Signature
Name (print, please)
Student No.

ECE 2300 Circuit Analysis
Summer 2009

Quiz 4

DO NOT OPEN THIS QUIZ BOOKLET UNTIL INSTRUCTED TO DO SO

This quiz has 4 pages including this cover page. If you are missing any pages, raise your hand. You have 30 minutes to complete the quiz.

Notes

1. Be sure your name and signature appear above.
2. The quiz is closed-book. You may have a calculator and one 8 ½ " x 11" crib sheet.
3. To receive full credit for a problem, you must:

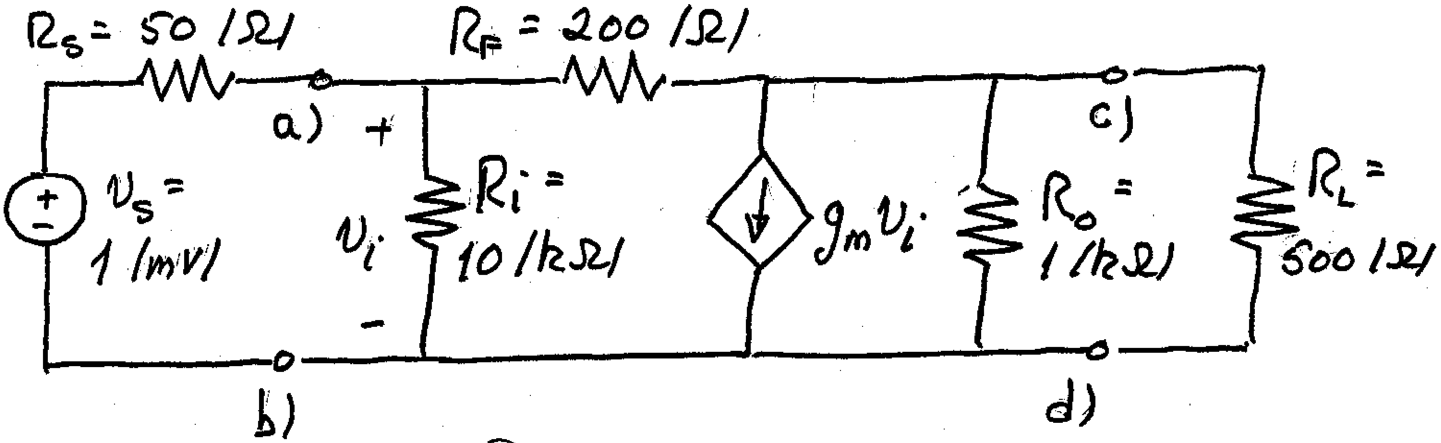
   - Show all work necessary to solve the problem;
   - Define all variables and parameters and label them on circuit diagrams;
   - Use the proper notation for all variables.
   - Show all units explicitly in intermediate and final results;
   - Indicate clearly whether power being calculated is absorbed or delivered;

__________________/20

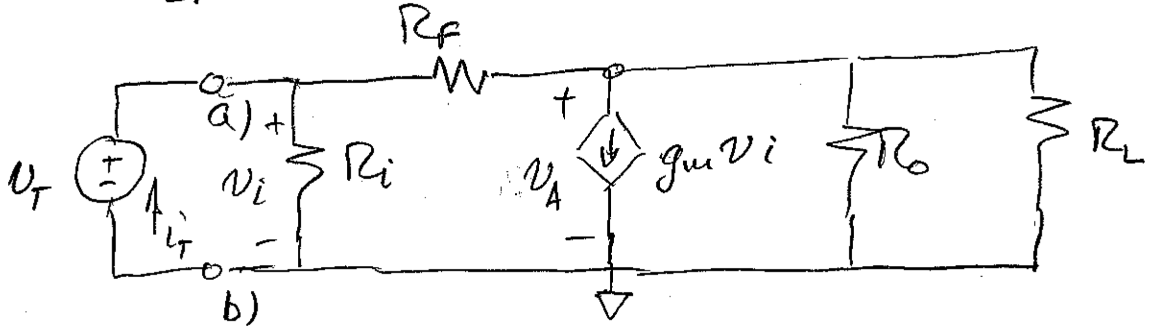
The circuit shown models what is known as a transconductance amplifier. The source is represented by a Thevenin Equivalent and the load is represented by R_L. The value of g_m is variable and so is left unspecified.

