pb

Ex 58

A 2000 KV 3ϕ 4 POLE STAR CONNECTED SYNCHRONOUS MACHINE HAS RESISTANCE AND SYNCHRONOUS REACTANCE PER PHASE OF 0.2 Ω AND 1.9 Ω RESPECTIVELY.

CALCULATE THE EMF AND THE ROTOR DISPLACEMENT WHEN THE MACHINE ACTS AS A MOTOR WITH AN INPUT OF 800 MW AT POWER FACTOR OF 0.8 LAGGING,

IF FIELD CURRENT OF 40 A IS REQUIRED TO PRODUCE AN EMF PER PHASE EQUAL TO RATED VOLTAGE DETERMINE ALSO THE FIELD CURRENT FOR EACH CONDITION

$$Z_s = 0.2 + j1.9$$

$$\theta = \cos^{-1} 0.8 = 36.8$$
LAGGING,

$$E_f = V - I Z_s$$

$$V = \frac{2000\times10^3}{\sqrt{3}} , \quad I = \frac{800\times10^6}{\sqrt{3}\times 2000\times10^3\times0.8} = 288 \angle{-36.8}$$

$$E_f = \frac{2000\times10^3}{1.7321} - 288\angle{-36.8}\,(0.2+j1.9)$$

$$E_F = \frac{2000 \times 10^3}{1.7321} - 288 \angle -36.8 \left(\sqrt{0.2^2 + 1.9^2} \angle \tan^{-1} \frac{1.9}{0.2} \right)$$

$$= \frac{2000 \times 10^3}{1.7321} - 288 \angle -36.8 \times 1.91 \angle 84$$

$$= \frac{2000 \times 10^3}{1.7321} - 288 \times 1.92 \angle 47.2$$

$$= \frac{2000 \times 10^3}{1.7321} - 288 \times 1.92 (\cos 47.2 + j \sin 47.2)$$

$$= 1154667 - (375.7 + j405.7$$

$$= 1154292 - j405.7$$

$$\simeq 1154 \text{ kV}$$

$$\text{RATED VOLTAGE} = \frac{2000}{\sqrt{3}} = 1150 \text{ kV} \longrightarrow \text{FIELD CURRENT} = 40 \text{ A}$$

$$1154 \longrightarrow ?$$

$$= 40 \times \frac{1154}{1150} = 40.13 \text{ Amp}$$

PD

Ex 59

THE FACTORY HAS THE FOLLOWING LOADS.

(i) TWO 50 HP 3ϕ INDUCTION MOTOR PF 0.707 LAGGING, EFFICIENCY 90%.

(ii) THREE 40 KW, 3ϕ INDUCTION MOTOR P.F 0.8 LAGGING, EFFICIENCY 95%.

CALCULATE TOTAL ACTIVE AND REACTIVE POWER ABSORBED FROM SUPPLY AND POWER FACTOR.

(iii) IF ONE 60 KW 3ϕ SYNCHRONOUS MOTOR WITH EFFICIENCY 98%, 0.6 LEADING PF IS CONNECTED IN PARALLEL, CALCULATE TOTAL ACTIVE AND REACTIVE POWER ABSORBED AND TOTAL POWER FACTOR.

A

TWO 50HP 3ϕ INDUCTION MOTOR

$$KW_1 = \frac{2 \times 50 \times 0.746}{0.9} = 82.88\ KW$$

13 Amp

$\phi = \cos^{-1} 0.707 = 45^\circ$

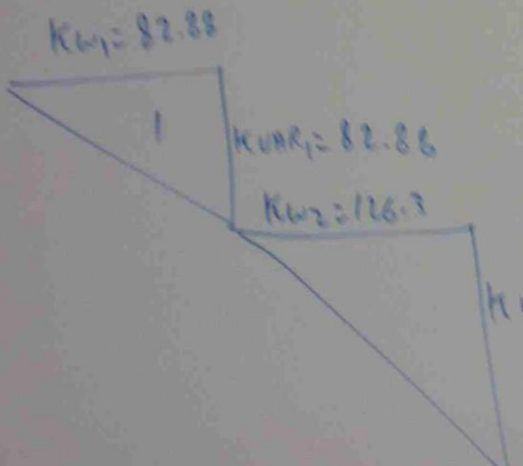
$KVAR_1 = KW_1 \tan \phi_1 = 82.88 \tan 45 = 82.88\ KVAR$

