MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Electrical Engineering and Computer Science

6.002 – Electronic Circuits
Fall 2002

Problem Set 2

Issued: September 11, 2002 **Due: September 18, 2002**

Reading Assignment:

- A&L Sections 3.5-3.7 for Thursday, September 12.
- A&L Chapter 4 for Tuesday, September 17.

Problem 2.1:

(A) Calculate the Thévenin equivalent resistance at the indicated port for each of the networks shown in Figures 1 and 2.

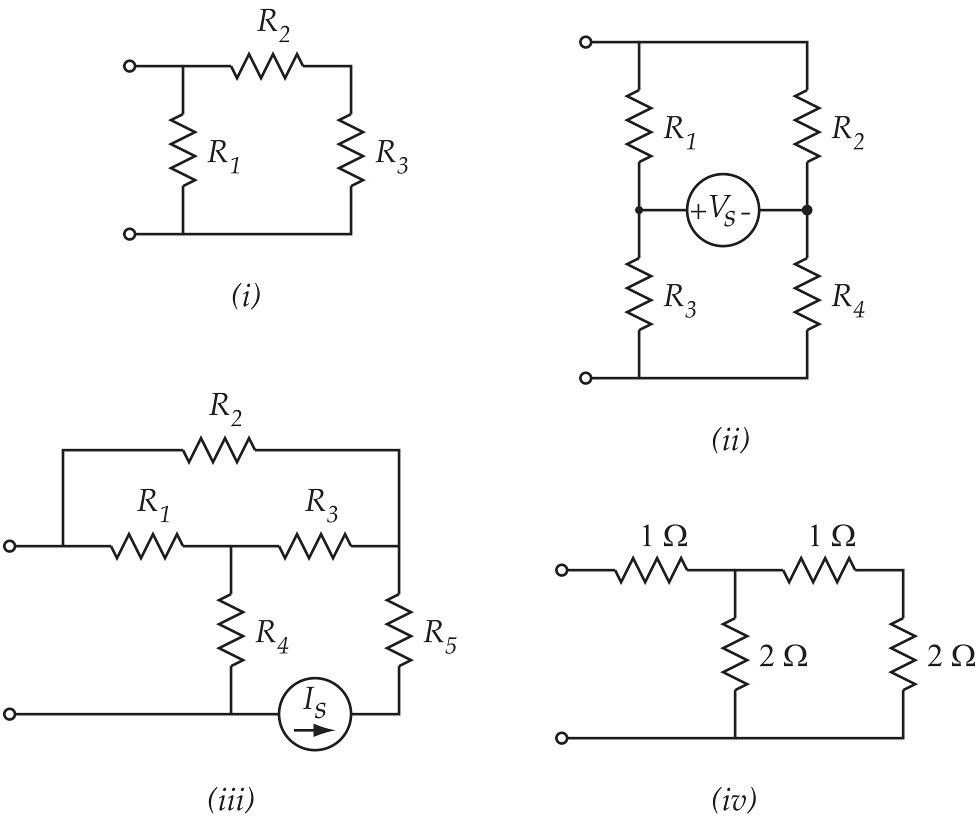
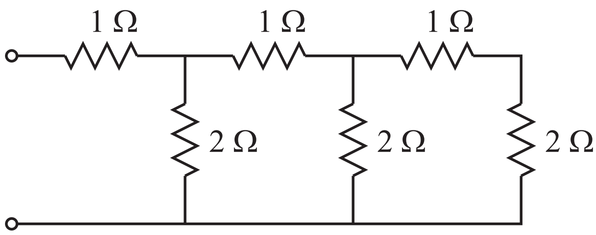


Figure 1: Networks for Problem 2.1A



(v)

Figure 2: Networks for Problem 2.1A (cont.)

(B) The answers to part (*iv*) and (*v*) above suggest that as more and more 1Ω-2Ω sections are added to this "ladder" network, the Thévenin resistance converges to a definite limit. To find this limit, let R_N be the resistance of N 1Ω-2Ω sections, as indicated in Figure 3.

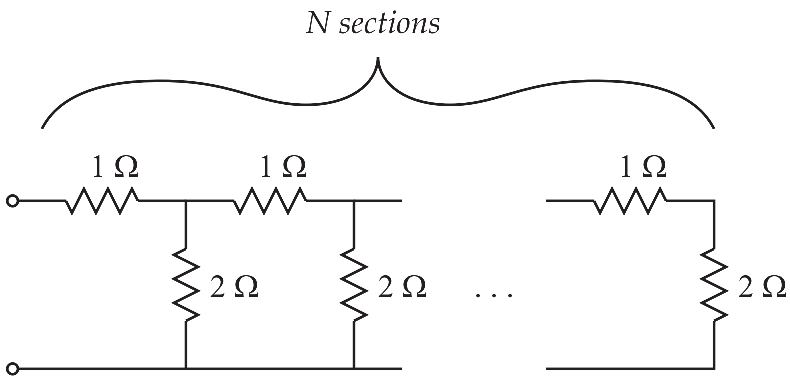


Figure 3: Network for Problem 2.1B

(i) Express R_{N+1} in terms of R_N.

(ii) Set

$$\lim_{N\to\infty} R_{N+1} = \lim_{N\to\infty} R_N = R_\infty$$

and solve for R_∞. Compare R_∞ to the answers for networks (*iv*) and (*v*) above.

