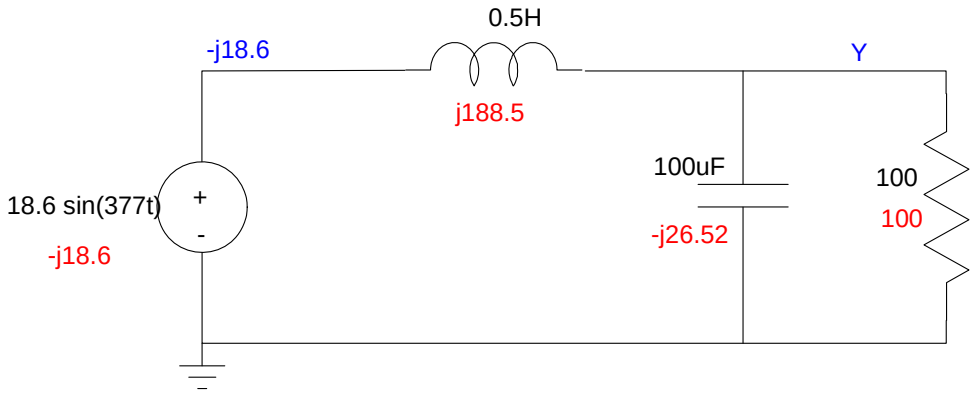
ECE 321 - Homework #3

Complex Numbers and Phasors. Due Monday, November 14th

1) Determine the voltage at y(t) asssuming

$$V_{in} = 18.6\sin(377t)$$



i) Convert to phasors (shown in red)

ii) Add the capacitor and resistor in parallel

$$R||C = \left(\frac{1}{-j26.52} + \frac{1}{100}\right)^{-1} = 6.57 - j24.78$$

iii) Use voltage division

$$Y = \left(\frac{(6.57-j24.78)}{(6.57-j24.78)+j188.5}\right)\cdot(-j18.6)$$

$$Y = -0.8581 + j2.7804 = 2.9098\angle 107^0$$

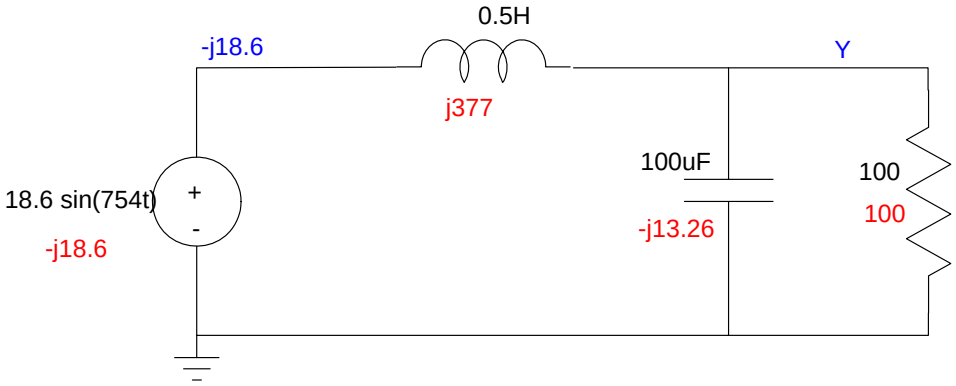
meaning

$$y(t) = -0.8581\cos(377t) - 2.7804\sin(377t) \qquad \textit{rectangular form}$$

$$= 2.9098\cos(377t + 107^0) \qquad \text{polar form}$$

2) Determine the voltage at y(t) asssuming

$$V_{in} = 18.6\sin(754t)$$



i) Convert to phasors (shown in red)

ii) Add the resistor and capacitor in parallel

$$\left(\frac{1}{-j13.26} + \frac{1}{100}\right)^{-1} = 1.728 - j13.033$$

iii) Use voltage division

$$Y = \left(\frac{(1.728 - j13.033)}{(1.728 - j13.033) + j377}\right) \cdot (-j18.6)$$

