Elektrische Aandrijvingen

WTB

Lokatie/evenement

P.BAUER

March 5, 2009

Delft University of Technology

Figure 16.1 **Schematic iagram and cross-section view of a typical 500 MW synchronous generator and its 2400 kW dc exciter. The dc exciting current I_x (6000 A) flows through the commutator and two slip-rings. The dc control current I_c from the pilot exciter permits variable field control of the main exciter, which, in turn, controls I_x.**

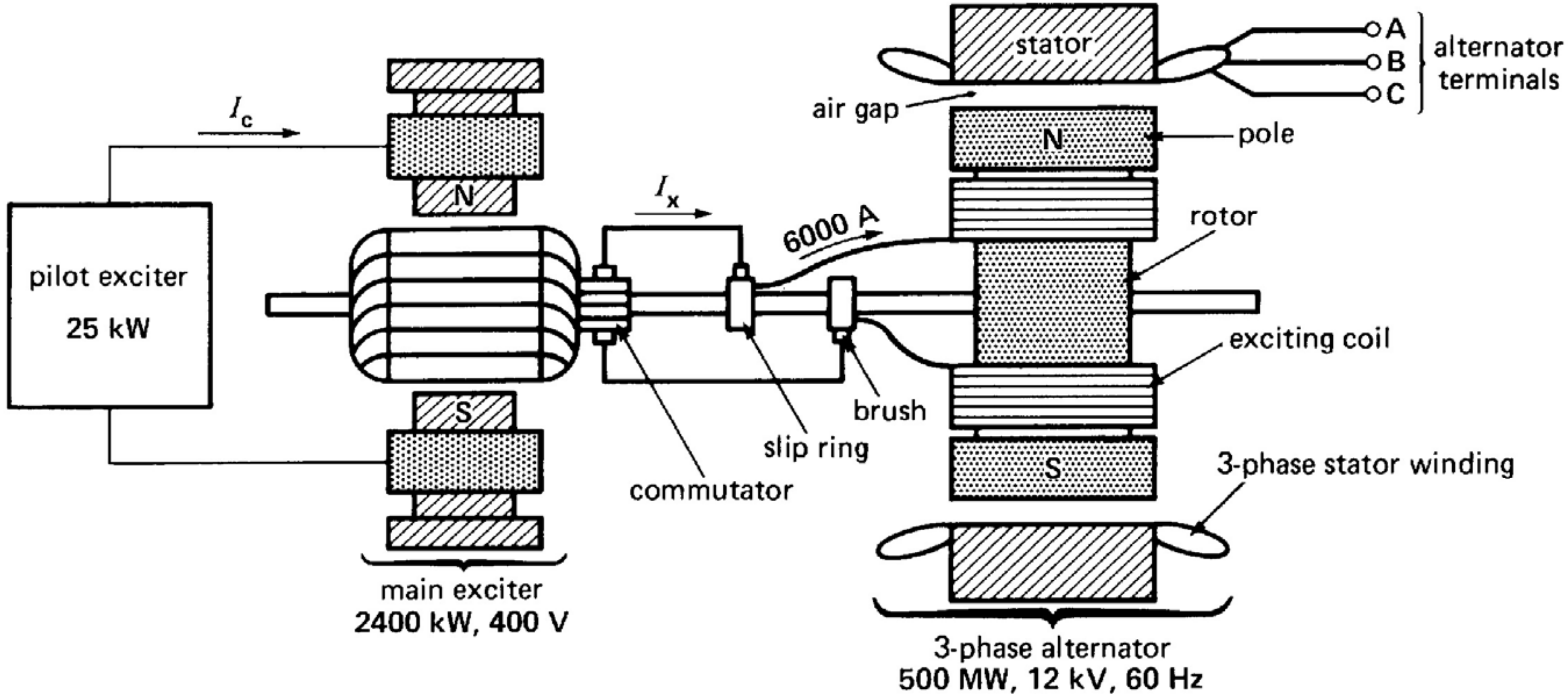
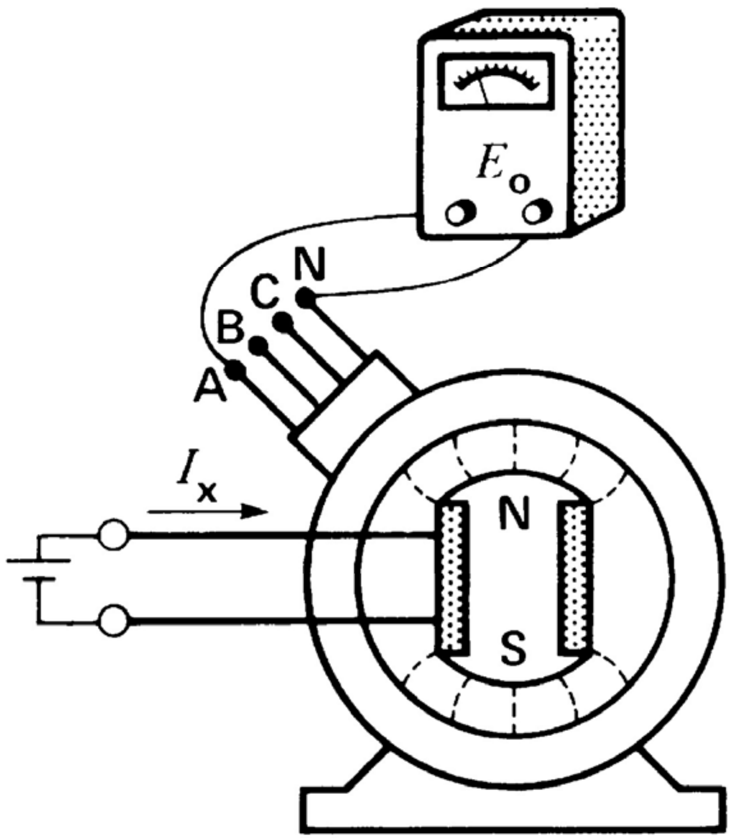
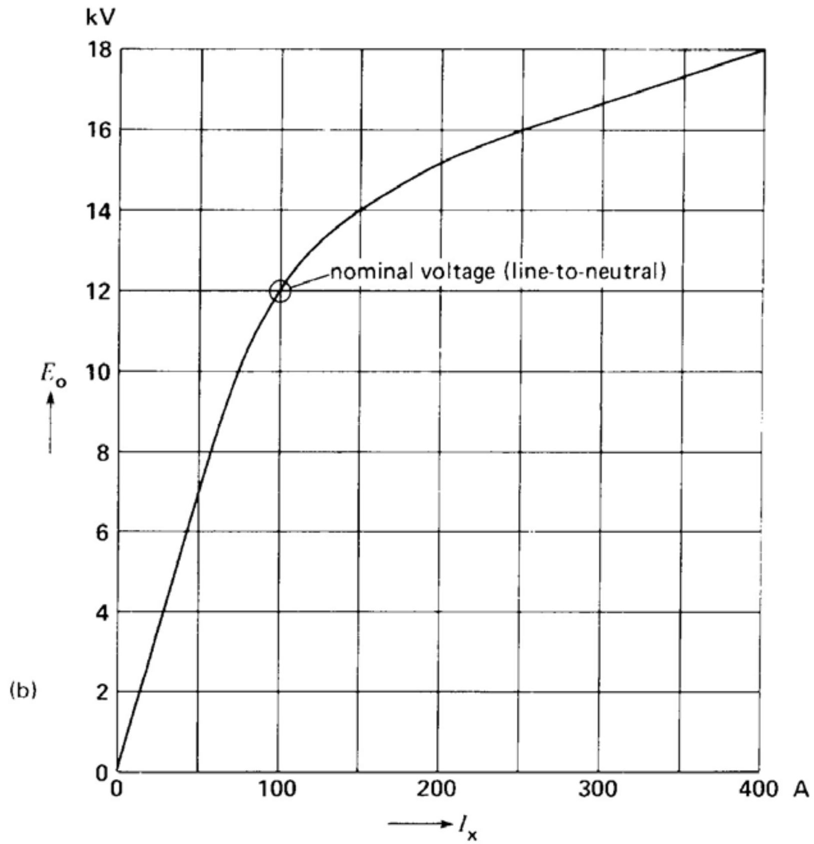
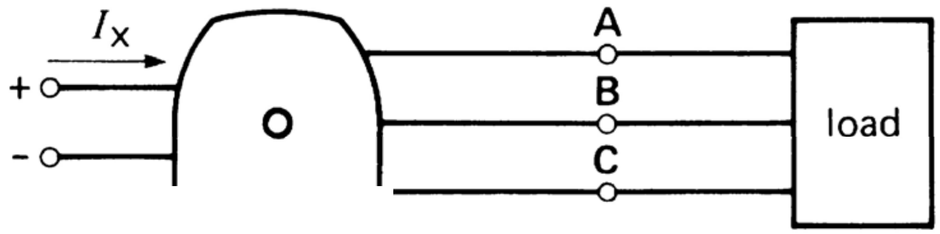


