



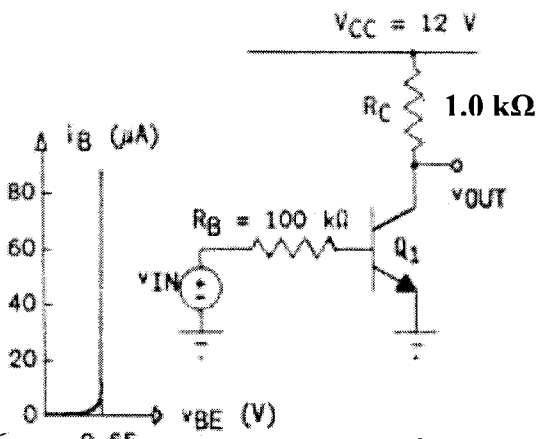
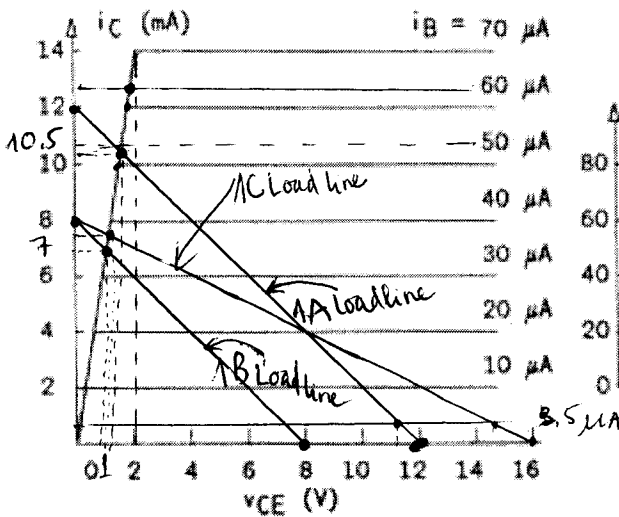
University of Texas at Arlington EE 2303 Fall 2007

Problem Set #7 Assigned Thu. 10/18/07, Due Thu. 10/25/07

Problem #1A:

A BJT with the indicated v-i characteristics is connected to the circuit shown. Using graphical techniques

- ✓ 1) Carefully plot the V_{OUT} - V_{IN} transfer characteristic. Vary V_{IN} from 0 to 7 Volts.
- ✓ 2) Carefully plot I_C vs. I_B over the range $I_B=0$ to $100 \mu A$.
- ✓ 3) Carefully plot I_C / I_B vs. V_{IN} over the range $I_B=0$ to $100 \mu A$.
- ✓ 4) In both graphs indicate Cutoff, Forward Active, and Saturation Regions.
- ✓ 5) In Saturation Region, what is saturating?
- ✓ 6) In the Forward Active Region, what is the ratio V_{OUT}/V_{IN} ?
- ✓ 7) In the Forward Active Region, what is the derivative $\frac{dV_{OUT}}{dV_{IN}}$?



Prob 1A

$$V_{CC} = R_C I_C + V_{CE}$$

$$I_C = -\frac{V_{CE}}{R_C} + \frac{V_{CC}}{R_C}$$

$$I_C = -\frac{V_{CE}}{1k} + \frac{12V}{1k}$$

Problem #1B:

Repeat Problem 1, except this time use $V_{CC}=8 V$.

Problem #1C:

Repeat Problem 1, except this time use $R_C=2.0 k\Omega$ $V_{CC}=16 V$.

Problem #1D:

Fill in the table below and compare and contrast the results of Problems 1A, 1B, and 1C and write a conclusion

Problem 1D →

	V_{CC}	R_C	V_{IN} @ onset of saturation	V_{OUT} @ onset of saturation	I_C Max	$\frac{dV_{OUT}}{dV_{IN}}$	V_{OUT}/V_{IN}
Problem 1A	12 V	1.0 k Ω	5.9V	1.5V	10.5 mA	-2	See table page 1.
Problem 1B	8 V	1.0 k Ω	4.15V	1.0V	7mA	-2	See table page 2.
Problem 1C	16 V	2.0 k Ω	4.385V	1.07V	7.47mA	-4	See table page 3