$$= -0.0915 + j0.6656$$

$$= 0.6719\angle 97.82^0$$

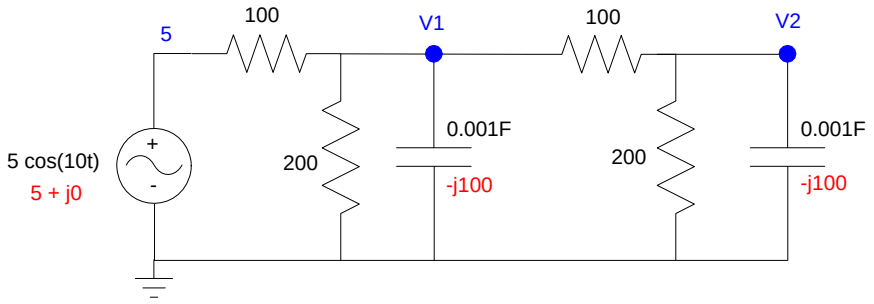
Meaning

$$y(t) = -0.0915\cos(754t) - 0.6656\sin(754t)$$

$$= 0.6919\cos(754t + 97.82^0)$$

3) Determine the voltages at each voltage node assuming

$$V_{in} = 5\cos(10t)$$



i) Convert to phasors (show in red)

ii) Write the voltage node equations

$$\left(\frac{V_1-5}{100}\right)+\left(\frac{V_1}{200}\right)+\left(\frac{V_1}{-j100}\right)+\left(\frac{V_1-V_2}{100}\right)=0$$

$$\left(\frac{V_2-V_1}{100}\right)+\left(\frac{V_2}{200}\right)+\left(\frac{V_2}{-j100}\right)=0$$

Group terms

$$\left(\frac{1}{100}+\frac{1}{200}+\frac{1}{-j100}+\frac{1}{100}\right)V_1+\left(\frac{-1}{100}\right)V_2=\left(\frac{5}{100}\right)$$

$$\left(\frac{-1}{100}\right)V_1+\left(\frac{1}{100}+\frac{1}{200}+\frac{1}{-j100}\right)V_2=0$$

Solve:

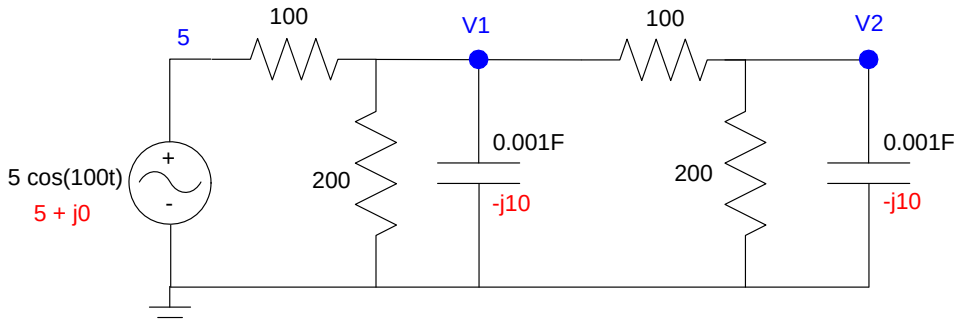
```
-->a11 = 1/100 + 1/200 + 1/(-j*100) + 1/100;
-->a12 = -1/100;
-->a21 = -1/100;
-->a22 = 1/100 + 1/200 + 1/(-j*100);

-->A = [a11,a12 ; a21, a22]

    0.025 + 0.01i  - 0.01
  - 0.01             0.015 + 0.01i

-->B = [5/100;0]

    0.05
    0.

-->V = inv(A)*B

    1.7377049 - 1.1147541i
    0.4590164 - 1.0491803i
```

meaning

$$V_1(t) = 1.7377\cos(10t) + 1.114\sin(10t)$$

$$V_2(t) = 0.459\cos(10t) + 1.049\sin(10t)$$

4) Determine the voltages at each voltage node assuming



i) Convert to phasors (show in red)

ii) Write the voltage node equations

$$\left(\frac{V_1-5}{100}\right)+\left(\frac{V_1}{200}\right)+\left(\frac{V_1}{-j10}\right)+\left(\frac{V_1-V_2}{100}\right)=0$$

$$\left(\frac{-1}{100}\right)V_1+\left(\frac{1}{100}+\frac{1}{200}+\frac{1}{-j10}\right)V_2=0$$