+10 i) Find the Thevenin Equivalent resistance seen by the source; that is, remove the source and find the Thevenin resistance at the terminals a), b). The load remains attached for this step. Express your answer in terms of g_m.

+10 ii) Find the Thevenin Equivalent resistance seen by the load; that is, remove the load and find the Thevenin resistance at the terminals c), d). The source remains attached for this step. Express your answer in terms of g_m.



i)



Because a dependent source is involved, we need a test source. Note $v_i = v_T$.

+6

$$i_T = \frac{v_T}{R_i} + \frac{v_T - v_A}{R_F}$$

$$\frac{v_A - v_T}{R_F} + v_A\left(\frac{1}{R_o} + \frac{1}{R_L}\right) + g_m v_T = 0$$

$$\Rightarrow v_A\left(\frac{1}{R_F} + \frac{1}{R_o} + \frac{1}{R_L}\right) = v_T\left(\frac{1}{R_F} - g_m\right)$$

Room for Extra Work

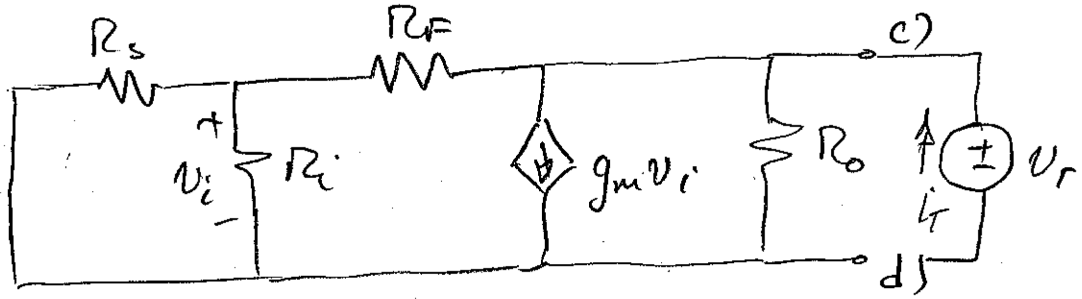
$\Rightarrow$

$$v_A = 0.625\, v_T (1 - g_m R_F)$$

So
$$i_T' = v_T \left(\cancelto{\approx 0}{\frac{1}{R_i}} + \frac{1}{R_F} - \frac{0.625(1-g_m R_F)}{R_F} \right)$$
$$= v_T (0.001875 + 0.625\, g_m)$$

+4
$$\therefore \boxed{\frac{v_T}{i_T'} = R_{th} = (0.001875 + 0.625 g_m)^{-1}}$$

ii)



Since we are using a test source, we need to short-circuit v_s.

+6
$$\begin{cases} i_T' = \dfrac{v_T}{R_o} + g_m v_i + \dfrac{v_T - v_i}{R_F} \\[2ex] \dfrac{v_i - v_T}{R_F} + \dfrac{v_i}{R_i} + \dfrac{v_i}{R_s} = 0 \end{cases}$$

$$\Rightarrow \quad v_i \left(\frac{1}{R_F} + \frac{1}{R_i} + \frac{1}{R_s} \right) = \frac{v_T}{R_F}$$

$$\therefore \quad v_i = \left(1 + \cancelto{\approx 0}{\frac{R_F}{R_i}} + \frac{R_F}{R_s}\right)^{-1} v_T$$

