Pb/ A TEST ON A $\frac{1}{4}$ HP, 120V, 60 HZ, 1725 RPM 1ϕ MOTOR

REVEALS THE FOLLOWING RESULTS

R_{s1} STATOR RESISTANCE = 2Ω $(1\Omega) \leftarrow$ DIVIDED BY (2)

R_r ROTOR RESISTANCE REFERRED TO STATOR = 4Ω (2Ω)

X_{s1} STATOR LEAKAGE REACTANCE = 3Ω $(j1.5\Omega)$

X_r ROTOR LEAKAGE REACTANCE REFERRED TO STATOR = 3Ω $(j1.5\Omega)$

R_{h+e} RESISTANCE CORRESPONDING TO WINDAGE, FRICTION, IRON LOSSES = 600Ω (300Ω)

X_m MAGNETIZING REACTANCE = 60Ω. $(j30\Omega)$

DRAW THE EQUIVALENT DIAGRAM AND DETERMINE THE POWER OUTPUT, EFFICIENCY AND POWER FACTOR OF THE MOTOR WHEN IT RUNS AT 1725 RPM.

R_m,

$$SLIP\ (S) = \frac{N_s - N_r}{N_s}$$

N_r 1725, $N_s \simeq 1800$ rpm

$$= \frac{1800 - 1725}{1800} = 0.0417$$

loss

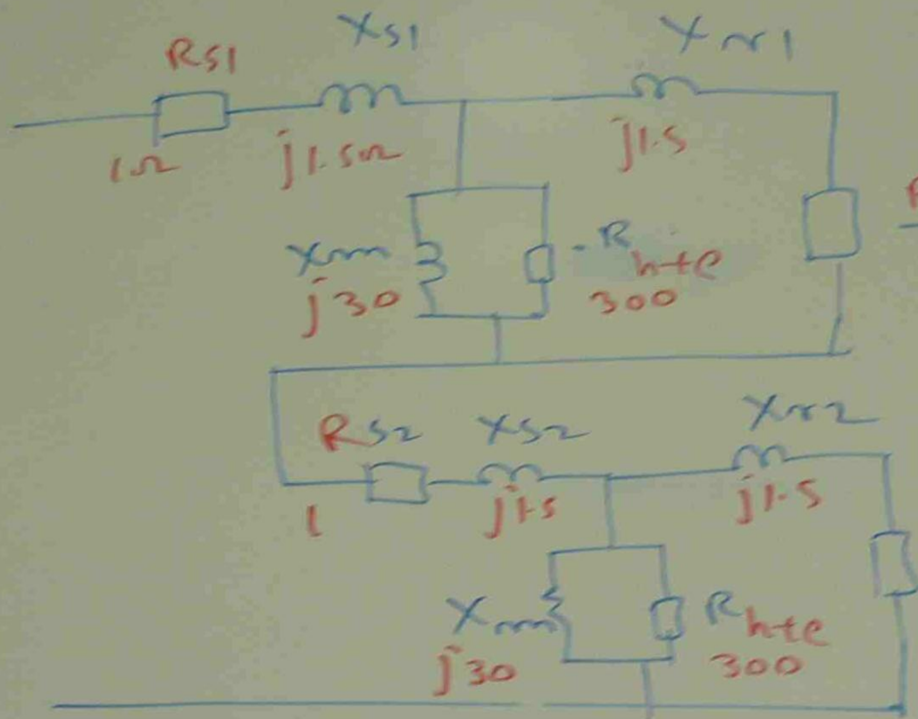
w

3)

15.4)

$$\frac{1780 \times 0.482}{9.55}$$

$= 177W$



$\frac{R_r}{s}$ STARTING WINDING (1)

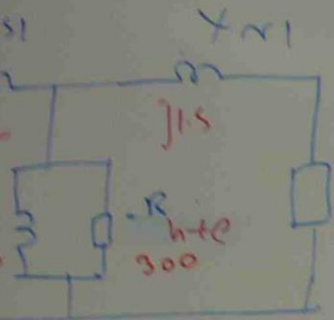
$\frac{2}{s} = \frac{2}{0.0417} = 46$

$\frac{R_r}{1-s}$ RUNNING WINDING (2)

$\frac{2}{1-0.0417} = 1.07$

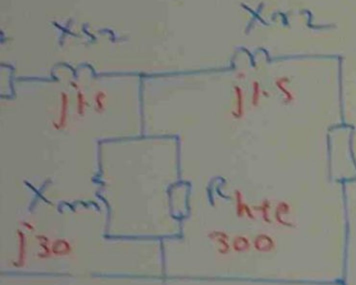
$R_m, X_m, R'_{s1}, X_{s1}, X_{r1}, X_{s2}, Z_{s2} = \frac{\text{GIVEN VALUE}}{2}$

1ϕ MOTOR EQUIVALENT DIAGRAM



$\frac{R_r}{(S)}$ STARTING WINDING(1)

$\frac{2}{(S)} = \frac{2}{0.0417} = 46$

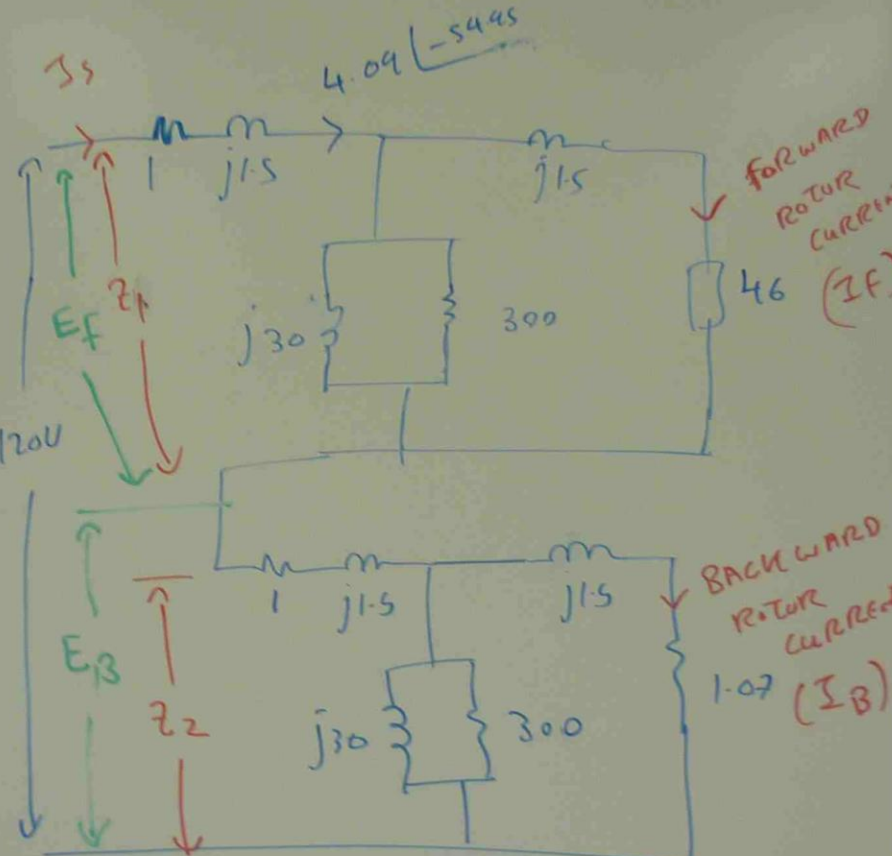


$\frac{R_r}{1-(S)}$ RUNNING WINDING (2)