Group terms

$$\left(\frac{1}{100}+\frac{1}{200}+\frac{1}{-j10}+\frac{1}{100}\right)V_1+\left(\frac{-1}{100}\right)V_2=\left(\frac{5}{100}\right)$$

$$\left(\frac{-1}{100}\right)V_1+\left(\frac{1}{100}+\frac{1}{200}+\frac{1}{-j10}\right)V_2=0$$

Solve:

```
-->a11 = 1/100 + 1/200 + 1/(-j*10) + 1/100;
-->a12 = -1/100;
-->a21 = -1/100;
-->a22 = 1/100 + 1/200 + 1/(-j*10);

-->A = [a11,a12 ; a21, a22]

    0.025 + 0.1i  - 0.01
  - 0.01            0.015 + 0.1i

-->B = [5/100;0]

    0.05
    0.

-->V = inv(A)*B

    0.1149100 - 0.4668750i
  - 0.0439744 - 0.0180872i
```

meaning

$$V_1(t)=0.1149\cos(100t)+0.4668\sin(100t)$$

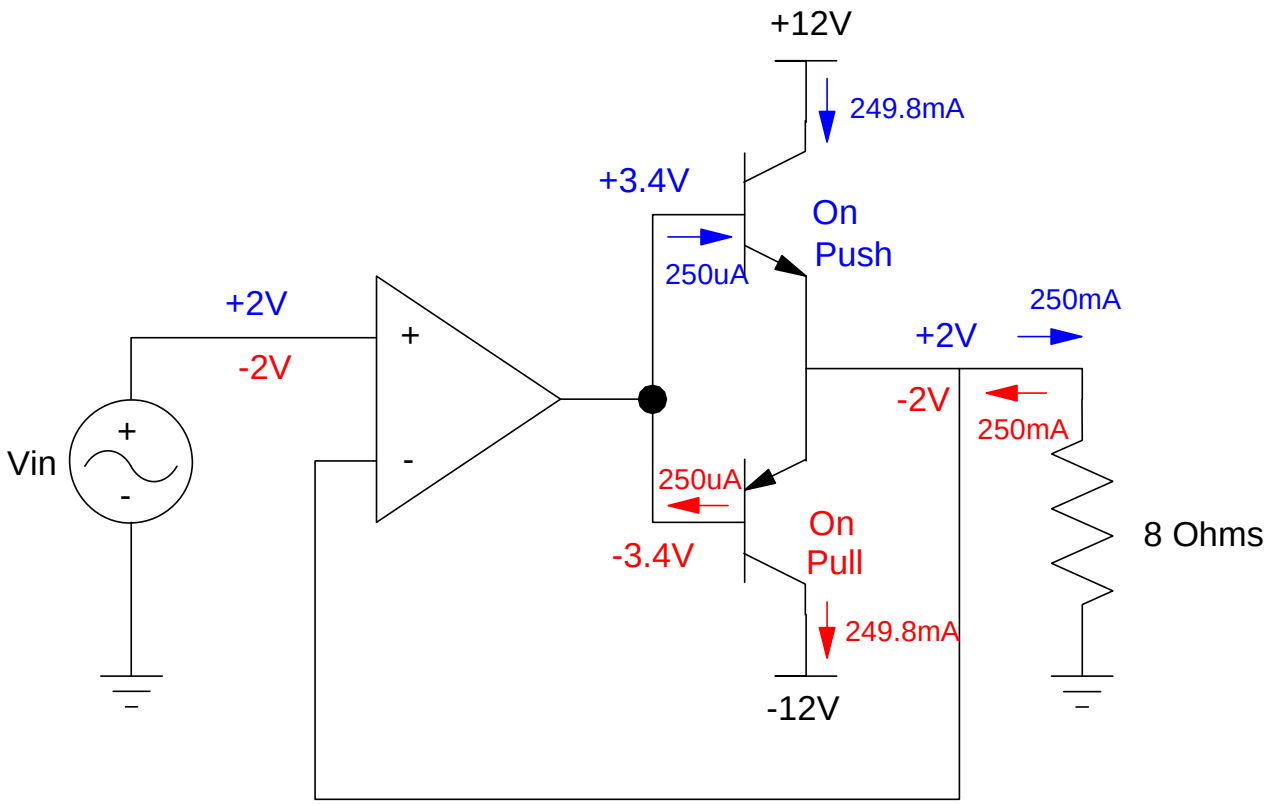
$$V_2(t)=-0.0439\cos(100t)+0.0180\sin(100t)$$

