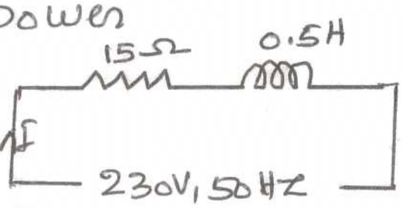
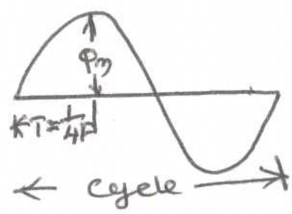
SCHEME OF VALUATION
(SCORING INDICATORS)

TED (15) - 3043

ELECTRICAL TECHNOLOGY

Qust No	Scoring Indicators	Split up Score	Sub Total	Total
	PART-A			
I 1.	It is the ratio of the rms value to average value. Form factor (K_F) $= \frac{\text{rms Value}}{\text{average Value}} = \frac{0.707 V_{max}}{0.637 V_{max}} = 1.11$	2	2	
2	(a) Copper loss (b) Core loss	1+1	2	10
3	(a) Demagnetises (b) Cross-magnetises	1+1	2	
4	3-Point starter	2	2	
5	The difference between the synchronous speed N_s and actual speed N of the rotor is known as slip	2	2	
	PART-B			
II 1	(a) Inductive reactance (X_L) — Total opposition offered by an inductance is called inductive reactance, $X_L = 2\pi f L$ (b) Capacitive reactance (X_C) — Total opposition offered by an capacitance, $X_C = \frac{1}{2\pi f C}\ \Omega$ (c) It is the ratio of resistance to impedance OR True power to apparent power	2x3	6	
2	$L = 0.5H$, $R = 15\Omega$. Voltage $= 230V$, $F = 50Hz$.  $X_L = 2\pi f L = 2\times3.14\times50\times.5 = 157\Omega$ $Z = \sqrt{R^2+X_L^2} = \sqrt{(15)^2+(157)^2} = 157.73\Omega$ $I = V/Z = 230/157.73 = 1.458A$	2+2+2 =6	6	
3	Let N_1 = No. of Primary turns. N_2 = No. of Secondary turns. Φ_m = Max. flux in core in weber F = frequency in hertz.  As shown, flux increases from its zero value to max. value Φ_m in $\frac{1}{4}$ cycle, ie $\frac{1}{4F}$ second Average rate of change of flux $= \frac{\Phi_m}{1/4F} = 4\Phi_m F$ wb/s			

rate of change of flux/turns = induced emf in volts
∴ Average emf/turn = $4\phi_m f$ Volt
rms Value of emf/turn = form factor × average Value
$= 1.11 \times 4\phi_m f = 4.44\phi_m f$ V

Emf induced in whole primary winding $E_1 = 4.44\phi_m f N_1$ | 6 | 6

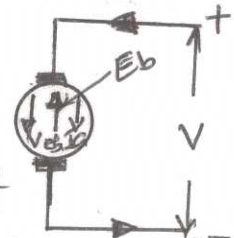
Emf induced in whole secondary winding $E_2 = 4.44\phi_m f N_2$ V

4. Advantages:- (1) Smaller Size (2) Higher efficiency (3) low cost (4) voltage regulation is also superior

Uses:- (1) To give small boost to a distribution cable to correct the voltage drop (2) Auto-transformer starter to give upto 50 to 60% of full voltage to an induction motor during starting (3) interconnecting transformers in 132kV/330kV system (4) Control equipment for single phase and 3φ electrical locomotives | 3+3 | 6

5. 1. Magnetic frame or yoke (2) pole core and pole shoes (3) Pole coils or field coils (4) Armature core (5) Armature windings (6) Commutator (7) Brushes and bearings | 1×6 | 6

6. When the motor armature rotates, the conductor also rotates and hence cut the flux. In accordance with the laws of electromagnetic induction, the emf is induced in them, whose direction is found by Fleming's right hand rule, is in opposition to the applied voltage. This opposing emf is called counter emf or back emf | fig-2, exp-4 | 6



$E_b = \phi Z \frac{N}{60} \times P/A$. The magnitude of back emf is dependent upon the speed. If speed is zero, the back emf is also zero, as the speed increases the magnitude of back emf also increases. The net voltage across the armature would be the difference between the applied voltage and back emf.

net voltage $= V - E_b$.

