Department of Electrical and Electronic Engineering
Shahjalal University of Science and Technology

EEE 126: Electrical Circuit Simulation Laboratory

Experiment # 02: Simulating Circuits with Dependent Sources in PSpice

1.0 Introduction

Some devices, such as transistors and amplifiers, act like controlled sources. For examples, the output voltage of an amplifier is controlled by the input voltage of that amplifier. Such devices can be modeled using dependent sources. A dependent source consists of two elements: the controlling element and the controlled element. The controlling element is either open circuit or short circuit and the controlled element is either voltage or current.

There are four types of dependent source that correspond to the four ways of choosing a controlling elements and a controlled element. These four dependent sources are

- Voltage-controlled voltage source (VCVS)
- Voltage-controlled current source (VCCS)
- Current-controlled voltage source (CCVS)
- Current-controlled current source (VCVS)

The modelings of these dependent sources are discussed in the next section.

1.1 Voltage-controlled voltage source (VCVS)

The symbol of a Voltage-controlled voltage source (VCVS) is shown in Fig 1(a). N+ and N- are the positive and negative output nodes, respectively, and NC+ and NC- are the positive and negative nodes, respectively of the controlling voltage.

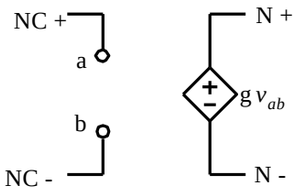

Fig. 1(a)

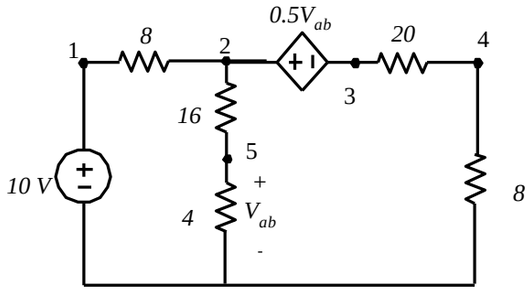

Fig. 1(b)

The description of VCVS is

E<name> N+ N- NC+ NC- g (gain value)

Typical statement

E1 1 2 3 4 2

The statement means that the VCVS E1 is connected between nodes 1 and 2 and its voltage is controlled by the voltage between nodes 3 and 4. The voltage gain is 2.

Now if for the circuit in Fig. 1(b) the italic numbers are parameter value and normal numbers are node number the Netlist may be written as

R1 1 2 8
R2 3 4 20
R3 0 4 8
R4 5 2 16

R4 0 5 4

E1 2 3 5 0 0.5
V1 1 0 10

Exercice 1

Try to write the Netlist of the following circuit

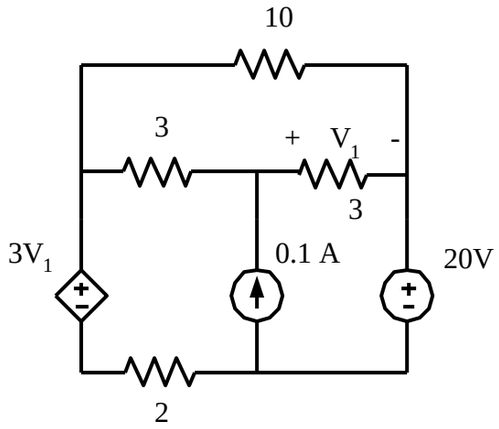

Fig. 2

Answer the following questions

1.a) Determine the current delivered by the dependent voltage source? Compare your result with that of the result obtained by mathematically solving the circuit.

b) Interchange the controlling nodes of the dependent voltage source as well as the controlled nodes and again determine the current delivered by the dependent source. How does this current compare with the previous one?

c) What will happen if you set a negative gain value?

1.2 Voltage-controlled current source (VCCS)

The symbol of a Voltage-controlled current source (VCCS) is shown in Fig 3(a). N+ and N- are the positive and negative output nodes, respectively, and NC+ and NC- are the positive and negative nodes, respectively of the controlling voltage.

