Elektrische Aandrijvingen

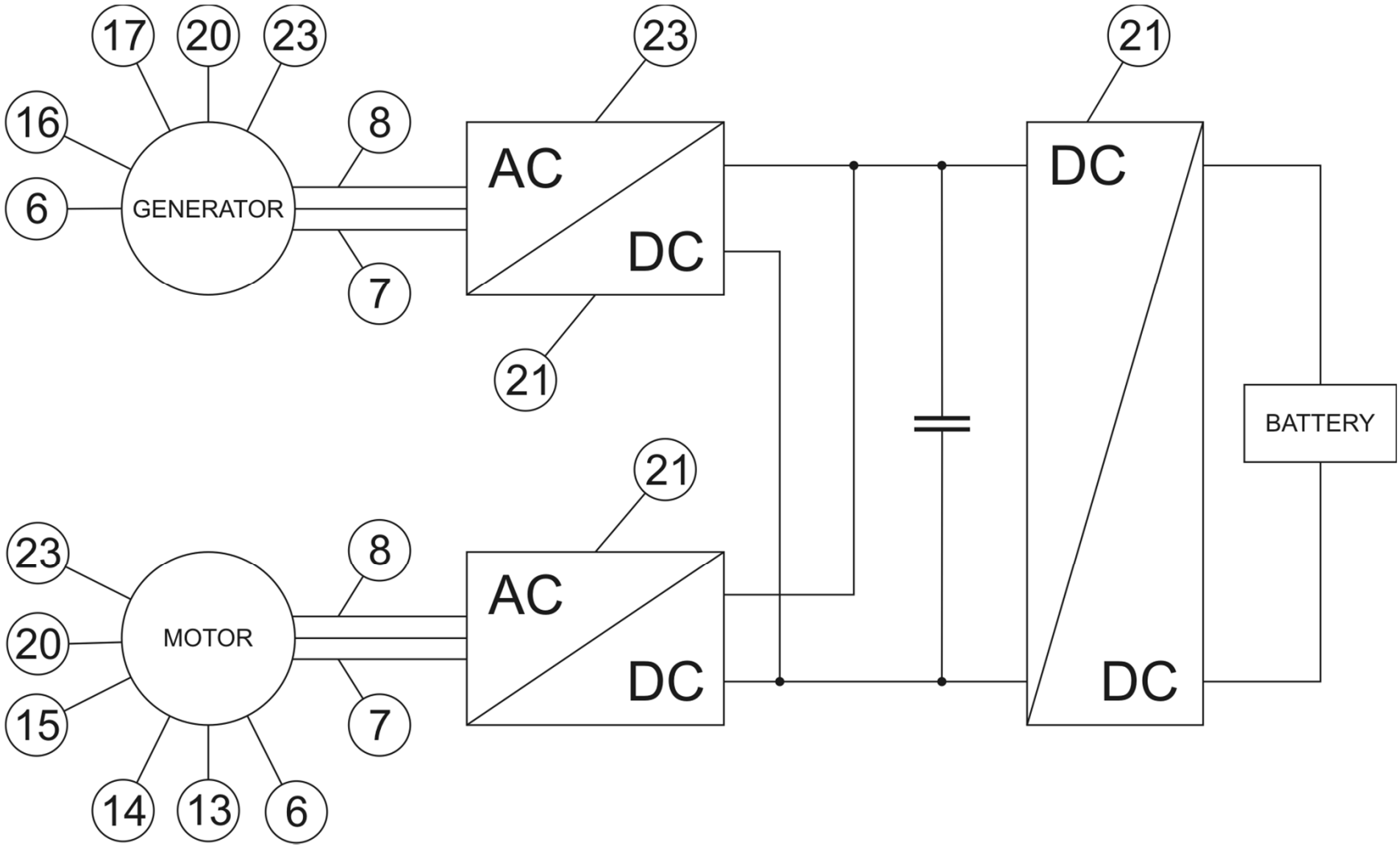
WTB

Lokatie / evenement

P.BAUER

February 22, 2013

TU Delft
Delft University of Technology


17
20
23
16
8
6
GENERATOR
7
23
AC
DC
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DC
DC
BATTERY
21
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8
20
MOTOR
15
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14
13
6
AC
DC

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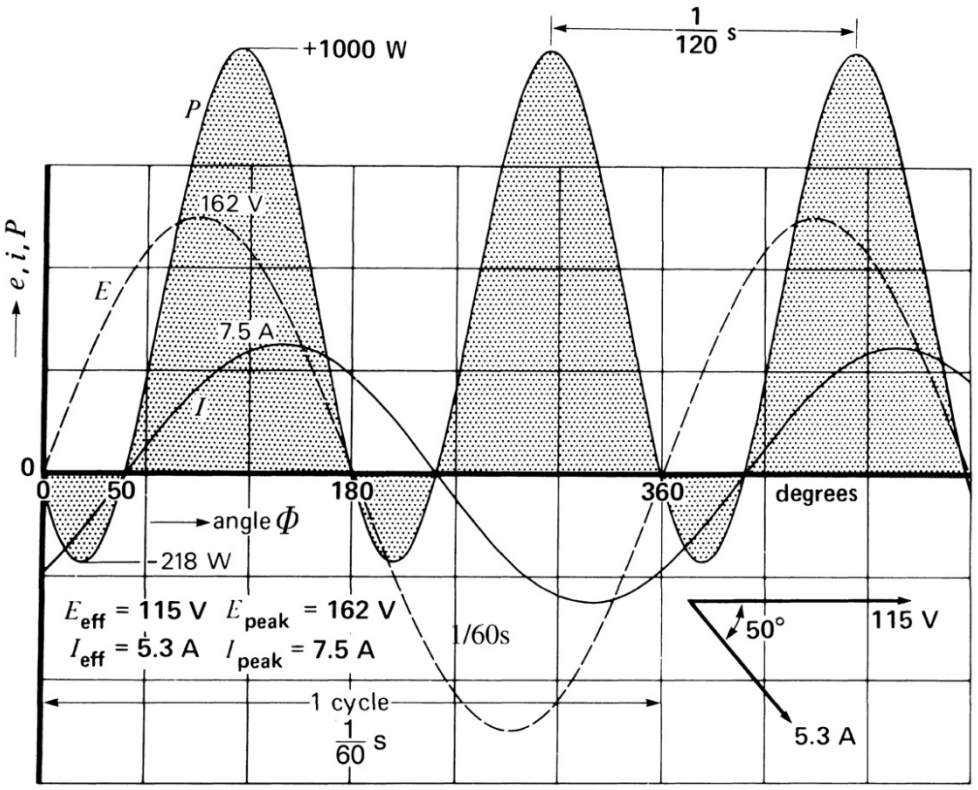
Active, Reactive and Apparent Power

