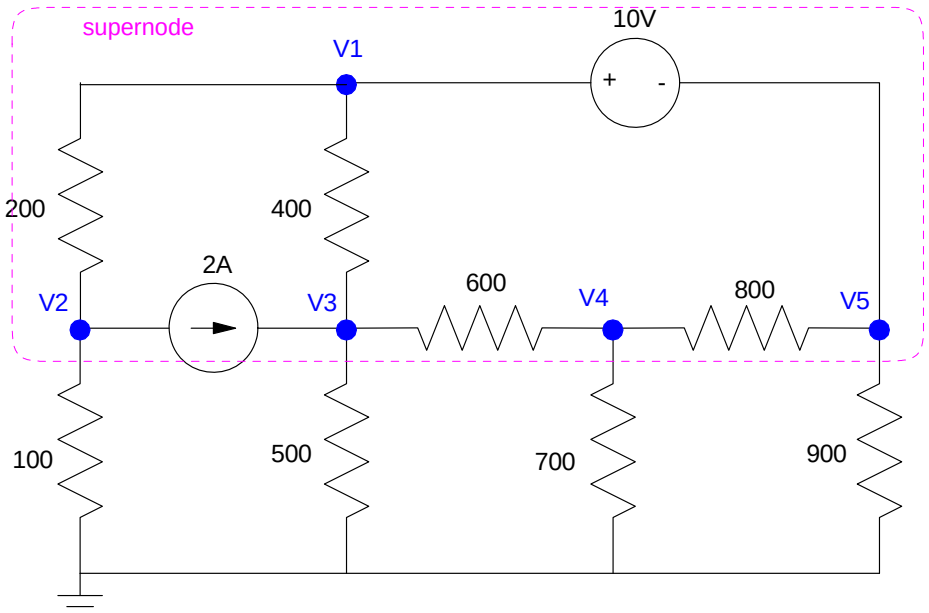
# EE 206 Final - Name _____

Closed-Book, Closed Notes, Calculators Permitted. - Spring 2019

1) Write N equations which allow you to solve for the N unknown voltages




Voltage Source

- $V_1 - V_5 = 0$

Node V2

- $\left(\frac{V_2 - V_1}{200}\right) + \left(\frac{V_2}{100}\right) + 2 = 0$

Node V3

- $-2 + \left(\frac{V_3}{500}\right) + \left(\frac{V_3 - V_1}{400}\right) + \left(\frac{V_3 - V_4}{600}\right) = 0$

