First Course on Power Systems

Module 1: (a) Overview and (b) Review

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Reference Textbook:
First Course on Power Systems by Ned Mohan, www.mnpere.com

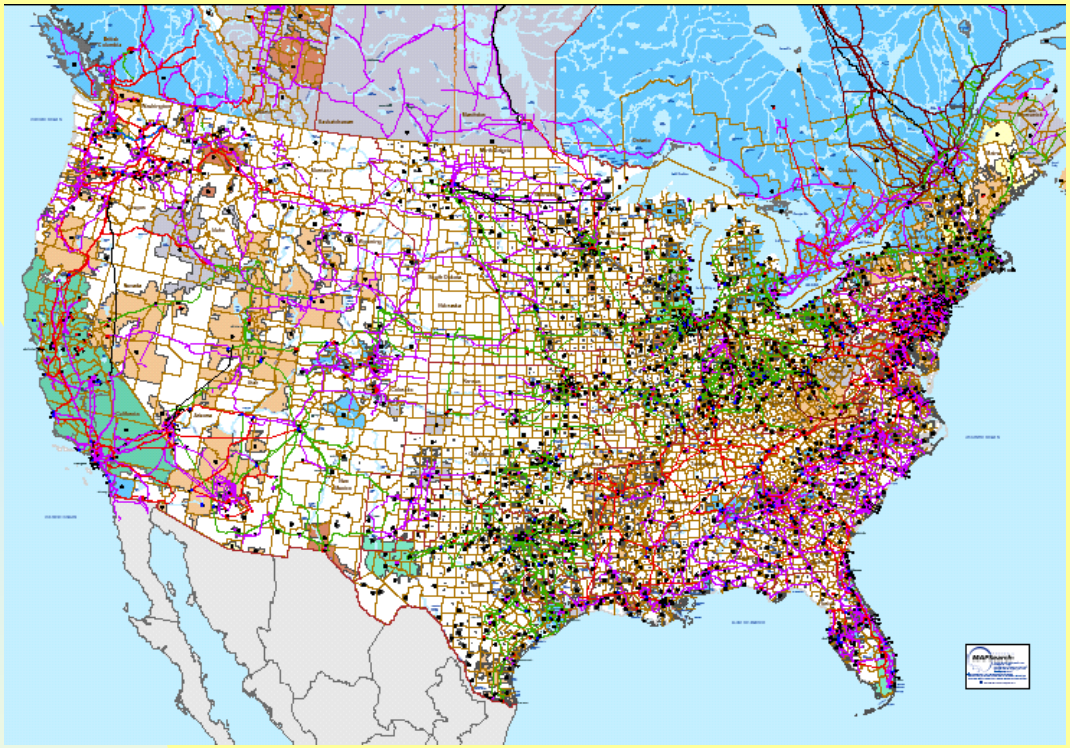
Module 1: (a) Overview

Module 1: (b) Review

Chapter 1

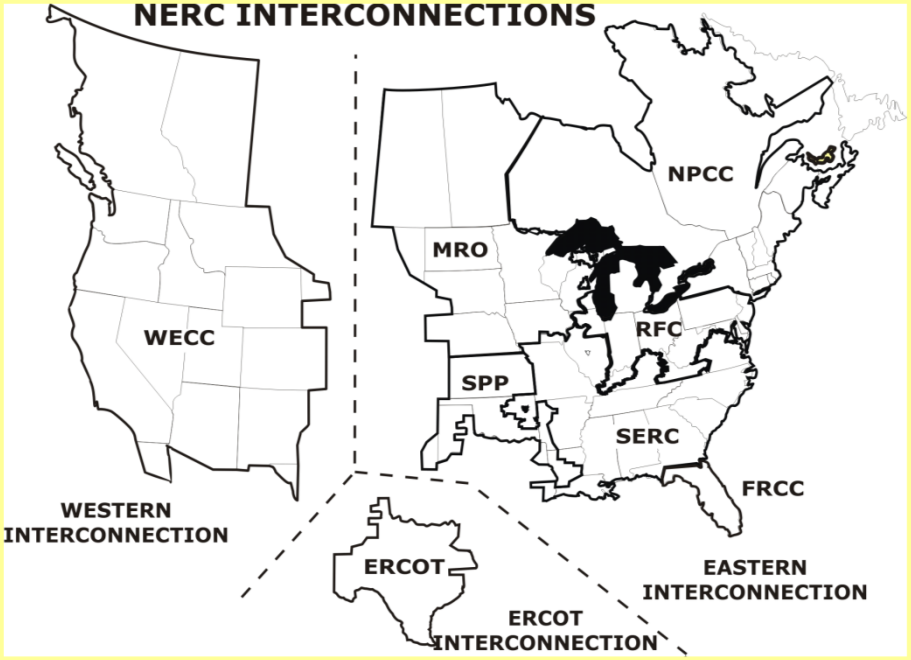
POWER SYSTEMS: A CHANGING LANDSCAPE

NATURE OF POWER SYSTEMS



- Thousands of Generators operating in synchronism
- Over 200,000 miles of Transmission Lines over 230 kV