FIGURE 7-1 **Instantaneous voltage, current, and power in an ac circuit. (See Example 7-1.)**



Voltage 162 V, 60Hz
Current 7,5A lags 50

Voltage and current Φ
Inst.voltage, current, p 120°

- $e=E_m \sin \Phi = 162 \sin \Phi$
- $i= I_m \sin(\Phi - \theta)$
  $=7,5 \sin(\Phi - 50°)$
- $\Phi = 120°$
- $i=7,05A$
- $p=e.i=140.3 \times 7,05$

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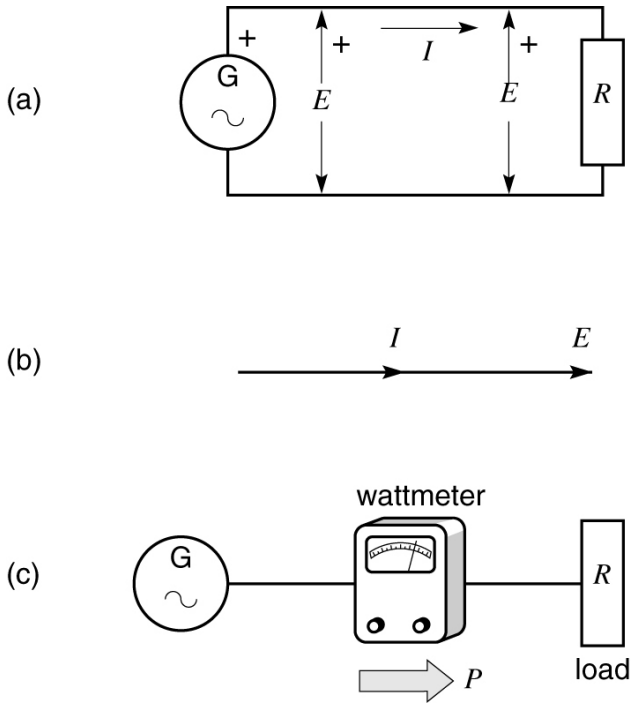
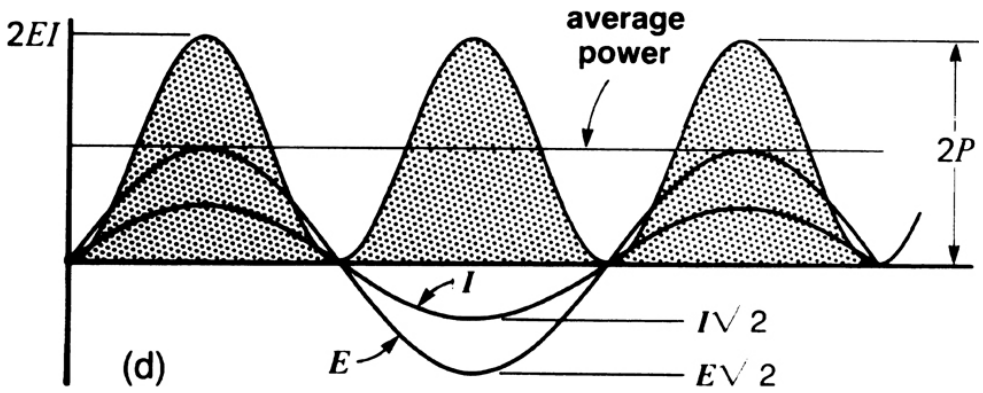
Active Power

FIGURE 7-2 **a. An ac voltage *E* produces an ac current *I* in this resistive circuit. b. Phasors *E* and *I* are in phase. c. A wattmeter indicates *EI* watts. d. The active power is composed of a series of positive power pulses.**





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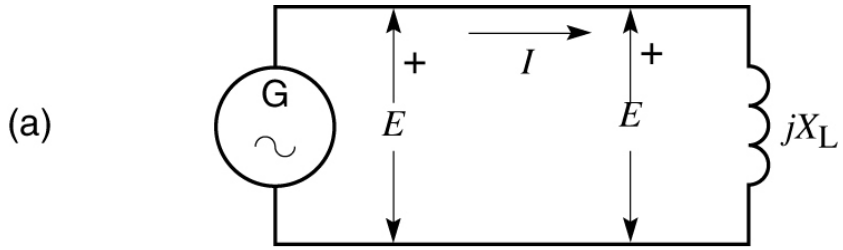
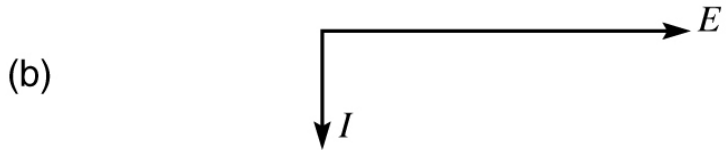
Reactive Power

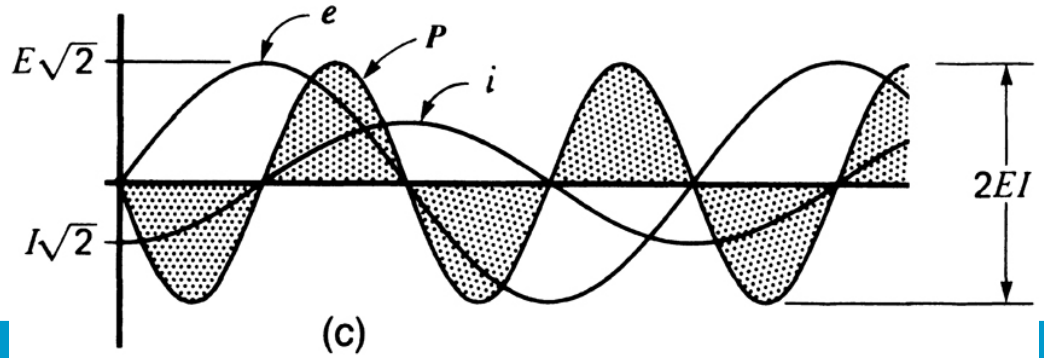
FIGURE 7-4 **a. An ac voltage *E* produces an ac current *I* in this inductive circuit. b. Phasor *I* lags 90° behind *E*. c. Reactive power consists of a series of positive and negative power pulses.**



What is load and what is source of reactive power?