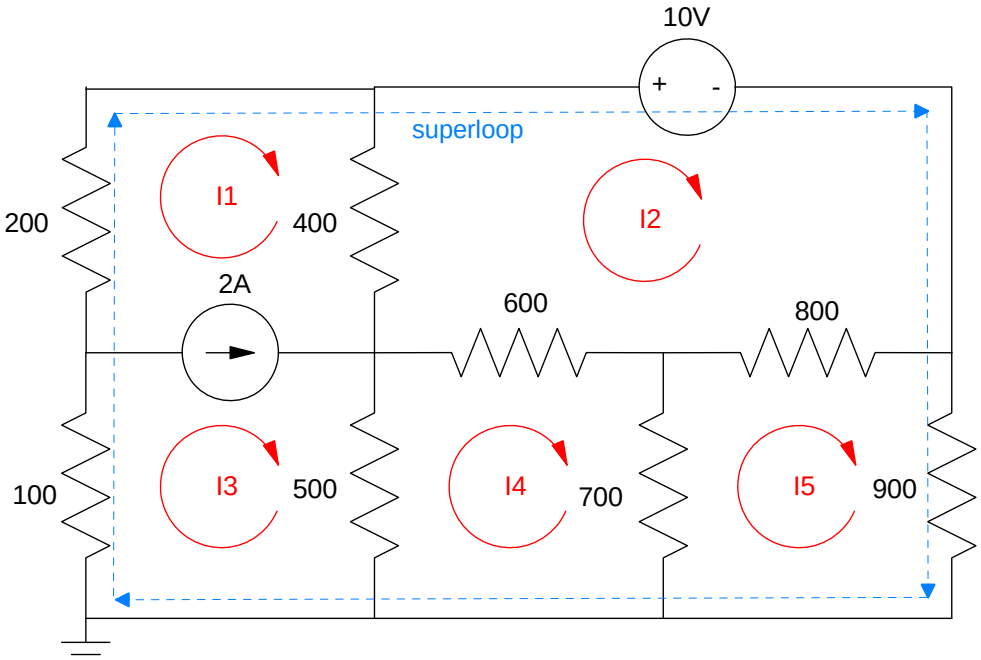
Node V4

- $\left(\frac{V_4 - V_3}{600}\right) + \left(\frac{V_4}{700}\right) + \left(\frac{V_4 - V_5}{800}\right) = 0$

Supernode

- $\left(\frac{V_2}{100}\right) + \left(\frac{V_3}{500}\right) + \left(\frac{V_4}{700}\right) + \left(\frac{V_5}{900}\right) = 0$

2) Write N equations which allow you to solve for the N unknown currents




Current Source

- $I_3 - I_1 = 2$

Loop I2

- $10 + 800(I_2 - I_5) + 600(I_2 - I_4) + 400(I_2 - I_1) = 0$

Loop I4

- $500(I_4 - I_3) + 600(I_4 - I_2) + 700(I_4 - I_5) = 0$

Loop I5

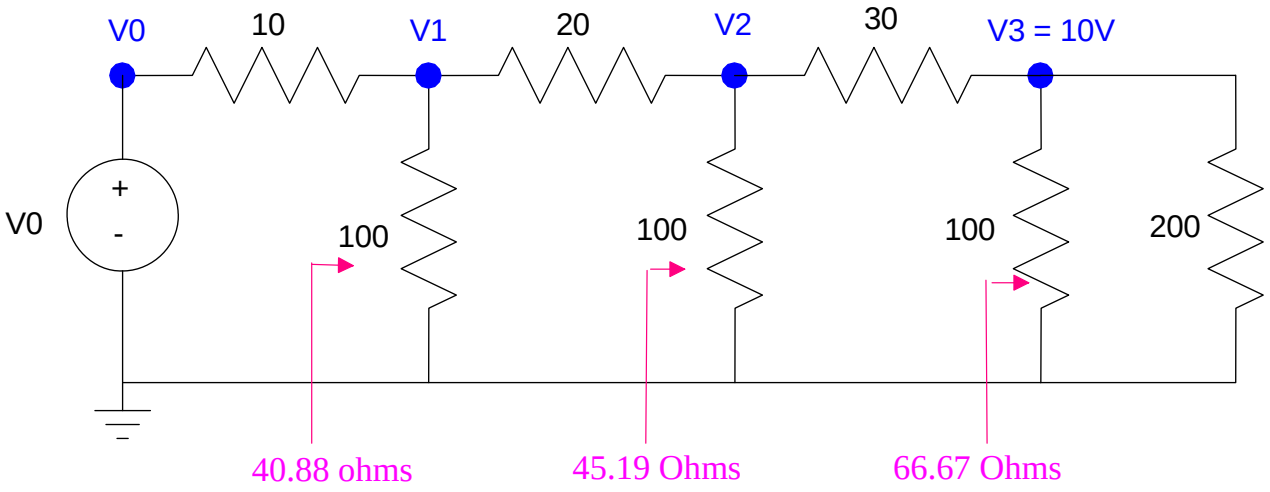
- $700(I_5 - I_4) + 800(I_5 - I_2) + 900I_5 = 0$