THREE 40 KW 3ϕ INDUCTION MOTOR

$$KW_2 = \frac{3 \times 40}{0.95} = 126.3\ KW$$

$$\phi_2 = \cos^{-1} 0.8 = 36.8$$

$$KVAR_2 = KW_2 \tan \phi_2 = 126.3 \tan 36.8 = 94.7\ KVAR$$



$$KW_T = KW_1 + KW_2$$
$$= 82.88 + 126.3$$
$$= 209.18\ KW$$

$$KVAR_T = KVAR_1 + KVAR_2$$
$$= 82.88 + 94.7$$
$$= 177.12\ KVAR$$

$$\theta_T = \tan^{-1} \frac{177.12}{209.18} = 40.2$$

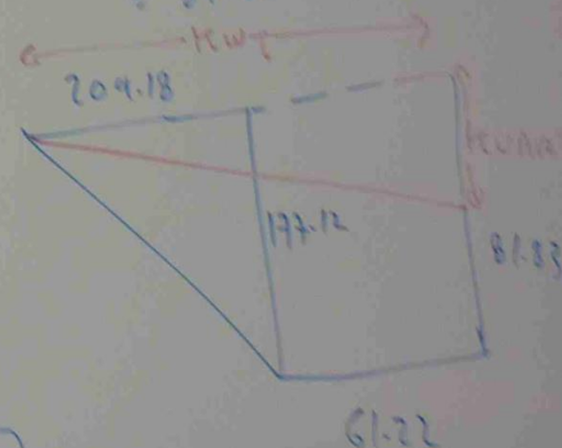
PF: $\cos 40.2 = 0.763$ LAG

SYNCHRONOUS MOTOR

$$KW_3 = \frac{60}{0.98} = 61.22\ KW$$

$$\phi_3 = \cos^{-1} 0.6 = 53.2$$

$$KVAR_3 = KW_3 \tan \phi_3$$
$$= 61.22 \tan 53.2$$
$$= 81.83\ KVAR$$



SYNCHRONOUS MOTOR

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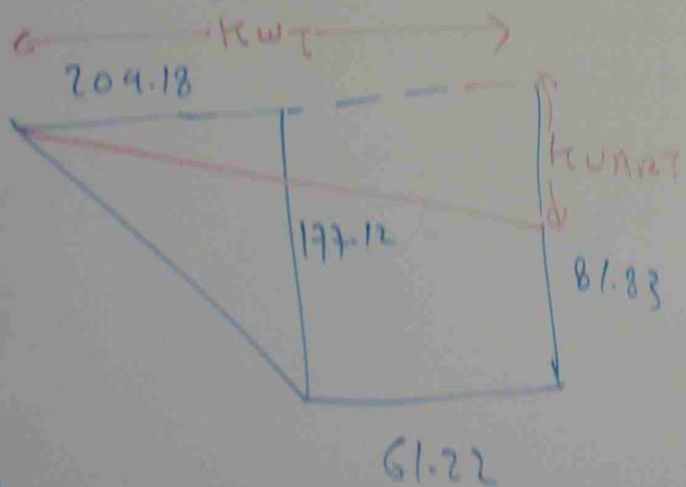