Impossible to say, reactor is considered to be a reactive load



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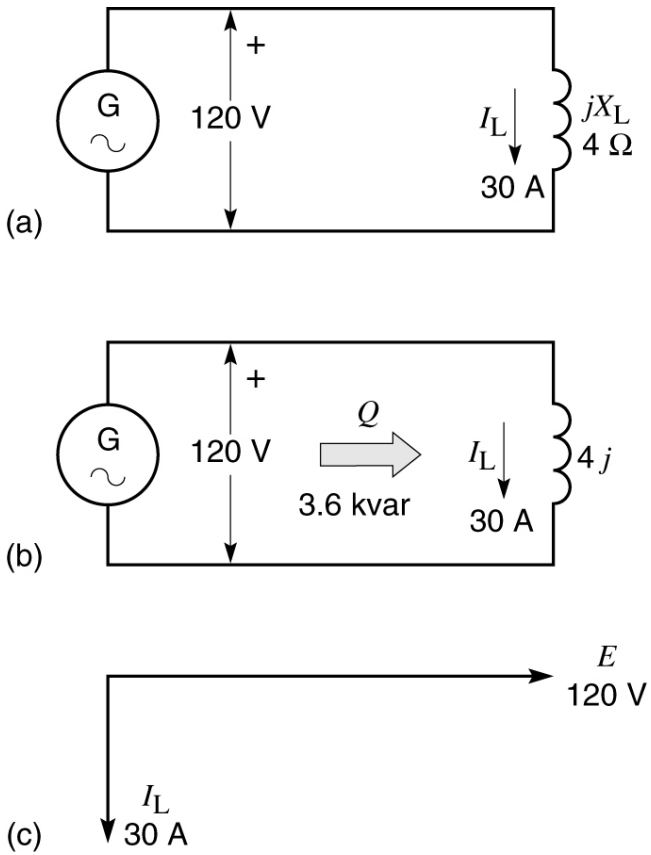
Reactive Load and Reactive Source

FIGURE 7-6 **See Example 7-2.**



Reactor having an inductive reactance 4 Ω, connected to 120 V AC generator

a. Calculate the current

b. Calculate the reactor power

c. Calculate generator power

d. Draw the phasor diagram

- $I_L = E/X_L = 120/4 = 30A$
- $Q = E\,I = 120 \cdot 30 = 3{,}6$ kVAr

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Capacitor and Reactive Power

Add capacitor

FIGURE 7-6 **See Example 7-2.**

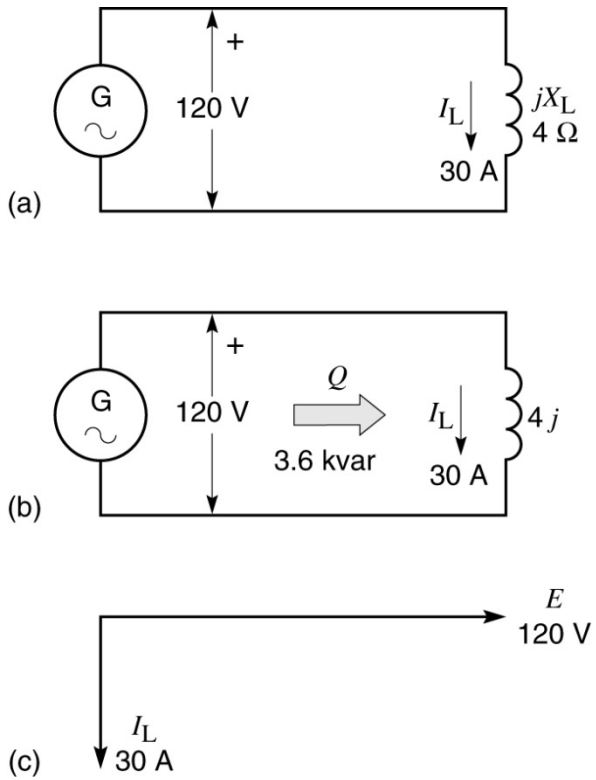
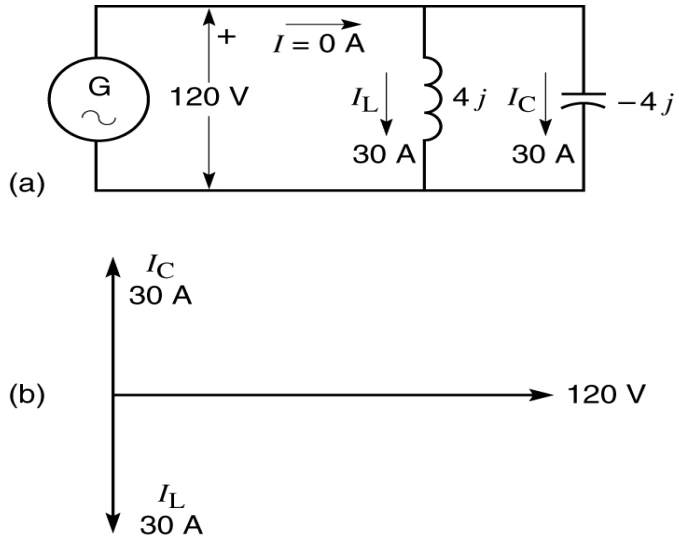


FIGURE 7-7 **See Example 7-3.**



Generator does not supply any power

- Reactive power delivered by capacitor
- $Q = E\, I_c = 120 \cdot .30 = 3{,}6$ kVAr

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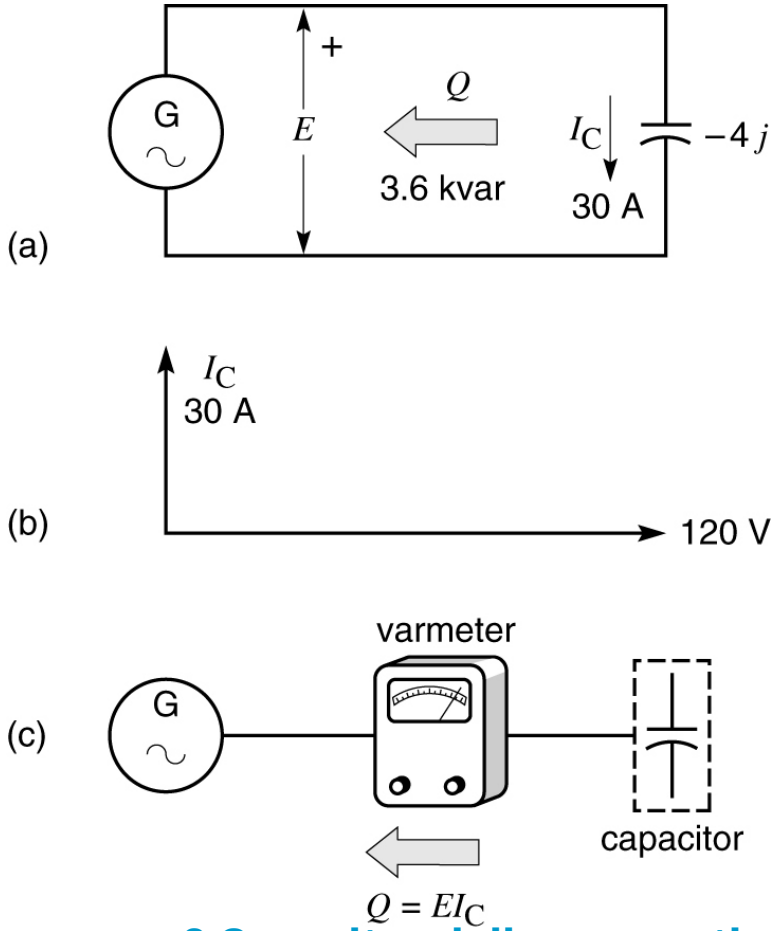
Capacitor and Reactive Power

