4.4 • THE SUPERMESH

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
B.E: Electronics & Communication Engineering / B.E: Electronics & Telecommunication Engineering
NEP, Outcome Based Education (OBE) and Choice Based Credit System (CBCS)
(Effective from the academic year 2021 – 22)

IV Semester

Circuits & Controls			
Course Code	**21EC43**	CIE Marks	50
Teaching Hours/Week (L: T: P: S)	(3:0:2:0)	SEE Marks	50
Total Hours of Pedagogy	40 hours Theory + 13 Lab slots	Total Marks	100
Credits	04	Exam Hours	03

Module-1	
Basic concepts and network theorems Types of Sources, Loop analysis, Nodal analysis with independent DC and AC Excitations. (Textbook 1: 2.3, 4.1, 4.2, 4.3, 4.4, 10.6) Super position theorem, Thevenin's theorem, Norton's Theorem, Maximum Power transfer Theorem. (Textbook 2: 9.2, 9.4, 9.5, 9.7)	
Teaching-Learning Process	Chalk and Talk, YouTube videos, Demonstrate the concepts using circuits **RBT Level:** L1, L2, L3

Module-2	
Two port networks: Short- circuit Admittance parameters, Open- circuit Impedance parameters, Transmission parameters, Hybrid parameters (Textbook 3: 11.1, 11.2, 11.3, 11.4, 11.5) **Laplace transform and its Applications**: Step Ramp, Impulse, Solution of networks using Laplace transform, Initial value and final value theorem (Textbook 3: 7.1, 7.2, 7.4, 7.7, 8.4)	
Teaching-Learning Process	Chalk and Talk **RBT Level:** L1, L2, L3
Module-3	
Basic Concepts and representation: Types of control systems, effect of feedback systems, differential equation of physical systems (only electrical systems), Introduction to block diagrams, transfer functions, Signal Flow Graphs (Textbook 4: Chapter 1.1, 2.2, 2.4, 2.5, 2.6)	
Teaching-Learning Process	Chalk and Talk, YouTube videos **RBT Level:** L1, L2, L3

Module-4	
Time Response analysis: Time response of first order systems. Time response of second order systems, time response specifications of second order systems (Textbook 4: Chapter 5.3, 5.4) **Stability Analysis:** Concepts of stability necessary condition for stability, Routh stability criterion, relative stability Analysis (Textbook 4: Chapter 5.3, 5.4, 6.1, 6.2, 6.4, 6.5)	
Teaching-Learning Process	Chalk and Talk, Any software tool to show time response **RBT Level:** L1, L2, L3

Module-5	
Root locus: Introduction the root locus concepts, construction of root loci (Textbook 4: 7.1, 7.2, 7.3) **Frequency Domain analysis and stability**: Correlation between time and frequency response and Bode plots (Textbook 4: 8.1, 8.2, 8.4) **State Variable Analysis:** Introduction to state variable analysis: Concepts of state, state variable and state models. State model for Linear continuous –Time systems, solution of state equations. (Textbook 4: 12.2, 12.3, 12.6)	
Teaching-Learning Process	Chalk and Talk, Any software tool to plot Root locus, Bode plot **RBT Level:** L1, L2, L3

Suggested Learning Resources:

Text Books

1. Engineering circuit analysis, William H Hayt, Jr, Jack E Kemmerly, Steven M Durbin, Mc Graw Hill Education, Indian Edition 8e.
2. Networks and Systems, D Roy Choudhury, New age international Publishers, second edition.
3. Network Analysis, M E Van Valkenburg, Pearson, 3e.
4. Control Systems Engineering, I J Nagrath, M. Gopal, New age international Publishers, Fifth edition.

4.4 • THE SUPERMESH

When a common current source occurs (whether dependent or independent)

between two meshes then it called Super mesh

When two meshes have a common current source then it is called Super mesh.

In super mesh the current source is in the interior of the mesh

If the current source lies in the perimeter (periphery) of the circuit then the mesh in which it is found is ignored

Then KVL is applied only to the redrawn or re interpreted mesh or super mesh.

Steps for Super mesh Analysis

1. **Determine if the circuit is a planar circuit.**

2. **Count the number of meshes** (*M*). Redraw the circuit if necessary.

3. **Label each of the *M* mesh currents.** Generally, defining all mesh
Currents to flow clockwise results in a simpler analysis.

**4. If the circuit contains current sources shared by two meshes,
form a super mesh to enclose both meshes**

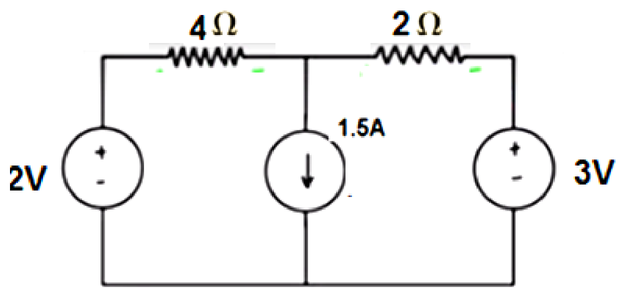
5. **Write a KVL equation around each mesh/super mesh.**
. Pay close attention to "−" signs.

If a current source lies on the periphery of a mesh, no KVL equation is needed and the

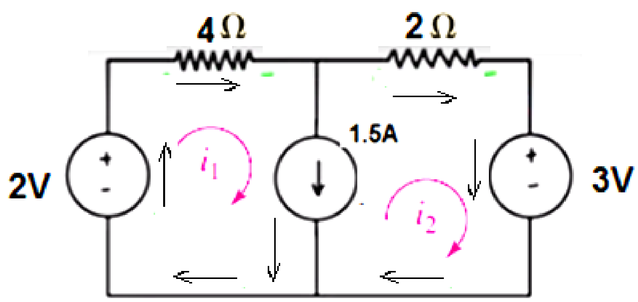
mesh current is determined by inspection.

