7) Solve for I_1, I_2, I_3 in the following set of equations using determinants.

$$2I_1 - 6I_2 + 10I_3 = 9$$

$$3I_1 - 7I_2 - 8I_3 = 3$$

$$10I_1 + 5I_2 - 12I_3 = 0$$

$$\begin{bmatrix} 2 & -6 & 10 \\ 3 & -7 & -8 \\ 10 & 5 & -12 \end{bmatrix} \begin{bmatrix} 9 \\ 3 \\ 0 \end{bmatrix}$$

Δ

$$\begin{array}{ccccc} 2 & -6 & 10 & 2 & -6 \\ 3 & -7 & -8 & 3 & -7 \\ 10 & 5 & -12 & 10 & 5 \end{array}$$

$(2 \times -7 \times -12) + (-6)(-8)(10) + (10 \times 3 \times 5) -$
$(10 \times -7 \times 10) + (5 \times -8 \times 2) + (-12\ 3\ -6)$

$(168 + 480 + 150) - (-700 + -80 + 216)$

$798 \quad - \quad -564$

$1362 = \Delta$

Δi_1

$$\begin{array}{ccccc} 9 & -6 & 10 & 9 & -6 \\ 3 & -7 & -8 & 3 & -7 \\ 0 & 5 & -12 & 0 & 5 \end{array}$$

$(9 \times -7 \times -12) + (-6 \times -8 \times 0) + (10 \times 3 \times 5) -$

$(10 \times -7 \times 0) + (5 \times -8 \times 9) + (-12 \times 3 \times -6)$

$-756 + 0 + 150 - 0 + -360 + +216$

$-606 - -144$

$-462 = \Delta i_1$

Δi_2

$$\begin{matrix} 2 & 9 & 10 & 2 & 9 \\ 3 & 3 & -8 & 3 & 3 \\ 10 & 0 & -12 & 10 & 0 \end{matrix}$$

$$(2 \times 3 \times -12) + (9 \times -8 \times 10) + (10 \times 3 \times 0) -$$
$$(10 \times 3 \times 10) + (0 \times -8 \times 2) + (-12 \times 3 \times 9)$$

$$-72 + -720 + 0 - 300 + 0 + -324$$

$$792 - -24$$

$$816 = \Delta i_2$$

Δi_3

$$\begin{array}{ccccc} 2 & -6 & 9 & 2 & -6 \\ 3 & -7 & 3 & 3 & -7 \\ 10 & 5 & 0 & 10 & 5 \end{array}$$

$$(2 \times -7 \times 0) + (-6 \times 3 \times 10) + (9 \times 3 \times 5) - (10 \times -7 \times 9) + (5 \times 3 \times 2) + (0 \times 3 \times -6)$$