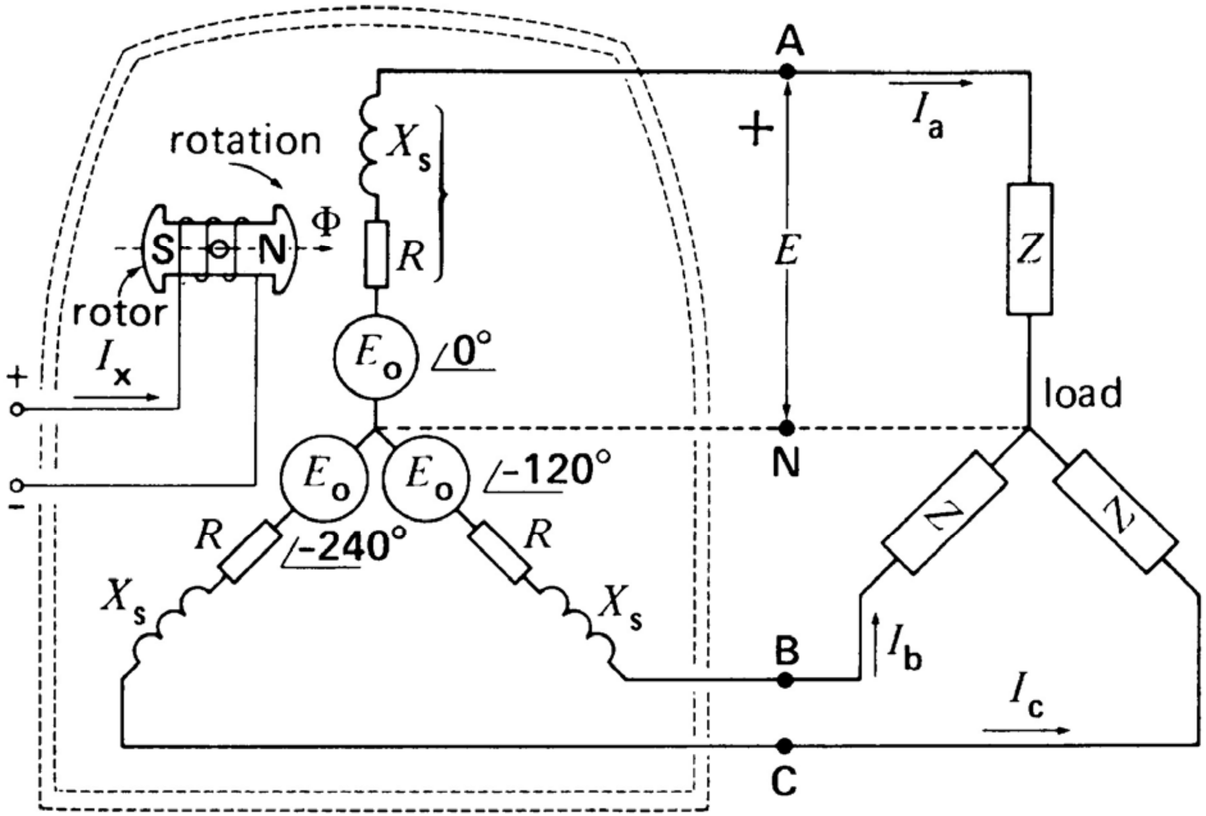
Figure 16.13a **Generator operating at no-load.**