FIGURE 7-8 **a. Capacitor connected to an ac source. b. Phase I_C leads E by 90°. c. Reactive power flows from the capacitor to the generator.**



Where does the power go ? Capacitor delivers reactive power to the generator

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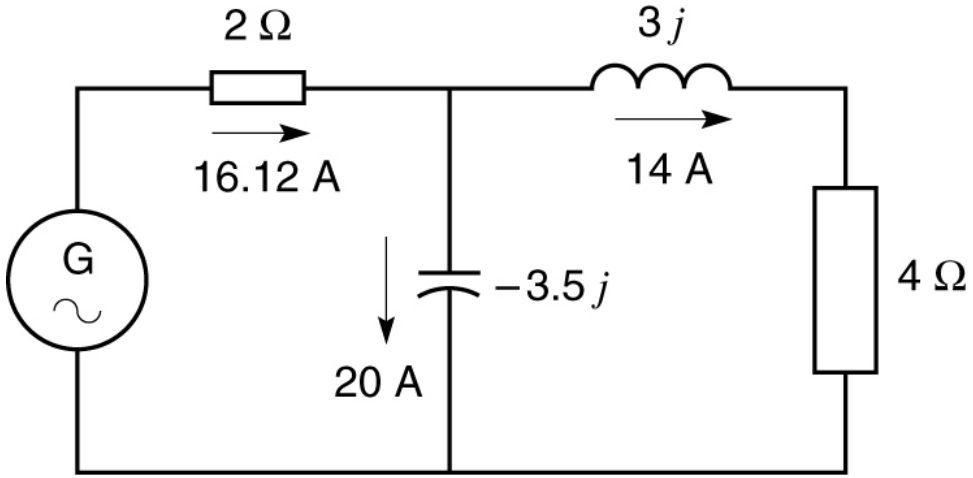
Example 7.3

- Calculate the Active and reactive power of G



- $P = R\ I^2 = 14^2 \cdot 4 + 16{,}12^2 \cdot 2 = 1304W$
- $Q_l = X_l\ I^2 = 14^2 \cdot 3 = 588$ VAr
- $Q_c = X_c I^2 = 20^2 \cdot 3{,}5 = 1400$ VAr
- 1400-588=812 VAr

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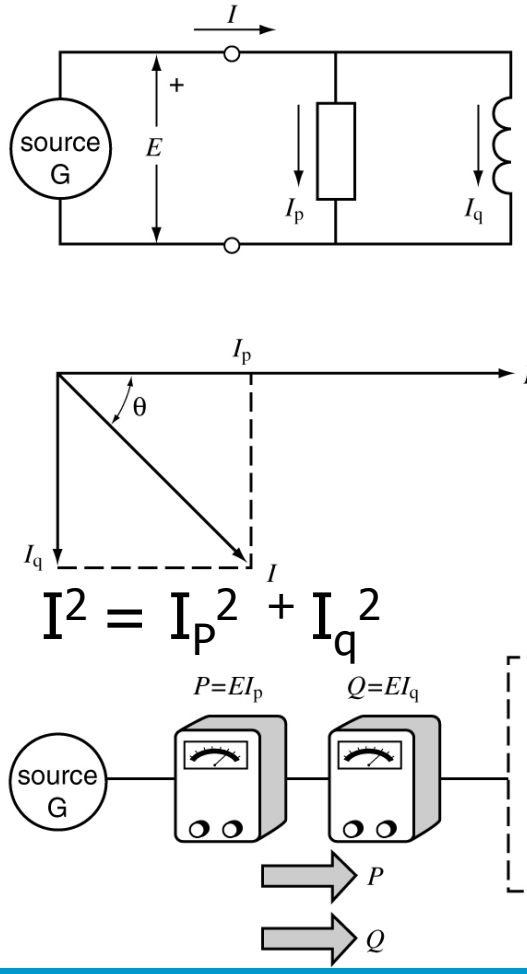
Active and Reactive load: Apparent power

FIGURE 7-10 a. Circuit consisting of a source feeding an active and reactive load. b. Phasor diagram of the voltage and cu
c. Active and reactive power flow from source to load.



Active and reactive power – cannot be converted

Function independently

Can be treated separately

Place a burden on line and generator

All inductive devices absorb reactive power

- $I^2 = I_p^2 + I_q^2$

Ammeter, power supplied P, EI

Apparent power

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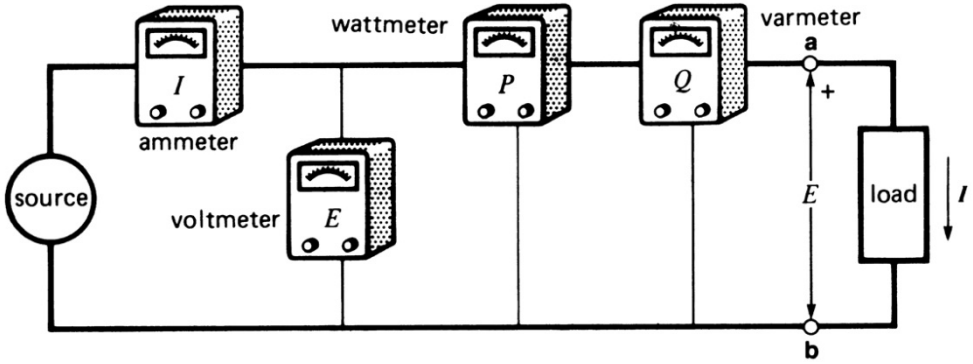
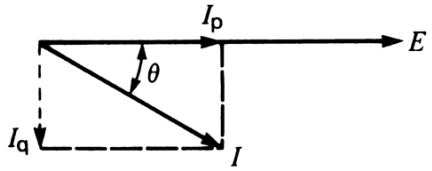
P,Q, and S

FIGURE 7-11 **a. Instruments used to measure *E*, *I*, *P*, and *Q* in a circuit. b. The phasor diagram can be deduced from the instrument readings.**



(a)



Generator does not supply any power

(b)

