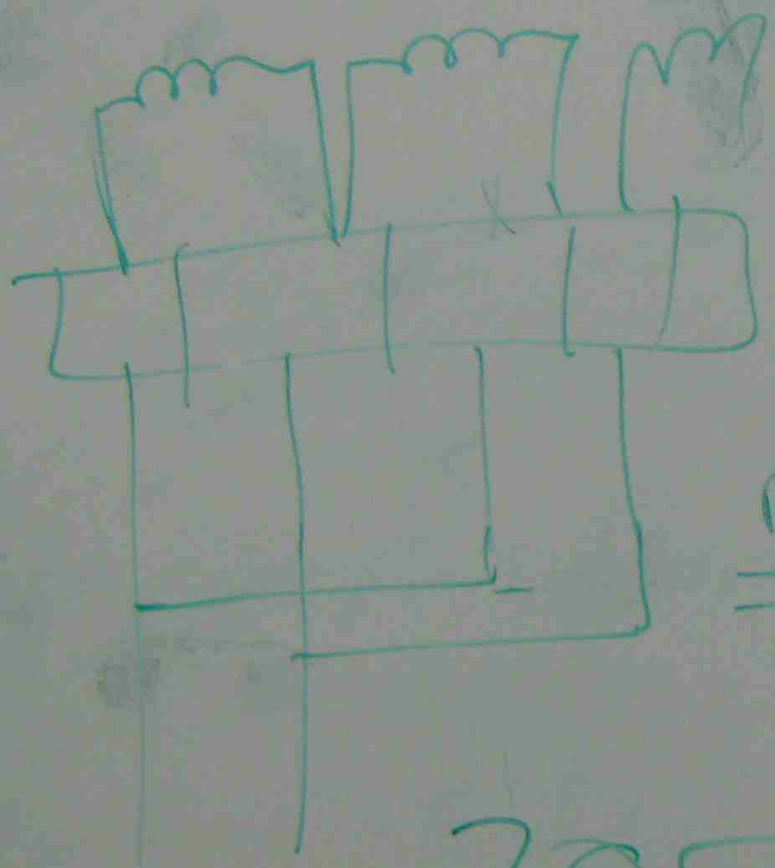


PARALLEL PATH

205

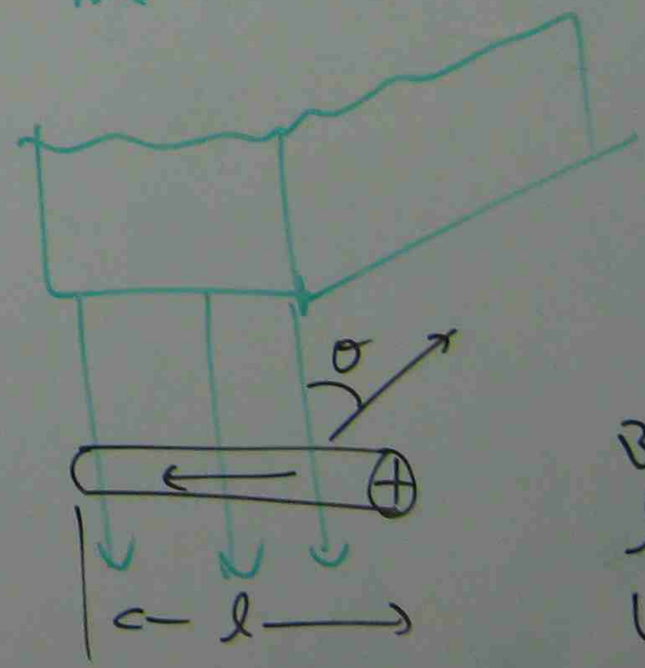
GENERATOR ACTION

(1) RATE OF MOMENT ACRO

(2) TOTAL FLUX IN THE A

(3) THE ANGLE BETW

AND ARMATURE MO



e

B=

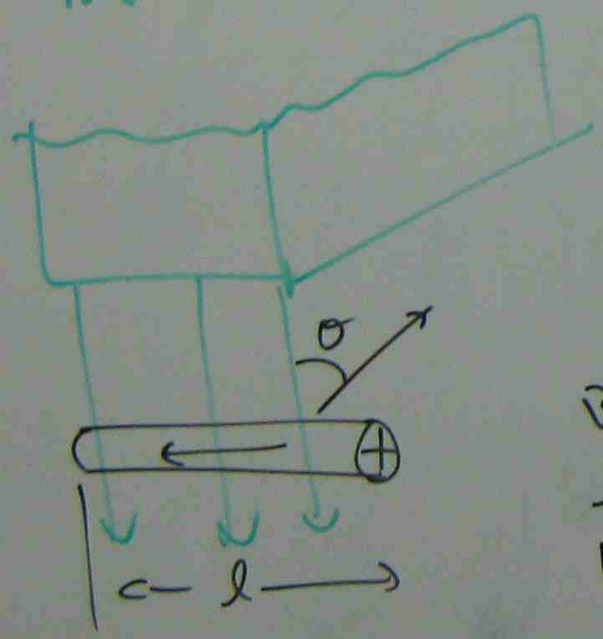
l=

v

C=

GENERATOR ACTION

1. RATE of MOMENT ACROSS MAGNETIC FIELD
2. TOTAL FLUX IN THE AREA SWEPT BY THE CONDUCTOR
3. THE ANGLE BETWEEN THE DIRECTION of MAGNETIC FIELD AND ARMATURE MOTION



$$e = B\,L\,U\,\sin\theta$$

B = FLUX DENSITY (T)
l = CONDUCTOR LENGTH (m)
U = VELOCITY (m/s)

e = GENERATED VOLTAGE (VOLT)

$$E = \frac{\phi\,P\,N}{60} \times \frac{Z}{a}$$

E = GENERATED VOLTAGE (V)

ϕ = flux (wb)
P = NO. of POLES
N = SPEED (RPM)
Z = NO. OF ARMATURE CONDUCTOR
a = NO. ARMATURE PARALLEL PATHS.

Ex 3.1

PAGE (55)

A SIX POLE WAVE WOUND DC GENERATOR HAS 410 ACTIVE CONDUCTORS. IF THE GENERATOR IS DRIVEN AT 750 RPM, CALCULATE THE OPEN CIRCUIT VOLTAGE IF THE USEFUL FLUX PER POLE IS 0.03 wb.

$Z = 410$ $\quad \phi = 0.03$ wb

$N = 750$ RPM

$P = 6$

$Z = 410$

$$E = \frac{\phi Z N}{60} \times \frac{P}{a}$$

$$= \frac{0.03 \times 410 \times 750}{60} \times \frac{6}{2}$$

$$= 461 \text{ V}$$

SIMPLEX WAVE

ARMATURE PARALLEL PATH $a = 2 \times m$

SIMPLEX $m = 1$

DUPLEX $m = 2$

$a = 2 \times 1 = 2$

LAP WINDING

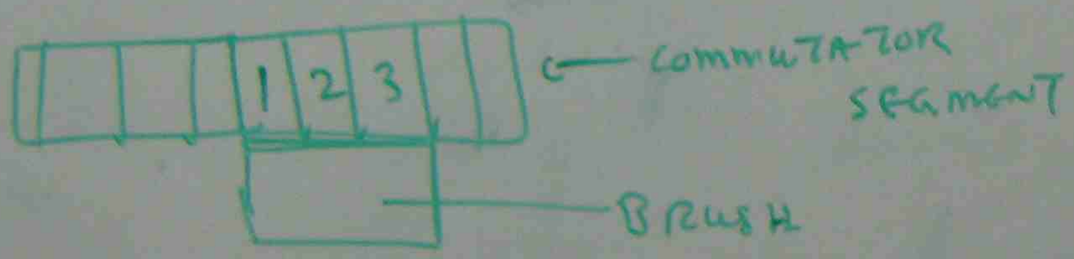
$a = m \times P$ $\quad P$ = NO. OF POLE.

COMMUTATION TIME

$$t_c = \frac{60 \quad C_b}{N \quad C}$$

t_c = COMMUTATION TIME

C_b = SPAN OF BRUSH BY SEGMENT



3 SEGMENTS (1, 2, 3) ARE TOUCHED BY BRUSH

$C_b = 3$

N = SPEED (RPM)

C = TOTAL NUMBER OF COMMUTATOR SEGMENTS.

Ex 3.2

A 240 SEGMENT COMMUTATOR ROTATES AT 1500 RPM. IF THE BRUSH SPANS 3 SEGMENTS, CALCULATE THE COMMUTATION TIME.

$C = 240$ $N = 1500$ RPM

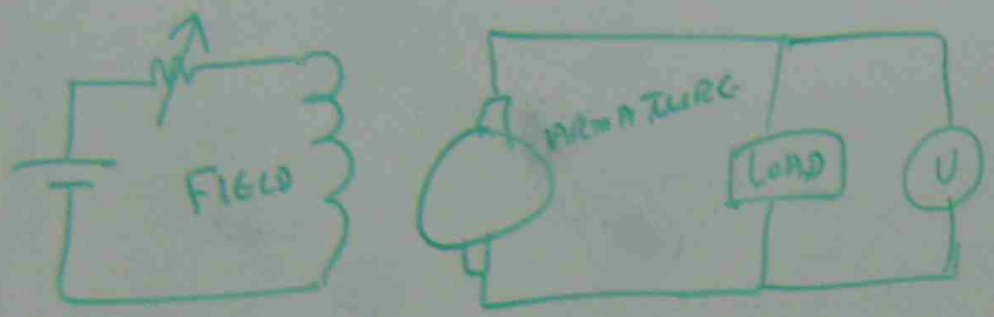
$C_b = 3$

$$t_c = \frac{60\ C_b}{N\ C} = \frac{60 \times 3}{1500 \times 240}$$

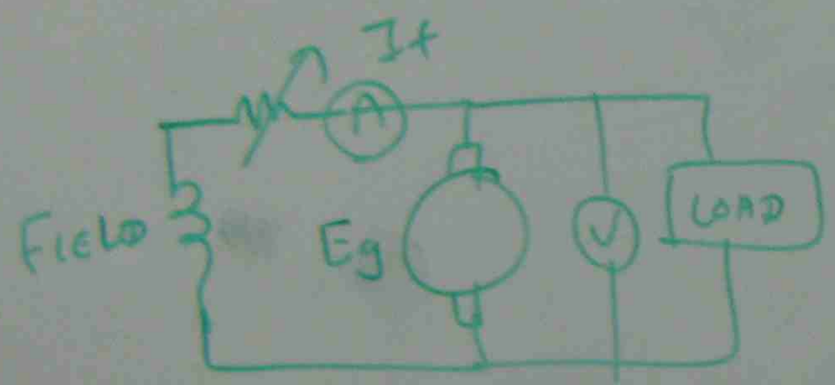
$$= 5 \times 10^{-4} \text{ sec}$$

Time constant $\Rightarrow \tau = \frac{L}{R}$

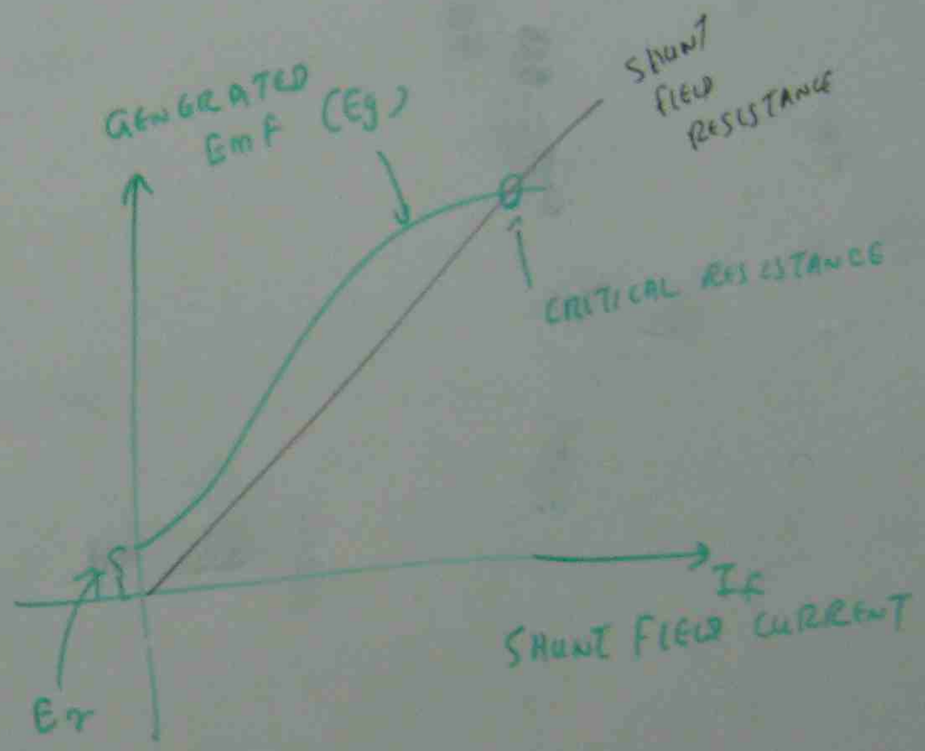
$t_c \geq 5\tau$



SEPARATELY EXCITED MACHINE



SELF EXCITED MACHINE



72

$$P = \frac{2\pi N T}{60}$$

T = TORQUE (N-m)

N = SPEED

P = POWER (WATT)

$$T = B L I r$$

B = FLUX DENSITY (TESLA - T)

L = LENGTH of CONDUCTOR (m)

I = CURRENT (AMP)

r = RADIUS of ARMATURE (m)

P 76
EX 4.1

A 4 POLES LAP WOUND ARMATURE HAS 720 ACTIVE CONDUCTORS. SPEED 1500 RPM

FLUX PER POLE IS 0.04 Wb,

ARMATURE CURRENT IS 31.4 AMP,

CALCULATE THE TORQUE DEVELOPED.

$$T = \frac{1}{2\pi} \frac{\phi Z P I_a}{a}$$

$a = m$
$= 1 \times 4 = 4$

ϕ = FLUX (Wb), Z = NO. of CONDUCTORS, P = NO of POLE

I_a = ARMATURE CURRENT, a = ARMATURE PARALLEL PATHS.

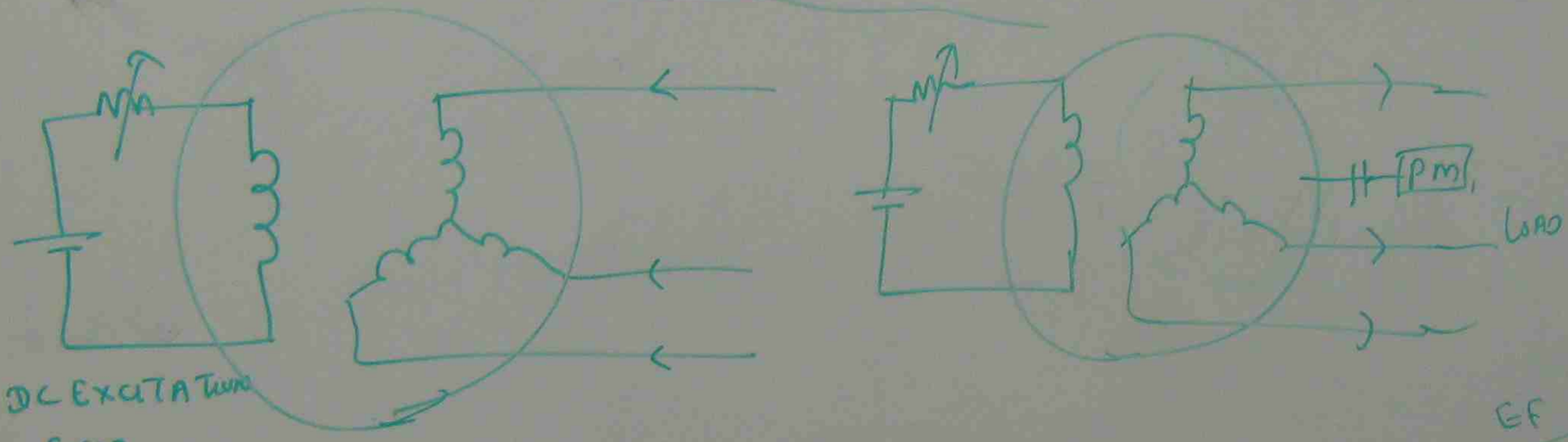
$$T = \frac{1}{2 \times 3.14} \times \frac{0.04 \times 720 \times 4 \times 3.14}{4}$$

≈ 144 N-m

$$P = \frac{2\pi NT}{60} = \frac{2 \times 3.14 \times N \times 144}{60} = \frac{2 \times 3.14 \times 1500 \times 144}{60}$$

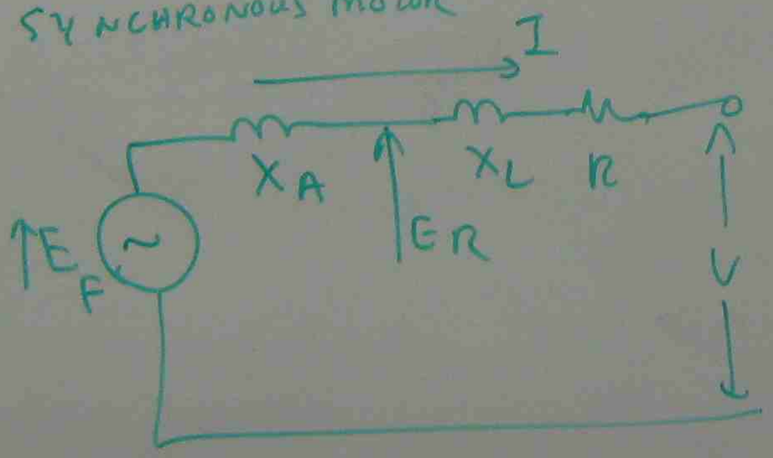
$= 36000$ W

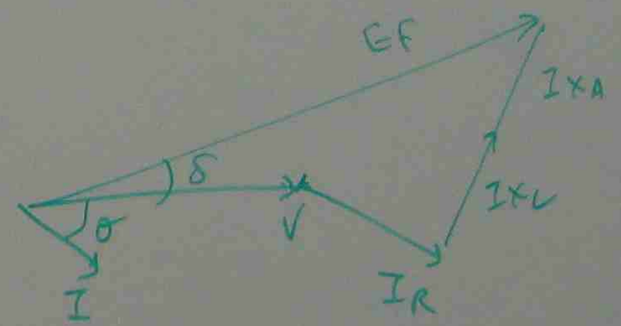
SYNCHRONOUS GENERATOR & MOTOR PERFORMANCE CHARACTERISTICS



WEEK (8)

SYNCHRONOUS MOTOR





$E_F = V + I Z_S$

$= V + I (R + j(X_L + X_A))$

X_A = SERIES REACTANCE

X_L = LEAKAGE REACTANCE

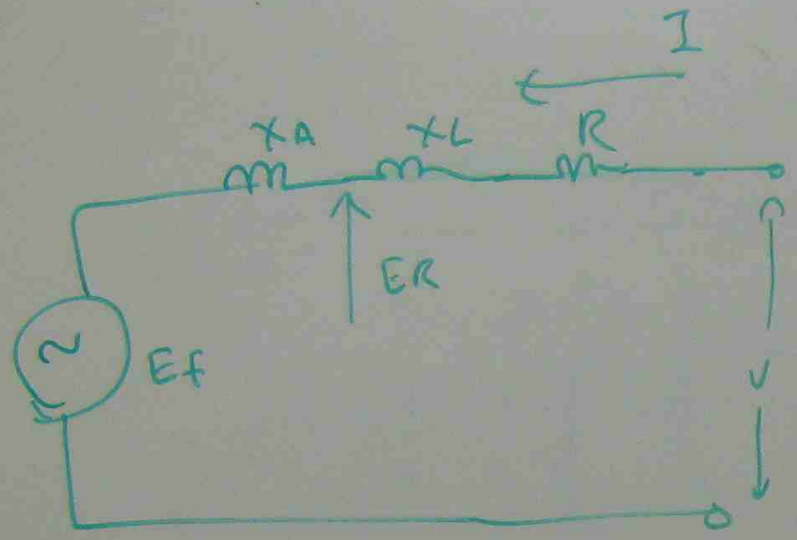
R = RESISTANCE of WINDING

V = TERMINAL VOLTAGE

E_F = GENERATED VOLTAGE

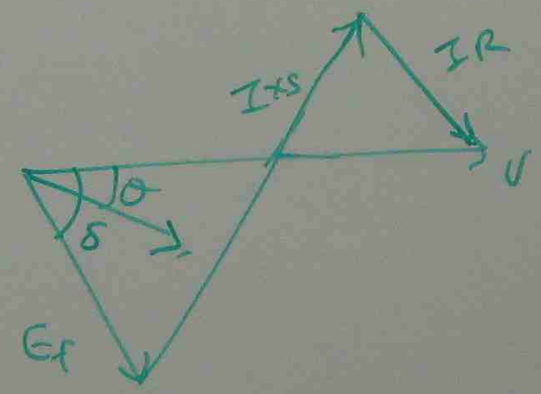
$X_S = X_L + X_A$

$Z_S = R + jX_S$



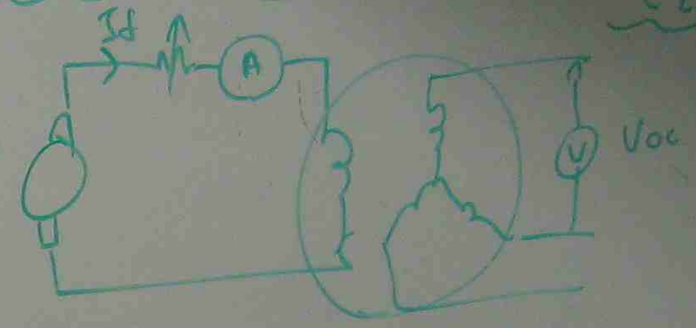
E_F = EXCITATION EMF

$E_F = V - I Z_s$

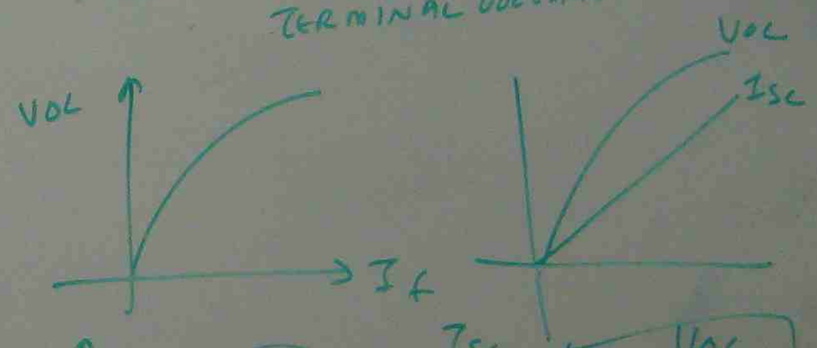


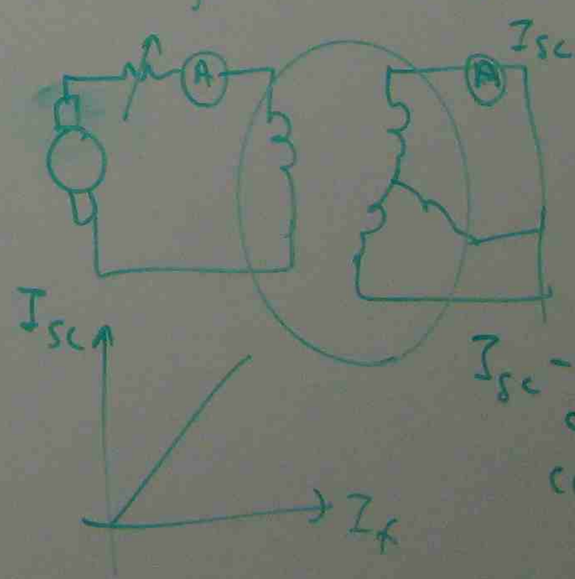
E_F DEPENDS ON FIELD EXCITATION

DETERMINATION OF SYNCHRONOUS IMPEDANCE (Z_S)



Voc = OPEN CIRCUIT TERMINAL VOLTAGE





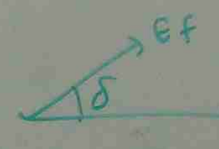
$Z_S = \frac{Voc}{I_{sc}}$

I_{sc} - SHORT CIRCUIT CURRENT

pb

Ex (4.9) A 3ϕ STAR CONNECTED ALTERNATOR HAS A RESISTANCE OF 0.5 Ω AND A SYNCHRONOUS REACTANCE OF 5Ω PER PHASE. IT IS EXCITED TO GIVE 6600V (LINE) ON OPEN CIRCUIT. DETERMINE THE TERMINAL VOLTAGE AND PER UNIT VOLTAGE REGULATION ON FULL LOAD CURRENT OF 130 A WHEN THE LOAD POWER FACTOR IS (a) 0.8 LAGGING (b) 0.6 LEADING

$$E_f(PH) = \frac{E_{LINE}}{\sqrt{3}} = \frac{6600}{\sqrt{3}} = 3810 \angle \delta$$



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

-36.8 for LAGGING

$$E_f = V\angle 0 + I\angle\phi \times Z$$

$$3810\angle\delta = V\angle 0 + 130\angle -36.8 \times (0.5 + j5)$$

$$3810\angle\delta = V\angle 0 + 130\angle -36.8 \times \sqrt{0.5^2+5^2}\ \angle \tan^{-1}\frac{5}{0.5}$$

$$3810\angle\delta = V\angle 0 + 130\angle -36.8 \times 5.02\angle 84.3$$

$$3810\angle\delta = V\angle 0 + 653\angle 84.3 - 36.8$$

$$3180\angle\delta = V\angle 0 + 653\angle 47.4$$

$$3810(\cos\delta + j\sin\delta) = V(\cos 0 + j\sin 0) + 653(\cos 47.4 + j\sin 47.4)$$

$$3810\cos\delta + j\,3810\sin\delta = V + 441 + j\,480.6$$

EQUATE REAL & IMAGINARY TERMS

$$3810\cos\delta = V + 441 \quad \text{—— (1)}$$

$$3810\sin\delta = 480.6 \quad \text{—— (2)}$$

$$\sin\delta = \frac{480.6}{3810} = 0.126$$

$$\delta = \sin^{-1} 0.126 = 7.24$$

SUBSTITUTE IN (1)

$3810\cos 7.24 = V + 441$

$3779.5 = V + 441$

$V = 3779.5 - 441$

$= 3338\ V$

VOLTAGE REG $= \frac{Ef - V}{V} \times 100$

$= \frac{3810 - 3338}{3338} \times 100$

$= 14.1\%$

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

$3810\angle\delta = V\angle 0 + 130\angle 53.2 \times (0.5 + j5)$

$3810\cos\delta + j3810\sin\delta = V - 653(-0.77 + j0.67)$

$3810\cos\delta + j3810\sin\delta = V - 476.69 + j440.7$

$3810\cos\delta = V - 476.69$ — (1)