6. **Relate the current flowing from each current source to mesh
currents. By using KCL**
.
8. **Organize the equations.** Group terms according to nodal voltages
.
9. **Solve the system of equations for the mesh currents**

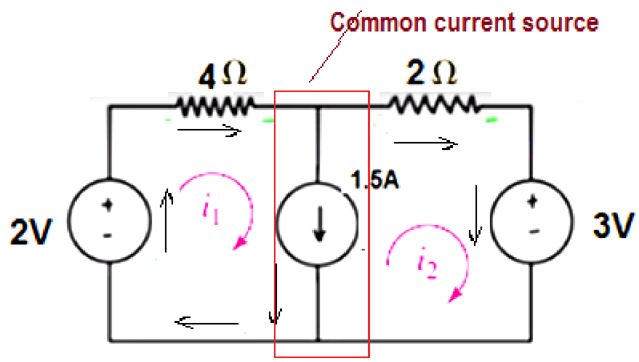
1) Find the branch currents of the circuit shown.



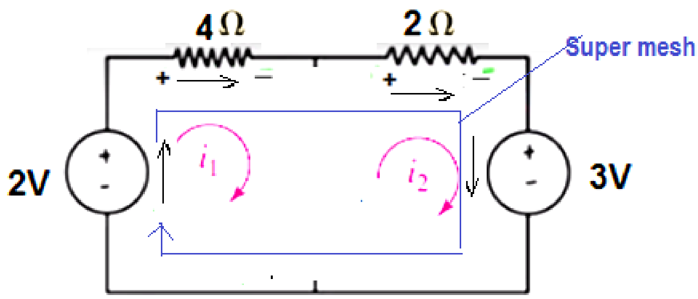
Mark the mesh current direction



Identify common current source



Draw super mesh



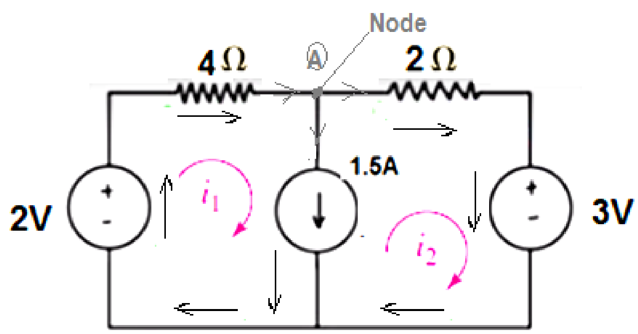
Apply KVL to super mesh

$$2 - 4\,i_1 - 2\,i_2 - 3 = 0$$

$$-4\,i_1 - 2\,i_2 = 1 \;\ldots\ldots\ldots\ldots\ldots(1)$$

Two unknowns one Eq. write another Eq. by applying KCL at the node A

Apply KCL at the node A



$$i_1 - i_2 - 1.5 = 0$$

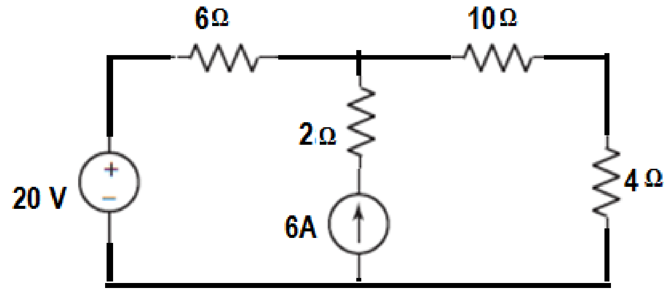
$$i_1 - i_2 = 1.5 \;\ldots\ldots\ldots\ldots\ldots(2)$$

From Eq. 1 & 2

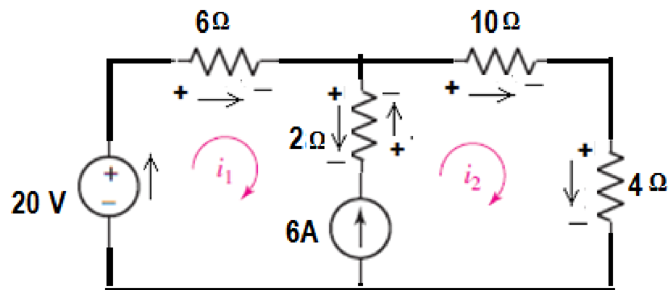
$i_1 = 0.33\ A$ $\quad$ $i_2 = -1.67\ A$

- ve sign indicates the current
should be in the reverse direction

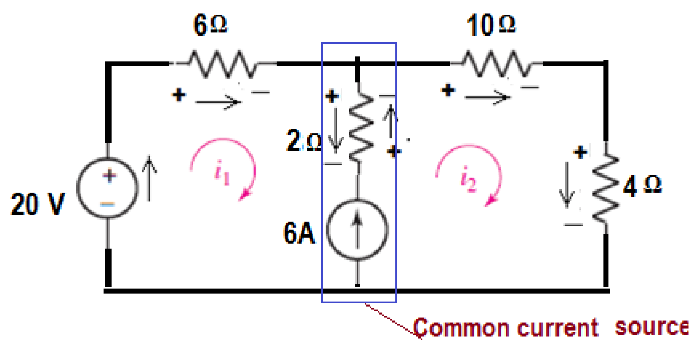
2) Find the branch currents of the circuit shown.

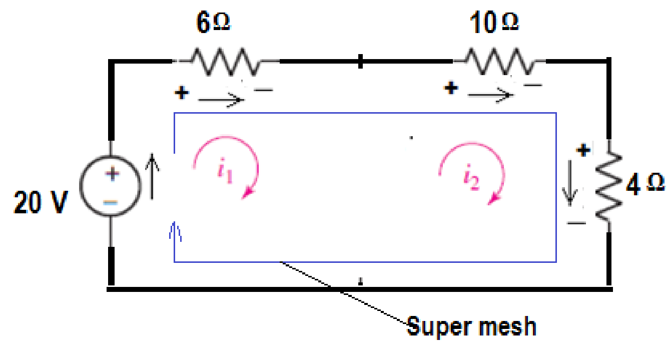


Mark the mesh currents



Identify super mesh





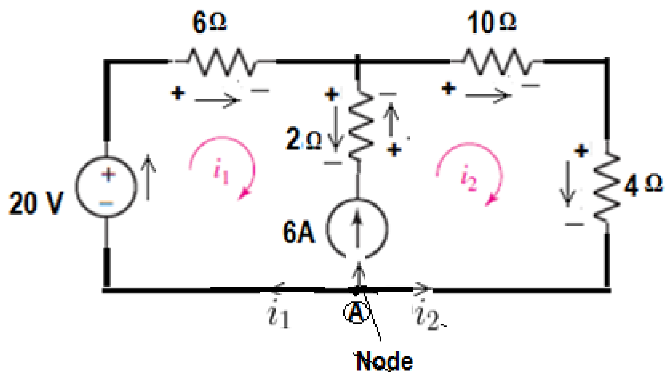
Apply KVL for super mesh.

