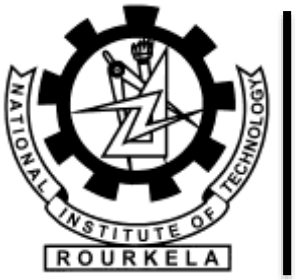
Simulation # 7

Superposition Theorem

Classical and modified method with dependant sources



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Aim of the Expt.:

1. Simulate superposition theorem for electric circuits with dependant sources
2. Verify the modified superposition method proposed by Leech.

Theory:

Independent Sources: Those voltage or current sources, which do not depend on any other quantity in the circuit (refer Figure 1).

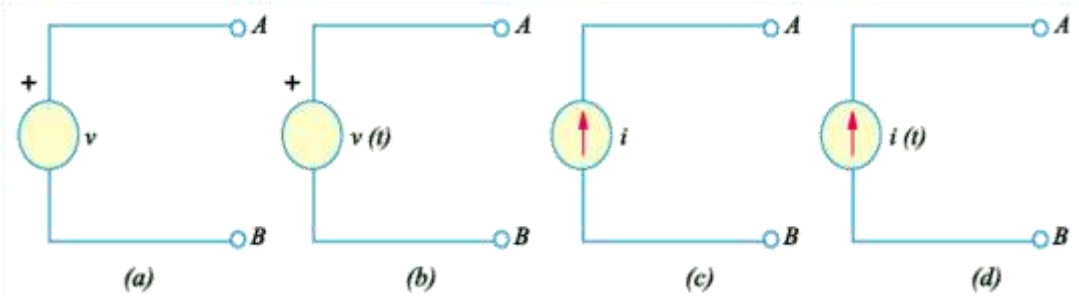

Figure 1 Dependant sources

Dependant Sources: Depends on some other quantity in the circuit which may be either a voltage or a current. Such a source is represented by a diamond-shaped symbol. There are four possible dependent sources (refer Figure 2) :

1. Voltage-dependent voltage source
2. Current-dependent voltage source
3. Voltage-dependent current source
4. Current-dependent current source

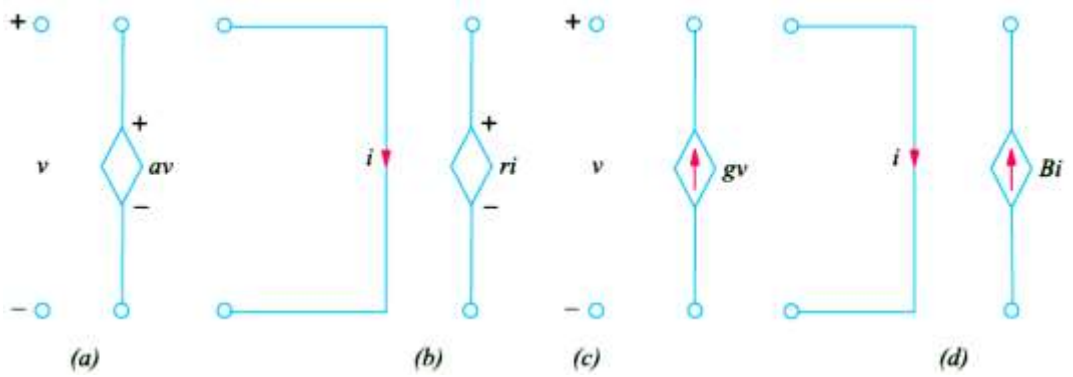

Figure 2 Dependant sources

The constants of proportionality are written as a, r, g and β. The constants a and β have no units, r has the unit of ohms and g has the unit of Siemens. Independent sources actually exist as physical entities such as a battery, a d.c. generator and an alternator etc. But dependent sources are parts of models that are used to represent electrical properties of electronic devices such as operational amplifiers and transistors etc.

Superposition theorem: In a network of linear resistances containing more than one generator (or source of e.m.f.), the current which flows at any point is the sum of all the currents which would flow at that point if each generator where considered separately and all

the other generators replaced for the time being by resistances equal to their internal resistances.
In classical method, only the independent sources are replaced with the internal resistance. Due to each source, the quantity (voltage/current) required is calculated. The final value is thus the addition of the result due to consideration of each source is the result.

Leach Method of superposition theorem:
In Leach method, the superposition principle is applied to dependant sources as well. Which means when considering one source, all other sources including dependant sources are replaced by their internal resistances. The published paper as a proof of the method is attached for further reading.

Illustrative example:

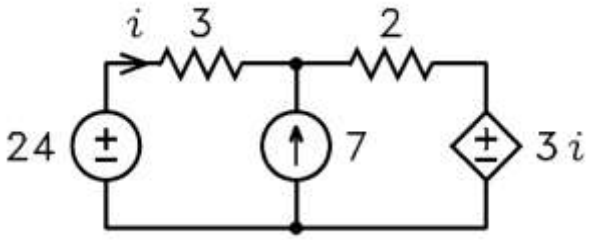

Figure 3 Circuit A for illustration

Classical Method:

Consider 24 V and 7 A sources individually while replacing other source by its internal resistance. Dependant source will remain active throughout the analysis.

Considering 24 V source:

$$24 - 5i' - 3i = 0$$
$$i' = 3 \text{ A } (\rightarrow)$$

Considering 7 A source:

$$-3i'' - 2(7 + i'') - 3i'' = 0$$
$$i'' = -7/4 \text{ A } (\leftarrow)$$

Total current I is given by superposition principle.

$$\mathbf{i = i' + i'' = 5/4 \text{ A } (\rightarrow)}$$

Modified Method:

Consider each source individually to calculate current while replacing all other (including dependant sources by its internal resistance). Use superposition principle as usual (for three sources in this case) to find the final answer.