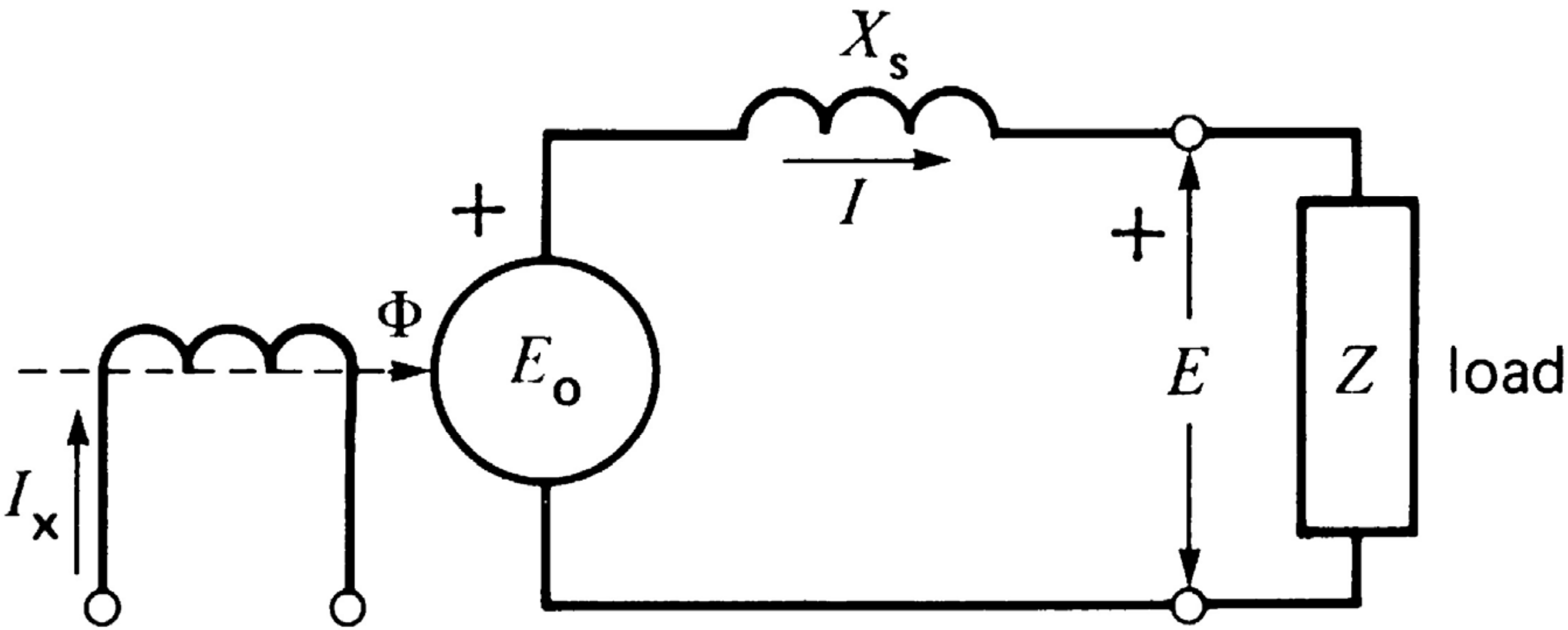


Synchronous generator



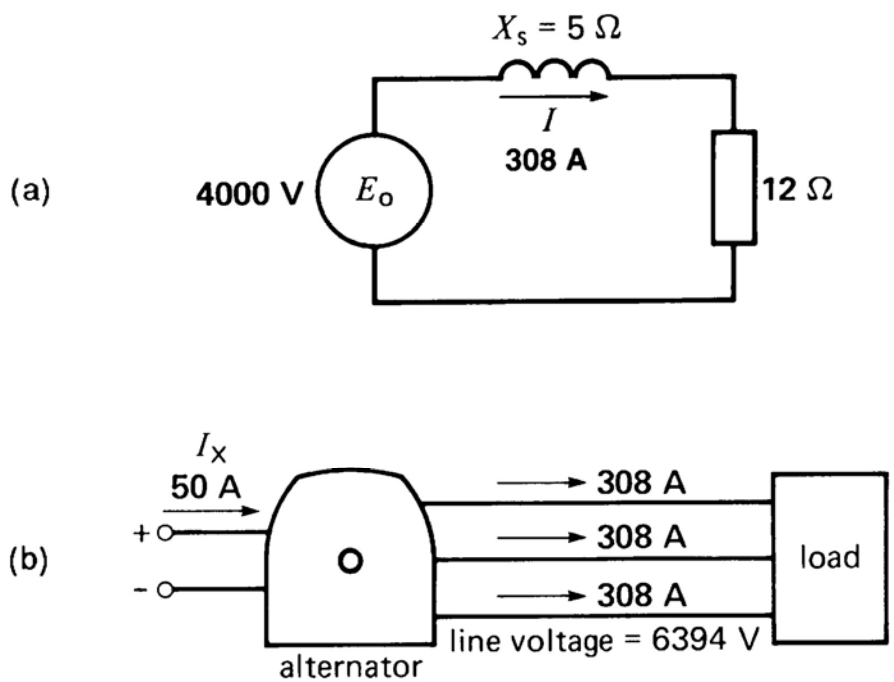


Determining the value of xs



Example 16.2

- 3 phase, SG produces an open circuit line voltage of 6928 V when the dc exc. current is 50 A. The AC terminals are short circuited and line currents are 800A.
- Calculate synchronous reactance
- Terminal voltage if three R 12 ohm are connected



- $E_o = E_L$ / Sqrt(3)= 4000 V
- $X_s = E_o$ / I= 4000/800
- Z = Sqrt $(R^2 + X_s^2)$

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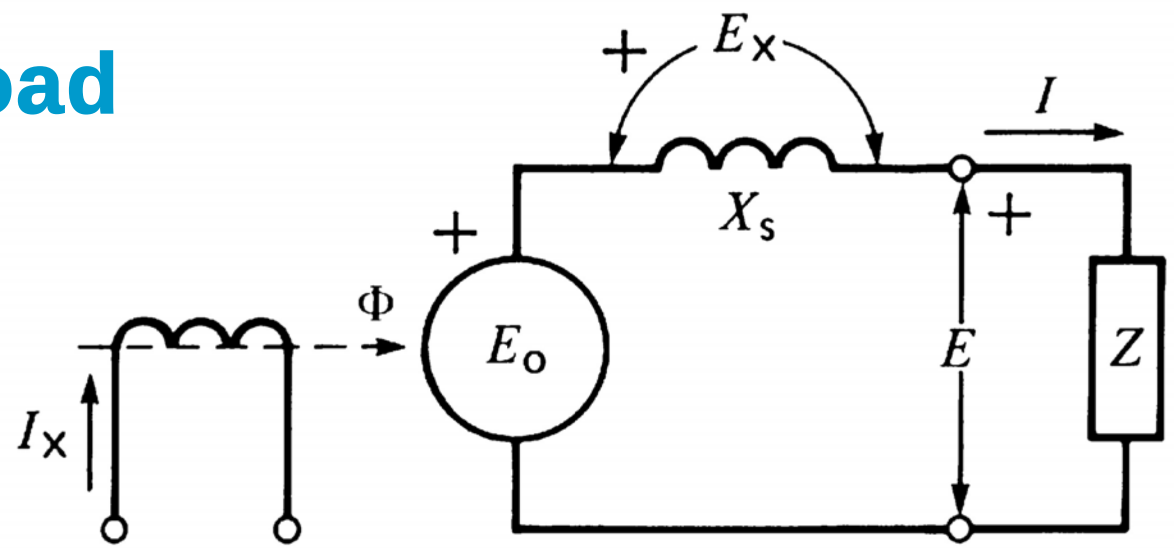
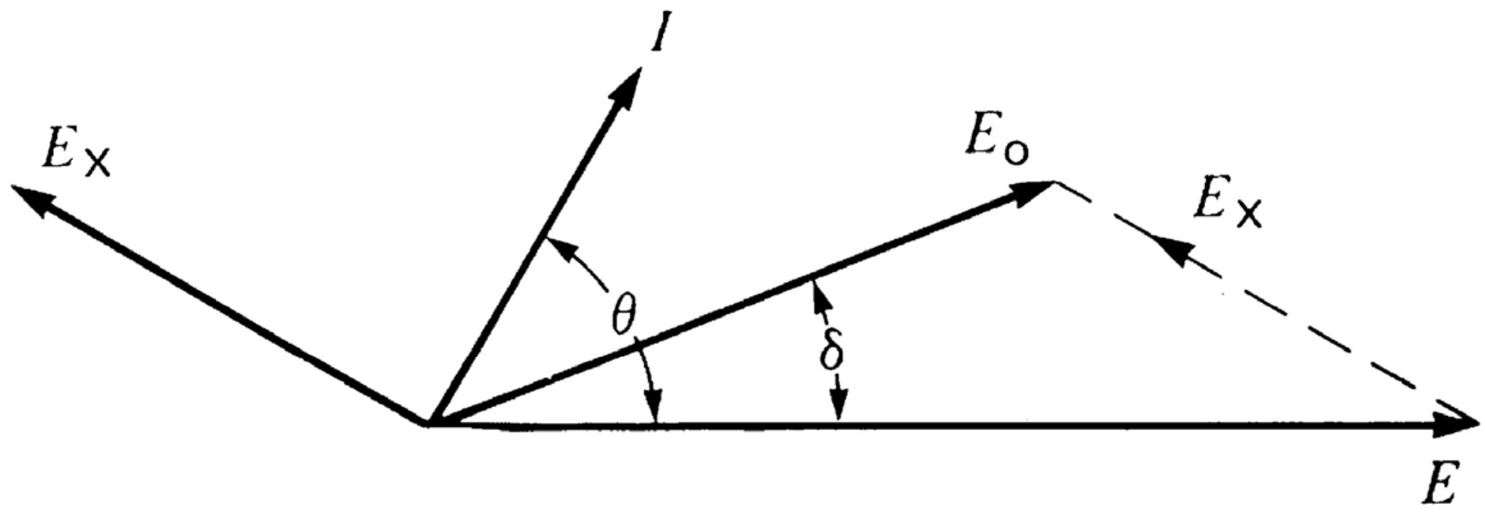
SG under load