$\frac{2}{1-0.0417} = 1.07$

$, X_{r_1}, X_{s_2}, Z_{s_2} = \frac{\text{GIVEN VALUE}}{2}$

MOTOR EQUIVALENT DIAGRAM



$$Z_1 = 1 + j1.5 + \cfrac{1}{\cfrac{1}{46+j1.5} + \cfrac{1}{300} + \cfrac{1}{j30}}$$

$$= 1 + j1.5 + \cfrac{1}{\cfrac{300 \times j30 + (46+j1.5) \times j30 + 300(46+j1.5)}{(46+j1.5)(300)(j30)}}$$

$$= 1 + j1.5 + \frac{(46+j1.5)(300)\,j30}{300 \times j30 + (46+j1.5) \times j30 + 300(46+j1.5)}$$

$$= 1 + j1.5 + \frac{j46 \times 300 \times 30 - 300 \times 1.5 \times 30}{j9000 + j46 \times 30 - 1.5 \times 30 + 46 \times 300 + j1.5 \times 300}$$

$$= 1 + j1.5 + \frac{-1.5 \times 30 \times 300 + j46 \times 300 \times 30}{46 \times 300 - 1.5 \times 30 + j(9000 + 46 \times 30 + 1.5 \times 300)}$$

$$= 1 + j1.5 + 13.89 + j19.53$$

$$Z_1 = 14.89 + j21.03 = \sqrt{14.89^2 + 21.03^2} \angle \tan^{-1}\frac{21.03}{14.89} = 25.77 \angle 54.7$$

$$Z_2 = 1 + j1.5 + \cfrac{1}{\cfrac{1}{1.07 + j1.5} + \cfrac{1}{300} + \cfrac{1}{j30}}$$

$$= 1 + j1.5 + 0.43 + j1.45$$

$$= 1.43 + j2.95\ \Omega = \sqrt{1.43^2 + 2.95^2}\ \angle \tan^{-1}\frac{2.95}{1.43} = 3.52\angle 56.3$$

STATOR CURRENT $= \dfrac{E}{Z_1 + Z_2} = \dfrac{120}{14.84 + j21.03 + 1.43 + j2.45}$

I_s

$$= \frac{120}{16.82 + j23.48}$$

$$= \frac{120}{\sqrt{16.82^2 + 23.48^2}\ \angle \tan^{-1}\frac{23.48}{16.82}}$$

$$I_s = \frac{120}{29.38\angle 54.93} = 4.09\angle -54.93$$

00

00)

$77\angle 54.7$

$E_F = I_s \times Z_1 = 4.09\angle{-54.95} \times 25.77\angle{54.7} = 105.6\angle{-0.25}$

$E_B = I_s \times Z_2 = 4.09\angle{-54.95} \times 3.52\angle{56.8} = 14.42\angle{1.85}$

$\angle{56.6}$

$$I_F = 4.09\angle{-54.95} \times \frac{\dfrac{1}{\frac{1}{300} + \frac{1}{j30}}}{46 + j1.5 + \dfrac{1}{\frac{1}{300} + \frac{1}{j30}}}$$

$$= 4.09\angle{-54.95} \; \frac{(13.84 + j14.5)}{48.02\angle{1.74}}$$

$$= \frac{4.09\angle{-54.95} \times 23.46\angle{54.58}}{48.02\angle{1.74}} = 2.044\angle{2.16}$$

$$I_B = 4.09\angle{-54.95} \times \frac{\dfrac{1}{\frac{1}{300} + \frac{1}{j30}}}{1.07 + j1.5 + \dfrac{1}{\frac{1}{300} + \frac{1}{j30}}}$$

$$= \frac{4.09\angle{-54.95} \times (0.43 + j1.45)}{1.81\angle{55.78}}$$

$$= \frac{4.09\angle{-54.95} \times 1.72\angle{57.32}}{1.81\angle{55.78}} = 3.89\angle{-53.4}$$

FORWARD POWER

$$P_F = I_f^2 \times R$$

$$= 2.044^2 \times 48 = 200.5 \text{ W}$$

$$P_B = I_B^2 \times R$$

$$= 3.79^2 \times 1.07$$

$$= 15.4 \text{ W}$$

$$T = \frac{9.55}{n}(P_F - P_B)$$

$$= \frac{9.55}{1800}(200.5 - 15.4)$$

$$= 0.982 \text{ N-m}$$

$$\boxed{\text{POWER} = \frac{nT}{9.55} = \frac{1780 \times 0.982}{9.55} = 177 \text{ W}}$$

Pb

A

RE UEA

Rs1 S

Rr R

Xs1

Xr

Rh+e

Xm

FORWARD POWER

$P_F = I_f^2 \times R\left(\frac{R_r}{S}\right)$

$= 2.044^2 \times 48 = 200.5\ W$

$P_B = I_B^2 \times R\left(\frac{R_r}{1-S}\right)$

$= 3.84^2 \times 1.09$

$= 15.4\ W$

$T = \frac{9.55}{n_s}(P_F - P_B)$

$= \frac{9.55}{1800}(200.5 - 15.4)$

$= 0.982\ N\text{-}m$

$\boxed{\text{POWER o/p} = \frac{n_r T}{9.55} = \frac{1780 \times 0.982}{9.55} = 177W}$

$I_s = 4.09 \angle -54.95$

$PF = \cos 54.95 = 0.57$ LAGGING

INPUT POWER $= E I_s \cos\phi = 110 \times 4.09 \times 0.57 = 282.3W$

OUTPUT POWER $= 177\ W$

EFFICIENCY $= \frac{\text{OUTPUT}}{\text{INPUT}} \times 100 = \frac{177}{282.3} \times 100 = 62.7\%$

P6

A RESISTANCE SPLIT PHASE MOTOR IS RATED AT $\frac{1}{4}$ HP (187 W) 1725 RPM, 115V, 60 HZ

WHEN THE ROTOR IS LOCKED, A TEST AT REDUCED VOLTAGE ON MAIN AND AUXILIARY WINDINGS YIELDS THE FOLLOWING RESULTS.