$I_a R_a = V - E_b$ ∴ $I_a = \frac{V - E_b}{R_a}$

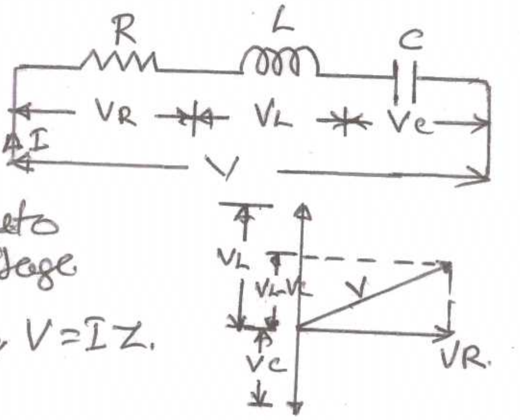
$V = E_b + I_a R_a$ ∴ $E_b = V - I_a R_a$.

I_a = Armature current, R_a = Armature resistance

7\. 1. The output current can be led directly from a fixed terminals on the stator to the load.
2. It is easier to insulate stationary armature winding for a high a.c. voltage
3. Only two slip rings are required for d.c. supply to the field winding on the stator 1.5x4 6
4. The armature winding can be more easily braced to prevent any deformation

PART-C

III (a) The circuit diagram connecting R, L, C circuit. The current due to inductive reactance lags the voltage whereas the current due to capacitive reactance leads the voltage.



ckt-2
Vect-2
Deri 5
2+2+5 =9 9

$V_R = IR$, $V_L = IX_L$, $V_C = IX_C$, $V = IZ$.

$V^2 = V_R^2 + (V_L - V_C)^2$

$(IZ)^2 = (IR)^2 + (IX_L - IX_C)^2 = I\sqrt{R^2 + (X_L - X_C)^2}$

$ZI = I\sqrt{R^2 + (X_L - X_C)^2}$ ∴ Impedance, $Z = \sqrt{R^2 + (X_L - X_C)^2}$

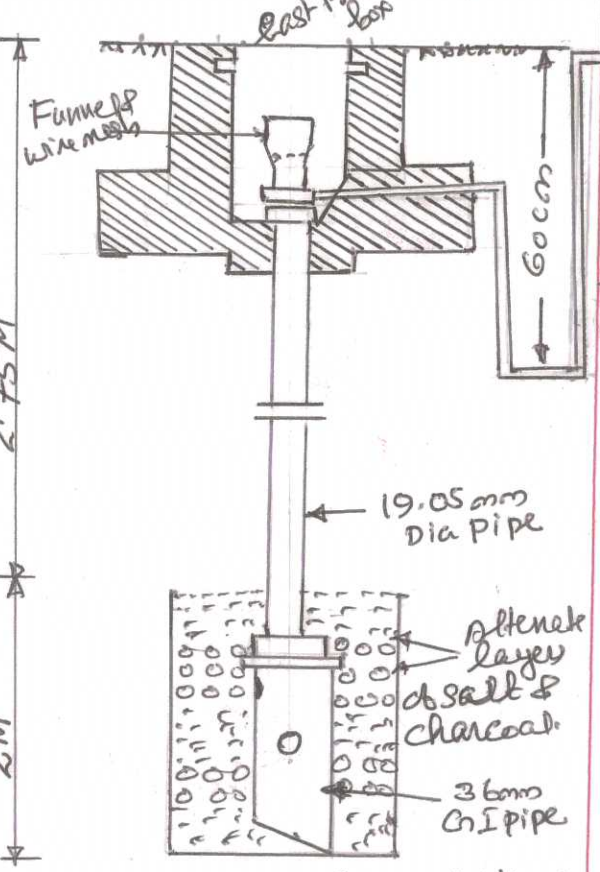
Power factor, $\cos\phi = \frac{R}{Z} = \frac{R}{\sqrt{R^2 + (X_L - X_C)^2}}$

∴ Power, $P = VI\cos\phi$ watts

(b) Electrical Earthing:- The process of transferring the immediate discharge of the electrical energy directly to the earth by the help of the low resistance wire is known as the electrical earthing. The earthing provides the simple path to the leakage current.

