Superposition

- Introduction and Discussion
- Example with DC and AC Sources
  - Work as we go in your calculator
  - Uses voltage divider instead of current divider (text)
- ICP with two AC Sources of the Same Frequency
  - Uses current divider (special case)

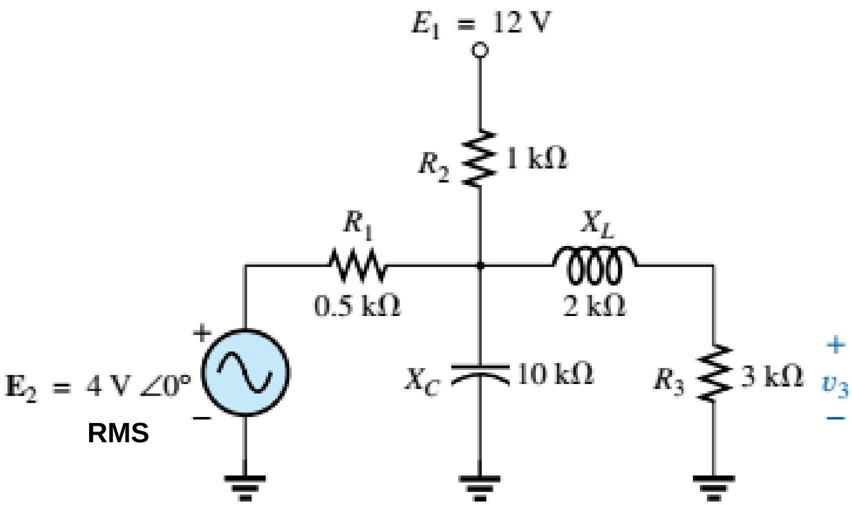
Superposition

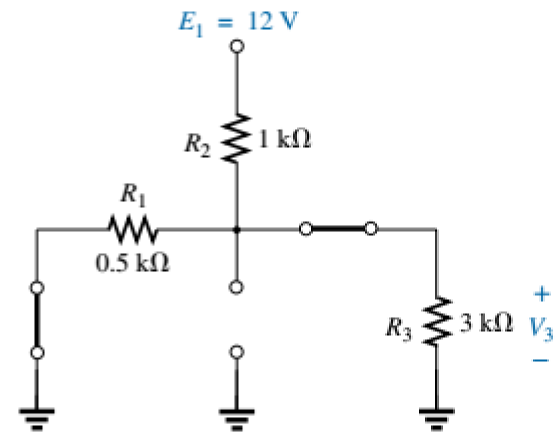
- You will recall from Chapter 9 that the superposition theorem eliminated the need for solving simultaneous linear equations by considering the effects of each source independently.
- To consider the effects of each source, we had to remove the remaining sources.
- This was accomplished by setting voltage sources to zero (short-circuit representation) and current sources to zero (open-circuit representation).
- The current through, or voltage across, a portion of the network produced by each source was then added algebraically to find the total solution for the current or voltage.
- Requires REDRAWING and ANALYZING as many circuits as there are sources in a specific problem

Superposition

- The only variation in applying this method to ac networks with independent sources is that we are now working with impedances and phasors instead of just resistors and real numbers.
- The superposition theorem is not directly applicable to power effects in ac networks since we are still dealing with a nonlinear relationship.
- It can be applied to networks with sources of different frequencies only if the total response for each frequency is found independently and the results are expanded in a nonsinusoidal expression. -> CH26 material
- Superposition is often used to analyze electronic systems where we determine the DC characteristics of a network (operating point) and the AC characteristics (small signal analysis) separately.

