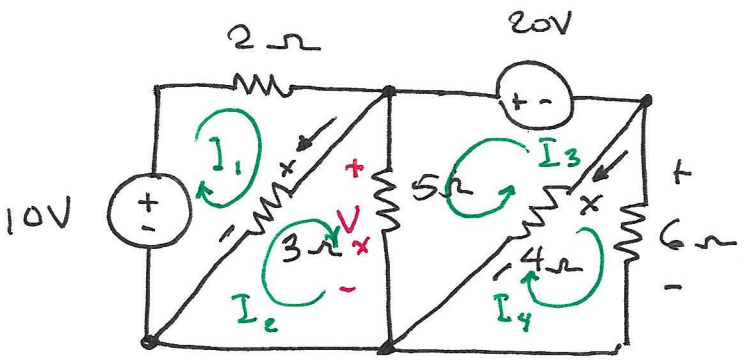
Mesh Analysis
KVL



a. Write mesh equations.

b. Solve the equations

c. Determine V_x.

For mesh 1: $-10V + 2I_1 + 3(I_1 - I_2) = 0$

For mesh 2: $-3(I_1 - I_2) + 5(I_2 + I_3) = 0$ ($+V_x$)

For mesh 3: $-5(I_2 + I_3) + 20V - 4(I_3 + I_4) = 0$ ($-V_x$)

For mesh 4: $4(I_3 + I_4) + 6I_4 = 0$

$V_x = 5(I_2 + I_3)$

$$\underbrace{\begin{bmatrix} 2+3 & -3 & 0 & 0 & 0 \\ -3 & 3+5 & 5 & 0 & 0 \\ 0 & -5 & -5-4 & -4 & 0 \\ 0 & 0 & 4 & 4+6 & 0 \\ 0 & 5 & 5 & 0 & -1 \end{bmatrix}}_{A} \underbrace{\begin{bmatrix} I_1 \\ I_2 \\ I_3 \\ I_4 \\ V_x \end{bmatrix}}_{b} = \underbrace{\begin{bmatrix} 10 \\ 0 \\ -20 \\ 0 \\ 0 \end{bmatrix}}_{c}$$

```
>> A = [2+3  -3   0   0   0; -3  3+5   5   0   0;
        0   -5  -5-4  -4   0; 0   0   4   4+6   0;
        0    5   5    0   -1]
```

$$A = \begin{bmatrix} 5 & -3 & 0 & 0 & 0 \\ -3 & 8 & 5 & 0 & 0 \\ 0 & -5 & -9 & -4 & 0 \\ 0 & 0 & 4 & 10 & 0 \\ 0 & 5 & 5 & 0 & -1 \end{bmatrix}$$

```
>> c = [10; 0; -20; 0; 0]
```

or

```
c = [10  0  -20  0  0]'
```

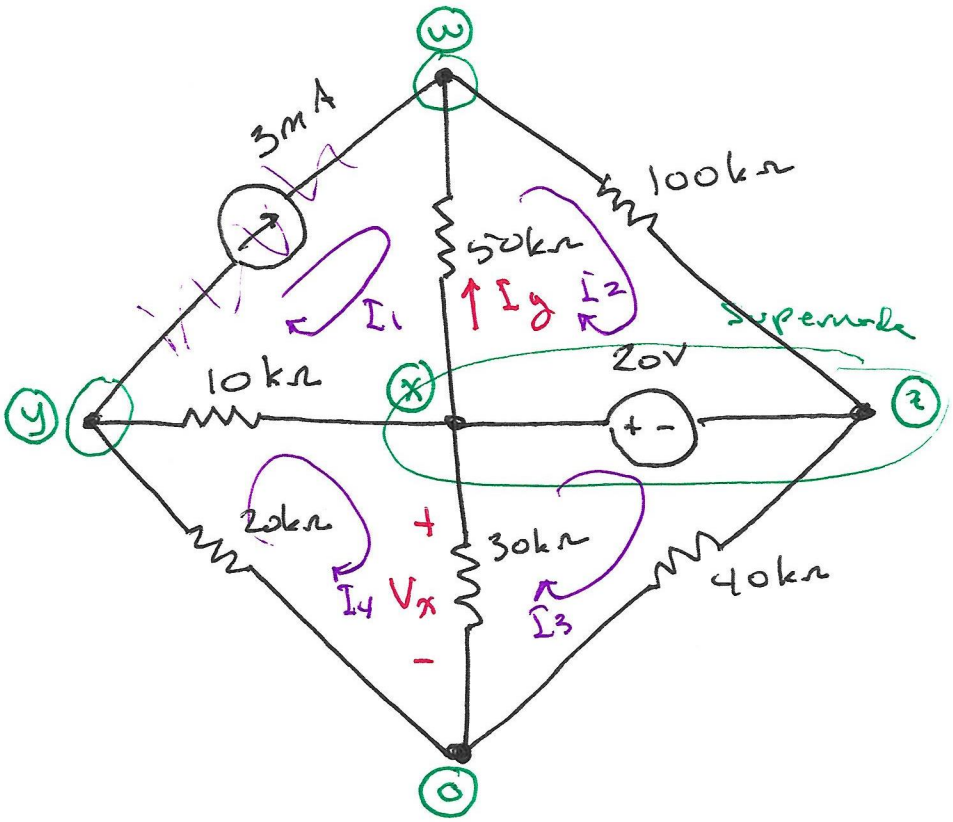
$$c = \begin{bmatrix} 10 \\ 0 \\ -20 \\ 0 \\ 0 \end{bmatrix}$$

```
>> b = inv(a) * c

b =
    .
    .
    .
    .
    .
```