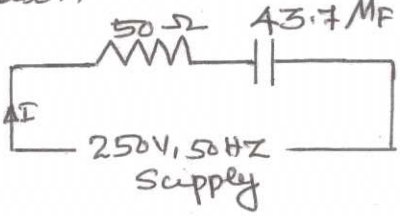
Earthing or grounding is done for safety of equipment and human being. The outer housing of an electrical equipment is earthed by directly connecting it to a earth electrode, thereby providing a low resistance path to ground. In case of a fault involving earth the live wire (part) of the equipment get connected with the low resistance earth path. This produces high earth fault current and the protective devices in the circuit disconnects the circuit from the power source thereby reducing further damage to the equipment. The alternate path for the current is created by keeping the potential of the conductive parts of equipment, lighting arrester, towers etc.... at ground potential or earth potential and is known as earthing 2+4 6

IV(a) Fig shows the pipe earthing where 36mm GI pipe is burried in a square pit of 40x40cm to about 4.75m deep should be placed. The depth should be depends moisture condition of the soil. The size of pipe depends upon (a) the current to be carried (b) the type of soil. The pit is filled with alternate layer of coke and salt. The GI pipe is drilled at an equal distance about 12mm hole. Concrete work is made on the top to protect the pipe from damage and funnel with a wire mesh is fitted for pouring water in summer season.



dig-5 cx-3 5+3 8

(b)



ckt-1 2+2+2 =7 7

Capacitive reactance, $X_C = \frac{1}{2\pi f C}$

$= \frac{10^6}{2\times3.14\times50\times43.7} = \underline{72.87\,\Omega}$

(1) Impedance, $Z = \sqrt{R^2+X_C^2} = \sqrt{50^2+72.87^2} = \underline{88.38\,\Omega}$

(2) Current, $I = V/Z = \frac{250}{88.38} = \underline{2.81\text{ A}}$

Power factor, $\cos\varphi = \frac{R}{Z} = \frac{50}{88.38} = 0.57$

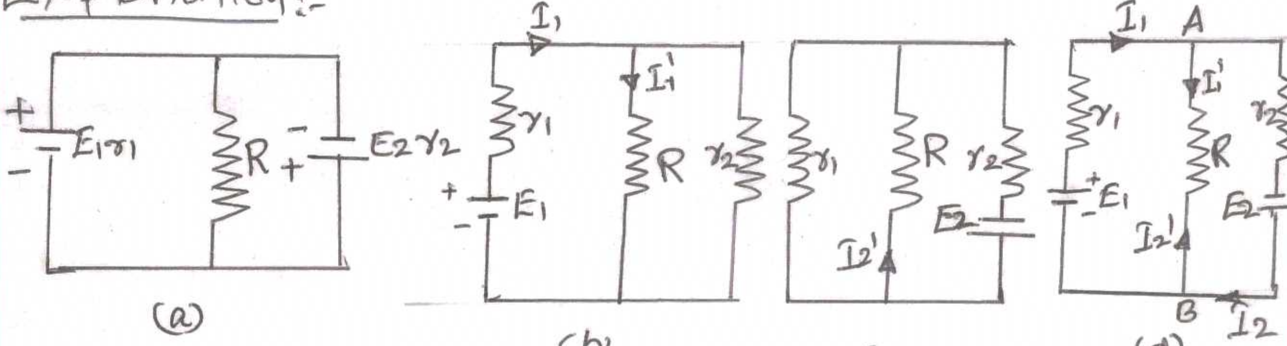
(3) Power $= VI\cos\varphi = 250\times2.81\times0.57 = \underline{400.425\text{ W}}$

UNIT-II

V (a) It state that, "In any linear bilateral resistive network having two or more voltage sources the current through any branch (resistance or source) is the algebraic sum of the currents produced by each source acting alone at a time, when all other sources are replaced by their internal resistances"

If the voltage source has no internal resistance, the terminal to which it is connected are to be joined together. If there are current sources present they are removed and the network terminals to which they are connected are left open.

