Problem 1 (10 points)

U=120V
F=60Hz
I=5A
Pf=cosφ=0,65

a. Calculate the reactive power generated by the capacitor. *(2 points)*

$$X_c = \frac{1}{2 \cdot \pi \cdot f \cdot C} = \frac{1}{2 \cdot \pi \cdot 60 \cdot 60 \cdot 10^{-6}} = 44,21\Omega \quad I_c = \frac{U}{X_c} = \frac{120}{44,21} = 2,71A$$

$$Q_c = U \cdot I_c = 120 \cdot 2,71 = 325VAr$$

b. Calculate the active power absorbed by the motor. *(2 points)*

$$P = U \cdot I \cdot \cos\varphi = 120 \cdot 5 \cdot 0,65 = 390W$$

c. The reactive power absorbed from the line. *(2 points)*

Reactive power absorbed by the motor. $Qm_r = U \cdot I \cdot \sin\varphi = 120 \cdot 5 \cdot \sin 49,46^0 = 455,96VA_r$

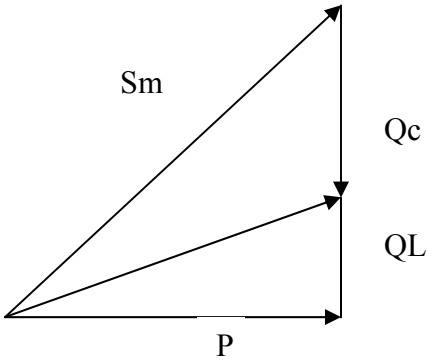
Add the reactive powers (Qc negative) 455,96-325=130,95VAr

d. The line current. *(2 points)*

$$S = \sqrt{P^2 + Q^2} = \sqrt{390^2 + 130,95^2} = 411,4VA$$

$$I = \frac{S}{U} = \frac{411,4}{120} = 3,43A$$

e. Draw the power triangle of the motor and capacitor connected to the line. *(2 points)*



Problem 2 (10 points).

A 300 hp, 2300V, 60 Hz, 3 phase squirrel-cage induction motor turns at a full load speed of 590 rpm. The synchronous speed is 600 rpm.
a. Calculate the approximate value of the rotor I^2R losses. *(2 points)*
Pl=300hp=300/1,34=223,9kW
s=(600-590)/600=0.0167
$P_m \approx P_L$ so, $P_m = P_r(1-s) \Rightarrow 223,9 = P_r(1-0,0167)$
$P_r = 227,7kW \;\; P_{jr} = rotorlosses = s \cdot P_r = 0,0167 \cdot 227,7 = 3,8kW$
If the line voltage then drops to 1944 V, calculate the following:
b. The new speed, knowing that the load torque remains the same. *(3 points)*

$$s_x = s_n(\frac{E_n}{E_x})^2 = 0,0167\left(\frac{2300}{1944}\right)^2 = 0,0233$$

$$speed = 600(1-0,0233) = 586r/\min$$

c. calculate the number of poles.

$$n_s = \frac{60 \cdot f}{p/2} \Rightarrow 600 = \frac{3600}{p/2} \Rightarrow p = 12$$

$P_L = 300 \text{ hp} = 300 \div 1.34 = 223.9 \text{ kW}$
$s = (600 - 590)/600 = 0.0167$
Because $P_m \approx P_L$ (Fig. 13-15), we have

$$P_m = P_r(1-s) \qquad \text{(Eq. 13-8)}$$

$223.9 = P_r(1 - 0.0167) \qquad \therefore P_r = 227.7 \text{ kW}$
$P_{jr} = \text{rotor losses} = sP_r = 0.0167 \times 227.7 = 3.8 \text{ kW}$
a. $s_x = s_n(E_n/E_x)^2 = 0.0167\,(2300/1944)^2 = 0.0233$
speed = 600 (1 – 0.0233) = 586 r/min
b. $P_L = 300 \times (586/590) = 298 \text{ hp} = 222.4 \text{ kW}$

Problem 3 (10 points)

21-34 a) DC voltage between A and 2 $= DE_H = 0.35 \times 600$
$= 210\ V$

A is (+) with respect to 2 $E_{A2} = +210\ V$

b) DC voltage between B and 2 $= (1 - D)\, E_H$
$= (1 - 0.35) \times 600$
$= 390\ V$

B is (+) with respect to 2 $E_{B2} = +390\ V$

c) From Kirchhoff's voltage law we can write:

$E_{AB} + E_{B2} + E_{2A} = 0$

$\therefore E_{AB} = E_{A2} - E_{B2} = +210 - 390 = -180\ V$

hence A is negative with respect to B.