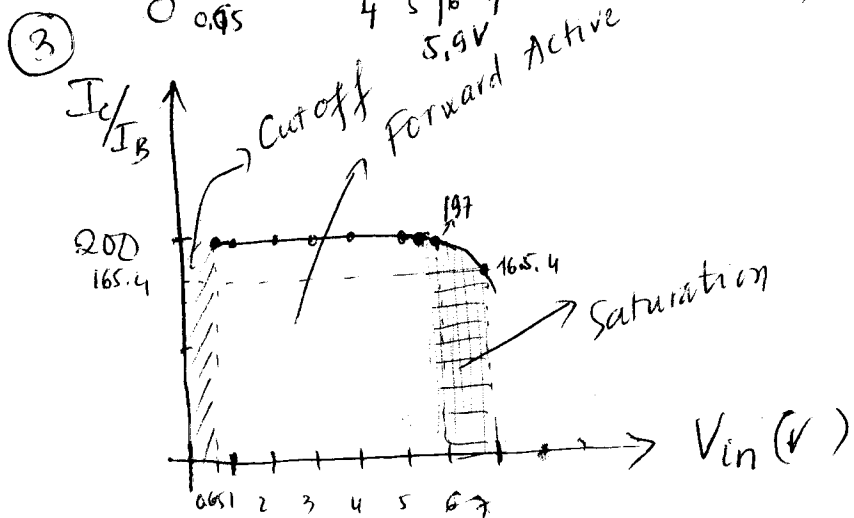
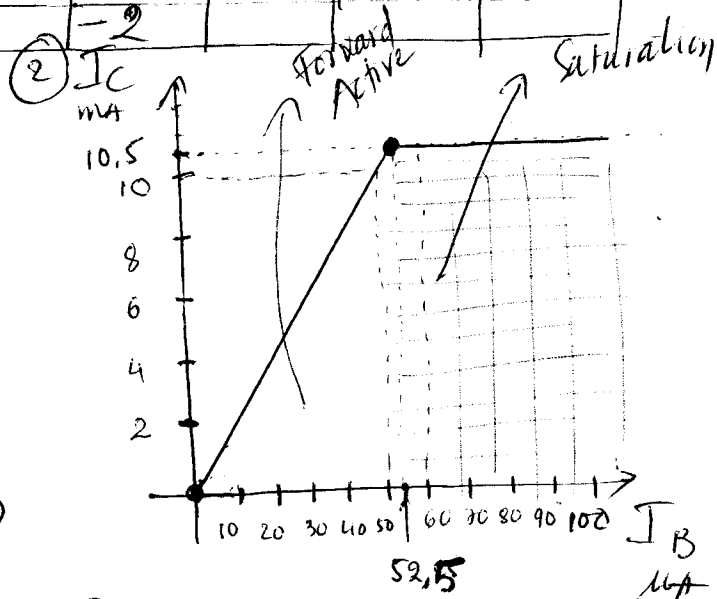
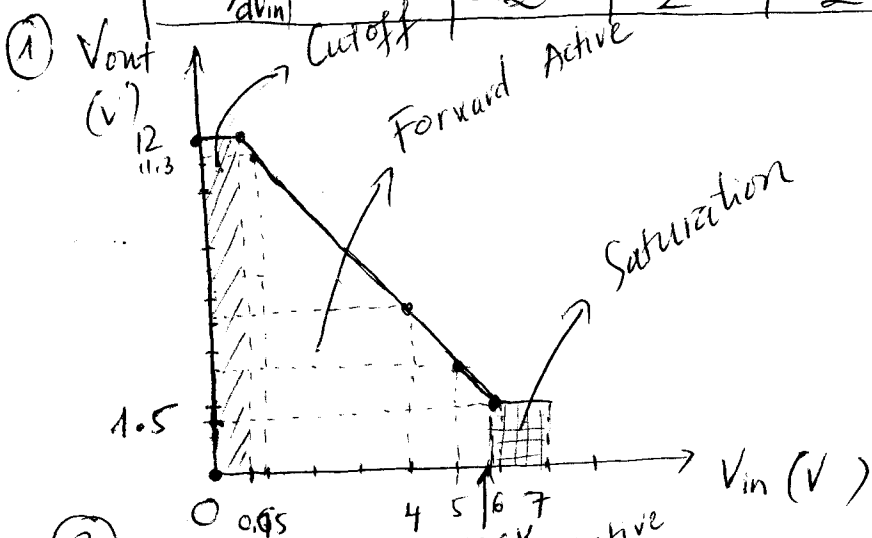
Problem Set #7