Explanation:-



(a) (b) (c) (d)

CKT-3 step 5 3+5 8

Consider a network shown fig (a) to determine the current through R using superposition theorem.

Step-I:- Replace battery E_2 by its internal resistance r_2 shown in fig (b). R and r_2 are in parallel

Total resistance $R_1 = r_1 + \frac{R \times r_2}{R + r_2}$

Total current due to $E_1 = I_1 = E_1 / R_1$

Current through $R = I_1' = I_1 \times \frac{r_2}{R + r_2}$

Step-2:- Replace battery E_1 as shown in fig (c). The R and r_1 are in parallel,

Total resistance, $R_2 = r_2 + \frac{R \times r_1}{R + r_1}$

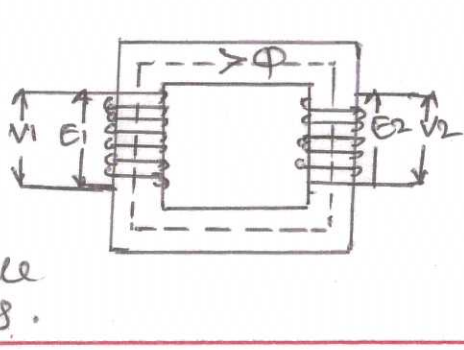
Total current due to $E_2' = I_2 = E_2 / R_2$

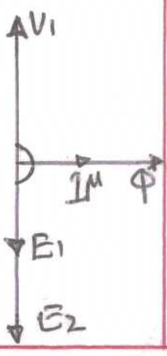
Current through R due to $E_2 = I_2' = I_2 \times \frac{r_1}{R + r_1}$

Step-3:- Now introduce two batteries along with their currents and superpose both the currents I_1' and I_2' as shown in fig (d)

$\therefore$ Current through $R = I_1' + (-I_2') = I_1' - I_2'$

(b) An ideal transformer is one which has no losses i.e, its winding have no ohmic resistance, there is no magnetic leakage and hence no copper loss and iron loss.





Consider an ideal transformer fig(a) whose secondary is open, primary is connected to alternating voltage V_1 and current flows through the primary I_M (Secondary open) only. This current magnetise the iron core, it is small in magnetude and lags V_1 by $90°$. The I_M produces an alternating flux ϕ is proportional to the current and is in phase with it. This change in flux linked both primary and secondary windings. Therefore it produces self-inducted emf in the primary. E_1 at every instant, equal to an opposition to V_1. Similarly emf induced in the secondary winding E_2 is known as mutually induced emf. This emf is antiphase with V_1 and its magnetude is proportional to the rate of change of flux and number of secondary turns. as shown in vector diagram fig(b).

fig 2, vector 2, exp. 3 | 2+2+3 = 7

VI (a) power rating = 50 KVA, $E_1 = 3300V$, $N_1 = 834$, $N_2 = 58$

(i) Transformation ratio $(K) = \frac{N_2}{N_1} = \frac{58}{834} = 0.0696$ | 2+2, 2+2 = 8 | 8