$$+20 - 6i_1 - 10i_2 - 4i_2 = 0$$

$$-6i_1 - 14i_2 = -20$$

$$6i_1 + 14i_2 = 20 \qquad \text{.............(1)}$$

Apply KCL at the node A



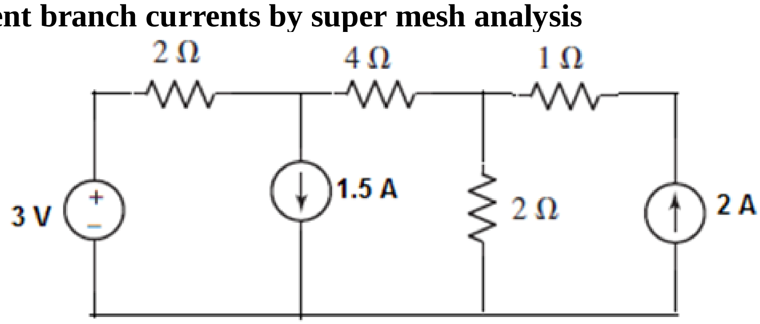
$$i_2 - i_1 - 6 = 0 \qquad \text{.............. (2)}$$

$$i_2 = i_1 + 6$$

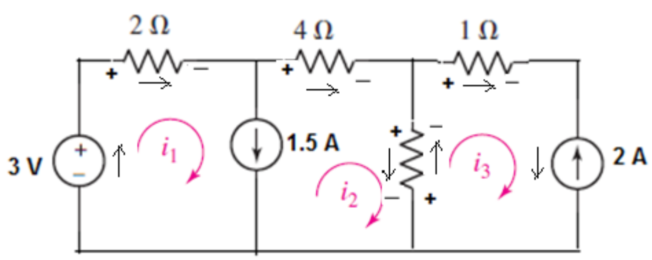
From 1 & 2

$$i_1 = -3.2A \qquad i_2 = 2.8A$$

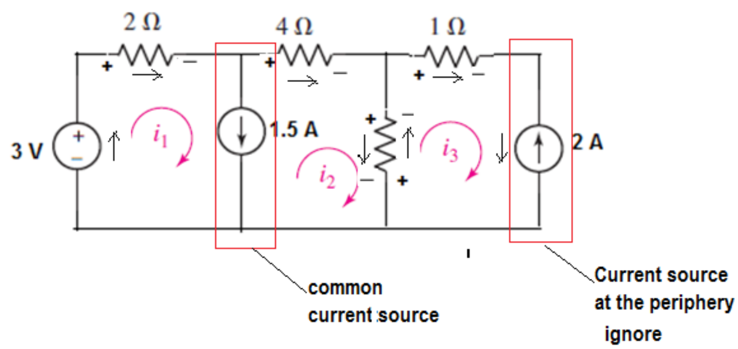
3) Find the different branch currents by super mesh analysis

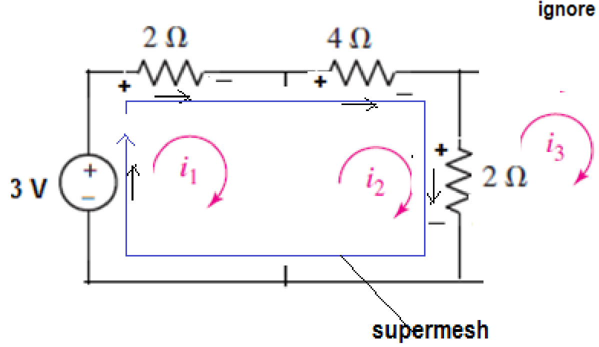


Mark mesh current



Identify super mesh





Apply KVL to super mesh

Apply KVL to super mesh

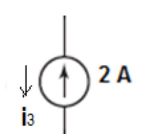
$3 - 2\,i_1 - 4i_2 - 2\,(i_2 - i_3) = 0$

$3 - 2\,i_1 - 6i_2 - 2\,i_3 = 0$

$i_3 = -2$

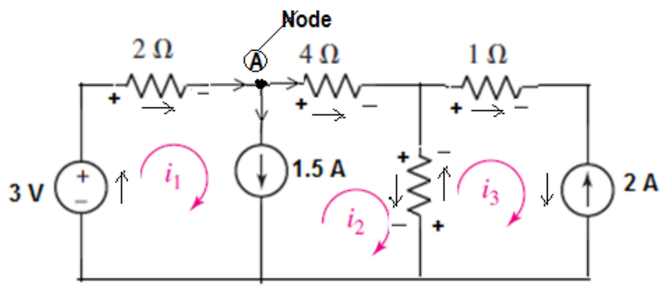
$3 - 2\,i_1 - 6i_2 - 2(-2) = 0$

$-2\,i_1 - 6i_2 = 1$ ....(1)



$\boxed{i_3 = -2\text{ A}}$

Apply KCL at the node A



$I_1 - i_2 - 1.5 = 0$

$I_1 = i_2 - 1.5$

$I_1 - i_2 - 1.5 = 0$

$\boxed{I_1 = i_2 + 1.5}$

$-2\,i_1 - 6\,i_2 = 1$ ....(1)