$$KW_T = 209.18 + 61.22 = 270.4\ KW$$

$$KVAR_T = 177.12 - 81.83 = 95.35\ KVAR$$

$$\theta_T = \tan^{-1} \frac{95.35}{270.4} = 19.45$$

$$PF = \cos\theta_T = \cos 19.45 = 0.942\ \text{LAGGING}$$

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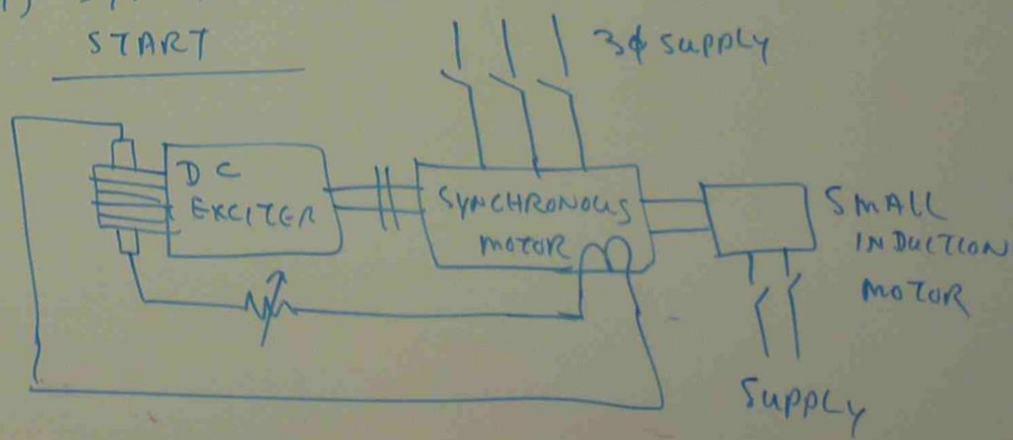
STARTING SYNCHRONOUS MOTOR

SYNCHRONOUS MOTOR CAN NOT START ITSELF.

TWO METHODS ARE UTILIZED TO START SYNCHRONOUS MOTOR

(1) SYNCHRONOUS MOTOR WITH INDUCTION MOTOR START



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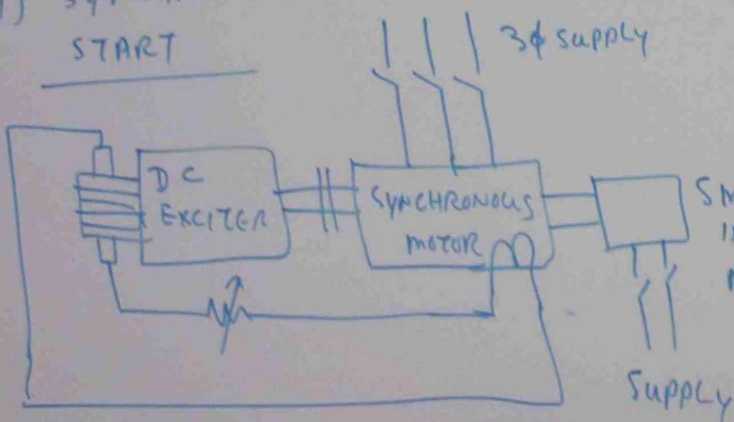
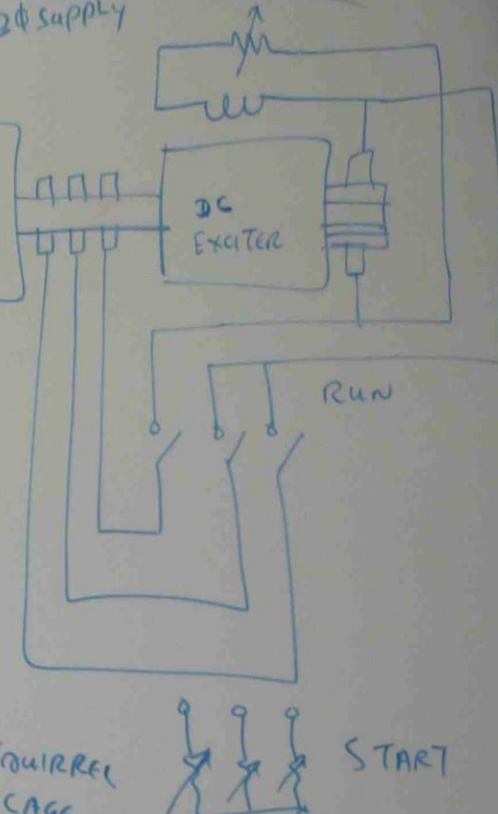
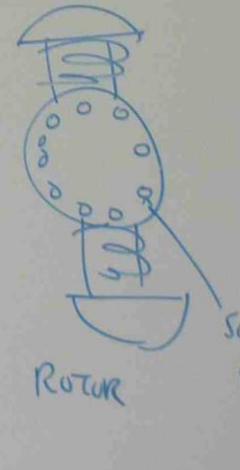