①

Problem 1 A

$$V_{BE} = 0.65 \text{ V}, \quad I_B = \frac{V_{IN} - 0.65}{R_B} = \frac{V_{IN} - 0.65}{100k\Omega}$$

$V_{in} (V)$	0	1	2	3	4	5	6	7
$I_B (\mu A)$	0	0.0035 3.5	13.5	23.5	33.5	43.5	53.5	63.5
$I_C (mA)$	0	0.7 mA	2.7	4.7	6.7	8.7	10.5	10.5
$V_{out} = V_{CE}$	12V	11.3V	9.3	7.3	5.3	3.3	1.5	1.5
V_{out}/V_{in}		11.3	4.65	2.43	1.34	0.75		
dV_{out}/dV_{in}		-2	-2	-2	-2			



④

- cutoff
- Saturation
- F. Active.

⑤ $I_{Cmax} = 10.5 (mA)$
 $V_{CE} = 1.5 V$

⑥ F.A. Region, $V_{out}/V_{in} \Rightarrow$ See Table above.

⑦ In F. Active Region $\frac{dV_{out}}{dV_{in}} = -2$

$$V_{in @ sat} = 0.65 + R_B I_B = 0.65 + 100k \cdot \frac{10.5 \mu A}{200} = \boxed{5.9 V}$$

Problem 1 B

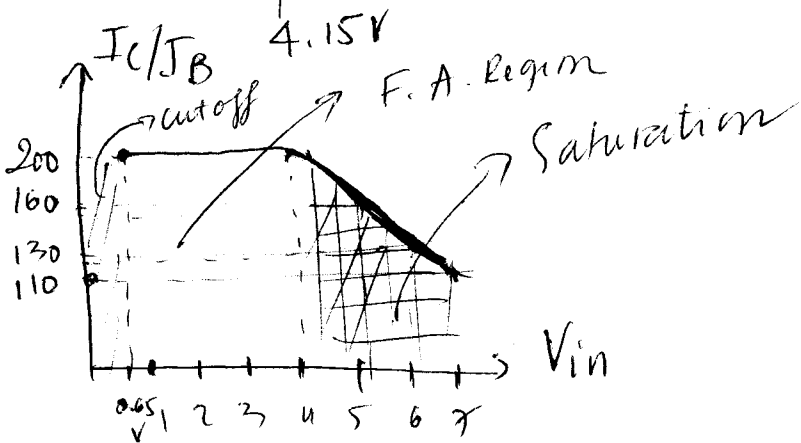
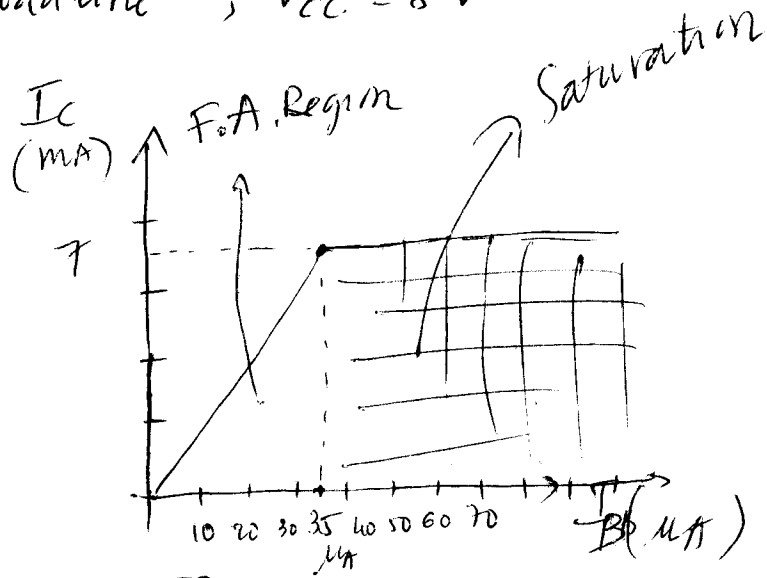
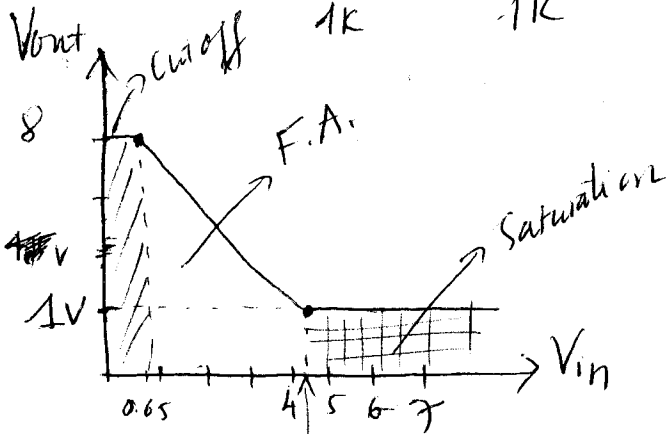
Problem Set # 7

