Lab3 Prelab

Superposition , Thevenin and Norton Equivalent Theorems

Objectives

The purpose of this experiment is to verify experimentally the Superpostion , Thevenin and Norton Theorems. The theorems will first be studied by theoretically analyzing a circuit in the preliminary part of this lab. Then the same circuit will be measured in the laboratory. Corresponding calculated and measured circuit response values will be compared.

Theory

1. Superposition Theorem

Superpostion Theorem states that: " In a linear circuit with several sources, the voltage and current responses in any branch is the algebraic sum of the voltage and current responses due to each source acting independently with all other sources replaced by their internal impedance. Basically, when we apply superposition theorem, the voltage and current sources are considered to be ideal. Thus at the time of evaluating the voltage or current through the circuit element, the voltage source to be replaced is short-circuited and the current source is open circuited, as shown in Figure (1)

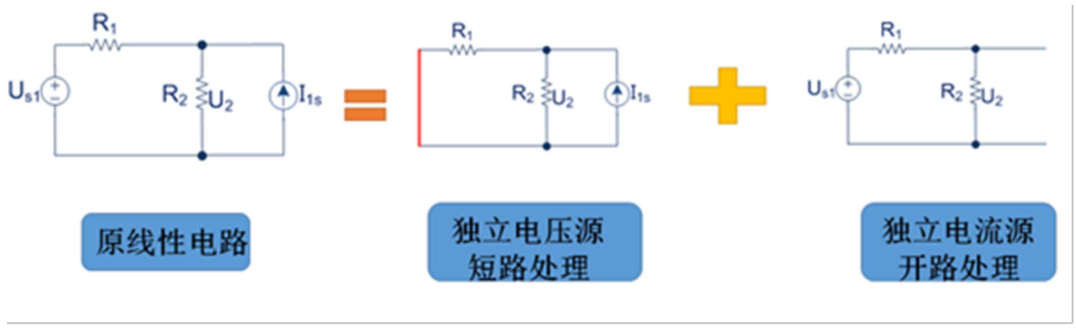
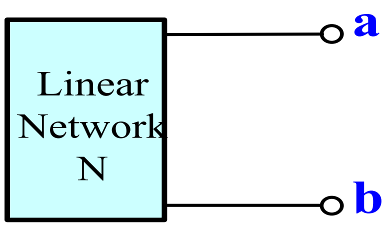


Figure 1. Superposition Theorem

2. Thevenin's Theorem and Norton's Theorem

Thevenin and Norton equivalents are circuit simplification techniques that focus on terminal behavior and thus are extremely valuable aids in analysis.

Thevenin's theorem states that a linear two-terminal circuit can be replaced by an equivalent circuit consisting of a voltage source U_S in series with a resistor R_0, where U_S is the open-circuit voltage at the terminals U_{OC} , and R_0 is the input or equivalent resistance at the terminals when the independent sources are all turned off.



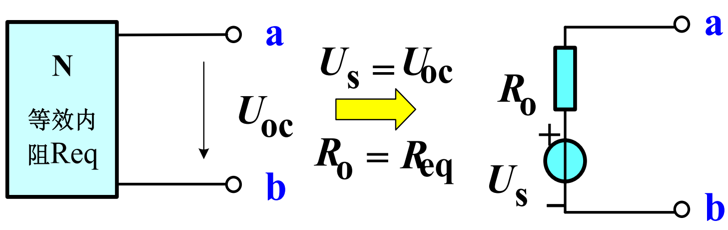


Figure 2(a) .Linear two terminal network Figure 2(b) Thevenin equivalent

Norton's theorem states that a linear two-terminal circuit can be replaced by an equivalent circuit consisting of a current source Is in parallel with a resistor R_0, where Is is the short-circuit current Isc through the terminals, and $R_0$is the input or equivalent resistance at the terminals when the independent sources are turned off.

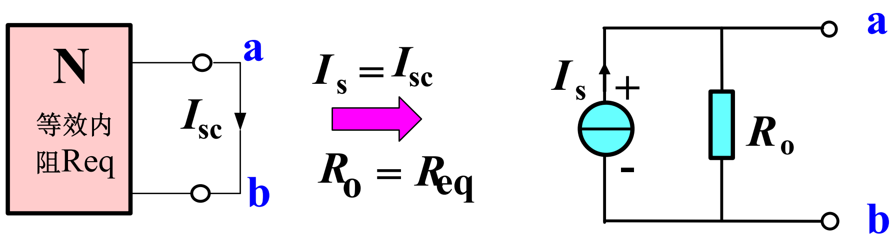


Figure 3.Replace a linear two-terminal circuit by its Norton equivalent

（1） Thevenin and Norton Parameters

Thevenin and Norton's theorems let us think of the inside of a linear two-terminal circuit as a simple equivalent circuit. There are three important quantities that make up a equivalent circuit, the open-circuit voltage U_{OC}, the short circuit current Isc and the Thevenin equivalent resistance R_0.