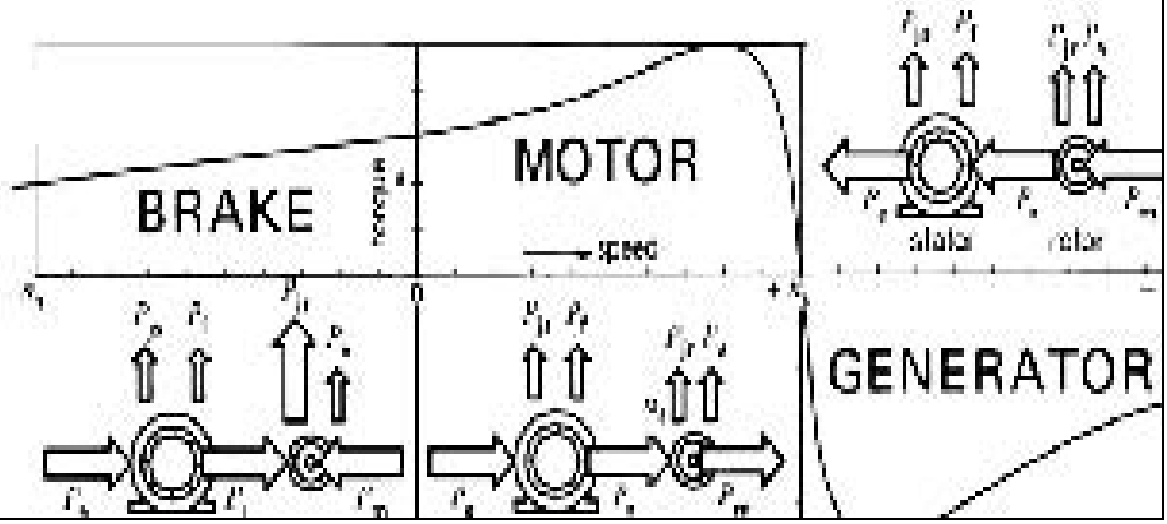
a. The average voltage between terminals A and 2. *(2 points)* 210V
b. Is terminal A positive with respect to terminal 2? *(1 point)* (+)
c. The average DC voltage between terminals B and 2. *(2 points)* 390V
d. Is terminal B positive with respect to terminal 2? *(1 point)* (+)
e. The average DC voltage between terminals A and B. *(2 points)* -180V
f. What is the polarity of A with respect to B? *(2 points)* (-)

Questions (10 points)

1. *(1 point)*
State the basic properties of a diode.

A diode conducts only in one direction.

2. *(3 points)*
Draw the complete torque speed curve of a 3 phase induction machine and mark the brake + motor and generator region.



3. *(3 points)*
Cycloconverter.
Draw the schematic of a cycloconverter and the typical output of a cycloconverter.

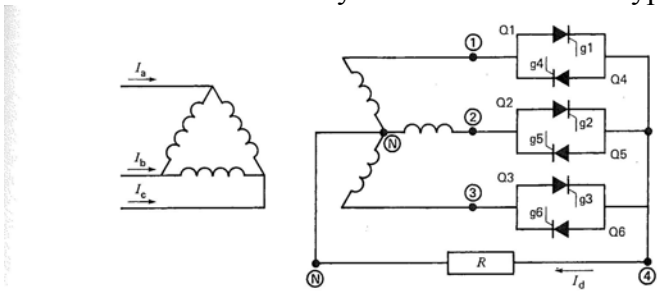
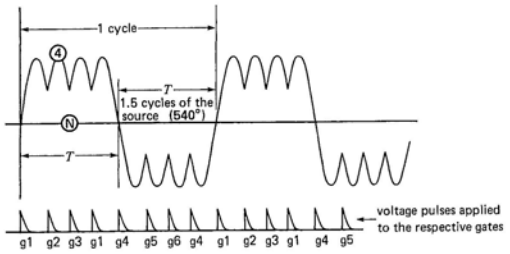
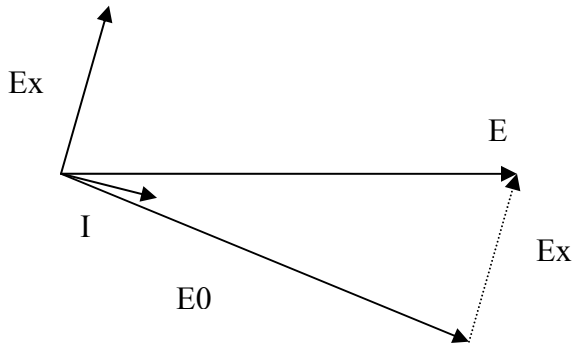


Figure 21.34
Elementary cycloconverter.



4. *(2points)*
Draw the fasor diagram of a synchronous motor with torque angle 30^o



5. *(1 point)*
What is the definition of "power factor" PF?

The cos of the angle between the current and the voltage.
PF=P/S