X070994

UNIVERSITY OF NORTH CAROLINA AT CHARLOTTE

Department of Electrical Engineering

Experiment No.________Three-Terminal Equivalent Networks

INTRODUCTION

The networks below are equivalent if V1, I1, V2, and I2 are related precisely the same way as V1', I1', V2', and I2'. In particular, if V1 and V2 are arbitrarily specified, then, whenever V1' = V1 and V2' = V2, for equivalence, I1 = I1' and I2 = I2' for all values of V1 and V2. Alternatively, if I1 and I2 are arbitrarily specified, then, whenever I1' = I1 and I2' = I2, for equivalence, V1 = V1' and V2 = V2' for all values of I1 and I2.

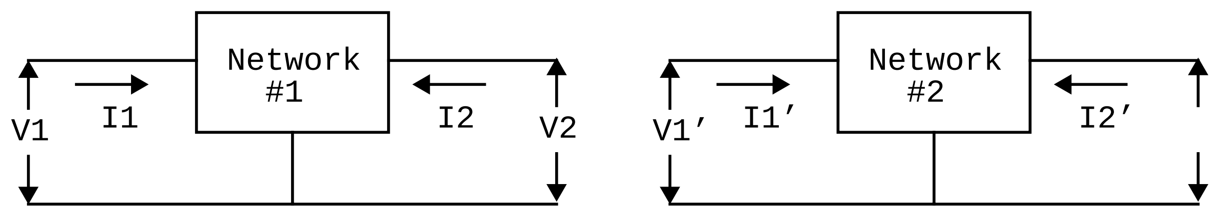


Figure 1.

Every three-terminal network containing only linear resistors can be represented by a “wye” or “delta” equivalent network. A “wye” network is also called a “tee” or “Y” network and would be represented by the network shown in Figure 2. A “delta” network is also called a “pi” or “ii“ network and would be represented by the network shown in Figure 3.

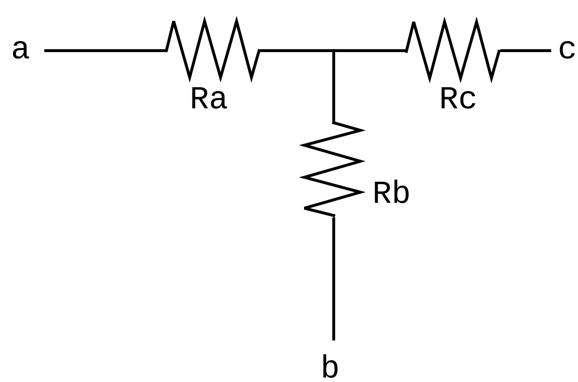


Figure 2. “Wye” Network

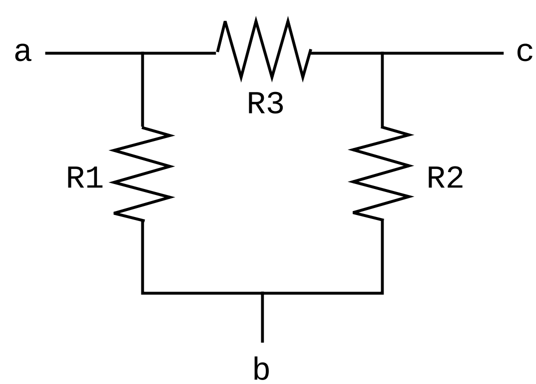


Figure 3. “Delta” Network

For the two passive three-terminal networks containing linear resistors in Figures 2 and 3 to be equivalent, it is necessary that the resistance between each of the three pairs of terminals ab, ac, and bc be identical for both networks, i.e.,

$$R_{ab} = R_a + R_b = R_1(R_2 + R_3)/(R_1 + R_2 + R_3) \quad (1)$$
$$R_{bc} = R_b + R_c = R_2(R_1 + R_3)/(R_1 + R_2 + R_3) \quad (2)$$
$$R_{ca} = R_c + R_a = R_3(R_1 + R_2)/(R_1 + R_2 + R_3) \quad (3)$$

Three-terminal networks containing elements in addition to linear resistors may be represented by a “wye” or “delta” equivalent network. However, this equivalence exists only under very specific terminal conditions, which must be specified.

