

## Lab 5

### Thevenin Circuits

For each of the circuits shown Fig. 1 – 4, follow the procedures outlined below to measure and calculate the Thevenin equivalents.

1. **Build the circuit as shown.** Measure the voltage across the load resistor ( $R_L$  in the circuit). Calculate the power dissipated in the load.

2. **Measure the Thevenin Voltage.** Remove the load resistor and use the voltmeter to measure the *open-circuit* voltage between the two output nodes (i.e. the nodes where  $R_L$  was previously attached). The open-circuit voltage is equal to the Thevenin equivalent voltage,  $V_{TH} = v_{oc}$ .

3. **Measure the Thevenin resistance.** There are several ways to measure the Thevenin resistance. We will use three different approaches.

a. **Short-circuit current method.** Attach the ammeter across the output terminals and measure the current that flows. (The ammeter serves as a short circuit at the output.) Then  $R_{TH} = V_{TH}/i_{sc} = v_{oc}/i_{sc}$ , where  $v_{oc}$  is the open-circuit voltage measured in step 2. Use this method to determine  $R_{TH}$  for the circuit in Fig. 1.

b. **Ohm-meter method.** When there are only independent sources and resistors in the circuit, you can just use an ohm-meter. De-activate all of the independent sources (remove the voltage sources and replace with short circuits) and then simply measure the resistance at the output terminals using an ohm-meter. Use this method to determine  $R_{TH}$  for the circuit in Fig.2. This method has limited applications, since it may not always be possible to deactivate the independent sources.

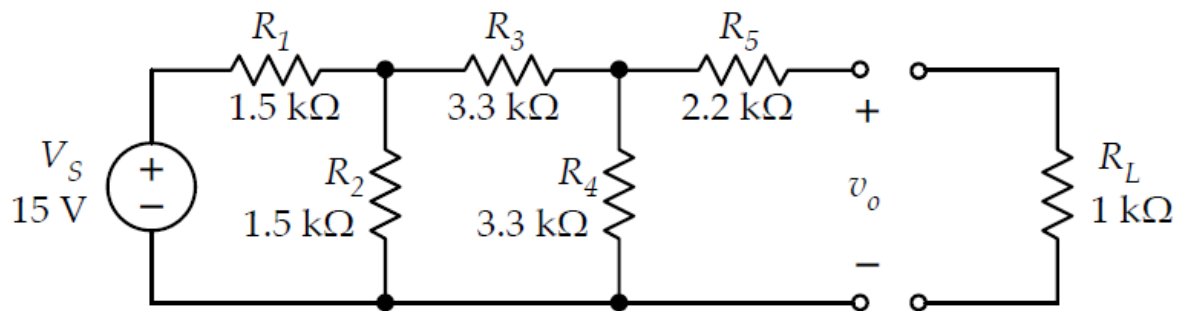
c. **Voltage-divider method.** Attach a potentiometer across the output terminals. While measuring the voltage across the output terminals, adjust the potentiometer until the output voltage is exactly *half* of the open-circuit voltage.  $v_o = v_{oc}/2 = V_{TH}/2$ . As we know from our study of voltage dividers, if the two resistors making up a divider have the same resistance, the voltage across either one will be exactly half of the source voltage. In this case, the two resistors are the Thevenin resistance of the circuit and the potentiometer. When the output voltage is exactly half the open-circuit voltage, the potentiometer resistance must be equal to the Thevenin resistance. Remove the potentiometer from the circuit (without changing the setting) and measure the resistance. Use this method to determine  $R_{TH}$  for the circuit in Fig. 3.

d. For the circuit of Fig. 4, measure the Thevenin resistance using all three methods. Confirm that they give the same result for  $R_{TH}$ .

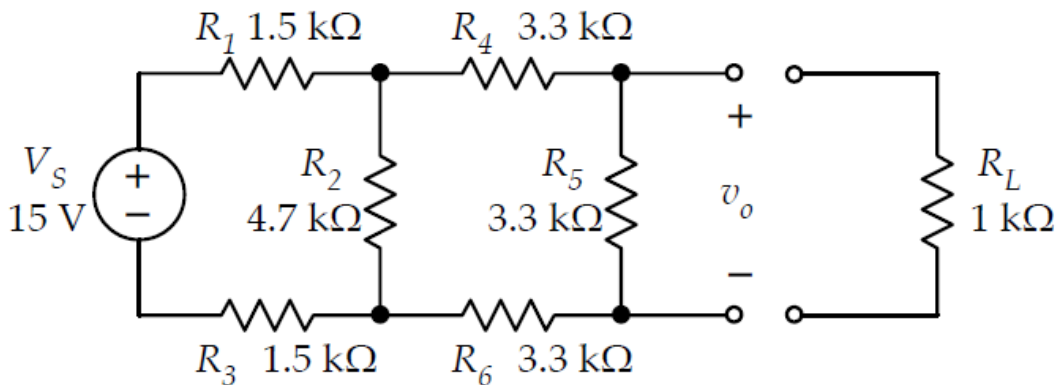
4. **Build the Thevenin equivalent circuit** in each case using a voltage source, set to  $V_{TH}$ , and a “resistor” equal to  $R_{TH}$ . (The resistor can be a potentiometer set to  $R_{TH}$  or a collection of fixed resistors that combine to give  $R_{TH}$ .) Attach the 1-k $\Omega$  load resistor to the equivalent circuit and measure the load voltage and calculate the power. Compare the results the measurements from

part (a). Point to ponder: In these circuits, the Thevenin resistance must be determined from the resistors making up the circuit. You can probably convince yourself that these same resistors can be combined in some way to construct  $R_{Th}$  in the equivalent circuit.