$$(0) + (-180) + (135) - (-630) + (30) + (0)$$

$$-45 - -600$$

$$555 = \Delta i_3$$

Δ	Values
Δ	1362
Δi_1	-462
Δi_2	816
Δi_3	555

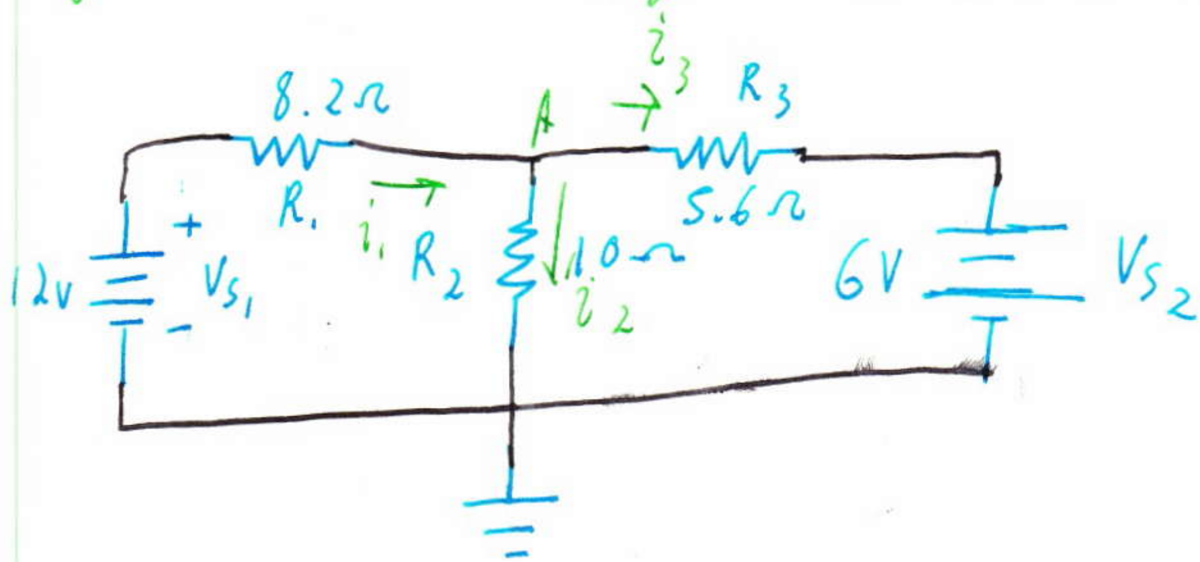
$$\frac{\Delta i_{Target}}{\Delta}$$

$$i_1 = \frac{-462}{1362} = -0.339\ A$$

$$i_2 = \frac{816}{1362} = 0.599\ A$$

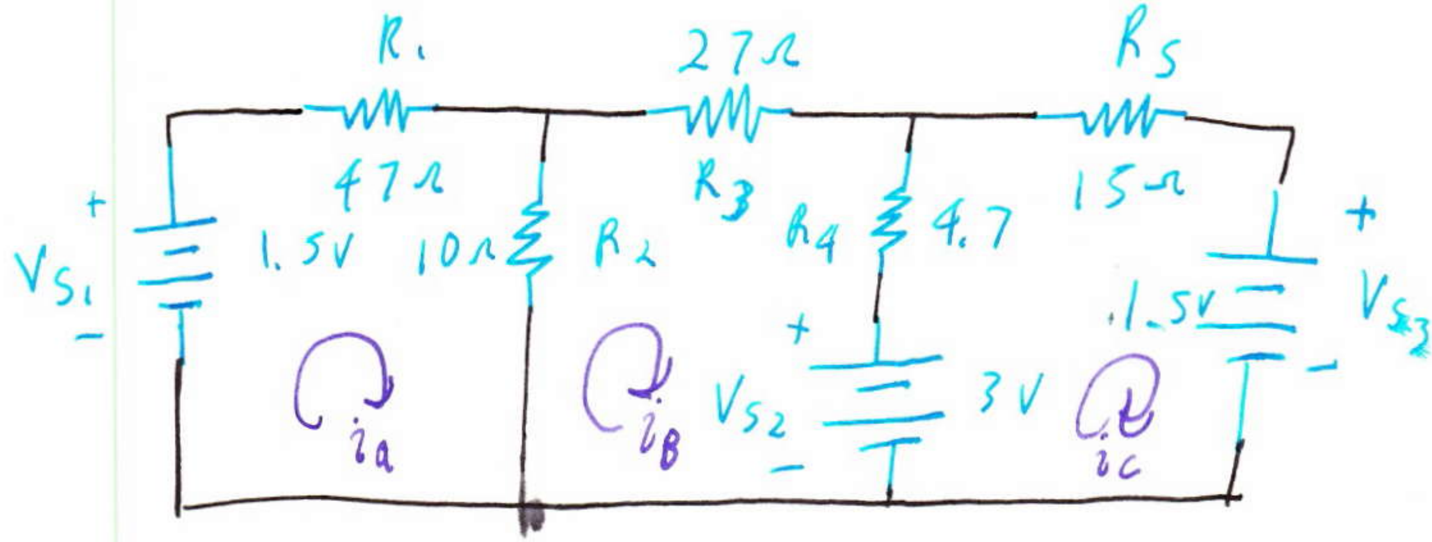
$$i_3 = \frac{555}{1362} = 0.407\ A$$

11) Write the Kirchhoff current equation for the current assignment shown at node A



$$i_1 = i_2 + i_3$$

21) Solve for loop currents using loop current method.