- $I_P = P/E$
- $I_q = Q/E$
- $S = E\,I$
- $I = S/E$
- $I^2 = I_P^2 + I_q^2$
- $S^2 = P^2 + Q^2$

- S apparent power [VA]
- P active power [W]
- Q reactive power [VAr]
- Power factor pf=P/S

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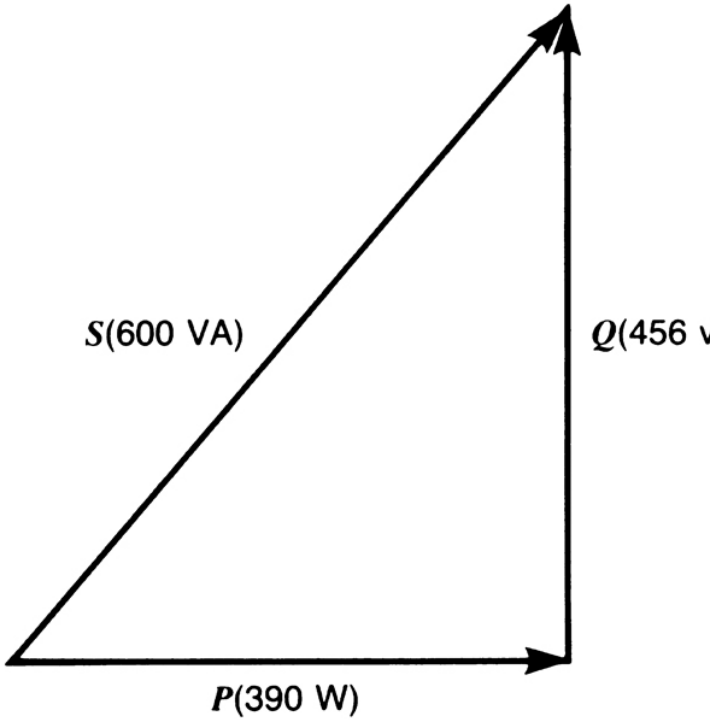
Example 7.8

- Motor draws 5 A from 120 V, 60 Hz, pf=0,65

- S = E I = 120. 5 = 600 VA
- P = S cos θ = 600 . 0,65 =390 W
- Q = SQRT(S^2-P^2)
- Q = 456 VAr



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Power Factor and Power Triangle

FIGURE 7-12 **Power triangle of a motor. See Example 7-8.**

- Power Factor = P/S

Active power – horizontally absorbed or delivered

Reactive power – vertically absorbed or delivered

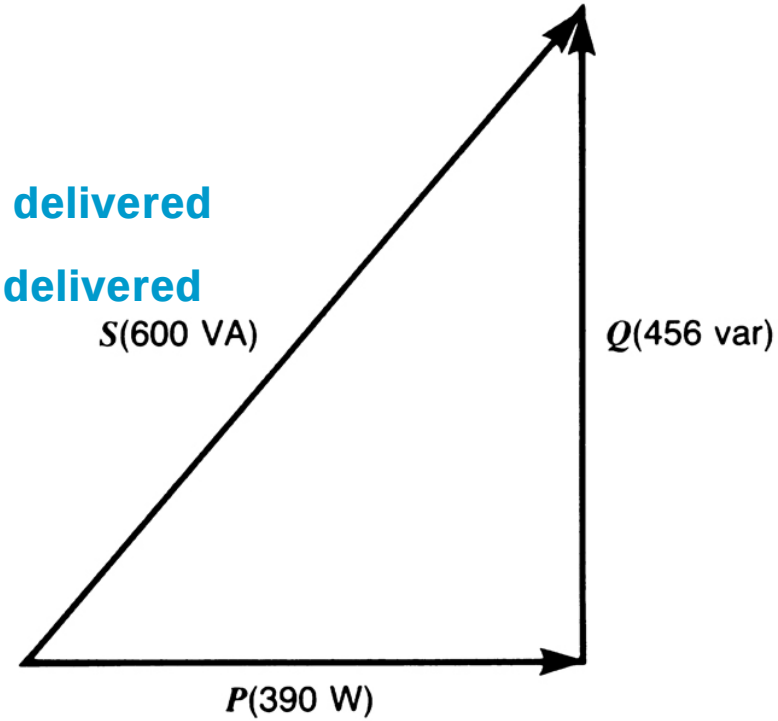

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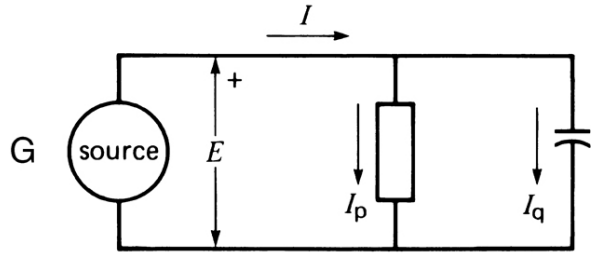
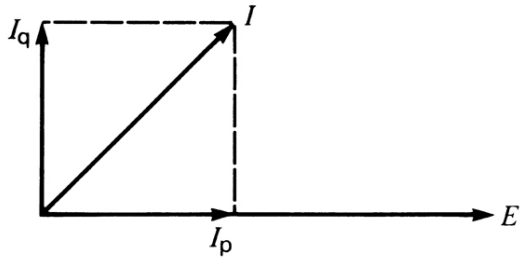
FIGURE 7-13 **a. Source feeding an active and reactive (capacitive) load. b. Phasor diagram of the circuit. c. The active and reactive powers flow in opposite directions.**

Two powers in opposite direction

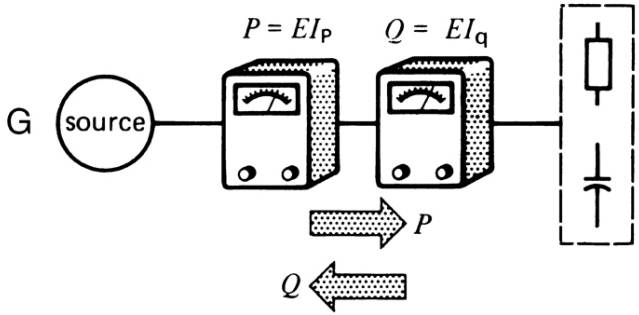
(a)



(b)



(c)



