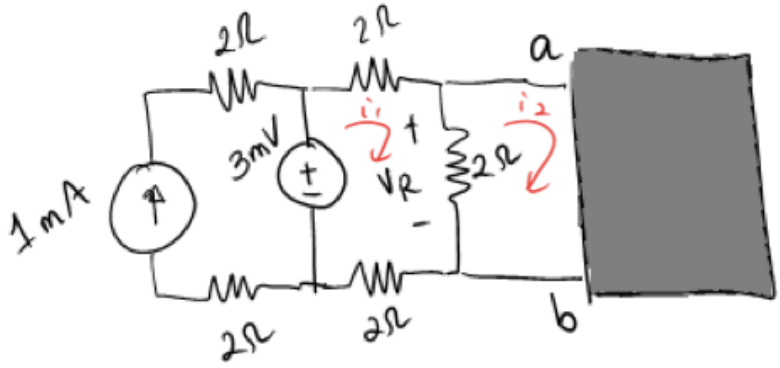
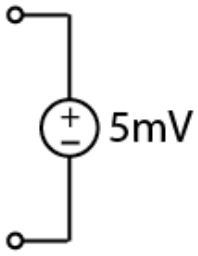
Midterm 1 Solution, Spring 2013

Problem 1:

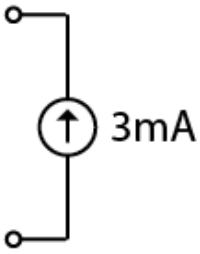
a) $R_{TH}=0$
$V_{TH}=\alpha\,(V_A/(R_1+R_2))$

b)





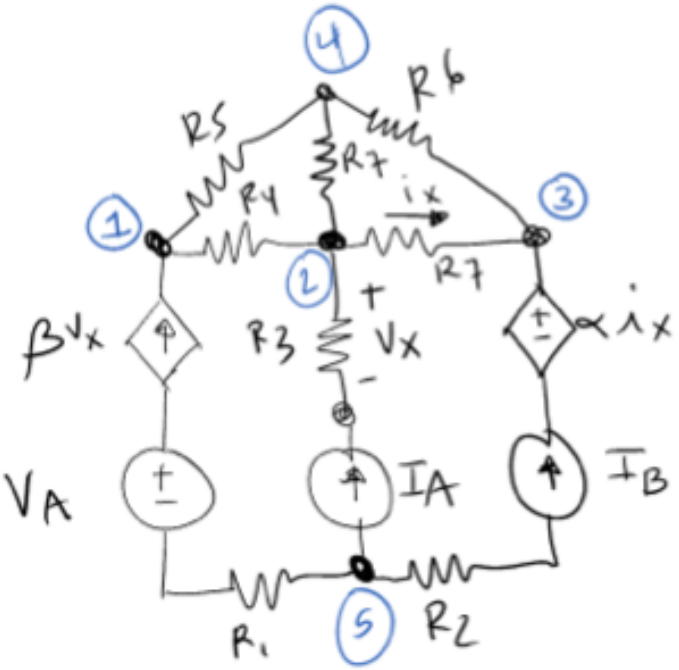
or



$3-6i_1+2i_2=0$
$2(i_1-i_2)=5$

$3-4i_1=5$
$i_1=-0.5$ mA
$i_2=i_1-2.5=-3$mA

Problem 2:

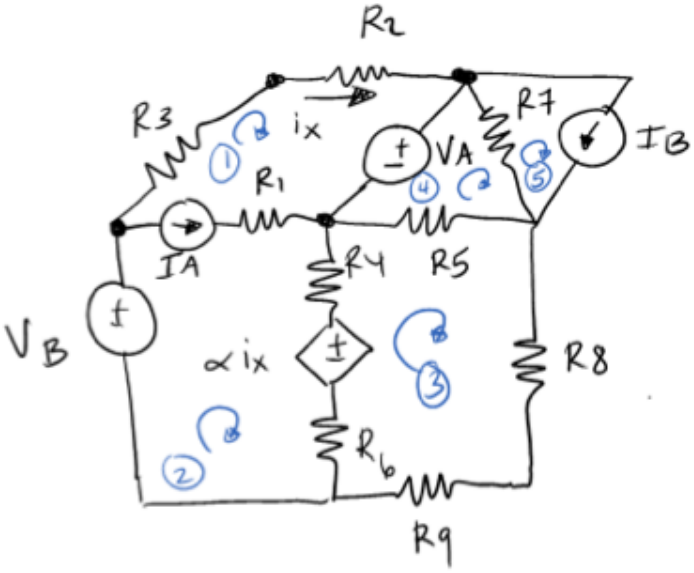


1) $(V_1-V_2)/R_4 + (V_1-V_4)/R_5 - \beta Vx=0$, $Vx=-R_3I_A$
2) $(V_2-V_1)/R_4 + (V_2-V_4)/R_7 + (V_2-V_3)/R_8 - I_A=0$
3) $(V_3-V_4)/R_6 + (V_3-V_2)/R_8 - I_B=0$
4) $(V_4-V_1)/R_5 + (V_4-V_2)/R_7 + (V_4-V_3)/R_6=0$
5) $\beta Vx+I_A+I_B=0$ $Vx=-(I_A+I_B)/\beta$

In 1, you could also use 5 to replace $(-R_3I_A)$ with $(-(I_A+I_B)/\beta)$, alternatively. Also, you could ground any of the nodes and set it to 0for that node voltage to simplify the equations further.

1) $(1/R_4 +1/R_5)V_1 -(1/R_4)V_2 -(1/R_5)V_4= -\beta R_3I_A$
2) $-(1/R_4)V_1+ (1/R_4 +1/R_7 +1/R_8)V_2 -(1/R_8)V_3 -(1/R_7)V_4=I_A$
3) $-(1/R_8)V_2 +(1/R_8 +1/R_6)V_3 -(1/R_6)V_4=I_B$
4) $-(1/R_5)V_1 -(1/R_7)V_2 -(1/R_6)V_3 +(1/R_5 +1/R_6 +1/R_7)V_4=0$

Problem 3:



Supermesh 1,2:
$R_3I_1+R_2I_1+V_A+R_4(I_2-I_3)+\alpha i_x+R_6(I_2-I_3)-V_B=0$
$I_2-I_1=I_A$

Mesh 3:
$R_4(I_3-I_2)+R_5(I_3-I_4)+R_8I_3+R_9I_3+R_6(I_3-I_2)-\alpha i_x=0$

Mesh 4:
$R_5(I_4-I_3)-V_A+R_7(I_4-I_5)=0$

Mesh 5:
$I_5=I_B$

$i_x=I_1$

1) $(R_2+R_3+\alpha)I_1+(R_4+R_6)I_2-(R_4+R_6)I_3=V_B-V_A$
2) $-I_1+I_2=I_A$
3) $-\alpha I_1-(R_4+R_6)I_2+(R_4+R_5+R_6+R_8+R_9)I_3-R_5I_4=0$
4) $-R_5I_3+(R_5+R_7)I_4-R_7I_5=V_A$
5) $I_5=I_B$

Problem 4:

a)

$R_L=R_{TH}$

$R_{TH}=7 \,||\, 1= 7/8$

b)

When R_L is fixed, $Rs=R_{TH}$ should be minimized to maximize power.

$R_{TH}=(6+Ro) \,||\, 1=(6+Ro)/(7+Ro)$

R_{TH} is minimized when $Ro=0$

c)

$V_{TH}=Voc$

Using mesh analysis, $Voc=3mV$

$R_{TH}= 7/8$