$3810\sin\delta = 440.7$ — (2)

$V = 4261.08$

$\%.Reg = \frac{3810 - 4261.08}{4261.08} \times 100$

$= -10.5\%$

Power & Torque

$$P = \frac{E_f \times V}{X_s} \sin\delta$$

P = MECHANICAL POWER OF THE MOTOR / PHASE (WATT)

E_f = LINE TO NEUTRAL VOLTAGE INDUCED BY I

V = LINE TO NEUTRAL VOLTAGE OF THE SOURCE

X_s = SYNCHRONOUS REACTANCE / PHASE

δ = ANGLE BETWEEN E_f & V

$$T = \frac{9.55\,P}{n_s}$$

T = TORQUE (N-m)

n_s = SYNCHRONOUS SPEED (RPM)

$$n_s = \frac{120\,f}{P}$$

EXAMPLE (52)

P 102

A 150 KW, 1200 RPM, 460V 3ϕ SYNCHRONOUS MOTOR HAS A SYNCHRONOUS REACTANCE OF 0.8Ω / PHASE. IF THE EXCITATION VOLTAGE E_f IS FIXED AT 300V/ph, DETERMINE THE FOLLOWING

(a) THE POWER Vs δ CURVE

(b) TORQUE Vs δ CURVE

(c) PULL OUT TORQUE OF MOTOR

$E_f = 300V$

$V = \frac{460}{\sqrt{3}} = 266V$

$P = \frac{E_f \ V}{X_s} \sin\delta$

$= \frac{300 \times 266}{0.8} \sin\delta$

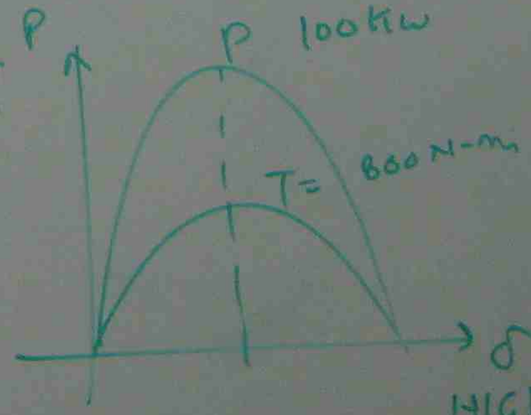
$P = 99750 \sin\delta$

$T = \frac{9.55 \ P}{n_s} = \frac{9.55 \times 99750 \sin\delta}{1200}$

$T = 0.793 \sin\delta \ (N\text{-}m)$

δ	P	T
0	0	0
30	50	400
60	86.6	693
90	100	800
120	86.6	693
150	50	400
180	0	0

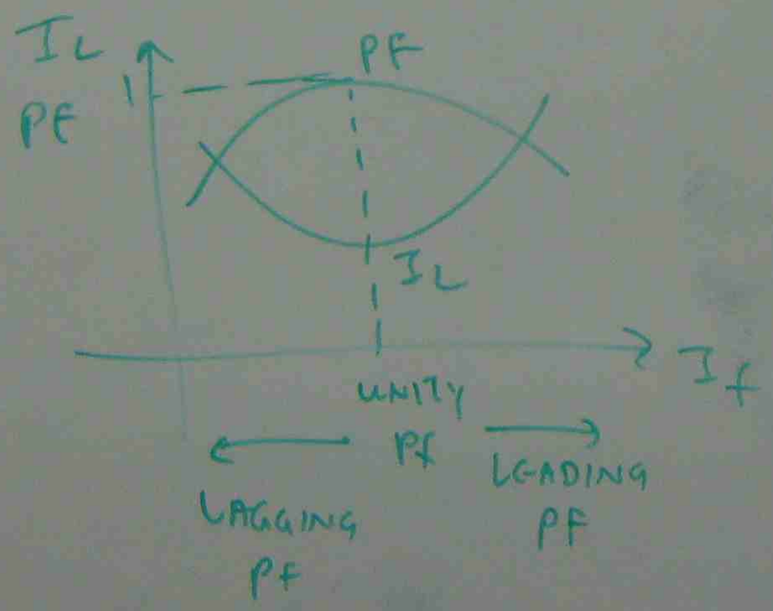
(a)



(b) PULL OUT TORQUE = HIGHEST TORQUE
= 800 N-m

SYNCHRONOUS USE CURVE CHARACTERISTICS





EX (5S)

P106 A 4000HP (3000KW), 6600 V, 60 Hz 200 RPM SYNCHRONOUS MOTOR OPERATES AT FULL LOAD, AT A LEADING P.F of 0.8. IF THE SYNCHRONOUS REACTANCE IS 11 Ω, CALCULATE THE FOLLOWINGS.

(a) THE APPARENT POWER of THE MOTOR PER PHASE

(b) THE AC LINE CURRENT

(c) THE VALUE AND PHASE of Ef

(d) DRAW PHASOR DIAGRAM

(e) DETERMINE THE TORQUE ANGLE δ

(a)

ACTIVE POWER / PHASE $= \frac{3000}{3} = 1000$ KW

APPARENT POWER / PHASE $= \frac{\text{ACTIVE POWER}}{\text{P.F}} = \frac{1000}{0.8} = 1250$ KVA

(b) AC LINE CURRENT $(I) = \frac{1\phi \text{ APPARENT POWER}}{\text{PHASE VOLTAGE}} = \frac{1250 \times 10^3}{6600/\sqrt{3}} = 328$ A

$\phi = \cos^{-1} 0.8 = 36.8^\circ$

$U = E_f + I Z_s$

$\frac{6600}{\sqrt{3}} \angle 0 = E_f + 328 \angle 36.8 \times (0 + j11)$

$3810 \angle 0 = E_f + 328 \angle 36.8 \times 11 \angle 90$

$3810 \angle 0 = E_f + 3608 \angle 126.8$

$E_f = 3810 \angle 0 - 3608 \angle 126.8$

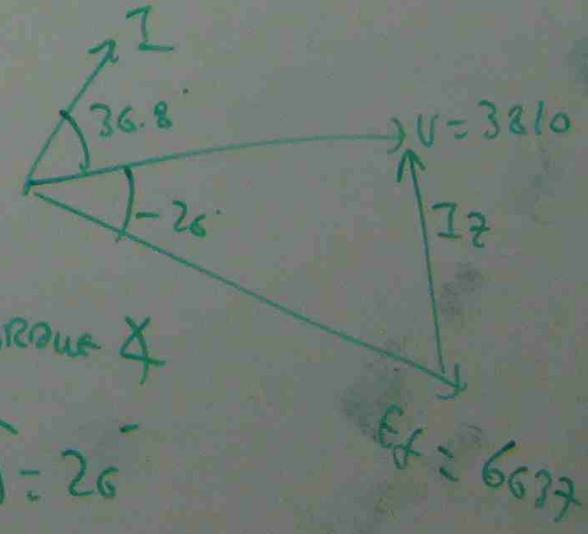
$= 3810 - 3608 (\cos 126.8 + j \sin 126.8)$

$E_f = 3810 + 2166 - j2885$

$= 5977 - j2885$

$E_f = \sqrt{5977^2 + 2885^2} \angle -\tan^{-1} \frac{2885}{5977}$

$= 6637 \angle -26^\circ$



TORQUE $\propto \delta$

$\delta = 26^\circ$

Cap = 38 chairs
38 desks

Lunch @ 12:30

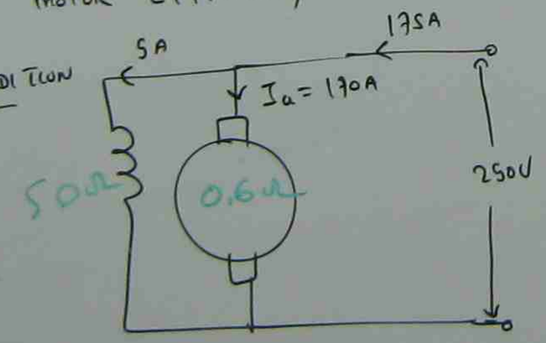
ph

A 50 HP 250V 1200 RPM SHUNT DC MOTOR HAS A RATED ARMATURE CURRENT OF 170 A AND RATED FIELD CURRENT OF 5A. WHEN THE ROTOR IS BLOCKED, THE ARMATURE VOLTAGE 10V PRODUCES A 170 A CURRENT FLOW. AND FIELD VOLTAGE 250 V PRODUCES A FIELD CURRENT FLOW OF 5A . AT NO LOAD WITH TERMINAL VOLTAGE EQUAL TO 240V, THE ARMATURE CURRENT IS EQUAL TO 13.2 Amp , FIELD CURRENT 4.8 A. MOTOR SPEED IS 1150 RPM

(a) HOW MUCH POWER IS OUT PUT FROM THIS MOTOR AT RATED CONDITION

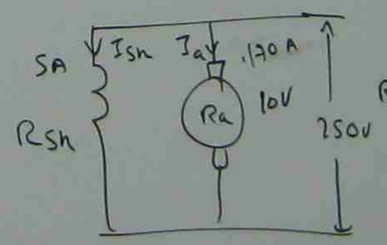
(b) MOTOR EFFICIENCY

RATED CONDITION



INPUT POWER = V x I = 250x175
= 43750 W

OUT PUT POWER = INPUT POWER − (ROTATIONAL LOSSES + COPPER LOSS)



$R_a = \frac{V}{I_a} = \frac{10}{170} = 0.06\,\Omega$

$R_{sh} = \frac{250}{I_{sh}} = \frac{250}{5} = 50\,\Omega$

BLOCKED ROTOR TEST ⟶ R_a / R_{sh}

ROTATIONAL LOSS

ROTATIONAL

COPPER LOSS

ROTATIONAL LOSS ⟶ NO LOAD TEST

ROTATIONAL LOSS = TERMINAL VOLTAGE × NO LOAD ARMATURE CURRENT

$= 240 \times 13.2$

$= 3168\ W$

COPPER LOSS = ARMATURE COPPER LOSS + FIELD COPPER LOSS

$= I_a^2 R_a + I_{sh}^2 R_{sh}$

$= 170^2 \times 0.06 + 5^2 \times 50$

$= 1734 + 1250$

$= 2984\ W$

OUT PUT POWER = IN PUT POWER − (COPPER LOSS + ROTATIONAL LOSS)

$= 43750 - (2984 + 3168)$

$= 43750 - 4152$

$= 39598\ W$

$$\text{EFFICIENCY} = \frac{\text{OUT PUT}}{\text{IN PUT}} \times 100$$

$$= \frac{39598}{43750} \times 100$$

$= 90.5\ \%$

Cap = 8 chairs
8 desks

POWER AND ENERGY IN SINGLE PHASE AND THREE PHASE BALANCED CIRCUITS

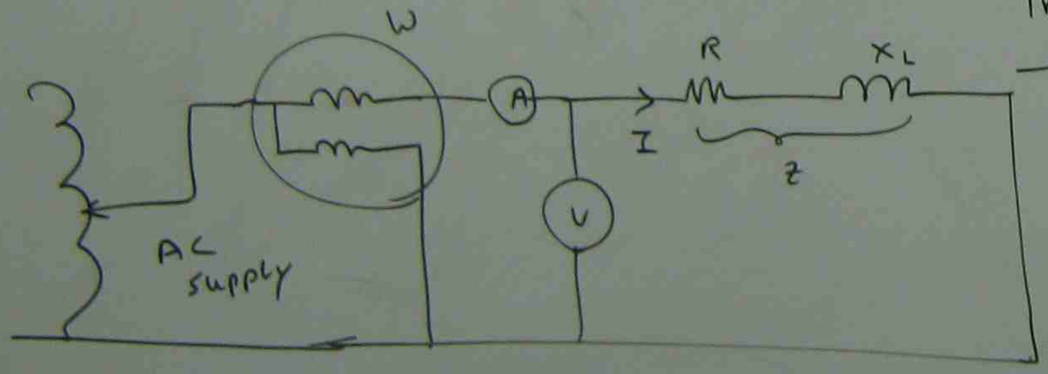
RESISTANCE R (Ω)

INDUCTANCE L (H)

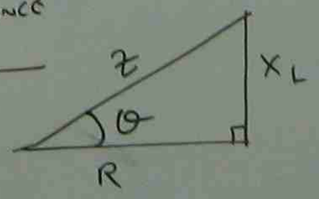
CAPACITANCE C (F)

INDUCTIVE REACTANCE $X_L = 2\pi f L$ (Ω) f = SUPPLY FREQUENCY

CAPACITIVE REACTANCE $X_C = \frac{1}{2\pi f c}$ (Ω)



IMPEDANCE Δ



Z = IMPEDANCE

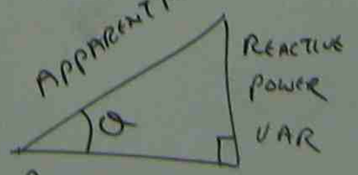
$Z = \sqrt{R^2 + X_L^2}$

$\tan\theta = \frac{X_L}{R}$

$\theta = \tan^{-1}\frac{X_L}{R}$

$I = \frac{V}{Z}$ (AMP).

POWER Δ



APPARENT POWER (S) = V x I = VOLT METER READING x AMMETER READING (V.A)

REAL POWER = WATT METER READING (P) = V x I cosθ (WATT)

REACTIVE POWER = $V I \sin\theta$ (VAR)

(θ)

POWER FACTOR (P.F) = $\cos\theta$

DC

POWER = $V \times I$

INDUCTOR - SHORT CIRCUIT

CAPACITOR - OPEN CIRCUIT

AC

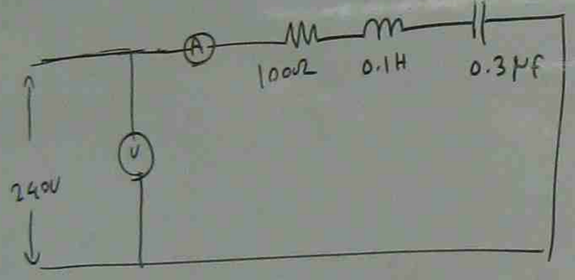
ACTIVE POWER	REACTIVE POWER	APPARENT POWER
$VI\cos\theta$	$VI\sin\theta$	VI

CURRENT CAN PASS THROUGH INDUCTOR & CAPACITOR IN AC

ph

RESISTANCE = 100 Ω, INDUCTANCE 0.1 H AND CAPACITANCE 0.3 μF ARE CONNECTED TO SINGLE PHASE 240V, 50 HZ POWER SUPPLY.

CALCULATE (a) INDUCTIVE REACTANCE (b) CAPACITIVE REACTANCE (c) IMPEDANCE (d) CURRENT (e) APPARENT POWER (f) POWER FACTOR ANGLE (θ) (g) ACTIVE POWER (h) REACTIVE POWER



(a) $X_L = 2\pi fL = 2 \times 3.14 \times 50 \times 0.1 = 31.4\Omega$

(b) $X_C = \frac{1}{2\pi fc} = \frac{1}{2 \times 3.1416 \times 50 \times 0.3 \times 10^{-6}}$

$= \frac{10^6}{2 \times 3.1416 \times 50 \times 0.3}$

$= 1061.5\Omega$

$Z = R^2 + (X_L - X_C)^2$

$= 100^2 + (31.4 - 1061.5)^2$

(c) $Z = \sqrt{100^2 + (-1058.3.6)^2} = 10584\Omega$

(d) $I = \frac{V}{Z} = \frac{240}{10584} = 0.0226$ Amp.

(e) $S = V \times I = 240 \times 0.0226 = 5.442$ VA

(f) $\tan\theta = \frac{X_L - X_C}{R} = \frac{31.4 - 1061.5}{100} = -\frac{1056.6}{100}$

$\tan\theta = -106.58 = -89.4$

(g) $P = VI\cos\theta = 240 \times 0.0226 \times \cos(-89.4)$

$= 5.442 \times 0.0104$

$= 0.056$ WATT

(h) $\theta = VI\sin\theta$

$= 5.442 \sin(-89.4) = 5.442 \times (-0.999) = -5.441$ VAR

Cap = ~~18~~ chairs
~~18~~ desks

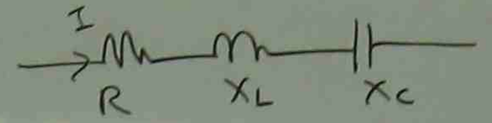
ph CALCULATE ACTIVE, REACTIVE AND APPARENT IN ABOVE PROBLEM BY USING ANOTHER METHOD.



$P = I^2 R$

$Q = I^2 X$

$S = I^2 Z$



$P = I^2 R$

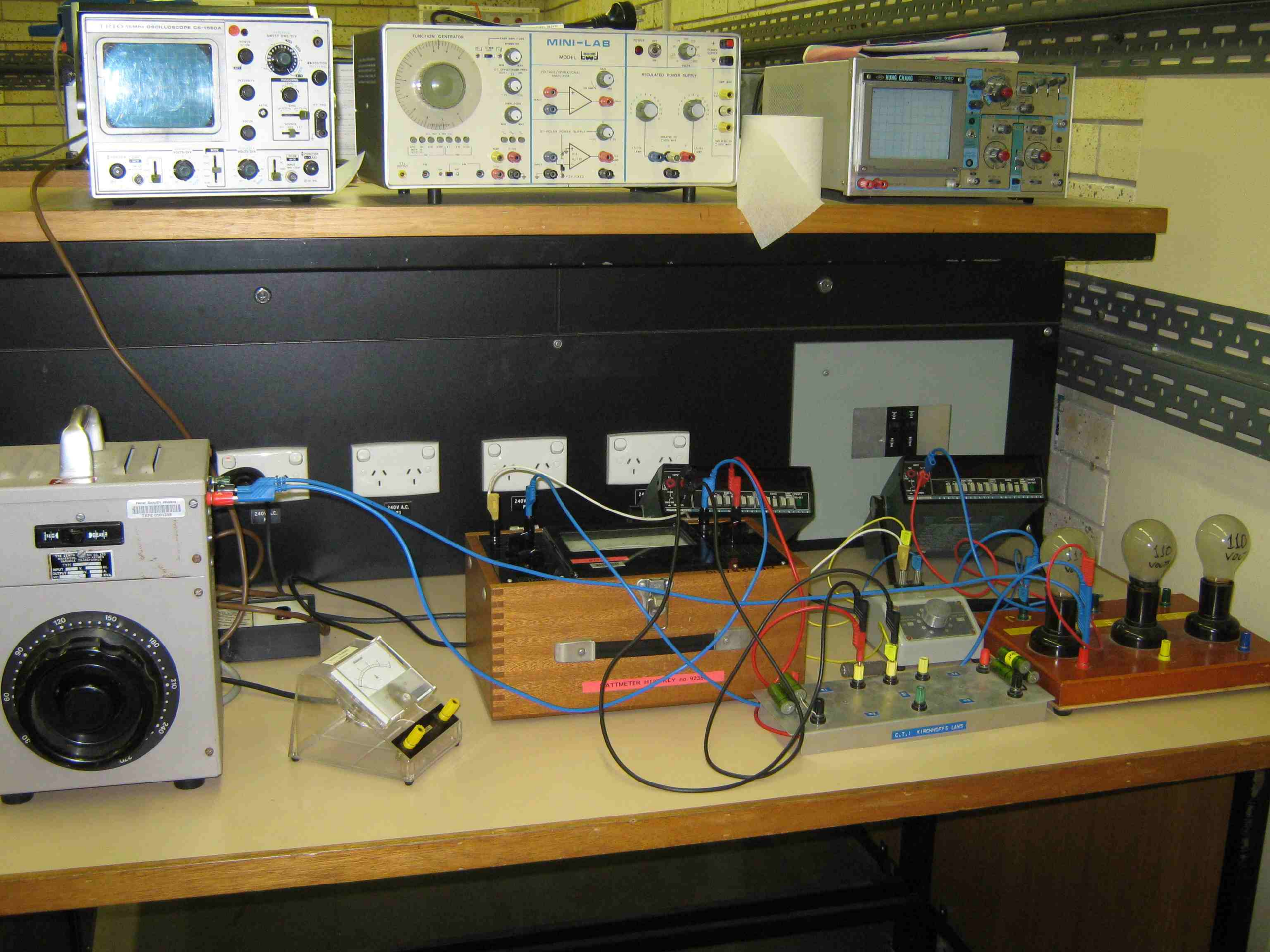
$Q = I^2 (X_L - X_C)$

$S = I^2 Z$

$P = I^2 R = (0.0226)^2 \times 100 = 0.051076$ WATT

$Q = I^2 (X_L - X_C) = (0.0226)^2 \times (-10583.6) = -5.405$ VAR

$S = I^2 Z = (0.0226)^2 \times 10584 = 5.4058$ VA

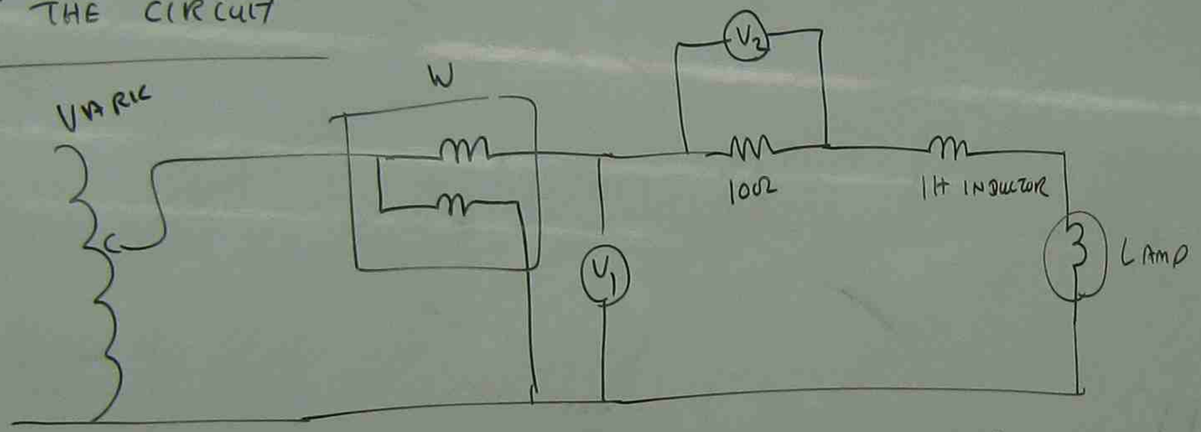

MINI-LAB
MODEL
FUNCTION GENERATOR
REGULATED POWER SUPPLY
HUNG CHANG
C.T.I KIRCHHOFFS LAWS
110 volts
110 volts

Mains desks

PRACTICAL

MEASUREMENT OF 1φ POWER

CONNECT THE CIRCUIT



TAKE THE READING

V_1 =

V_2 =

W =

FILL IN TABLE

WATT = W =

CURRENT = A = $\frac{V_2}{100\Omega}$ = Amp

LOAD POWER: V_1 = VOLT

CALCULATE

ACTUAL POWER = W = WATT METER READING = WATT

APPARENT POWER = VOLTMETER READING × CURRENT (A)

V_1

= ×

= V.A

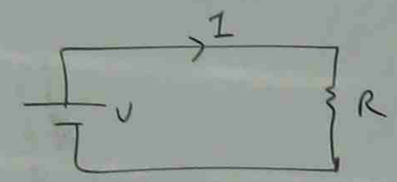
POWER FACTOR = $\frac{W}{VA}$

Lunch @ 12.30

Cap = 38 chairs
38 desks

POWER MEASUREMENT IN SINGLE PHASE AND BALANCED THREE PHASE SYSTEM

DC POWER

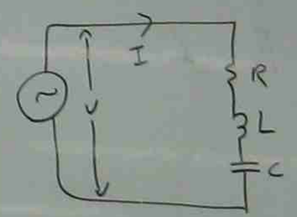


POWER = V × I

THERE IS ONLY RESISTANCE IN DC.

	IN DC
INDUCTOR ⟶	SHORT
CAPACITOR ⟶	OPEN CIRCUIT

AC POWER



INDUCTOR

INDUCTIVE REACTANCE $X_L = 2\pi fL\ (\Omega)$

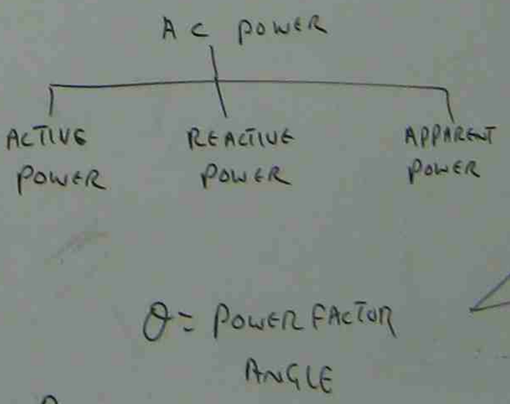
L = INDUCTANCE (H)

f = SUPPLY FREQUENCY

CAPACITOR

CAPACITIVE REACTANCE $X_C = \frac{1}{2\pi fc}\ (\Omega)$

C = CAPACITANCE (F)



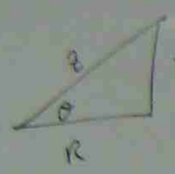
θ = POWER FACTOR ANGLE

POWER FACTOR (PF) = cos θ

RL CIRCUIT

Z = IMPEDANCE

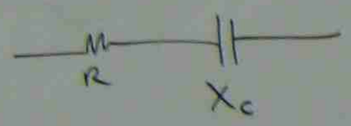


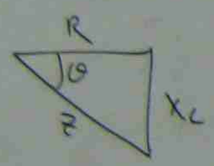


$$Z = \sqrt{R^2 + X_L^2}$$

$$\tan\theta = \frac{X_L}{R}$$

RC CIRCUIT





$$Z = \sqrt{R^2 + X_c^2}$$

$$\tan\theta = \frac{X_c}{R}$$

RLC CIRCUIT



$$Z = \sqrt{R^2 + (X_L - X_c)^2}$$

$$\tan\theta = \frac{X_L - X_c}{R}$$

P - ACTIVE POWER = $VI\cos\theta$ (WATT)

Q - REACTIVE POWER = $VI\sin\theta$ (VAR)

S. APPARENT POWER = VI (V.A)

$$P = I^2 R$$

$$Q = I^2 X$$

$$S = I^2 Z$$

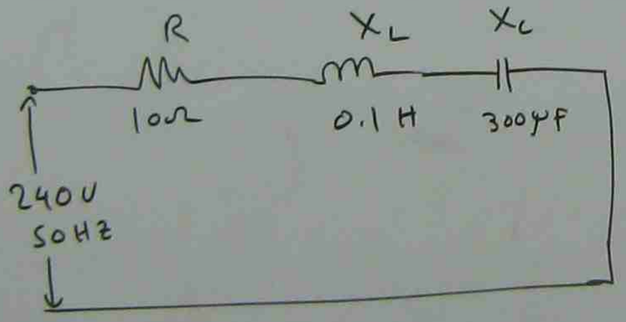
Cap = 8 chairs
8 desks

Lunch @ 12:30

Pb

10Ω RESISTOR, 0.1 HENRY INDUCTOR AND 300μf CAPACITORS ARE CONNECTED IN SERIES ACROSS SINGLE PHASE 240V 50 HZ AC POWER SUPPLY.