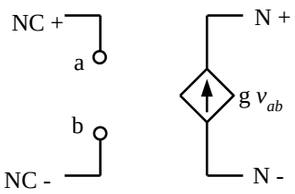

Fig. 3(a)

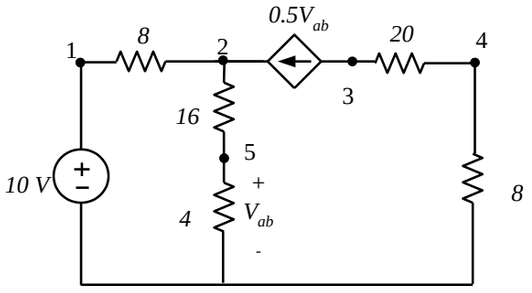

Fig. 3(b)

The description of VCCS is

G<name> N+ N- NC+ NC- g (transconductance value)

Typical statement

G1 1 2 3 4 2 z

The statement means that the VCCS G1 is connected between nodes 1 and 2 and its current is controlled by the voltage between nodes 3 and 4. The transconductance value is 2.

Now if for the circuit in Fig. 1(b) is redrawn by replacing the VCVS with a VCCS, we get the circuit in Fig 3(b) and the Netlist may be written as

```
R1      1    2    8
R2      3    4    20
R3      0    4    8
R4      5    2    16
R4      0    5    4

G1      2    3    5   0    0.5
V1      1    0    10
```

1.3 Current-controlled current source (CCCS)

The symbol of a Current-controlled current source (CCCS) is shown in Fig 4(a). N+ and N- are the positive and negative nodes, respectively, of the current source. VN is a voltage source through which controlling current flows. The controlling current is assumed to flow from the positive node of VN through the voltage source VN to the negative node of VN.

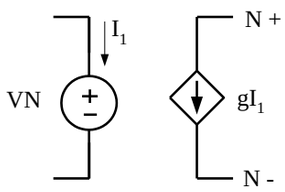

Fig. 4(a)

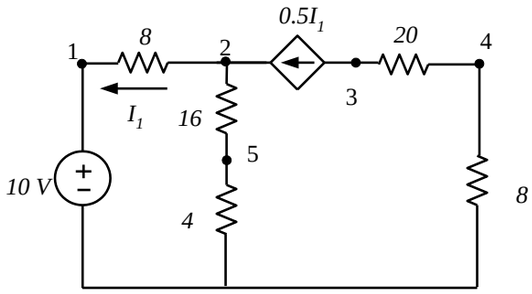

Fig. 4(b)

The description of CCCS is

F<name> N+ N- VN g (current gain value)

Typical statement

F1 1 2 V1 1

The statement means that the CCCS F1 is connected between nodes 1 and 2 and its current is controlled by the voltage source V1's current. The current gain value is 1.

So, the Netlist of the circuit shown in Fig 4(b) can be written as

```
V1      1    0    10

R1      1    2    8
R2      3    4    20
R3      0    4    8
R4      5    2    16
R4      0    5    4

F1      3    2    V1    0.5
```

The voltage source VN that mentions the controlling current must be an independent source, and it can have a zero or finite value. If the current through a resistor controls the source, a dummy voltage source of 0V value should be connected in series with the resistor to monitor the controlling current.

For example, if the current source of Fig. 4(b) is controlled by the current of 16 ohm resistor's current as shown in Fig. 5(a), we can redraw the circuit as shown in Fig. 5(b) and write the Netlist.

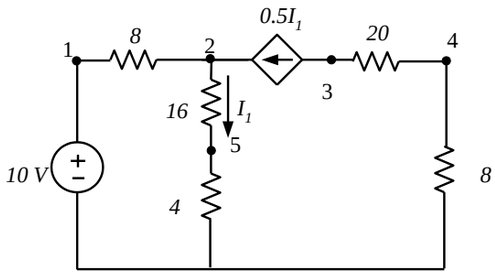

Fig. 5(a)

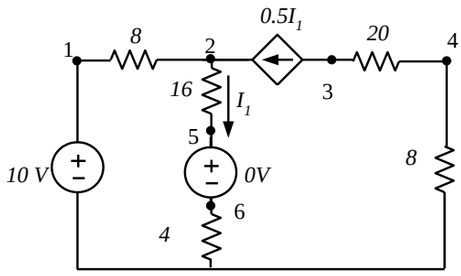

Fig. 5(b)

Exercise 2

Write the Netlist for the circuit shown in Fig. 5(b)

Now answer the following questions

2. a) Determine the voltage across the dependent current source. Compare your result with that of the result obtained by mathematically solving the circuit.

   b) Connect a zero volt independent source in series with the dependent current source to find the value of the controlled current. What value does Spice show for this voltage source? How does it compare with I1?

