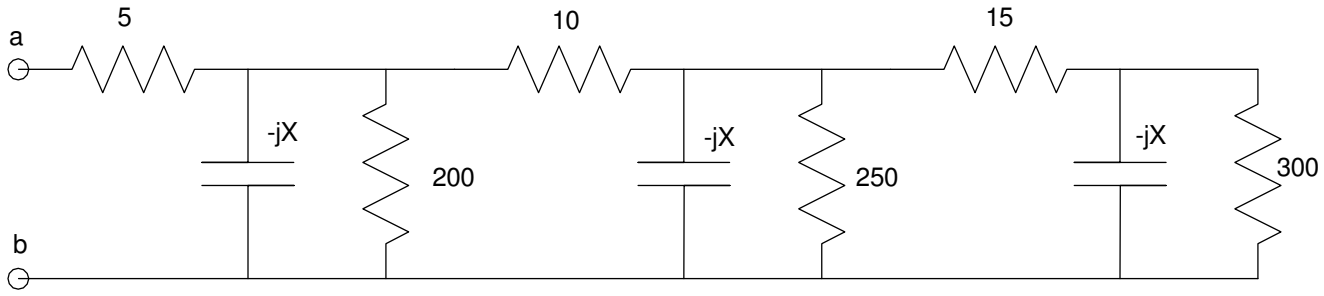
ECE 320 - Homework #1

EE 206 Review, Phasors. Due Wed, Jan 20th

Please submit as a Word or pdf file if submitting on Blackboard or emailing to Jacob_Glower@yahoo.com with subject ECE 320 HW#1

Resistors in series and parallel



1) Assume X = infinity (DC analysis). Determine the resistance Rab

300 + 15 = 315

315 || 250 = 139.381

139.381 + 10 = 149.381

149.381 || 200 = 85.512

85.512 + 5 = 90.512

answer: 90.512 Ohms

2) Assume -jX = -j200. Determine the resistance Rab (it will be a complex number)

300 || -j200 = 92.308 - j138.462

(92.308 - j138.462) + 15 = 107.308 - j138.462

(107.308 - j138.462) || 250 || -j200 = 51.109 - j64.848

(51.109 - j64.848) + 10 = 61.109 - j64.848

(61.109 - j64.848) || 200 || -j200 = 37.947 - j39.354

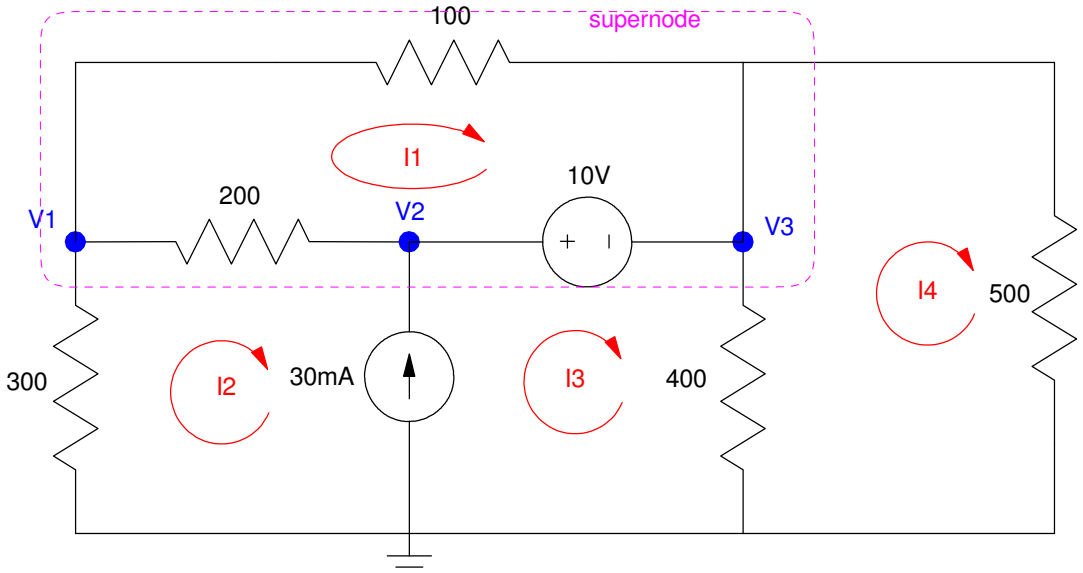
(37.947 - j39.354) + 5 = 42.947 - j39.354