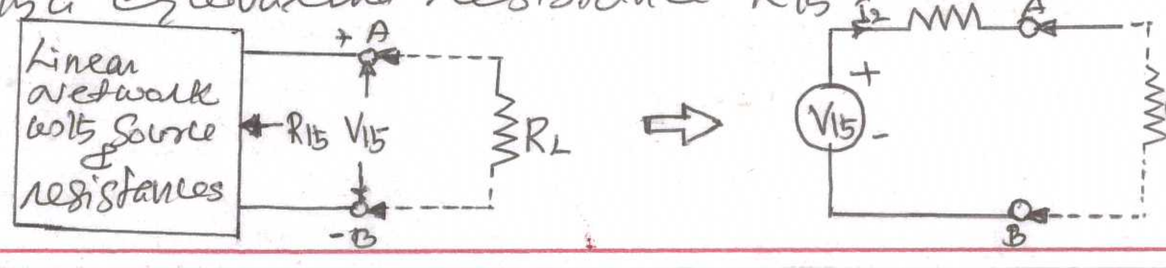
(ii) Secondary voltage, $E_2 = E_1 \times K = 330 \times 0.0696$
$= 229.5 V$

(iii) Primary current, $I_1 = \frac{50,000}{3,300} = 15.2 A$

(iv) Secondary current, $I_2 = \frac{50,000}{229.5} = 217.86 A$

(b) Thevenin's theorem is a method used to change a complex network into a simple equivalent network, especially in determining through a specified branch of a network.

It states that, any linear network consisting of voltage sources and resistances, if viewed from any two terminals in the network can be replaced by an equivalent voltage sources V_{th} in series with a equivalent resistance R_{th}



V_{th} = Thevenin's voltage that would appear across the terminals AB, it is also known as open-circuit voltage

R_{th} = Thevenin's resistance across the terminals AB with voltage sources short-circuited | Ckt 3 Exp-4

R_L = load resistance. | 7

If current I_L through load resistance R_L connected across A and B of a linear network shown in fig (a) is to be found, then,

Step-1: Find R_{th} removing R_L viewed from A & B terminals

Step-2: Find V_{th} across A & B by removing R_L again

Step-3: Now current I_L through R_L is fig (b)

$$\therefore I_L = \frac{V_{th}}{(R_{th}+R_L)}$$

VII (a) Electrical generator is a machine which converts mechanical energy into electrical energy. The energy conversion is based on the principle of the production of dynamically induced e.m.f. Whenever a conductor cuts magnetic flux, dynamically induced emf is produced in it according to Faraday's laws of electromagnetic induction, the magnitude of the induced emf is proportional to the rate of change of flux linkages.

Mathematically the law can be expressed as, | 8 | 8

N = No. of turns of the coil; φ_1 = initial flux in wb

φ_2 = final flux in wb; t = time in seconds during which the flux changes from φ_1 to φ_2 wb.

Flux linkage is the product of flux and No. of turns

Initial flux linkage = $N\varphi_1$

Final flux linkage = $N\varphi_2$

Change in flux linkage = $N(\varphi_2-\varphi_1)$

$\therefore$ emf induced in the coil is proportional the rate of change of flux linkages, i.e., $\propto N\frac{(\varphi_2-\varphi_2)}{t}$