Considering 24 V source:

$$i = 24 / 2 + 3$$
$$i' = 24/5 \text{ A } (\rightarrow)$$

Considering 7 A source:

$$i'' = 7 * (2/2+3) \text{ using CDR}$$
$$i'' = 14/5 \text{ A } (\leftarrow)$$

Considering 3i V source:

$i''' = 3i/(3+2)$

$i'' = 3i/5$ A (←)

Total current i isgiven by superposition principle.

$i = i' + i''+i''' = 24/5 – 14/5 -3i/5$

Solving $i = \mathbf{5/4\ A\ (\rightarrow)}$

Simulation of Circuit A

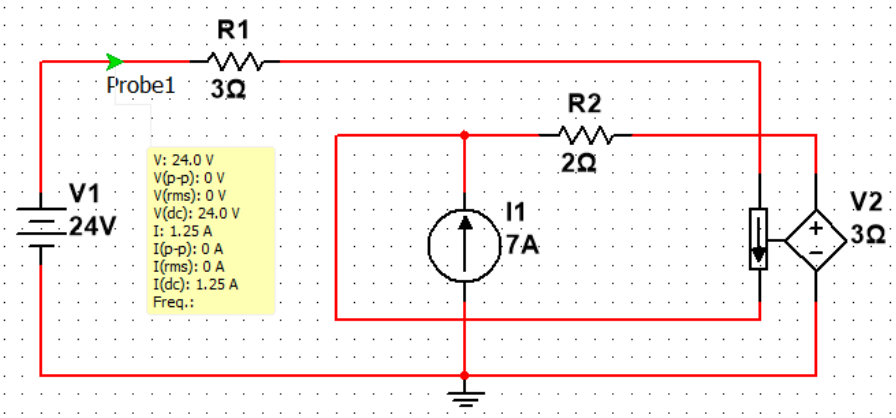

Figure 4 Multisim simulation of circuit A which uses ICVS of 3i

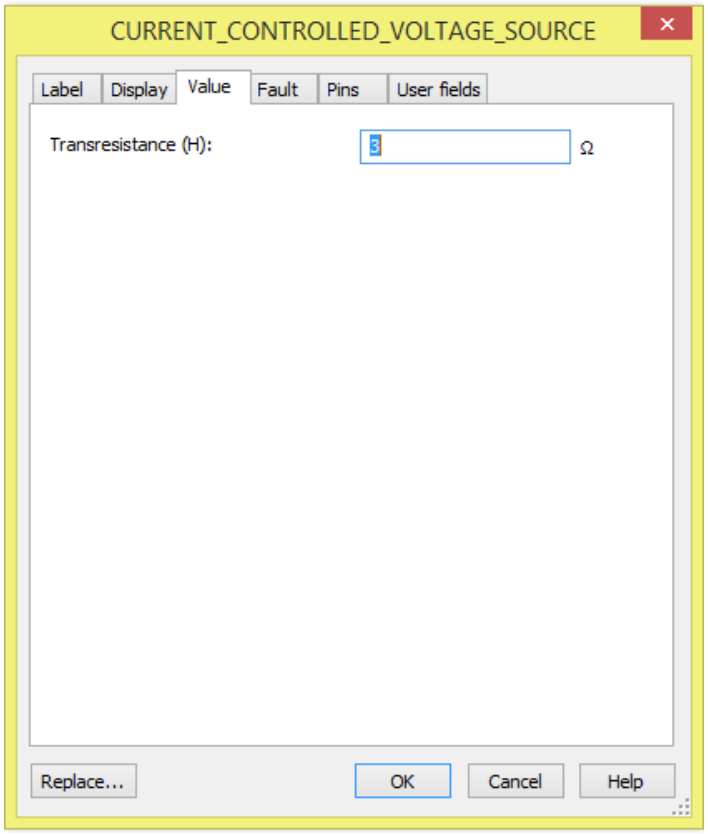

Figure 5 for adjusting the value of current source, set the value of transresistance to 3

Circuit for simulation:

Use circuit B to calculate the current 'i' manually using both classical and modified method

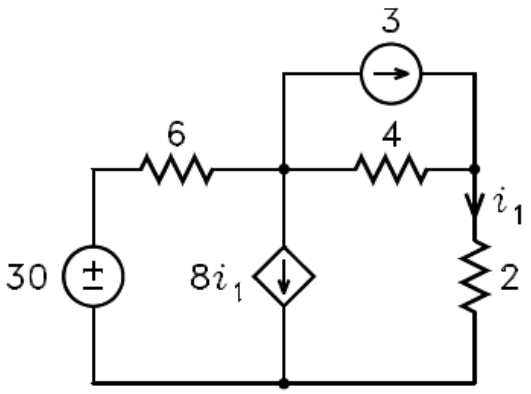

Figure 6 Circuit B for manual calculation and simulation

Simulation:

- Use the circuit B for calculation and simulation.
- Solve the circuit manually using classical and modified method.
- Simulate the circuit using Multisim and fill the values in table 1.

Questions:

1. Fill in the table using the value obtained manually and by simulation:

Table 1 Result table

Quantity / Method	Calculated		Simulated	
	Classical	Modified	Classical	Modified
Current due to 3A				
Current due to 30 V				
Current due to 8i A	-		-	
Total current i				

2. Define the terms: Linear network and bilateral network
3. Comment on the outcome of classical and modified superposition method. Which out of these two is more suitable for faster calculation?