5-7) Design a push-pull amplifier to drive an 8-Ohm speaker at -5V to +5V DC:

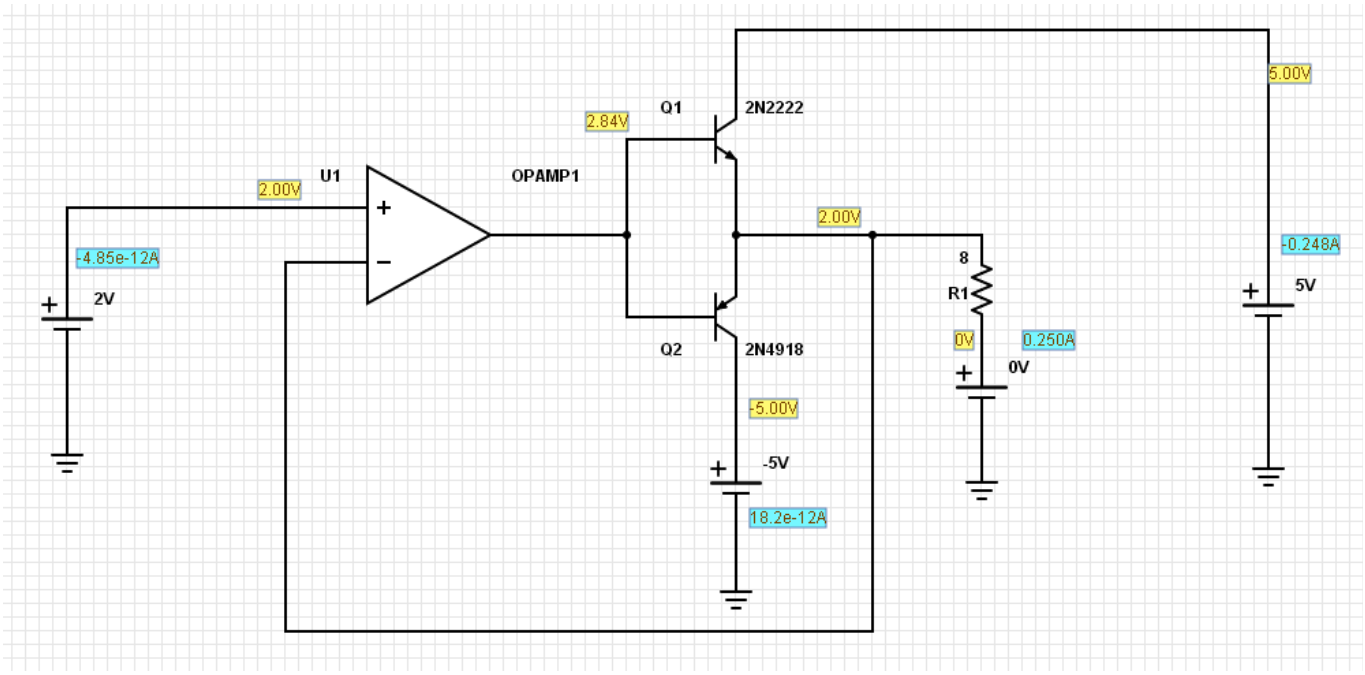
- Input: -5V to +5V, capable of 10mA
- Output: 8 Ohm Speaker
- Relationship: Y = X, +/- 0.1V