$\downarrow$

$(i_2 + 1.5)$

$-2\,(i_2 + 1.5) - 6\,i_2 = 1$

$-2\,i_2 - 3 - 6\,i_2 = 1$

$-8\,i_2 = 4$

$i_2 = -4/8 = -0.5$

$I_1 = i_2 + 1.5$

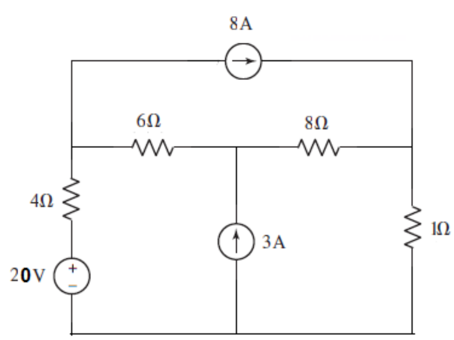
$I_1 = -0.5 + 1.5 = 1\text{ A}$

$I_1 = 1\text{ A}$

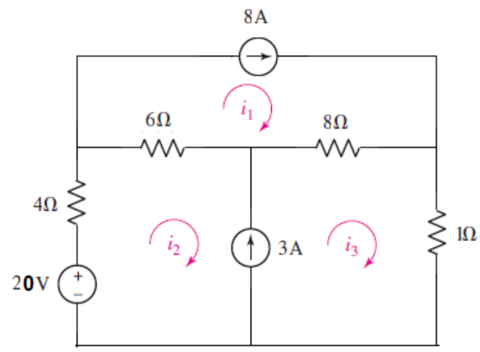
$i_2 = -0.5$

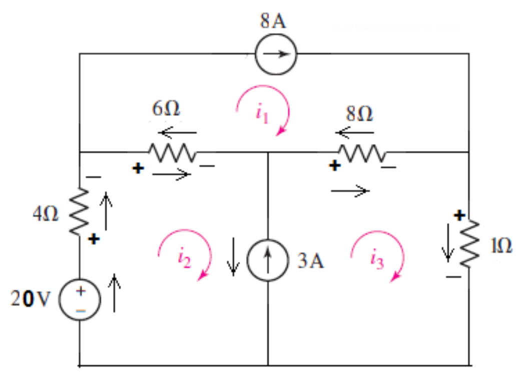
$i_3 = -2$

4) Using super mesh analysis find the current through 8 Ω resistor

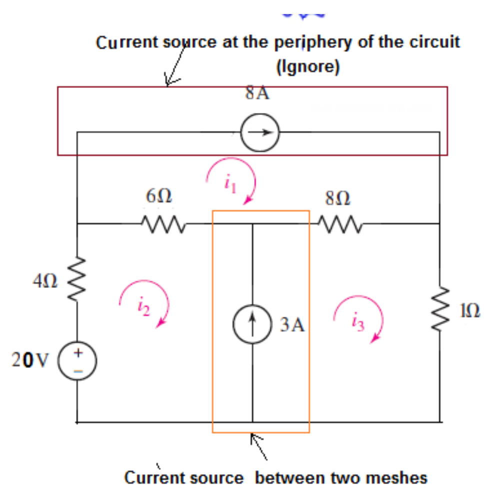


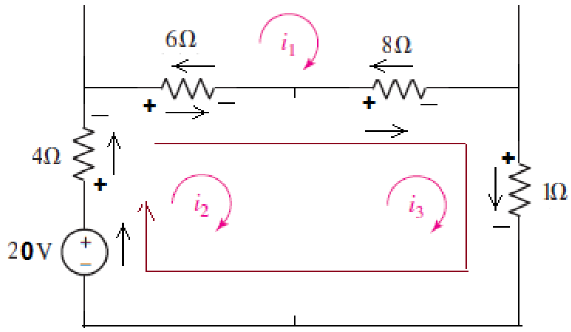
Mark the mesh loops





Identify the super mesh





$\boxed{i_1 = 8A}$

Apply KVL to super mesh

$$20 - 4i_2 - 6(i_2 - i_1) - 8(i_3 - i_1) - 1\, i_3 = 0$$

$$20 - 10\, i_2 + 14\, i_1 - 9\, i_3 = 0$$

$$10\, i_2 + 9\, i_3 = 20 + 14\, i_1$$

$$10\, i_2 + 9\, i_3 = 20 + 14\, i_1$$

$i_1 = 8A$

$$10\, i_2 + 9\, i_3 = 132 \text{ ...... (1)}$$

One Eq. two variables, another Eq. is obtained by applying KCL at the node A

Apply KCL at node A