Super Loop

- $100I_3 + 200I_1 + 10 + 900I_5 = 0$

3) Find the voltages V0, V1, V2 given that V3 = 10.0V

| V0 | V1 | V2 | V3 |
|---|---|---|---|
| **25.39** | **20.40** | **14.50** | **10.0V** |




By voltage division

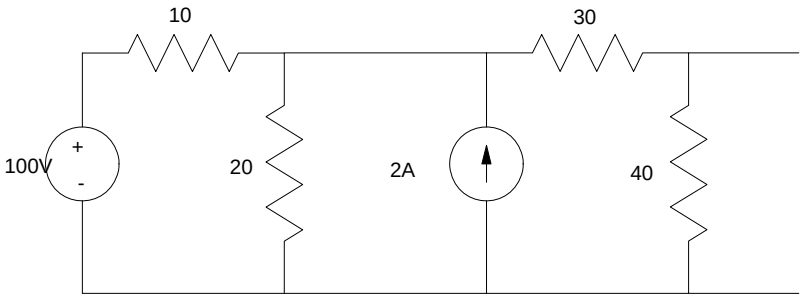
$$V_3 = \left(\frac{66.67}{66.67+30}\right) V_2 \qquad \Rightarrow V_2 = 14.5V$$

$$V_2 = \left(\frac{49.15}{49.15+20}\right) V_1 \qquad \Rightarrow V_1 = 20.4V$$

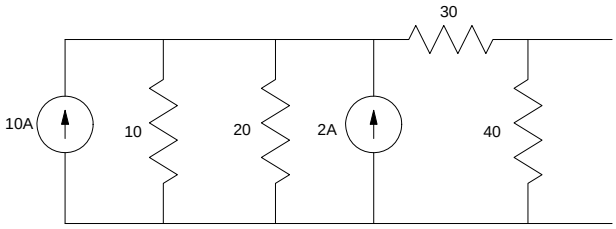
$$V_1 = \left(\frac{40.88}{40.88+10}\right) V_0 \qquad \Rightarrow V_0 = 25.39V$$

4) Find the Thevenin equivalent for the following circuit:

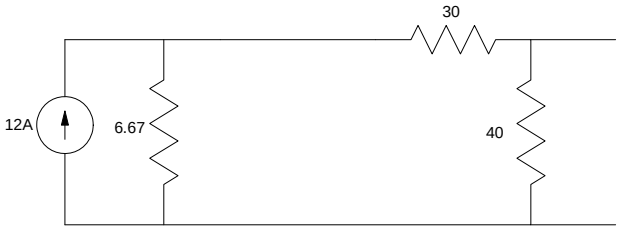
| Vth | Rth |
|---|---|
| **41.7 V** | **19.13 Ohms** |