CALCULATE (a) INDUCTIVE REACTANCE (b) CAPACITIVE REACTANCE (c) IMPEDANCE (d) CURRENT (e) POWER FACTOR ANGLE (f) ACTIVE POWER (g) REACTIVE POWER (h) APPARENT POWER



(a) $X_L = 2\pi fL = 2 \times 3.1416 \times 50 \times 0.1 = 31.4\,\Omega$

(b) $X_C = \frac{1}{2\pi fC} = \frac{1}{2 \times 3.1416 \times 50 \times 300 \times 10^{-6}}$

$= \frac{10^6}{2 \times 3.1416 \times 50 \times 300} = 10.6\,\Omega$

(c) $Z = \sqrt{R^2 + (X_L - X_C)^2}$

$= \sqrt{10^2 + (31.4 - 10.6)^2}$

$= \sqrt{10^2 + 20.8^2}$

$= 23\,\Omega$

(d) $I = \frac{V}{Z} = \frac{240}{23} = 10.43$ Amp

(e) $\tan\theta = \frac{X_L - X_C}{R} = \frac{31.4 - 10.6}{10} = \frac{20.8}{10}$

$= 2.08$

$\theta = \tan^{-1} 2.08 = 64.32^\circ$

(f) $P = VI\cos\theta = 240 \times 10.43 \times \cos 64.32$

$= 2503.2 \times 0.4337$

$= 1084$ WATT

(g) $\theta = VI\sin\theta = 240 \times 10.43 \times \sin 64.32$

$= 2503.2 \times 0.901 = 2255.85$ VAR

Lunch @ 12:30

$$R^2 + (X_L - X_C)^2$$

$$10^2 + (31.4 - 10.6)^2$$

$$10^2 + 20.8^2$$

23Ω

$$= \frac{240}{23} = 10.43 \text{ Amp}$$

$$= \frac{X_L - X_C}{R} = \frac{31.4 - 10.6}{10} = \frac{20.8}{10}$$

$$= 2.08$$

$$\tan^{-1} 2.08 = 64.32^\circ$$

$\cos\theta = 240 \times 10.43 \times \cos 64.32$

$= 2503.2 \times 0.4333$

$= 1084$ WATT

$\theta = 240 \times 10.43 \times \sin 64.32$

$= 2503.2 \times 0.901 = 2255.95$ VAR

(h) $S = VI = 240 \times 10.43 = 2503.2$ VA

Ph IN ABOVE PROBLE FIND (a) ACTIVE POWER (b) REACTIVE POWER (c) APPARENT POWER BY USING ANOTHER METHOD

$$P = I^2 R = (10.43)^2 \times 10 = 1087.84 \text{ WATT}$$

$$\theta = I^2 X_L = (10.43)^2 \times 31.4 = 3415.84 \text{ VAR}$$

$$S = I^2 Z = (10.43)^2 \times 23 = 2502 \text{ VA}$$

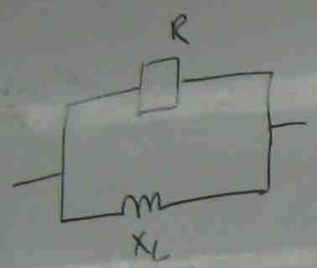
(k) $S = VI = 240 \times 10.43 = 2503.2$ VA

2. IN ABOVE PROBLE FIND (a) ACTIVE POWER (b) REACTIVE POWER (c) APPARENT POWER BY USING ANOTHER METHOD

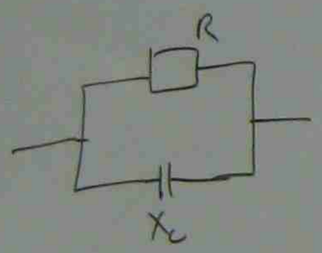
$I^2R = (10.43)^2 \times 10 = 1087.84$ WATT

$I^2X_L = (10.43)^2 \times 31.4 = 3415.84$ VAR

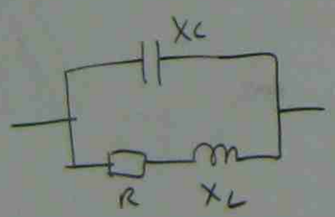
$I^2Z = (10.43)^2 \times 23 = 2502$ VA



$$Z = \frac{R X_L}{\sqrt{R^2 + X_L^2}}$$



$$Z = \frac{R X_C}{\sqrt{R^2 + X_C^2}}$$

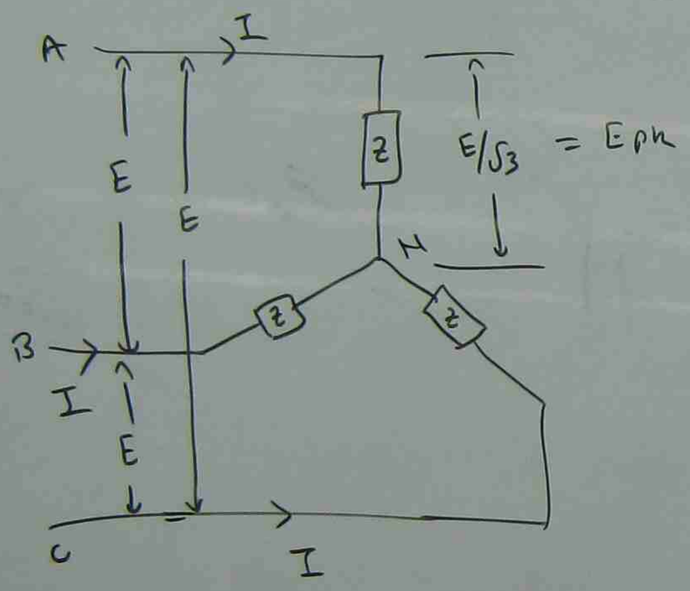


$$Z = \frac{X_C \cdot \sqrt{R^2 + X_L^2}}{\sqrt{R^2 + (X_L - X_C)^2}}$$

Cap = 18 chairs
18 desks

THREE PHASE BALANCED LOAD

STAR / WYE / Y CONNECTION



E = LINE VOLTAGE (E_{AB}, E_{BC}, E_{CA})

E_{ph} = PHASE VOLTAGE (E_{AN}, E_{BN}, E_{CN})

$$E_{ph} = \frac{E}{\sqrt{3}} \rightarrow \text{PHASE VOLTAGE} = \frac{\text{LINE VOLTAGE}}{\sqrt{3}}$$

LINE CURRENT = PHASE CURRENT

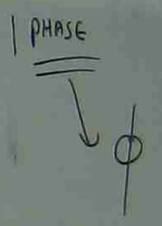
1φ POWER = $E_{ph} \times I \cos\theta$

3φ POWER = $3\, E_{ph}\, I \cos\theta$

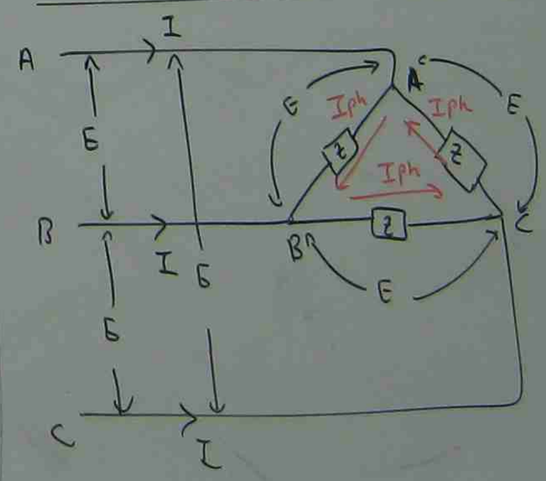
(OR)

3φ POWER = $\sqrt{3}\, E\, I \cos\theta$

1 PHASE



DELTA / △ CONNECTION



A B C

A → B → C

E = LINE VOLTAGE (E_{RB}, E_{BC}, E_{CA})

PHASE VOLTAGES

FOR Y & Δ

I_{ph} = PHASE CURRENT

I = LINE CURRENT

3ϕ POWER = $\sqrt{3}\ E\ I\ \cos\theta$

$$I_{ph} = \frac{I}{\sqrt{3}}$$

1ϕ POWER: $E_{ph}\ I_{ph}\ \cos\theta$

$= E\ I_{ph}\ \cos\theta$

3ϕ POWER: $3\ E\ I_{ph}\ \cos\theta$

$= 3\ E \times \frac{I}{\sqrt{3}}\ \cos\theta$

3ϕ POWER = $\sqrt{3}\ E\ I \cos\theta$

FOR Y & Δ

3φ POWER = √3 E I COSΘ

ph

THREE COILS ARE CONNECTED IN DELTA ACROSS A 240V, THREE PHASE SUPPLY. THE LINE CURRENT IS 20 AMPERES. THE TOTAL POWER DELIVERED TO THE THREE COILS IS 6000 WATT. DETERMING

(a) THE TOTAL LOAD , IN VOLT AMPERES

(b) THE THREE PHASE POWER FACTOR

(c) THE CURRENT IN EACH COIL AND THE VOLTAGE ACROSS EACH COIL

(d) THE IMPEDANCE IN OHM OF EACH COIL

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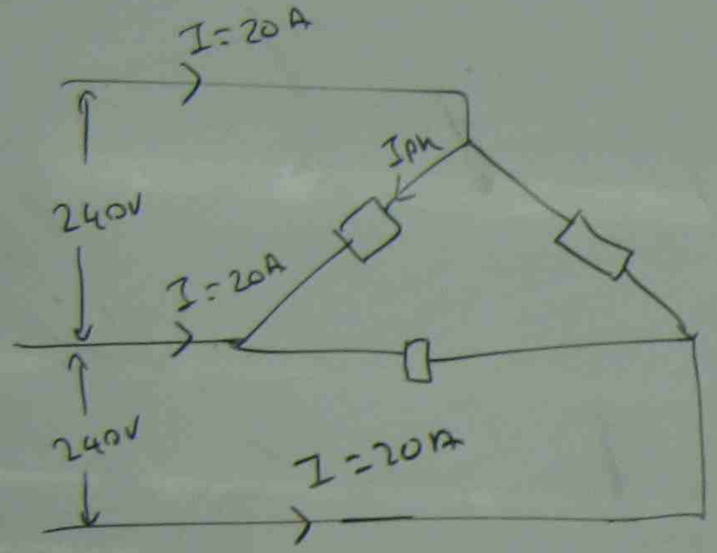
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EMERGENCY STOP
OPERATION OF THIS PUSH BUTTON WILL ISOLATE ELECTRICAL POWER TO MACHINES AND POWER OUTLETS IN THIS AREA

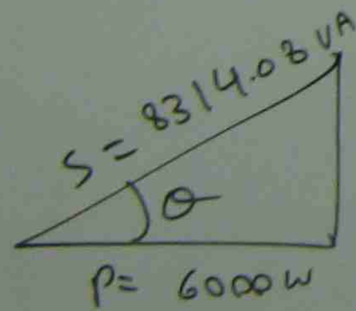
up = 8 chairs, 8 desks



(a) $S = \sqrt{3}\ V\ I = 1.7321 \times 240 \times 20$

$= 8314.08\ VA$

(b)



$P.F = \cos\theta = \frac{P}{S} = \frac{6000}{8314.08}$

$= 0.72$

(c) $I_{ph} = \frac{I}{\sqrt{3}} = \frac{20}{1.7321} = 11.54$ amp

(d)

$Z = \frac{E_{ph}}{I_{ph}}$	$= \frac{E}{I_{ph}}$	$= \frac{240}{11.54}$	$= 20.79\ \Omega$

(c) $I_{ph} = \frac{I}{\sqrt{3}} = \frac{20}{1.7321} = 11.54$ amp

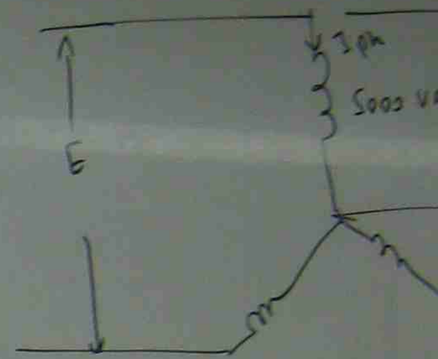
(d) $Z_{ph} = \frac{E_{ph}}{I_{ph}} = \frac{E}{11.54} = \frac{240}{11.54} = 20.79\ \Omega$

---

pb THE THREE WINDINGS OF A THREE PHASE 60 HZ GENERATOR ARE CONNECTED IN WYE. EACH OF THE THREE COIL WINDINGS IS RATED AT 5000 VOLT AMP AND 120 VOLTS. DETERMINE (a) LINE VOLTAGE

(b) THE LINE CURRENT WHEN THE GENERATOR IS DELIVERING ITS FULL LOAD OUT PUT

(c) THE FULL LOAD RATING OF THE THREE PHASE GENERATOR (KVA)



(b) $I_{ph} = \frac{\text{PHASE VA}}{\text{PHASE VOLTAGE}} =$

$I_L = I_{ph} = 41.66$ AMP

(c) 3ϕ V.A = 3 x 1ϕ

= 3 x 5000

= 15000 V

$\frac{P}{S} = \frac{6000}{8314.08}$

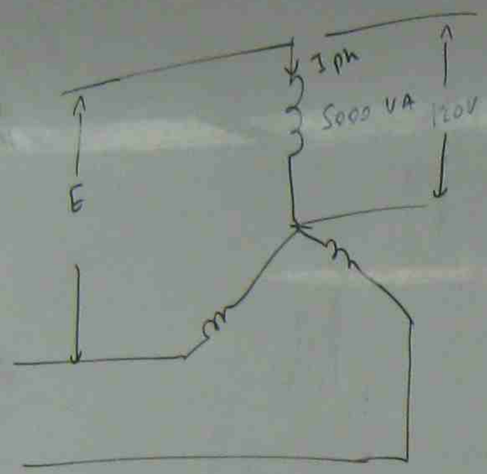
$= 0.72$

= 11.54 amp

$= \frac{240}{11.54} = 20.79\,\Omega$

F A THREE PHASE 60 HZ
IN WYE. EACH OF THE THREE
T 5000 VOLT AMP AND 120 VOLTS.

LENT WHEN THE GENERATOR IS
ITS FULL LOAD OUT PUT
OAD RATING OF THE THREE PHASE
(KVA)



(a) $E = \sqrt{3}\, E_{ph}$

$= 1.7321 \times 120$

$= 207.85\ V$

(b) $I_{ph} = \frac{\text{PHASE VA}}{\text{PHASE VOLTAGE}} = \frac{5000}{120} = 41.66$ Amp

$I_L = I_{ph} = 41.66$ Amp

(c) $3\phi\ V.A = 3 \times 1\phi.VA$

$= 3 \times 5000$

$= 15000\ V.A$

ph

THREE COILS ARE CONNECTES

240V, THREE PHASE SUPPLY. THE

AMPERES. THE TOTAL POWER DE

COILS IS 6000 WATT. DETER

(a) THE TOTAL LOAD, IN VOLT

(b) THE THREE PHASE POWER F

(c) THE CURRENT IN EACH COIL

ACROSS EACH COIL

(d) THE IMPEDANCE IN OH

3ph

5000 VA 120V = Eph

= 5000 / 120 = 41.66 Amp

AGE

1φ. UA

D

D V.A

Pb/ THE THREE PHASE GENERATOR IN ABOVE PROBLEM DELIVERS THE RATED OUT PUT TO A THREE PHASE NONINDUCTIVE HEATING LOAD. AS A RESULT, THE CURRENT IN EACH COIL OF THE GENERATOR IS IN PHASE WITH IT'S RESPECTIVE VOLTAGE.

(a) DETERMINE THE FULL LOAD OUT PUT OF GENERATOR IN KILOWATT

(b) DRAW THE VECTOR DIAGRAM.

(a) $E = \sqrt{3}\, E_{ph}$

$= 1.7321 \times 120$

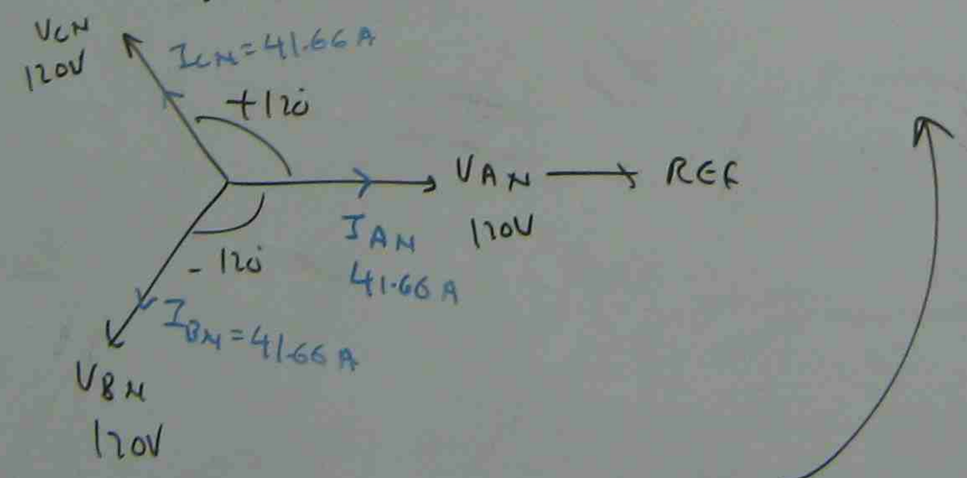
$= 207.85\ V$

HEATING LOAD = POWER FACTOR = 1

(a) OUTPUT = V.A × P.F

= 15000 × 1 = 15000 WATT = 15 KW

(b)



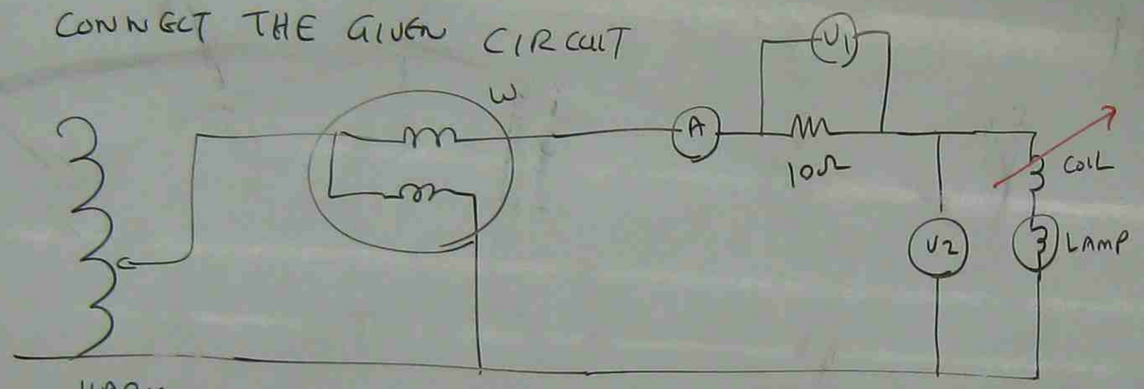


Cap = 18 chairs
18 desks

PRACTICAL

SINGLE PHASE AC POWER MEASUREMENT

CONNECT THE GIVEN CIRCUIT



SET COIL AT 1 H INDUCTANCE

TAKE THE READING OF WATTMETER, AMMETER (A), VOLTMETERS (V_1 & V_2)

FILL IN TABLE, STEP (1)

	W	V_1	$I = \frac{V1}{10\Omega}$	V_2	$VA = V_2 I$	$PF = \frac{W}{VA}$
STEP ①						
STEP ②						

STEP (2)

SET THE COIL AT 0 HENRY

TAKE THE READINGS OF WATT METER, AMMETER (A), VOLT METERS (V_1 & V_2)

FILL IN TABLE, STEP (2)

COMPARE P.f

WHAT HAPPENS IN P.F IF INDUCTIVE LOAD IS SET TO ZERO ?

EMERGENCY STOP

240V A.C. P1

240V A.C. P1

240V A.C. P1

DANGER. VOLTS.

GUARD

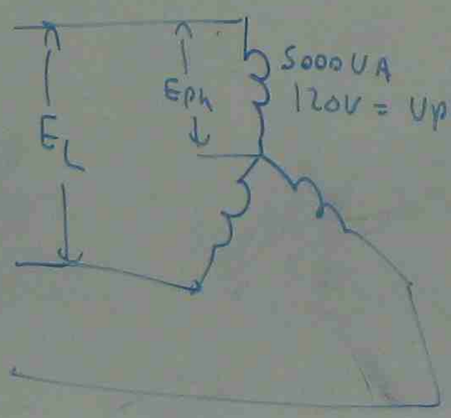
THE THREE WINDINGS OF 3ϕ 60 Hz GENERATOR ARE CONNECTED IN STAR. EACH OF 3 WINDINGS IS RATED AT 5000 VA AND 120 V.

DETERMINE (a) LINE VOLTAGE

(b) THE LINE CURRENT WHEN THE GENERATOR IS DELIVERING ITS FULL LOAD OUT PUT

IF THE GENERATOR IS SUPPLYING NON INDUCTIVE HEATING LOAD, DETERMING THE VECTOR DIAGRAM

IF THE GENERATOR IS SUPPLYING INDUCTIVE LOAD IN WHICH THE CURRENT IN THE COIL LAGS THE RESPECTIVE VOLTAGE BY 30°, DRAW THE VECTOR DIAGRAM.



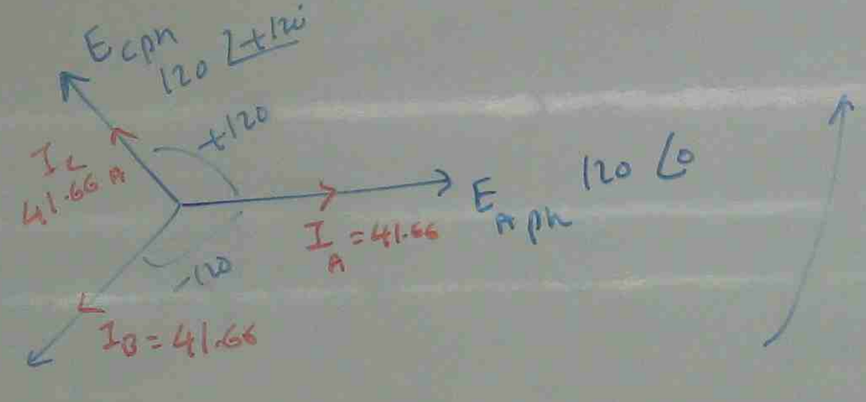
$E_L = \sqrt{3}\, E_{ph}$

$= 1.732 \times 120$

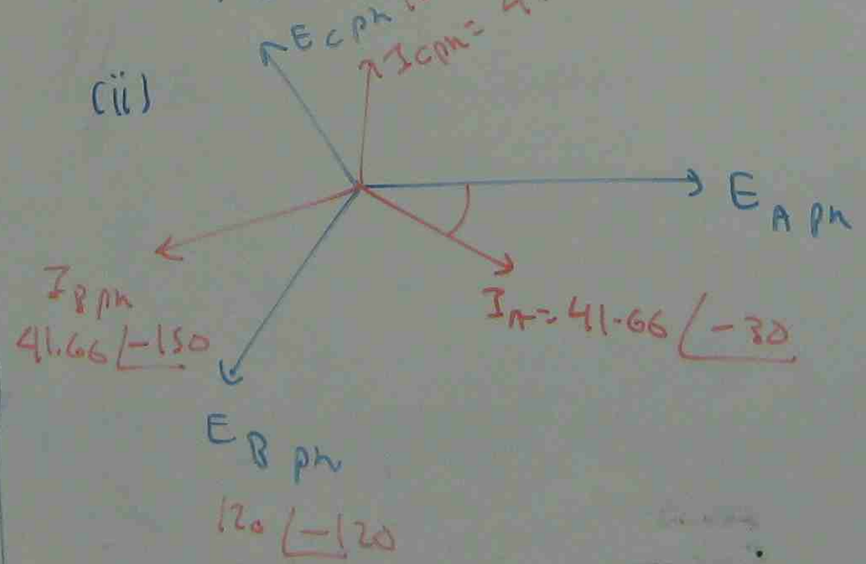
$= 207.8$ V

$I_L = I_{ph} = \frac{VA\ /ph}{E_{ph}} = \frac{5000}{120} = 41.66$ A

(i)



(ii)



Cap = ~~18~~ Chairs
~~18~~ desks

Ph

A 3 PHASE Y CONNECTED ALTERNATOR IS RATED AT 720 KVA, 2400V, 60HZ

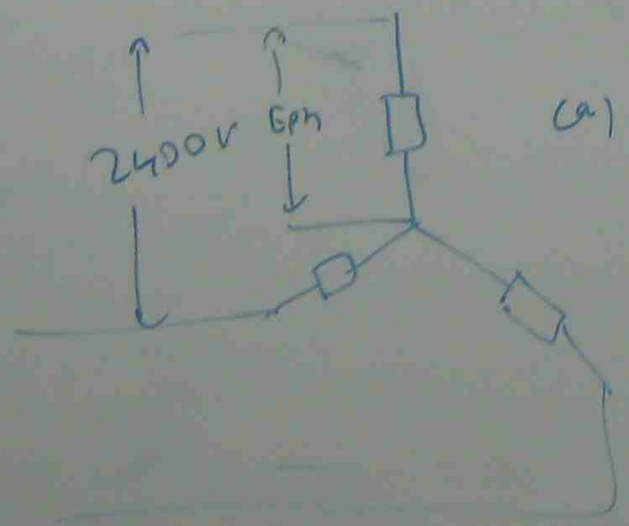
AT THE RATED LOAD, DETERMINE

(a) THE OUT PUT IN KW AT 80% LAGGING POWER FACTOR

(b) FULL LOAD LINE CURRENT

(c) FULL LOAD RATING OF EACH OF 3 WINDINGS

(d) THE VOLTAGE ACROSS EACH PHASE WINDING.