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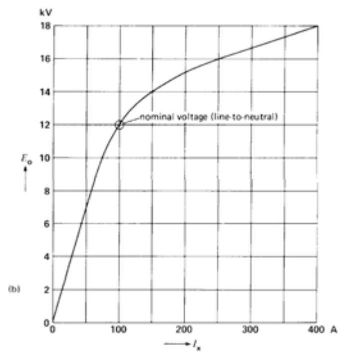
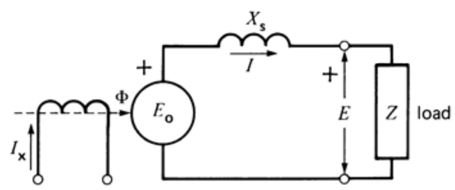
Example 16.4

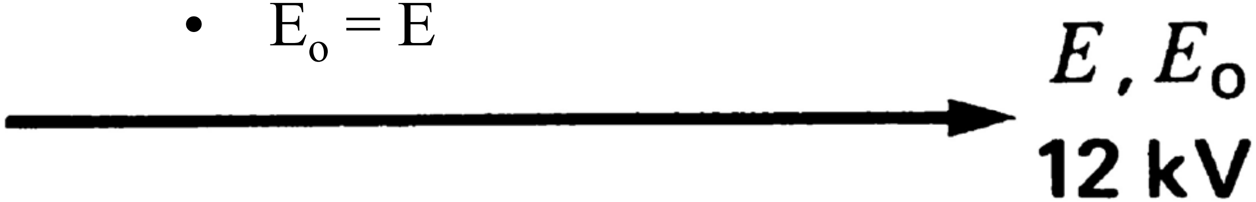
- 36 MVA, 20,8 kV 3phase, synchr. Reactance 9 ohm, the no load saturation curve is given.Terminal voltage remain 21kV., calculate the exciting current and draw the phasor diagram at:
- No load
- Resistive load of 36 MW
- Capacitive load of 12 MVAr





- $E = 20{,}8 / \text{Sqrt}(3) = 12\text{kV}$
- $E_o = E$

- $I_s = 100$



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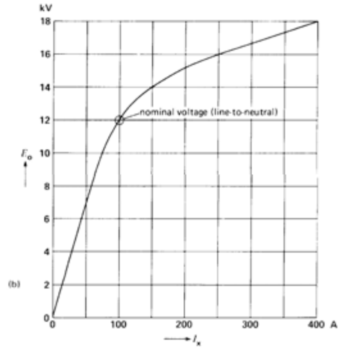
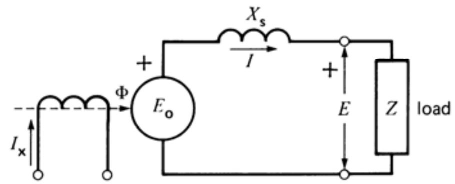
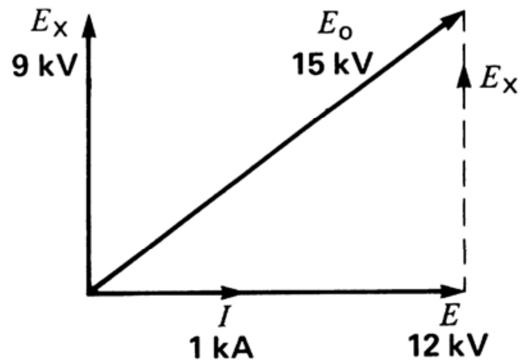




- $P = 36 / 3 = 12MW$
- $I = P/E = 1000\ A$

- $E_x = j\, I\, X_s$
- $E_o =$
- $I_s = 100$



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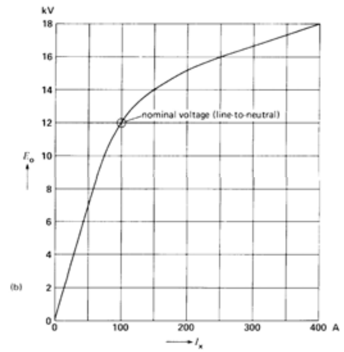
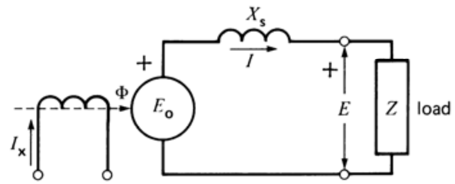




- $Q = 12 / 3 = 12MVAr$
- $I = Q/E = 333A$
- $E_x = j\, I\, X_s$
- $E_o =$
- $I_s = 70A$