SYNCHRONOUS INDUCTION MOTOR





A DISADVANTAGE OF SYNCHRONOUS MOTOR IS THAT IT HAS NO STARTING TORQUE. THE SYNCHRONOUS INDUCTION MOTOR COMBINES THE HIGH STARTING TORQUE OF THE INDUCTION MOTOR WITH LEADING POWER FACTOR OF THE SYNCHRONOUS MOTOR. THE MACHINE CONSISTS ESSENTIALLY OF A WOUND ROTOR INDUCTION MOTOR.

IT IS STARTED BY RESISTANCE STARTING AS INDUCTION MOTOR AND WHEN IT HAS RUN UP TO SPEED, THE STARTING RESISTANCE IS DISCONNECTED AND DIRECT CURRENT FROM A SMALL EXCITER ON THE SAME SHAFT AS THE MOTOR IS FED IN TO THE ROTOR.

THE MACHINE THEN RUNS AS A SYNCHRONOUS MOTOR.

THE POWER FACTOR IS VARIED BY CONTROLLING THE DIRECT CURRENT IN THE ROTOR.

THE SYNCHRONOUS MOTOR VS INDUCTION MOTOR

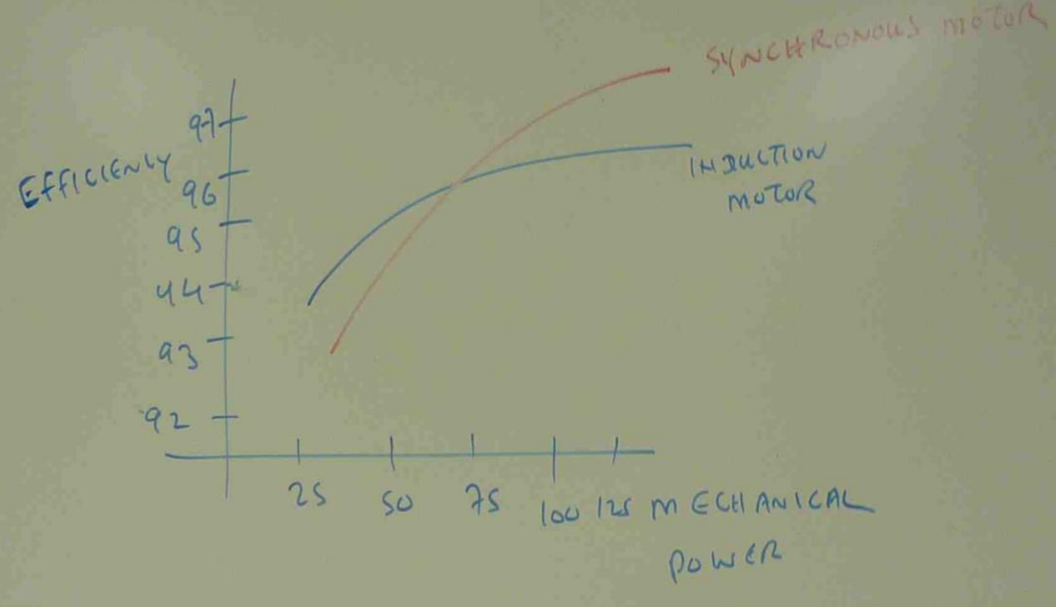
SYNCHRONOUS MOTORS ARE OFTEN USED WITHOUT A LOAD. THEY CAN BE USED FOR POWER FACTOR CORRECTION. THE MACHINE WILL DO THE SAME AMOUNT OF WORK AS BEFORE POWER FACTOR CORRECTION.