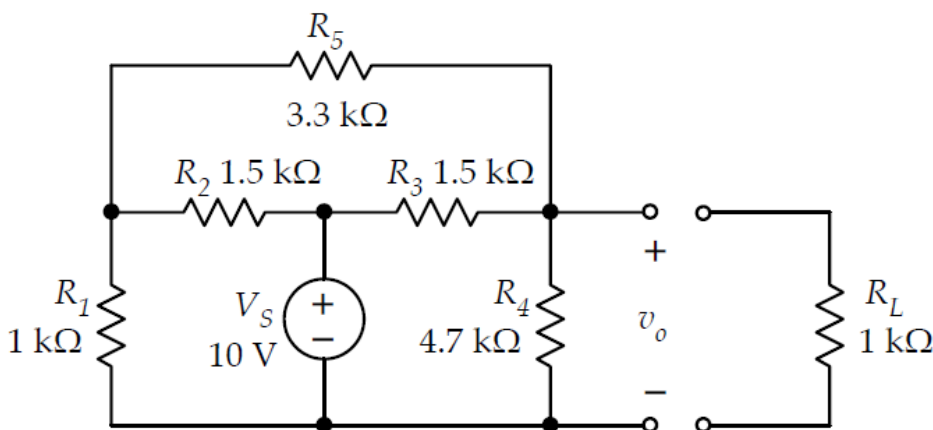
**5. Calculate the Thevenin equivalent analytically.** Now use circuit analysis to calculate the values for the Thevenin equivalent circuit in each case.



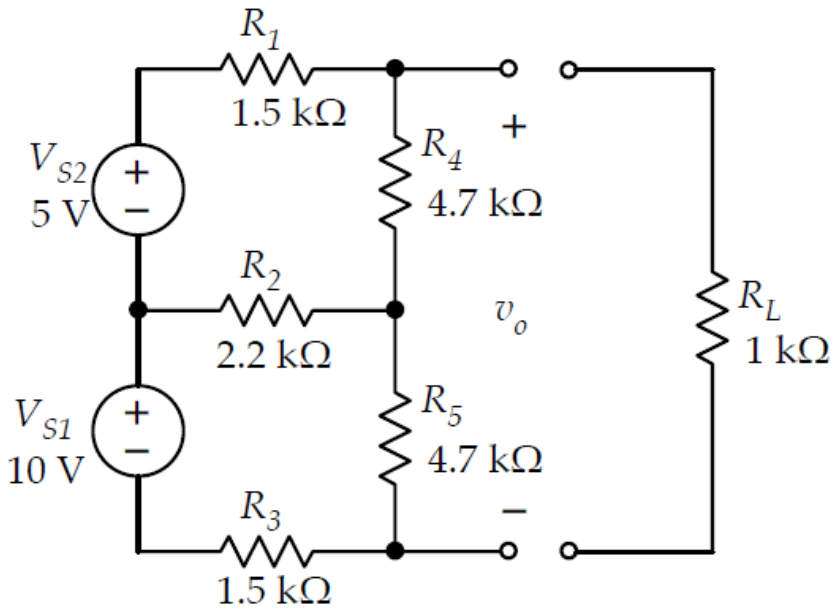
**Fig 1.**



**Fig 2.**



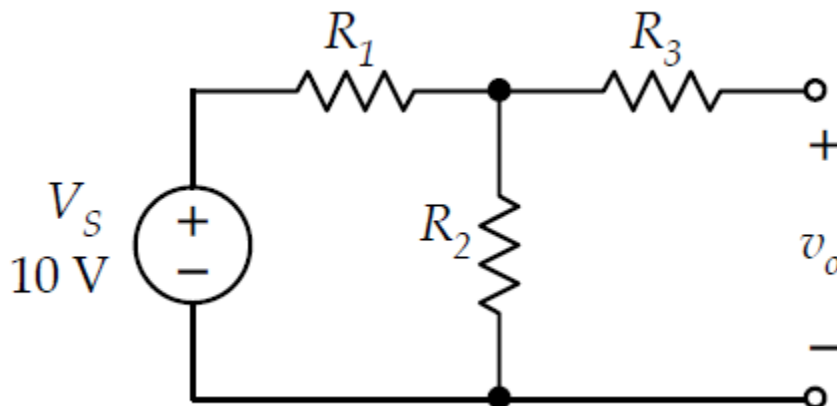
**Fig 3.**



**Fig 4**

**Design it.**

Design the circuit shown in Fig. 5 so that the Thevenin equivalent voltage is 5 V and the Thevenin equivalent resistance is 1.5 k $\Omega$ . You will need to choose values for  $R_1$ ,  $R_2$ , and  $R_3$ . Build the circuit using and perform measurements to confirm that it has the correct Thevenin voltage and resistance.



**Fig 5.**