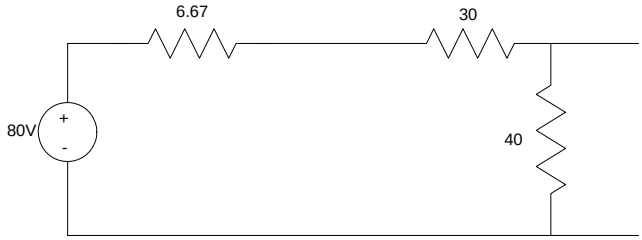

Convert the 100V / 10 Ohm to a Norton equivalent




Add current sources and resistors in parallel



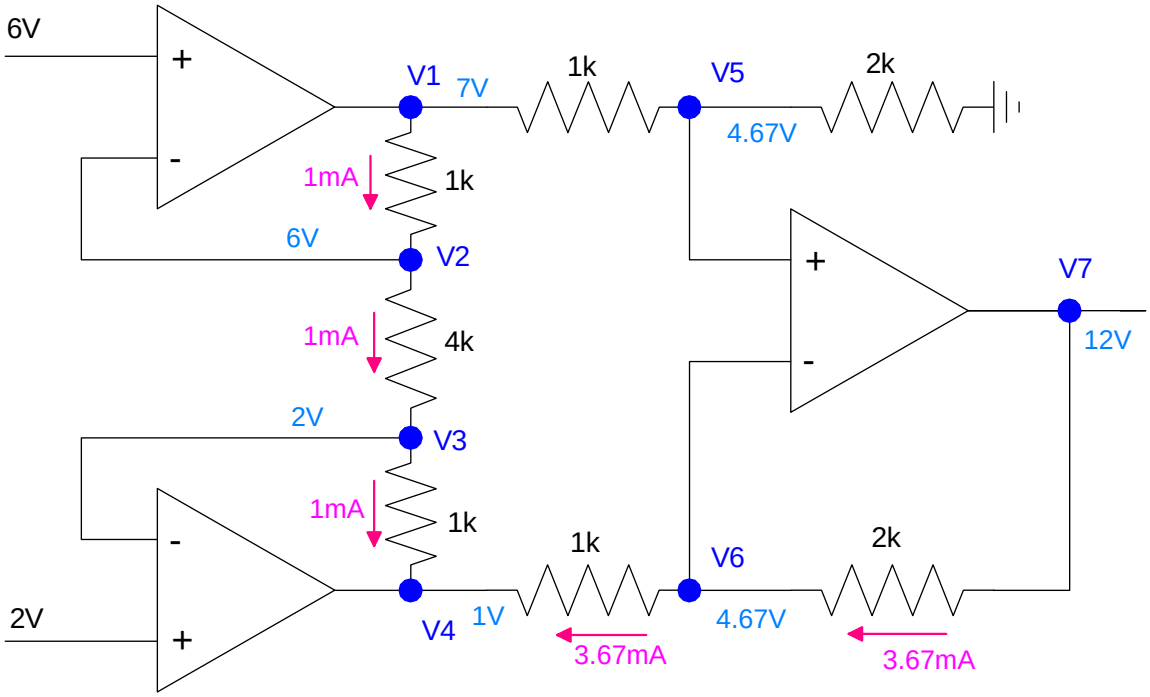

Convert back to a Thevenin




Now find Vopen (Vth) and R when V = 0

5) Find the voltages V1 .. V7

| V1 | V2 | V3 | V4 |
|---|---|---|---|
| **7 V** | **6 V** | **2 V** | **1 V** |
| V5 | V6 | V7 | |
| **4.67 V** | **4.67 V** | **12 V** | |




For an op-amp with negative feedback, Vp = Vm

- V2 = 6V
- V3 = 2V

4V across the 4k resistor produces 1mA. This 1mA also flows through the 1k resistors

- $V_1 - V_2 = 1mA \cdot 1k = 1V \quad \Rightarrow V_1 = 7V$
- $V_3 - V_4 = 1mA \cdot 1k = 1V \quad \Rightarrow V_4 = 1V$