(a) $KW = KVA \times PF$
$= 720 \times 0.8$
$= 576\ KW$

$KVA \times 10^3 = \sqrt{3}\, E I$

(b) $720 \times 10^3 = 1.732 \times 2400 \times I$

$I = \frac{720 \times 10^3}{1.732 \times 2400} = 41.65A$

(c)
ALL 3 WINDINGS RATING = 720 KVA

EACH WINDING RATING = $\frac{3 \text{ WINDING RATING}}{3}$

$= \frac{720}{3}$

$= 240\ KVA$

(d) $E_{ph} = \frac{E_{LINE}}{\sqrt{3}} = \frac{2400}{1.732}$

$= 1385V$

Cap = 18 chairs
18 desks

24 A 3 PHASE Y CONNECTED ALTERNATOR IS RATED AT 720 KVA, 2400V, 60 HZ

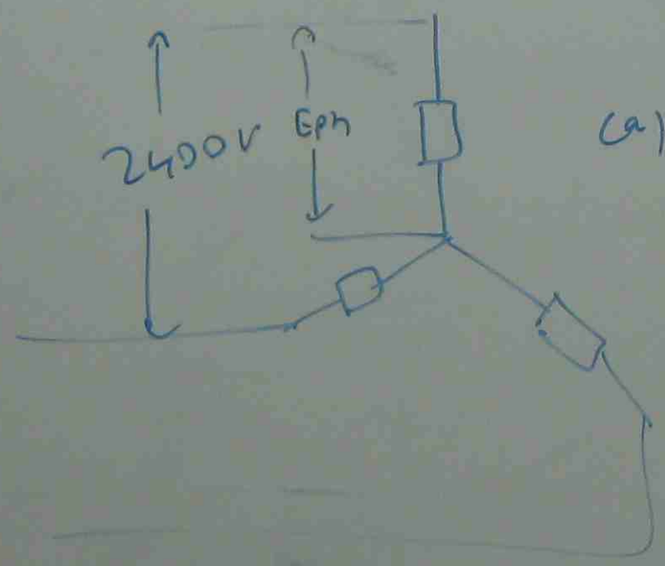
AT THE RATED LOAD, DETERMINE

(a) THE OUT PUT IN KW AT 80% LAGGING POWER FACTOR

(b) FULL LOAD LINE CURRENT

(c) FULL LOAD RATING OF EACH OF 3 WINDINGS

(d) THE VOLTAGE ACROSS EACH PHASE WINDING.



(a) $KW = KVA \times PF$
$= 720 \times 0.8$
$= 576\ KW$

$KVA \times 10^3 = \sqrt{3}\, E I$

(b) $720 \times 10^3 = 1.732 \times 2400 \times I$

$I = \frac{720 \times 10^3}{1.732 \times 2400} = 173\ A$

(c)
ALL 3 WINDINGS RATING = 720 KVA

EACH WINDING RATING = $\frac{720}{3}$

$= \frac{720}{3}$

$= 240\ KVA$

(d) $E_{ph} = \frac{E_{LINE}}{\sqrt{3}} = \frac{2400}{1.732}$

$= 1385\ V$

$E_{ph} = \frac{S_{ph}}{I_{ph}} = \frac{240 \times 10^3}{173} = 1387\ V$

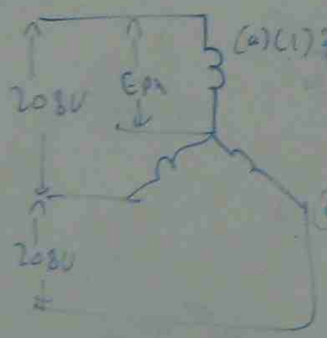
Qn. A 5 KVA 208 V 3ϕ AC GENERATOR IS CONNECTED IN WYE

(a) DETERMINE (1) THE VOLTAGE OF EACH COIL OF THE PHASE WINDINGS

(2) THE [illegible] CURRENT AT FULL LOAD

(b) IF THE PHASE WINDINGS OF THIS ALTERNATOR ARE CONNECTED IN DELTA, DETERMINE THE NEW LINE VOLTAGE AND THE CURRENT VALUES AT FULL LOAD

5 KVA = 5000 VA

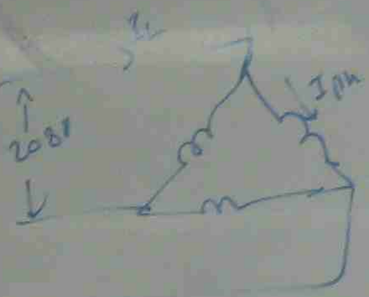


(a)(1) 3ϕ VA = 5000 VA

COIL VOLTAGE = $E_{PH} = \frac{E_{LINE}}{\sqrt{3}} = \frac{208}{1.732} = 120V$

(a)(2) $\sqrt{3} E I = 5000$

$I = \frac{5000}{1.732 \times 208} = 13.87$ A



5000 VA

$E_{ph} = E_L = 208$ V

$\sqrt{3} E_L I_L = 5000$ VA

$1.7321 \times 208 \times I_L = 5000$

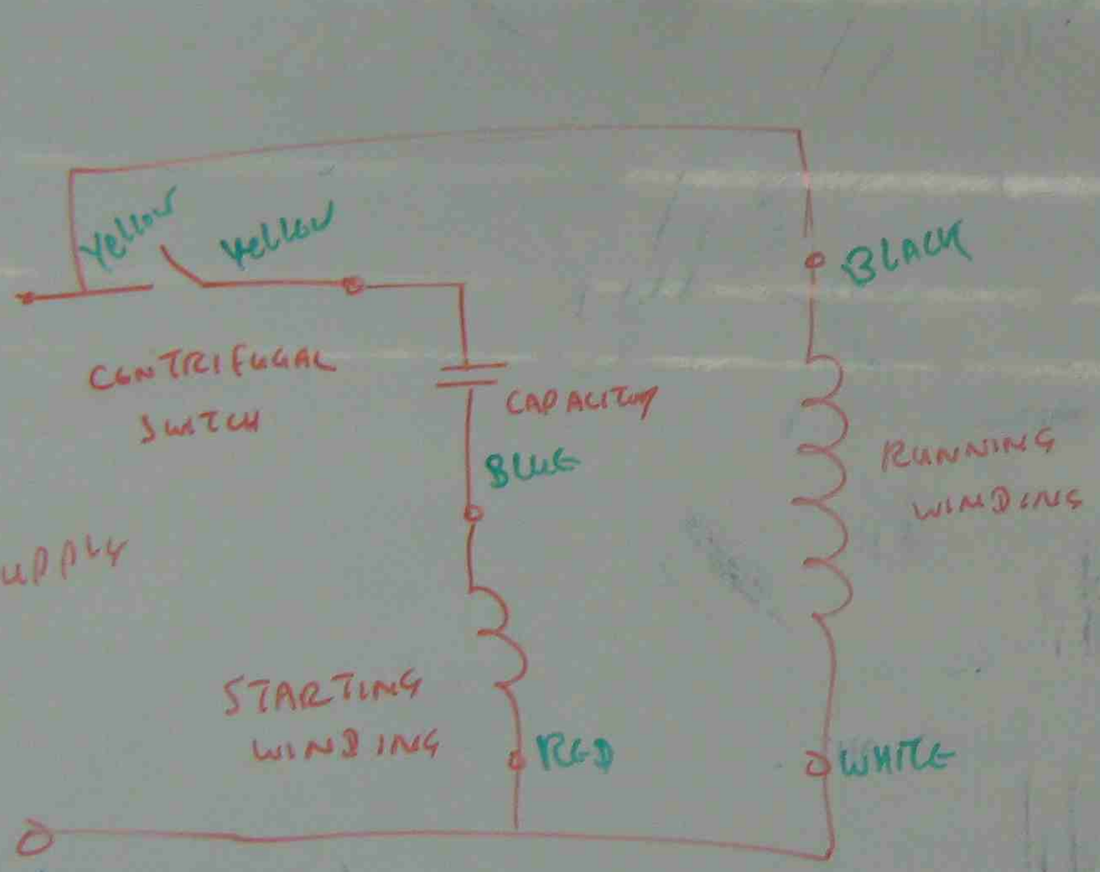
$I_L = \frac{5000}{1.7321 \times 208} = 13.87$ A

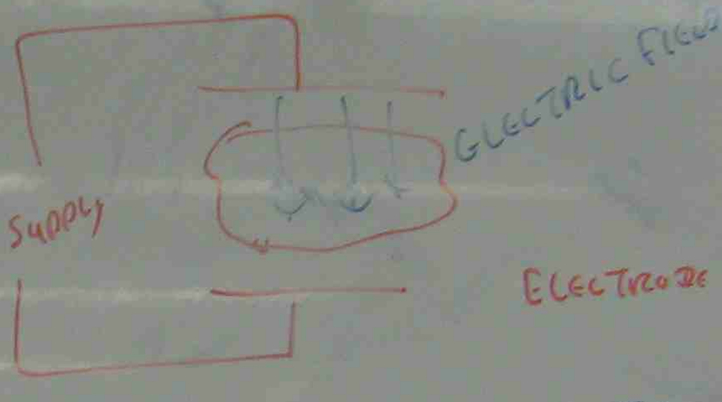
$I_{ph} = \frac{I_L}{\sqrt{3}} = \frac{13.87}{1.7321} = 8$ A

- 1 OF 4

STEP (3) MAKE CONNECTION

DIELECTRIC HEATING





THE MATERIAL TO BE HEATED IS PLACE BE

TWO ELECTRODES OF DIELECTRIC HEATER.

THE ELECTRIC FIELD QUICKLY MOVES THE MOL

PRODUCE THE HEAT (MICROWAVE OV

Cap = ~~18~~ chairs
~~18~~ desks

ELECTRICAL EQUIPMENTS, ELECTRICAL LOADS AND POWER & ENERGY USAGE

ELECTRICAL EQUIPMENTS / LOAD

- LIGHTING
  - HIGH DENSITY VAPOR
  - INCANDESCENT LIGHT
  - FLOURESCENT LIGHT
- POWER
  - DC SHUNT MOTOR
  - DC COMPOUND MOTOR
  - DC SERIES MOTOR
  - AC 1ϕ MOTOR
  - AC 3ϕ MOTOR
- HEATING
  - RESIDENTIAL
    - COOKER
    - OVER
    - RANGE
    - WATER HEATER
    - POWER FACTOR = 1
  - INDUSTRIAL
    - LARGE SPACE HEATER
    - INDUCTION HEATER
    - HEAT TREATMENT
    - FURNACE
    - ELECTRIC FURNACE
    - DIELECTRIC HEATING
- ELECTRONIC
  - RADIO, TV, LASER, COMPUTER
  - ANALOG / DIGITAL
  - RECTIFIER / OSCILLATOR

CONTINUOUS

INTERMITTENT

FLUCTUATION OF LOAD

Supply QUALITY

NEED TO ELIMINATE

SURGE + FILTER + SURGE DIVERTER

USE APPRIATE WIRE SIZE

WIRING / CONTROL SYSTEM

Cap = ~~18~~ Chairs
~~18~~ desks

ELECTRICAL EQUIPMENTS, ELECTRICAL LOADS AND POWER & ENERGY USAGE

ELECTRICAL EQUIPMENTS / LOAD

- LIGHTING — VOLT 120 → 277V
  - HIGH DENSITY VAPOR
  - INCANDESCENT LIGHT
  - FLOURESCENT LIGHT — PF = 50%
  - DC & AC
- POWER
  - DC SHUNT MOTOR — 200HP
  - DC COMPOUND MOTOR — 200HP
  - DC SERIES MOTOR — 200HP
  - AC 1φ MOTOR UP TO 10HP
  - AC 3φ MOTOR UP TO 1000 HP
- HEATING
  - RESIDENTIAL
    - COOKER
    - OVER
    - RANGE — 120V/240V, PF UNITY
    - WATER HEATER — POWER FACTOR = 1
  - INDUSTRIAL
    - LARGE SPACE HEATER
    - INDUCTION HEATER
    - HEAT TREATMENT FURNACE
    - ELECTRIC FURNACE
    - DIELECTRIC HEATING
    - WELDING (30 → 50V)
    - HIGH FREQUENCY HEATING (FROM 60HZ)
- ELECTRONIC
  - RADIO, TV, LASER, COMPUTER
  - ANALOG | DIGITAL
  - RECTIFIER | OSCILLATOR
  - SUBJECT TO INTERFERENCE

CONTINUOUS

INTERMITTENT

FLUCTUATION OF LOAD

USE APPRIATE WIRE SIZE

WIRING | CONTROL SYSTEM

LOAD 60% → 95%

SUPPLY QUALITY

NEED TO ELIMINATE SURGE + FILTER + SURGE DIVERTER

Cap = 18 chairs
1B desks

ELECTRICAL EQUIPMENTS, ELECTRICAL LOADS AND POWER & ENERGY USAGE

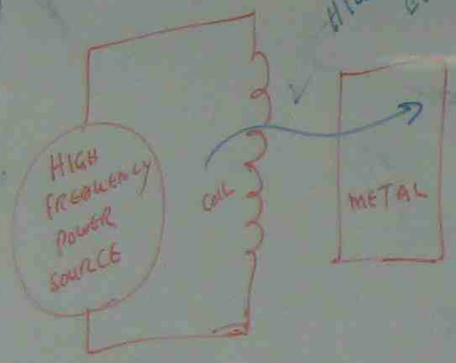
ELECTRICAL EQUIPMENTS / LOAD

- LIGHTING (vat 170 → 277V)
  - HIGH DENSITY VAPOR
  - INCANDESCENT LIGHT
  - FLOURESCENT LIGHT PF = 50%
  - DC & AC
- POWER
  - DC SHUNT motor 200 HP
  - DC compound motor 200HP
  - DC SERIES motor 200HP
  - AC 1φ motor UP TO 10HP
  - AC 3φ motor UPTO 1000 HP
  - CONTINUOUS
  - INTERMITTENT
  - FLUCTUATION OF LOAD
- HEATING
  - RESIDENTIAL
    - COOKER
    - OVER
    - RANGE
    - WATER HEATER
    - 120V/240V
    - PF UNITY
    - POWER FACTOR = 1
  - INDUSTRIAL
    - LARGE SPACE HEATER
    - INDUCTION HEATER
    - HEAT TREATMENT
      - FURNACE
      - ELECTRIC FURNACE
      - DIELECTRIC HEATING
    - WELDING (30 → 50V)
    - HIGH FREQUENCY HEATING (FROM 60Hz)
- ELECTRONIC
  - RADIO, TV, LASER, COMPUTER
  - ANALOG | DIGITAL
  - RECTIFIER | OSCILLATOR
  - SUBJECT TO INTERFERENCE

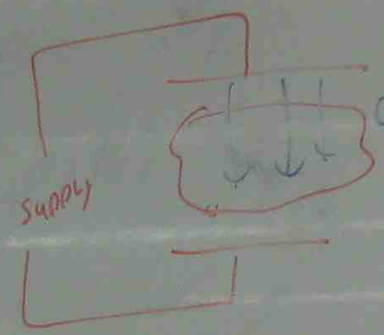
Supply Quality
Need to eliminate
- SURGE
- +
- FILTER
- +
- SURGE DIVERTER

← USE APPRIATE WIRE SIZE
WIRING | CONTROL SYSTEM
LOAD 60% → 95%

Q — EXPLAIN (i) INDUCTION HEATING (ii) DIELECTRIC HEATING



THE METAL TO BE HARDENED IS PLACED INSIDE THE COIL CONNECTED TO HIGH FREQUENCY SOURCE OF POWER. THE EDDY CURRENT FLOW IN THE SKIN MOVES THE ATOMS VERY QUICKLY AND THE SURFACE CAN BE HARDENED.



THE MATERIAL TO BE HEATED IS PLACE BETWEEN TWO ELECTRODES OF DIELECTRIC HEATER.

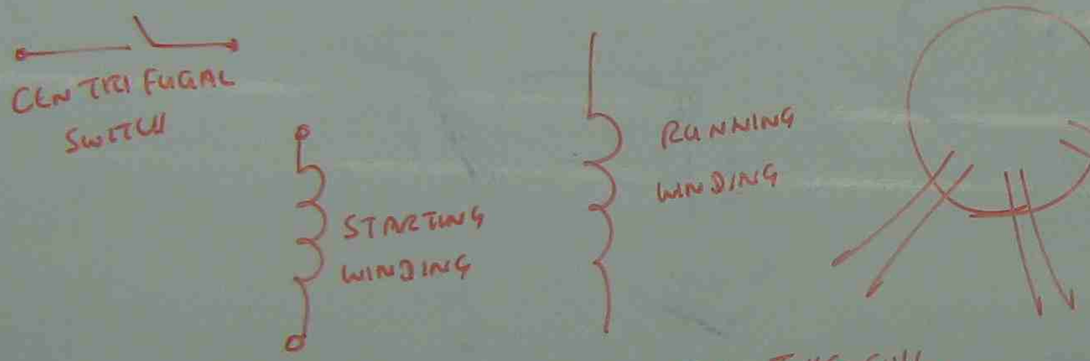
THE ELECTRIC FIELD QUICKLY MOVES THE MOLECULES AND PRODUCE THE HEAT (MICROWAVE OVEN)

- CONT

18 chairs
18 desks

PRACTICAL

TEST & CONNECTION OF SINGLE PHASE AC MOTOR



STEP 4) IDENTIFY & SEPARATE THE COIL

USE OHM METER TO CHECK THE CONTINUITY AND RESISTANCE OF THE LEADS.

	COLOUR	RESISTANCE
1	2	
3	4	
5	6	

RESISTANCE

LOWEST → TERMINAL FOR STARTING SWITCH CENTRIFUGAL SWITCH

MIDDLE → RUNNING WINDING

HIGHEST → STARTING WINDING

STEP(2) CHECK THE INSULATION RESISTANCE

USE MEGGER

RESISTANCE BETWEEN STARTING & RUNNING WINDING	RESISTANCE BETWEEN STARTING WINDING & BODY	RESISTANCE BETWEEN RUNNING WINDING & BODY

CHECK VOLTAGE LEVEL

TRIO 15MHz OSCILLOSCOPE CS1560A

MINI-LAB

MODEL 9208

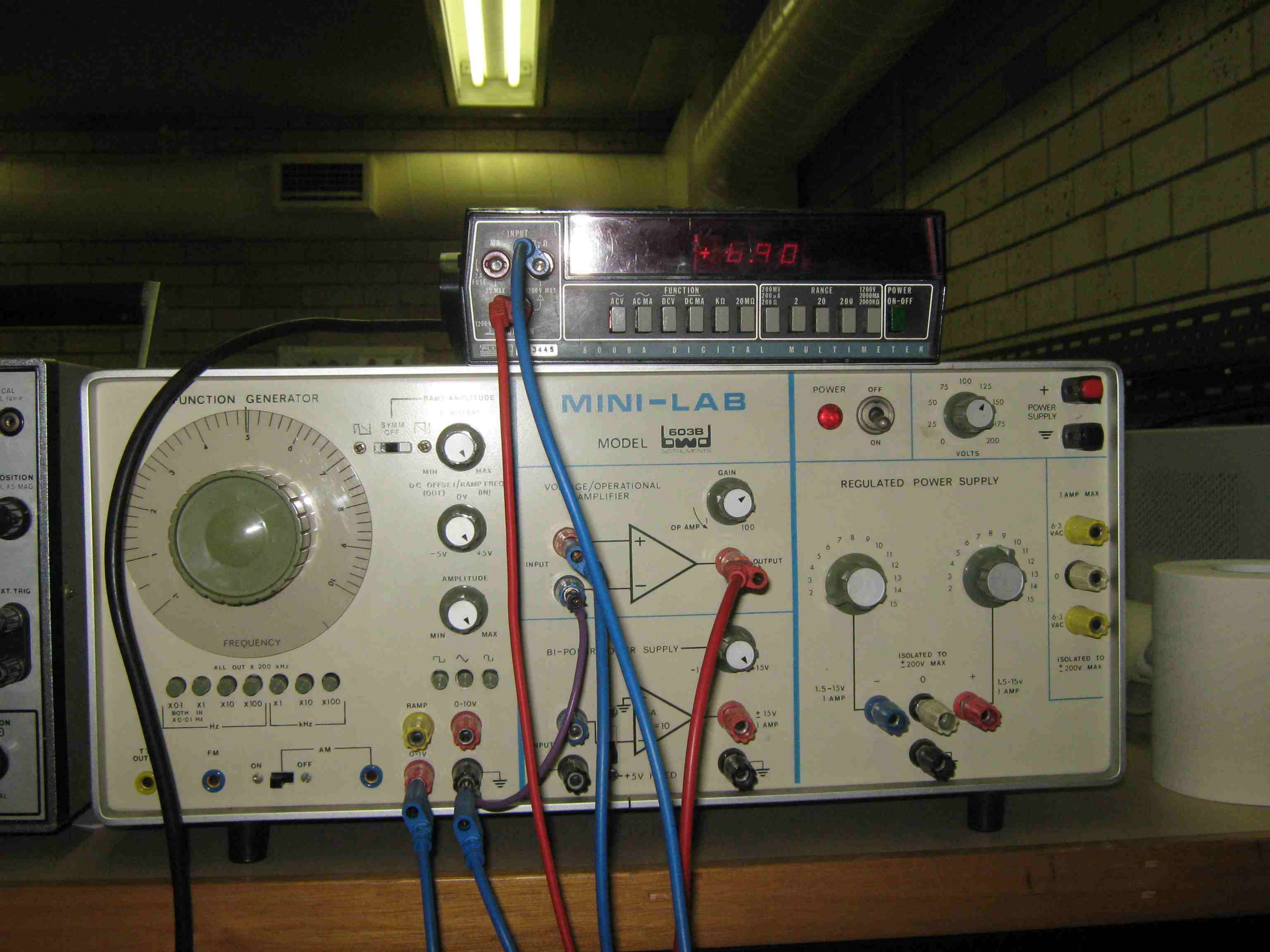
REGULATED POWER SUPPLY

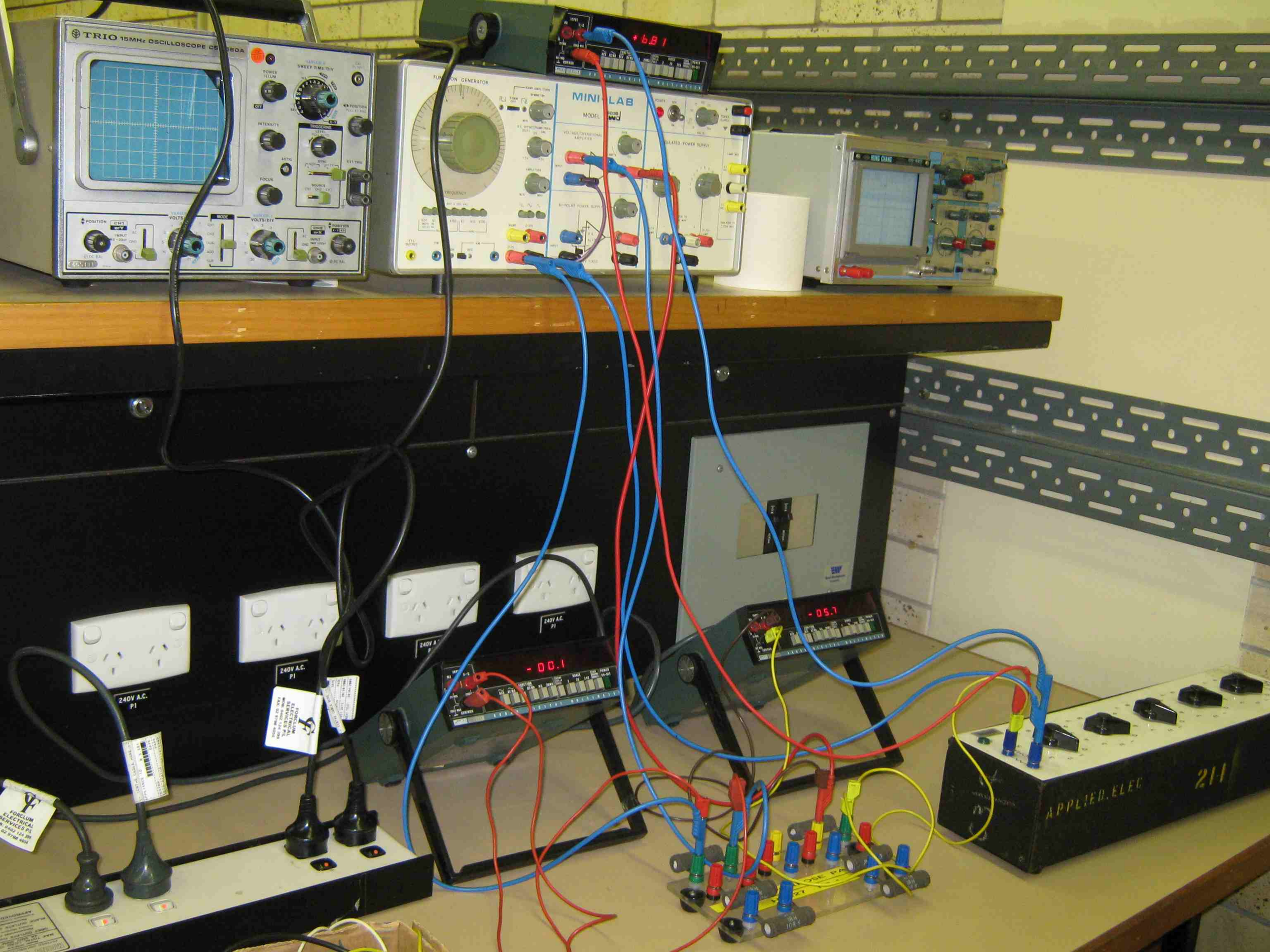
HUNG CHANG

EMERGENCY STOP

240V A.C.