$$-1.5 + 47 i_a + 10(i_a - i_B) = 0$$

$$10(i_B - i_A) + 27 i_B + 4.7(i_B - i_C) + 3V = 0$$

$$-3 + 4.7(i_C - i_B) + 15 i_C + 1.5 = 0$$

$$-1.5 + 47 i_a + 10 i_a - 10 i_B = 0$$

$$10 i_B - i_a + 27 i_B + 4.7 i_B - 4.7 i_C + 3 = 0$$

$$-3 + 4.7 i_C - 4.7 i_B + 15 i_C + 1.5 = 0$$

$$57 i_a - 10 i_B + 0 i_C = +1.5$$

$$-10 i_a + 41.7 i_B - 4.7 i_C = -3$$

$$0 i_q + -4.7 i_B + 19.7 i_C = 1.5$$

$$\begin{bmatrix} 57 & -10 & 0 \\ -10 & 41.7 & -4.7 \\ 0 & -4.7 & 19.7 \end{bmatrix} \begin{bmatrix} 1.5 \\ -3 \\ 1.5 \end{bmatrix}$$

Δ

$$\begin{array}{ccccc} 57 & -10 & 0 & 57 & -10 \\ -10 & 41.7 & -4.7 & 57 & 41.7 \\ 0 & -4.7 & 19.7 & 0 & 4.7 \end{array}$$

$$((57 \times 41.7 \times 19.7) + (-10 \times -4.7 \times 0) + (0 \times 57 \times 4.7)) - ((0 \times 41.7 \times 0) + (57 \times -4.7 \times -4.7) + (-10 \times 57 \times 19.7))$$

$$(46824.93 + 0 + 0) - (0 + 1259.13 + 11229)$$

$$46824.93 - 12488.13$$

$$34336.8 = \Delta$$

Δi_1

$$\begin{matrix} 1.5 & -10 & 0 & 1.5 & -10 \\ -3 & 41.7 & -4.7 & -3 & 41.7 \\ 1.5 & -4.7 & 19.7 & 1.5 & -4.7 \end{matrix}$$

$$((1.5 \times 41.7 \times 19.7) + (-10 \times -4.7 \times 1.5) +$$
$$(0 \times -3 \times -4.7)) - ((1.5 \times 41.7 \times 0) +$$
$$(-4.7 \times -4.7 \times 1.5) + (19.7 \times -3 \times -10))$$

$$1232.235 + (-705) + 0 -$$
$$0 + 33.135 + 591$$

$$527.235 - 624.135$$

$$-96.9 = \Delta i_1$$

Δi_2

$$\begin{matrix} 57 & 1.5 & 0 & 57 & 1.5 \\ -10 & -3 & -4.7 & -10 & -3 \\ 0 & 1.5 & 19.7 & 0 & 1.5 \end{matrix}$$

$$((57 \times -3 \times 19.7) + (1.5 \times -4.7 \times 0) + (0 \times -10 \times 1.5)) - ((0 \times -3 \times 0) + (1.5 \times -4.7 \times 57) + (19.7 \times -10 \times 1.5))$$

$$(3368.7 * 0 + 0) -$$

$$(0 + (-401.85) + (-295.5))$$

$$3368.7 + 697.35$$

$$\Delta i_2 = 4066.05$$

Δi_3

$$
\begin{array}{ccccc}
57 & -10 & 1.5 & 57 & -10 \\
-10 & 41.7 & -3 & -10 & 41.7 \\
0 & -4.7 & 1.5 & 0 & -4.7
\end{array}
$$

$$((57 \times 41.7 \times 1.5) + (-10 \times -3 \times 0) + (1.5 \times -10 \times -4.7)) - ((1.5 \times 41.7 \times 0) + (4.7 \times -3 \times 57) + (1.5 \times -10 \times -10))$$