By voltage division

$$V_5 = \left(\frac{2k}{2k+1k}\right)7V \quad \Rightarrow V_5 = 4.67V$$

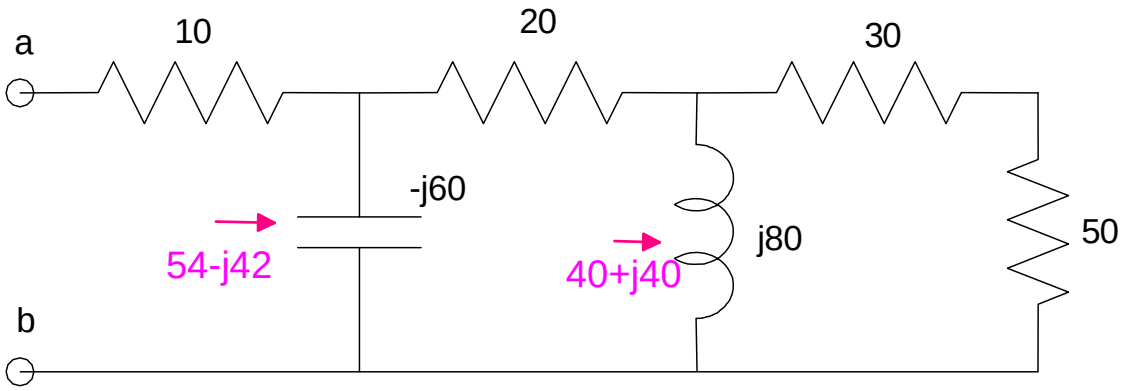
Vp = Vm

$$\Rightarrow V_6 = 4.67V$$

$$V_7 = 2(V_1 - V_4) = 12V$$

6) Determine the impedance between a and b

Zab = 64 - j42




$$50 + 30 = 80$$

$$80 \,||\, j80 = 40 + j40$$

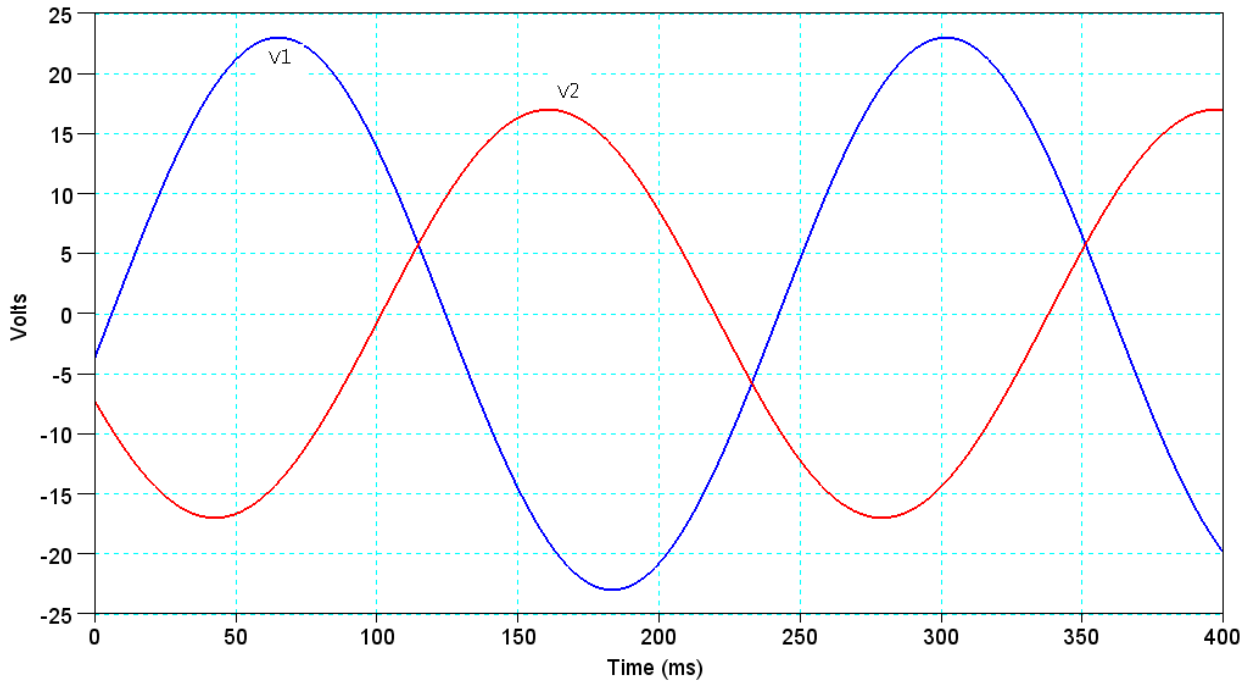
$$(40 + j40) + (20) = 60 + j40$$

$$(60 + j40) \,||\, (-j60) = 54 - j42$$

$$(54 - j42) + (10) = 64 - j42$$

7) Determine the voltages V1 and V2

| Frequency (Hz) | V1 | | V2 | |
|---|---|---|---|---|
| | Amplitude (Vp) | Phase (degrees) | Amplitude (Vp) | Phase (degrees) |
| **4.38 Hz** | **23 Vp** | **-101 deg** | **17 Vp** | **-250 deg** |