Two three-terminal networks, with only the terminals exposed, will be analyzed in the laboratory. The only access to the enclosed circuitry will be through the voltage-current analyses performed on the box via its three terminal connections.

A passive network of arbitrary complexity (EXCLUDING CAPACITORS AND INDUCTORS) is enclosed in one box and an ACTIVE network is enclosed in the other box. The task is to determine a “wye” equivalent network that would produce the same voltage-current relationship as the box analyzed.

PRELIMINARY

P-1. Calculate the “wye” equivalent for the network in Figure 4 below using the derived equations (1), (2), and (3) above.

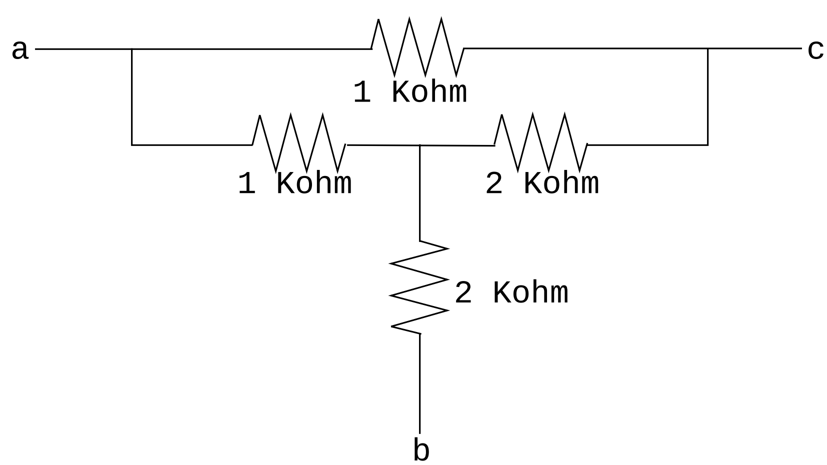


Figure 4.

P-1. (Continued)

Ra=___________________; Rb=__________________; Rc=__________________.

P-2. Derive the general equations for determining the elements of a “delta” network in terms of the elements of a “wye” network, assuming all the elements are resistors. (HINT: Apply two voltage sources to the terminals ab and cb of the “wye” network and formulate the mesh equations. Next apply two current sources to the corresponding terminals of the “delta” network and formulate the node equations. Solve for the mesh currents in the “wye” network and equate them to the currents in the “delta” network.)

P-3. Derive the general equations for determining the elements of a “wye” network in terms of the elements of a “delta” network, assuming all the elements are resistors. (HINT: Using the derivations from P-2 above, solve for the node voltages in the “delta” network and equate them to the voltages in the “wye” network.)

(INSTRUCTOR'S SIGNATURE___________________________DATE___________)

## PROCEDURE

L-1. Apply a DC voltage source to the terminals ab, bc, and ca of the unknown “passive” network and make a current and voltage measurement. STAY WITHIN THE FOLLOWING LIMITS FOR VOLTAGE AND CURRENT.

$V <= 20$ volts.

$0 < I <= 5$ mA

L-2. Repeat Procedure L-1 above for the unknown “passive” network EXCEPT STAY WITHIN THE FOLLOWING LIMITS FOR VOLTAGE AND CURRENT.

$V <= 20$ volts

5 mA $< I <=$ 10 mA

L-3. Before applying an external DC voltage to the “active” unknown network, measure for voltage across terminal ab, bc, and ca with a high impedance voltmeter and note which terminals have positive voltage on them.

L-4. Repeat Procedures L-1 and L-2 above for the unknown “active” network making sure that the externally applied DC voltage source always opposes the internal voltage source.

## REPORT

R-1. Based on measured data, calculate a “wye” equivalent for the unknown “passive” network for each of the two current conditions. If the two equivalent circuits are different, provide an explanation for difference.

R-2. Repeat R-1 above for the “active” network.