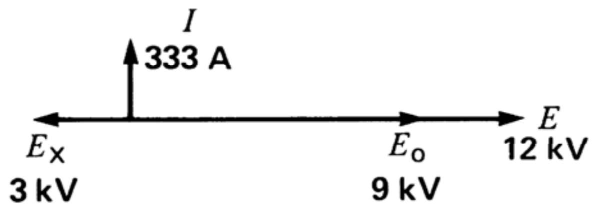
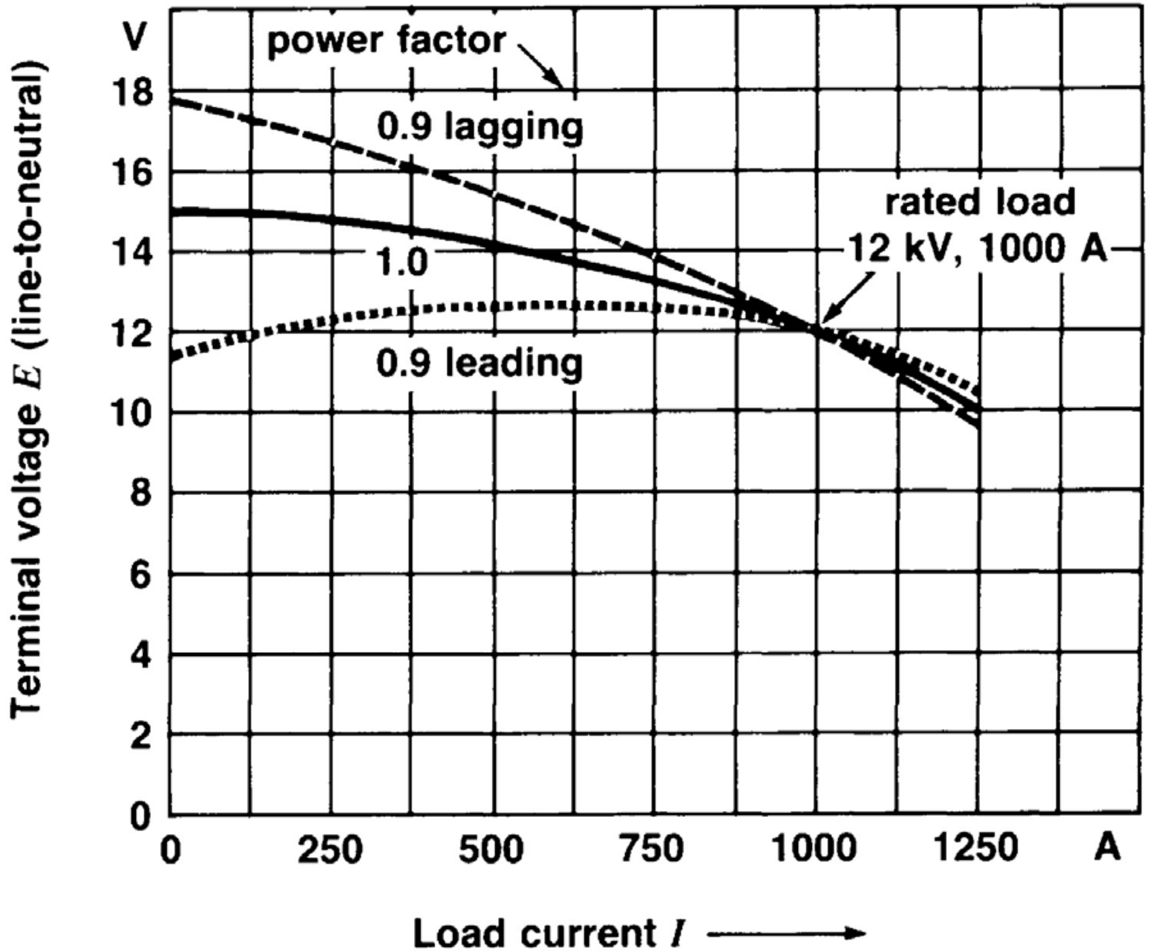


Figure 16.23 **Regulation curves of a synchronous generator at three different load power factors.**



Synchronization

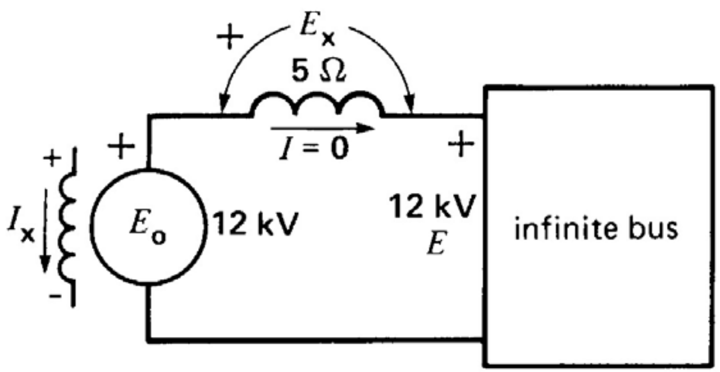
- The generator frequency is equal to system frequency
- Voltage equal
- Voltage in phase
- Phase sequence the same

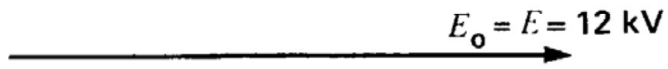
Synchronous generator on an infinite bus

- Imposes voltage and frequency

- The exciting current
- Mechanical torque

Figure 16.26a **Generator floating on an infinite bus.**



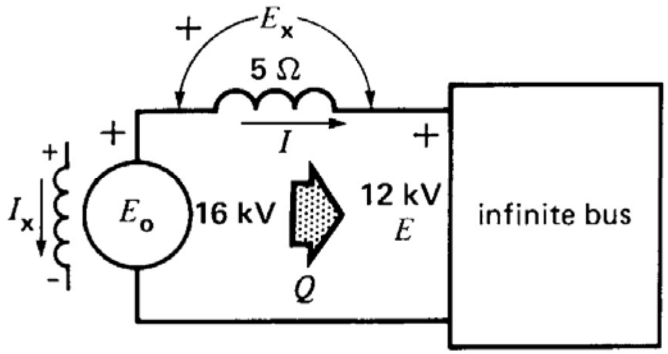


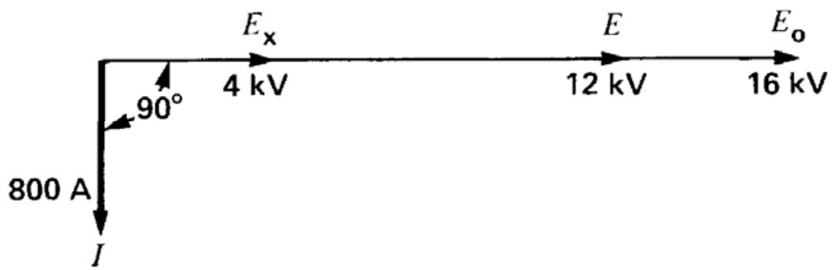
Synchronous generator on an infinite bus

- Increase the exciting current

- $E_x = E_0 - E$
- $I = (E_0 - E) / X_s$

Figure 16.26b **Over-excited generator on an infinite bus.**



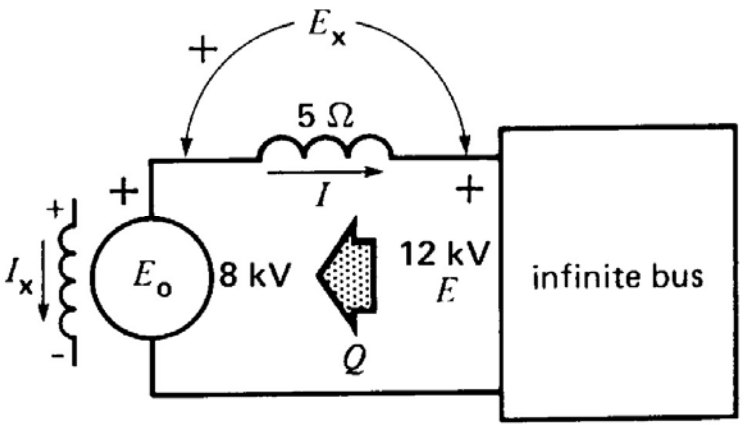


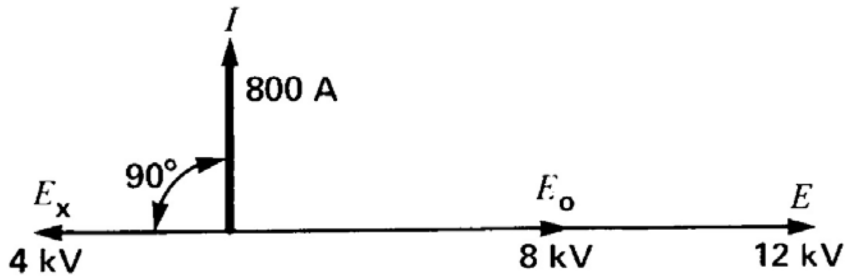
Synchronous generator on an infinite bus

- Decrease the exciting current

Figure 16.26c Under-excited generator on an infinite bus.

