Experiment 2: Kirchhoff's Law and Superposition Theorem

1 Purpose

- Verify the Kirchhoff's Law and understand what is Kirchhoff's Law.

- Learn how to measure the branch current by using current plugs.

- Verify the superposition theorem and understand superposition and homogeneous properties of linear electric circuits.

2 Principal

2.1 Kirchhoff's Law:

- Kirchhoff's current Law (KCL): The algebraic sum of all the currents at any node in a circuit equals zero, $\sum I = 0$.

- Kirchhoff's voltage Law (KVL): The algebraic sum of all the voltages around any closed path in a circuit equals zero, $\sum U = 0$.

2.2 Superposition Theorem

- A linear system obeys the principle of superposition, which states that whenever a linear system is excited, or driven, by more than one independent source of energy, the total response is the sum of the individual responses. An individual response is the result of an independent source acting alone.

3 Contents and Steps

The electric circuit of Kirchhoff's Law and the Superposition theorem are the same as shown in the Fig. 1.

1. Verify the Kirchhoff's Law

- Set the reference direction of three branch current I_1, I_2 and I_3(Through the ammeter socket to set the reference direction of the current, as shown in the Fig. 1(b), red means incoming current and black means outgoing current).

- Turn the switch S_1 to the left and switch S_2 to the right, then connect them with voltage source with $U_{S1} = 6V$ and $U_{S2} = 12V$.

- Insert the current plug(red and black) to the ammeter socket (+ and -). Then insert the current plug to the branch current socket and record the current value into Table 1.

- Measure the voltage value of source and resistances with the voltmeter, and then record them into Table 1.
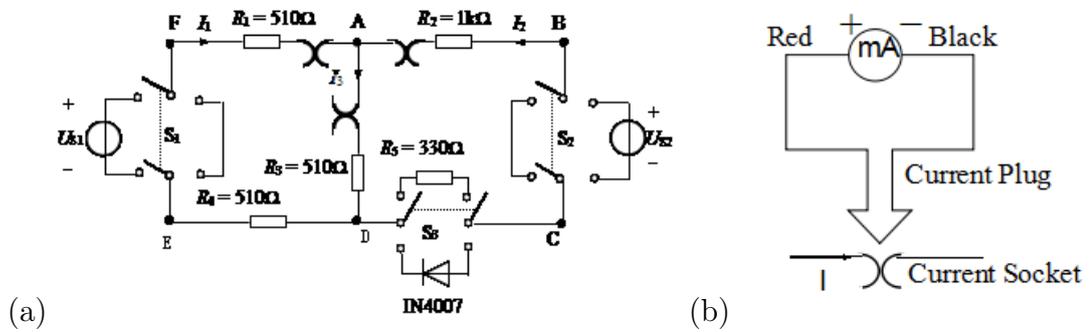

(a)

(b)

Figure 1: (a) The electric circuit of Kirchhoff's Law and the Superposition theorem, (b) the electric circuit of ammeter.

	$I_1(mA)$	$I_2(mA)$	$I_3(mA)$	$U_{S1}(V)$	$U_{S2}(V)$
Calculated Value					
Measured Value					
Relative Error					

	$U_{FA}(V)$	$U_{AB}(V)$	$U_{AD}(V)$	$U_{CD}(V)$	$U_{DE}(V)$
Calculated Value					
Measured Value					
Relative Error					

Table 1: The Measured Data to verify the Kirchhoff's Law.

2. Verify the Superposition Theorem

- The electric circuit as shown in the Fig. 1. Use single voltage source U_{S1}(turn the switch S_1 and S_2 to the left), measure the branch current and resistances with ammeter and voltmeter and then record them to the Table 2.

- Use the single voltage source U_{S2}(turn the switch S_1 and S_2 to the right), measure the branch current and resistances with ammeter and voltmeter and then record them to the Table 2.

- Use both U_{S1} and U_{S2}(turn the switch S_1 to the left and S_2 to the right), measure the branch current and resistances with ammeter and voltmeter and then record them to the Table 2.

- Use the single voltage source U_{S2}, but change the voltage to 24V, measure the branch current and resistances with ammeter and voltmeter and then record them to the Table 2.

NOTE: When using the single voltage source, DO NOT mistake the positive and negative terminals of the voltmeter.

Experiment\Measured Item	$I_1(mA)$	$I_2(mA)$	$I_3(mA)$	$U_{S1}(V)$	$U_{S2}(V)$
Single Source U_{S1}					
Single Source U_{S2}					
Source U_{S1} and U_{S2}					
Single Source $U_{S2}=24V$					
	$U_{FA}(V)$	$U_{AB}(V)$	$U_{AD}(V)$	$U_{CD}(V)$	$U_{DE}(V)$
Single Source U_{S1}					
Single Source U_{S2}					
Source U_{S1} and U_{S2}					
Single Source $U_{S2}=24V$					

Table 2: The measured data of Superposition theorem.

4   Questions

When you do the experiment of the Superposition theorem, how to operate in the experiment? Could we just replacing all other independent voltage sources (U_{S1} or U_{S2}) with a short circuit?

5   Writing Your Report

1. Complete the calculation (Calculated Value) in Table 1.

2. Based on the measured value, choose one node as reference node and verify the Kirchhoff's current Law (KCL).

3. Based on the measured value, choose one node as reference node and verify the Kirchhoff's voltage Law (KVL).

4. Based on the measured value, verify the superposition and homogeneity of the linear electric circuit.

5. Based on the measured value, could you calculate the power of resistances, are they follow the superposition theorem?

6. Answer the question (section 4).