APPLIED.ELEC


+6.90
INPUT
FUSE
FUNCTION
ACV
AC MA
DCV
DC MA
KΩ
20MΩ
RANGE
200MV
200 μA
200 Ω
2
20
200
1200V
2000MA
2000KΩ
POWER
ON-OFF
8000A DIGITAL MULTIMETER
FUNCTION GENERATOR
RAMP AMPLITUDE
SYMM
OFF
MIN
MAX
DC OFFSET/RAMP FREQ
(OUT)
0V
(IN)
-5V
+5V
AMPLITUDE
MIN
MAX
FREQUENCY
ALL OUT X 200 kHz
X0·1
X1
X10
X100
BOTH IN X0·01 Hz
Hz
X1
X10
X100
kHz
RAMP
0-10V
0-1V
FM
ON
OFF
AM
MINI-LAB
MODEL 603B
GAIN
OP AMP
100
INPUT
OUTPUT
BI-POLAR POWER SUPPLY
+15V
± 15V
1 AMP
+5V FIXED
POWER
OFF
ON
VOLTS
POWER SUPPLY
REGULATED POWER SUPPLY
1 AMP MAX
6·3 VAC
0
6·3 VAC
ISOLATED TO ±200V MAX
1.5-15V 1 AMP
ISOLATED TO ±200V MAX
1.5-15V 1 AMP


TRIO 15MHz OSCILLOSCOPE
MINILAB
240V A.C.
P1
APPLIED ELEC
211

Cap = 18 chairs
18 desks

ELECTRICAL LOADS AND POWER / ENERGY CONSUMPTION

- LIGHTING
  - INCANDESCENT LAMP
  - SODIUM VAPOUR LAM
  - NEON LAMP
  - MERCURY VAPOUR ← INDUCTIVE
  - 120V → 277V
  - AC 1φ (OR) DC
  - UNITY POWER FACTOR
  - 5% LOWERED VOLTAGE = LIGHT OUT PUT 16% WILL DROP
  - RESISTIVE LOAD
- POWER
  - DC MOTOR (SHUNT / COMPOUND SERIES) (UP TO 200HP)
  - INDUCTIVE
    - SINGLE PHASE ($\frac{1}{50}$ HP → 10 HP)
    - THREE PHASE UP TO 1000 HP
- HEATING
  - RESIDENTIAL
    - RANGE, COOKER, HEATER
    - TOASTER, CLOTH DRYER
    - 120V / 240V
    - P.F UNITY
  - INDUSTRIAL
    - SPACE HEATER
    - INDUCTION HEATER
    - ELECTRIC FURNACE
    - SOLDERING
    - DIELECTRIC HEATING (MICROWAVE)
    - HIGH FREQUENCY (HF) HEATING
    - SURFACE HARDENING
- ELECTRONICS
  - DOMESTIC
    - TV, RADIO, COMPUTER, DVD
  - INDUSTRIAL
    - TELECOMMUNICATION SERVICE
    - DATA TRANSMISSION
    - INTERNET COMPUTER SYSTEM

LOAD ANALYSIS → PROVIDE APPROPRIATE ELECTRICAL SYSTEM.
(POWER / CURRENT / VOLTAGE RATING)

ELECTRONICS LOAD – NEED STABLE SUPPLY.

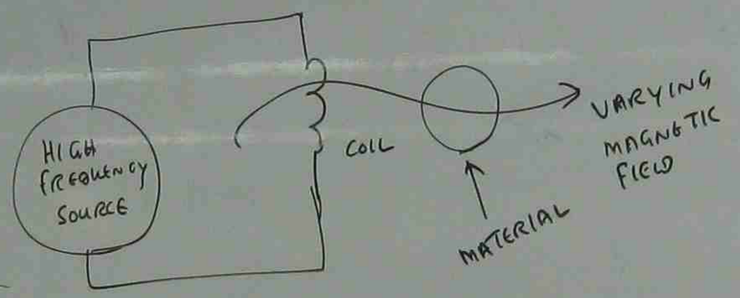
LOAD & CHARACTERISTICS

LOAD	CHARACTERISTICS & SUITABLE APPLICATION
DC SHUNT MOTOR	CONSTANT SPEED, LIGHT & MEDIUM LOAD
DC COMPOUND MOTOR	VARYING SPEED UP TO 25% SPEED DIFFERENCE HEAVY STARTING DUTY LOAD
DC SERIES MOTOR	VARIABLE SPEED, HEAVY INTERMITTENT STARTING
AC 1Φ MOTOR	CONSTANT SPEED, LIGHT & MEDIUM LOAD
AC 3Φ MOTOR	HEAVY STARTING LOAD

Q/ EXPLAIN THE FOLLOWINGS:

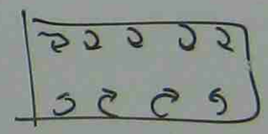
(a) IN DUCTION HEATING (b) DI ELECTRIC HEATING

(a) IN DUCTION HEATING



THE INDUCTION COIL IS CONNECTED TO HIGH FREQUENCY SOURCE. WHEN THE HIGH FREQUENCY CURRENT FLOWS IN TH THE COIL, IT PRODUCES VARYING MAGN FLUX WITH HIGH FREQUENCY.

THE METALLIC MATERIALS ARE PLACED NEAR THE COIL. THE FLUX PRODUCES THE CURR FLOW IN THE SURFACE OF THE METAL. THIS CURRENT PRODUCES HEAT AND CAUSES THE SURFACE OF METAL TO BE HARDEN E

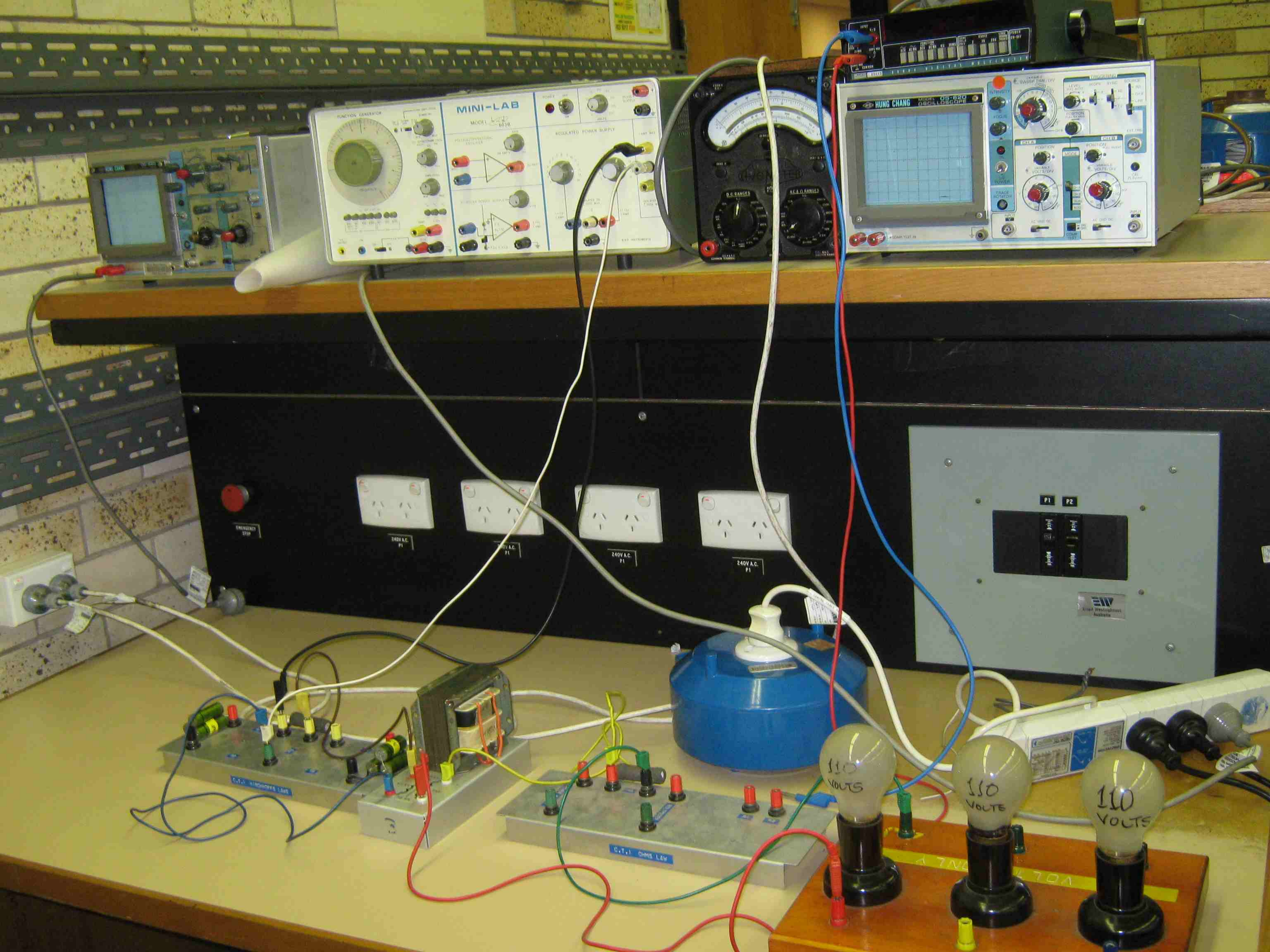


(b) DIELECTRIC HEATING



POOR CONDUCTING MATERIALS ARE PLACED BETWEEN TWO ELECTRODES OF HIGH FREQUENCY WAVE.

THE WAVE CREATES THE ELECTRIC FIELD THAT CAUSES THE MOVEMENT OF MOLECULES OF FOODS AND THE FRICTION CAUSES THE HEAT.


MINI-LAB
MODEL 603B
FUNCTION GENERATOR
REGULATED POWER SUPPLY
D.C RANGES
A.C & D RANGES
HUNG CHANG
MODEL DS-220
OSCILLOSCOPE
EMERGENCY STOP
240V A.C. P1
P1
P2
C.T.I OHMS LAW
110 VOLTS
110 VOLTS
110 VOLTS

R1
R4
R3
R2
R5
4 T.P.V.
41.5V
70 VA.
MA
VOLTMETER
POWER SUPPLY
R1
R2

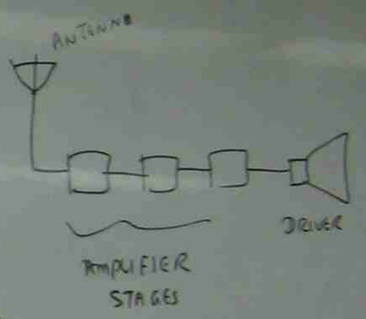
Cap = $8 chairs
$8 desks

CHANGING VOLTAGE, CURRENT AND POWER LEVEL

CHANGE VOLTAGE & CURRENT WITH CONSTANT POWER → TRANSFORMER

CHANGE THE MAGNITUDE OF CURRENT WITH INCREASED POWER → AMPLIFIER

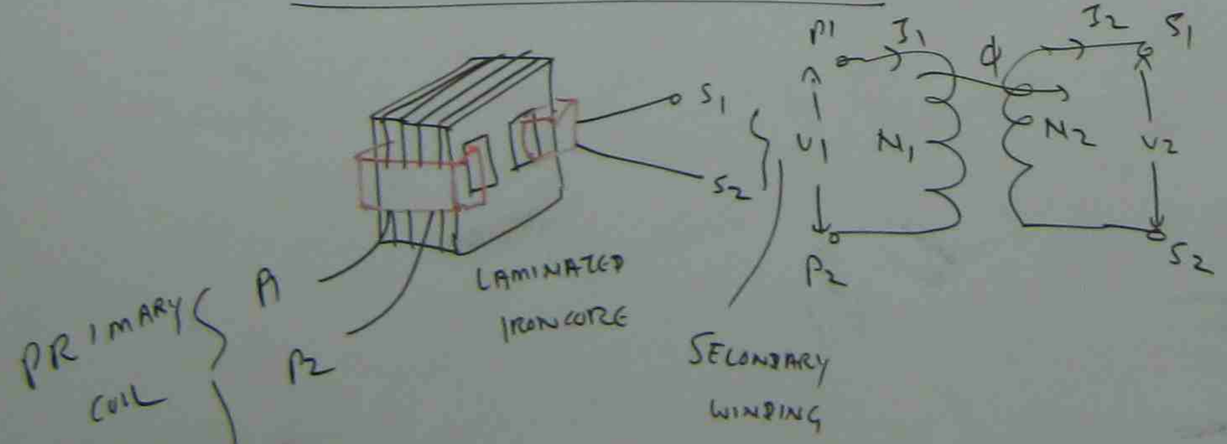
- → ELECTRONIC / RADIO WAVE



- → INDUSTRIAL ELECTRONIC

AMPLIFY THE POWER ENOUGH TO DRIVE THE CONTROL MACHINERY

PRINCIPLE of TRANSFORMER



$$\frac{V_1}{V_2} = \frac{N_1}{N_2} = \frac{I_2}{I_1}$$

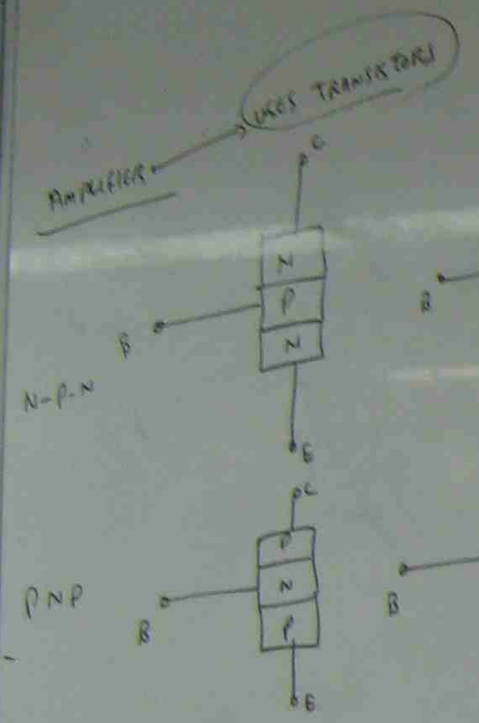
$V_1 I_1$ = PRIMARY POWER

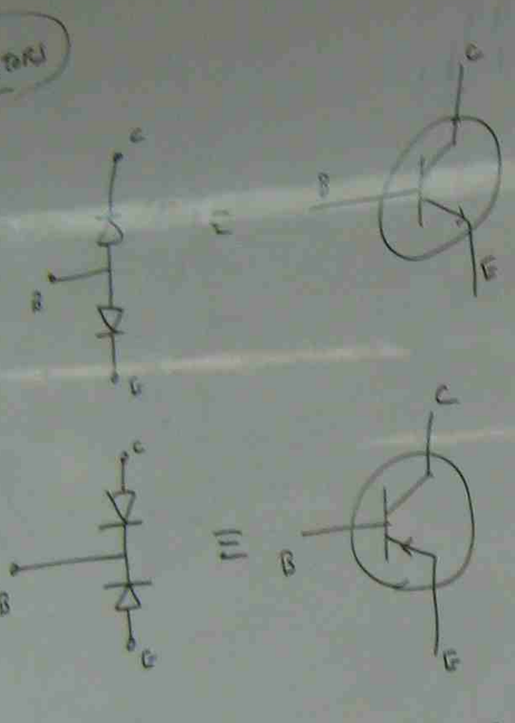
$V_2 I_2$ = SECONDARY POWER

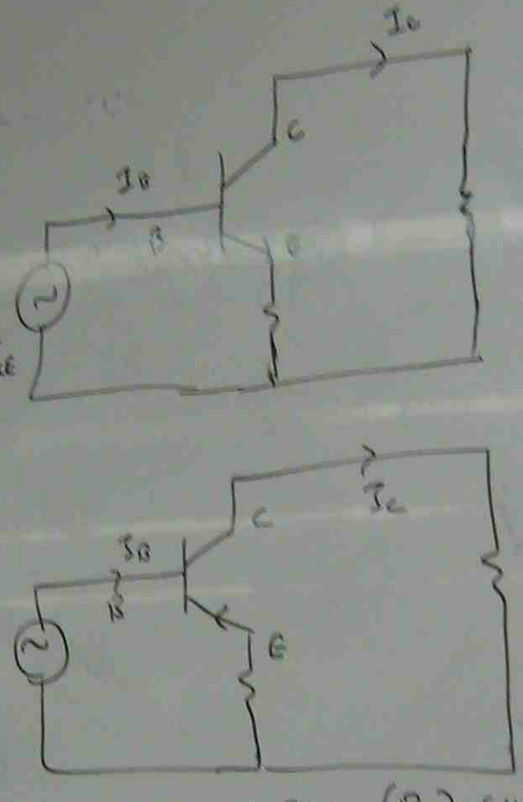
$V_1 I_1 = V_2 I_2$

TRANSFORMER CAN NOT CHANGE THE POWER LEVEL, CAN ONLY CHANGE VOLTAGE / CURRENT LEVEL

AMPLIFIER → USES TRANSISTORS







$I_C = \beta \times I_B$

↑ CURRENT GAIN

AMPLIFIER CONSISTS OF TRANSISTORS WHICH CAN CHANGE THE CURRENT LEVEL BY (β) CURRENT GAIN.

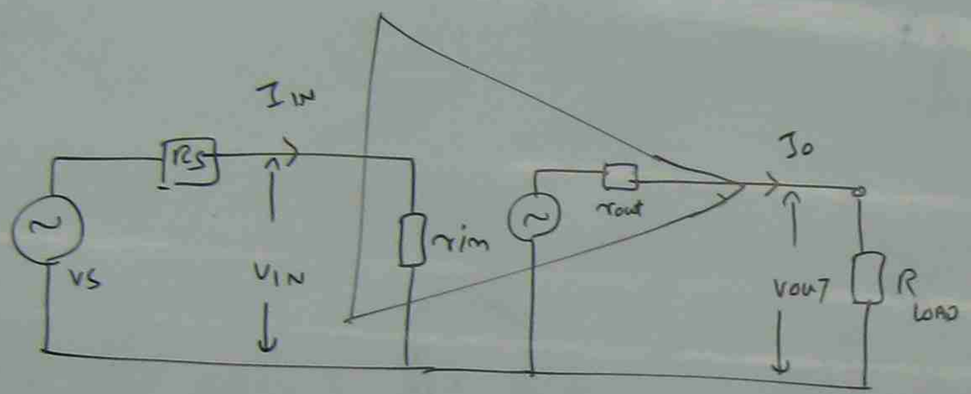
THE HEAT / HUMIDITY AND TEMPERATURE INFLUENCE ON THE MAGNITUDE OF β.

WHEN THE β CHANGES, THE CURRENT OUT PUT WILL CHANGE AND THE OPERATION CAN BE MALFUNCTION.

IT NEEDS TO MAINTAIN THE CONSTANT OPERATING TEMPERATURE & FILTER THE IN PUT SIGNAL.

Cap = 18 chairs
18 desks

EQUIVALENT CIRCUIT OF AMPLIFIER



$$\text{VOLTAGE GAIN} = \frac{V_{OUT}}{V_{IN}}$$

$$\text{CURRENT GAIN} = \frac{I_{OUT}}{I_{IN}}$$

$$\text{POWER GAIN} = \frac{P_{OUT}}{P_{IN}}$$

Pb (1)

A TRANSFORMER HAS THE FOLLOWING SPECIFICATION

PRIMARY TURN = 200 SECONDARY TURN 100

IF PRIMARY IS CONNECTED TO 240V SUPPLY

CALCULATE (i) SECONDARY VOLTAGE

IF IT'S CAPACITY IS 1000 V.A, CALCULATE (ii) PRIMARY CURRENT

(iii) SECONDARY CURRENT

Pb (2)

AN AMPLIFIER INPUT VOLTAGE & CURRENT ARE 1V AND 1mA RESPECTIVELY.

OUTPUT VOLTAGE IS 2V AND CURRENT IS 3mA

CALCULATE (i) VOLTAGE GAIN (ii) CURRENT GAIN (iii) POWER GAIN.

pb ①

$N_1 = 200$

$N_2 = 100$

(i) $V_1 = 240V$

$V_2 = ?$

$\frac{V_1}{V_2} = \frac{N_1}{N_2}$

$\frac{240}{V_2} = \frac{200}{100}$

$\frac{240}{V_2} = \frac{2}{1}$

$2V_2 = 240$

$V_2 = \frac{240}{2} = 120V$

$I_1 V_1 = 1000VA$

$I_1 \times 240 = 1000$

$I_1 = \frac{1000}{240}$ A

$= 4.1$

$I_2 V_2 = 1000$

$I_2 \times 120 = 1000$

$I_2 = \frac{1000}{120}$ A

$= 8.2$ AMP

pb ②

$V_I = 1V$ $I_{IN} = 1mA$

$V_0 = 2V$ $I_{OUT} = 3mA$

VOLTAGE GAIN $(A_V) = \frac{V_0}{V_I} = \frac{2}{1} = 2$

CURRENT GAIN $(A_I) = \frac{I_{OUT}}{I_{IN}} = \frac{3mA}{1mA} = 3$

$P_I = V_I I_I = 1 \times 1mA = 1mW$

$P_0 = V_0 I_0 = 2 \times 3mA = 6mW$

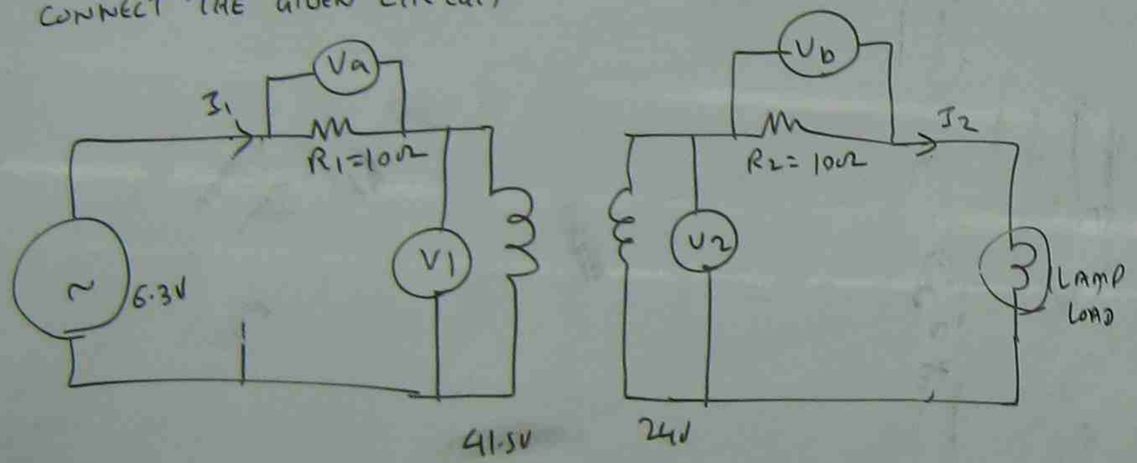
POWER GAIN $(A_P) = \frac{P_0}{P_I} = \frac{6mW}{1mW} = 6$

= 18 chairs
18 desks

INPUT & OUT PUT POWER OF TRANSFORMER & AMPLIFIER

PART (1) TRANSFORMER

CONNECT THE GIVEN CIRCUIT



TAKE THE READINGS & FILL IN TABLE

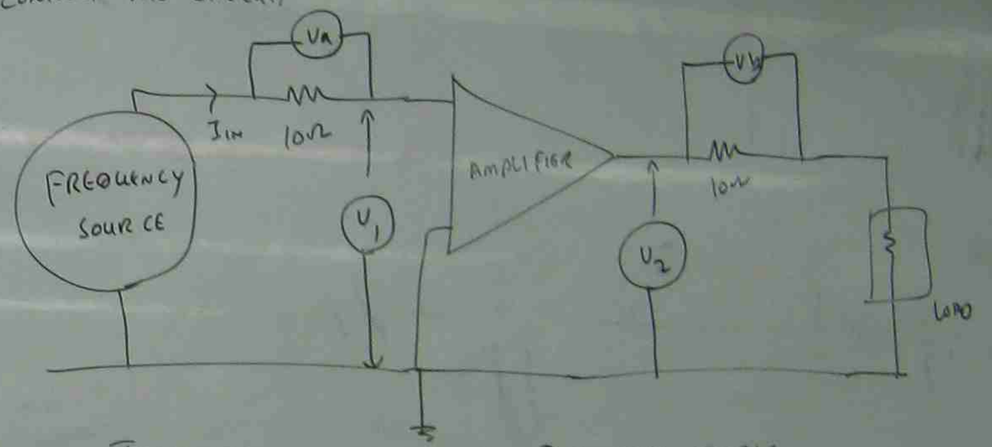
IN PUT				OUT PUT			
V_1	V_a	$I_1 = \frac{V_a}{10\Omega}$	$P_1 = V_1 I_1$	V_2	V_b	$I_2 = \frac{V_b}{10\Omega}$	$P_2 = V_2 I_2$

FIND THE RATIO of IN PUT & OUT PUT POWER

$$RATIO = \frac{P_2}{P_1} =$$ ← RESULT (1)

PART (2) AMPLIFIER

CONNECT THE CIRCUIT

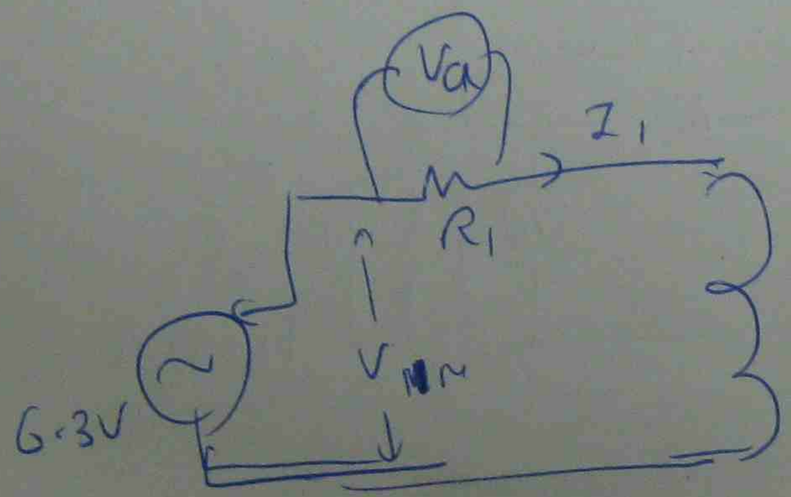


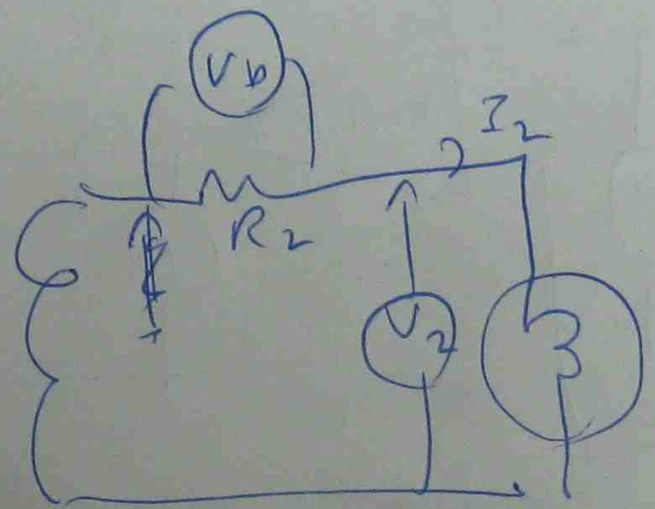
TAKE THE READINGS & FILL THE TABLE

IN PUT				OUT PUT			
V_1	V_a	$I_{IN} = \frac{V_a}{10\Omega}$	$P_{IN} = V_1 I_{IN}$	V_2	V_b	$I_o = \frac{V_b}{10\Omega}$	$P_{out} = V_2 I_o$

FIND THE RATIO OF IN PUT & OUT PUT POWER

$$RATIO = \frac{P_o}{P_1} =$$ ← RESULT (2)