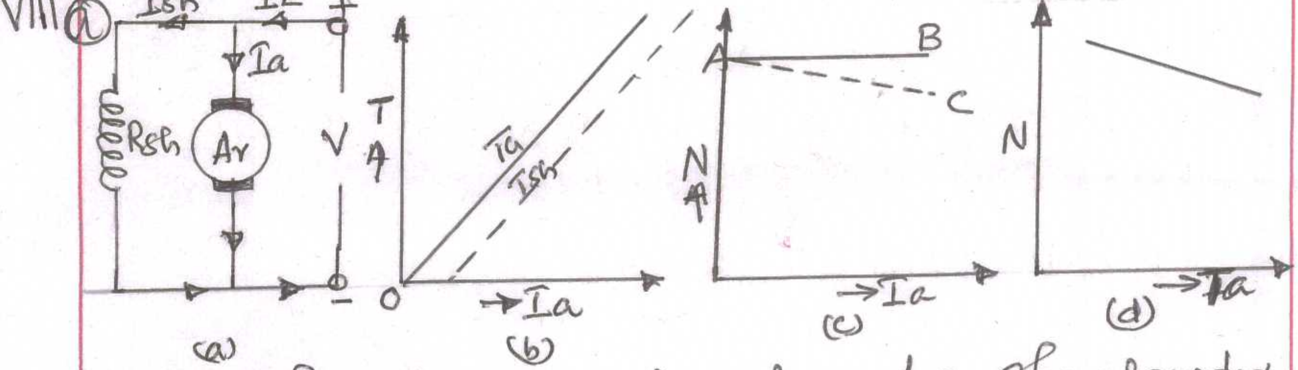
$= $ rate of change of flux linkage

$$= -N\frac{d\phi}{dt}$$

$$\therefore e = \frac{N(\phi_2 - \phi_1)}{t}$$

(b) At starting, when the motor is stationary there is no back emf in the armature. Consequently, if the motor is directly switched on the mains, the armature will draw heavy current ($I_a = \frac{V-E_b}{R_a} = \frac{V-0}{R_a} = V/R_a$) because of smaller armature resistances. For example, 5HP, 220V shunt motor has a full load current of 20A and Ra about 0.5Ω of the motor is directly switched on the supply $I_a = \frac{220}{0.5} = 440A$ which is 20 times the full load current. The high starting current may results:
① burning of armature due to excessive heating effect 7 7
② Damage the commutator and brushes due to heavy sparking ③ Excessive voltage drop in the line.
To avoid the starting of high current, a variable resistance is added in series with the armature circuit. The resistance is gradually reduced as the motor gains speed (back emf increased) and eventually it is cut out completely when the motor has attained full speed.

VIII ①



(a) (b) (c) (d)

Fig (a) shows the connection of a d.c shunt motor. The field Ish is constant since field winding is directly connected to the supply voltage V which assumed constant, the flux is approximately constant.

(1) Ta/Ia characteristics:- $T_a \propto \phi I_a$

Since motor operated from Constant Supply Voltage ϕ is Constant. ∴ $T_a \propto I_a$
Hence, T_a/I_a characteristics is a straight line passing through the origin as shown in fig (b)
The T_{sh} is less than T_a as shown by a dotted line It is clear that a very large current is required to start a heavy load. Therefore, shunt motor should not be started on heavy load

(ii) N/Ia characteristic:- The speed N is given by $N \propto \frac{E_b}{\phi}$, flux and back emf ($E_b$) in a shunt motor are almost constant, under normal conditions. Therefore, speed of a shunt motor will remains Constant as the armature current varies (line AB as shown fig. c). If load is increased $E_b = V - I_a R_a$ and ϕ decreases due to the armature resistance drop and armature reaction respectively However, E_b decreases slightly more than ϕ So that the speed of the motor decreases slightly with load (line AC).

fig-4
Exp-4
4+4 8

(iii) N/Ta characteristic:- The curve is obtained by plotting the values of N and Ta for various armature currents as shown fig (d). It may be seen that speed falls some what as the load-torque increases.

(b) $P = 4$, Total Armature Conductor, $Z = 45 \times 18 = \underline{810}$

$N = 1200$ rpm; $\phi = 0.016$ wb, $A = 2$

Generated Emf, $E_g = \phi Z \frac{N}{60} \times P/A$

$$= \frac{0.016 \times 810 \times 1200 \times 4}{60 \times 2}$$

7 7

$$= \underline{518.4 \text{ V}}$$

IX (a) An alternator works on the principle of Faraday's laws of electromagnetic induction. which state that, ① whenever a Conductor cuts the magnetic flux emf is induced in it ② The rate of change flux linkage is equal to induced emf. From the above it is evident that to generate emf conductor, magnetic flux and motion of the conductor is required. The stator consists of magnetic material and supports a laminated armature core having slots into 3φ winding is housed. The 3φ windings are displaced 120°e apart. The windings are connected in star and the neutral is earthed. The rotating parts consists of a rotor supported on bearings with salient or cylindrical pole which produces a magnetic flux with the help of an exciter, usually d.c shunt generator is mounted to the same shaft. 8 8

