Last Class…

1. Why is the phasor domain useful for analyzing ac circuits?

   Representing AC circuits as complex numbers

2. Differentiation in the time domain corresponds to what mathematical operation in the phasor domain?

   $$\frac{dV_c(t)}{dt} \longleftrightarrow j\omega V_c(j\omega)$$

3. Transform $i_1(t) = 10\, sin(8t + 75°)\, A$ into its phasor counterparts.

   $-90°$

   $\hookrightarrow i_1(t) = 10\cos(8t - 15°)$ ← General Form

   $$I_1(j8) = 10e^{-15j} = 10\angle{-15°}$$

4. How does a resistor, capacitor, and inductor look like in the phasor domain?

   – All in Ohms –

   $Z_R = R$

   $Z_L = j\omega L$

   $Z_c = \frac{1}{j\omega C} = \frac{-j}{\omega C}$

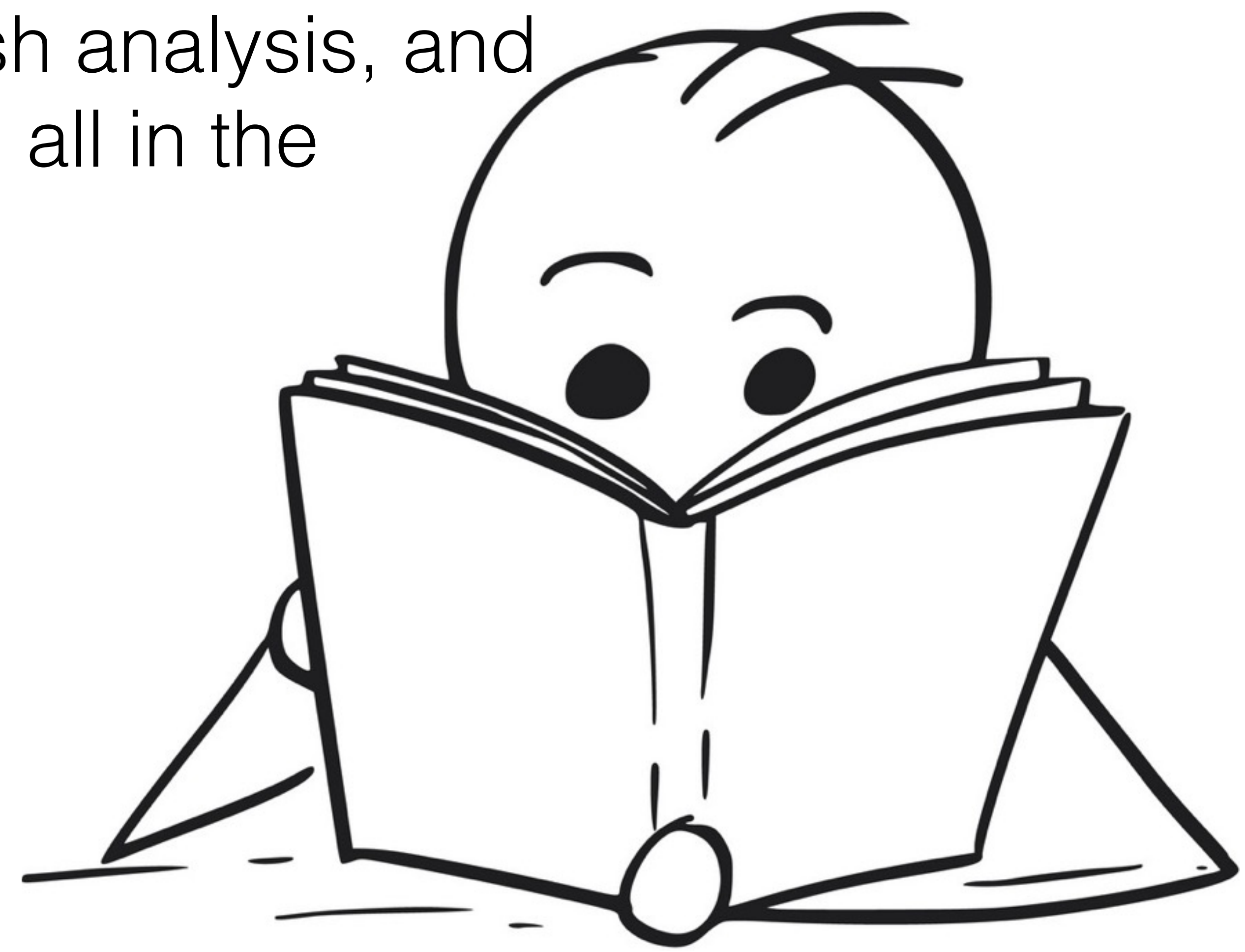
THE OHIO STATE UNIVERSITY

COLLEGE OF ENGINEERING

AC Circuit Analysis

This Lecture…

- Learning Objectives:
    - Perform source transformations, current division and voltage division, and determine Thévenin and Norton equivalent circuits, all in the phasor domain.
    - Apply nodal analysis, mesh analysis, and other analysis techniques, all in the phasor domain.



Phasor Domain Analysis

1. Represent all sources in the general form (cosine).

   $12\cos(10^5 t - 135)$

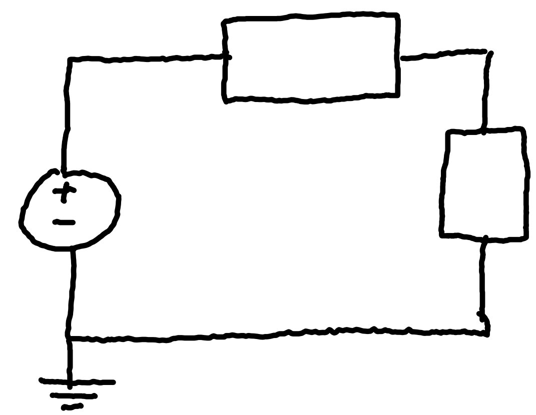
2. Convert sources to phasor form.