	MAIN WINDING	AUXILIARY WINDING
APPLIED VOLTAGE	$E = 23V$	$E = 23V$
CURRENT	$I_s = 4A$	$I_a = 1.5A$
ACTIVE POWER	$P_s = 60W$	$P_a = 30W$

CALCULATE (a) PHASE ANGLE BETWEEN I_s AND I_a

(b) LOCKED ROTOR CURRENT DRAWN FROM THE LINE AT 115V

(pb)

A RESISTANCE SPLIT PHASE MOTOR IS RATED AT $\frac{1}{4}$ HP (187 W) 1725 RPM, 115V, 60 HZ

WHEN THE ROTOR IS LOCKED, A TEST AT REDUCED VOLTAGE ON MAIN AND AUXILIARY WINDINGS YIELDS THE FOLLOWING RESULTS.

	MAIN WINDING	AUXILIARY WINDING
APPLIED VOLTAGE	$E = 23V$	$E = 23V$
CURRENT	$I_s = 4A$	$I_a = 1.5A$
ACTIVE POWER	$P_s = 60W$	$P_a = 30W$

CALCULATE (a) PHASE ANGLE BETWEEN I_s AND I_a

(b) LOCKED ROTOR CURRENT DRAWN FROM THE LINE AT 115V

(a)

MAIN WINDING

APPARENT POWER $S_s = E I_s = 23 \times 4 = 92\,VA$

POWER FACTOR $= \frac{P_s}{S_s} = \frac{60}{92} = 0.65$

$\phi_s = \cos^{-1} PF = \cos^{-1} 0.65 = 49.6$

AUXILIARY WINDING

APPARENT POWER $= S_a = E I_a$

$= 23 \times 1.5$

$= 34.5\,VA$

POWER FACTOR $= \frac{P_a}{S_a} = \frac{30}{34.5} = 0.87$

$\phi_a = \cos^{-1} 0.87 = 29.6^\circ$

ANGLE DIFFERENCE $= \phi_s - \phi_a = 49.6 - 29.6$

$= 20^\circ$

(b) TOTAL ACTIVE POWER ABSORBED BY MAIN AND AUXILIARY WINDING P_T $= P_s + P_a = 60 + 30 = 90\,W$

REACTIVE POWER

$$Q_s = \sqrt{S_s^2 - P_s^2} = \sqrt{92^2 - 60^2} = 69.7\ VAR$$

$$Q_a = \sqrt{S_a^2 - P_a^2} = \sqrt{34.5^2 - 30^2} = 17\ VAR$$

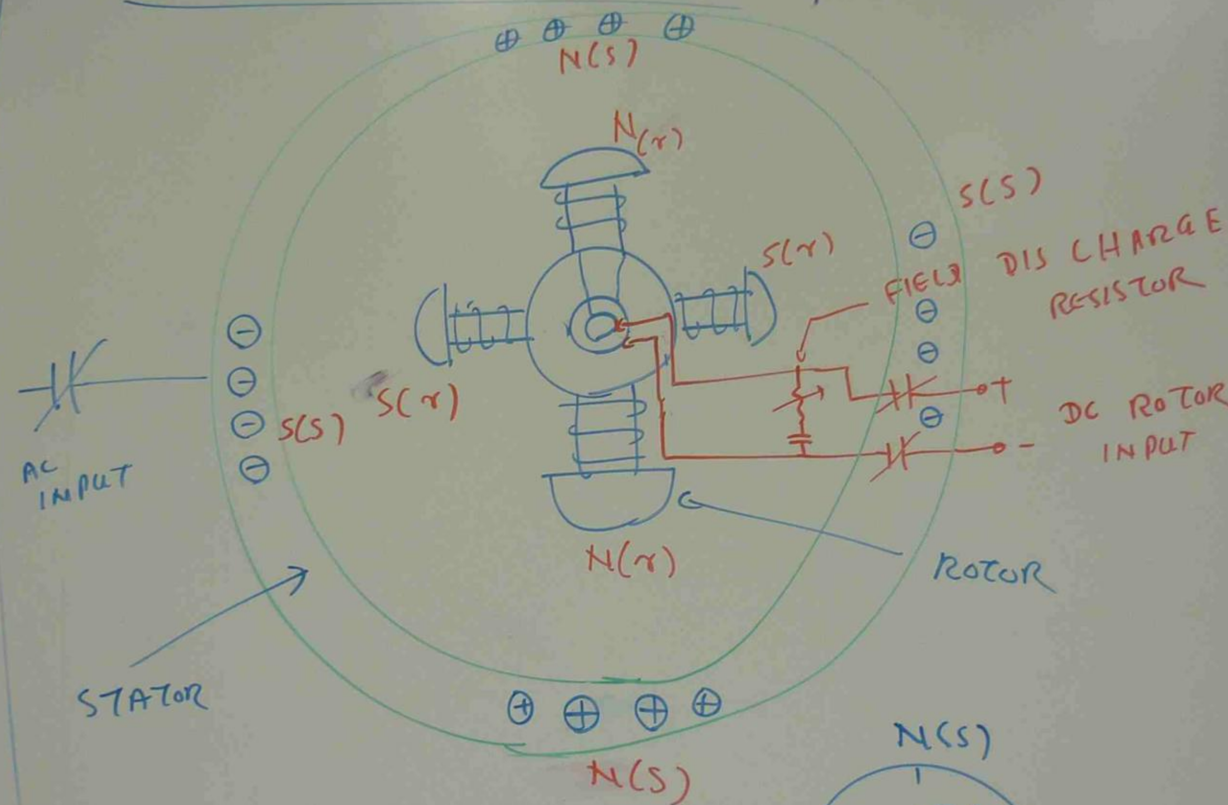
$$Q_T = Q_s + Q_a = 69.7 + 17 = 86.7\ VAR$$

$$S_T = \sqrt{P_T^2 + Q_T^2} = \sqrt{90^2 + 86.7^2} = 125\ VA$$

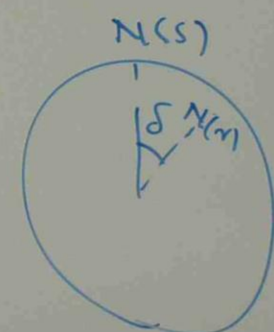
LOCKED ROTOR CURRENT $= \dfrac{S_T}{E} = \dfrac{125}{23} = 5.44\,A$