$$(3565.35 + 0 + 70.5) -$$

$$(0 + -803.7 + 150)$$

$$3635.85 - -653.7$$

$$4289.55 = \Delta i_3$$

Δ label	value
Δ	34336.8
Δi_1	-96.9
Δi_2	4066.05
Δi_3	4289.55

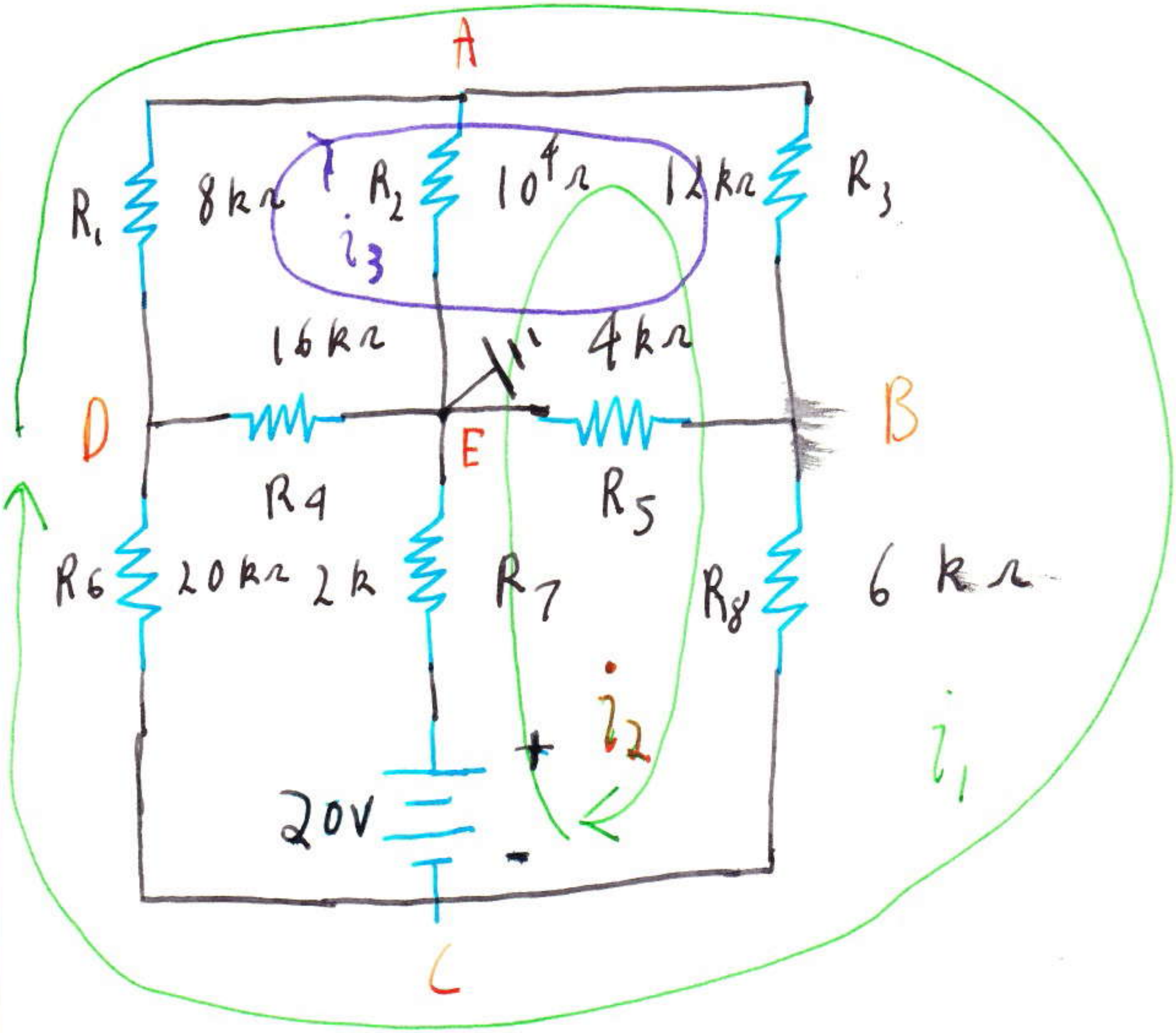
$$i_{target} = \frac{\Delta i_{target}}{\Delta}$$