or

```
b = A\c
```

```
>> A * b

ans =
    c1
    c2
    c3
    c4
    c5
```



5 eqns for nodal analysis to completely solve.

6 eqns for mesh analysis to completely solve.

Nodal Analysis Approach

$$V_x - V_z = 20 \qquad \text{(constraint)}$$

$$3\times10^{-3} + \frac{V_y - V_x}{10\times10^{3}} + \frac{V_y}{20\times10^{3}} = 0 \qquad \text{(KCL at node y)}$$

$$5\times10^{-3} + \frac{V_x - V_w}{50\times10^{3}} + \frac{V_z - V_w}{100\times10^{3}} = 0 \qquad \text{(KCL at node w)}$$

$$\frac{V_z - V_w}{100\times10^{3}} + \frac{V_x - V_w}{50\times10^{3}} + \frac{V_x - V_y}{10\times10^{3}} + \frac{V_x}{30\times10^{3}} + \frac{V_z}{40\times10^{3}} = 0 \qquad \text{(KCL at supernode)}$$

$$I_y = \frac{V_x - V_w}{50\times10^{3}} \qquad \text{(definition of } I_y\text{)}$$

Mesh Analysis Approach

$I_1 = 3 \times 10^{-3}$ (constraint)

$100 \times 10^3 I_2 - 20 + 50 \times 10^3 (I_2 - I_1) = 0$ (KVL for mesh 2)

$20 + 40 \times 10^3 I_3 + 30 \times 10^3 (I_3 - I_4) = 0$ (KVL for mesh 3)

$10 \times 10^3 (I_4 - I_1) + 30 \times 10^3 (I_4 - I_3) + 20 \times 10^3 I_4 = 0$ (KVL for mesh 4)

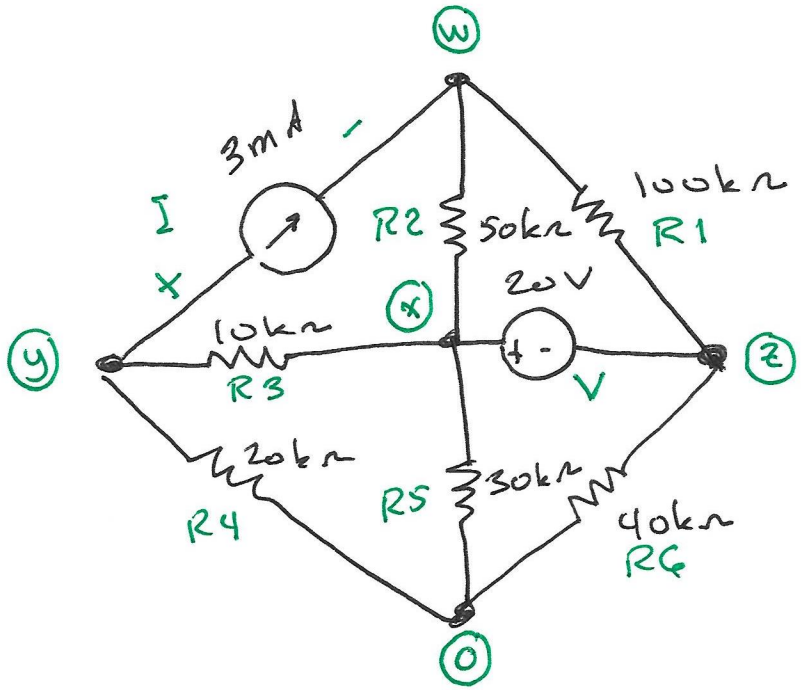
$I_y = I_2 - I_1$ (definition of I_y)

$V_x = 30 \times 10^3 (I_4 - I_3)$ (definition of V_x)

LTspice

Simulation Program with Integrated Circuit Emphasis

~~Linear Technology~~ Analog Devices



Spice assumes every component satisfies the passive sign convention.

.003
3E-3

MEG = 10^6

I	y	w	DC	3m
R2	w	x	50k	
R1	w	z	100k	
R3	y	x	10k	
V	x	z	DC	20
R4	y	0	20k	
R5	x	0	30k	
R6	z	0	40k	

.OP