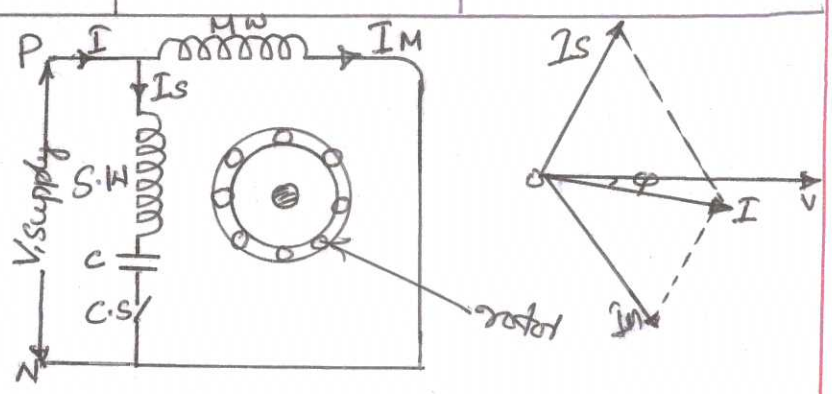
When the rotor is rotated by the prime mover, the stator windings are cut by the magnetic flux of the rotor poles. Hence, e.m.f is induced in the stator conductors. The rotor poles are alternately N and S. They induced an alternating emf in the stator conductors. The frequency of the induced emf is given by, $f=\frac{PN}{120}$ and its direction can be found by fleming's right hand rule.

(b)

Sl NO	particulars	Squirrel-cage induction motor	Slip-ring induction motor
1.	Construction	Simple	Not so simple.
2.	Cost	low	High.
3.	efficiency	Higher than slipring	lower than squirrel cage
4.	Starting torque	low	High.
5.	maintenance cost	very less	More.
6.	speed control	Difficult	easy
7.	Reliability	Very reliable	reliable.

1×7 =7 7

X (a) MW – Main Winding
S.W – Starting winding
C – Capacitor
C.S – Centrifugal switch.



In a capacitor start induction run motor having two windings (i) Main winding (ii) Starting winding, two winding are 90° displaced. The main winding having low resistance and high inductance, the starting winding having high resistance and low inductance. The capacitor and centrifugal switches are connected in series with the starting winding. The value of capacitor is used I_S leads the voltage and I_M lags behind voltage angle between I_M and I_S is about 80°. The resultant current I develope a torque. When the motor attains 75% of the full speed. The starting winding and capacitor are opened by the help of centrifugal switch. When the motor at full load speed the main winding only

fig-4 4
exp-4 4
4
=8

(b) Let, Z = No. of conductors or coil sides in series/phase $= 2T$

P = No. of poles, f = frequency of induced emf in Hz

ϕ = flux/pole in weber; N = rotor rpm, K_F = form factor = 1.11

K_d = distribution factor $= \dfrac{\sin m\beta/2}{m \sin \beta/2}$, K_c = coil span factor $= \cos\frac{\alpha}{2}$

In one revolution of rotor (i.e., 60/N second) each stator conductor is cut by a flux of ϕP weber.

$d\phi = \phi P$ and $dt = 60/N$ second

average emf induced per conductor $= \dfrac{d\phi}{dt} = \dfrac{\phi P}{60/N} = \dfrac{\phi P N}{60}$ —(i)

We know that, $f = \dfrac{PN}{120}$ or $N = 120f/P$.

Substitute the value of N in equ. 1, we get,

average e.m.f/conductor $= \dfrac{\phi P}{60} \times \dfrac{120f}{P} = 2\phi f$ Volt

If there are Z conductor in series/phase,

average e.m.f/phase $= 2\phi f Z = 2\phi f \times 2T = 4\phi f T$ V

R.m.s value of e.m.f/phase $= 1.11 \times 4\phi f T$

$= 4.44\,\phi f T$ Volt

Actually available voltage/phase $= 4.44\,K_c K_d \phi f T$ Volt

7 7