LOCKED ROTOR CURRENT AT 115V $= \dfrac{115}{23} \times 5.44 = 27.2\,A$

SYNCHRONOUS MOTOR CONTROL

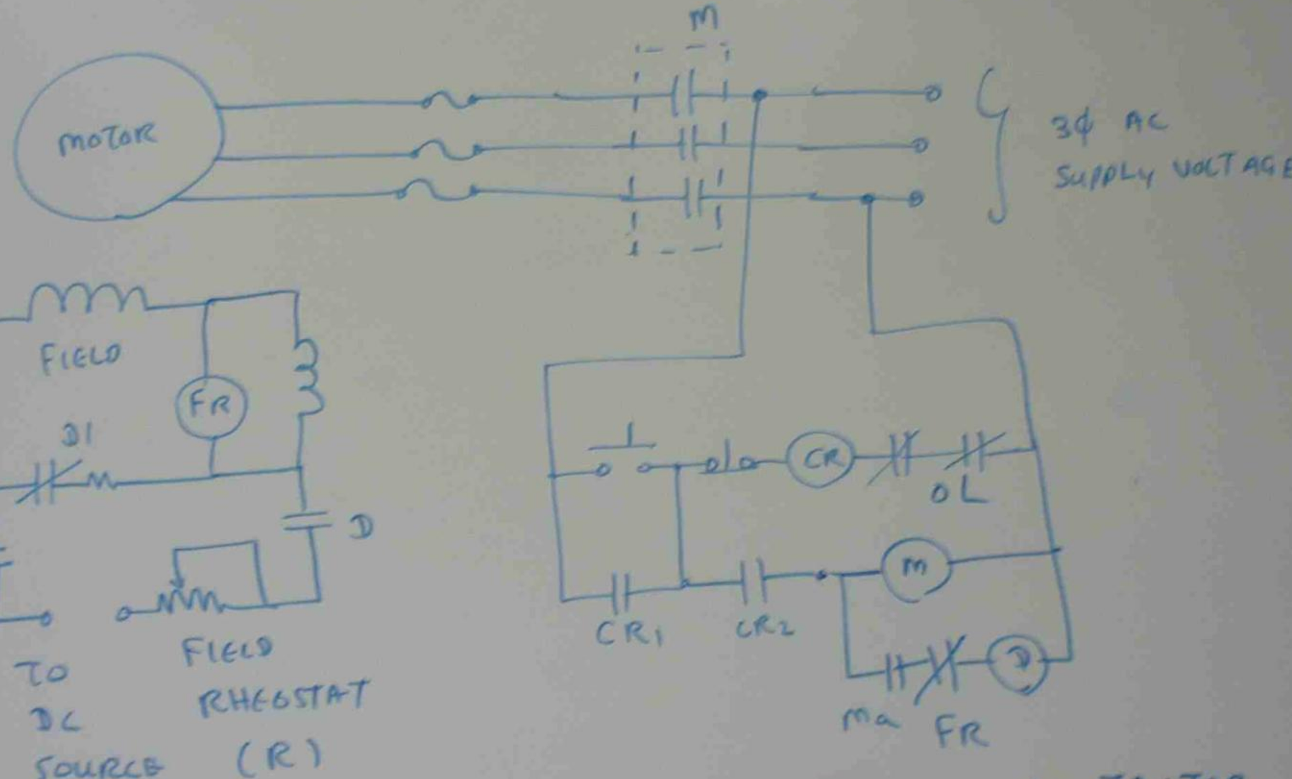


$$P = \frac{E_S \times E_r}{X_S} \sin\delta$$



δ = COUPLING ANGLE

STARTER CONNECTION DIAGRAM OF SYNCHRONOUS MOTOR



Ma = ACCELERATION CONTACTOR

OPERATION

(1) WHEN THE START BUTTON IS PRESSED, CR RELAY WILL ENERGIZE CAUSING

CONTACT CR_1 AND CR_2. M COIL TO ENERGIZE

(2) M CONTACTS CLOSE, MOTOR STARTS (8)

(3) EMF IS INDUCED IN FIELD WINDING (4)

(4) THE CURRENT WILL FLOW THROUGH THE FIELD (10)

(5) IT DEVELOPS THE VOLTAGE ACROSS FR COIL. (11)

FR COIL ENERGIZES AND FR CONTACTS ARE OPEN

Ma IS CLOSED

(6) THE ROTOR FIELD WILL START TO ROTATE BECAUSE (12

THE FIELD IS CONNECTED THROUGH D1.

(7) AS THE SPEED OF ROTATING FIELD INCREASE

THE VOLTAGE ACROSS FR IS DECREASED.