Example – DC and AC Analysis (follow along in your calculator, slightly different approach than the text)





Find: the voltage across R_3, $v_3(t)$

Two sources: E_1 (DC) and E_2 (AC)

For source E_1 active, **redraw the circuit**:

- Replace E_2 with a s/c
- Replace the capacitors and inductors with their DC equivalents
- Find V_3, the DC value of $v_3(t)$

R_1 and R_3 are in parallel, therefore:

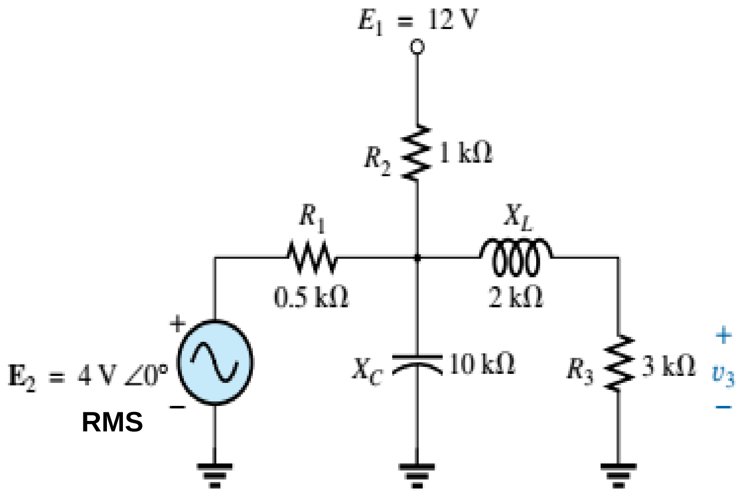
$$R' = R_1 \| R_3 = 0.5\text{ k}\Omega \| 3\text{ k}\Omega = 0.429\text{ k}\Omega$$

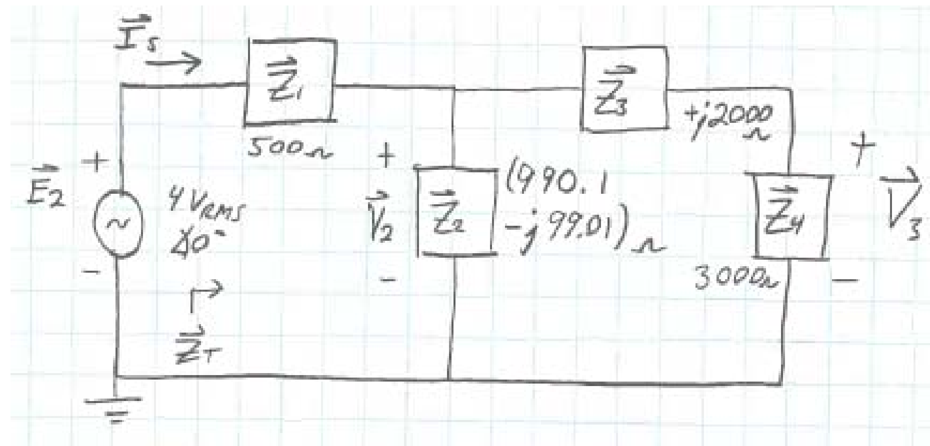
$$V_3 = \frac{R'E_1}{R' + R_2} = \frac{(0.429\text{ k}\Omega)(12\text{ V})}{0.429\text{ k}\Omega + 1\text{ k}\Omega}$$

V_3 = 3.60V, the DC component

3.6VDC due to source **E_1**

Example – DC and AC Analysis (follow along in your calculator, slightly different approach than the text)





V_3 = 3.60V, the DC component

For source E_2 active, **redraw the circuit**:

- Replace E_1 with a s/c
- Use the impedance box convention
- Find $\mathbf{V_3}$, the AC value of $v_3(t)$

Develop an Approach to find $\mathbf{V_3}$:

