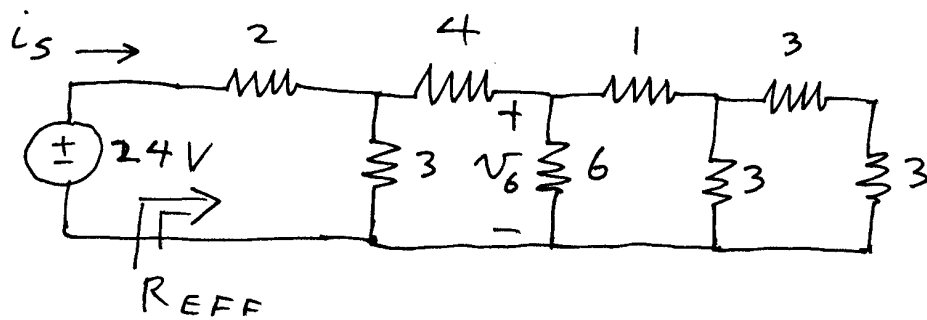


# BEYOND KVL, KCL

- NETWORK REDUCTION
- SUPERPOSITION
- THEVENIN
- THEVENIN - NORTON / SOURCE TRANSFORMATION
- NODE EQUATIONS
- MESH (LOOP) EQUATIONS

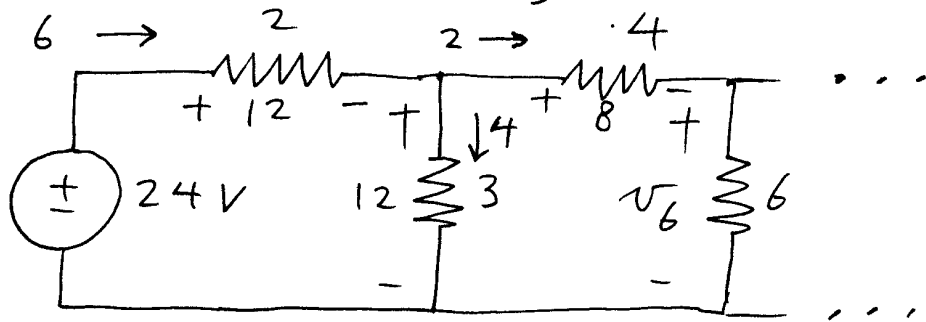
## NETWORK REDUCTION



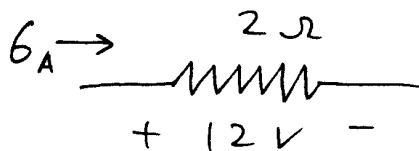
$$i_s = \frac{24V}{R_{EFF}}$$

$$\begin{aligned} R_{EFF} &= 2 + 3 \parallel (4 + 6 \parallel (1 + 3 \parallel (3 + 3))) \\ &= 4 \Omega \quad i_s = 6 A \end{aligned}$$

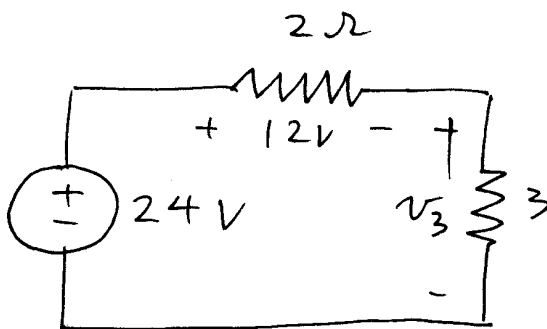
WHAT ABOUT  $v_5$  ?