$$-3 - i_2 + i_3 = 0$$

$$i_3 - i_2 = 3 \text{ ....(2)}$$

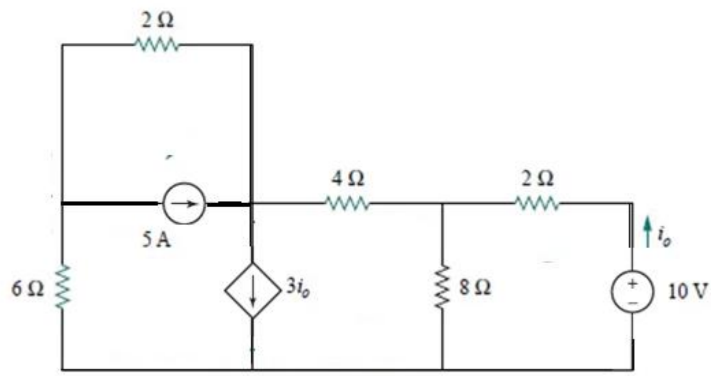
From Eq. 1 and 2 find

i_2 =

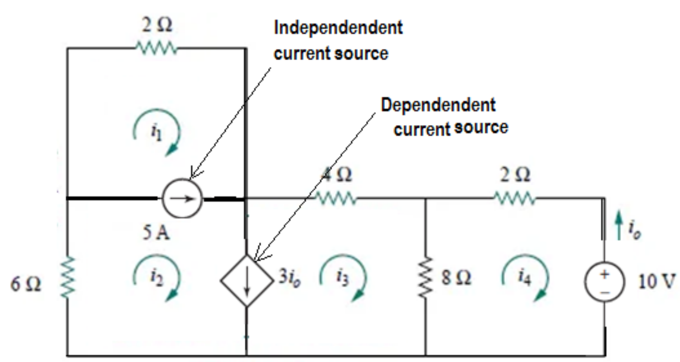
i_3 =

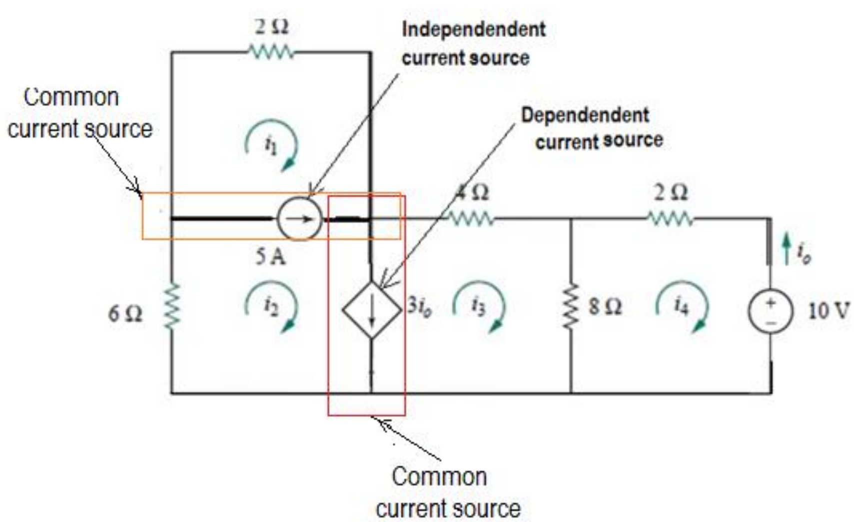
i_1 = 8A

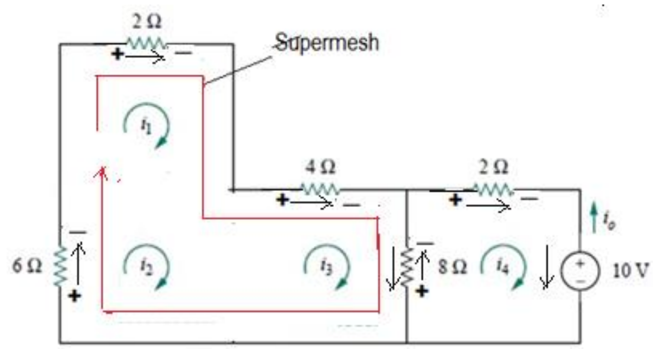
5) For the circuit find i_1 to i_4 by using super mesh analysis



Mark mesh loops







Apply KVL to complete super mesh

$$-2i_1 - 4i_3 - 8(i_3 - i_4) - 6i_2 = 0$$

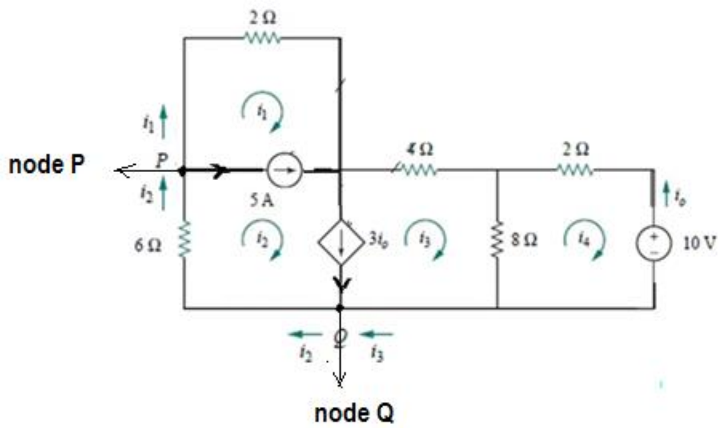
$$-i_1 - 3i_2 - 6i_3 + 4i_4 = 0 \quad \ldots\ldots\ldots\ldots(1)$$

Apply KVL to mesh= 4

$$-2i_4 - 8(i_4 - i_3) - 10 = 0$$

$$-5i_4 + 4i_3 = +5 \quad \ldots\ldots\ldots\ldots(2)$$

Apply KCL at the node P & Q



For the independent current source, we apply KCL to node P:

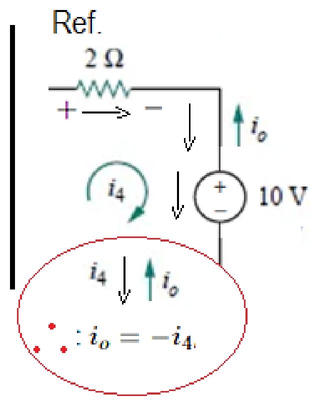
$$i_2 = i_1 + 5$$

For the dependent current source, we apply KCL to node Q:

$$i_2 = i_3 + 3i_o$$

But $i_o = -i_4$, hence,

$\therefore\ i_2 = i_3 - 3i_4$ ....(3)