   $12e^{-135j} = 12\angle -135^\circ$

3. Use exciting frequency to determine impedance of each circuit element.

   ω

$Z_R = 10\Omega$

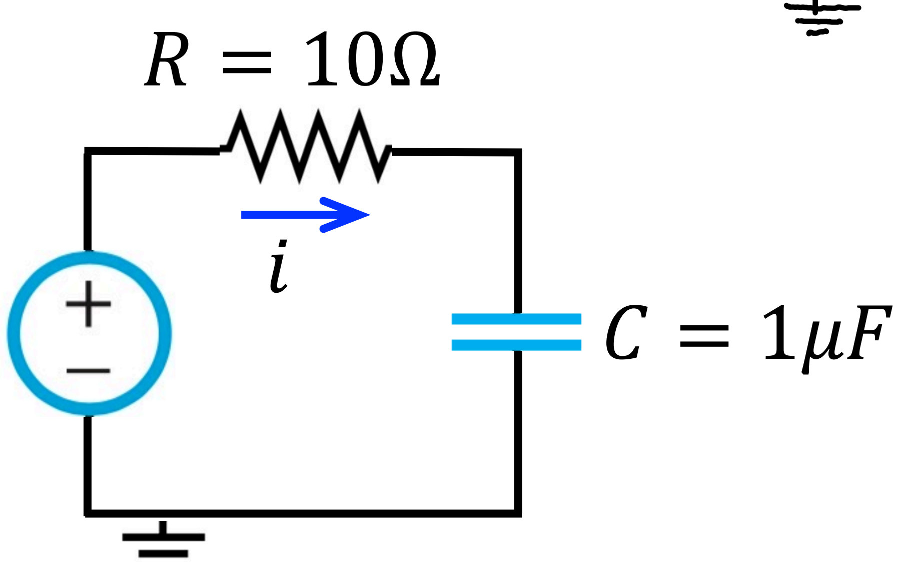


$Z_c = \dfrac{1}{j(10^5)(10^{-6})}$

$= -10j$

$v_s(t) = 12\,sin(\boxed{10^5}t - 45^\circ)$

ω



Phasor Domain Analysis

1. Represent all sources in the general form (cosine).

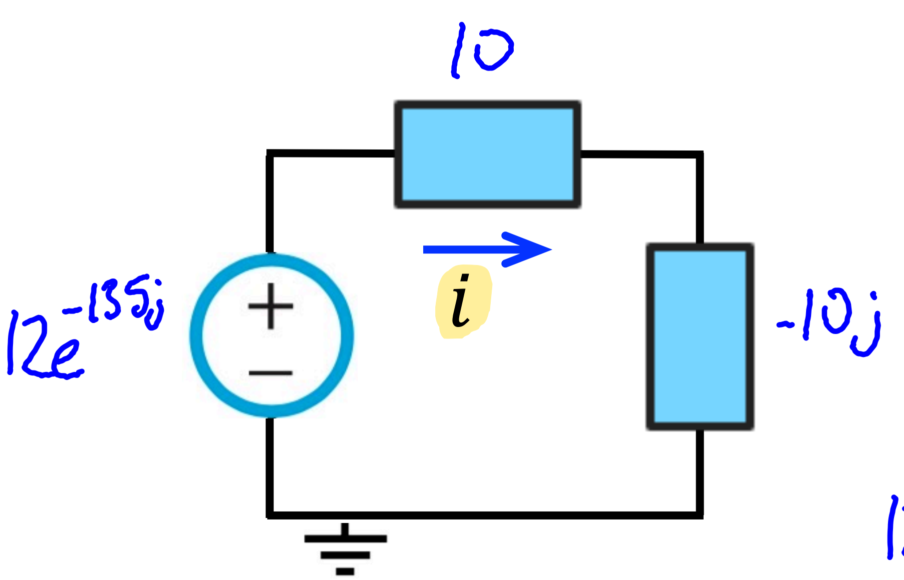
2. Convert sources to phasor form.

3. Use exciting frequency to determine impedance of each circuit element.

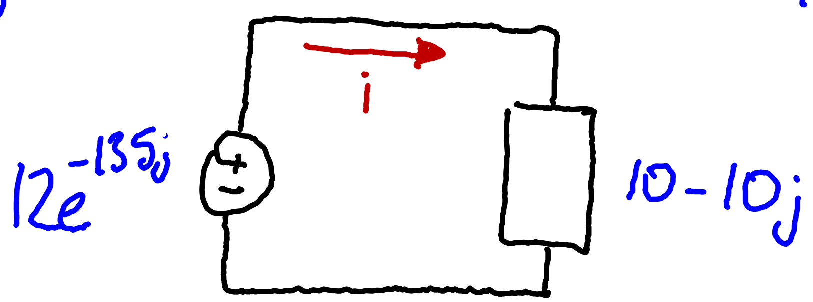
4. Apply DC circuit analysis solution methods.