(8) FR RELAY DROPS OUT

(4) FR CONTACT TO CLOSE

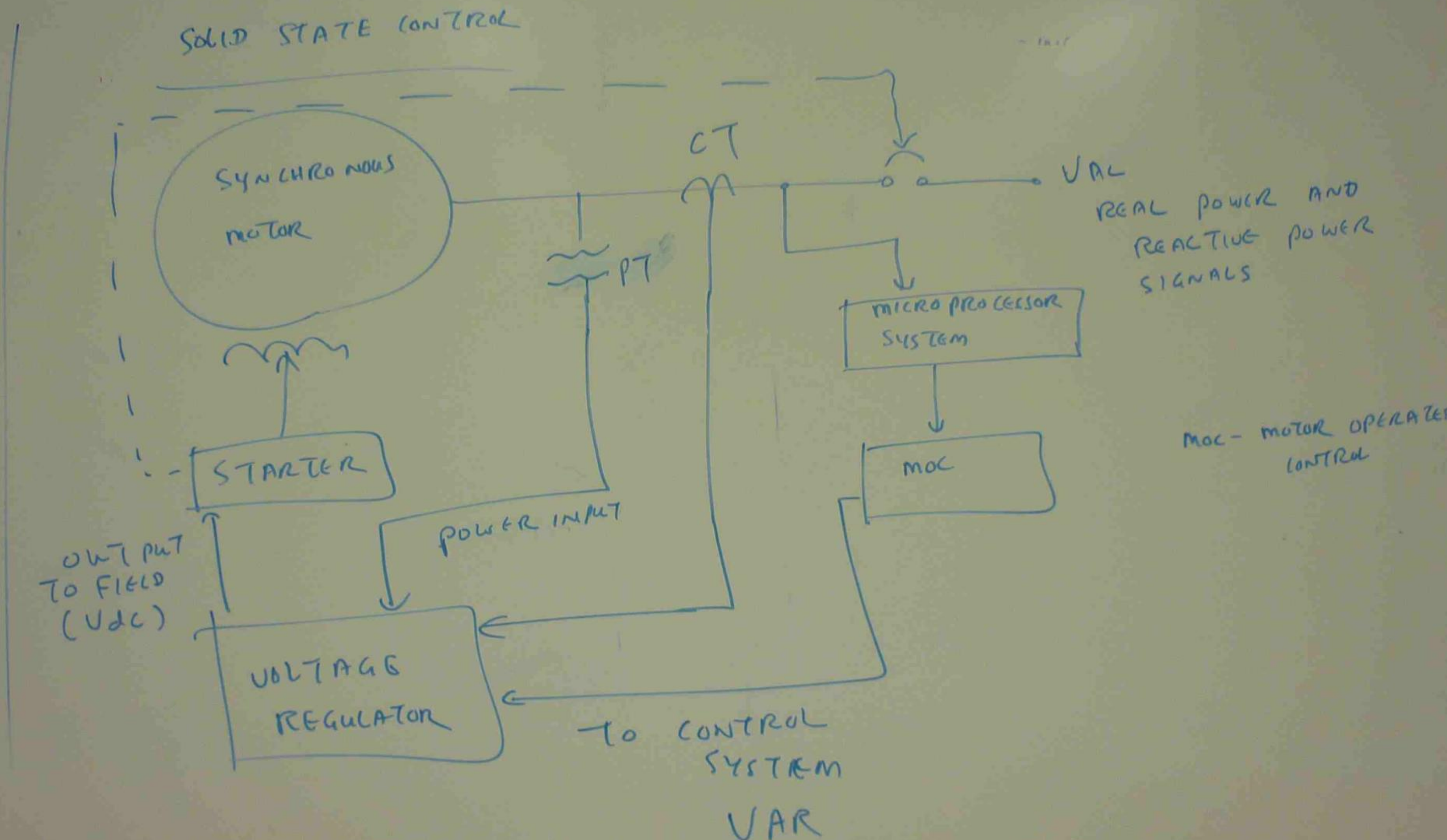
(10) D RELAY ENERGIZES

(11) D_1 CONTACT OPENS

D CONTACTS CLOSED.

(12) ROTOR FIELD EXCITATION

CAN BE GIVEN


SOLID STATE CONTROL
SYNCHRONOUS MOTOR
CT
PT
VAL
REAL POWER AND REACTIVE POWER SIGNALS
MICRO PROCESSOR SYSTEM
MOC
MOC - MOTOR OPERATED CONTROL
STARTER
POWER INPUT
OUTPUT TO FIELD (VDC)
VOLTAGE REGULATOR
TO CONTROL SYSTEM
VAR

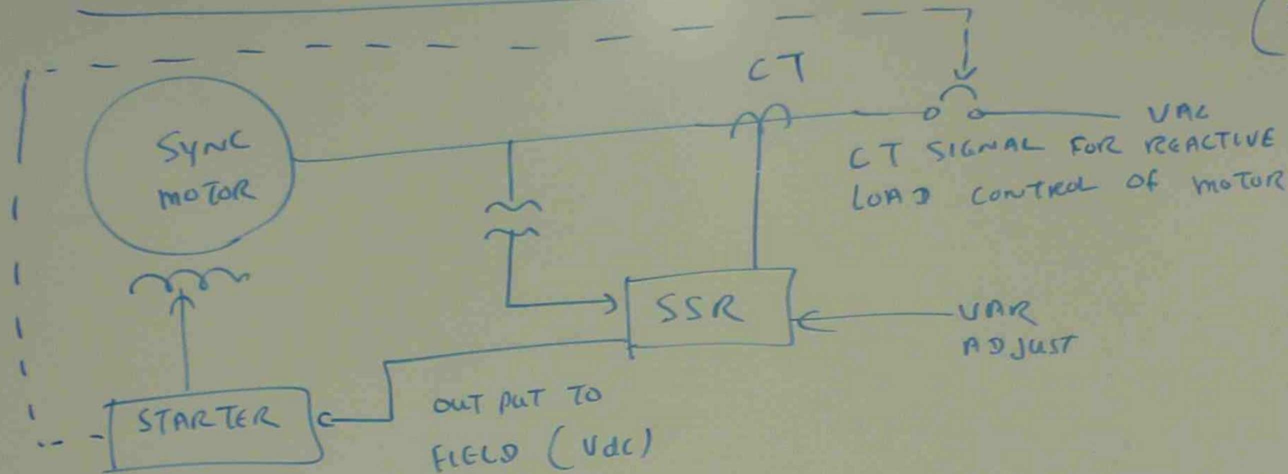
THE MICROPROCESSOR SENSES OUTPUT ACTIVE & REACTIVE POWER AND PROVIDES THE SUPERVISORY SIGNAL TO MOTOR OPERATED CONTROL MOC. MOC THEN ADJUSTS THE VOLTAGE REGULATOR WHICH CHANGES THE AMOUNT OF FIELD EXCITATION CURRENT.

UNDER EXCITATION CAN DEVELOP LAGGING POWER FACTOR AND OVER EXCITATION CAN DEVELOP LEADING POWER FACTOR OF SYNCHRONOUS MOTOR.

DEPENDING ON THE WHOLE SYSTEM ACTIVE AND REACTIVE POWER FLOW, THE SYNCHRONOUS MOTOR PROVIDES APPROPRIATE POWER FACTOR CORRECTION

EXCITATION SYSTEM WORKING IN TO THE FIELD OF A SYNCHRONOUS MOTOR

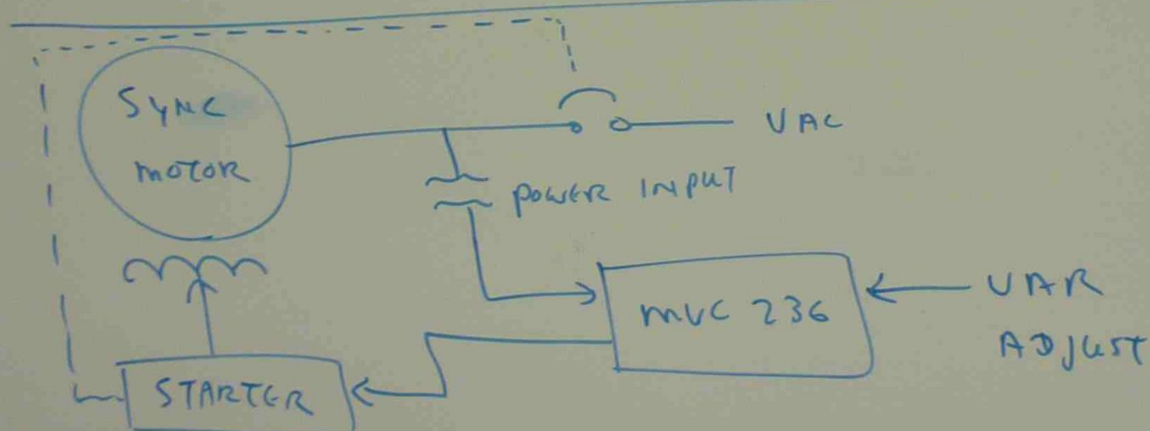
(SCHEMATIC)