2

V_{in}	0	1	2	3	4	5	6	7
$I_B (\mu A)$	0	3.5	13.5	23.5	33.5	43.5	53.5	63.5
$I_C (mA)$	0	0.7	2.7	4.7	6.7	7	7	7
$V_{out} = V_{CE} (V)$	8V	7.3	5.3	3.3	1.3	1	1	1
V_{out}/V_{in}		7.3	2.65	1.1	0.32			
dV_{out}/dV_{in}		-2	-2	-2	-1			

$V_{CC} = R_C I_C + V_{CE} \Rightarrow D.L. \text{ load line}, V_{CC} = 8V$

$I_C = \frac{-V_{CE}}{1k} + \frac{8V}{-1k}$



4

5 $I_{Cmax}^{Sat} = 7mA$

$V_{CE} = 1V$

$V_{in @ Sat} = 4.15V$

6 $V_{out}/V_{in} \rightarrow$ settable

7 $\frac{dV_{out}}{dV_{in}} = -2$ in F.A.R

Problem Set # 7

(3)

Problem 1C

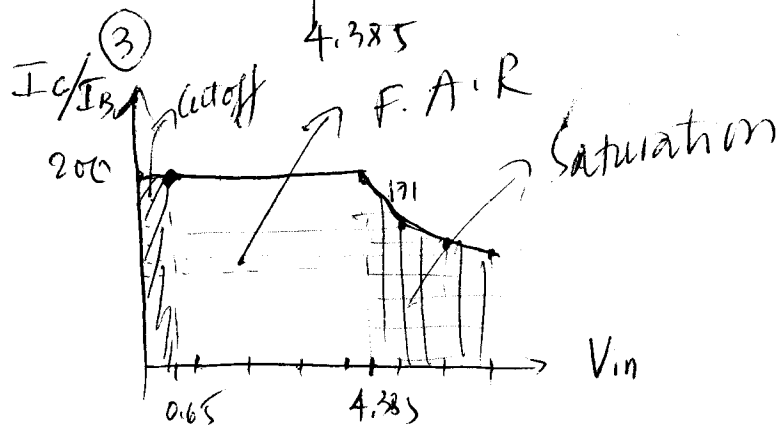
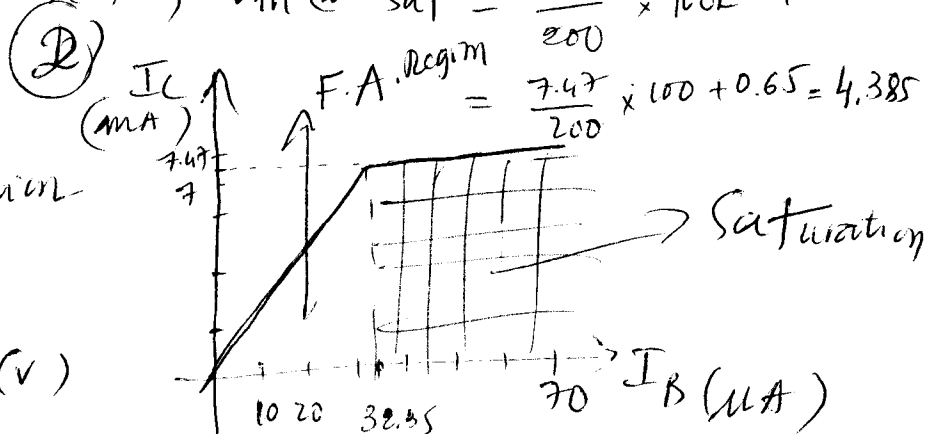
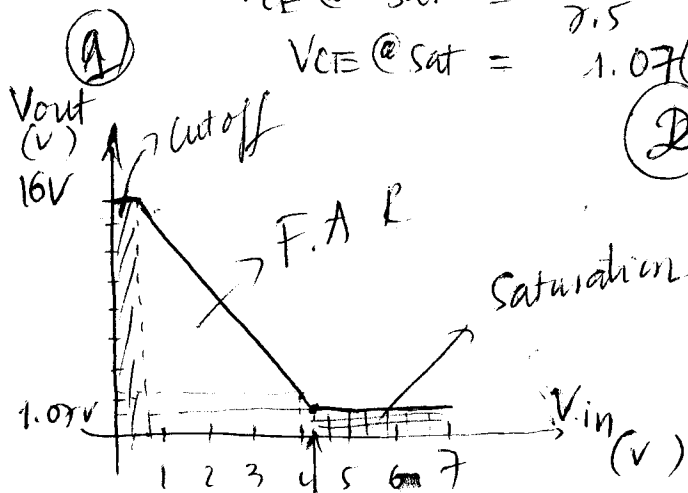
V_{in}	0	1	2	3	4	5	6	7
