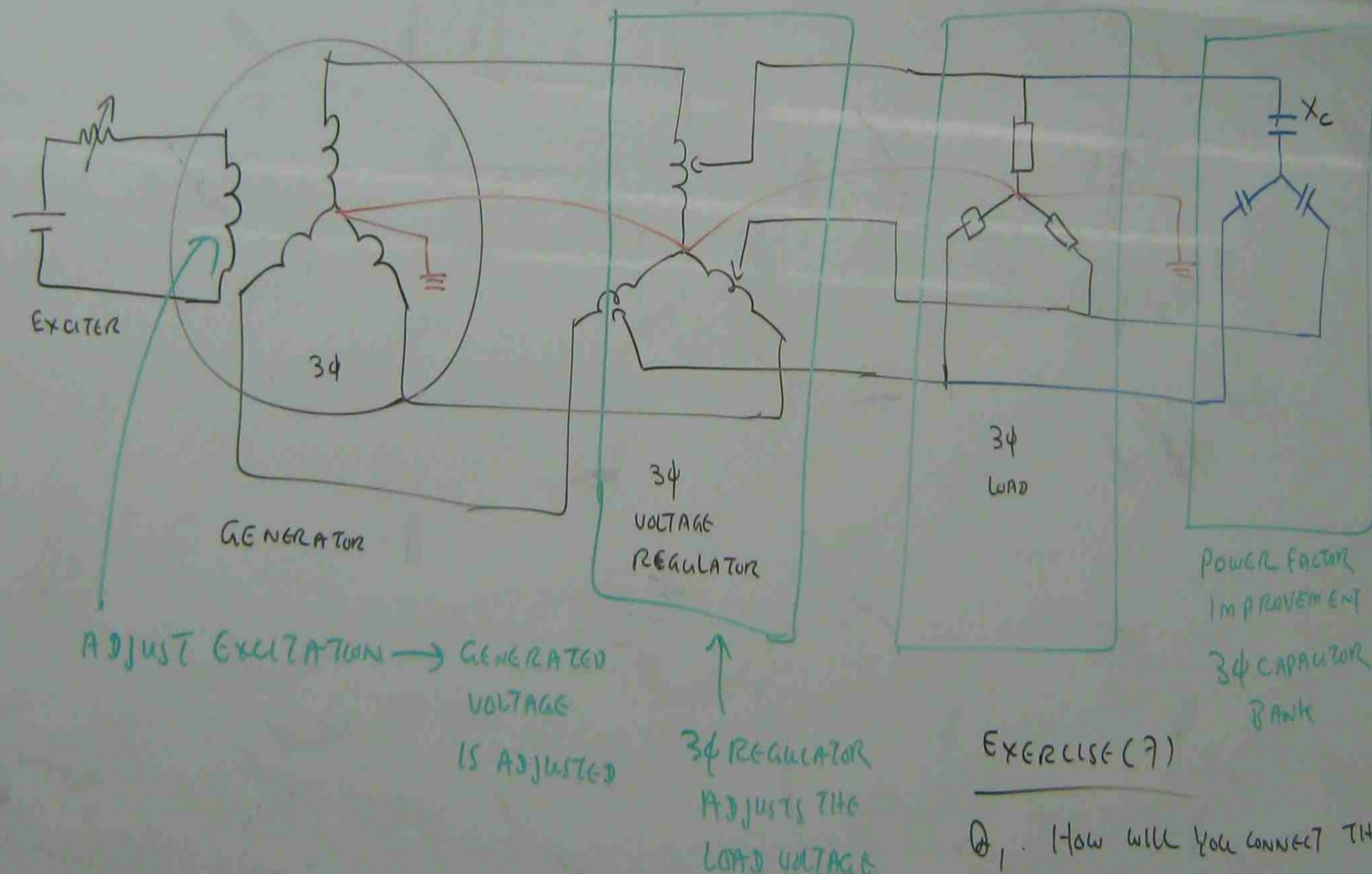
VOLTAGE AND POWER FACTOR CONTROL



EXERCISE (7)

Q1. HOW WILL YOU CONNECT THE REACTIVE POWER CONTROL CAPACITOR BANK TO 3φ POWER SUPPLY SYSTEM?