ans: 42.947 - j39.354

Voltage Nodes & Current Loops

3) (Voltage Nodes): For the following circuit

a) Write the voltage node equations



$$V_2 - V_3 = 10$$

$$\left(\frac{V_1}{300}\right) + \left(\frac{V_1 - V_2}{200}\right) + \left(\frac{V_1 - V_3}{100}\right) = 0$$

$$\left(\frac{V_1}{300}\right) - 30mA + \left(\frac{V_3}{400}\right) + \left(\frac{V_3}{500}\right) = 0$$

b) Solve using Matlab (or similar program)

Group terms

$$V_2 - V_3 = 10$$

$$\left(\frac{1}{300} + \frac{1}{200} + \frac{1}{100}\right) V_1 - \left(\frac{1}{200}\right) V_2 - \left(\frac{1}{100}\right) V_3 = 0$$

$$\left(\frac{1}{300}\right) V_1 + \left(\frac{1}{400} + \frac{1}{500}\right) V_3 = 30mA$$

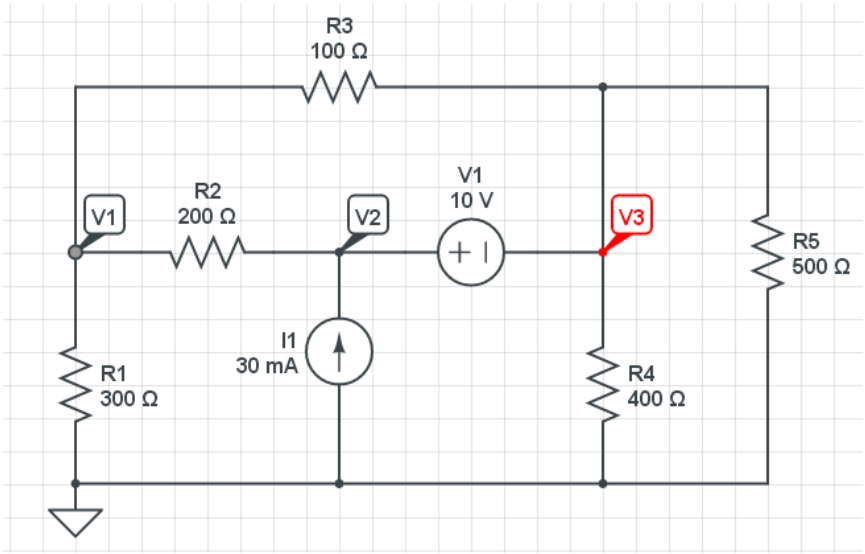
Place in matrix form

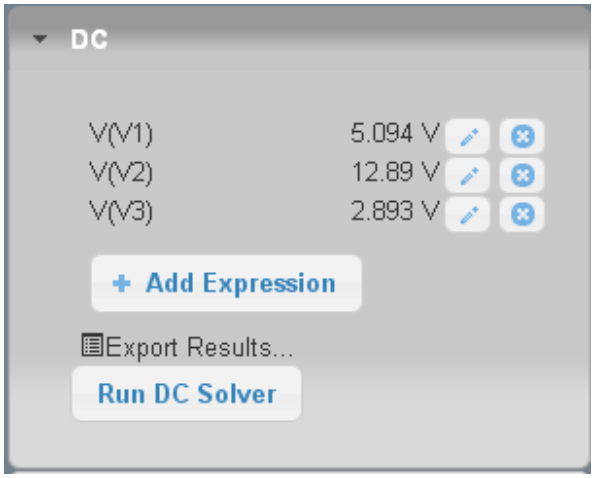
$$\begin{bmatrix} 0 & 1 & -1 \\ \left(\frac{1}{300} + \frac{1}{200} + \frac{1}{100}\right) & \left(\frac{-1}{200}\right) & \left(\frac{-1}{100}\right) \\ \left(\frac{-1}{300}\right) & 0 & \left(\frac{1}{400} + \frac{1}{500}\right) \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} 10 \\ 0 \\ 0.03 \end{bmatrix}$$