IATE

MANUAL VOLTAGE CONTROL WORKING INTO THE FIELD OF A SYNCHRONOUS MOTOR

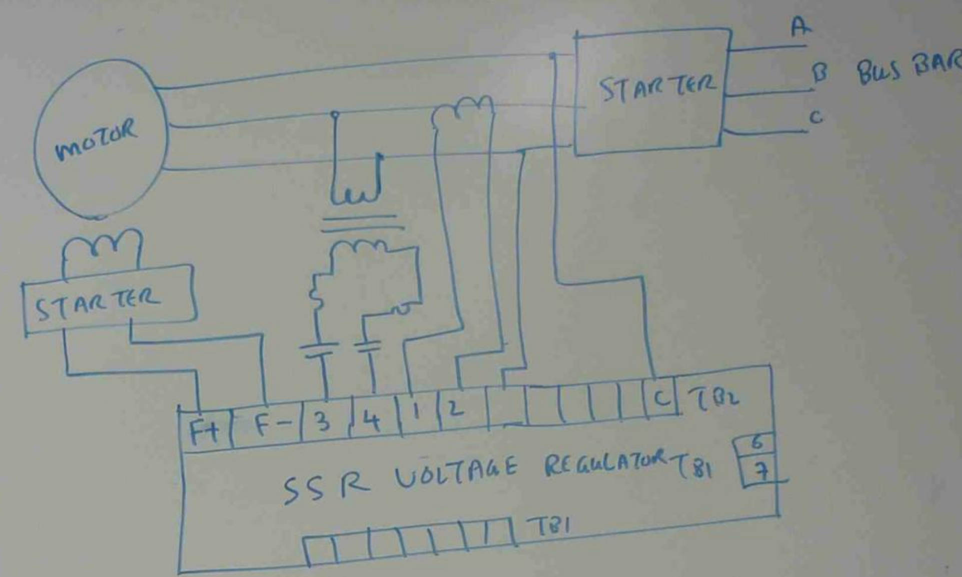
(SCHEMATIC)



SYNCHRONOUS MOTOR

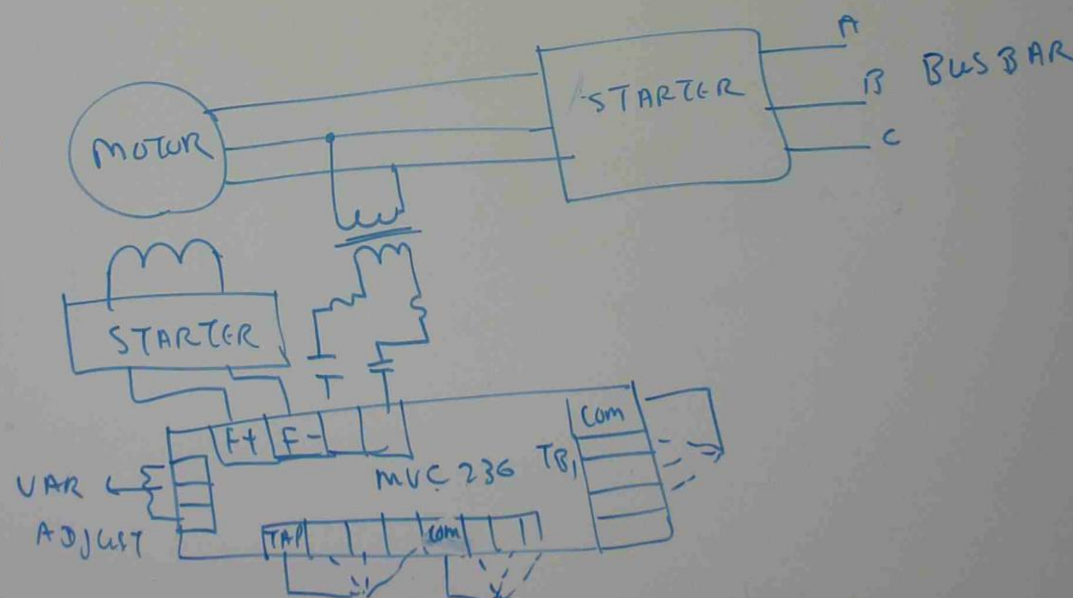
(SCHEMATIC)

VAR
REACTIVE
of motor



FIELD of

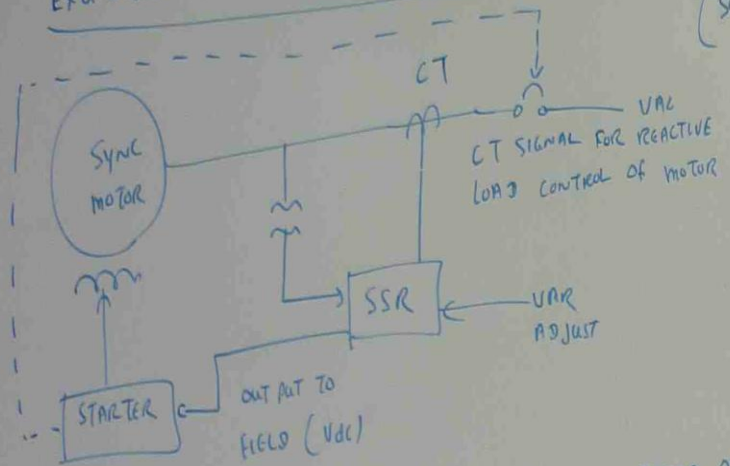
(SCHEMATIC)