$E_g = 4.44\, f\, T_p\, \phi$

TURNS/PH

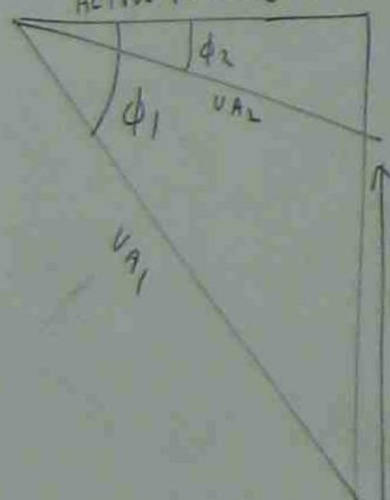
FIELD EXCITATION FLUX

$E_g \propto \phi \propto$ FIELD EXCITATION CURRENT

CAPACITOR BANK TO CONTROL THE OVER ALL P.F OF THE LOAD.

W

ACTIVE POWER (WATT) $= I^2 R$



VAR IMPROUGMENT $= I^2 X_c$

$$W(\tan\phi_1 - \tan\phi_2) = I^2 X_c$$

$$X_c = \frac{W(\tan\phi_1 - \tan\phi_2)}{I^2}$$

$$\frac{1}{2\pi f c} = \frac{W(\tan\phi_1 - \tan\phi_2)}{I^2}$$

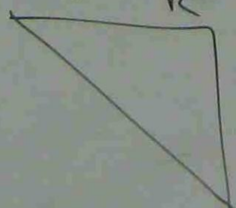
1ϕ

$$\boxed{C = \frac{I^2}{W(\tan\phi_1 - \tan\phi_2) \times 2\pi f}}$$

F

REQUIRED CAPACITOR TO IMPROVE P.F

$$W = \frac{V^2}{R}$$



$$VAR = \frac{V^2}{X_c}$$

$$W(\tan\phi_1 - \tan\phi_2) = \frac{V^2}{X_c}$$

$$X_c = \frac{V^2}{W(\tan\phi_1 - \tan\phi_2)}$$

$$\frac{1}{2\pi f c} = \frac{V^2}{W(\tan\phi_1 - \tan\phi_2)}$$

1ϕ

$$\boxed{C = \frac{W(\tan\phi_1 - \tan\phi_2)}{2\pi f\, V^2}}$$

$3\phi\ \lambda$

$$\frac{V_{ph}^2}{X_c} = \frac{VAR}{3}$$

$$\boxed{C = \frac{\frac{W}{3}(\tan\phi_1 - \tan\phi_2)}{2\pi f \left(\frac{V_{LINE}}{\sqrt{3}}\right)^2}}$$

$3\phi\ \Delta$

$$\frac{V_{ph}^2}{X_c} = \frac{VAR}{3}$$

$$\boxed{C = \frac{\frac{W}{3}(\tan\phi_1 - \tan\phi_2)}{2\pi f\, V_{LINE}^2}}$$

$\Delta \rightarrow V_{ph} = V_{LINE}$

pb CALCULATE THE CAPACITANCE REQUIRED TO IMPROVE THE P.F OF 50 KW 0.8 P.F LAGGING TO 0.95 P.F LAGGING

50 Hz, 415 V SYSTEM

BY USING (i) λ CAPACITOR BANK (ii) Δ CAPACITOR BANK

$PF_1 = 0.8 \longrightarrow \cos\phi_1 = 0.8 \longrightarrow \phi_1 = \cos^{-1} 0.8 = 36.8^\circ$

$PF_2 = 0.95 \longrightarrow \cos\phi_2 = 0.95 \longrightarrow \phi_2 = \cos^{-1} 0.95 = 18.2^\circ$