$I_B (\mu A)$	0	3.5	13.5	23.5	33.5	43.5	53.5	63.5
$I_C (mA)$	0	0.7	2.7	4.7	6.7	7.47	7.47	7.47
$V_{out} = V_{CE}$	16	14.6	10.6	6.6	2.6	1.07	1.07	1.07
V_{out}/V_{in}		14.6	5.3	2.2	0.65			
dV_{out}/dV_{in}		-4	-4	-4	-4			

$V_{CC} = R_C I_C + V_{CE}$ D.C Load line $V_{CC} = 16$

$I_C = -\frac{V_{CE}}{2k} + \frac{16V}{2k} = -\frac{V_{CE}}{2} + 8$

$V_{CE} @ Sat = \frac{8}{7.5} (V)$, $I_{Cmax} = \frac{7 \times 8}{7.5} = 7.47 \text{ mA}$

$V_{CE} @ Sat = 1.07 (V)$, $V_{in} @ Sat = \frac{I_{Cmax}}{200} \times 100k + 0.65$



(4)

(5)

$I_{Cmax} = 7.47 \text{ mA}$

$V_{CE} = 1.07 \text{ V @ Sat}$

$V_{in @ Sat} = 4.385 \text{ V}$

(6)

$V_{out}/V_{in} \rightarrow$ see table

(7)