- U_{OC}: Remove the load resistor at the terminal points a-b, to make the output in open circuit condition, and measure the output voltage across the terminal a and b , is U_{OC}.
- Isc : The output current I, when the output terminals are short circuited (load resistance is 0), the current through terminal a and b is Isc
- For R_0, Thevenin equivalent resistance, there are three common methods to get:

a) Open-circuit Voltage method & Short-circuit current method

Firstly, the two output terminals a and b of the linear network are made opened, a voltmeter is used to measure the open-circuit voltage between the two output nodes, U_{OC}. Secondly, reduce the load resistance to zero, that is short connect terminals a and b, use an ammeter across the output terminals and measure the current that flows, I_{SC} (The ammeter can serve as a short circuit at the output.) Then the equivalent resistance of the two-terminal network is :

$$R_0 = \frac{U_{oc}}{I_{SC}}$$

If the internal resistance of the active two-terminal network is very small, it is not suitable to use this method, because if the output port is short-circuited, it is easy to damage its internal components.

b) Voltage-current method

Attach a potentiometer across the output terminals a and b, that is the output end of the active two-terminal network is loaded with a variable resistor R_L. Use a voltmeter and an ammeter to measure the external characteristic of the two-terminal active network, as shown in Fig4. The voltage and current relationship measured when the resistor R_L is given different values is called the output characteristic or external characteristic of the active two-terminal network, as shown in Fig5.

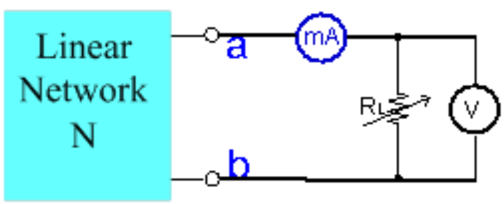


Fig 4 Voltage-current method

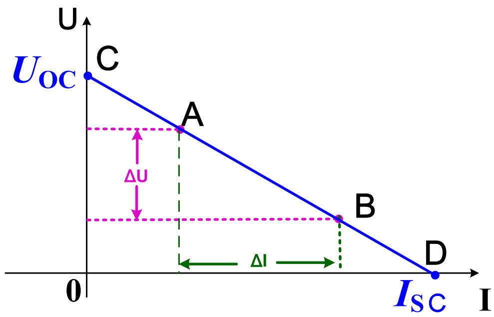


Fig5. external characteristic of the active two-terminal network

Utilized the external characteristic curve, we can calculated the slope , and the equivalent resistance of the two-terminal network can be determined as:

$$R_0 = tg\varphi = \frac{\Delta U}{\Delta I} = \frac{U_{oc}}{I_{SC}}$$

For the Point C, $I = 0, \quad U = U_{oc}$

For the Point D, $U = 0, \quad I = I_{SC}$

c) Half voltage method

As we know, if two resistors making up a divider have the same resistance, the voltage across either one will be exactly half of the source voltage. As a result, attach a potentiometer across the output terminals and measuring the voltage across the output terminals, adjust the potentiometer until the output voltage is exactly half of the open-circuit voltage, when the output voltage is exactly half the open-circuit voltage, the potentiometer resistance must be equal to the Thevenin resistance. Then, remove the potentiometer from the circuit (without changing the setting) and measure the resistance.

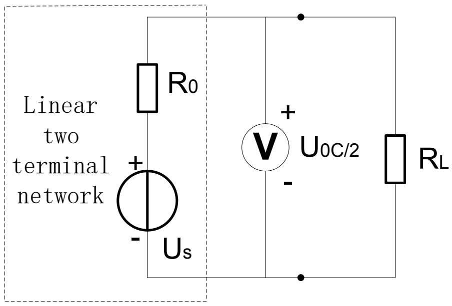


Fig 6. Half voltage method

（2） How to verify the Thevenin’s Theorem and Norton’s Theorem?

As we know, when two circuits are equivalent, the external characteristics of the two circuits are exactly the same. For example, when two circuits are connected to the same load, the current flowing through the load is the same, that is the two circuits have the same voltage/current relationship at terminals a-b. Therefore, the external characteristics of the original circuit and the equivalent circuit are measured and compared to verify the Thevenin’s Theorem and Norton’s Theorem.

So we will verify the Thevenin’s Theorem and Norton’s Theorem by the following steps:

1) Determined Thevenin and Norton Parameters
2) Connectthe load resistor to the original circuit and measuring the resulting load V-I relationship.
3) Physically creating the Thevenin/Norton equivalent circuit, connect the load resistor to equivalent circuit, and measuring the resulting load V-I relationship.
4) Comparing the results obtained from the Thevenin/Norton circuit and the original circuit.