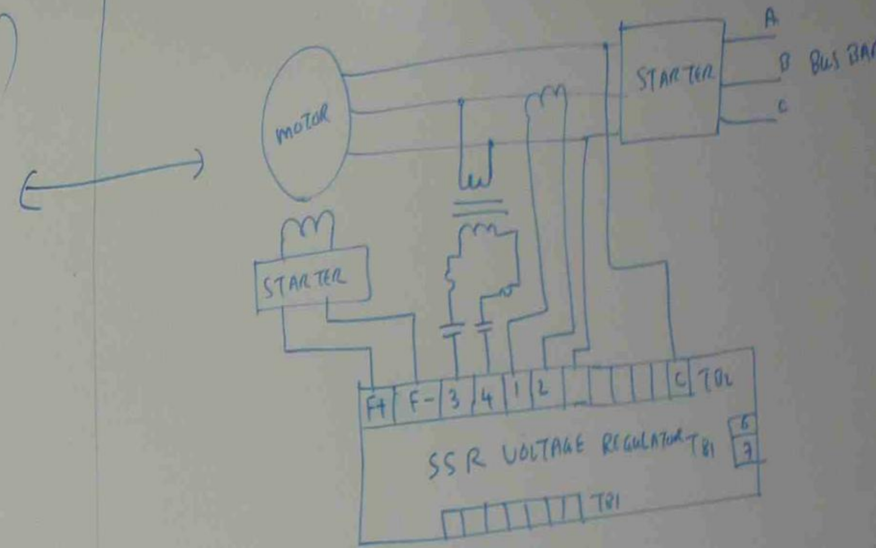


R

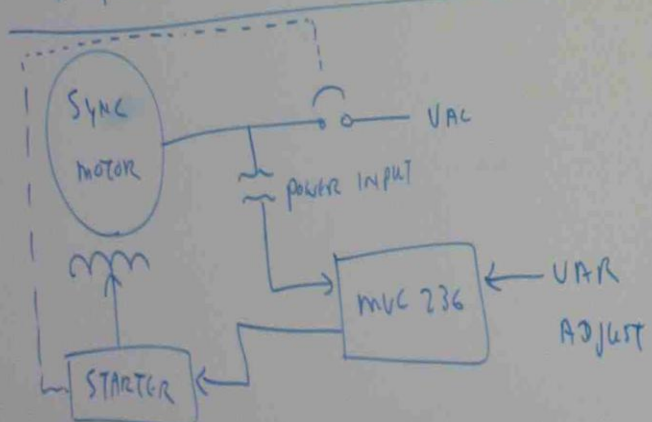
JUST

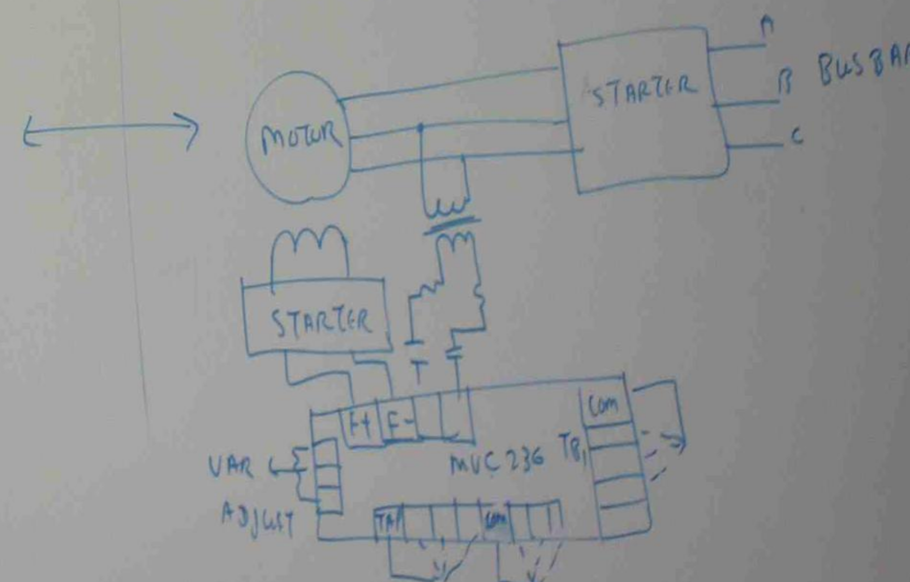
EXCITATION SYSTEM WORKING INTO THE FIELD OF A SYNCHRONOUS MOTOR (SCHEMATIC)