From Eq. 1, 2 and 3

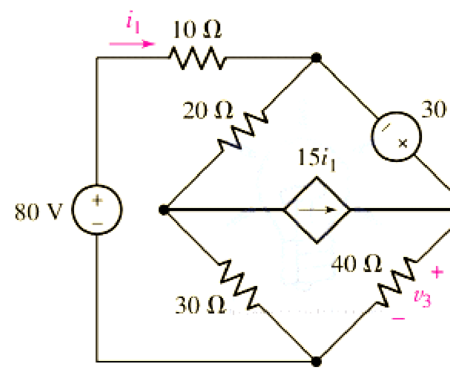
$$i_1 = -7.5A,$$

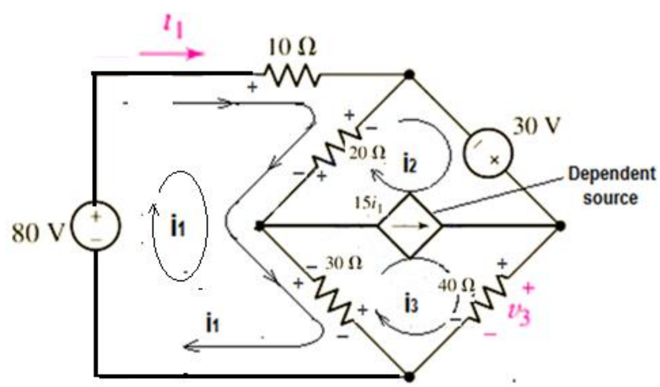
$$i_2 = -2.5A,$$

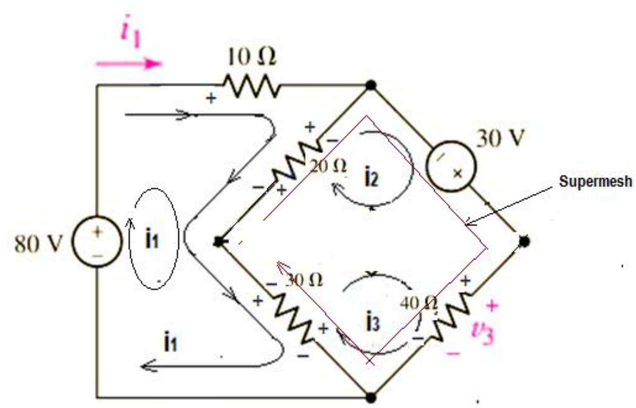
$$i_3 = 3.93A$$

$$i_4 = 2.143A$$

6) Determine V3 by using super mesh analysis in the circuit







Apply KVL to super mesh

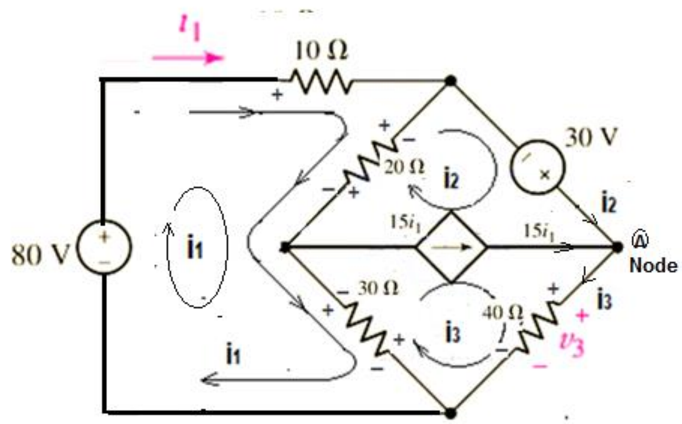
$30 - 40\boldsymbol{i_3} - 30(\boldsymbol{i_3} - \boldsymbol{i_1}) - 20(\boldsymbol{i_2} - \boldsymbol{i_1}) = 0$

$30 = 70\boldsymbol{i_3} - 50\boldsymbol{i_1} + 20\boldsymbol{i_2}$ ….. → (1).

Apply KVL to mesh -1

$80 - 10i_1 - 20(i_1 - i_2) - 30\ (i_1 - i_3) = 0$
$80 = 60i_1 - 20i_2 - 30i_3$ ….. → (2)

There are three variable i.e. $i1$, $i2$ and $i3$. And only two equations. The third Eq. is obtained by applying KCL



Applly KVL at the node A

$15ix = \boldsymbol{i_3} - \boldsymbol{i_2}$
$\boldsymbol{i_3} = 15\boldsymbol{ix} + \boldsymbol{i_2}$ ….. → Eq 3

Solving equations 1, 2 and 3

$i_1 = 0.583\ A$

$i_2 = -6.15\ A$

$i_3 = 2.6$ A

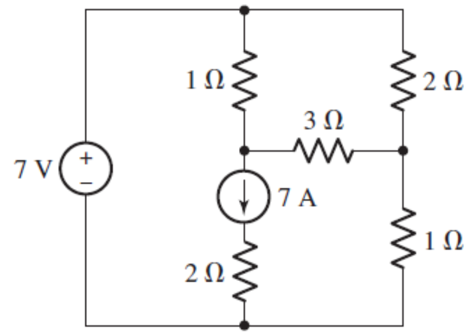
Also, we can find the value of $\mathbf{V_3}$,

$\mathbf{V_3 = i_3 \times R_3}$

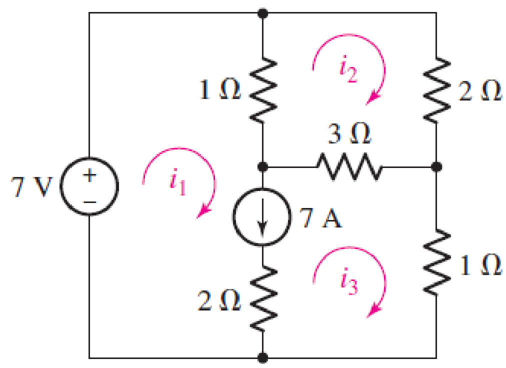
Putting the values,

$V_3 = 2.6A \times 40\Omega$
$\mathbf{V_3 = 104\ V.}$

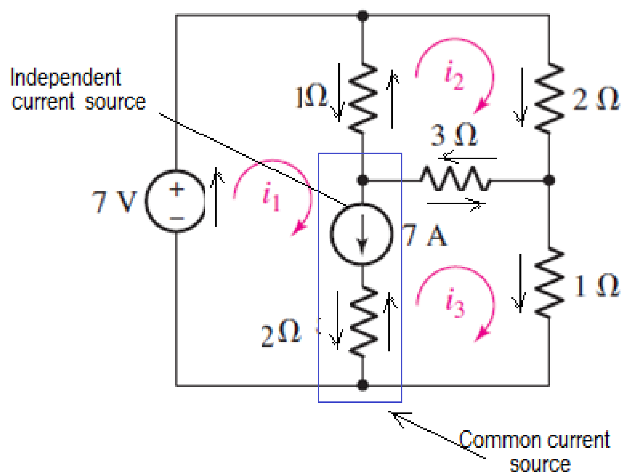
7) **Determine the three mesh currents in Fig**