- Advantages of an interconnected system
  - Continuity of service
  - Lowest cost

Interconnections and Control Areas



NERC's Mission

- Bulk Electric System is Reliable, Adequate and Secure
- Three interconnections are divided into 152 Control Areas
  - Each control area controls its own generation
    - maintain its interchange schedule
    - contributes to frequency regulation of interconnection

One-line Diagram

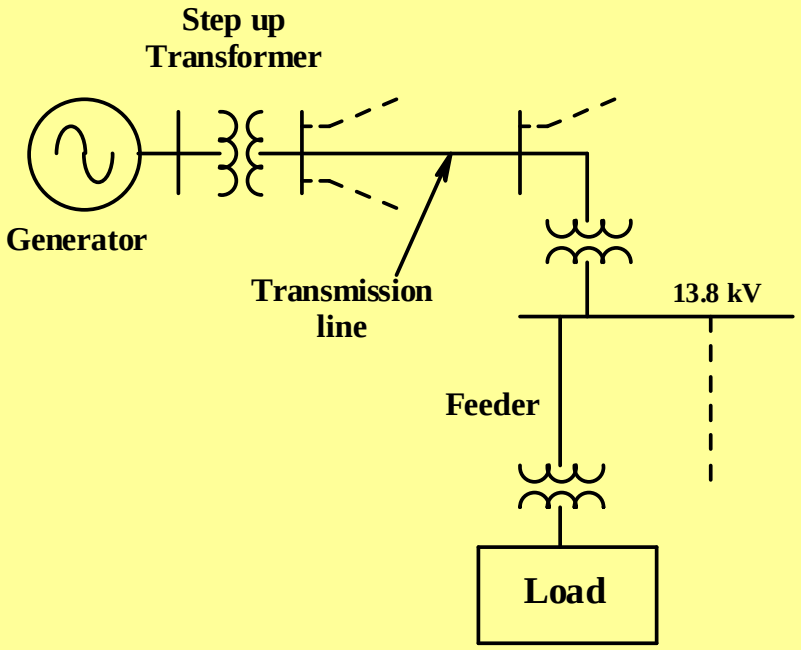
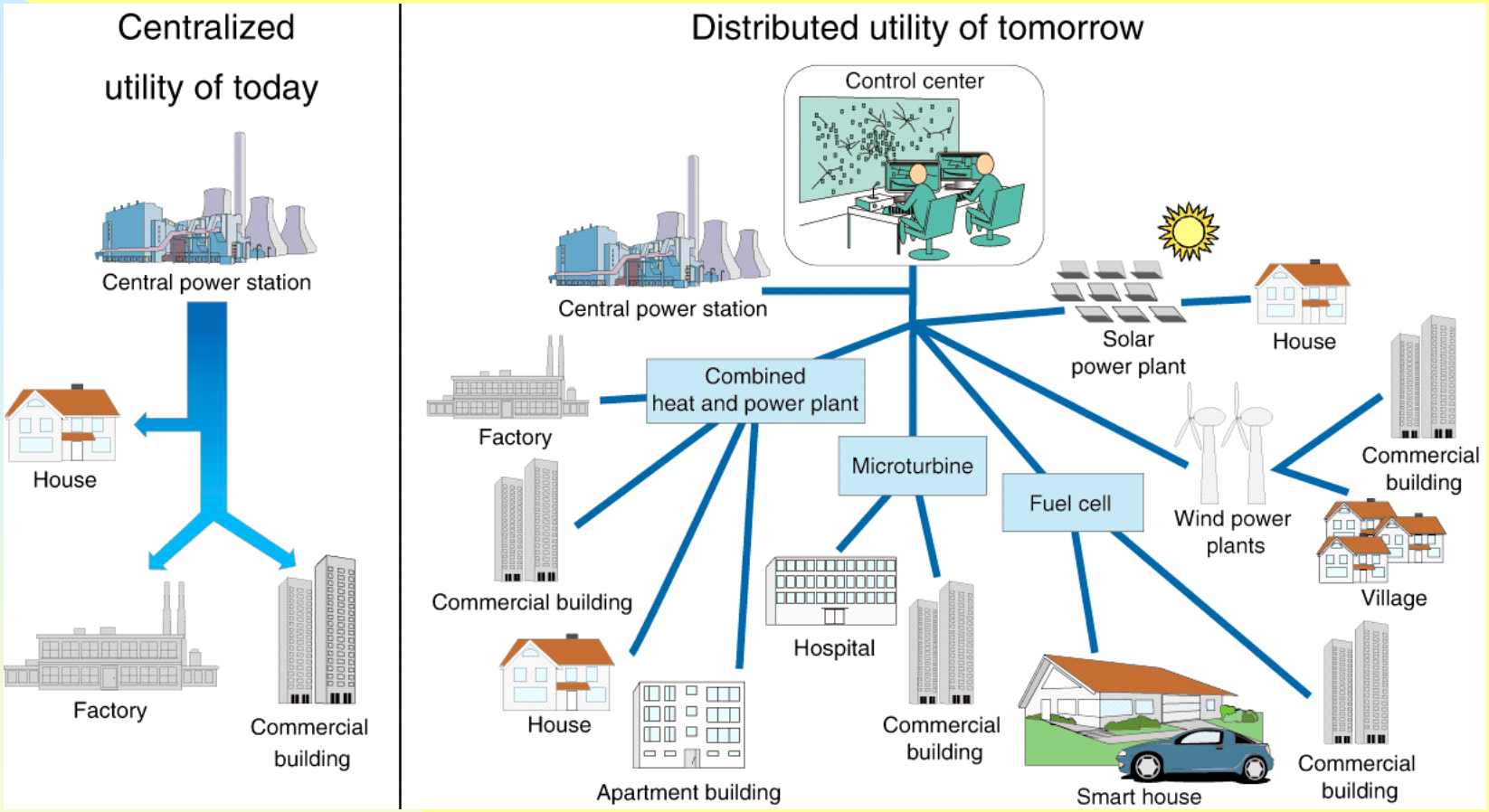