$$i_1 = \frac{-96.9}{34336.8} \qquad i_2 = \frac{4066.05}{34336.8}$$

$$i_3 = \frac{4289.55}{34336.8}$$

$$\boxed{\begin{aligned} i_1 &= -2.822 \text{ mA} \\ i_2 &= 0.118 \text{ A} \\ i_3 &= 0.124 \text{ A} \end{aligned}}$$

33)



$$\cancel{i_1 R_6 + i_1 (R_1 + R_2) + i_1}$$

$$(i_1)(R_6) + (i_1 + i_3)(R_1) + (i_1 + i_3)(R_3) + (i_1 + i_2)(R_8) = 0$$

$$-20 + (i_2(R_7)) + (i_2(R_2)) + \cancel{(i_2 + i_1(R_3))}$$

$$((i_2 + i_3 + i_1)(R_3))$$

$$i_3 R_4 + (i_3 + i_1(R_1)) + (i_3 + i_1(R_3)) +$$

$$i_3 R_5$$

$$\cancel{(i_2 + i_1) 6000 +}$$

$$i_1(2\times10^4) + i_1(8\times10^3) + i_3(8\times10^3) +$$

$$i_1(12\times10^3) + i_3(12\times10^3) + i_1(6\times10^3) +$$

$$i_2(6\times10^3)$$

$$(20 + 8 + 12 + 6)\times10^3\, i_1 +$$

$$(6\times10^3)\, i_2 + (8 + 12)\times10^3\, i_3 = 0$$

$$\cancel{46 i_1} \quad \cancel{46 i_1 \times 10^3 + 0}$$

eq1

$$(46 \times 10^3)\, i_1 + (6 \times 10^3)\, i_2 + (20 \times 10^3)\, i_3 = 0$$

$$(2 \times 10^3)\, i_2 + (10^4)\, i_2 + (12 \times 10^3)\, i_2 +$$

$$\cancel{(12 \times 10^3 \times i_2)} + (12 \times 10^3) \times i_3 + (12 \times 10^3 (i_1))$$

$$+ (6 \times 10^3)\, i_2 + 6 \times 10^3\, i_1 - 20 = 0$$

$$(12 \times 10^3)\, i_1 + (2 + 10 + 12 + 6) \times 10^3\, i_2 +$$

$$(12 \times 10^3)\, i_3 = 20$$

eq2 $$(12 \times 10^3)\, i_1 + (30 \times 10^3)\, i_2 + (12 \times 10^3)\, i_3 = 20$$

$$(16\times10^3)\, i_3 + (8\times10^3) i_3 + (8\times10^3) i_1 +$$

$$(12\times10^3\, i_2) + (12\times10^3)\, i_3 + (12\times10^3)\, i_1 + (4\times10^3)\, i_3 = 0$$

$$((8+12)\times10^3\times i_1) + (12\times10^3)\, i_2 +$$

$$(16+8+4)\, i_3 = 0$$

$$eq_3 \quad 20\times10^3(i_1) + (12\times10^3)\, i_2 + (28\times10^3)\, i_3 = 0$$

$$\begin{bmatrix} 46\times10^3 & 6\times10^3 & 20\times10^3 \\ 12\times10^3 & 30\times10^3 & 12\times10^3 \\ 20\times10^3 & 12\times10^3 & 28\times10^3 \end{bmatrix} \begin{bmatrix} 0 \\ 20 \\ 0 \end{bmatrix}$$

