EEE 250: Circuits, Devices, and Motors

Lecture 14

Assignment Reminder

- Read 5.5-5.6, 6.2, AND 10.1 – 10.6 (diodes)
- Practice problems:
  - P5.63, P5.68, P5.77, P5.85
  - P6.23, P6.26
  - P10.7, P10.8, P10.37

- D2L Quiz #7 will be posted this week. It is due by 11AM on Monday 14 Oct.

- REMINDER: Lab #5 will be performed this week—be sure to do the pre-lab assignment calculations!
  There will be no EELE 250 labs *next* week.

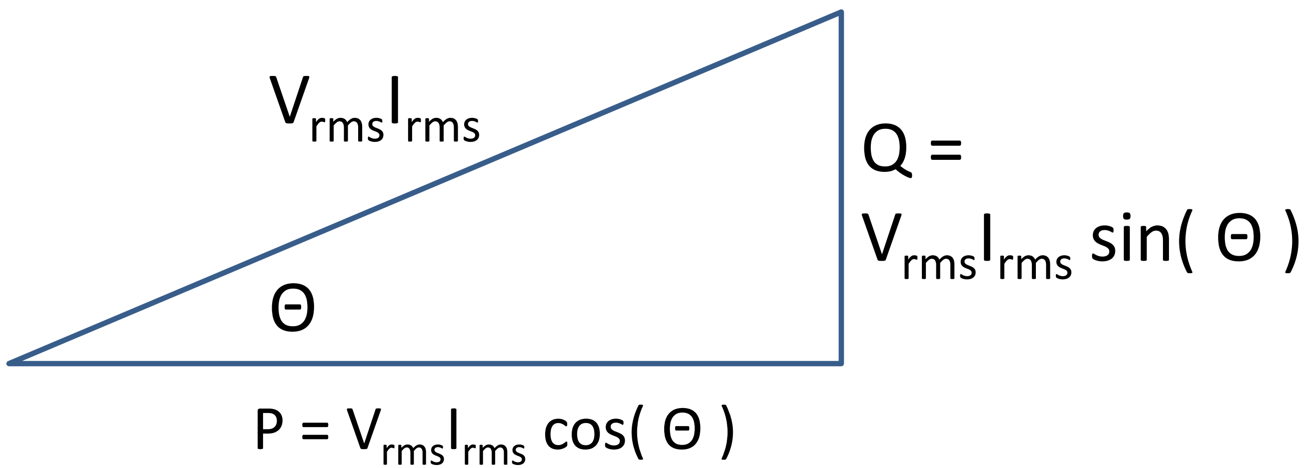
- Exam #2: in class on Wednesday 23 Oct.

Power in AC circuits

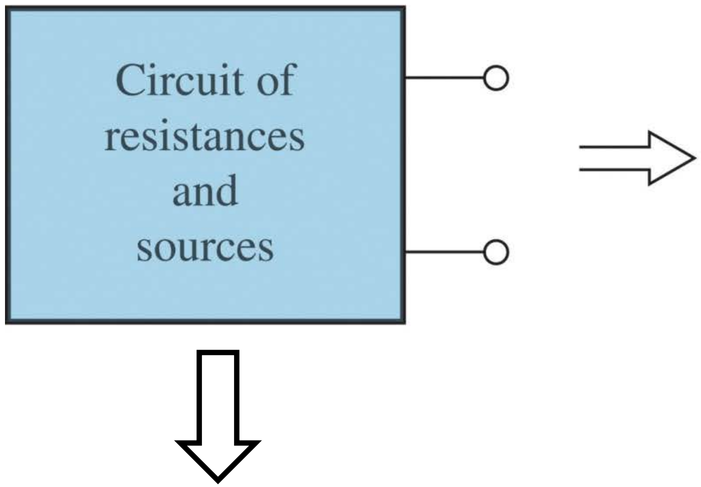
- With *reactive* loads, voltage and current are not generally in phase.
- We define the *power angle*: $\Theta = \Theta_v - \Theta_i$
- The *power factor* is: $\cos(\Theta)$
- Average power $P = V_{rms} I_{rms} \cos(\Theta)$ [watts]
- Apparent power $= V_{rms} I_{rms}$ [VA: volt amps]
- Reactive power $Q = V_{rms} I_{rms} \sin(\Theta)$ [VAR]