- $E_x = E_0 - E$
- $I = (E_0 - E) / X_s$





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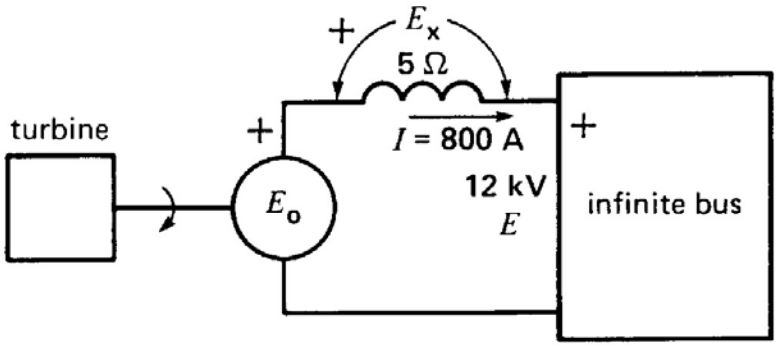
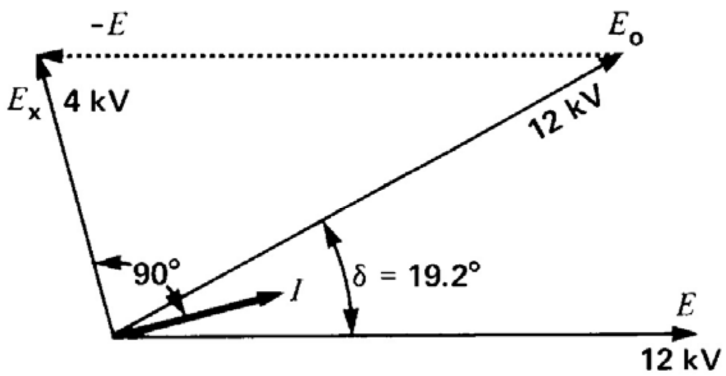
Effect of varying the mechanical torque

- $E_x = E_0 - E$



(a)



(b)

- Rotor accelerates, angle σ increases, electrical power too
- Electrical power=Mechanical power

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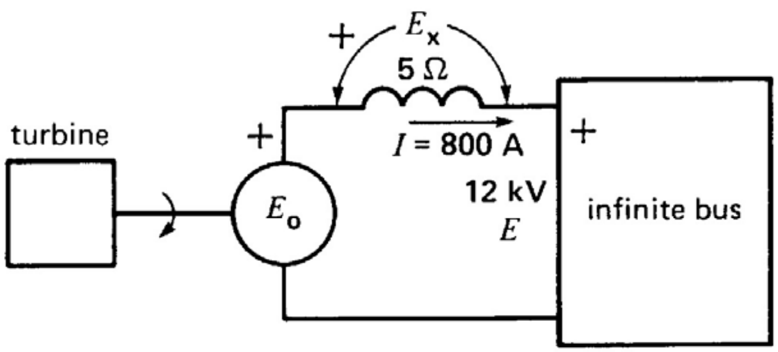
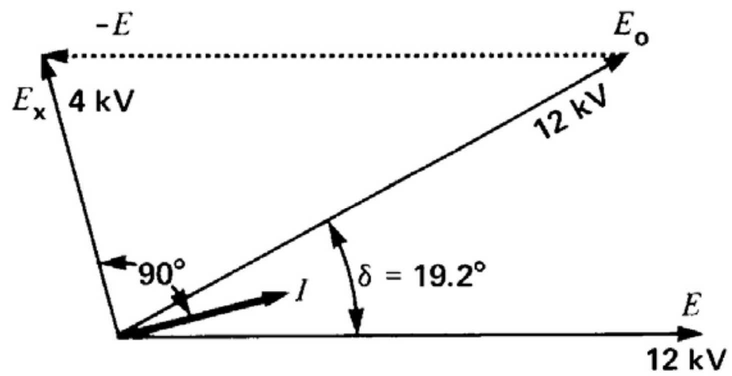
Effect of varying the mechanical torque

- $E_x = E_0 - E$



(a)



(b)

- Difference of potential is created when 2 equal voltages are out of the phase
- Increased phase angle=increased I=incr. active power

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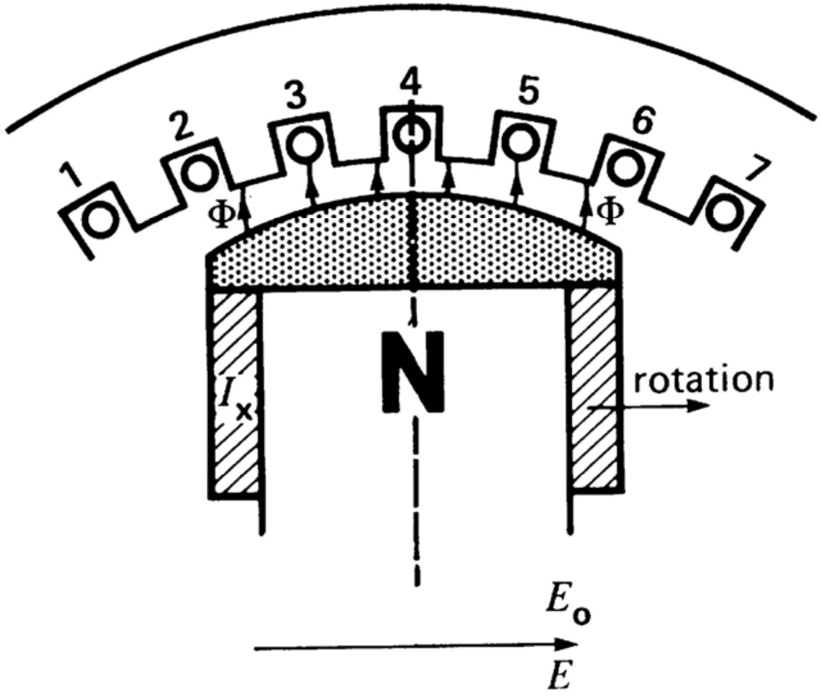
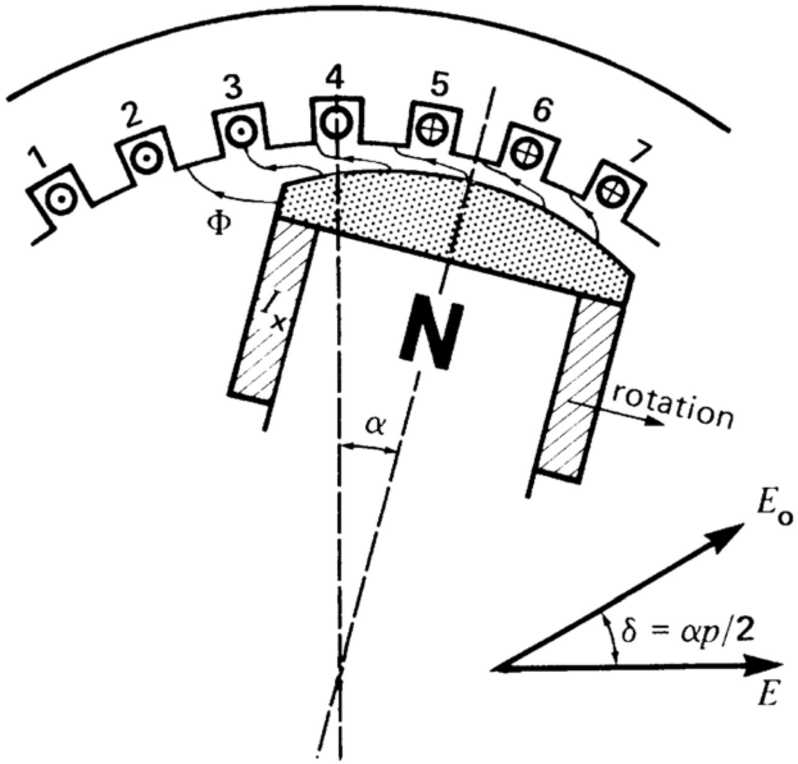
Figure 16.28a **The N poles of the rotor are lined up with the S poles of the stator.**