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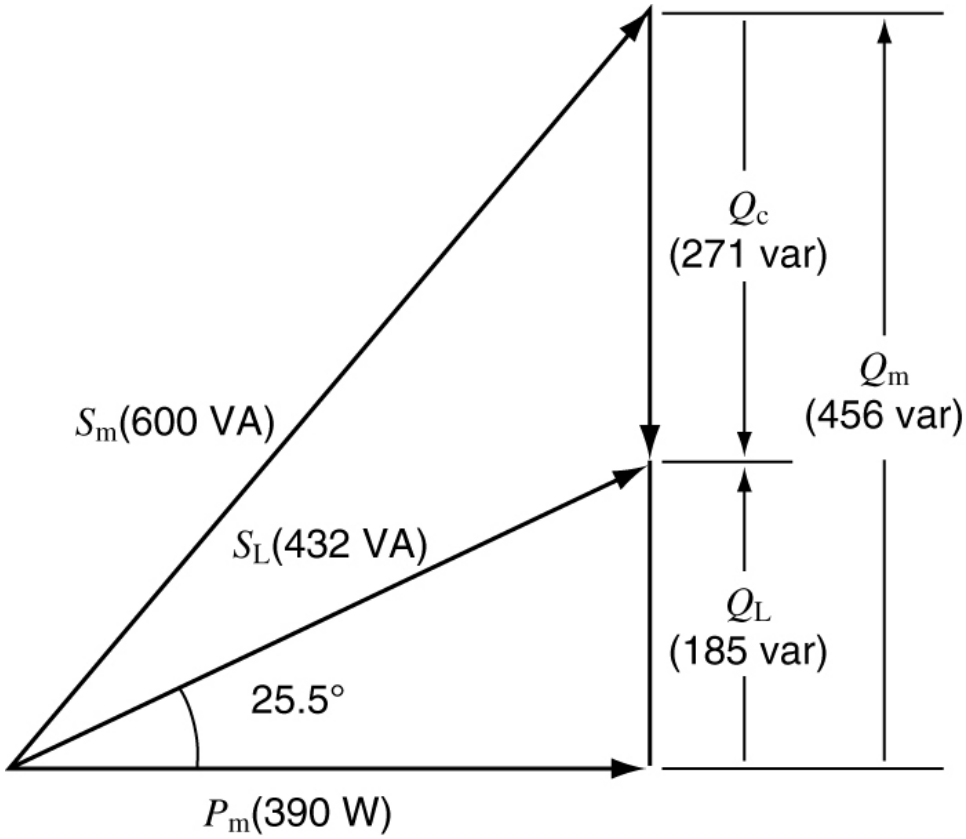
- **Motor draws 5 A from 120 V, 60 Hz, pf=0,65**

Example 7-9

FIGURE 7-14 **Power triangle of a motor and capacitor connected to an ac line. See Example 7-9.**

+ Capacitor 50uF



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- **Motor draws 5 A from 120 V, 60 Hz, pf=0,65**

Example 7-9

+ Capacitor 50uF

- $X_C = 1/\omega C = 53\ \Omega$
- $I = E/X_C = 2{,}26$ A
- $Q_c = E\ I_q = 271$ VAr
- $P_m = 390$ W
- $Q_m = 456$ VAr
- $Q_L = Q_m - Q_c$
- $S_L = SQR\ (P_{L2} + Q_{L2})$
- $I = S_L/E = 3{,}6$ A

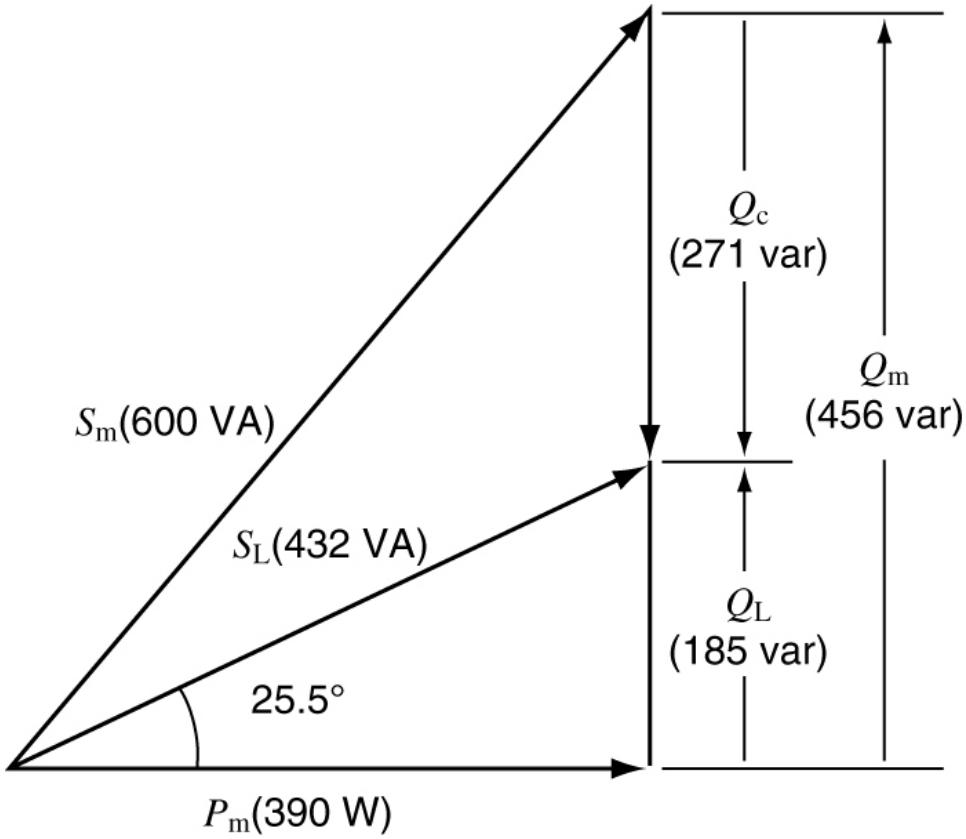

FIGURE 7-14 **Power triangle of a motor and capacitor connected to an ac line. See Example 7-9.**

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Several Loads

FIGURE 7-15 **a. Example of active and reactive loads connected to a 380 V source. b. All loads are assumed to be directly connected to the 380 V receptacle.**