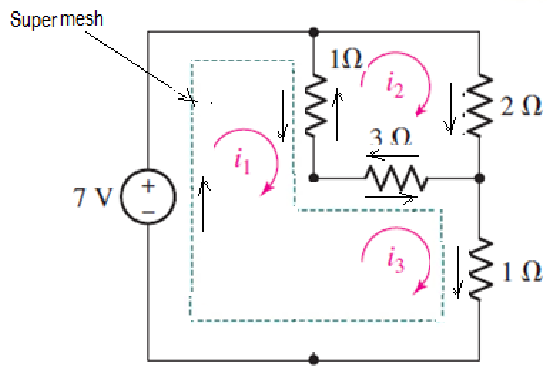
Mark the mesh current



Identify and mark common current source



Identify super mesh and represent by dotted line



Apply KVL to super mesh

$$+7 - 1(i_1 - i_2) - 3(i_3 - i_2) - 1i_3 = 0$$

$$-i_1 + 4i_2 - 4i_3 = -7 \quad \text{.................(1)}$$

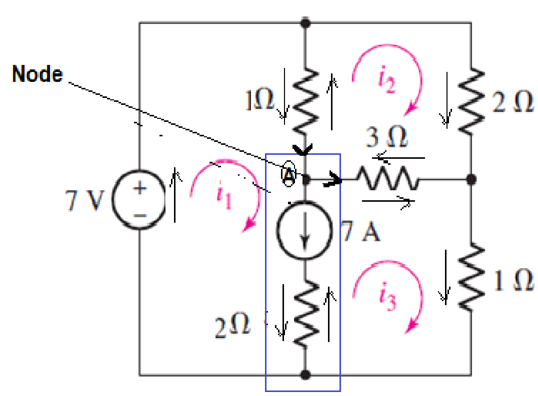
Apply KVL to mesh-2

$$-1(i_2 - i_1) - 2i_2 - 3(i_2 - i_3) = 0$$

$$+i_1 - 6i_2 + 3i_3 = 0 \quad \text{................(2)}$$

There are three unknown two Eq. the other Eq. is obtained By applying KCL

Apply KCL at the node A



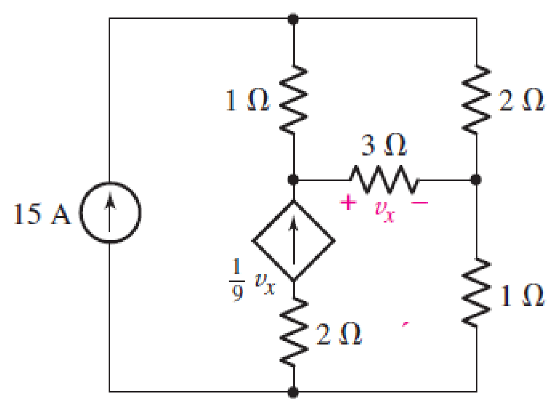
$i_1 - i_3 - 7 = 0$

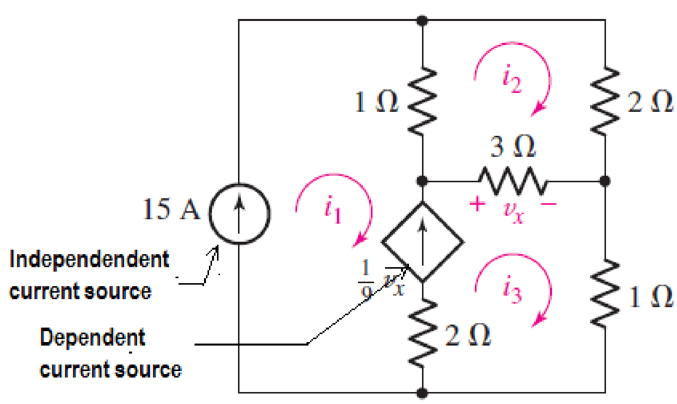
$i_1 - i_3 = 7$ .... (3)

From Eq. 1, 2 & 3

$i_1 = 9$ A, $i_2 = 2.5$ A, and $i_3 = 2$ A.

8) Evaluate the three unknown currents in the circuit of Fig





The dependent current sources appear in meshes 1 and 3.

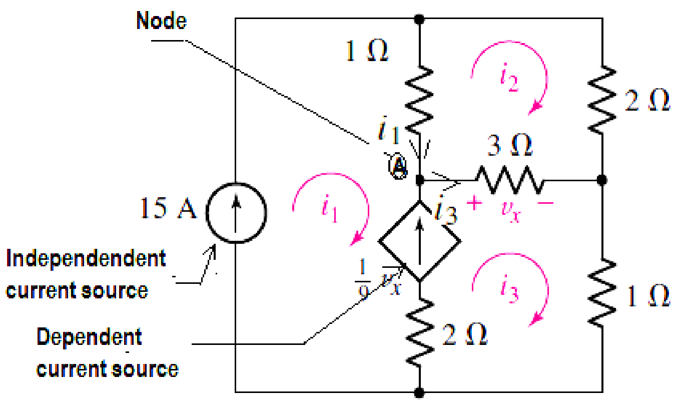
The independent current source15 A is located on the perimeter of the circuit,
We may eliminate mesh 1 from consideration

The current i_1 = 15 A.

The two mesh currents i_1 and i_3 related to the dependent current source,

There is no need to write a super mesh equation about meshes 1 and 3.
Instead, relate i_1 and i_3 to the current from the dependent source using KCL

Apply KCL at node A



$$\frac{v_x}{9} + i_1 - i_3 = 0$$

$$\therefore \quad \frac{v_x}{9} = i_3 - i_1$$

$$v_x = 3(i_3 - i_2)$$

$$\frac{v_x}{9} = i_3 - i_1 = \frac{3(i_3 - i_2)}{9}$$

$$i_3 - i_1 = \frac{3(i_3 - i_2)}{9}$$

$$i_3 - i_1 = \frac{i_3}{3} - \frac{i_2}{3}$$

$$i_3 - \frac{i_3}{3} + \frac{i_2}{3} = i_1$$

$$\frac{3i_3 - i_3 + i_2}{3} = i_1$$

$$\frac{2i_3 + i_2}{3} = i_1$$

$$\frac{1}{3}i_2 + \frac{2}{3}i_3 = 15 \quad \text{................(1)}$$

Apply KVL to mesh – 2

$$-1(i_2 - i_1) - 2i_2 - 3(i_2 - i_3) = 0$$

$$-6i_2 + 3i_3 = -15 \quad \text{..................(2)}$$

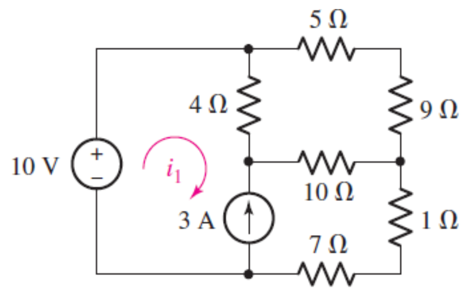
From Eq. 1 and 2

$$i_2 = 11 \text{ A and } i_3 = 17 \text{ A}$$

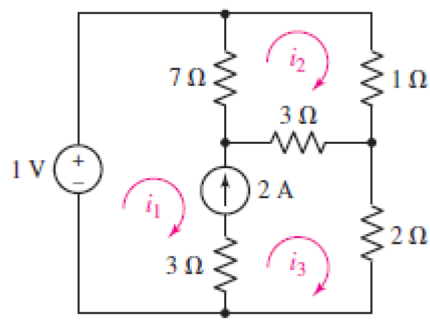
we already determined that $i_1 = 15$ A by inspection.