λ CAPACITOR BANK

$$C = \frac{\frac{W}{3}\left(\tan\phi_1 - \tan\phi_2\right)}{2\pi f \left(\frac{V_{LINE}}{\sqrt{3}}\right)^2}$$

$$= \frac{\frac{50,000}{3}\left(\tan 36.8 - \tan 18.2\right)}{2 \times 3.1416 \times 50 \left(\frac{415}{\sqrt{3}}\right)^2}$$

$$= \frac{16666.67\,(0.75 - 0.328)}{314.16 \times (240)^2}$$

$$= 3.886 \times 10^{-4}\ F = 388.6\ \mu F$$

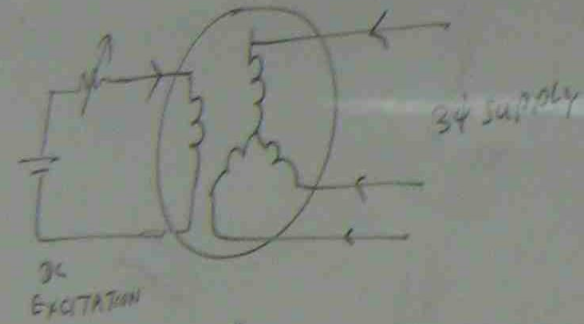
Δ CAPACITOR BANK

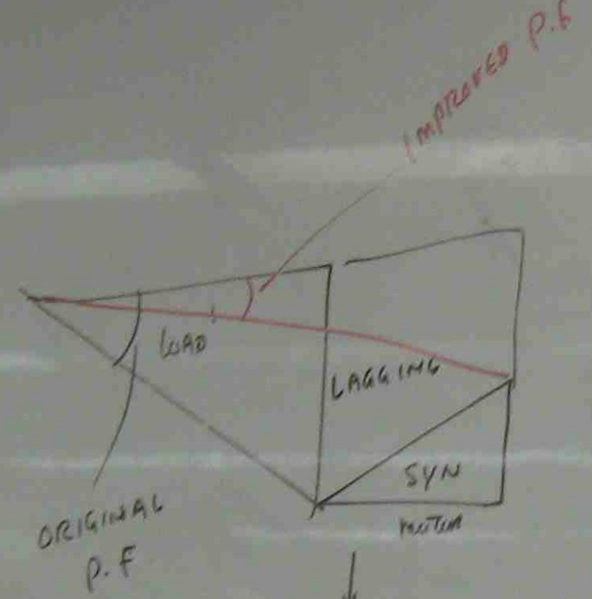
$$C = \frac{\frac{W}{3}\left(\tan\phi_1 - \tan\phi_2\right)}{2\pi f \left(V_{LINE}\right)^2}$$

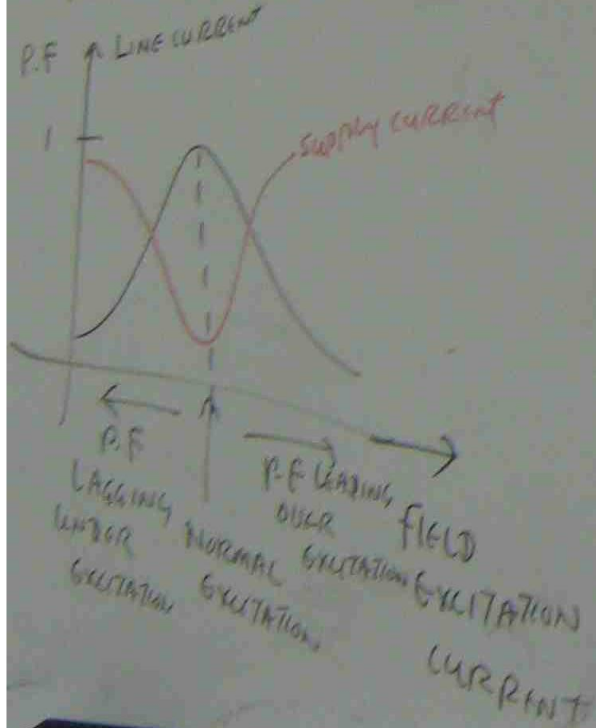
$$= \frac{\frac{50{,}000}{3}\left(0.75 - 0.328\right)}{2 \times 3.1416 \times 50 \times \left(415\right)^2}$$