5. Convert phasor solution to its time-domain form.

↳ $i(t) = 0.85\cos(10^5 t - 90)$

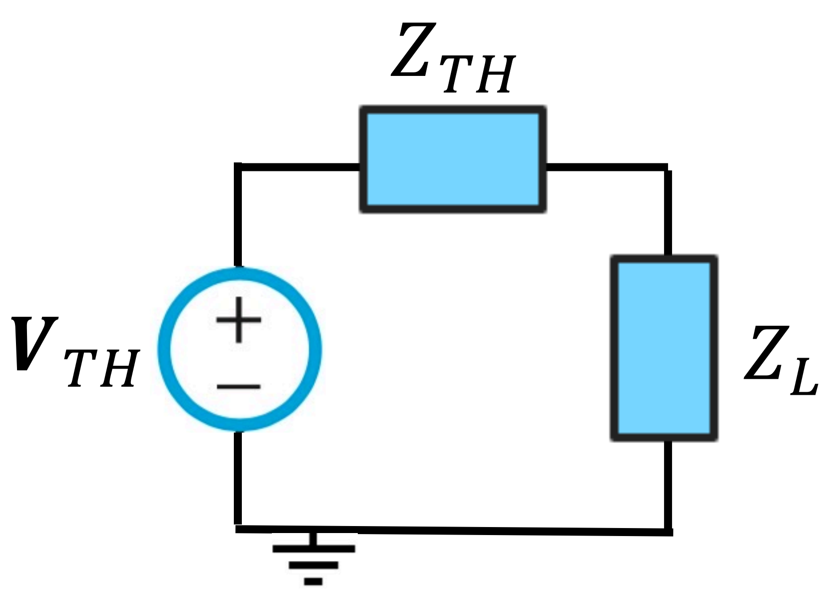


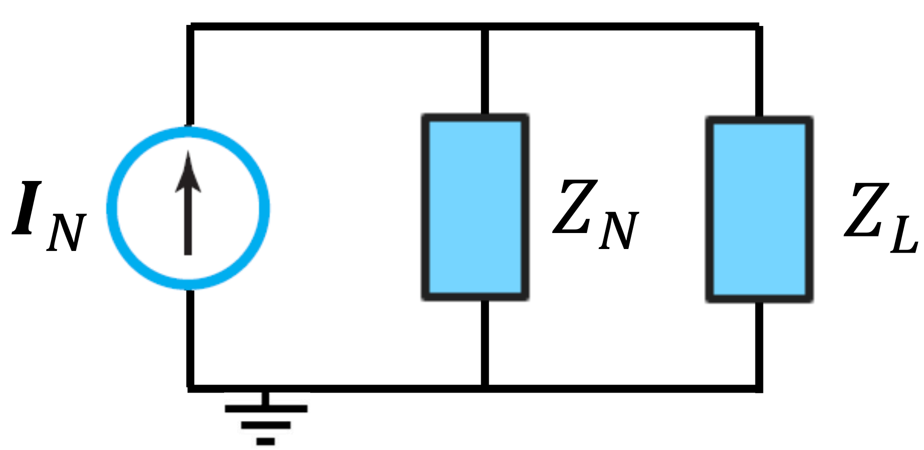
$$i = \frac{V}{Z_{eq}} = \frac{12e^{-135j}}{10-10j} = -0.85j = 0.85e^{-90j}$$



Equivalent Circuits

- You can find Thevenin and Norton equivalent circuits in the phasor domain.





The procedure is the same as in time domain:

V_{TH}: Remove the load, leaving the load terminals open-circuit.

Z_{eq}: Remove the load and set all independent sources to zero.

I_N: Replace the load with a short circuit.