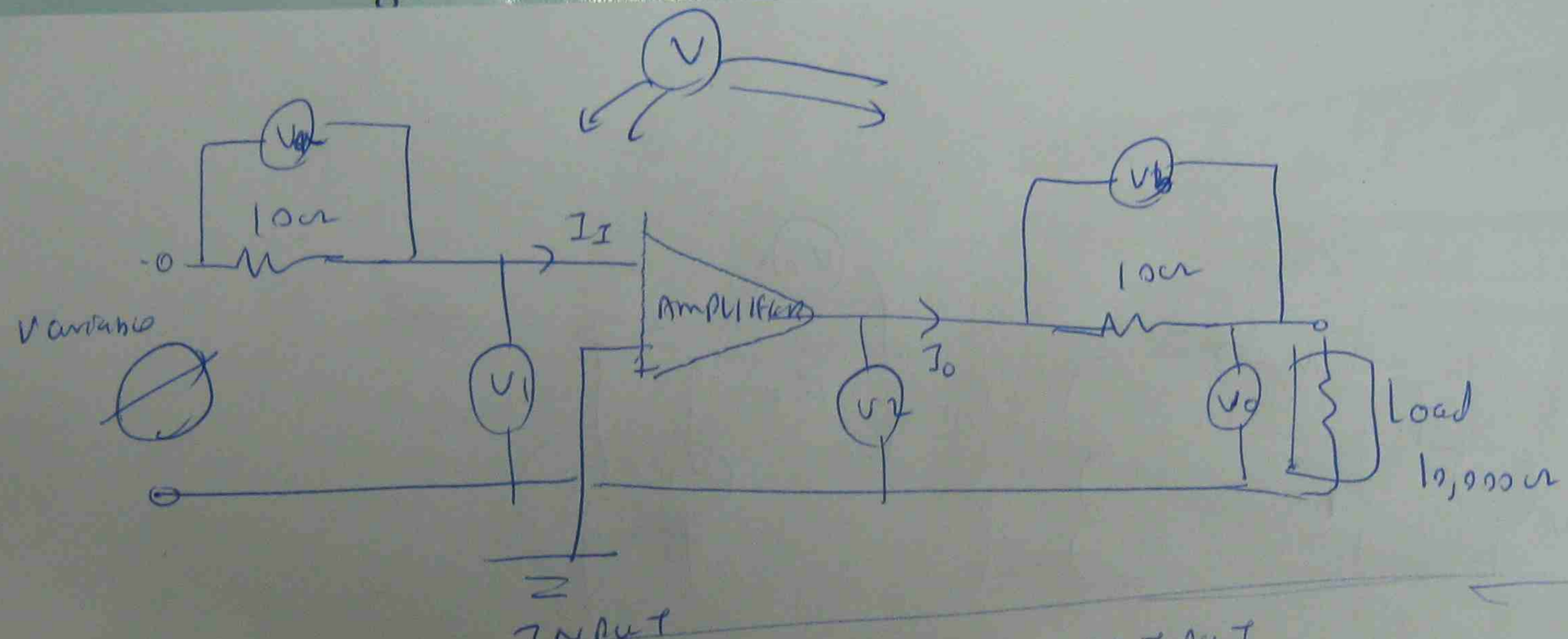
$$I_1 = \frac{V_a}{R_1}$$

$$I_2 = \frac{V_b}{R_2}$$

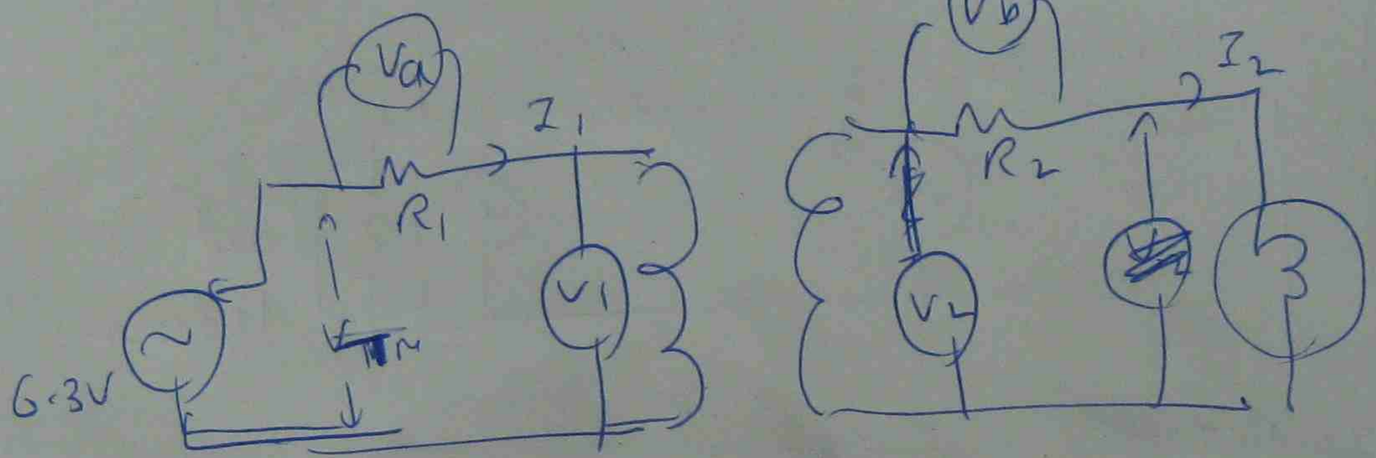
$$P_{IN} = I_1 \times V_1$$

$$P_{out} = I_2 V_2$$

compare P_{IN} & P_{OUT}



Freq:	V_1	$I_I = \frac{V_a}{10\Omega}$	$P_{IN} = V_1 \times I_I$	V_{O2}	$I_o = \frac{V_b}{10\Omega}$	$P_o = V_2 \times I_o$	Gain: $\frac{P_o}{P_i}$



$I_1 = \frac{V_a}{R_1}$ $\therefore$

$I_2 = \frac{V_b}{R_2}$

$P_{IN} = I_1 \times V_1$

$P_{out} = I_2 V_2$

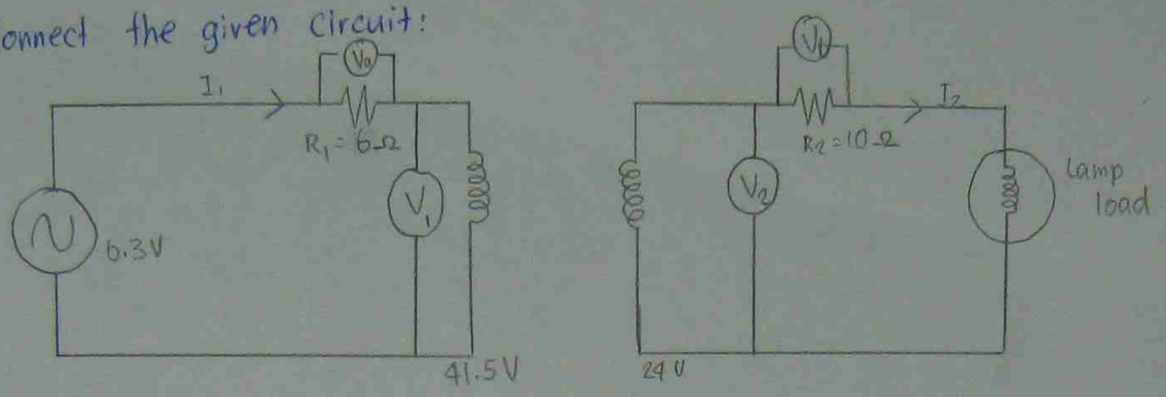
Compare P_{IN} & P_{out}

8/4/09
Tamara Tran

Input and Output Power of Transformer and Amplifier:

Part (1) transformer:

Connect the given circuit:



Take the readings and fill out information:

Input:

$V_1 = 6.2\ V$

$V_a = 0.71\ V$

$I_1 = \frac{V_a}{6\Omega} = \frac{0.71}{6} = 0.118\ A$

$P_1 = V_1 I_1 = 6.2 \times 0.118 = 0.7316\ W$

Output:

$V_2 = 3.9\ V$

$V_b = 0.33\ V$

$I_2 = \frac{V_b}{6\Omega} = \frac{0.33}{6} = 0.055\ A$

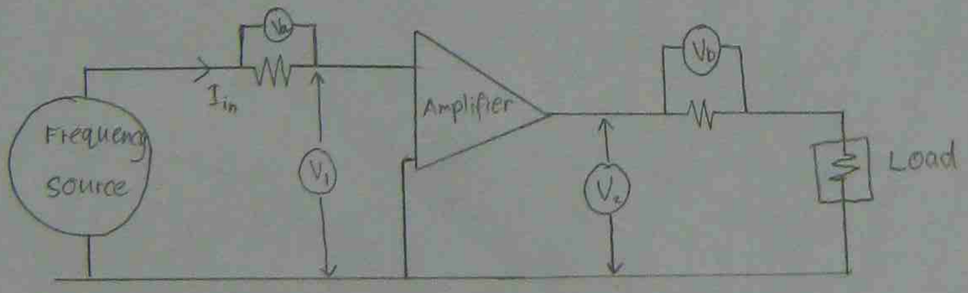
$P_2 = V_2 I_2 = 3.9 \times 0.055 = 0.2145\ W$

Ratio of input and output power:

$\text{Ratio} = \frac{P_2}{P_1} = \frac{0.2145}{0.7316} = 0.29 \Rightarrow 0.3$

Part (2) amplifier:

Connect the circuit:



Take the readings and fill out information:

Input:

$V_1 = 0.02\ V$

$V_a = 0.1\ V$

$I_{in} = \frac{V_a}{10\Omega} = \frac{0.1}{10} = 0.01\ A$

$P_{in} = V_1 I_{in} = 0.02 \times 0.01 = 0.0002$

Output:

$V_2 = 1.76\ V$

$V_b = 6\ V$

$I_{out} = \frac{V_b}{10\Omega} = \frac{6}{10} = 0.6\ A$

$P_{out} = V_2 I_{out} = 1.76 \times 0.6 = 0.1056\ W$

Ratio of input and output power:

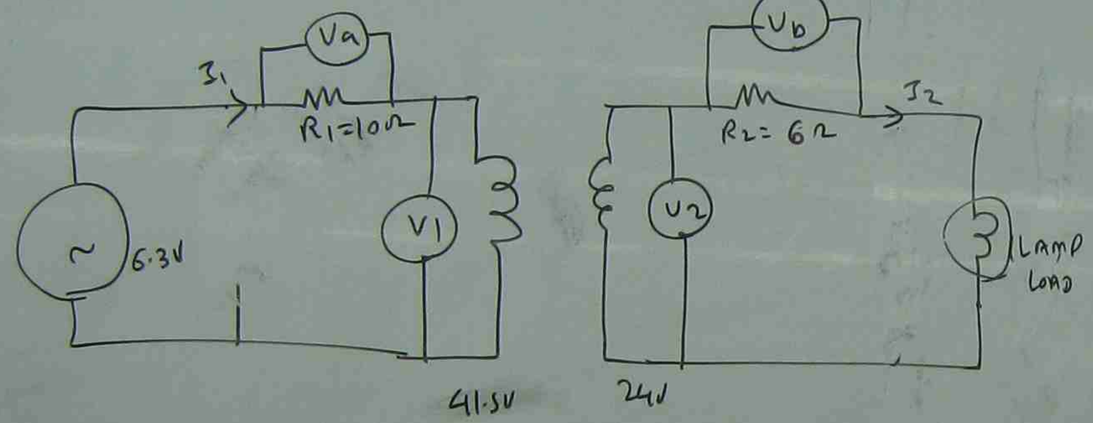
$\text{Ratio} = \frac{P_{out}}{P_{in}} = 528$

Cap = ~~28~~ 18 chairs
~~18~~ 18 desks

INPUT & OUT PUT POWER OF TRANSFORMER & AMPLIFIER

PART (1) TRANSFORMER

CONNECT THE GIVEN CIRCUIT



TAKE THE READINGS & FILL IN TABLE

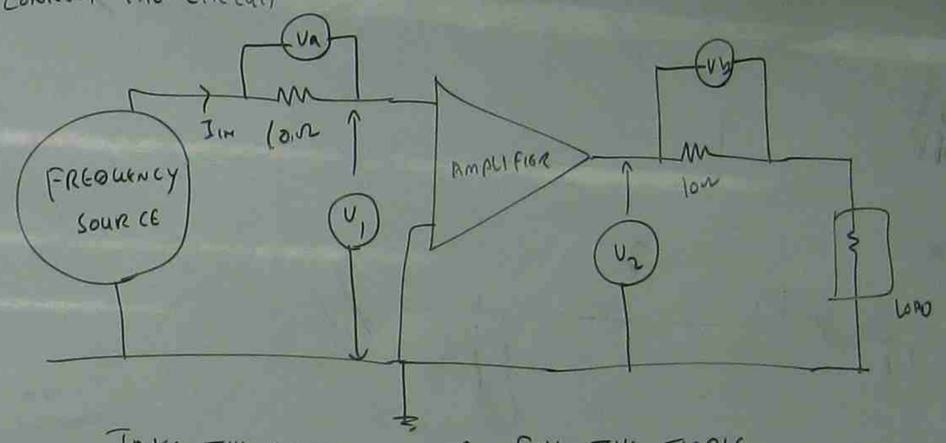
IN PUT				OUT PUT			
V_1	V_a	$I_1 = \frac{V_a}{10\Omega}$	$P_1 = V_1 I_1$	V_2	V_b	$I_2 = \frac{V_b}{10\Omega}$	$P_2 = V_2 I_2$

FIND THE RATIO OF IN PUT & OUT PUT POWER

$$RATIO = \frac{P_2}{P_1} =$$ ← RESULT (1)

PART (2) AMPLIFIER

CONNECT THE CIRCUIT



TAKE THE READINGS & FILL THE TABLE

IN PUT				OUT PUT			
V_1	V_a	$I_{IN} = \frac{V_a}{10\Omega}$	$P_{IN} = V_1 I_{IN}$	V_2	V_b	$I_o = \frac{V_b}{10\Omega}$	$P_{out} = V_2 I_o$

FIND THE RATIO OF IN PUT & OUT PUT POWER

$$RATIO = \frac{P_o}{P_1} =$$ ← RESULT (2)

8 chairs
8 desks

EFFECT OF POWER & ENERGY ON ELECTRICAL & ELECTRONIC DEVICES

INCREASE / REDUCE VOLTAGE / CURRENT ⟶ TRANSFORMER

IN PUT ⟶ TRANSFORMER ⟶ OUT PUT POWER

↓

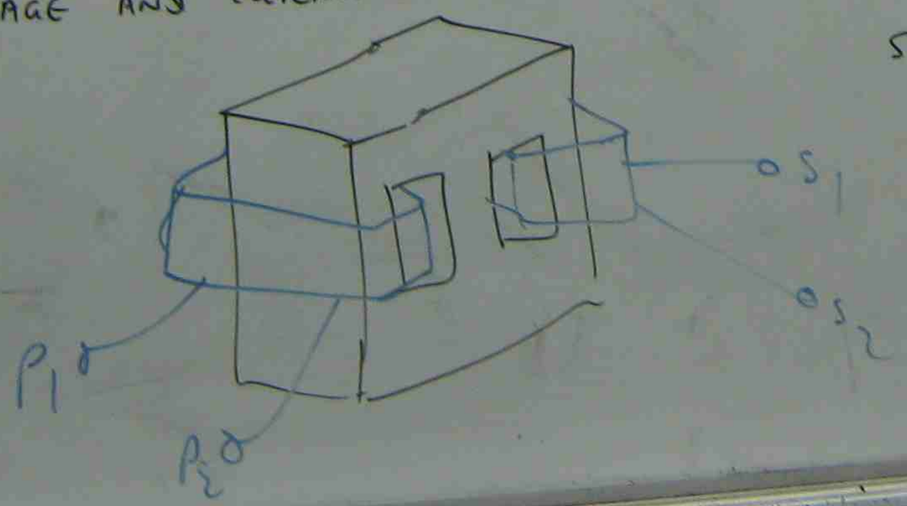
LOSSES

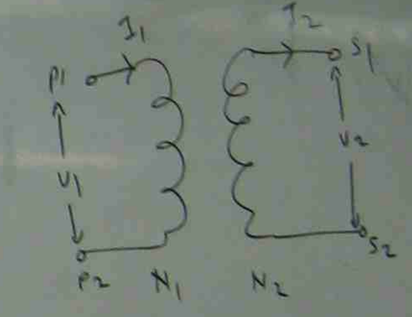
IN PUT IS EVER GREATER THAN OUT PUT POWER IN MOST ELECTRICAL DEVICES.

TRANSFORMER DOES NOT INCREASE THE POWER LEVEL, IT JUST CHANGES THE VOLTAGE AND CURRENT LEVEL

P_1, P_2 - PRIMARY WINDING

S_1, S_2 - SECONDARY WINDING





N_1 = PRIMARY NUMBER OF TURNS

N_2 - SECONDARY NUMBER OF TURNS

V_1 - PRIMARY VOLTAGE

V_2 - SECONDARY VOLTAGE

I_1 - PRIMARY CURRENT

I_2 - SECONDARY CURRENT

$$\frac{V_1}{V_2} = \frac{I_2}{I_1} = \frac{N_1}{N_2}$$

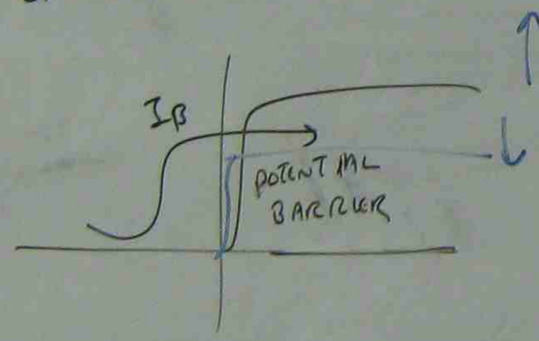
Q/ EXPLAIN THE IMPACT of TEMPERATURE ON TRANSISTOR AMPLIFIER.

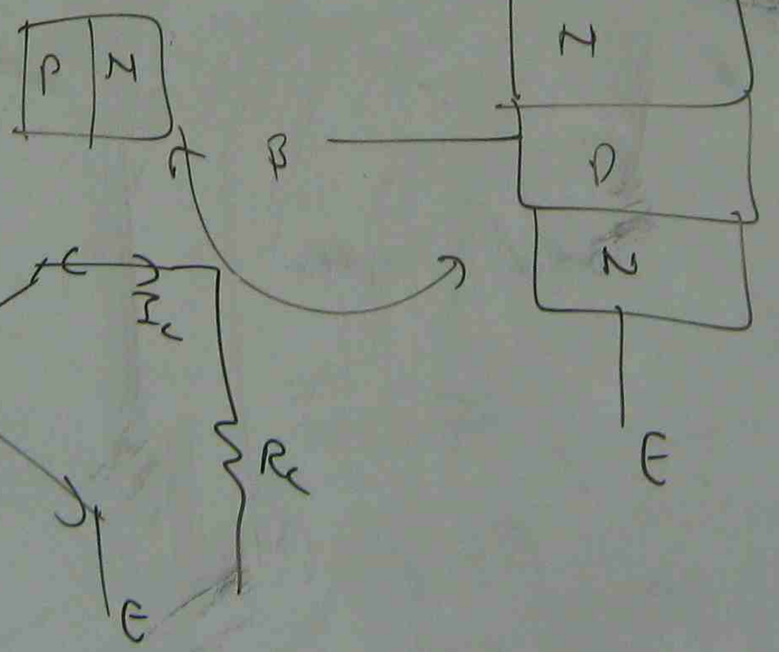
WHEN THE TEMPERATURE CHANGE, THE BARRIER VOLTAGE OF BASE-EMITTER (PN JUNCTION CHANGES.

WHEN TEMPERATURE RISES, THE BARRIER VOLTAGE DROPS. ALLOWING MORE BASE CURRENT FLOWS.

ACCORDING $I_c = \beta I_B$, MORE COLLECTOR CURRENT FLOWS

IT CAUSES MORE VOLTAGE IS DROP AT COLLECTOR RESISTOR.





IDEAL TRANSFORMER

INPUT POWER = OUT PUT POWER

$V_1 I_1 = V_2 I_2$

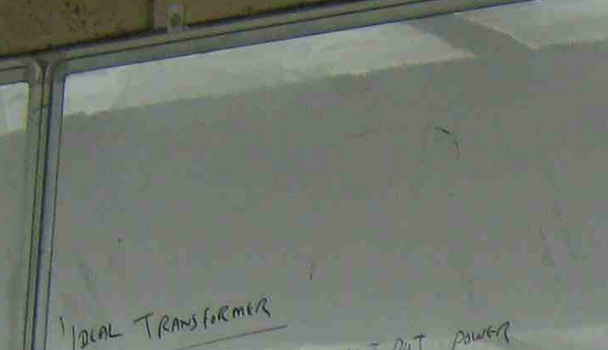
NORMAL TRANSFORMER

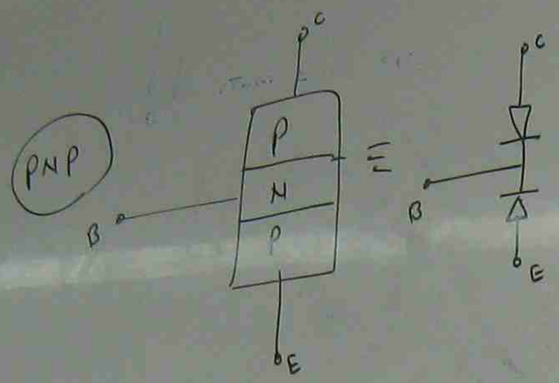
IN PUT POWER > OUT PUT POWER

AMPLIFIER

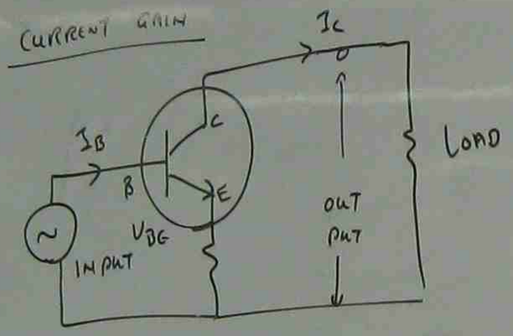
TO INCREASE OUT PUT VOLTAGE / CURRENT AND POWER LEVEL, AMPLIFIER IS TO BE UTILIZED

AMPLIFIER INCLUDES TRANSISTORS.





CURRENT GAIN



$I_C = \beta I_B$

β = CURRENT GAIN

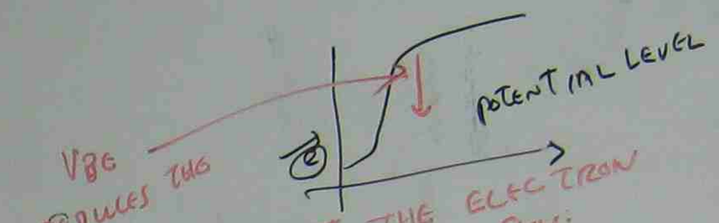
P.b AMPLIFIER $I_B = 1mA$, $\beta = 50$ CALCULATE I_C

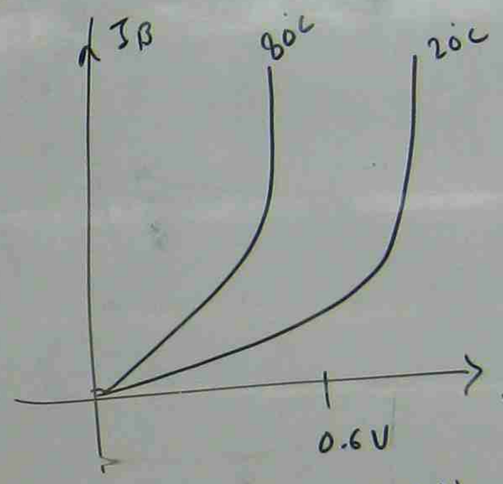
$I_C = \beta I_B = 50 \times 1mA = 50\,mA$

β = DEPENDS ON TEMPERATURE.

OPERATING TEMPERATURE OF ELECTRONIC EQUIPMENTS NEEDS TO BE KEPT AT CONSTANT TO PREVENT MALFUNCTIONING

B - BASE
C - COLLECTOR
E - EMITTER





WITH IN THE SAME TRANSISTOR AND AT THE SAME BASE TO EMITTER VOLTAGE LEVEL, THE CHANGE OF TEMPERATURE AFFECTS THE CHANGE OF CURRENT FLOWS IN TO BASE AND CURRENT. FLOWS OUT FROM COLLECTOR

$$\frac{V_o}{V_i} = \frac{6}{1} = 6$$

$$\frac{I_o}{I_i} = \frac{3mA}{1mA} = 3$$

$$V_I \times I_I = 1V \times 1mA = 1mW$$

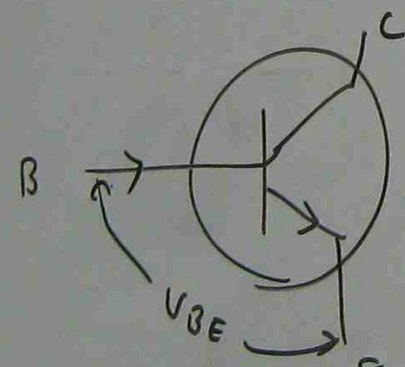
$$V_o \times I_o = 6V \times 3mA = 18mW$$

$$\frac{P_o}{P_I} = \frac{18mW}{1mW} = 18$$

CHARACTERISTICS OF TRANSISTOR

(VOLTAGE, CURRENT, POWER RATING, TEMPERATURE IMPACT)

- TRANSISTOR IS A CURRENT AMPLIFIER.
- TO PRODUCE BASE TO EMITTER CURRENT, A VOLTAGE EQUAL TO BARRIER POTENTIAL OF PN JUNCTION (0.6 V FOR SILICON, 0.2 V FOR GERMANIUM) IS REQUIRED.



0.6 V FOR (SI)
0.2V FOR (Ge)

$$I_C = \beta I_B$$

- CURRENT GAIN β IS AFFECTED BY TEMPERATURE

= 18 chairs
18 desks

CURRENT GAIN OF AMPLIFIER CAN EITHER REFER TO DC OPERATING CONDITION (OR) AC OPERATING CONDITION

DC CURRENT GAIN (β)

AC CURRENT GAIN (h_{fe})

EXAMPLE BC 547 TYPE

CURRENT GAIN RANGING FROM 110 TO 800

COLLECTOR CURRENT 2 mA

CURRENT VARIES WITH TEMPERATURE, INCREASES WITH TEMPERATURE.

MAXIMUM VALUE OF COLLECTOR CURRENT

I_{CMAX} IS THE HIGHEST VALUE OF COLLECTOR CURRENT A TRANSISTOR CAN PASS WITHOUT DAMAGE AND RANGES FROM 100mA FOR TYPICAL SMALL SIGNAL AMPLIFIER TO 20A (OR) MORE FOR LARGER TYPES.