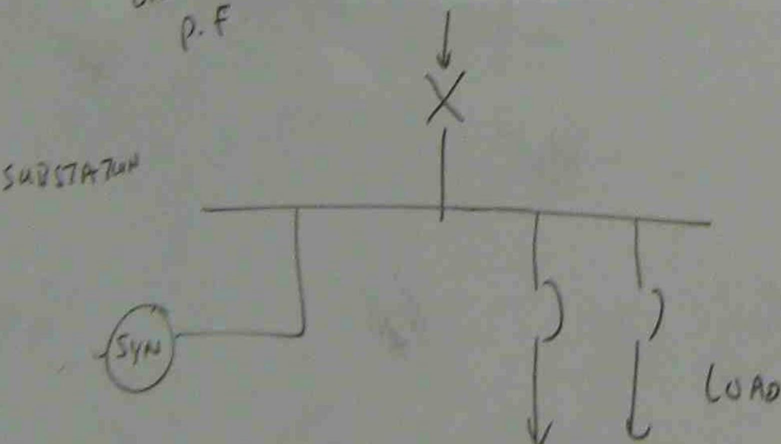
$$\doteq 130\,\mu F$$

REACTIVE POWER CONTROL BY SYNCHRONOUS MOTOR









SYNCHRONOUS MOTOR POWER FACTOR IS ADJUSTABLE

DEPENDING ON FIELD EXCITATION CURRENT, IT CAN BE

LAGGING (OR) UNITY (OR) LEADING.

THE SYNCHRONOUS MOTOR IS CONNECTED TO

BUSBAR TERMINALS OF THE SUBSTATION.

BY ADJUSTING IT'S POWER FACTOR BY FIELD EXCITATION

THE POWER OF OVER ALL PLANT CAN BE

ADJUSTED.

ph

A 415V, 50 HZ 3φ SYSTEM, THE LOADS ARE AS FOLLOWS

MOTOR GROUP (1) TOTAL 600 HP, P.F 0.8 LAGGING, EFFICIENCY 90%

MOTOR GROUP (2) TOTAL 1000 HP, P.F 0.7 LAGGING, EFFICIENCY 80%

LIGHTING LOAD TOTAL 1000 KW.

CALCULATE THE SIZE OF SYNCHRONOUS MOTOR TO IMPROVE THE P.F TO 0.95 LAGGING WITH OVER ALL ACTIVE POWER IS EQUAL TO OVER ALL APPARENT POWER OF ORIGINAL CONDITION

MOTOR GROUP(1) INPUT POWER = $\frac{600 \text{ HP} \times 0.746 \text{ (KW)}}{\text{Efficiency } (0.9)} = 497.3 \text{ KW}$

MOTOR GROUP(2) INPUT POWER = $\frac{1000 \times 0.746}{0.8} = 932.5 \text{ KW}$

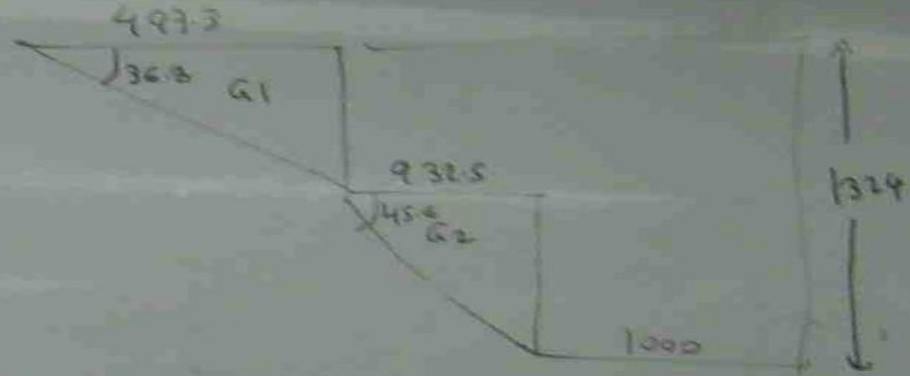
LIGHT = 1000 KW

$PF_1 = 0.8$

$\phi_1 = \cos^{-1} 0.8 = 36.8$

$PF_2 = 0.7$

$\phi_2 = \cos^{-1} 0.7 = 45.6$



$KW_T = 497.3 + 932.5 + 1000 = 2429.8$ KW

KW

$KVAR_T = 497.3 \tan 36.8 + 932.5 \tan 45.6 +$

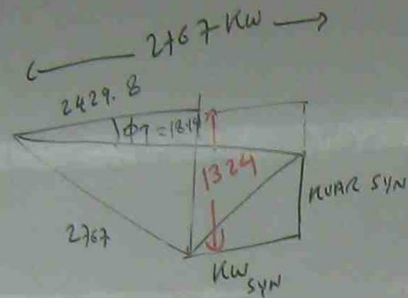
$= 497.3 \times 0.75 + 932.5 \times 1.02$