Fig. 1-3 One-line diagram as an example.

CHANGING LANDSCAPE OF POWER SYSTEMS AND UTILITY DEREGULATION



(*a*) (*b*)

Fig. 1-4 Changing landscape [4]. Source: ABB.

Module 1: (b) Review

Symbols and Conventions

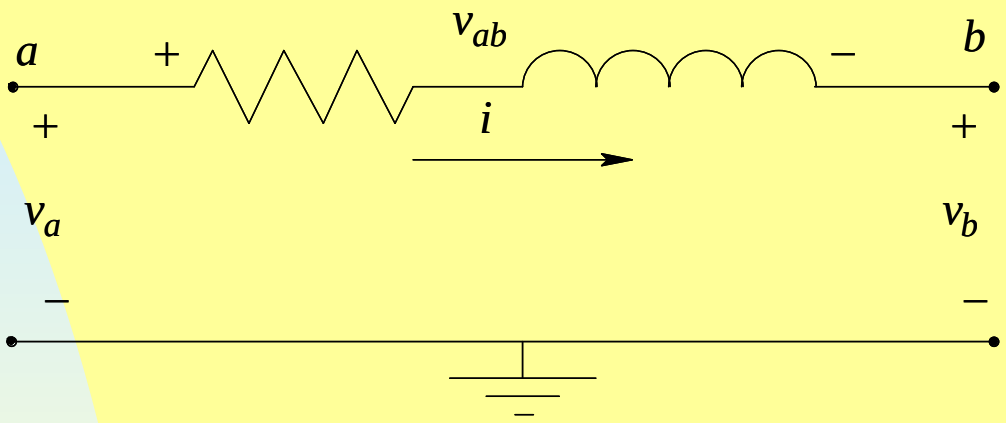


Fig. 2-1 Convention for voltages and currents.