Physical interpretation

$\delta = p \text{ alpha} /2$





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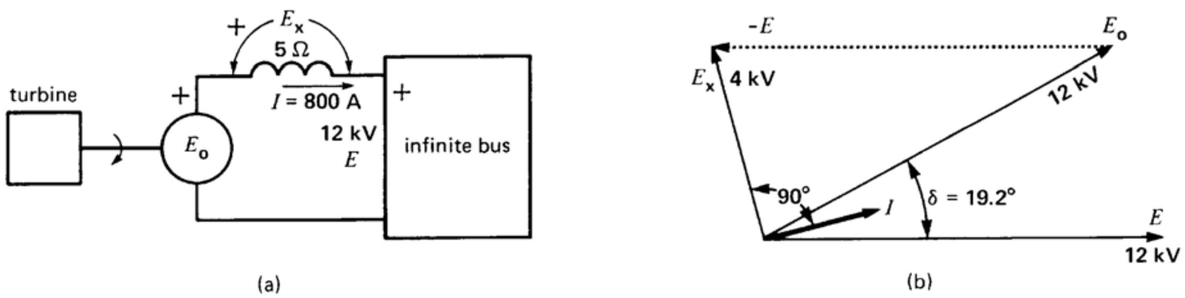
Example 16.6

- The rotor poles of an 8 pole SG shift by 10 mechanical degrees from no load full load
- Calculated the torque angle between E_o and E

$$\delta = p \text{ alpha } /2 = 8 \,.\, 10 /2 = 40$$

- Which voltage E or E_o is leading ?



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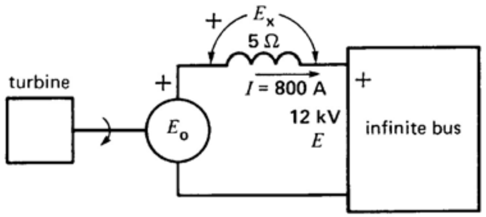
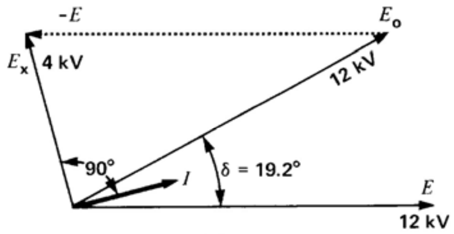
Active power

- $P = E_0 \, E \sin \delta \, / \, X_S$

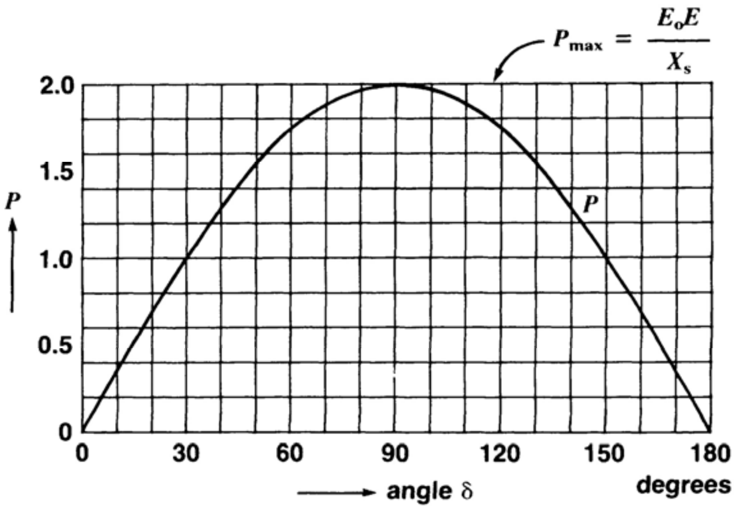


(a)



(b)

us generator and the torque angle.



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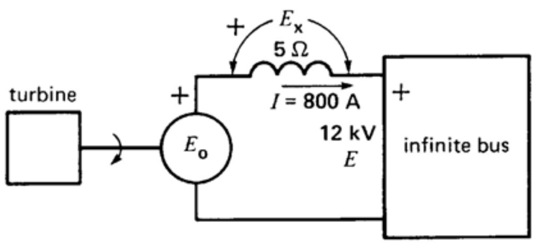
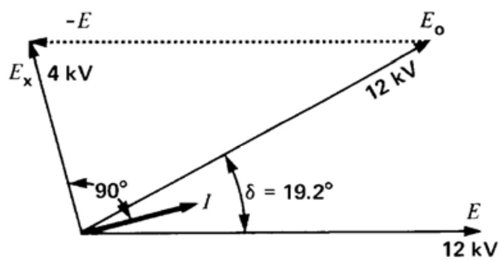
Example 16.7

- 36 MVA, 21 kV 1800 r/min 3 phase generator , Xs= 9 ohm per phase, Eo=12kV, E= 17,3kV
- Calculated the active power when δ=30
  - $P = E_0 E \sin \delta / X_S$
- The peak power ?



(a)



(b)