Δ

$$\begin{matrix} 46\times10^3 & 6\times10^3 & 20\times10^3 & 46\times10^3 & 6\times10^3 \\ 12\times10^3 & 30\times10^3 & 12\times10^3 & 12\times10^3 & 30\times10^3 \\ 20\times10^3 & 12\times10^3 & 28\times10^3 & 20\times10^3 & 12\times10^3 \end{matrix}$$

$(46\times10^3 \times 30\times10^3 \times 28\times10^3 +$
$6\times10^3 \times 12\times10^3 \times 20\times10^3 +$
$20\times10^3 \times 12\times10^3 \times 12\times10^3) -$

$(20\times10^3 \times 30\times10^3 \times 20\times10^3 +$
$12\times10^3 \times 12\times10^3 \times 46\times10^3 +$
$28\times10^3 \times 12\times10^3 \times 6\times10^3)$

$$(38640 \times 10^9 + 1440 \times 10^9 + 2880 \times 10^9)$$

$$-(12000 \times 10^9 + 6624 \times 10^9 + 2016 \times 10^9)$$

$$42960 \times 10^9 - 20640 \times 10^9$$

$$22320 \times 10^9 = \Delta$$

Δi_1

$$\begin{matrix} 0 & 6\times10^3 & 20\times10^3 & 0 & 6\times10^3 \\ 20 & 30\times10^3 & 12\times10^3 & 20 & 30\times10^3 \\ 0 & 12\times10^3 & 28\times10^3 & 0 & 12\times10^3 \end{matrix}$$

$$\big((0\times30\times10^3\times28\times10^3)+$$
$$(6\times10^3\times12\times10^3\times0)+$$
$$(20\times10^3\times20\times12\times10^3)-$$
$$((0\times30\times10^3\times20\times10^3)+$$
$$(12\times10^3\times12\times10^3\times0)+$$
$$(28\times10^3\times20\times6\times10^3)$$

$$(0+0+4.8\times10^9)-(0+0+3.36\times10^9)$$

$$4.8\times10^9-3.36\times10^9$$

$$1.44\times10^9=\Delta i_1$$

Δi_2

$$\begin{array}{ccccc}
46\times10^3 & 0 & 20\times10^3 & 46\times10^3 & 0 \\
12\times10^3 & 20 & 12\times10^3 & 12\times10^3 & 20 \\
20\times10^3 & 0 & 28\times10^3 & 12\times10^3 & 0
\end{array}$$

$$((46\times10^3 \times 20 \times 28\times10^3) + (0 \times 12\times10^3 \times 12\times10^3) + (20\times10^3 \times 12\times10^3 \times 0)) -$$
$$((20\times10^3 \times 20 \times 20\times10^3) + (12\times10^3 \times 0 \times 46\times10^3) + (28\times10^3 \times 12\times10^3 \times 0))$$

$$25760\times10^6 - 8000\times10^6$$

$$17760\times10^6 = \Delta i_2$$

Δi_3

$$\begin{array}{ccccc} 46\times10^3 & 6\times10^3 & 0 & 46\times10^3 & 6\times10^3 \\ 12\times10^3 & 30\times10^3 & 20 & 12\times10^3 & 30\times10^3 \\ 20\times10^3 & 12\times10^3 & 0 & 20\times10^3 & 12\times10^3 \end{array}$$

$$\begin{aligned}
&((46\times10^3 \times 30\times10^3 \times 0) + \\
&(6\times10^3 \times 20 \times 20\times10^3) + \\
&(0 \times 12\times10^3 \times 12\times10^3)) - \\
&((20\times10^3 \times 30\times10^3 \times 0) + \\
&(12\times10^3 \times 20 \times 46\times10^3) + \\
&(6\times10^3 \times 12\times10^3 \times 0))
\end{aligned}$$

$$2.4\times10^9 - 11.04\times10^9$$

$$-8.64\times10^9 = \Delta i_3$$

Δ_{label}	value
Δ	22320×10^9
Δi_1	1.44×10^9
Δi_2	17.76×10^9
Δi_3	-8.64×10^9

$$i_{target} = \frac{\Delta i_{target}}{\Delta}$$

$$\frac{1.44 \cancel{\times 10^9}}{22320 \cancel{\times 10^9}} = \cancel{\Delta}\ i_1 = 64.516\,\mu A$$