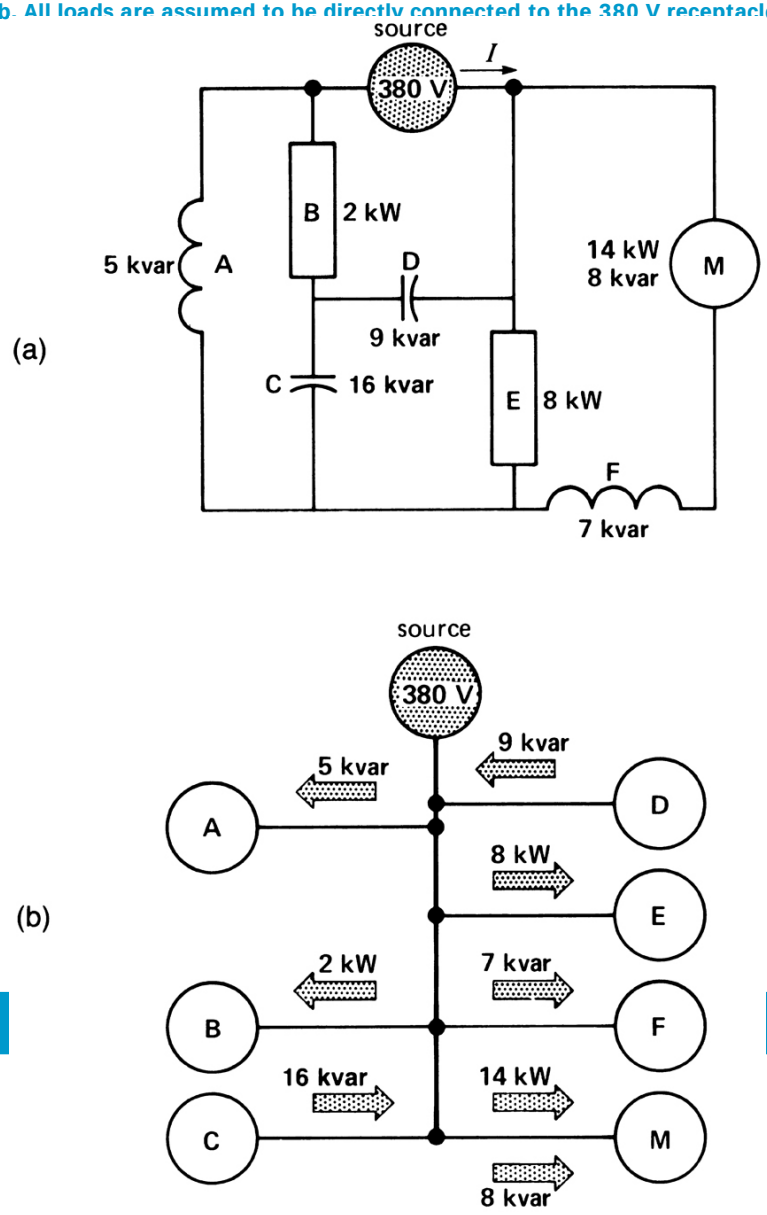

FIGURE 7-15c **Power triangle of the system.**

Several Loads

FIGURE 7-15 **a. Example of active and reactive loads connected to a 380 V source. b. All loads are assumed to be directly connected to the 380 V receptacle.**

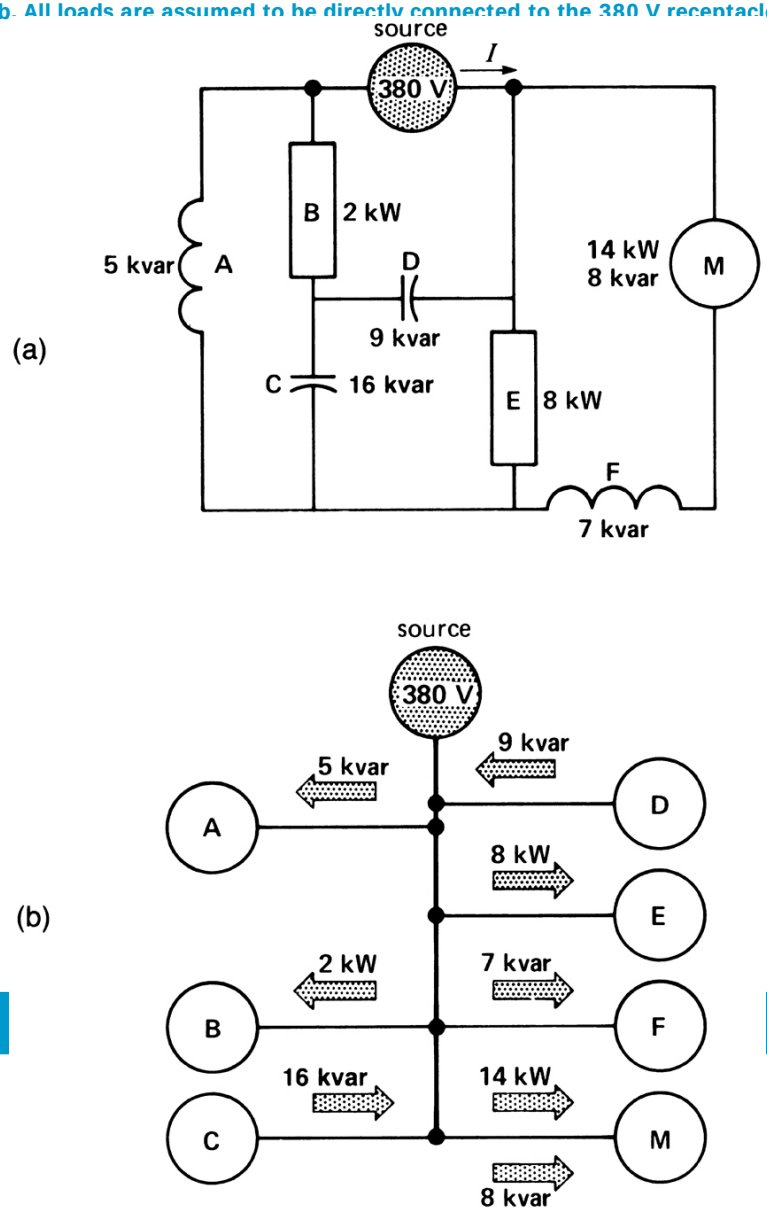

FIGURE 7-15c **Power triangle of the system.**

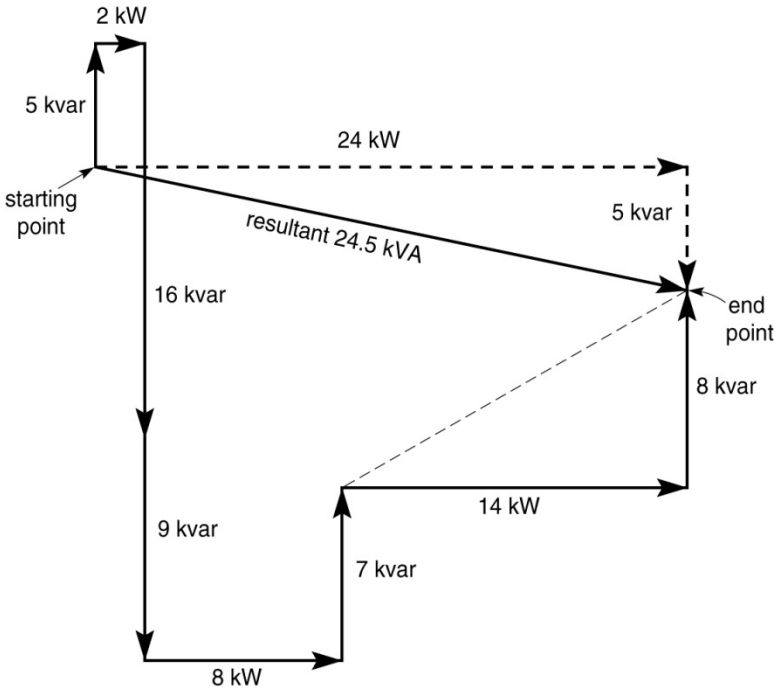

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FIGURE 7-16 **a. Active and reactive power flow in a switched resistive load. b. The delayed current flow is the cause of the reactive power absorbed by the system.**