1.4 Current-controlled voltage source (CCVS)

The symbol of a Current-controlled voltage source (CCVS) is shown in Fig 6(a). N+ and N- are the positive and negative nodes, respectively, of the voltage source. VN is a voltage source through which controlling current flows. The controlling current is assumed to flow from the positive node of VN through the voltage source VN to the negative node of VN.

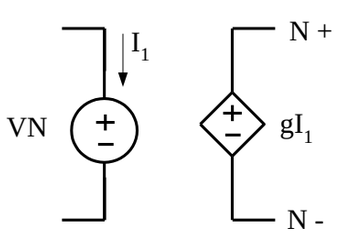

Fig. 6(a)

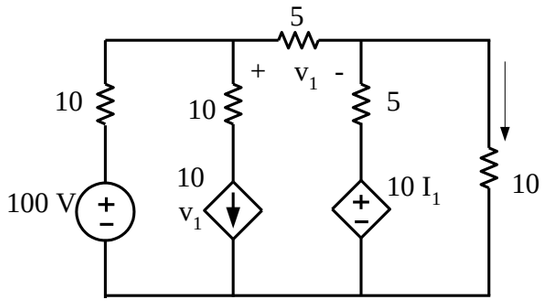

Fig. 6(b)

The voltage source VN that mentions the controlling current must be an independent source, and it can have a zero or finite value. If the current through a resistor controls the source, a dummy voltage source of 0V value should be connected in series with the resistor to monitor the controlling current.

The description of CCVS is

H<name> N+ N- VN g (transresistance value)

Typical statement

H1 1 2 V1 4

The statement means that the CCVS H1 is connected between nodes 1 and 2 and its voltage is controlled by the voltage source V1's current. The transresistance value is 4.

Exercise 3
Try to write the Netlist for the circuit shown in Fig. 6(b)

Now answer the following questions

3. a) Calculate the power associated with each source (both independent and dependent).

   b) Calculate the power absorbed by each resistor.

   c) Compare your results with that of the result obtained by mathematically solving the circuit and show that conservation of energy holds true for this circuit.

2.0 Spice Schematics

In spice schematics, the dependent sources can be found in the parts list. Click on the get parts list and write E(for VCVS) in the part name box. Now, click the place & close option to work with the VCVS. You can get the other type of dependent sources by writing F,G or H) in the part name box. The parts are the following shapes