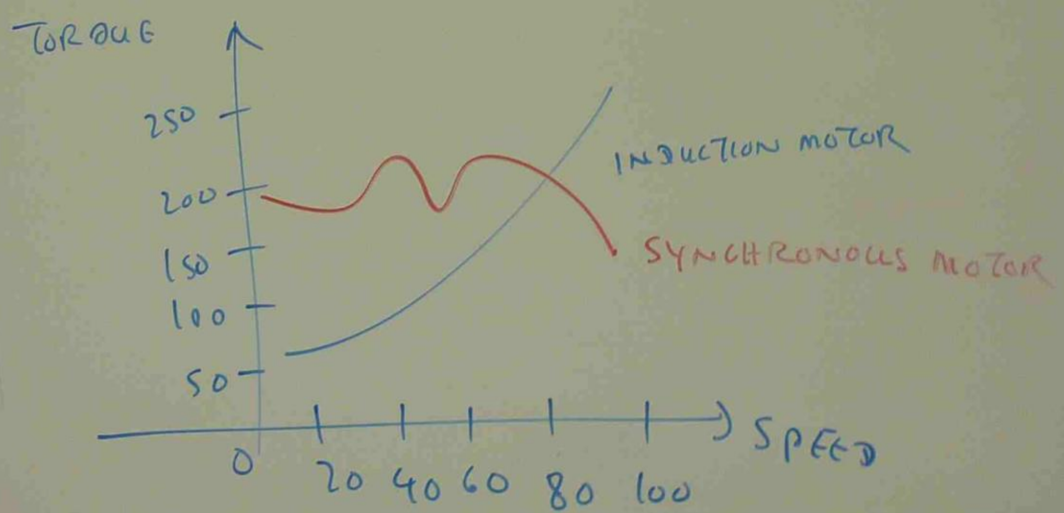
SYNCHRONOUS CONDENSERS

- LOW VOLTAGE DC IS APPLIED TO WOUND ROTOR
- EXACT SPEED IS MAINTAINED FOR POWER FACTOR CORRECTION

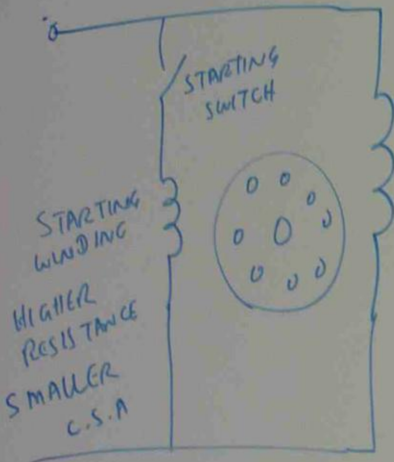
FEATURES OF SYNCHRONOUS MOTOR

- MORE EXPENSIVE AT LOWER H.P RATING
- EXCELLENT PROPERTIES FOR SPEED ABOVE 600RPM
- A SYNCHRONOUS MOTOR CAN IMPROVE THE POWER FACTOR OF THE PLANT WHILE CARRYING THE RATED LOAD.