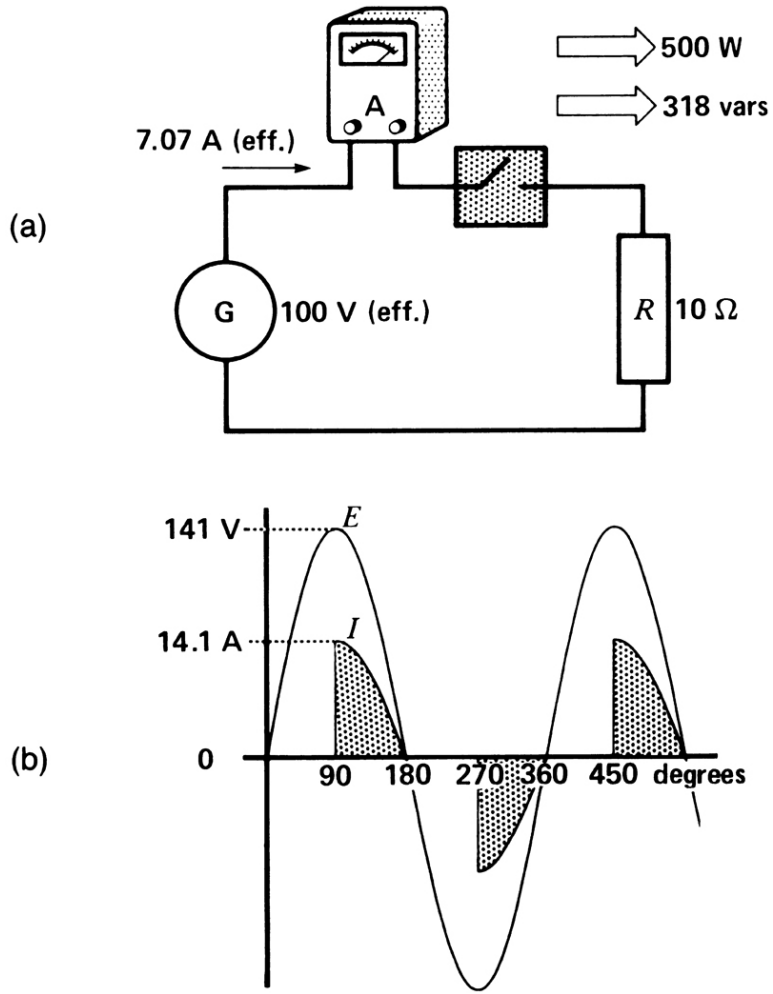
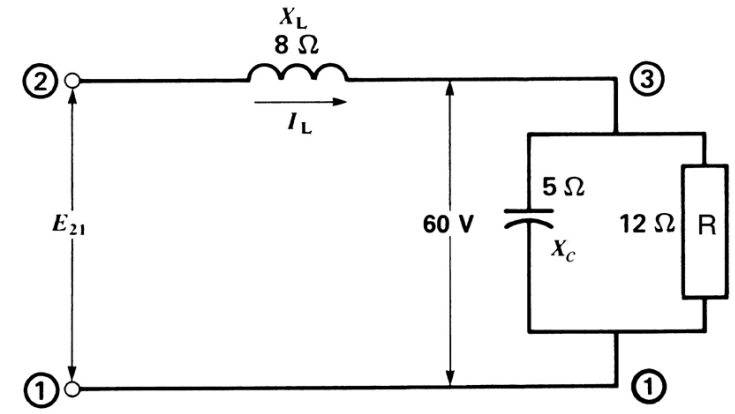
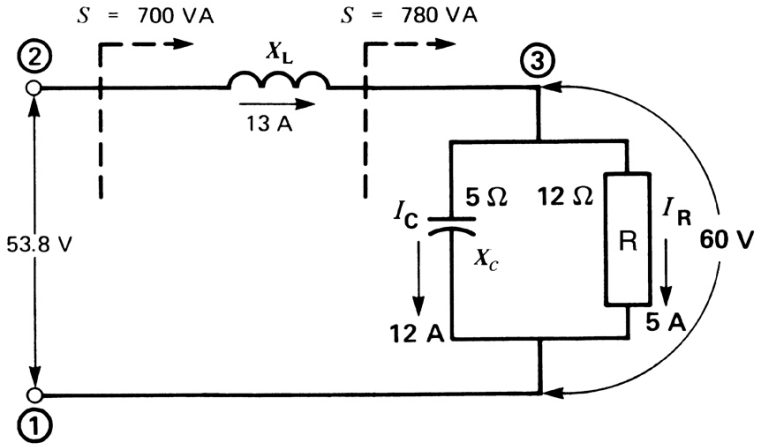


FIGURE 7-17 **a. Solving ac circuits by the power triangle method. b. Voltages and currents in the circuit. See Example 7-10.**



(a)



(b)

Current in each element

Voltage between 1 -2

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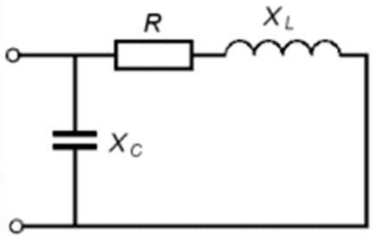
AC Voltage 1

1	An inductance and a resistor are in series connected to a power source of 220 V and 50 Hz. R = 30 Ω; L = 127.3 mH. Calculate the rms current in the source [in A]
2	For the same inductance and resistor: What is the powerfactor?
3	For the same inductance and resistor: Calculate the rms voltage of the resistor [in V]
4	For the same inductance and resistor: Calculate the rms voltage of the inductance [in V]
5	For the same inductance and resistor connected to a power source of 220 V and 60 Hz. (R = 30 Ω; L = 127.3 mH) Calculate the rms current in the source [in A]
6	A capacitor is connected to a voltage source of 220 V / 50 Hz. C = 33 µF. Calculate the rms current in the source [in A]
7	A resistor and a inductor in series, are in parallel connected with a capacitor as shown in the schematic. X_L= 4 Ω; R_L= 3 Ω; X_C= 8 Ω Calculate the total equivalent impedance .



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