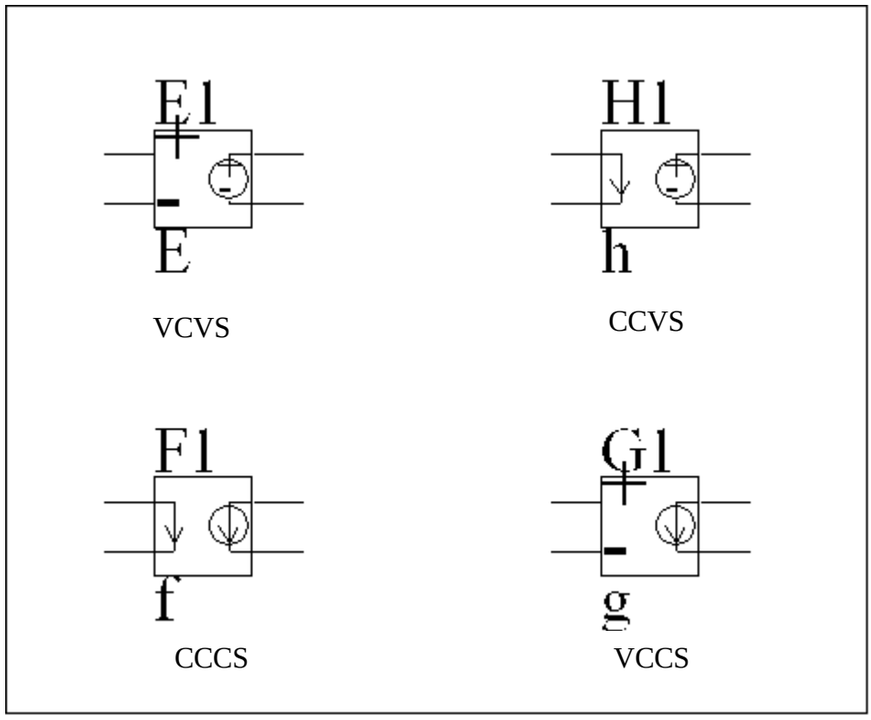

Fig. 7

The circular box represents the source and the other terminals are for the controlling parameter.

The circuit in fig 1(b) can be drawn in schematics in the following way

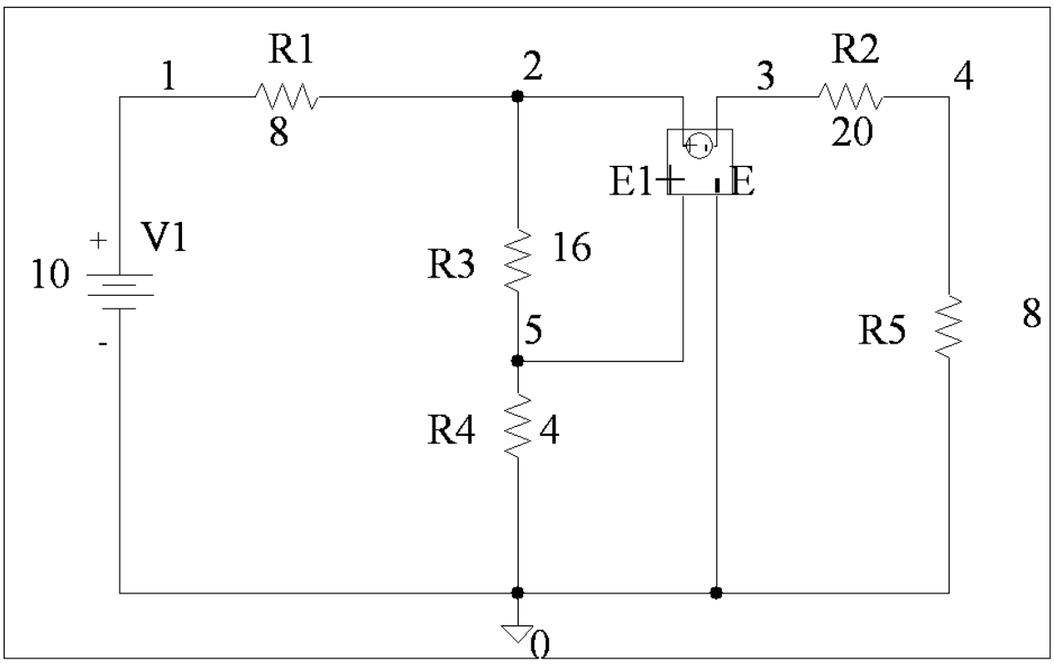

Fig. 8

To set the gain value, click the VCVS or select it and double click. The part attributes option will be activated. Click on the gain option and the write the gain value on the value box. Click the save Attr. and then click ok.