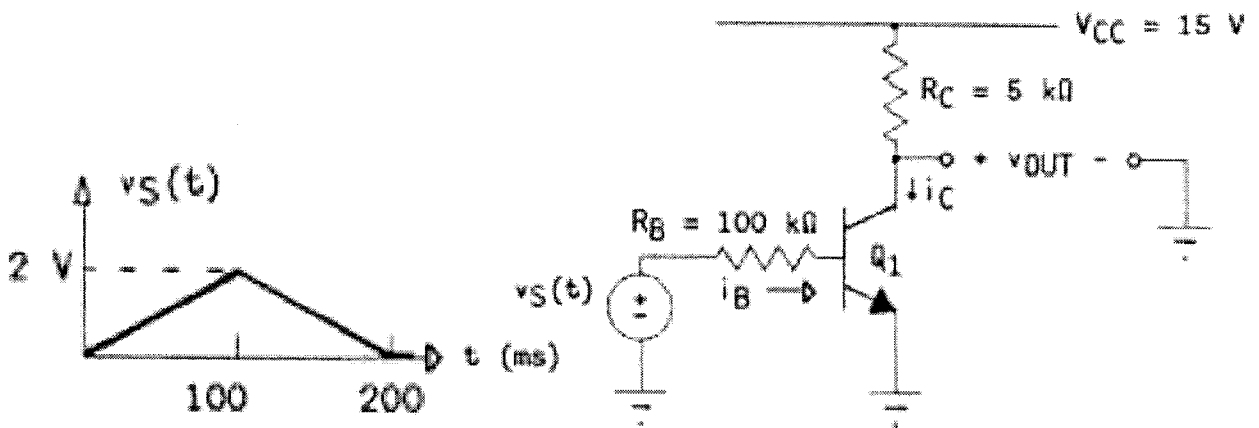
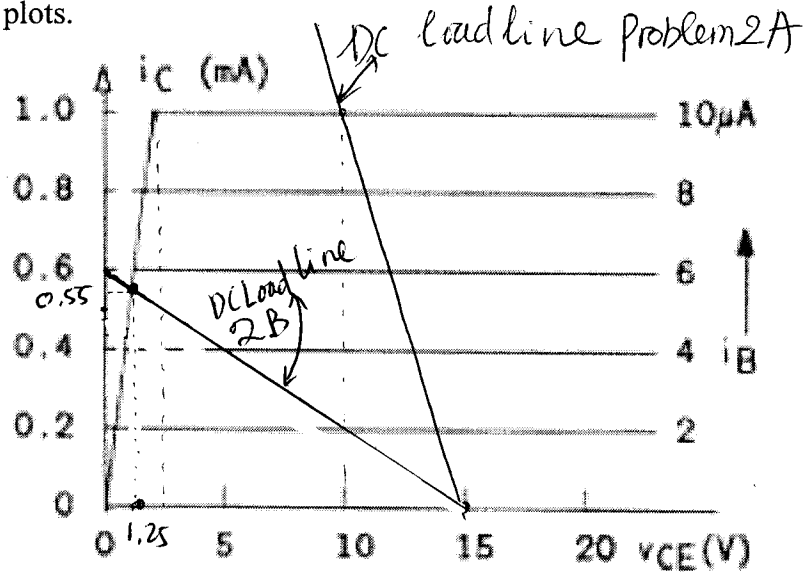
$\frac{dV_{out}}{dV_{in}} = -4$ in F.A.R

Problem #2A

A bipolar junction transistor (BJT) has the v-i characteristics shown below. The device is connected to a simple inverter circuit whose input consists of a triangular voltage pulse $v_s(t)$ that rises from zero to 2 V in 100 ms, then falls to zero after another 100 ms.

Assume that $V_f = 0.7$ V for the base-emitter junction.

Using graphic method *carefully* plot base current, collector current, and output voltage V_{OUT} vs. time in 3 separate plots.



Problem #2B

Repeat Problem 2 if R_C is changed from 5 kΩ to 25 kΩ

Problem #2C

Compare and contrast results of Problem #2A and Problem# 2B.