$$v_6 = 12 - 8 = 4V$$



POSITIVE - PASSIVE  
OHM'S LAW

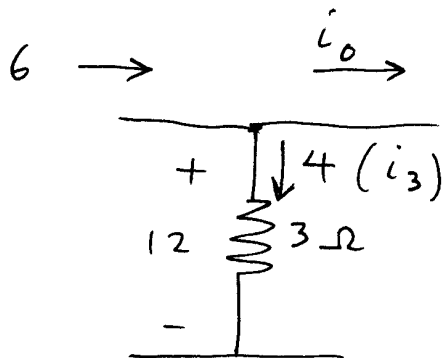


KVL

$$-24 + 12 + v_3 = 0$$

$$v_3 = 24 - 12$$

$$= 12V$$



KCL

$$-6 + i_3 + i_0 = 0$$

$$i_0 = 6 - i_3$$

$$= 6 - \frac{12V}{3\Omega}$$

$$= 2A$$

SUPPOSE  $v_6 = 2V$

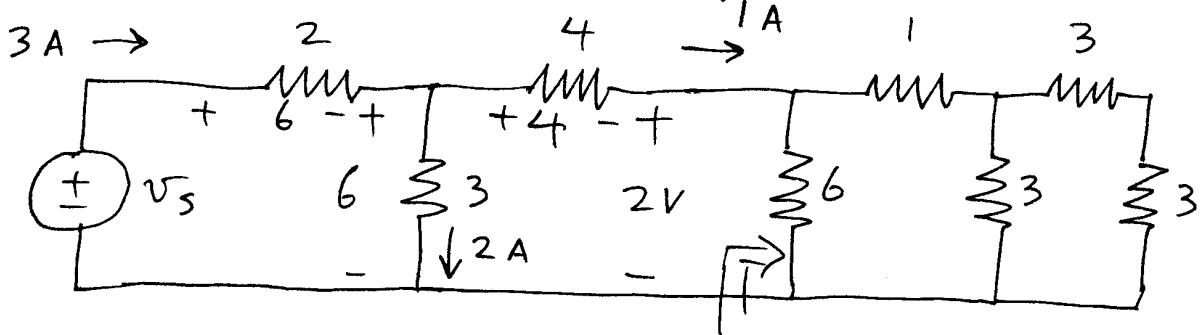
$v_3 = 12V$

SUPPOSE  $v_6 = -4V$

$v_3 = -24V$

CUT INPUT IN HALF  $\longrightarrow$  CUT OUTPUT IN HALF

CAN WE SHOW THIS?

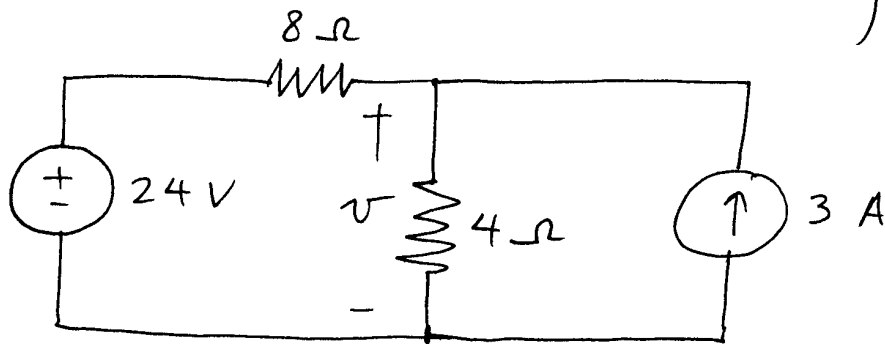


$-v_3 + 6 + 6 = 0$

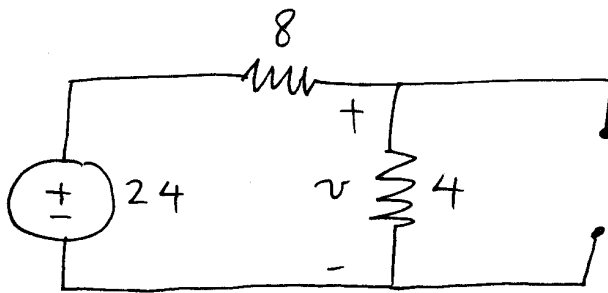
OR  $v_3 = 12V$

$R_{EFF} = 6 \parallel (1 + 3 \parallel (3 + 3)) = 2 \Omega$

SUPERPOSITION (2 OR MORE SOURCES)



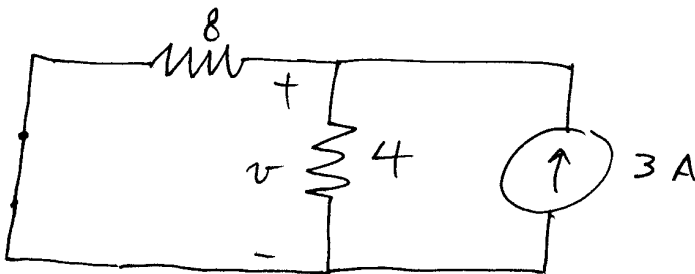
$v$  ON  
 $i$  OFF



VOLTAGE DIVIDER

$$v = \frac{4}{12} 24 = 8 \text{ V}$$

$v$  OFF  
 $i$  ON



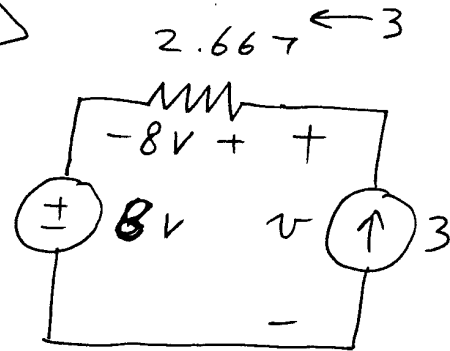
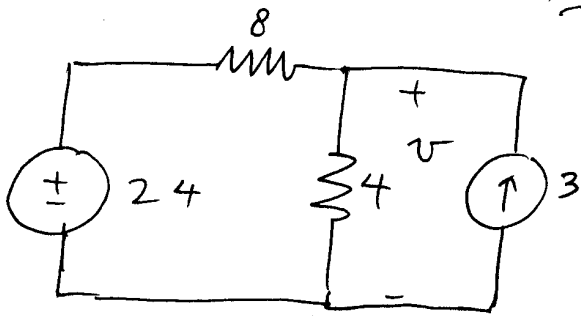
$$R_{\text{EFF}} = 8 // 4 = 2.667 \Omega$$