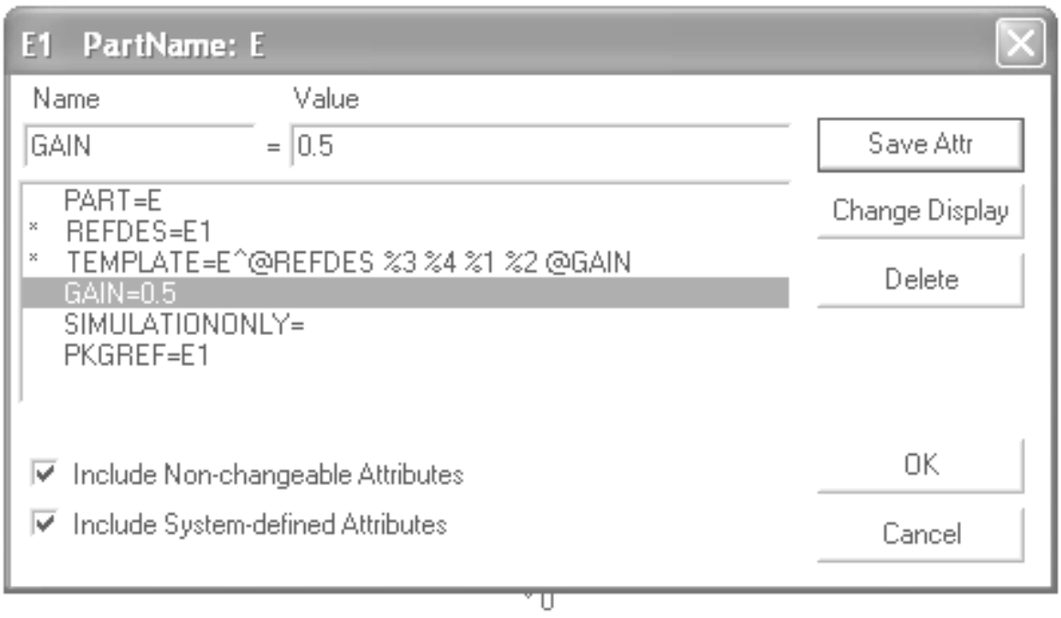

Fig. 9

The circuit in Fig. 3(b) can be drawn in the following way

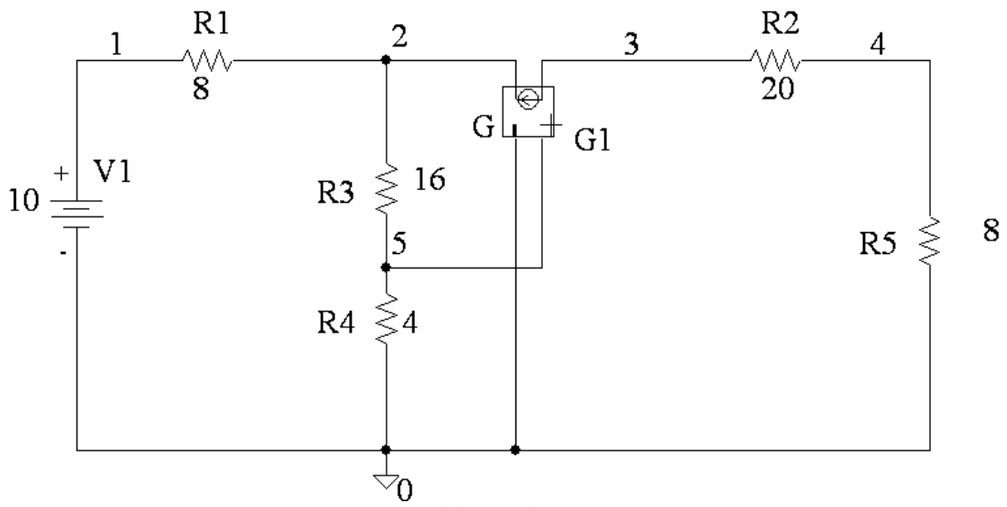

Fig. 10

For a circuit with multiple number of dependent sources and mesh. The inter connection of the controlling nodes may become complicated. To make the interconnections easier, a connection bubble named **Bubble** can be used.

To work with the bubble connector, click on the add new parts option and write b on the parts name box. Then select bubble from full list column. Now, click the place and close option to work with the connection bubble.