The period is 230ms

$$f = \frac{1}{T} = 4.38Hz$$

The delay tells you the phase shift. V1 is delayed by 65ms

$$\theta = -\left(\frac{\text{delay}}{\text{period}}\right) \cdot 360^0$$

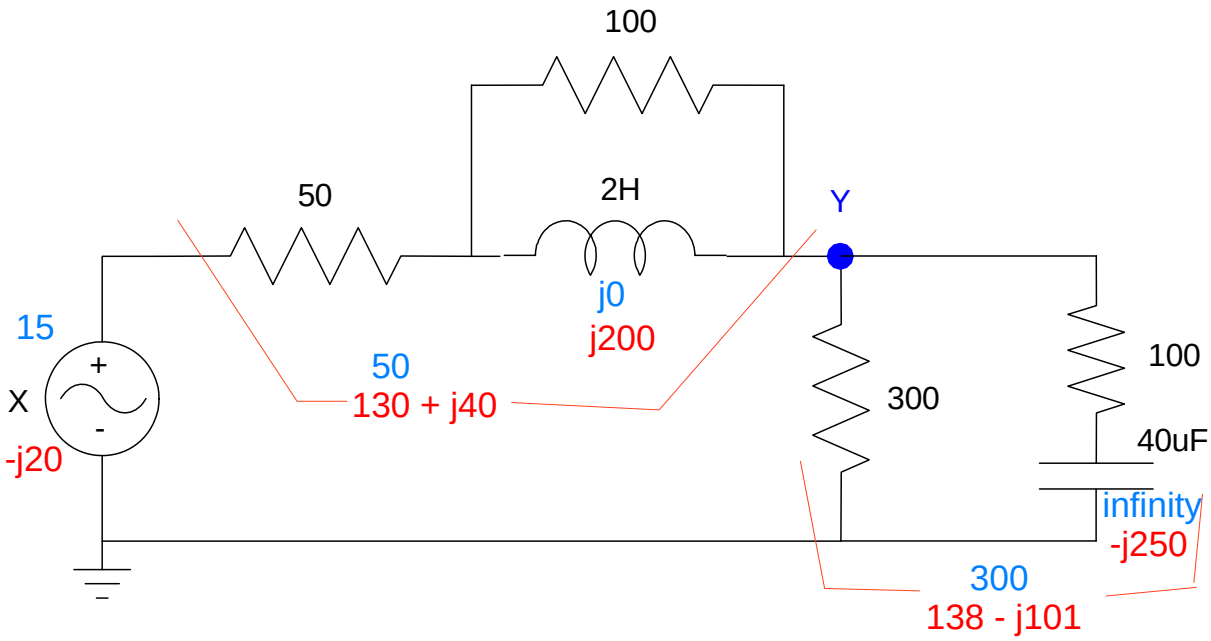
$$\theta_1 = -\left(\frac{65ms}{230ms}\right) 360^0 = -101^0$$

$$\theta_2 = -\left(\frac{160ms}{230ms}\right) 360^0 = -250^0$$

8) Determine the votlage at Y. Assume

$$x(t) = 15 + 20\sin(100t)$$

y(t) = $12.85 - 4.93\cos(100t) + 11.43\sin(100t)$




DC Analysis: (Blue)

X = 15

L = 0

C = infinity (open)

$$Y = \left(\frac{300}{300+50}\right)15 = 12.85$$

AC Analysis (red)

X = 0 - j20

L = j200

C = -j250

$$Y = \left(\frac{138-j101}{(138-j101)+(130+j40)}\right)(-j20)$$

$$Y = -4.93 - j11.43$$

real means cosine

complex means minus sine