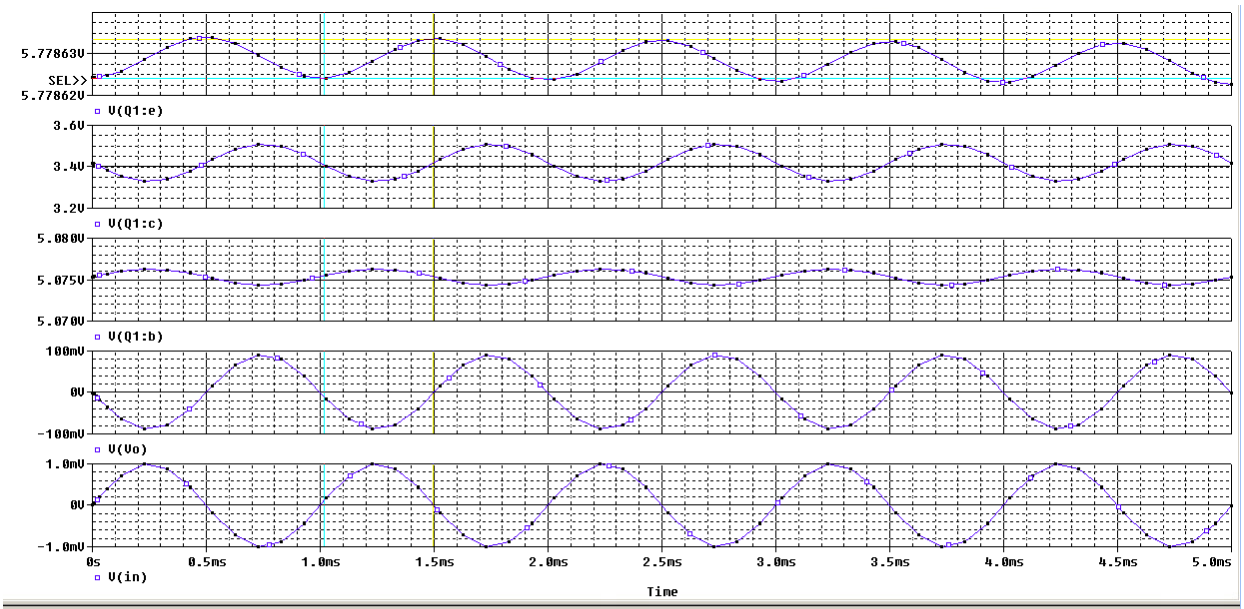
$r_o = \frac{74}{1mA} = 74k\Omega$ Assume $V_A = 74V$.

$A_V = -g_m(R_C \| R_L \| r_o)\left[\frac{R_{in}}{R_{in}+R_S}\right]$ .95

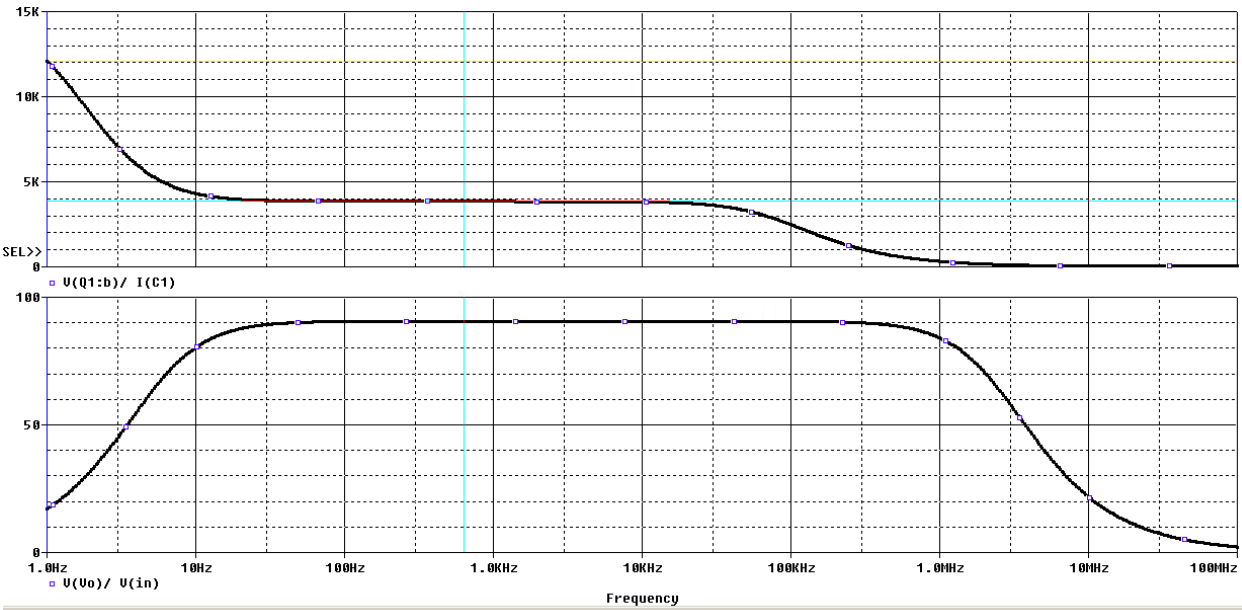
$= -38\,(3.5 \| 15 \| 74)\left[\frac{2.2}{2.2+0.1}\right] \approx -97$

$R_{in} = R_B \| R_\pi = \frac{2.7}{\frac{1}{15}+\frac{1}{2.6}} = 2.21591\,K\Omega$





Trace Color	Trace Name	Y1	Y2	Y1 - Y2		Y1(Cursor1) - Y2(Cursor2)		-9.3732u		
	X Values	1.0175m	1.4956m	-478.070u		Y1 - Y1(Cursor1)	Y2 - Y2(Cursor2)	Max Y	Min Y	Avg Y
	V(in)	108.434u	12.048u	96.386u		-5.7785	-5.7786	108.434u	12.048u	60.241u
	V(Vo)	-10.843m	-1.2048m	-9.639m		-5.7895	-5.7798	-1.2048m	-10.843m	-6.0241m
	V(Q1:b)	5.0754	5.0753	84.836u		-703.195m	-703.289m	5.0754	5.0753	5.0754
	V(Q1:c)	3.4085	3.4172	-8.7828m		-2.3702	-2.3614	3.4172	3.4085	3.4128
CURSOR 1,2	V(Q1:e)	5.7786	5.7786	-9.3732u		0.000	0.000	5.7786	5.7786	5.7786



Trace Color	Trace Name	Y1	Y2	Y1 - Y2		Y1(Cursor1) - Y2(Cursor2)		-8.2500K		
	X Values	634.923	1.0000	633.923		Y1 - Y1(Cursor1)	Y2 - Y2(Cursor2)	Max Y	Min Y	Avg Y
	V(Vo)/ V(in)	90.612	17.060	73.552		-3.7492K	-12.073K	90.612	17.060	53.836
CURSOR 1,2	V(Q1:b)/ I(C1)	3.8398K	12.090K	-8.2500K		0.000	0.000	12.090K	3.8398K	7.9648K