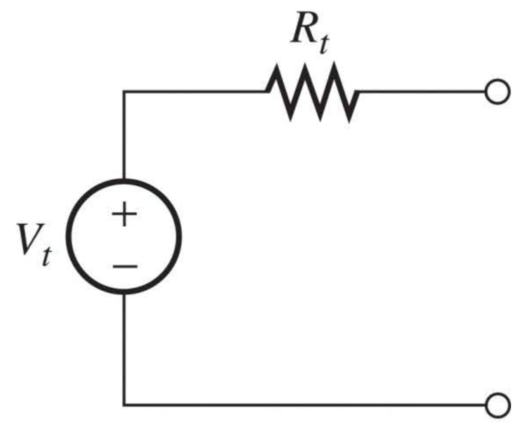
Power “Triangle”

- Relationship between average power (P), reactive power (Q), and apparent power $V_{rms}I_{rms}$

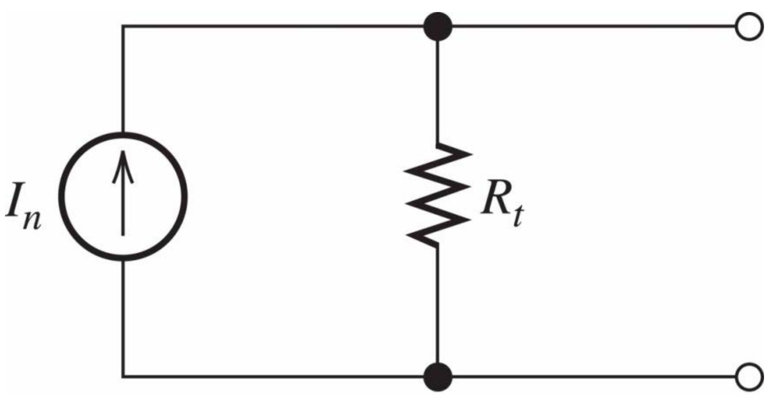


Review: Thévenin and Norton Circuits





Thévenin equivalent circuit



Norton equivalent circuit

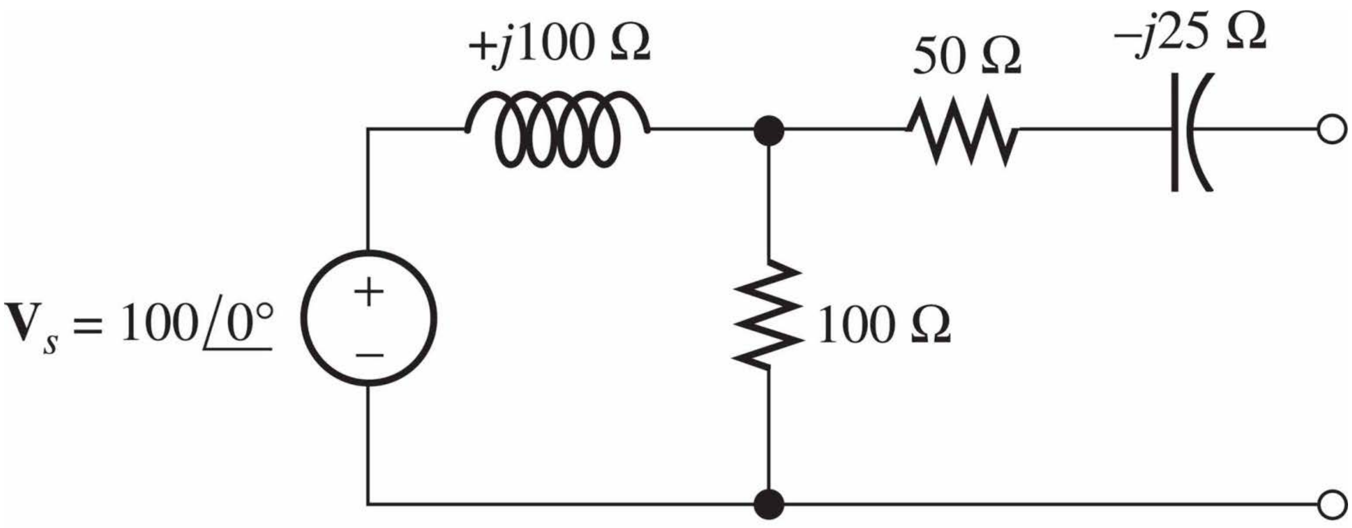
Thévenin and Norton (cont.)