Solve in Matlab

```
A = [0,1,-1 ;
1/300+1/200+1/100, -1/200, -1/100 ;
1/300, 0, 1/400+1/500]

    0.           1.      - 1.
    0.0183333  - 0.005   - 0.01
    0.0033333    0.        0.0045

-->B = [10;0;0.03]

    10.
    0.
    0.03

-->V = inv(A)*B

V1    5.0943396
V2   12.893082
V3    2.8930818
```

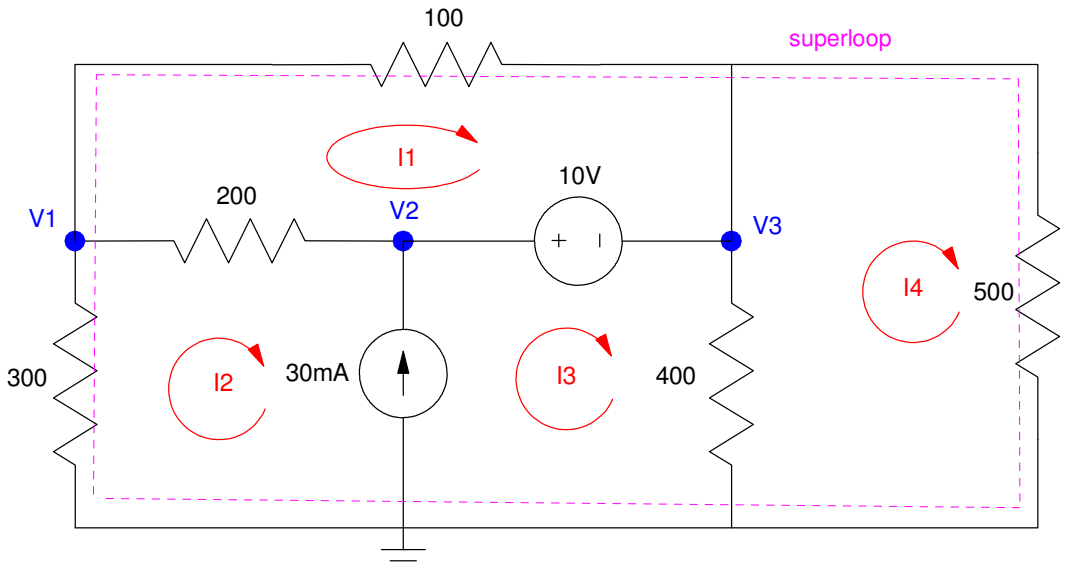
c) Check your answers in CircuitLab (or similar circuit simulator)





4) (Current Loops) For the following circuit

a) Write the current loop equations



$$I_3 - I_2 = 30mA$$

$$100I_1 - 10 + 200(I_1 - I_2) = 0$$

$$400(I_4 - I_3) + 500I_4 = 0$$

Superloop

$$300I_2 + 100I_1 + 500I_4 = 0$$

b) Solve using Matlab (or similar program)

Group terms

$$I_3 - I_2 = 30mA$$

$$300I_1 - 200I_2 = 10$$

$$-400I_3 + 900I_4 = 0$$

$$300I_2 + 100I_1 + 500I_4 = 0$$

Place in matrix form

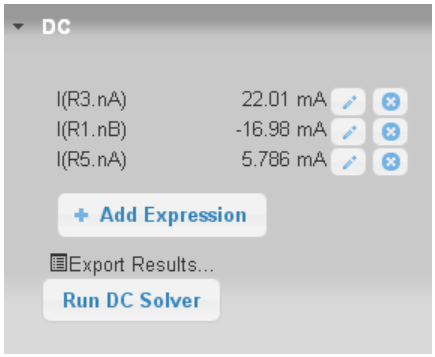
$$\begin{bmatrix} 0 & -1 & 1 & 0 \\ 300 & -200 & 0 & 0 \\ 0 & 0 & -400 & 900 \\ 100 & 300 & 0 & 500 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \\ I_4 \end{bmatrix} = \begin{bmatrix} 0.03 \\ 10 \\ 0 \\ 0 \end{bmatrix}$$

Solve in Matlab

```
-->A = [0,-1,1,0 ; 300,-200,0,0 ; 0,0,-400,900 ; 100,300,0,500]

    0.    - 1.      1.      0.
    300.  - 200.    0.      0.
    0.      0.    - 400.    900.
    100.    300.    0.      500.

-->B = [0.03;10;0;0]

    0.03
    10.
    0.
    0.

-->I = inv(A)*B

I1   0.0220126
I2  -0.0169811
I3   0.0130189
I4   0.0057862
```

c) Check your answers in CircuitLab (or similar circuit simulator)