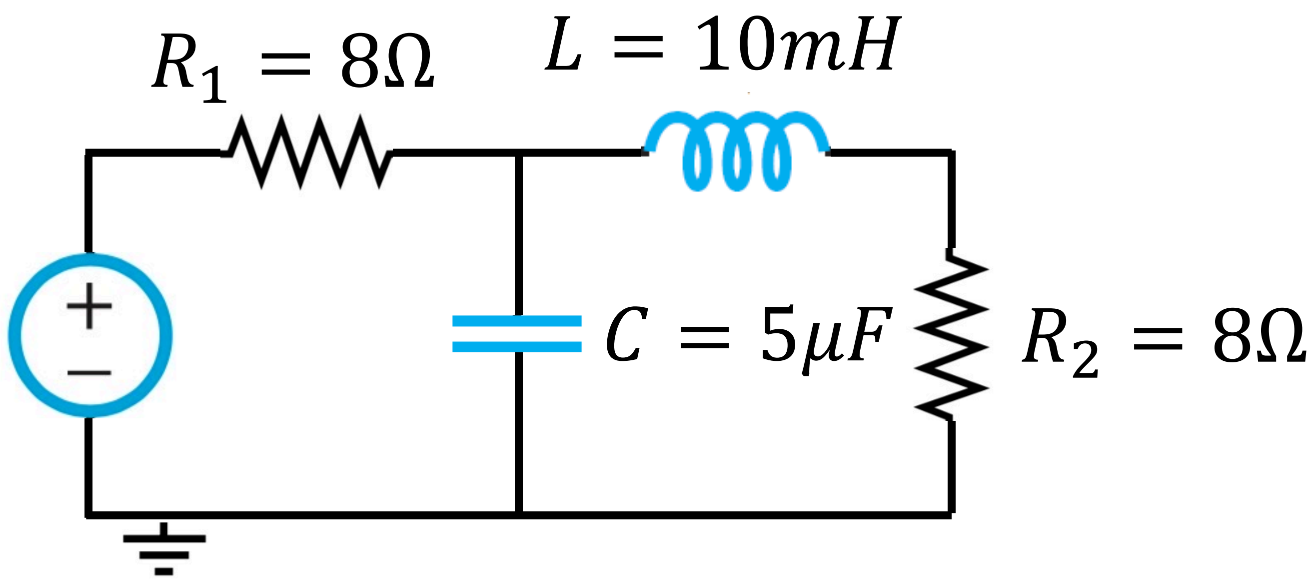
Example 1

load

A. Find the Thévenin equivalent network seen by the capacitor C.
B. Use the result and voltage division to determine $v_C(t)$.

$v_s(t) = sin(100t + 90°)$

$= \cos(100t)$



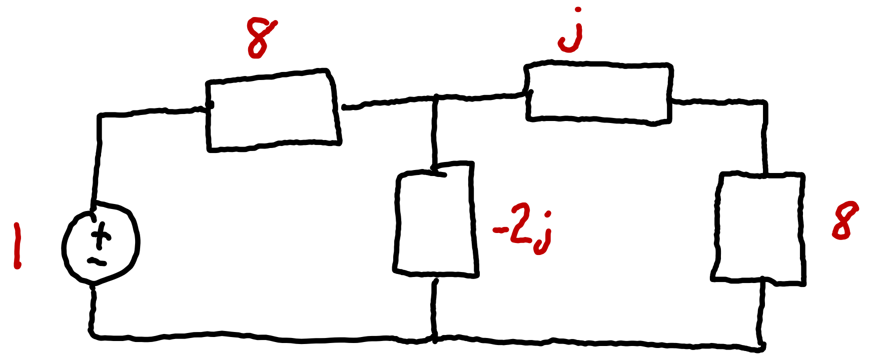
$V_s(j100) = 1e^{0j} = 1$ ← not DC $\quad \omega = 100$

$Z_{R1} = 8\Omega$

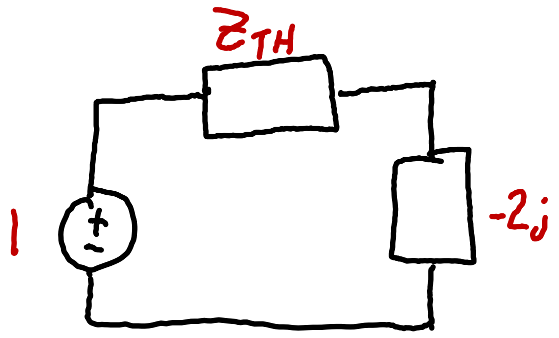
$Z_{R_2} = 8\Omega$

$Z_L = j\omega L = j(100)(10\times10^{-3}) = j$

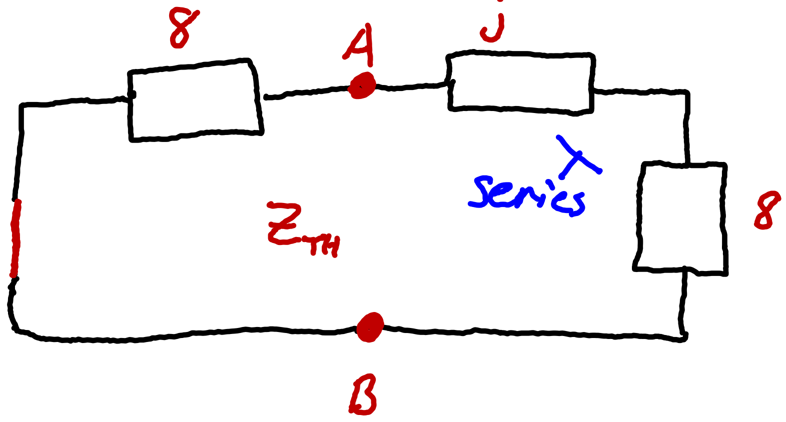
$Z_C = \frac{1}{j\omega C} = \frac{1}{j(100)(5\times10^{-3})} = -2j$