VOLTAGE RATING

COLLECTOR - EMITTER VOLTAGE 5 → 7 V

CAN BE UP TO 40 → 100V (POWER AMPLIFIER)

COLLECTOR - EMITTER SATURATION VOLTAGE

0.2 → 0.7V

BASE TO EMITTER VOLTAGE

0.6 V FOR SILICON

0.2V FOR GERMANIUM

CASE OUTLINE & POWER RATING

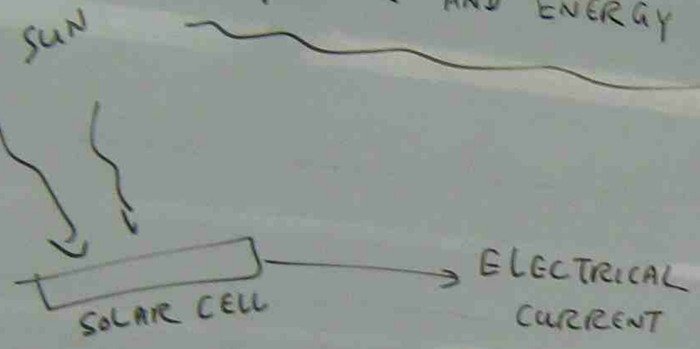
PACKAGE STYLE - TO 18, TO 92 STYLE

POWER RATING — 300 mW FOR SMALL SIGNAL TRANSISTOR TO SEVERAL HUNDRED WATTS FOR LARGER TYPE

POWER DISSIPATION ↕ TYPE OF CASE OUTLINE.

Cap = $8 chairs
$8 desks

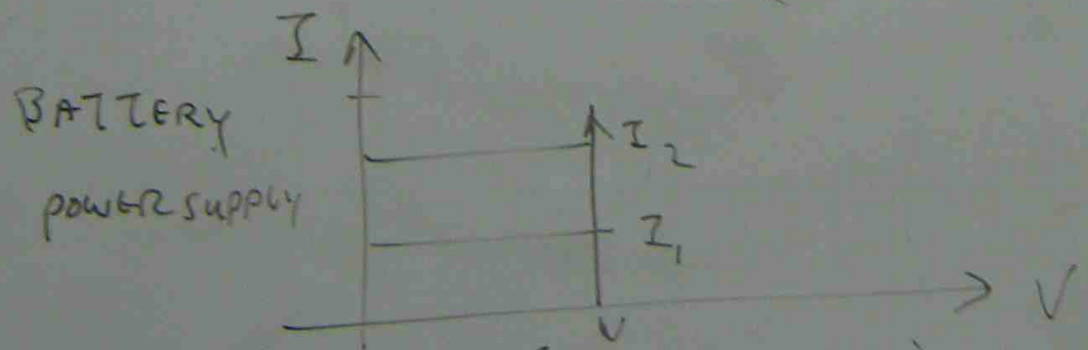
POWER AND ENERGY IN SOLAR CELL (RENEWABLE ENERGY)



SOLAR CELL CONVERTS SUN / THERMAL / LIGHT ENERGY TO ELECTRICAL ENERGY

CONSTANT VOLTAGE SOURCE (BATTERY, POWER SUPPLY)

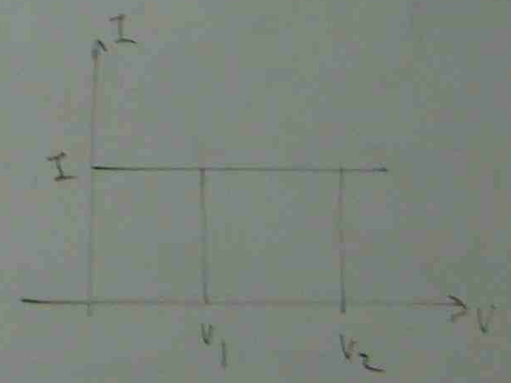
CONSTANT CURRENT SOURCE (CONSTANT CURRENT)



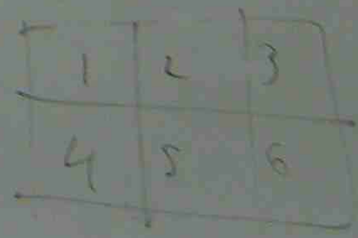
I V (CURRENT-VOLTAGE) CURVE FOR CONSTANT VOLTAGE SOURCE

SOLAR CELL

I V CURVE FOR CONSTANT CURRENT SOURCE

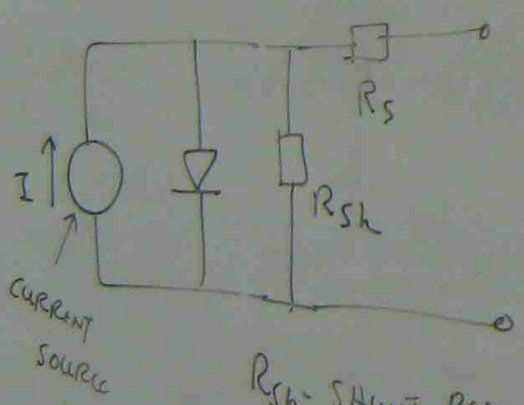


SOLAR CELL PRODUCES CONSTANT CURRENT



IT IS IMPORTANT NOT PUT SHADING ON SOLAR CELL AS THE REMAINING CELLS TRY TO PRODUCE THE SAME CURRENT AND THE CELL CAN BE OVER LOADED.

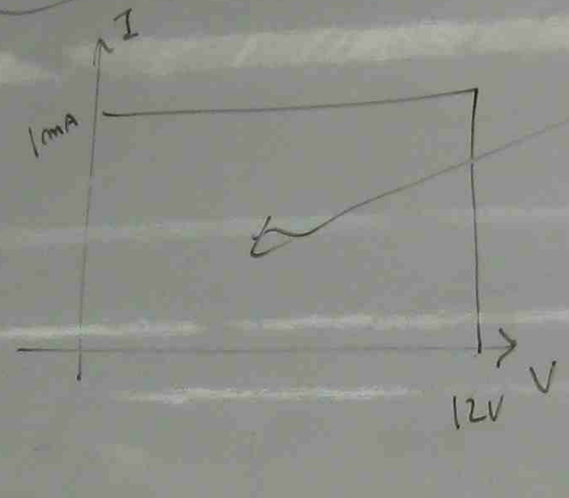
EQUIVALENT CIRCUIT OF P.V CELL

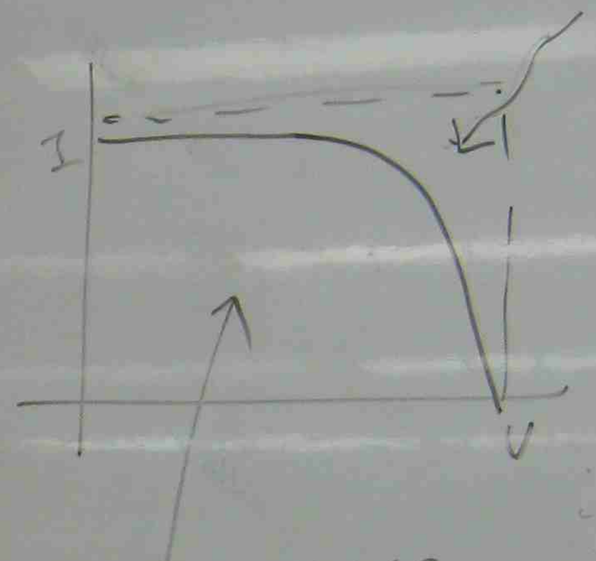


R_{sh} - SHUNT RESISTANCE (HIGH)

R_s - LOW RESISTANCE (LOW)

IDEAL CELL OUT PUT POWER. CURVE



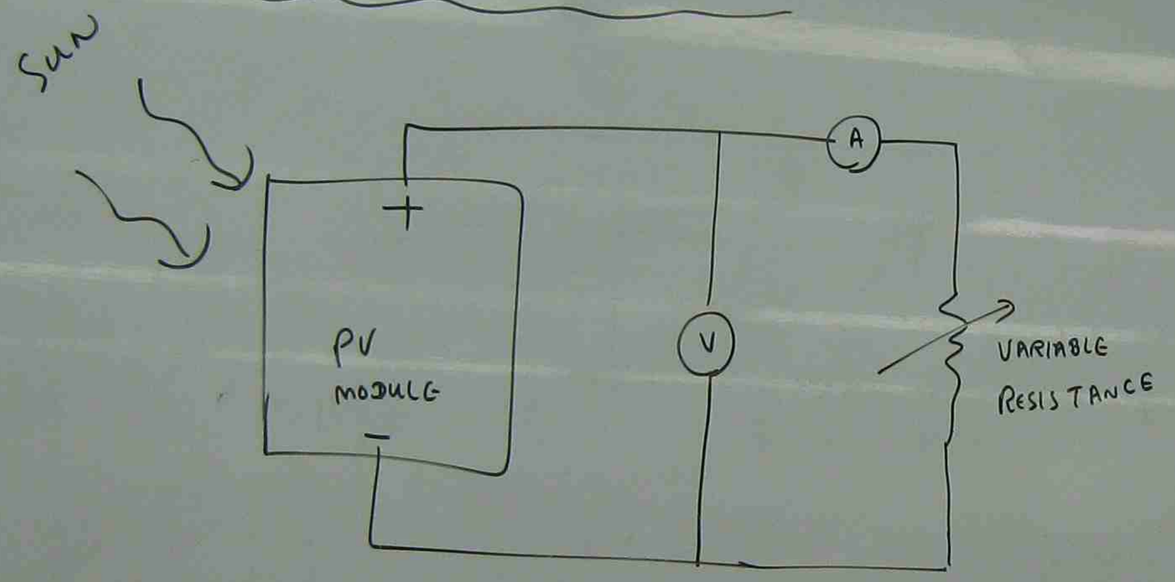


ACTUAL POWER DEVELOPED BY SOLAR CELL

ACTUAL POWER OUT PUT BY CELL = MAXIMUM POWER OUT PUT BY IDEAL CELL × FILL FACTOR

Cap = ~~18~~ chairs
~~18~~ desks

TESTING THE SOLAR CELL



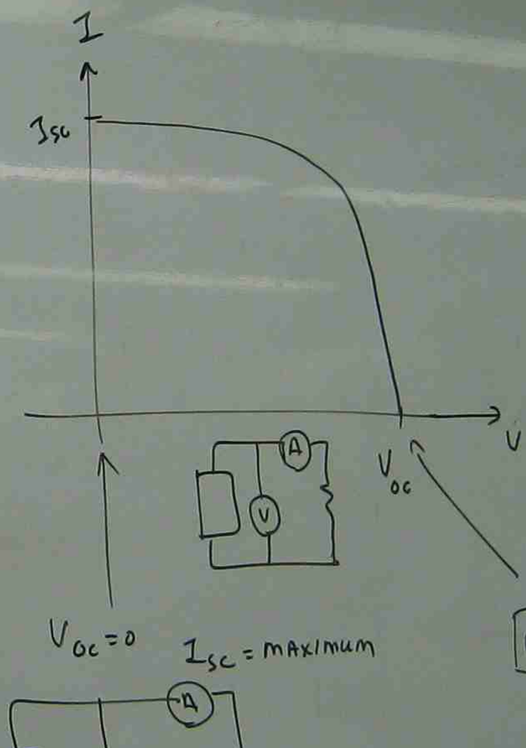
PV - PHOTO VOLTIC

(SOLAR) CELL)

CHANGE VARIABLE RESISTANCE

READ VOLTAGE & CURRENT VALUES.

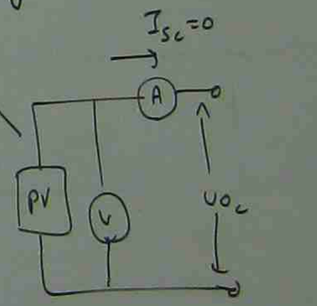
PLOT THE GRAPH



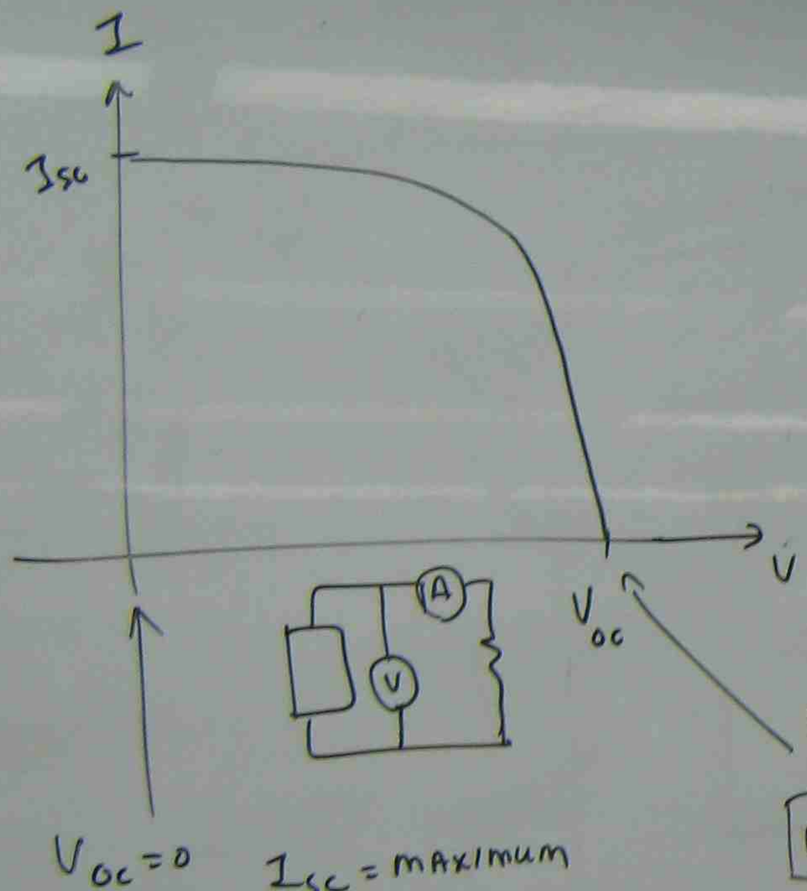
V_{OC} - OPEN CIRCUIT VOLTAGE

I_{SC} = SHORT CIRCUIT CURRENT

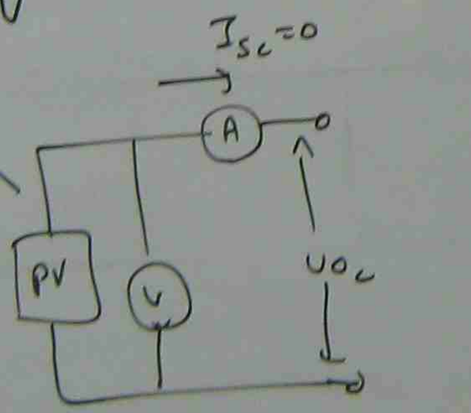
R_S PREVENTS THE ACCIDENTIAL SHORT CIRCUIT CURRENT



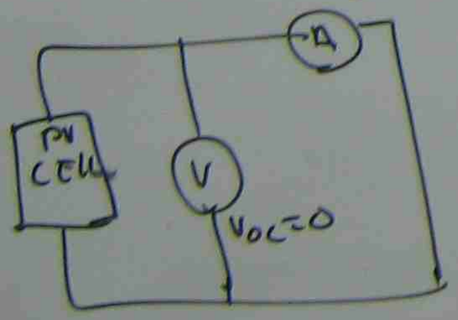
OPEN CURRENT



R_S PREVENTS THE ACCIDENTIAL SHORT CIRCUIT CURRENT



OPEN CURRENT

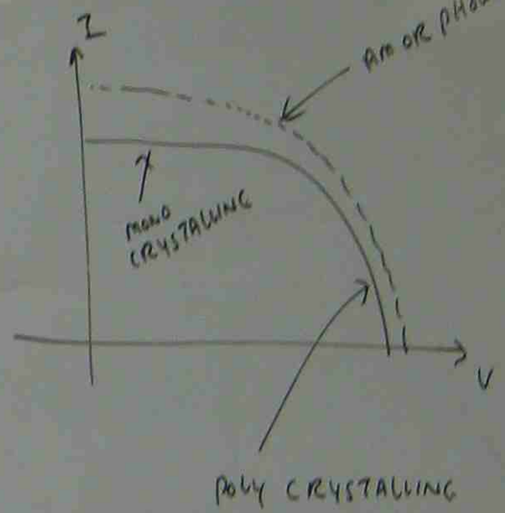


V_{OC} - OPEN CIRCUIT VOLTAGE

I_{SC} - CURRENT

CELL TECHNOLOGY AND I V CURVE

- MONO CRYSTALLING SOLAR CELL
- POLY CRYSTALLING SOLAR CELL
- AMORPHOUS SOLAR CELL



8. EXPLAIN THE SU
AND THE FACTO

nology and I V curve

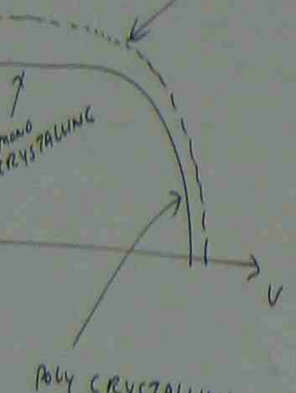
ystalling solar cell

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solar cell

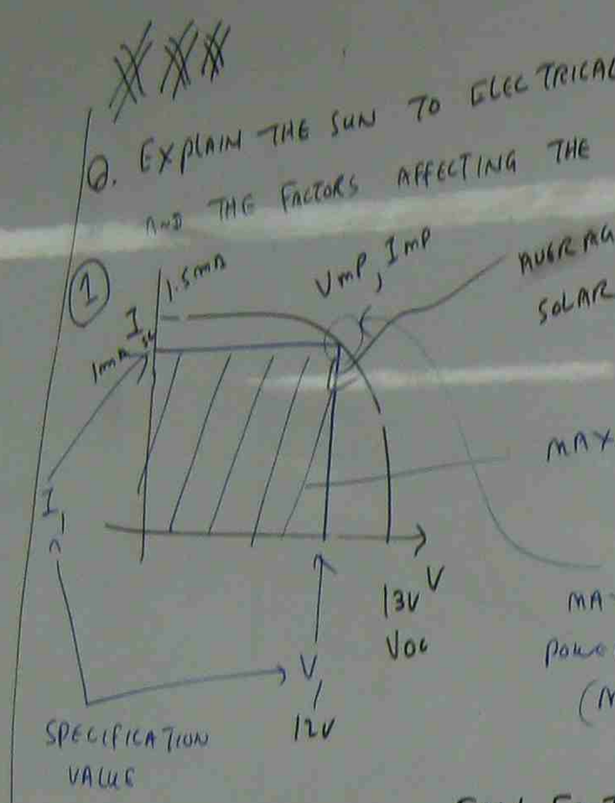
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Q. EXPLAIN THE SUN TO ELECTRICAL POWER AND ENERGY CONVERSION EFFICIENCY OF SOLAR CELL AND THE FACTORS AFFECTING THE ELECTRICAL ENERGY PRODUCTION.



CELL V = 12V

I = 1mA

$$\text{FILL FACTOR (FF)} = \frac{V_{mp} \times I_{mp}}{V_{oc} \times I_{sc}}$$

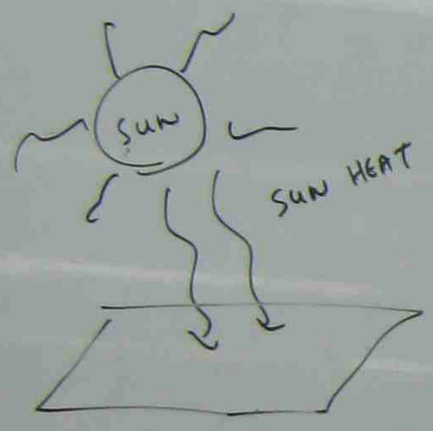
THE CELL VOLTAGE AND CURRENT AT MAXIMUM POWER POINT PRODUCES THE MAXIMUM AUAILABLE POWER.

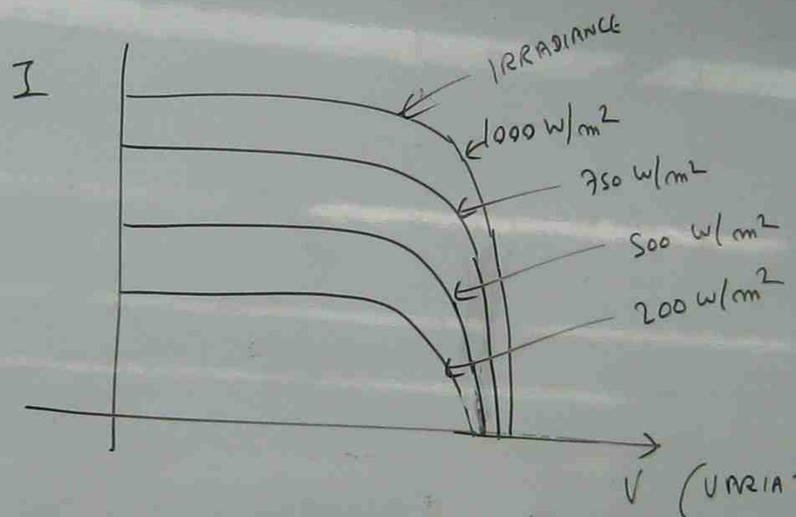
FILL FACTOR IS UTILIZED TO CONUERT OPEN CIRCUIT CELL VOLTAGE X SHORT CIRCUIT CELL CURRENT IN TO MAXIMUM POWER OF CELL

AS THE SUN POSITION, SUN LIGHT IS VARYING, IT AFFECTS THE POWER OUT PUT BY CELL

= 18 chairs
18 desks

(2) VARIATION of POWER WITH IRRADIANCE





(VARIATION of SOLAR MODULE OUT PUT WITH IRRIDIANCE)

$$\frac{\text{SUN HEAT POWER (WATT)}}{\text{SURFACE AREA}} = \text{DENSITY of SUN HEAT POWER} = \text{IRRADIANCE}$$

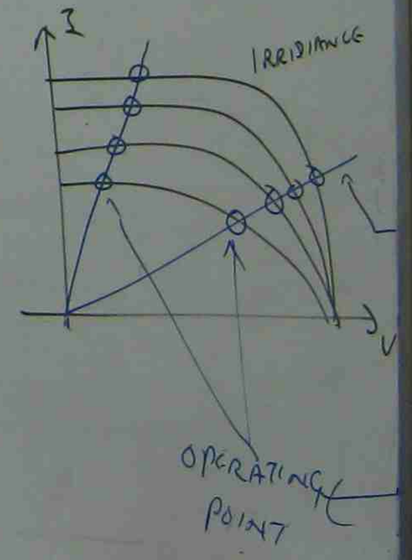
DEPENDS ON SUN POSITION
WEATHER CONDITION

AS THE SUN POSITION IS CHANGING, AND WEATHER CONDITION AFFECTS THE SUN HEAT DENSITY, THE SOLAR CELL MODULE POWER OUT PUT IS VARIATION.

THE I.V CURVE THAT SHOWS THE VARIATION OF SOLAR MODULE OUT PUT WITH IRRIDIANCE IS PLOTTED FOR A MODULE.

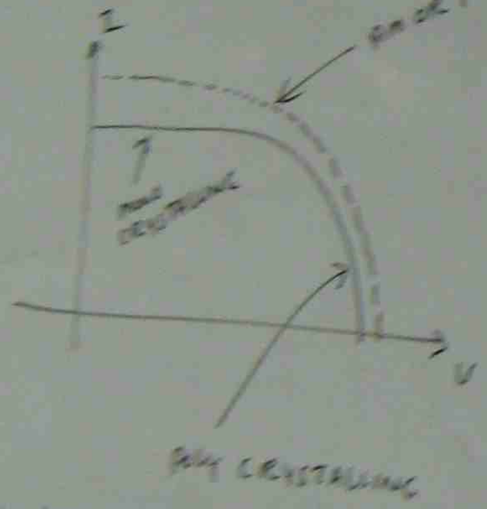
THE CURVE IS USEFUL TO DETERMINE THE POWER OUT PUT AT PARTICULAR SUN AND WEATHER CONDITION

BY USING THE IRRIDIANCE CURVE, THE MODULE OPERATING POINT IS TO BE CHOSEN.