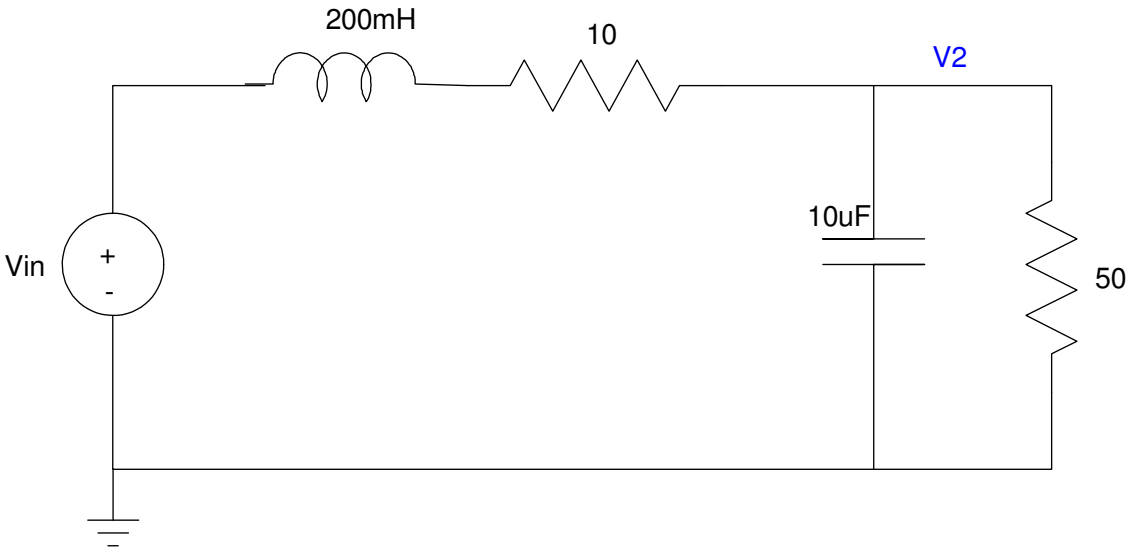
I1, I2, and I4 can be measured directly



5) Assume Vin contains a DC and 400 rad/sec (63.66Hz) signal:

$$V_{in} = 10 + 5\cos(400t) + 6\sin(400t)$$

a) Determine the voltage, V2, using phasor analysis



DC: Vin = 10

s = 0

Vin = 10 + j0

$$L \rightarrow j\omega L = 0$$

$$C \rightarrow \frac{1}{j\omega C} = \infty$$

$$V_2 = \left(\frac{50}{50+10}\right)10 = 8.333V$$ *DC term*

AC: Vin = 5 cos(400t) + 6 sin(400t)

s = j400

$$V_{in} \rightarrow 5 - j6$$

$$L \rightarrow j\omega L = j80$$

$$C \rightarrow \frac{1}{j\omega C} = -j250$$

$$50\Omega \;||\; -j250\Omega = 48.077 - j9.615\Omega$$

$$V_2 = \left(\frac{(48.077-j9.615)}{(48.077-j9.615)+j(10+j80)}\right)(5 - j6)$$

$$V_2 = -1.570 - j3.891$$

meaning

v2(t) = -1.570 cos(400t) + 3.891 sin(400t) *AC term*

v2(t) = 8.333 - 1.570 cos(400t) + 3.891 sin(400t) *total answer: DC + AC*

b) Check your answer using CircuitLab (or similar program)

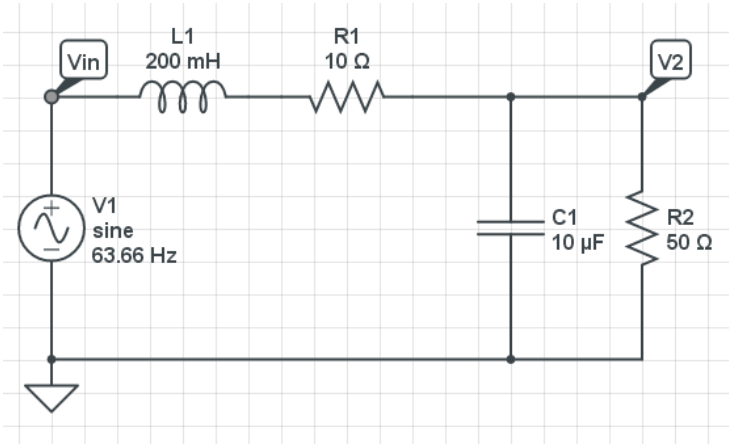
Vin:

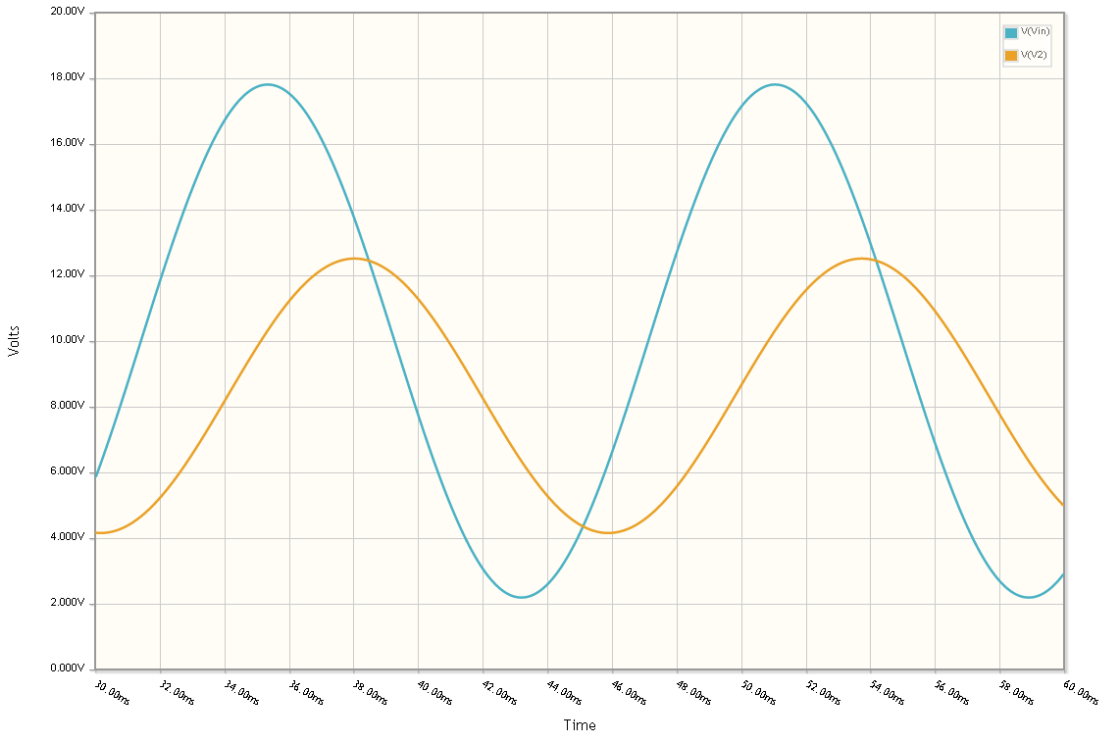
$$\omega = 400 = 2\pi f$$

$$f = 63.66Hz$$

$$V_{in} = 5 - j6 = 7.810\angle -50.19^0$$

The amplitude is 7.81. The phase (sine / cosine relationship) can be accounted for with the phase of Vin. I'll ignore the phase and compute V2 relative to V2





Vor V2 (orange line)

- max = 12.51V
- min = 4.155V

V2 = 8.355Vpp

From our calculations,

V2 = -1.570 - j3.891 *rectangular form*

V2 = 4.196 ∠ -111.974 deg *polar form*

V2pp = 2 * 4.196 = 8.392Vpp

which matches uip with CircuitLab (8.355Vpp)

The phase also matches. The phase of V1 is

$$V_1 = 5 - j6 = 7.810\angle -50.194^0$$

The phase of V2 is

$$V_2 = -1.570 - j3.891 = 4.196\angle -111.974^0$$

V2 lags V1 by 61.78 degrees

From the graph,

The peak of V1 is at 35.40ms

The peak of V2 is at 38.19ms

The period is 15.72ms

V2 lags V1 by

$$\left(\frac{38.19ms - 35.40ms}{15.72ms}\right)360^0 = 63.89^0$$

which matches our calculations.