Phasors

$$v(t) = \sqrt{2}\,V\cos\omega t$$

$$i(t) = \sqrt{2}\,I\cos(\omega t - \phi)$$

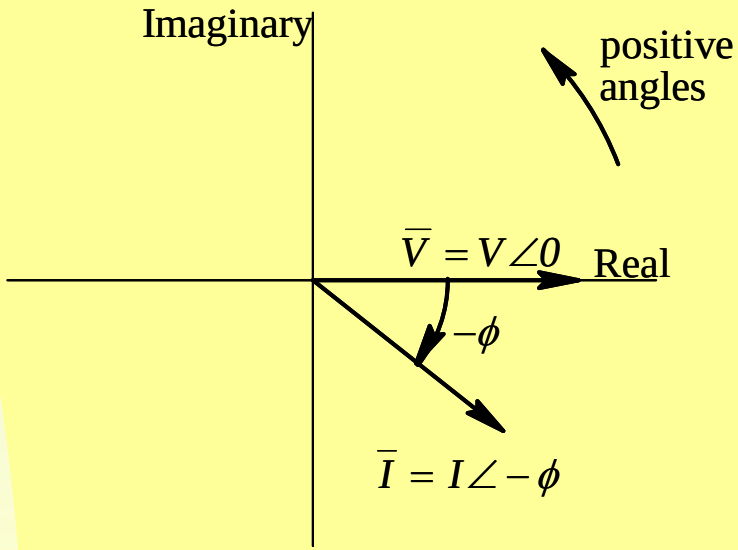


Fig. 2-2 Phasor diagram.

Phasor Analysis

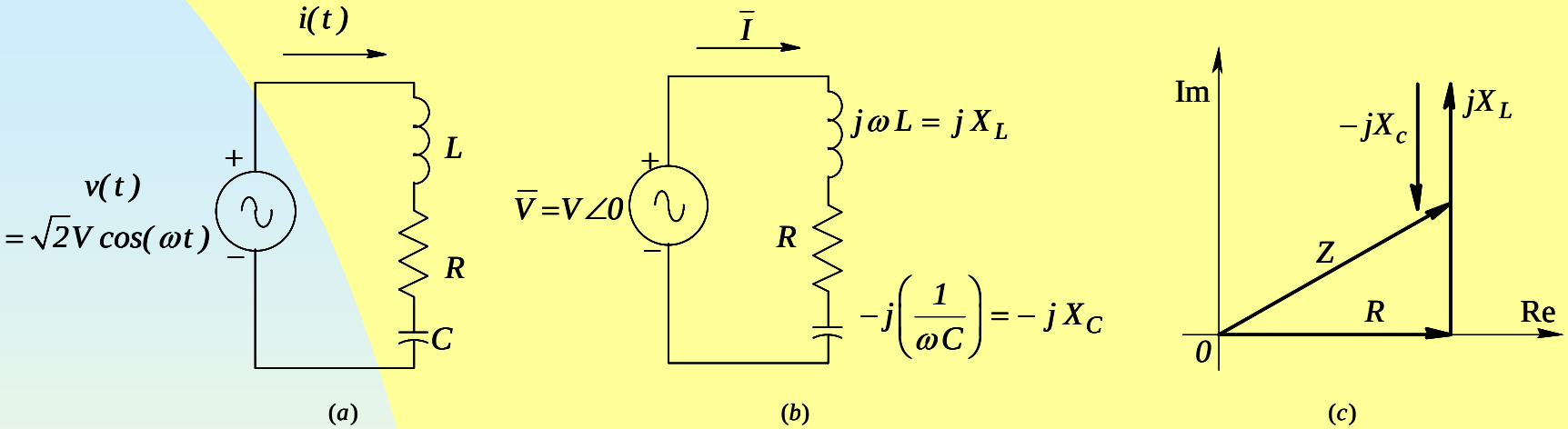


Fig. 2-3 A circuit (a) in time-domain and (b) in phasor-domain; (c) impedance triangle.