$$\frac{17.76 \cancel{\times 10^9}}{22320 \cancel{\times 10^9}} = i_2 = 795.698\,\mu A$$

$$\frac{-8.64 \cancel{\times 10^9}}{22320 \cancel{\times 10^9}} = i_3 = 387.096\,\mu A$$

$$V_{R_7} = R_7 \, i_2$$

$$V_{R_7} = 2 \times 10^3 \times 795.698 \times 10^{-6}$$

$$\boxed{V_{R_7} = 1.591 \text{ V}}$$

$$V_{R_2} = R_2 \, i_2$$

$$V_{R_2} = 10^4 \times 795.698 \times 10^{-6}$$

$$V_{R_2} = 795.698 \times 10^{-2}$$

$$\boxed{V_{R_2} = 7.956 \text{ V}}$$

$$V_{R_3} = R_3 \times (i_2 + i_1)$$

$$V_{R_3} = 12 \times 10^3 \times (795.698 \times 10^{-6} + 64.516 \times 10^{-6})$$

$$V_{R_3} = 12 \cancel{\times 10^3} \times (0.860 \cancel{\times 10^{-3}})$$

$$\boxed{V_{R_3} = 10.322 \text{ V}}$$

$$V_{R_4} = R_4 \times i_3$$

$$V_{R_4} = 16 \times 10^3 \times 387.096 \times 10^{-6}$$

$$\boxed{V_{R_4} = 6.195 \text{ V}}$$

$$V_{R_1} = R_1 \times (i_1 + i_3)$$

$$V_{R_1} = 8 \times 10^3 \times (64.516 \times 10^{-6} + 387.096 \times 10^{-6})$$

$$\boxed{V_{R_1} = 3.612 \text{ V}}$$

$$V_{R_3} = R_3 \times (i_3 + i_1)$$

$$V_{R_3} = 12 \times 10^3 \times (64.516 \times 10^{-6} + 387.096 \times 10^{-6})$$

$$\boxed{V_{R_3} = 5.419\ V}$$

$$V_{R_5} = R_5 \times i_3$$

$$V_{R_5} = 4 \times 10^3 \times 387.096 \times 10^{-6}$$

$$\boxed{V_{R_5} = 1.548\ V}$$

$$V_{R_6} = R_6 \times i_1$$

$$V_{R_6} = 20 \times 10^3 \times 64.516 \times 10^{-6}$$

$$\boxed{V_{R_6} = 1.290\ V}$$

$$V_{R_8} = R_8 \times (i_2 + i_1)$$

$$V_{R_8} = 6 \times 10^3 \times (795.698 \times 10^{-6} + 64.516 \times 10^{-6}$$

$$\boxed{V_{R_8} = 5.161\ V}$$

nodes

A

$$i_{R_2} = i_2$$

$$i_{R_1} = i_3 + i_1$$

$$i_{R_3} = i_1 + i_2 + i_3$$

B

$$i_{R_3} = i_1 + i_2 + i_3$$

$$i_{R_5} = i_3$$

$$i_{R_8} = i_2 + i_1$$

C

$i_{R_8} = i_2 + i_1$

$i_{R_7} = i_2$

$i_{R_6} = i_1$

D

$i_{R_6} = i_1$

$i_{R_4} = i_{R_3}$

$i_{R_1} = i_3 + i_1$

E

$$\dot{i}_{R_7} = \dot{i}_2$$

$$\dot{i}_{R_4} = -\dot{i}_3$$

$$\dot{i}_{R_5} = +\dot{i}_3$$

$$\dot{i}_{R_{\text{[illegible]}}} = -\dot{i}_2$$

Voltage label	value (V)
V_{R_1}	3.612
V_{R_2}	7.956
V_{R_3}	10.322
V_{R_4}	6.195
V_{R_5}	1.548
V_{R6}	1.290
V_{R7}	1.591
V_{R8}	5.161