SYNCHRONOUS MOTOR
97
EFFICIENCY
96
INDUCTION MOTOR
95
94
93
92
25
50
75
100
125
MECHANICAL POWER


TORQUE
250
INDUCTION MOTOR
200
150
SYNCHRONOUS MOTOR
100
50
0
20
40
60
80
100
SPEED

SINGLE PHASE AC MOTOR

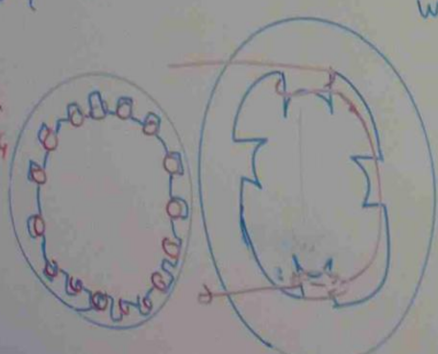


RUNNING WINDING
LOW RESISTANCE
LARGER C.SA
HIGHER NO. OF TURNS

ROTATING MAGNETIC FIELD THEORY

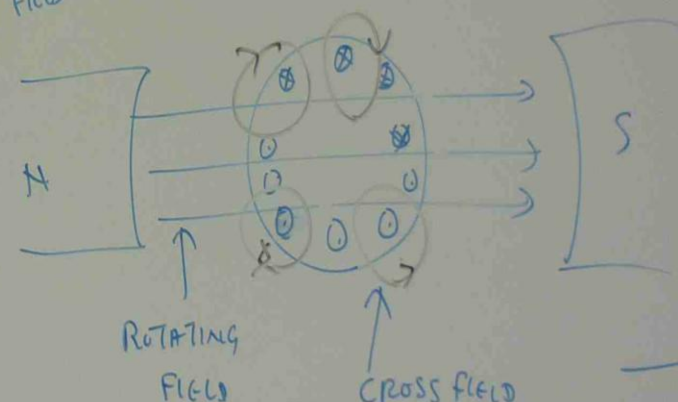
AC SUPPLY → STATOR WINDING → ROTATING FIELD WITH $N = \frac{120f}{P}$

STATOR WINDING



CROSS FIELD THEORY

STATOR ROTATING MAGNETIC FIELD → ROTOR → MAGNETIC FIELD



STATOR FLUX INTERACTS WITH ROTOR FLUX → SPEED UP THE MOTOR

$\boxed{T = kI_1}$

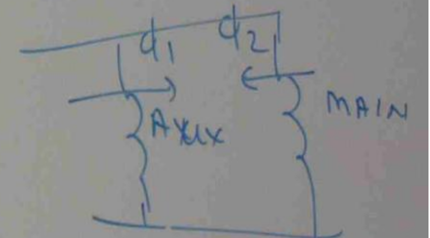
T = LOC

I_1 = AU

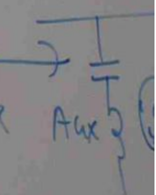
I_2 = M

α = AN

K = CONST



STARTING CAPACITOR



$$\boxed{T = k I_1 I_2 \sin\alpha}$$

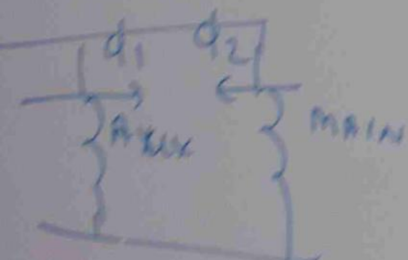
T = LOCKED ROTOR TORQUE (N-m)

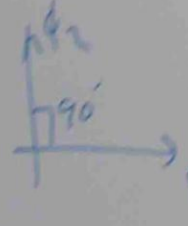
I_1 = AUXILIARY WINDING CURRENT

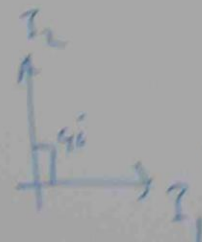
I_2 = MAIN WINDING CURRENT

α = ANGLE BETWEEN I_1 & I_2

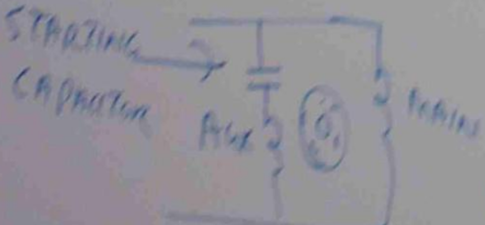
k = CONSTANT, (DEPENDS ON DESIGN)

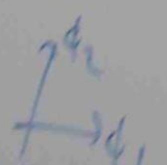


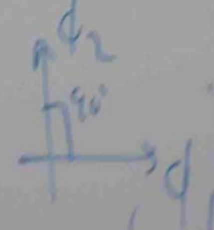




$\Rightarrow$ MAXIMUM TORQUE.







WITH CAPACITOR.

1φ MOTOR

- SPLIT PHASE
- CAPACITOR START
- CAPACITOR START CAPACITOR RUN
- UNIVERSAL {BOTH AC + DC}
- HYSTERESIS MOTOR
- SHADED POLE MOTOR (FAN)