CELL TECHNOLOGY AND I V CURVE

- [illegible] CRYSTALLINE SOLAR CELL
- POLY CRYSTALLINE SOLAR CELL
- AMORPHOUS SOLAR CELL

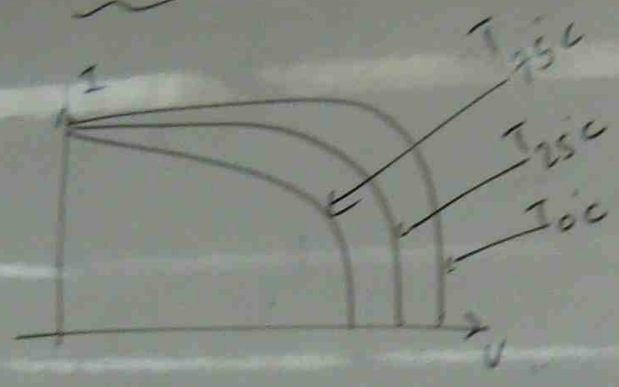


POLY CRYSTALLINE

MODULE LOAD LINE → DEPENDS ON LOAD RESISTANCE

TO SELECT APPROPRIATE APPLIANCES FOR SOLAR CELL

(3) TEMPERATURE EFFECT



INCREASING THE TEMPERATURE OF A P.V CELL REDUCES LESS PROTON REQUIRED TO MAKE ELECTRON HOLE PAIR (BAND GAP ENERGY)

Cap = ~~18~~ chairs
~~18~~ desks

MAXIMUM POWER POINT TRACKING

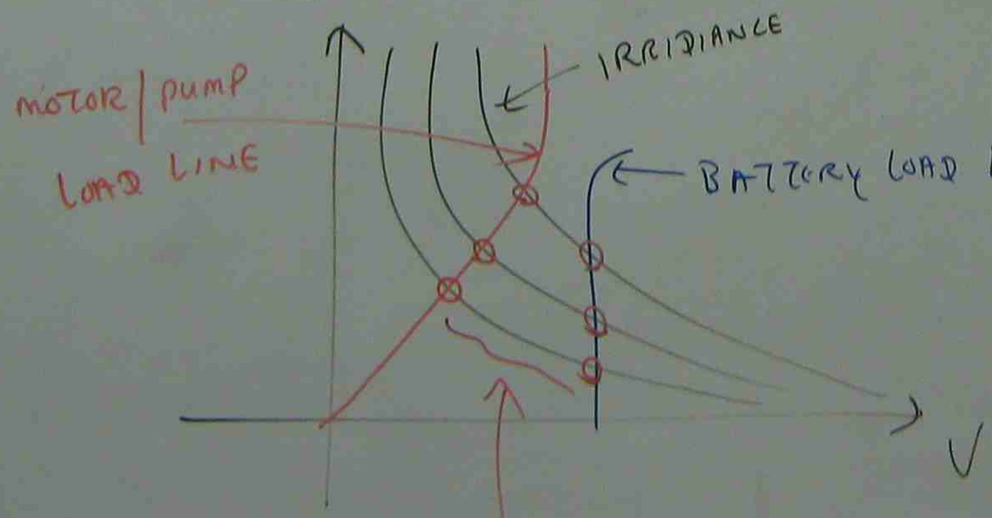
USE SOLAR MODULE WITH PUMP

SOLAR MODULE → OUTPUT POWER IS AFFECTED BY IRRIDIANCE

→ BATTERY

+

LOAD CHARACTERISTICS LINE of PUMP/MOTOR



NORMAL OPERATING CELL TEMPERATURE (NOCT)

THE STANDARD CONDITIONS FOR NOCT ARE

IRRADIANCE	800 W/m²
AMBIENT TEMPERATURE	20°C
WIND SPEED	1 m/s
LOAD	NIL (OPEN CIRCUIT)

MODULE OPERATING TEMPERATURE

$$T_{cell} = T_A + K \times G$$

T_{cell} = CELL TEMPERATURE

T_A = AMBIENT AIR TEMPERATURE (°C)

K = CELL TEMPERATURE COEFFICIENT ($°C / W m^2$)

G = IRRADIANCE (W/m^2)

$$K = \frac{NOCT - 20}{800}$$

NOCT = NORMAL OPERATING CELL TEMPERATURE

$$T_{cell} = T_A + \left(\frac{NOCT - 20}{800} \times G\right)$$

pb

(a) WHAT IS CELL TEMPERATURE COEFFICIENT (NOCT = 49°C),

(b) WHAT WILL BE IT'S CELL TEMPERATURE IF AMBIENT TEMPERATURE IS 35°C AND THE IRRADIANCE IS 65 W/m^2

(a) $K = \frac{NOCT - 20}{800} = \frac{49 - 20}{800} = 0.036\ °C / W-m^2$

(b) $T_A = 35°C$, $T_{cell} = ?$

$$T_{cell} = T_A + \frac{NOCT - 20}{800} \times G = 35 + \frac{49 - 20}{800} \times 65 = 37.35°C$$

8 chairs
8 desks

SOLAR CELL EQUATIONS

P_{mp} = MAXIMUM POWER (PEAK POWER)

I_{mp} = CURRENT AT MAXIMUM POWER

V_{mp} = VOLTAGE AT MAXIMUM POWER

I_{sc} = SHORT CIRCUIT CURRENT

V_{oc} - OPEN CIRCUIT VOLTAGE

α = TEMPERATURE COEFFICIENT of SHORT CIRCUIT CURRENT

β = TEMPERATURE COEFFICIENT OF OPEN CIRCUIT VOLTAGE

γ = TEMPERATURE COEFFICIENT OF POWER

I_{SCT} = SHORT CIRCUIT CURRENT AT TEMPERATURE T

I_{sc-STC} = SHORT CIRCUIT CURRENT AT STC (MODULE TESTING)

V_{OCT} - OPEN CIRCUIT VOLTAGE

$V_{OC\ STC}$ - OPEN VOLTAGE AT MODULE TESTING (STC)

$P_{mp\ T}$ = MAXIMUM POWER AT TEMPERATURE (T)

$P_{mp\ STC}$ = MAXIMUM POWER AT MODULE TESTING (STC)

T_{STC} = CELL TEMPERATURE AT MODULE TESTING (STANDARD TEST)

T_{cell} = CELL TEMPERATURE.

$$I_{scT} = I_{sc-STC}\left(1+\alpha\left(T_{cell}-T_{STC}\right)\right)$$

$$V_{ocT} = V_{oc-STC}\left(1-\beta\left(T_{cell}-T_{STC}\right)\right)$$

$$P_{MOT} = P_{MPSTC}\left(1-\gamma\left(T_{cell}-T_{STC}\right)\right)$$

THE GIVEN FORMULAS ARE TO BE UTILIZED TO DETERMINE THE MODULE ACTUAL WORKING CONDITION.

AS SOLAR CELLS ARE SUBJECT TO VARYING SUN POSITION, SUN LIGHT AND WEATHER CONDITIONS, THEIR WORKING VOLTAGE, CURRENT AND TEMPERATURE WILL BE DIFFERENT FROM FACTORY'S TEST SPECIFICATIONS.

$$I_{sc\,T} = I_{sc\text{-}STC}\left(1+\alpha\left(T_{cell}-T_{STC}\right)\right)$$

$$V_{oc\,T} = V_{oc\text{-}STC}\left(1-\beta\left(T_{cell}-T_{STC}\right)\right)$$

$$P_{mp\,T} = P_{mp\text{-}STC}\left(1-\gamma\left(T_{cell}-T_{STC}\right)\right)$$

THE GIVEN FORMULAE ARE TO BE UTILIZED TO DETERMINE THE MODULE ACTUAL WORKING CONDITION.

AS SOLAR CELLS ARE SUBJECT TO VARYING SUN POSITION, SUN LIGHT AND WEATHER CONDITION, THEIR WORKING VOLTAGE, CURRENT AND TEMPERATURE WILL BE DIFFERENT FROM FACTORY'S TEST SPECIFICATION.

$$I_{SCT} = I_{SC-STC}\left(1 + \alpha(T_{cell} - T_{STC})\right)$$

$$V_{OCT} = V_{OC-STC}\left(1 - \beta(T_{cell} - T_{STC})\right)$$

$$P_{MPT} = P_{MP-STC}\left(1 - \gamma(T_{cell} - T_{STC})\right)$$

α = TEMPERATURE COEFFICIENT of CURRENT

β = TEMPERATURE COEFFICIENT OF VOLTAGE

γ = TEMPERATURE COEFFICIENT OF POWER

η = POWER CONVERSION EFFICIENCY OF SOLAR CELL

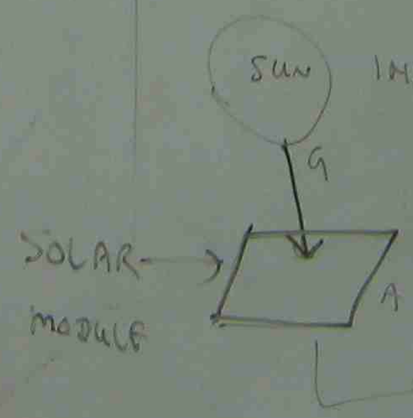
P_{PV} = TOTAL POWER IN SUN LIGHT INCIDENT ON THE MODULE SURFACE AREA

$= G \times A$

WHERE G - IRRADIANCE $\left(W/m^2\right)$

A - SURFACE AREA $\left(m^2\right)$

V_{mp} - MAXIMUM VOLTAGE, I_{mp} - MAXIMUM CURRENT



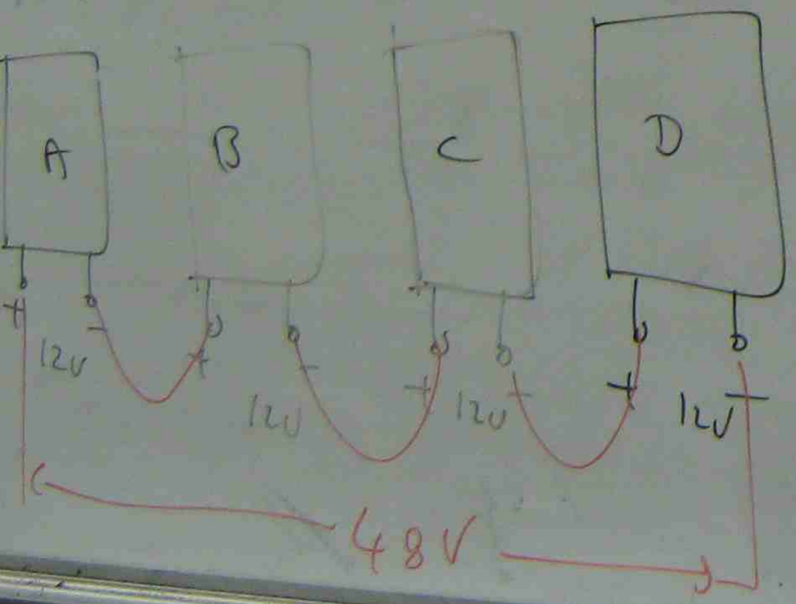
INPUT = $P_{PV} = G \times A$

SUN POWER CONVERSION EFFICIENCY $= \dfrac{V_{mp} \times I_{mp}}{G \times A}$

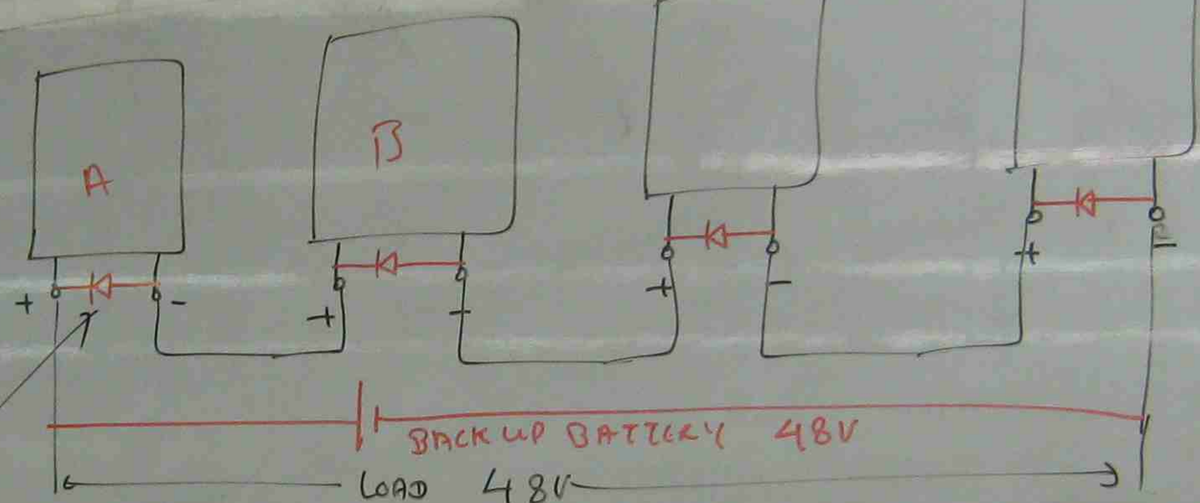
POWER VERSION = $\frac{FF \times V_{oc} \times I_{sc}}{G \times A}$

FF - FILL FACTOR

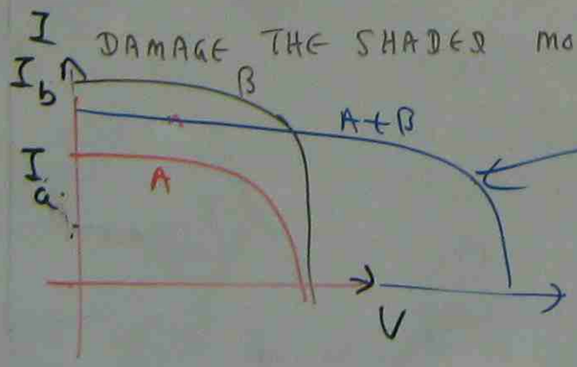
EXPLAIN HOW SOLAR MODULES ARE INTERCONNECTED AND HOW THE MODULE PERFORMANCE IS PREDICTED.



APPLICATION OF BY PASS DIODE



SHUNT OF BY PASS DIODE IS PROVIDED TO PREVENT THE CURRENT FLOW IN TO A PARTICULAR MODULE WHICH IS SHADED. (THAT CURRENT CAN DAMAGE THE SHADED MODULE)

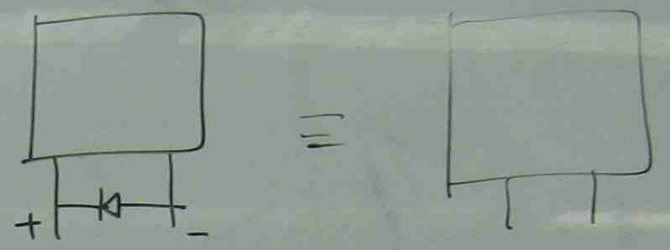


A+B CHARACTERISTICS CURVE

AVERAGE OPERATING CURRENT = $\frac{I_a + I_b}{2}$

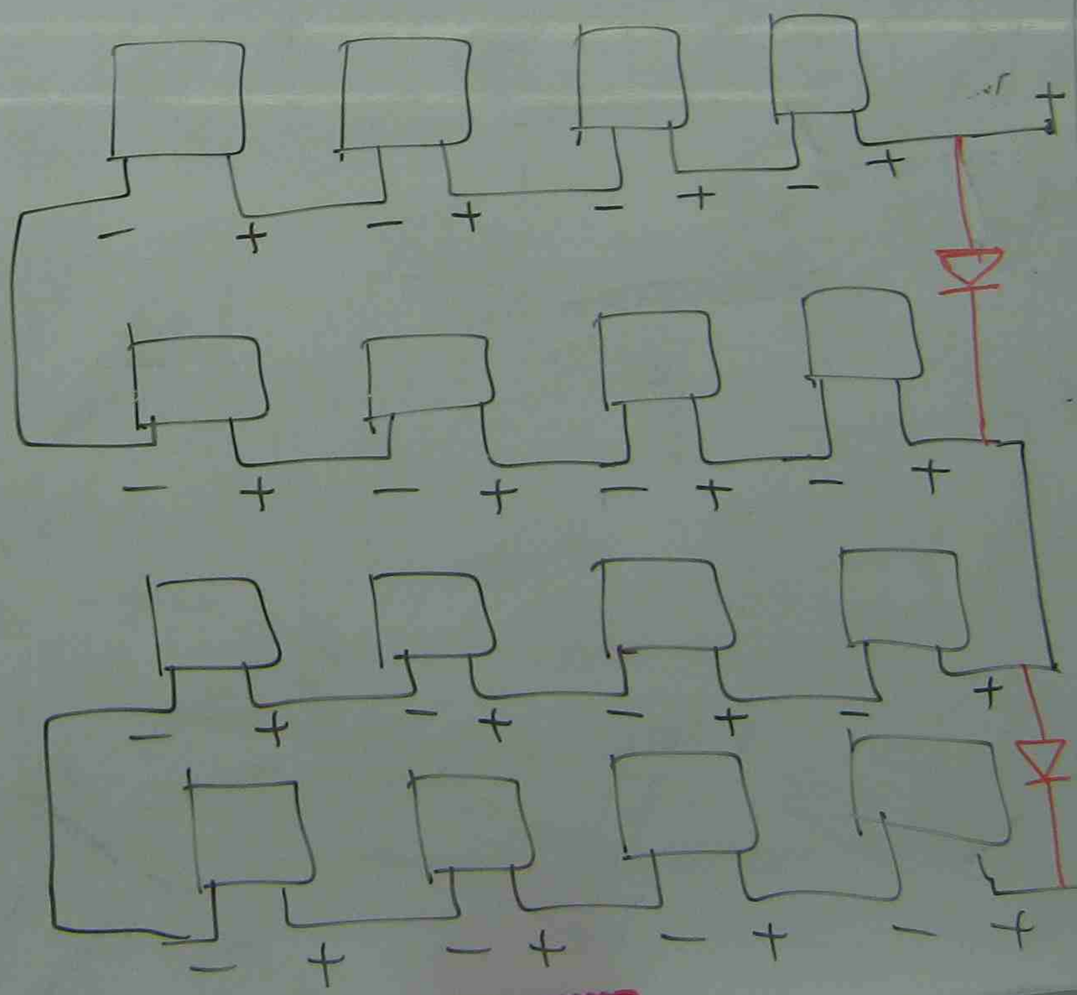
η_{pv} = 18 chains
18 desks

CONNECTION of SOLAR PANEL



≡

SOLAR CELL WITH
INTERNAL DIODE



POWER CO

P_{PV} = TOT

=

WHERE

V_{mp} -

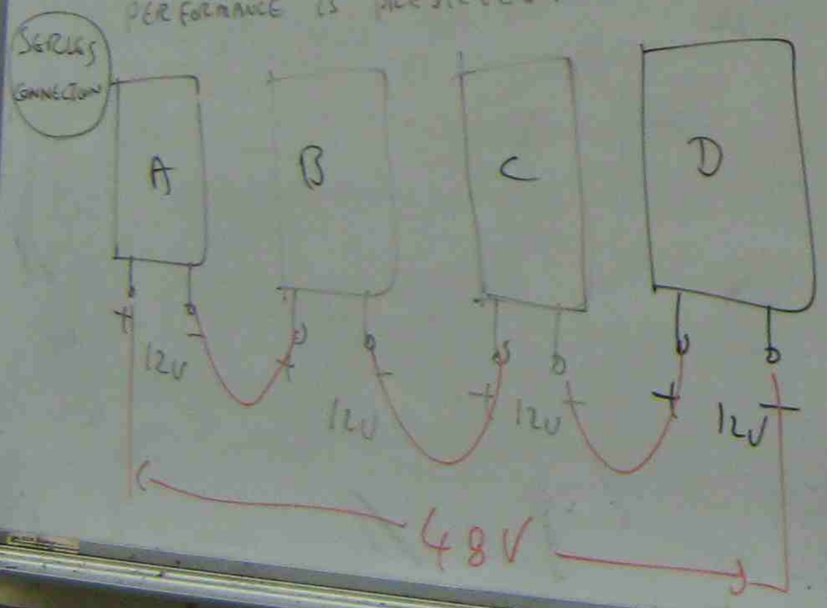


SUN PANEL CONVERSION = $\frac{FF \times V_{oc} \times I_{sc}}{G \times A}$

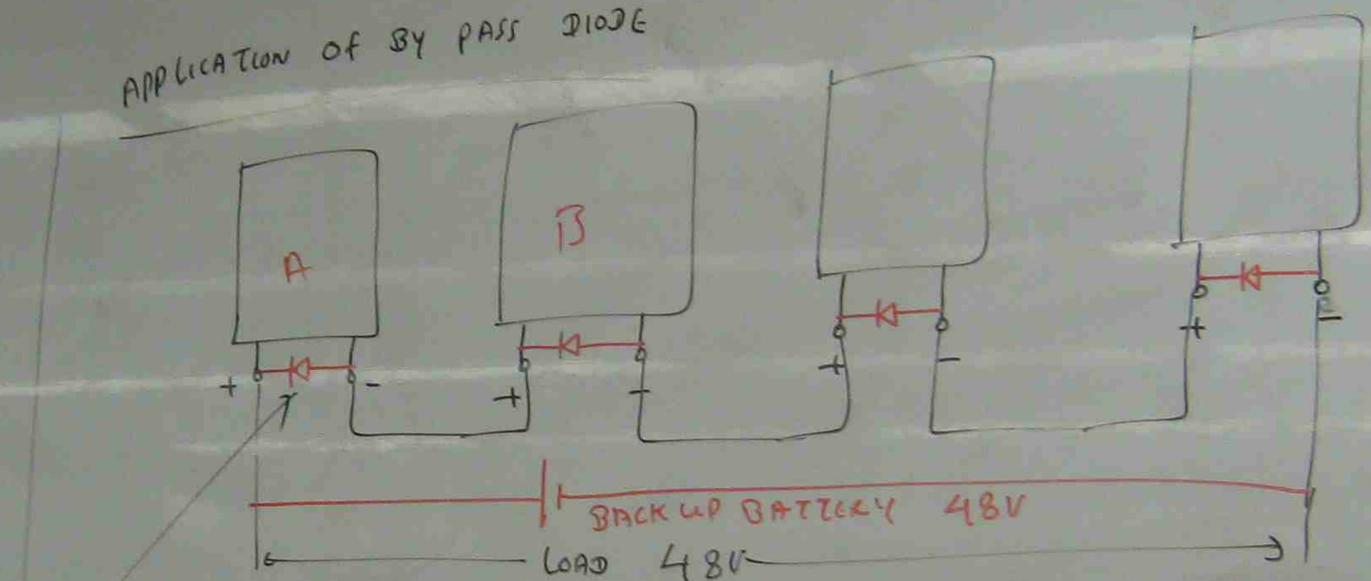
FF - FILL FACTOR

**

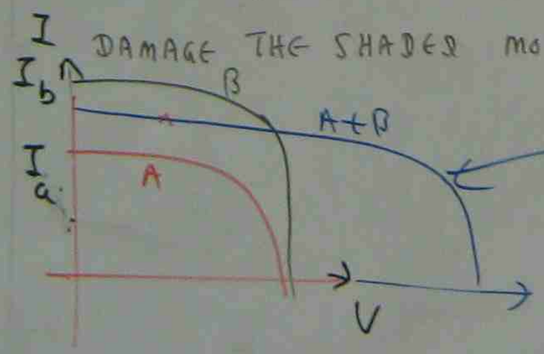
Q/ EXPLAIN HOW SOLAR MODULES ARE INTERCONNECTED AND HOW THE MODULE PERFORMANCE IS PREDICTED.



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A+B CHARACTERISTICS CURVE

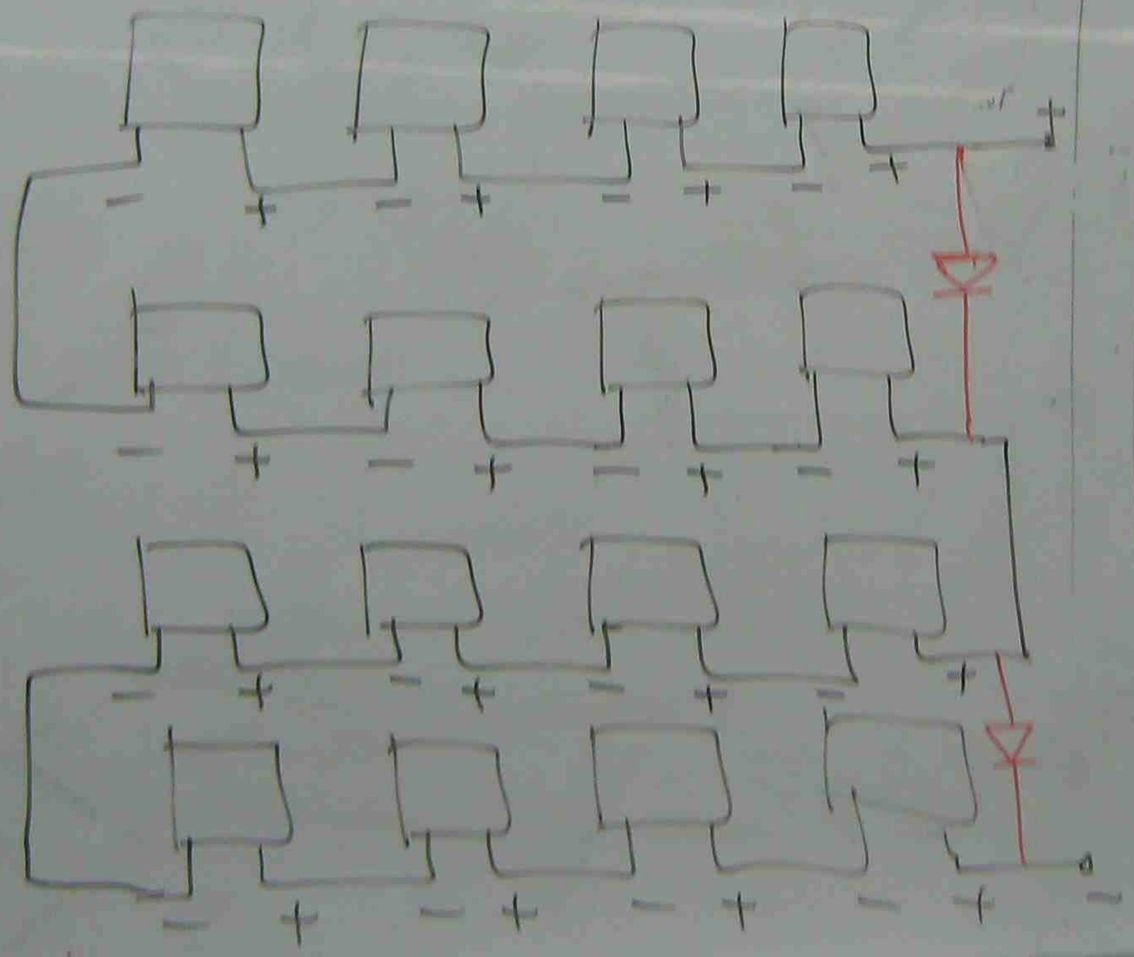
AVERAGE OPERATING CURRENT = $\frac{I_a + I_b}{2}$

ap = 18 chairs
18 desks

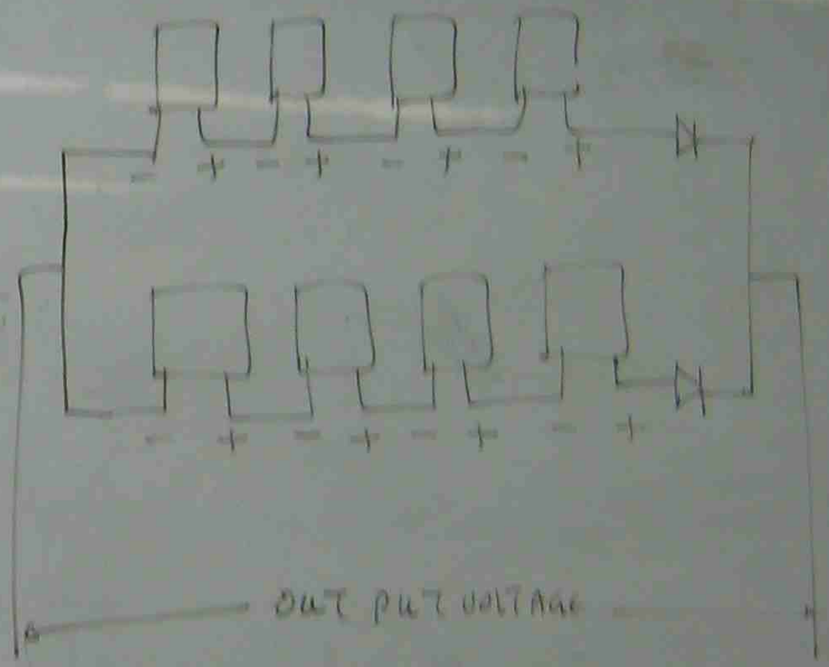
CONNECTION of SOLAR PANEL



= SOLAR CELL WITH INTERNAL DIODE



PARALLEL CONNECTION



OUTPUT VOLTAGE