- Thévenin voltage is the *open circuit voltage*
- Norton current is the *short circuit current*
- The equivalent resistance is V_{oc}/I_{sc}
- We can also find the equivalent resistance by turning "off" the independent voltage and current sources and finding the equivalent resistance of the resulting circuit

Generalize to Impedances…

- We can extend the Thévenin and Norton equivalent circuits to RLC circuits and AC steady-state analysis
- Same principles apply: find open-circuit voltage and short-circuit current
- Can also determine impedance by finding equivalent impedance with independent sources turned “off”

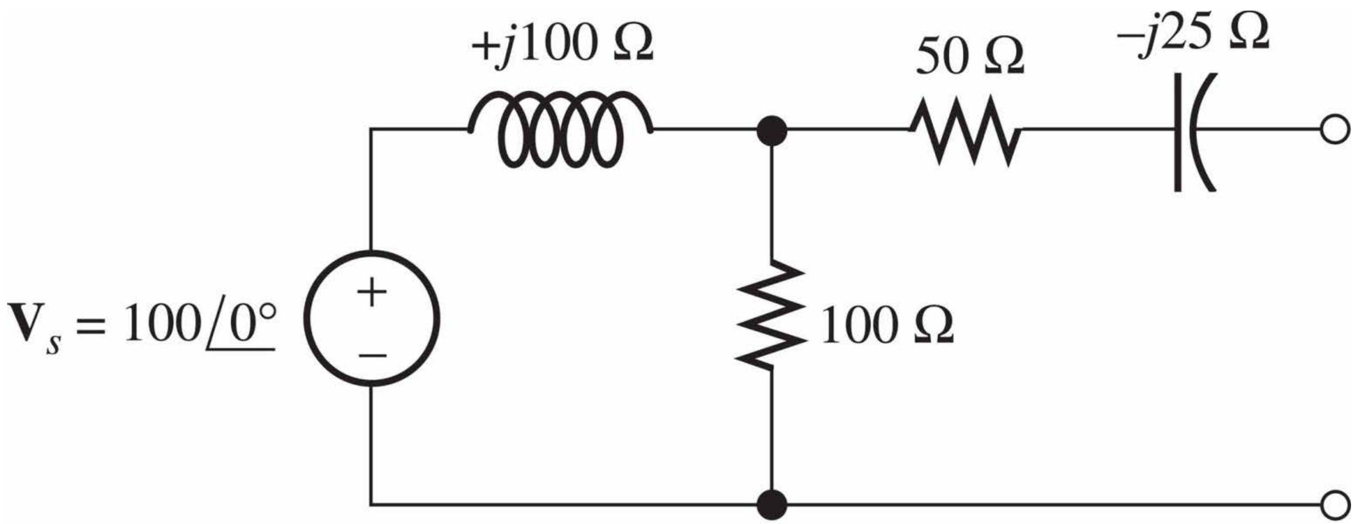
Thévenin example



Plan:

- Find open-circuit voltage
- Find impedance

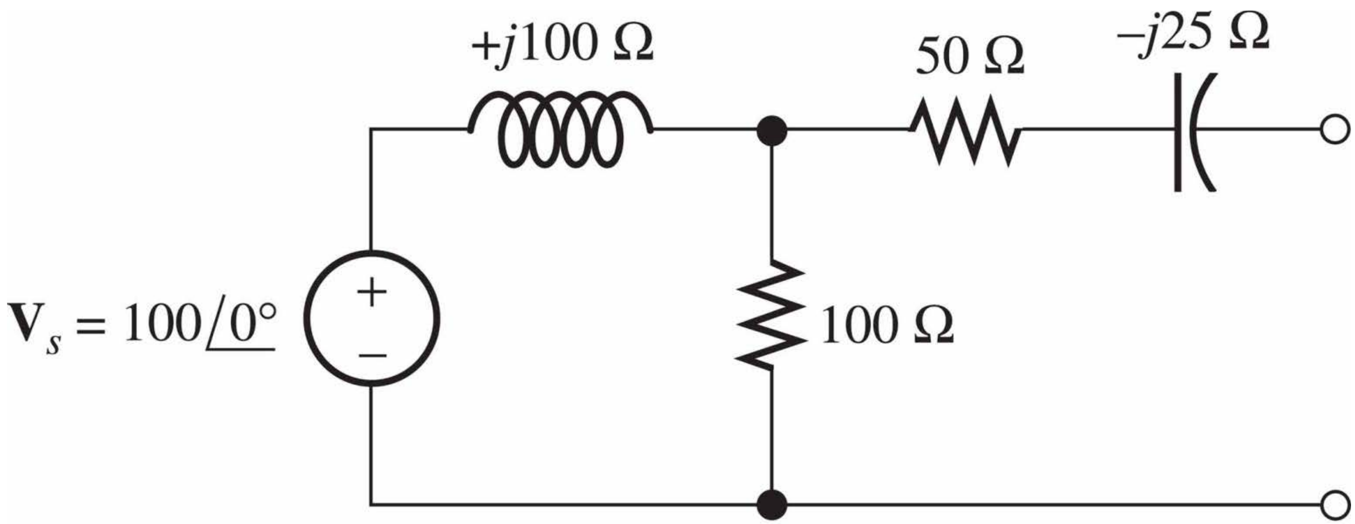
Thévenin example (cont.)