Problem 2.2: Find both Thévenin and Norton equivalents circuits at the indicated ports for the two networks shown below. Note that the results from Problem 2.1 may be useful in calculating R_{Th}, while voltage and current divider relations are useful in finding V_{Th} or I_N.

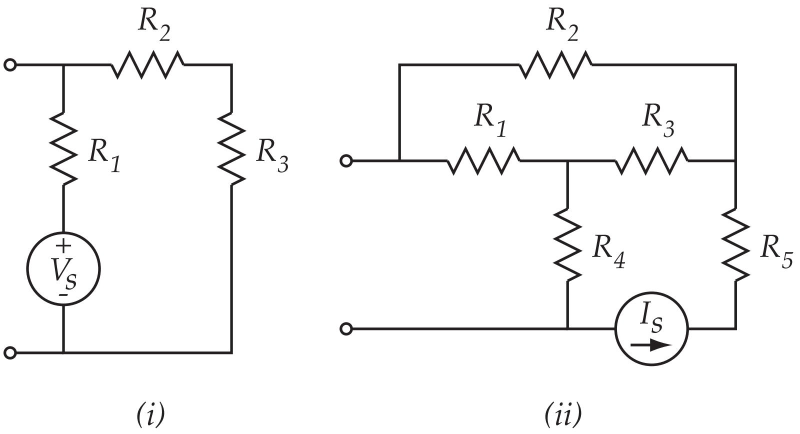


Figure 4: Networks for Problem 2.2

Problem 2.3: The network shown schematically below contains an unknown number of resistors and sources in an unknown configuration. In order to develop a Thévenin equivalent for the mystery network at the indicated terminal pair, 6.002 student Sally Toolkit puts a $2k\Omega$ resistor across the terminals and measures a current i of $2mA$. She then puts a $6V$ battery across the terminal (positive at the top terminal) and measures a current i of $-1mA$.

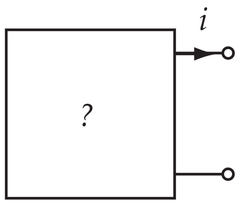


Figure 5: Networks for Problem 3

(A) From Sally's data, determine the Thévenin equivalent of the mystery network.

(B) A variable voltage source is placed across the terminals (positive reference at the top) and the source voltage is varied over the range $-10V$ to $+10V$. Plot the current i through the voltage source vs. the voltage as it is swept over this range.

Problem 2.4: Refer to the network shown below for parts (A) and (B).

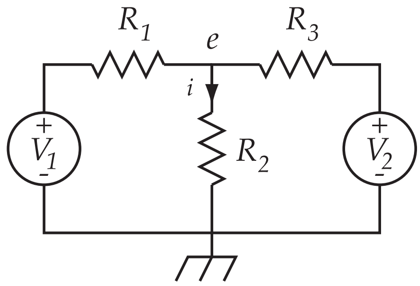


Figure 6: Networks for Problem 2.4A&B

(A) Write and solve a node equation determining the node voltage e.

(B) Find the node voltage e using superposition, i.e., determine e due to each source acting alone and add the results. Compare with the answer found in part (A).

Refer to the network shown below for parts (C) and (D).

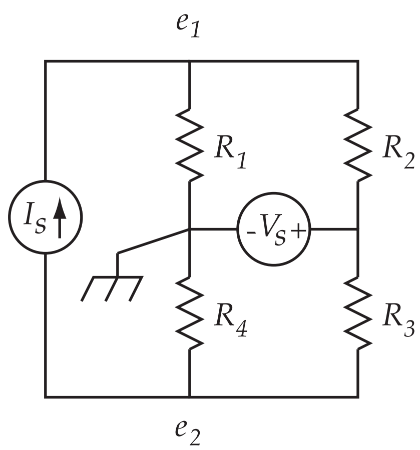


Figure 7: Networks for Problem 2.4C&D

(C) Write and solve node equations determining the node voltages e_1 and e_2.

(D) Solve for e_1 and e_2 using superposition and compare your results with those from part (C).

Notice that shortcut methods (series-parallel reductions, voltage-current divider relations) can often be used when the method of superposition is applied.

Problem 2.5: While most of the networks that we'll see in 6.002 can be solved by shortcut methods (series-parallel reductions, voltage-current divider relations), it will sometimes be the case that these methods cannot be applied and we must resort to the formal node method. The "bridged-T" network shown below is an example.

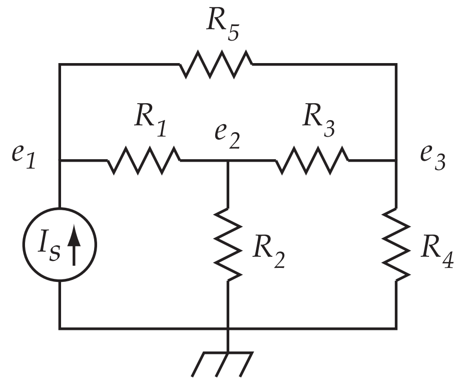


Figure 8: Networks for Problem 2.5

(A) Write a set of node equations for the node-to-datum voltages e_1, e_2 and e_3 in the above network. Put the equations in matrix form:

$$G \cdot [e] = [s]$$

where G is a 3×3 matrix of conductance terms, e is a vector containing the three node voltages e_1, e_2 and e_3, and s is a vector containing source values.

(B) Solve these equations for the special case $G_1 = G_2 ... = G_5 = 1 mho$.

(C) What is the Thévenin resistance seen by the source?