Figure 16.30 **Variation of generator reactance following a short-circuit.**

Transient reactance

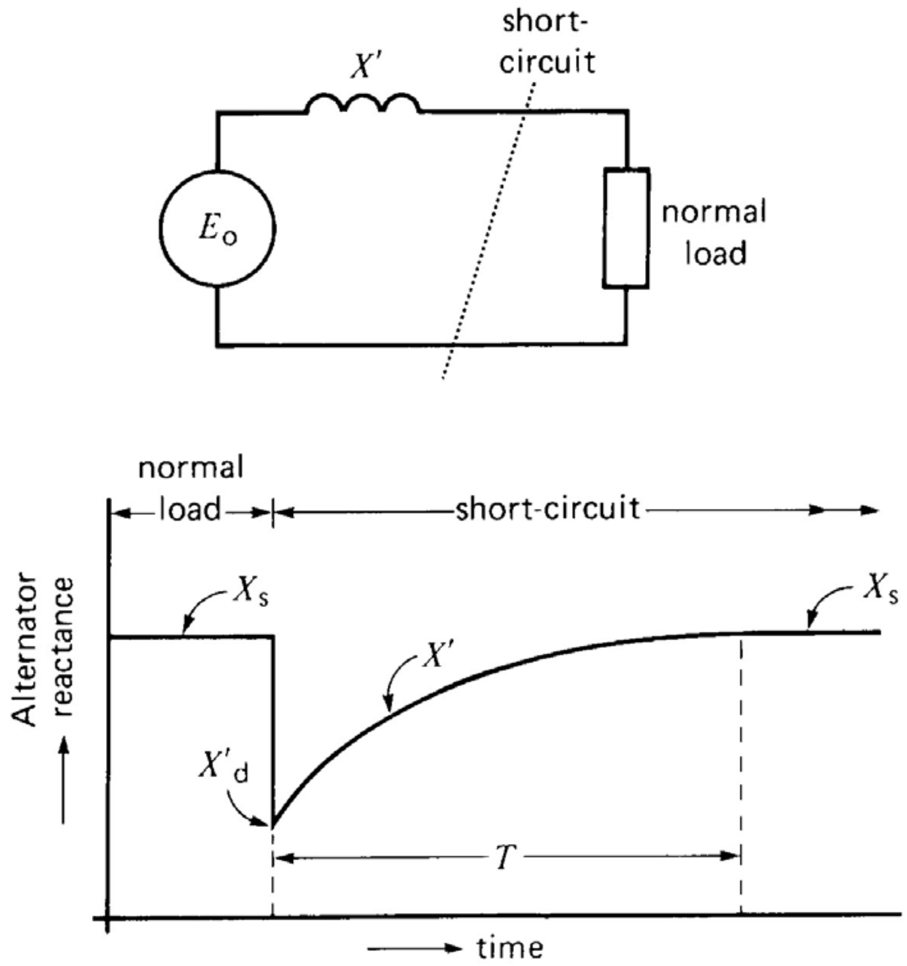


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Figure 16.32 **Change in current when a short-circuit occurs across the terminals of a generator. See Example 16-8.**

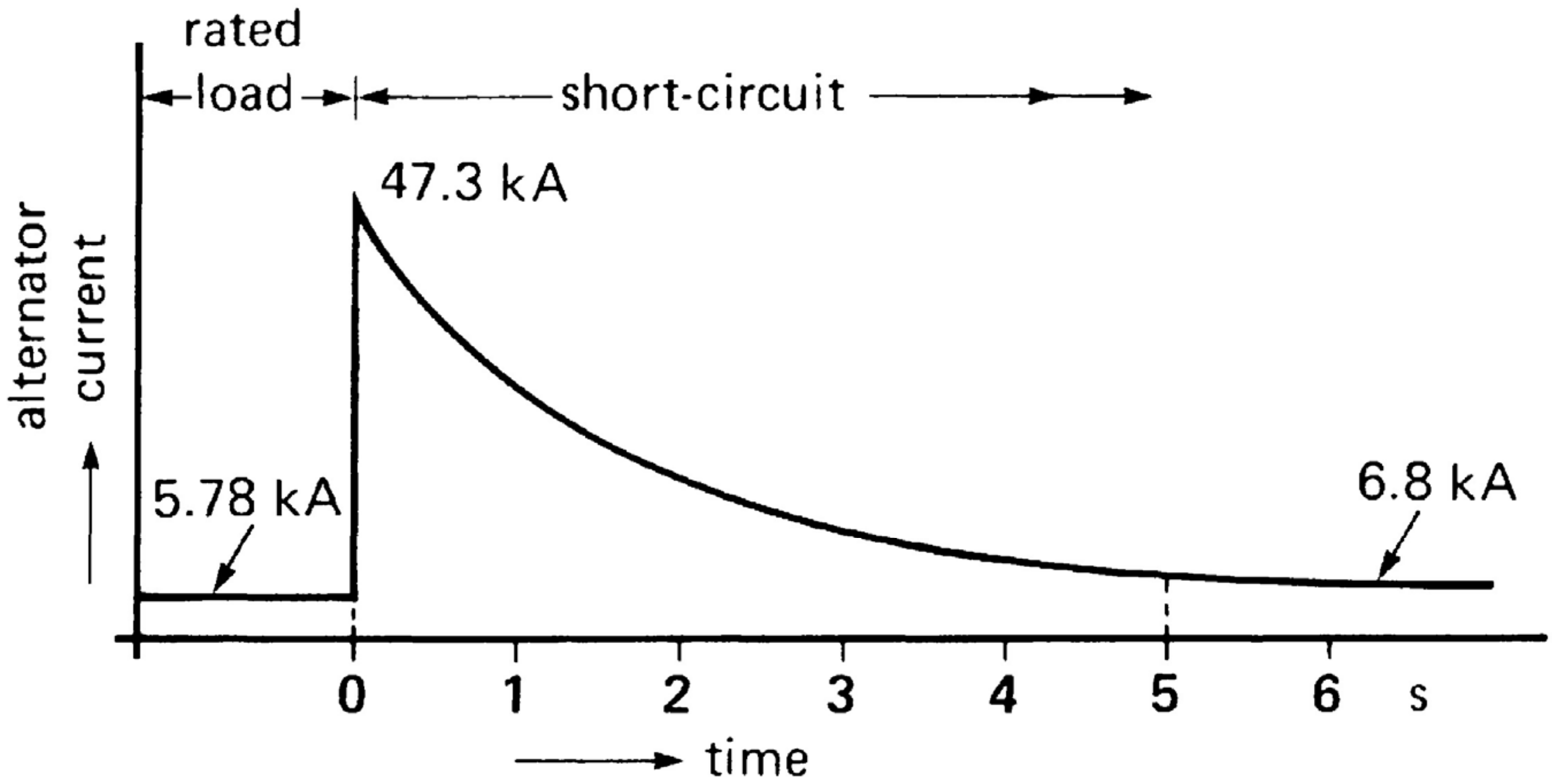

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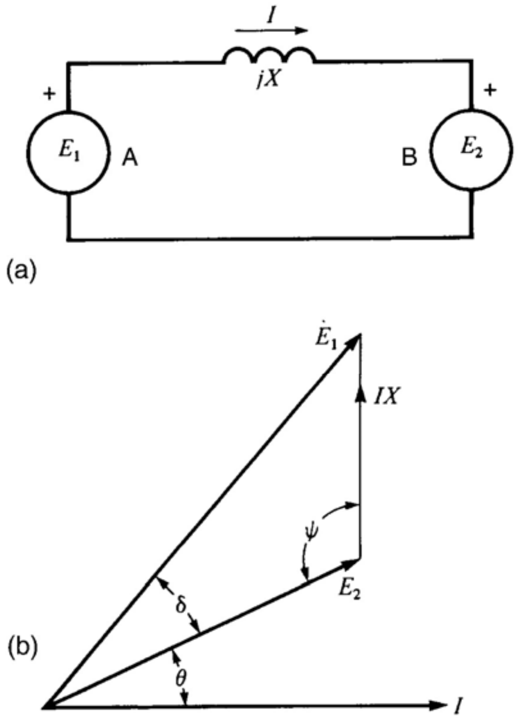
Figure 16.33 **Power flow between two voltage sources.**

Power transfer



- $E_1 = E_2 + jIX$
- $P = E_2 I \cos\theta$
- $P = E_1 E_2 \sin\delta / X_S$

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