Open circuit voltage:

- NOTE that no current upper-right branch, since o.c.
- This means V_{oc} = V across 100Ω resistor
- Current in 100Ω resistor is $\mathbf{V_s}$ /(j100 + 100)
  $\mathbf{I_s} = 100\angle 0° / 141 \angle 45° = 0.707\angle -45°$
- So $\mathbf{V_{oc}} = 100\ \mathbf{I_s} = 70.7\angle -45°$

Thévenin example (cont.)



Equivalent impedance:

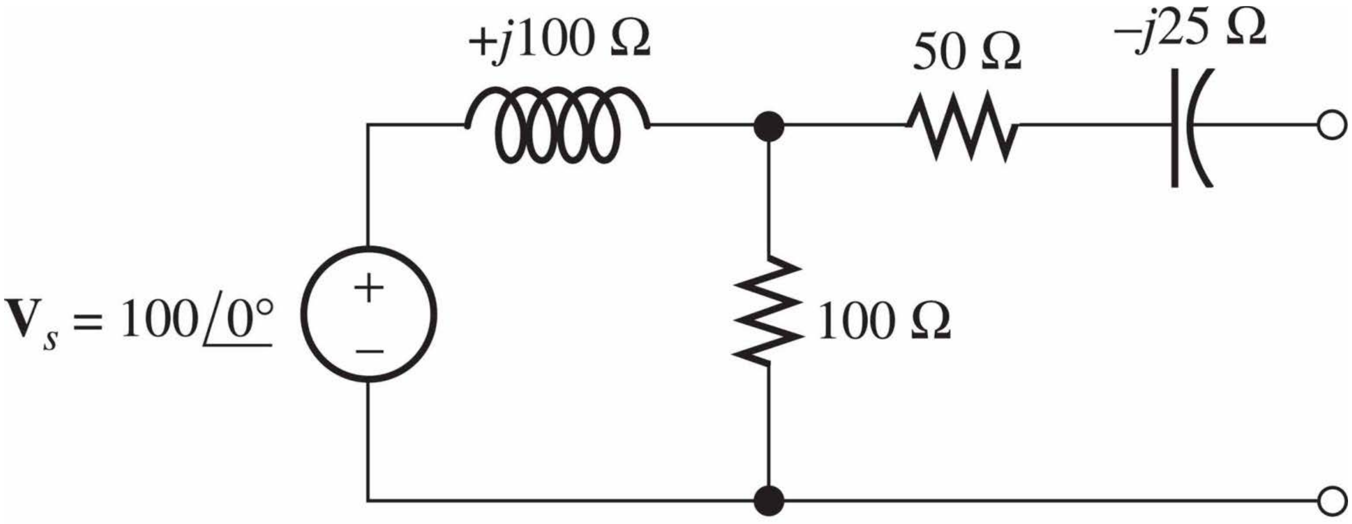
- Turn "off" $\mathbf{V_s}$ (zero volts means short circuit)
- $\mathbf{Z_t} = 50 - j25 + (\ 100 \parallel j100\ )$

  $= 50 - j25 + j10000/(100 + j100)$

  Note $10000\angle 90° \ / \ 141\angle 45° \ = 70.92 \ \angle 45°$

$= 50 - j25 + 50.15 + j50.15 = 100.15 + j25.15$

Thévenin example (cont.)



- $\mathbf{V_t =}$ 70.7∠-45° volts
- $\mathbf{Z_t}$ = 100 + j25 = 103 ∠14° Ω
- $\mathbf{I_n}$ = $\mathbf{V_t/Z_t}$ = 70.7 ∠-45° / 103 ∠14°
  = 0.686 ∠-59° amps

Maximum Power Transfer

- To maximize the power delivered to a load impedance:

$$\mathbf{Z_{load} = Z_t^*}$$

The load is matched to the *complex conjugate* impedance

- To maximize the power delivered to a *resistive* load:

$$R_{load} = |\mathbf{Z_t}|$$

The resistive load is matched to the *magnitude* impedance

Summary and Review

- Thévenin and Norton concept applies to impedances and steady-state AC analysis
- Apply calculations and simplifications using phasor and complex rectangular arithmetic
- Maximize power transfer with a matched load, either $\mathbf{Z}_{\mathbf{load}} = \mathbf{Z}_{\mathbf{t}}^*$ if complex impedance, or $R_{load} = |\mathbf{Z}_{\mathbf{t}}|$ if resistive load.