$$v = i R_{\text{EFF}} = (3)(2.667) = 8 \text{ V}$$

BOTH ON:  $v = 8 + 8 = 16 \text{ V}$

CAN WE VERIFY THIS ANSWER?

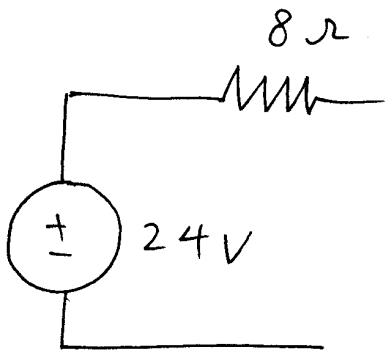
THEVENIN



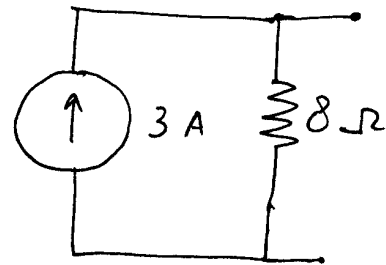
$$v = 8 + 8 = 16 \text{ V}$$

THEVENIN - NORTON /

SOURCE TRANSFORMATION



SAME AS

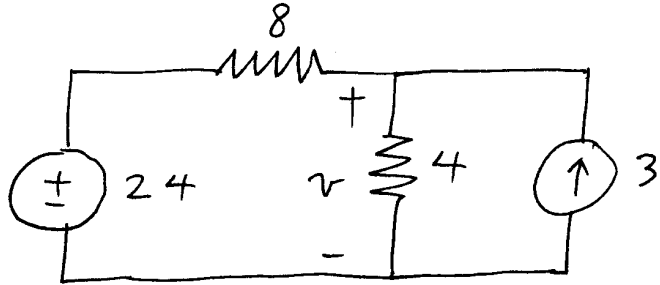


$$V_{oc} = 24 \text{ V}$$

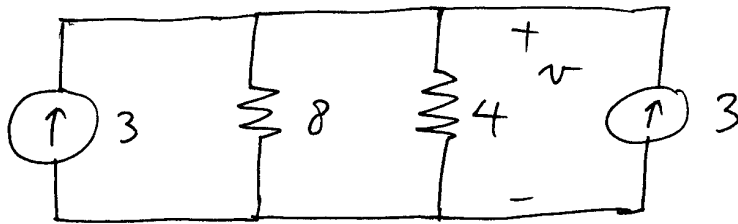
$$i_{sc} = \frac{24 \text{ V}}{8 \Omega} = 3 \text{ A}$$