Instantaneous Power Flow

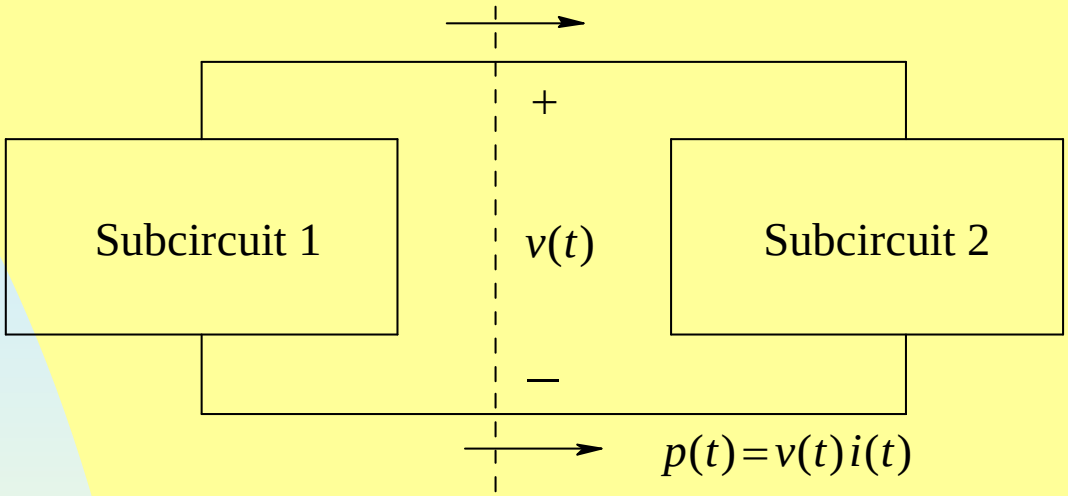
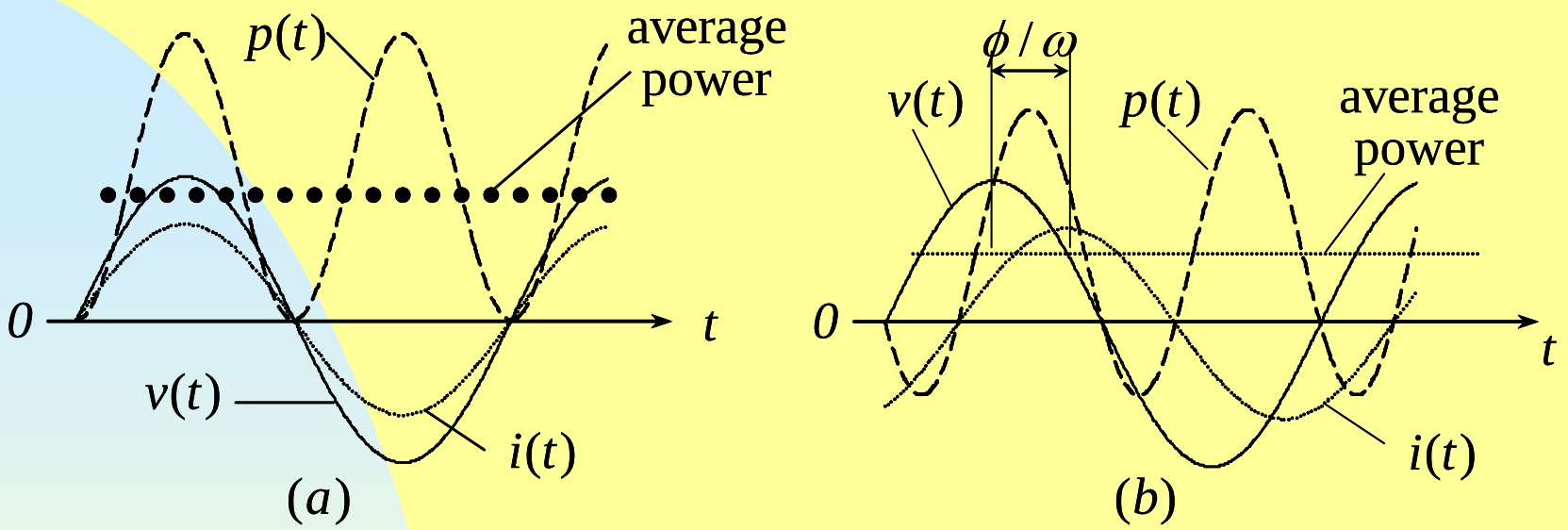


Figure 2-6 A generic circuit divided into two sub-circuits.