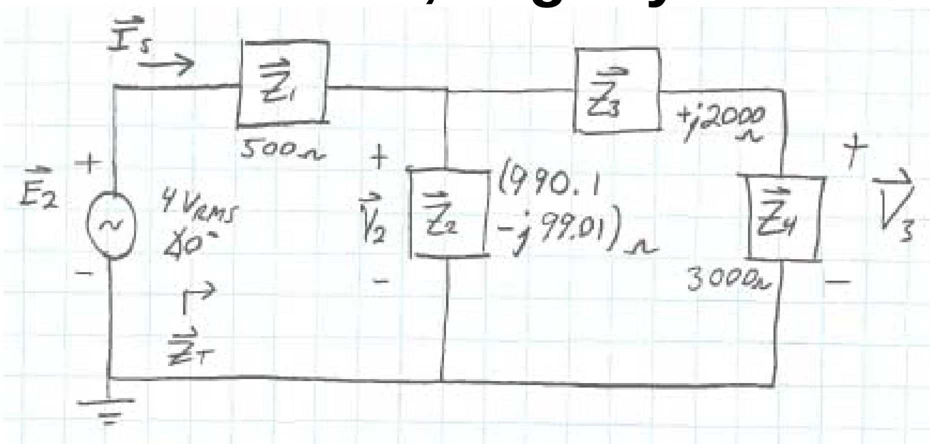
- Find $\mathbf{Z_T}$ (series/parallel combinations)
- Calculate $\mathbf{I_S}$ (Ohm's Law)
- Find $\mathbf{V_2}$ (KVL/Ohm's Law)
- Find $\mathbf{V_3}$ (Voltage Divider)

$$\vec{Z}_T = \left[(\vec{Z}_3 + \vec{Z}_4) \parallel \vec{Z}_2 \right] + \vec{Z}_1$$

$(\vec{Z}_3 + \vec{Z}_4) = (3000 + j2000)$; $\left[(\vec{Z}_3 + \vec{Z}_4) \parallel \vec{Z}_2 \right] = (810.9 + j35.48)\ \Omega$

$$\vec{Z}_T = (1{,}311 + j\,35.48)\ \Omega$$

Example – DC and AC Analysis (follow along in your calculator, slightly different approach than the text)



$$\vec{Z}_T = (1{,}311 + j\,35.48)\ \Omega$$

$$\vec{I}_s = \frac{\vec{E}_2}{\vec{Z}_T} = \frac{4 V_{RMS} \angle 0^\circ}{(1311 + j\,35.48)\ \Omega}$$

$$= 3.050\ mA_{RMS} \angle -1.550^\circ$$

$$\vec{V}_2 = \vec{E}_2 - \vec{I}_s \vec{Z}_1$$

$$= 4 V_{RMS} \angle 0^\circ - 1.525 V_{RMS} \angle -1.550^\circ$$

$$= 2.476 V_{RMS} \angle 0.955^\circ$$

$$\vec{V}_3 = \vec{V}_2 \left(\frac{\vec{Z}_4}{\vec{Z}_4 + \vec{Z}_3} \right)$$

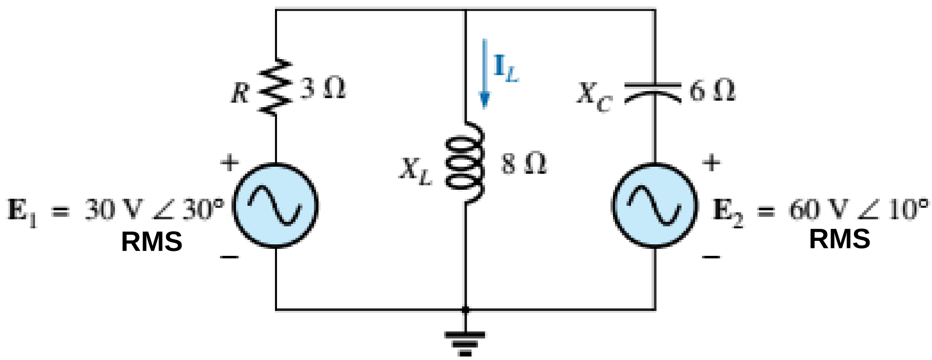
$$= (2.476 V_{RMS} \angle 0.955^\circ)(0.8321\ \Omega \angle -33.69^\circ)$$

$$\boxed{\vec{V}_3 = 2.06 V_{RMS} \angle -32.7^\circ}$$

So we have 3.60 VDC + 2.06V_{RMS} < -32.7º or:

$V_3(t) = 3.60 + 2.91 \sin(wt - 32.7^\circ)$ V

In Class Problem



Find:

- The current through the inductor, **I_L**

Approach:

- Use superposition
- 2 Sources, 2 Circuits to **REDRAW and ANALYZE**