$R_s = 8 \Omega$  IN BOTH CASES

# USE OF SOURCE TRANSFORMATION



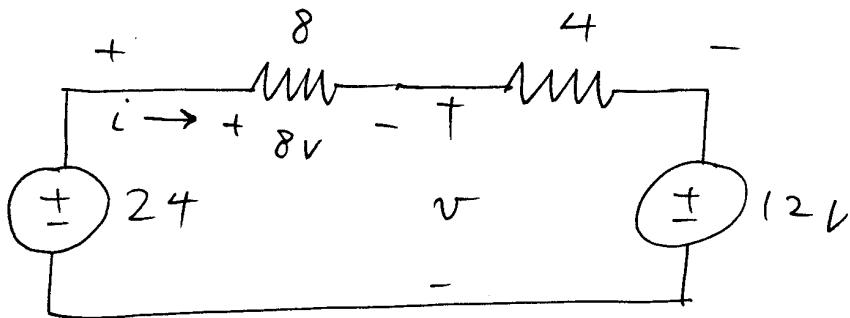
SAME AS



$$v = (3A + 3A) (8 \parallel 4)$$

$$= 6 \cdot 2.667 = 16V$$

SAME AS



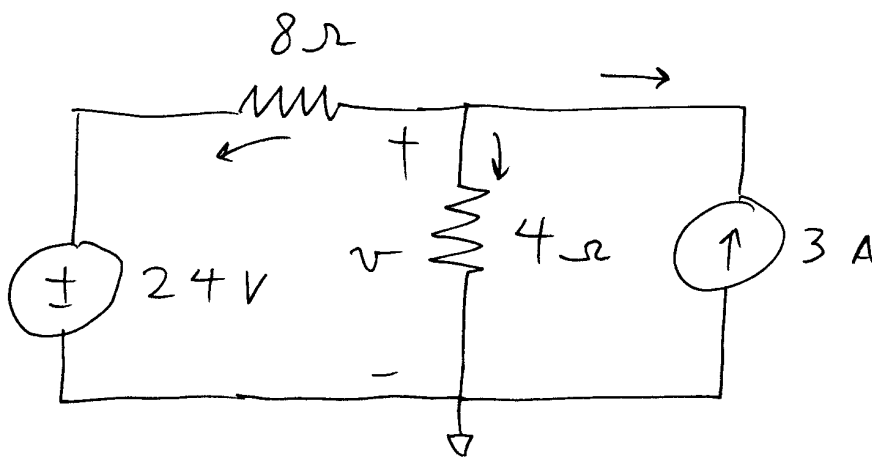
$$i = \frac{(24 - 12)V}{(8 + 4)\Omega} = 1A$$

$$v = 24V - 8V = 16V$$

## NODE EQ

VOLTAGE'S AT NODES ARE  
UNKNOWN

USE KCL AT UNKNOWN VOLTAGE  
NODES TO GENERATE EQ'S



$$\text{KCL } \leftarrow \downarrow \rightarrow \quad \frac{v - 24}{8} + \frac{v}{4} + (-3) = 0$$

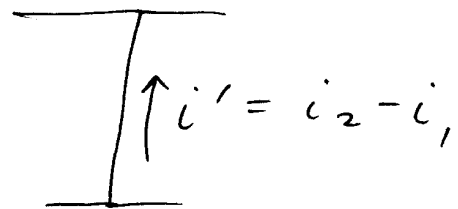
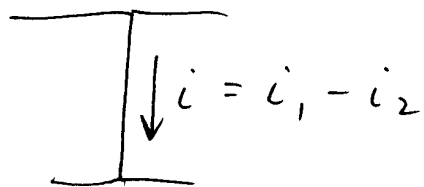
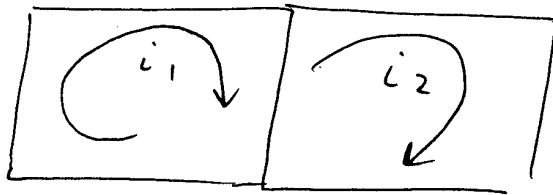
$$\left( \frac{1}{8} + \frac{1}{4} \right) v = 6$$

$$v = 16 \text{ V}$$

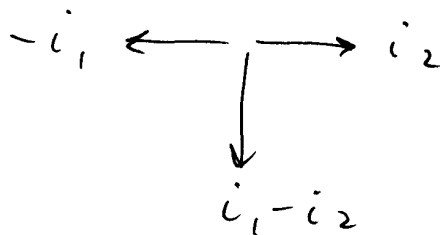
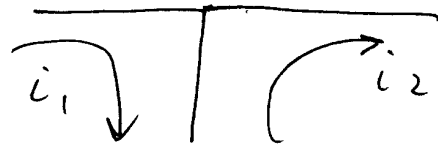
## MESH EQ

"MESH" CURRENTS ARE UNKNOWN

USE KVL TO GET EQUATIONS

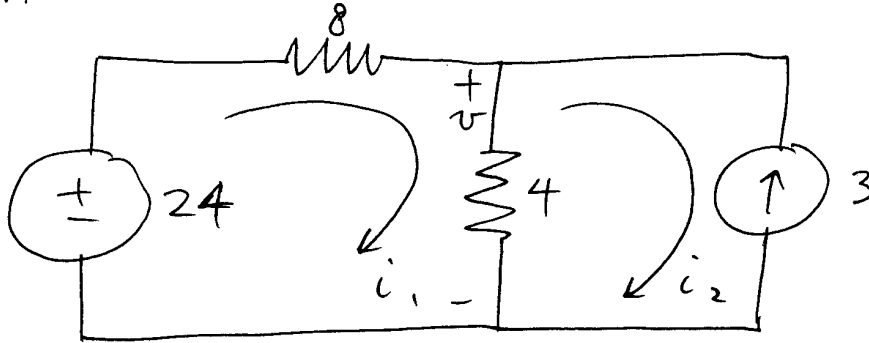


WHAT MESH CURRENT IS —  
ACCOUNTING DEVICE FOR KCL



$$-i_1 + i_1 - i_2 - i_2 = 0$$

# APPLICATION



$$\text{KVL} \quad -24 + 8i_1 + 4(i_1 - i_2) = 0$$

$$\text{CONSTRAINT} \quad i_2 = -3$$

$$12i_1 = 12 \quad i_1 = 1$$

$$\begin{aligned} v &= 4(i_1 - i_2) = 4(1 - (-3)) \\ &= 16 \text{ V} \end{aligned}$$