PLUS

Hambley EXERCISES: 4.14, 4.15, 4.26, 4.27,

Problem 2A

4

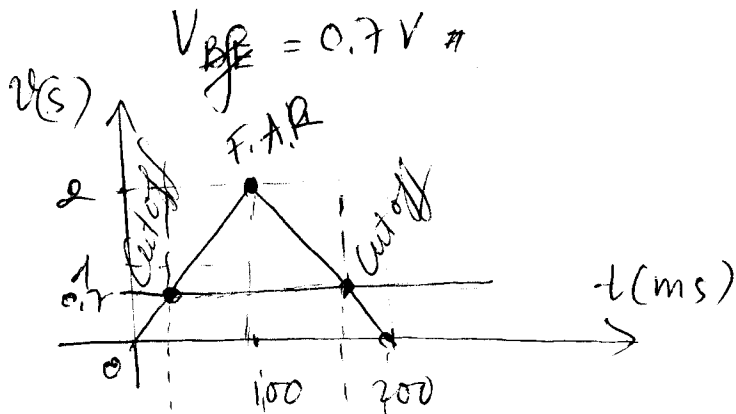
D.C load line -

$$V_{CC} = R_C i_C + V_{CE} \Rightarrow i_C = -\frac{V_{CE}}{R_C} + \frac{V_{CC}}{R_C}$$

$$i_C = -\frac{V_{CE}}{5K} + \frac{15V}{5K}$$

$$\rightarrow V_{CE} = 10 \Rightarrow i_C = 1mA$$

$$V_{CE} = 15 \Rightarrow i_C = 0$$



$$* I_{Cmax} = 2V \text{ at } t=100$$

$$\Rightarrow I_{BQ} = \frac{V_s - 0.7}{100K} = 13 \mu A$$

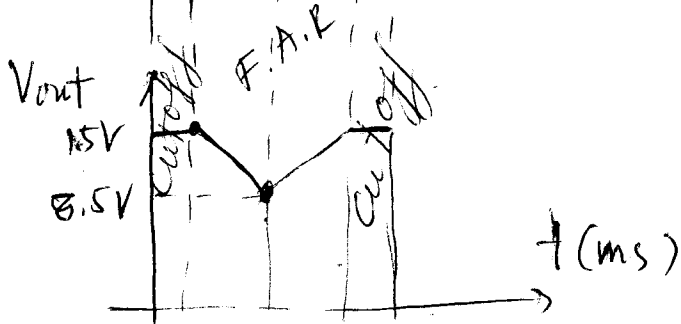
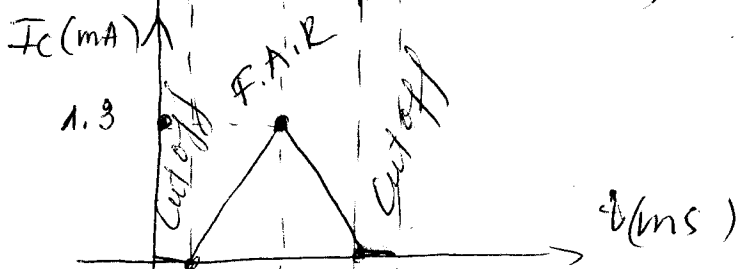
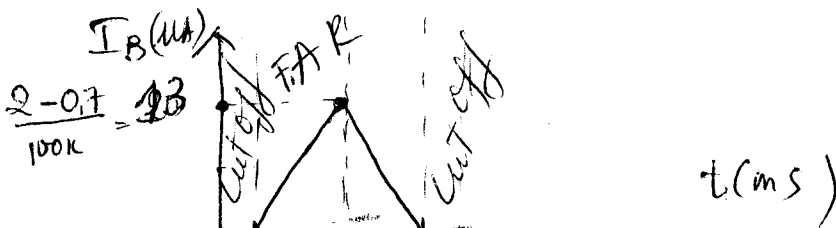
\Rightarrow F.A. Region

$$\Rightarrow I_{CQ} = 1.3 mA$$

$$\Rightarrow V_{out} = 15V - R_C I_{CQ}$$

$$= 15V - 5 \times 1.3$$

$$V_{out} = 8.5V$$



Problem 2-B

5

If $R_C = 25K\Omega$

$$i_C = \frac{-V_{CE}}{25} + \frac{15V}{25K} \quad (\text{D.C load line})$$

at $t = 100 \Rightarrow V_S = 2V \Rightarrow I_{BQ} = 13\mu A$

$I_{Cmax} = 0.55 \text{ (mA)}$ (load line)

$V_{CE} \text{ at Sat} \approx 1.25 \text{ (V)}$

$$V_{in @ Sat} = \frac{I_{Cmax}}{100} \times 100K + 0.7 = 1.25V$$