Place the bubble in one corner of the interconnection and double click it. In the set attributes option write a in the label box and click ok. Copy the bubble in the other corner of the interconnection. The connection is then automatically made; you need not have to draw the wire to complete the connection. Similarly you can connect another bubble with different label for another interconnection. The circuit in Fig. 1(b) can be drawn with bubble in the following way

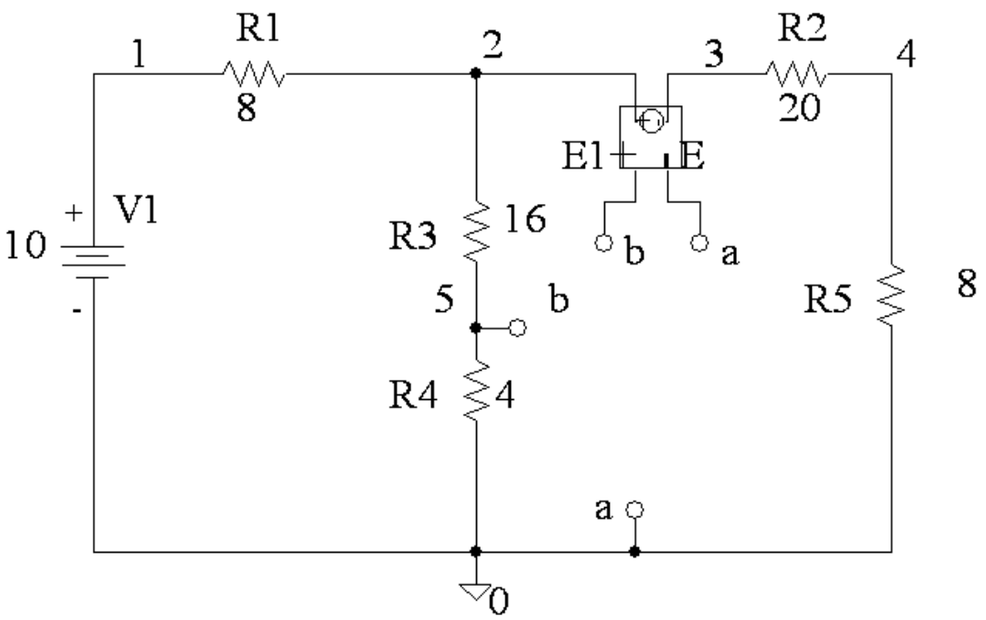

Fig. 11

The circuit in Fig 4(b) can drawn as

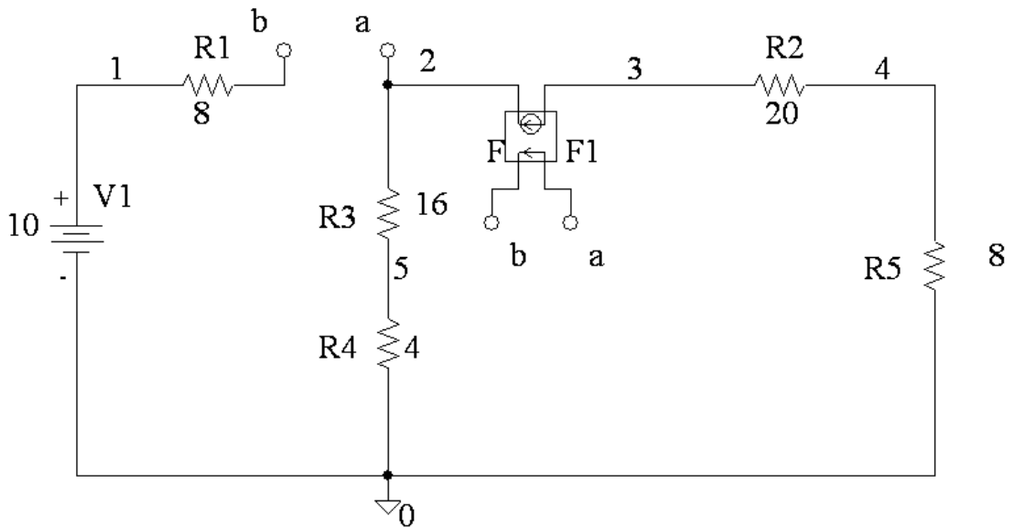

Fig. 12

Exercise 4

Try to draw and simulate the circuit of Fig. 5(a) and Fig. 6(b)

Now answer the following questions

4. a) Calculate the power associated with each source (both independent and dependent).

   b) Calculate the power absorbed by each resistor.

   c) Compare your results with that of the result obtained by mathematically solving the circuit and show that conservation of energy holds true for this circuit.