$$\cong 0.2\, v_T$$

↗

Room for Extra Work

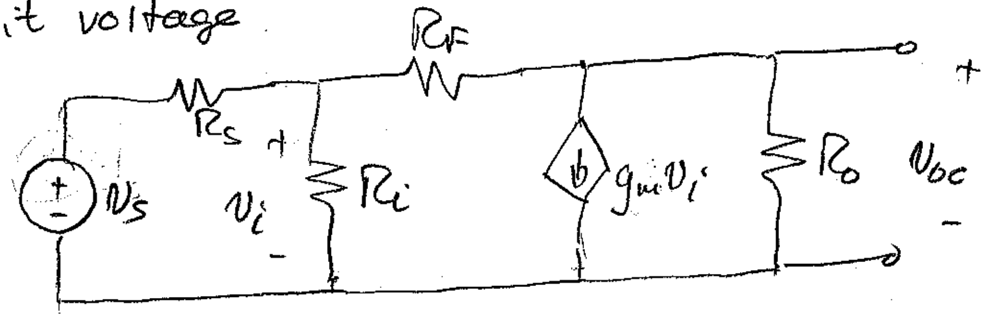
$$i_T = v_T\left(\frac{1}{R_O} + \frac{1}{R_F}\right) + v_i\left(g_m - \frac{1}{R_F}\right)$$

$$= v_T\,(0.005 + 0.2\,g_m)$$

+4 $$\therefore \boxed{\frac{v_T}{i_T} = R_{Th} = (0.005 + 0.2\,g_m)^{-1}}$$

ALTERNATIVE SOLUTION

Open circuit voltage



$$\frac{v_i - v_s}{R_S} + \frac{v_i}{R_i} + \frac{v_i - v_{oc}}{R_F} = 0$$

$$v_i\left(\frac{1}{R_S} + \overset{\text{no}}{\cancel{\frac{1}{R_i}}} + \frac{1}{R_F}\right) = \frac{v_S}{R_S} + \frac{v_{oc}}{R_F}$$

$$v_i\,(0{,}0250) = 0{,}02\,v_S + 0{,}005\,v_{oc}$$

$$v_i = 0.8\,v_S + 0.2\,v_{oc}$$

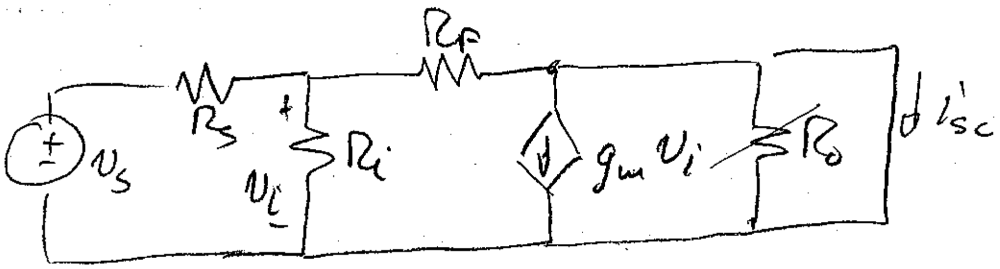
$$\frac{v_{oc}}{R_O} + g_m v_i + \frac{v_{oc} - v_i}{R_F} = 0$$

$$v_{oc}\left(\frac{1}{R_O} + \frac{1}{R_F}\right) + (0.8\,v_s + 0.2\,v_{oc})\left(g_m - \frac{1}{R_F}\right) = 0$$

↗

$$v_{oc} = \frac{-8\times10^{-4} g_m + 4\times10^{-6}}{0.005 + 0.2\, g_m}$$

short-circuit current:



$$\frac{v_i - v_s}{R_s} + \frac{v_i}{R_i} + \frac{v_i}{R_F} = 0$$

$$v_i\left(\frac{1}{R_s} + \overset{\sim 0}{\cancel{\frac{1}{R_i}}} + \frac{1}{R_F}\right) = \frac{v_s}{R_s}$$

$$v_i = 0.8\, v_s = 8\times10^{-4}\ |V|$$

$$i_{sc} = \frac{v_i}{R_F} + g_m v_i = 4\times10^{-6} - 8\times10^{-4} g_m$$

$$\frac{v_{oc}}{i_{sc}} = \frac{-8\times10^{-4} g_m + 4\times10^{-6}}{0.005 + 0.2 g_m} \cdot \frac{1}{4\times10^{-6} - 8\times10^{-4} g_m}$$

$$\therefore R_{Th} = (0.005 + 0.2 g_m)^{-1}$$

This was considerably more difficult but at least we got the same answer!