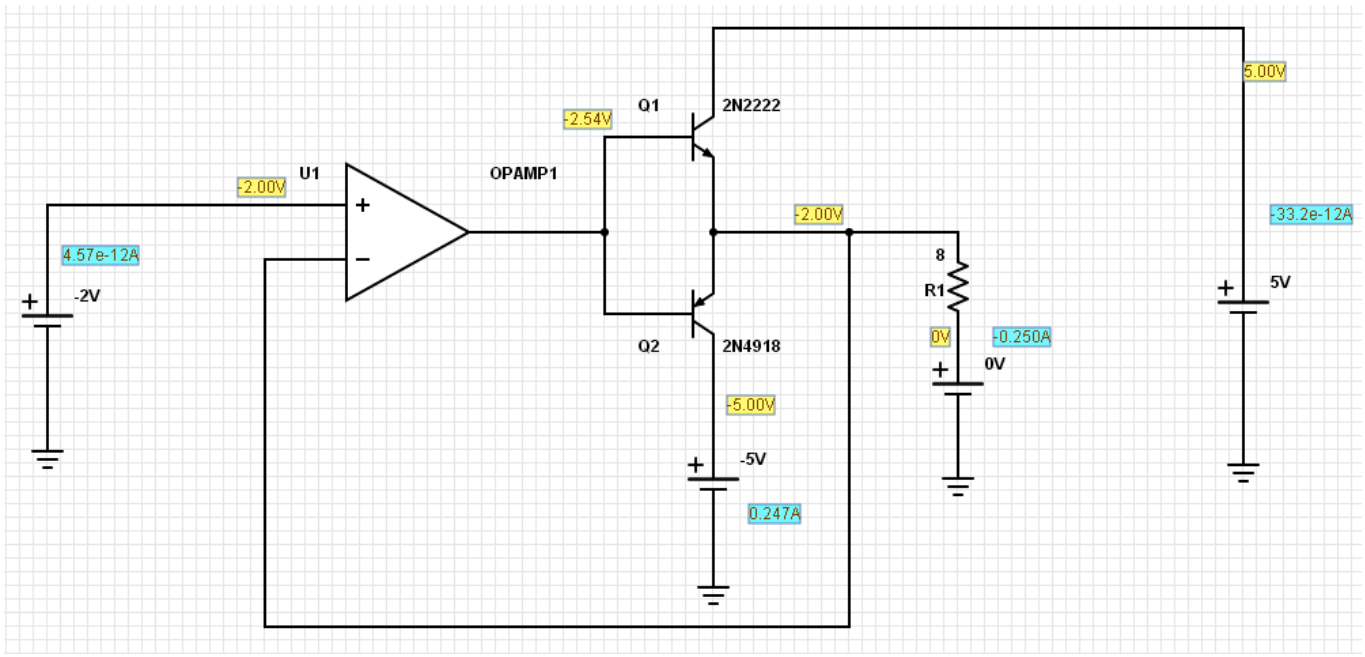
5) Analysis: Design the push-pull amplifier on paper. Compute the voltages for

- Vin = +2V
- Vin = -2V



6) Simulation: Check your analysis in PartSim at Vin = +2V and -2V





7) Lab: Build your circuit and measure the voltages at Vin = +2V and Vin = -2V.