PRACTICE

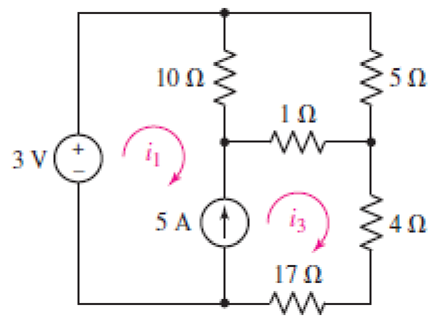
1) Determine the current *i*1 in the circuit of Fig.



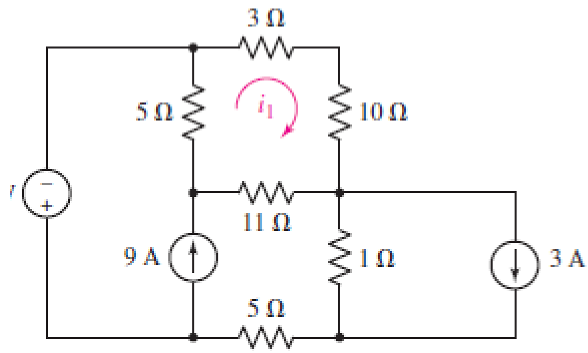
2) Determine values for the three mesh currents of Fig.



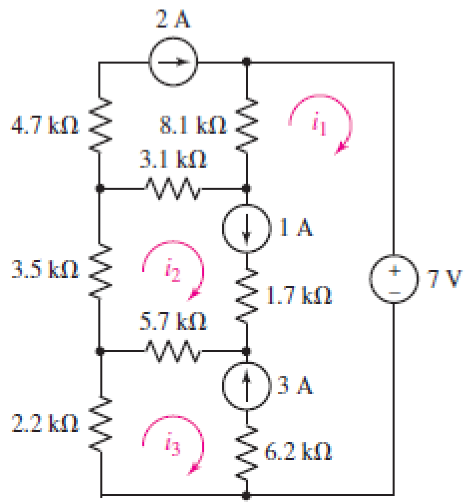
3) **Through appropriate application of the super mesh technique, obtain a numerical value for the mesh current i_3 in the circuit of Fig. and calculate the power dissipated by the 1 *ohm* resistor.**



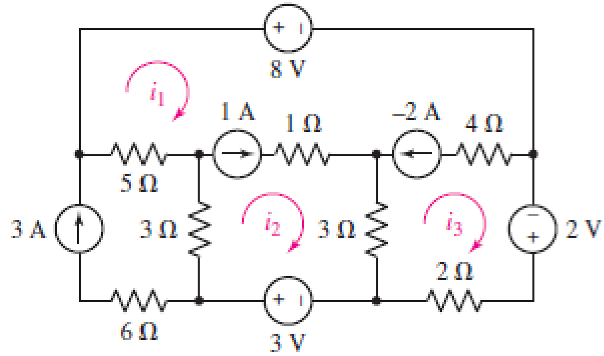
4) **For the circuit of Fig. determine the mesh current i_1 and the power dissipated by the 1 *ohm* resistor.**



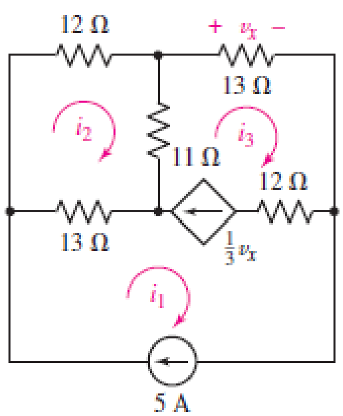
5) **Calculate the three mesh currents labeled in the circuit diagram of Fig**.



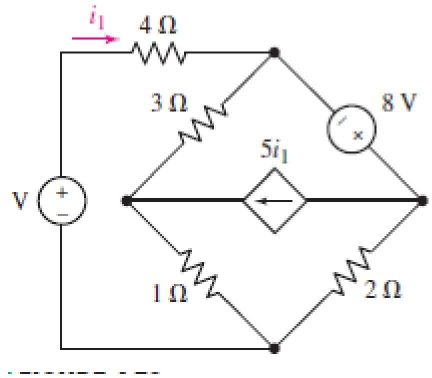
***6)* Employing the super mesh technique to best advantage, obtain numerical values for each of the mesh currents identified in the circuit depicted in Fig.**



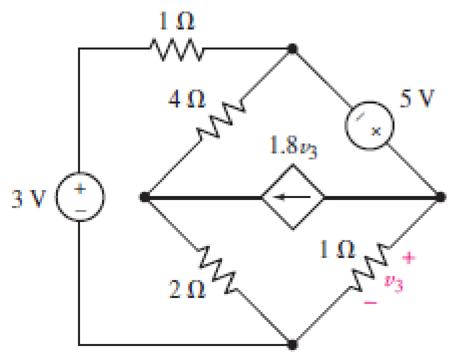
***7)* Through careful application of the super mesh technique, obtain values for all three mesh currents as labeled in Fig.**



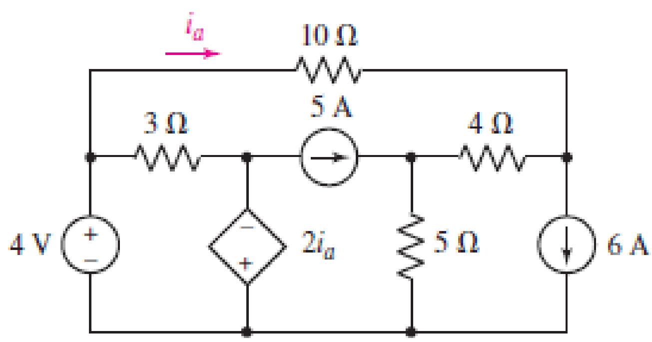
8) Determine the power supplied by the 1 V source in Fig.



9) Define three clockwise mesh currents for the circuit of Fig. 4.74, and employ the super mesh technique to obtain a numerical value for each.



10) Determine the power absorbed by the 10 *ohms* resistor in Fig.



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