$= 1324$ KVAR

$KVA_T = \sqrt{KW^2 + KVAR^2}$

$= \sqrt{2429.8^2 + 1324^2}$

$= 2767$ KVA



$$Pf_{TOTAL} = 0.95$$

$$\phi_{TOTAL} = \cos^{-1} 0.95 = 18.19^\circ$$

$$KW_{SYN} = 2767 - 2429.8 = 337.2\ KW$$

$$KVAR_{SYN} = 1324 - 2767 \tan 18.19 = 1324 - 2767 \times 0.32 = 1324 - 909.. = 415\ KVAR$$

SYNCHRONOUS MOTOR RATING $= \sqrt{KW_{SYN}^2 + KVAR_{SYN}^2}$

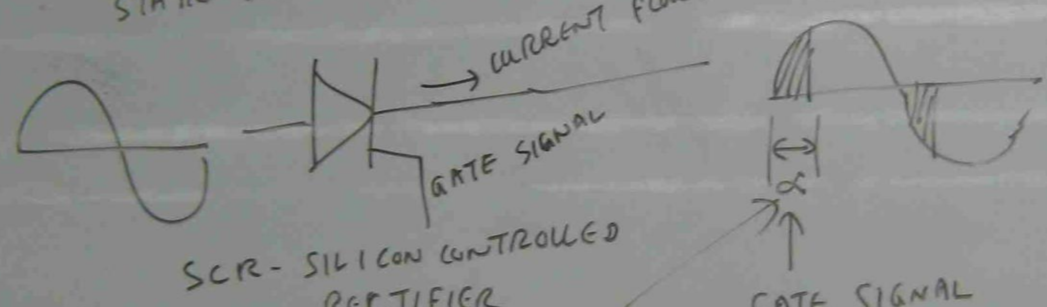
$$= \sqrt{337.2^2 + 415^2}$$

$$= 534\ KVA$$

III REACTIVE POWER CONTROL BY STATIC VAR COMPENSATION SYSTEM

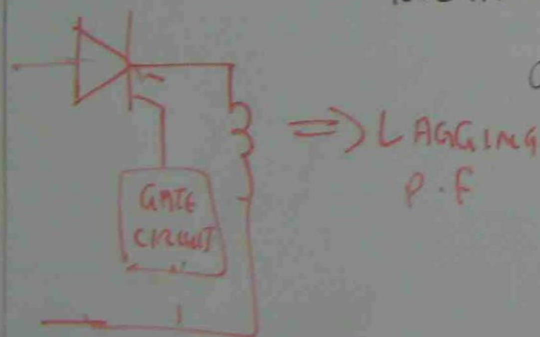
EXERCISE 7 / 02

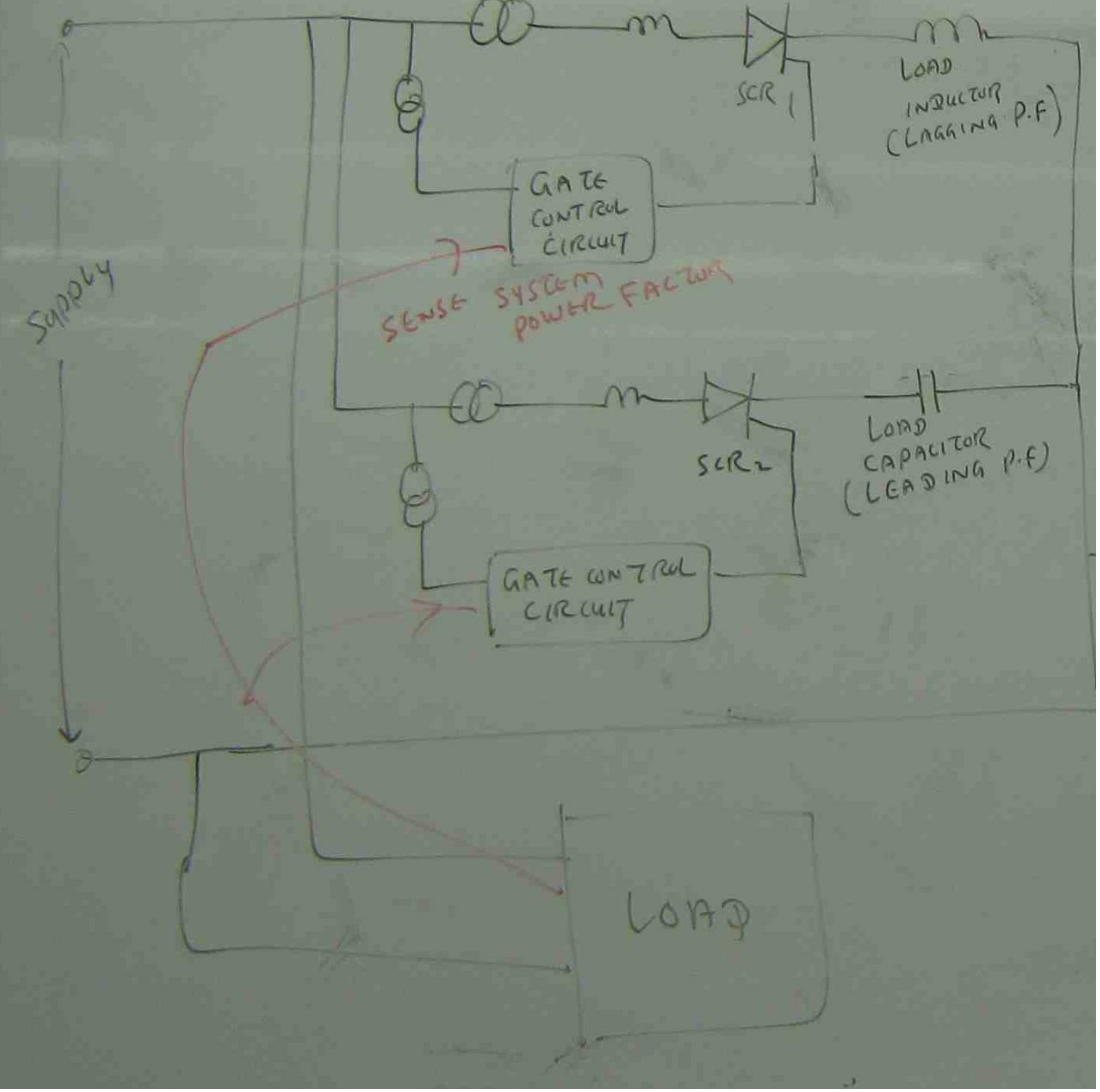
EXPLAIN HOW REACTIVE POWER IS CONTROLLED BY USING STATIC VAR COMPENSATION SYSTEM.



SCR - SILICON CONTROLLED RECTIFIER

GATE FIRING ANGLE





SCR 1
LOAD INDUCTOR (LAGGING P.F)
GATE CONTROL CIRCUIT
SUPPLY
SENSE SYSTEM POWER FACTOR
SCR2
LOAD CAPACITOR (LEADING P.F)
GATE CONTROL CIRCUIT
LOAD

(S.V.C)

STATIC VAR COMPENSATION UTILIZES SILICON CONTROL RECTIFIERS WHOSE CONDUCTION DEPENDING ON GATE FIRING SIGNAL PROVIDED BY GATE CONTROL CIRCUIT. IF MORE CURRENT IS ALLOWED TO PASS THROUGH INDUCTOR BY SCR, P.F BECOMES LAGGING & IF MORE CURRENT IS ALLOWED TO PASS THROUGH THE CAPACITOR, PF BECOMES LEADING.

- THE GATE CONTROL CIRCUITS SENSES THE SYSTEM POWER FACTOR AND PRODUCES THE GATE FIRING SIGNALS TO SCR S THAT ALLOW THE CURRENTS TO PASS THROUGH THE INDUCTOR OR CAPACITOR.

- THE OVER ALL PLANT POWER FACTOR CAN AUTOMATICALLY BE ADJUSTED BY SVC.