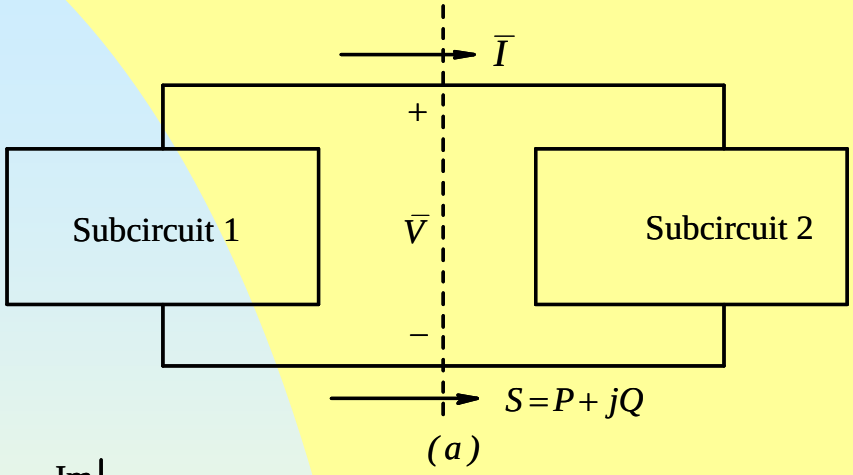
Real and Reactive Power



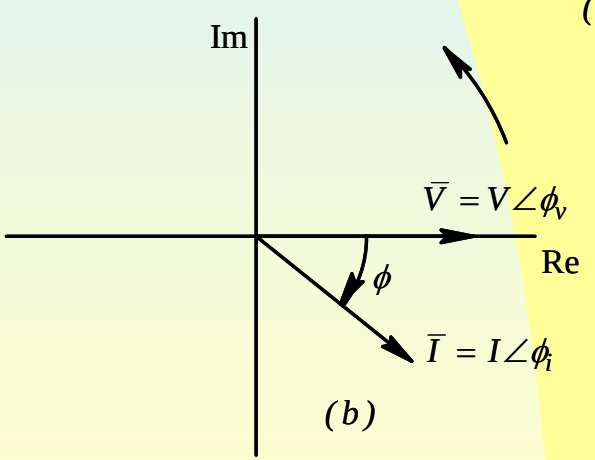
$$(a)\quad p(t) = \sqrt{2}V\cos\omega t \cdot \sqrt{2}I\cos\omega t = 2VI\cos^2\omega t = VI + VI\cos 2\omega t$$

$$(b)\quad p(t) = \sqrt{2}V\cos\omega t \cdot \sqrt{2}I\cos(\omega t - \phi) = VI\cos\phi + VI\cos(2\omega t - \phi)$$

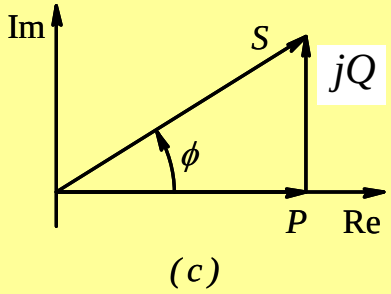
P, Q, VA and Power Factor



(a)



(b)



(c)

$$S = \bar{V}\,\bar{I}^{*}$$

$$S = V\,I\angle\phi = P + jQ$$

$$P = V\,I\cos\phi$$

$$Q = V\,I\sin\phi$$

$$|S| = \sqrt{P^2 + Q^2}$$

$$\phi = \tan^{-1}\left(\frac{Q}{P}\right)$$

$$\text{Power Factor} = \frac{P}{VI} = \cos\phi$$

Example of Power Factor Correction

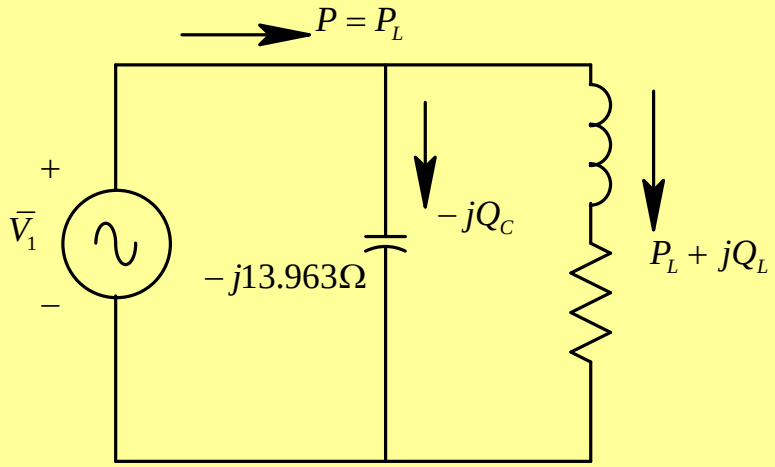


Fig. 2-9 Power factor correction in Example 2-5.

One-line Diagram