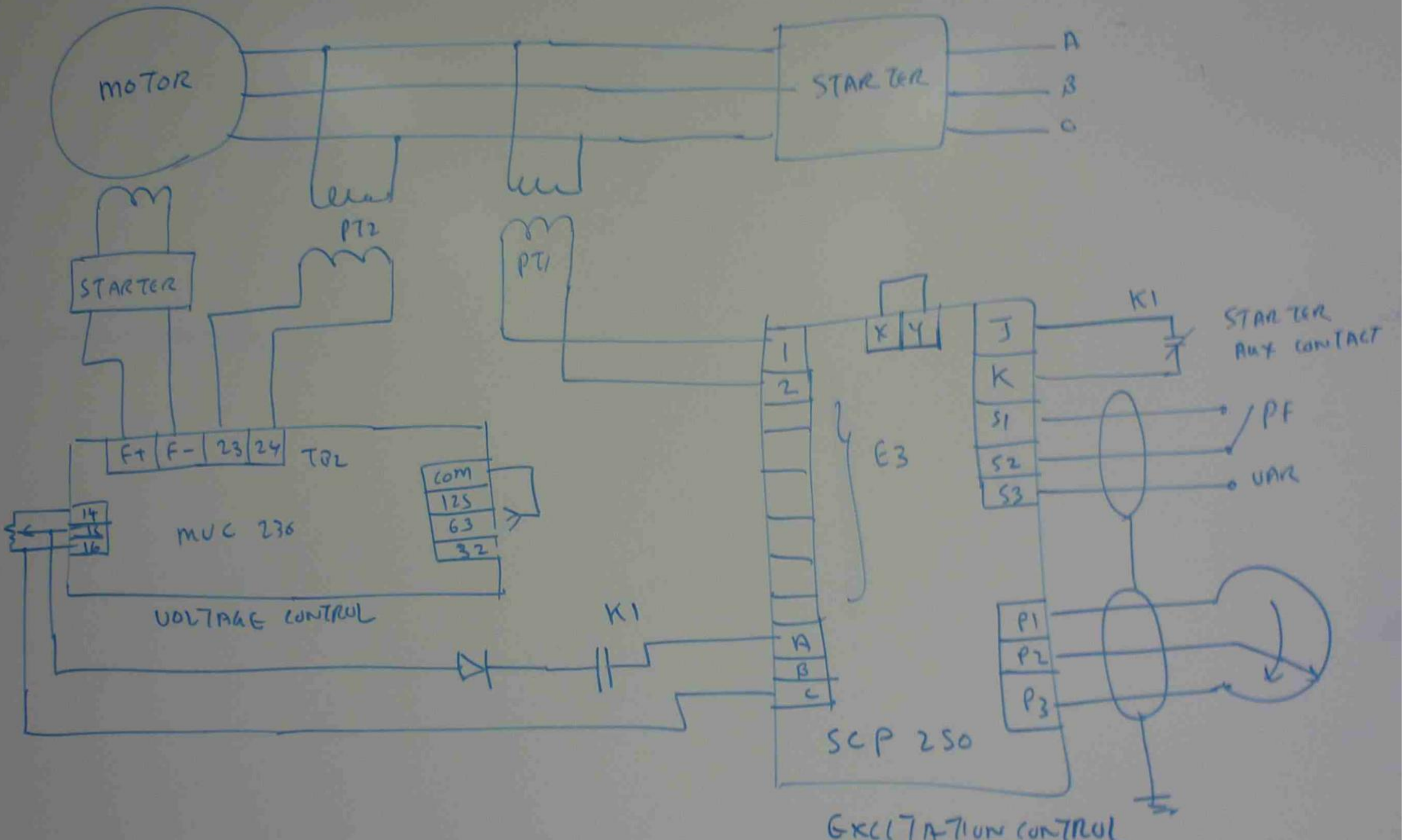




MANUAL VOLTAGE CONTROL WORKING INTO THE FIELD OF A SYNCHRONOUS MOTOR (SCHEMATIC)







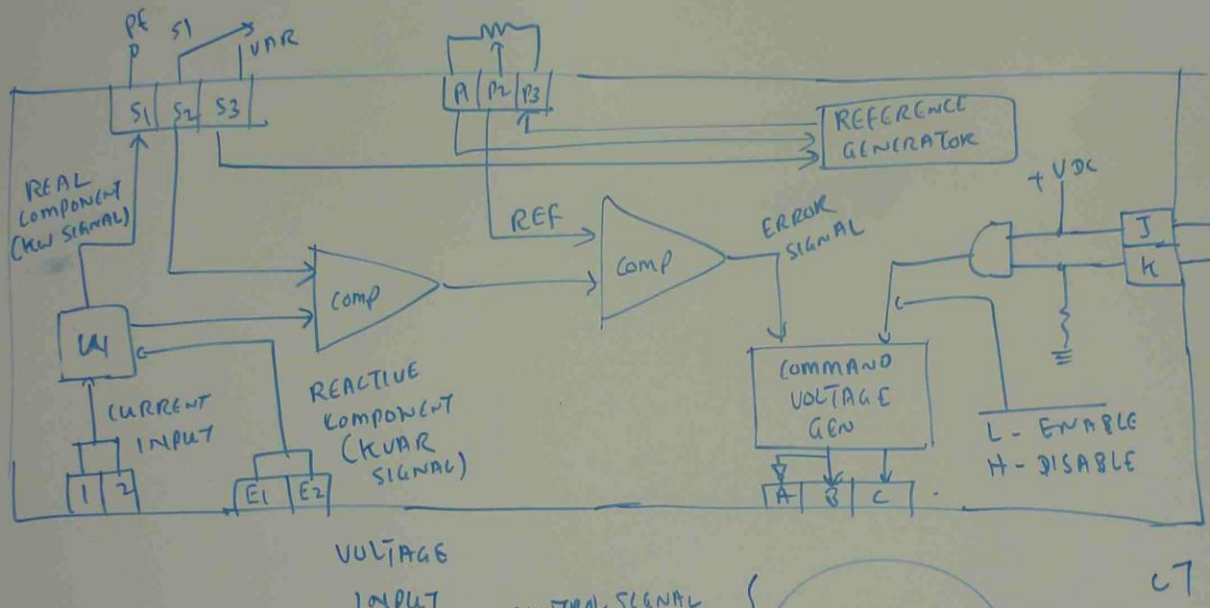
PF CONTROL

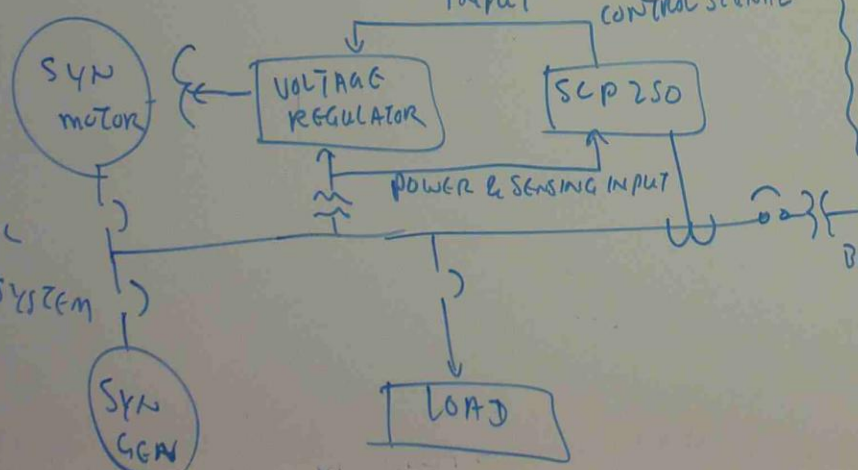
TYPIC

POWE

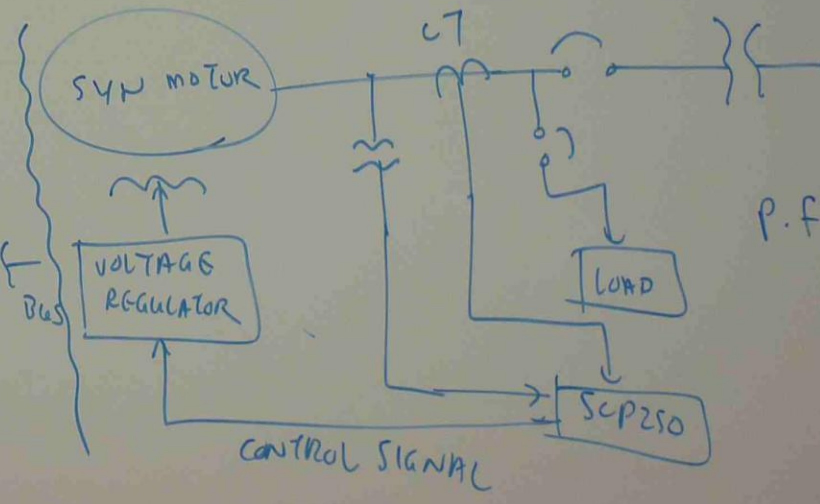
EXCITATION CONTROL BLOCK INTERNAL CONNECTION DIAGRAM (SCP 250)

TER
CONTACT





TYPICAL POWER SYSTEM



P.F CONTROL SYSTEM