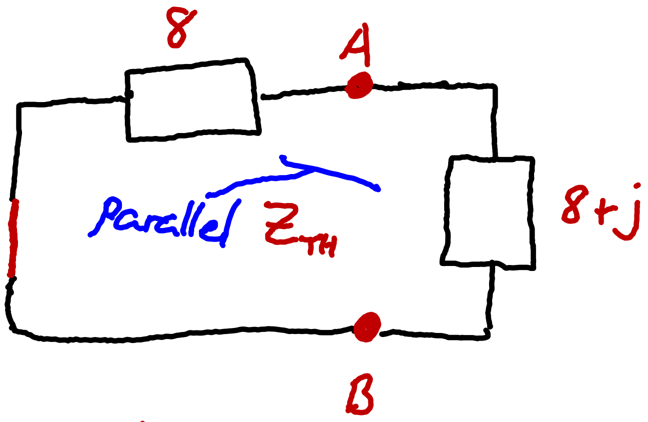


A. Thevenin Circuit

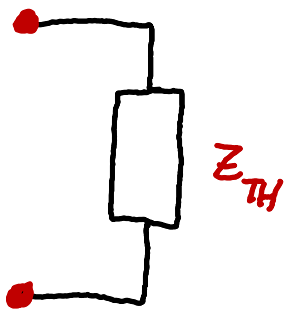


Thevenin Impedance

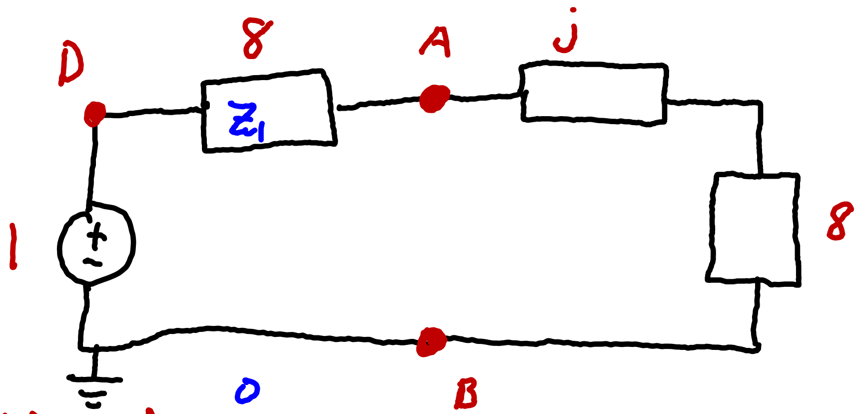




$$Z_{TH} = \frac{(8)(8+j)}{8+8+j} = \frac{64+8j}{16+j} = 4.02+0.25j$$



Thevenin Voltage



$$V_{TH} = V_A - \cancel{V_B}^{\,0} = V_A$$

$$V_{Z_1} = V_D - V_A$$

$$V_A = V_D - V_{Z_1} = 1 - V_{Z_1}$$

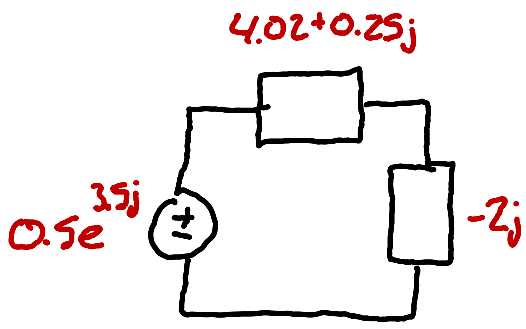
$$V_{TH} = 1 - V_{Z_1} = 0.5 + 0.03j$$
$$= 0.5e^{3.5j}$$

Voltage Division

$$V_{Z_1} = \frac{8}{8+j+8} \cdot 1$$
$$= 0.5e^{-3.5j}$$
$$= 0.5 - 0.03j$$

B.

Voltage Division



$$V_C = \frac{-2j}{4.02+0.25j-2j} \cdot 0.5e^{3.5j}$$
$$= 0.1 - 0.2j$$
$$= 0.26e^{-62.9j}$$

$$V_C(t) = 0.23\cos(100t - 62.9)\,V$$