PART - A CIE (F)

M-3

(1) A 25 KW, 250 V DC shunt Generator has armature field resistance of 0.06 Ω and 100 ohms respectively; Determine the total armature power delivered when working

(i) As generator delivering 25 KW output.

$P_L = 25\text{ KW}$
$V = 250\text{ V}$
$R_a = 0.06\ \Omega$
$R_{sh} = 100\ \Omega$

Sol: Armature current; $I_a = I_L + I_{sh}$

load current; $I_L = P_L / V$

$$I_L = \frac{25000}{250}$$

$$I_L = 100\text{ A}$$

Shunt field current; $I_{sh} = \frac{V}{R_{sh}} = \frac{250}{100}$

$$= 2.5\text{ A}$$

$$\therefore I_a = I_L + I_{sh} = 100 + 2.5$$

$$= 102.5\text{ A}$$

Induced voltage in armature $(E_g) = V + I_a R_a$

$$E_g = 250 + 102.5(0.06)$$

$$E_g = 256.15\text{ V}$$

Power delivered; $P = E_g I_a = 256.15 \times 102.5$

$$\boxed{P = 26.25\text{ KW}}$$

(2) A 8 pole DC shunt generator with 778 wave armature conductors and running at 500 rpm. supplies a load of 12.5 ohm resistance at terminal voltage of 250 volts. The armature resistance is 0.24 Ω and the field resistance is 250 Ω. Find the (i) armature current (ii) Induced EMF (iii) flux per pole.

Sol: $Z = 778$; $N = 500 rpm$; $R_a = 0.24\,\Omega$; $R_L = 12.5\,\Omega$; $R_{sh} = 250\,\Omega$

(1) $I_a = ?$; $I_L = V/R_{sh} = \frac{250}{250} = 1A$;

$I_L = V/R_L = \frac{250}{12.5} = 20A$

$I_a = I_L + I_{sh} = 20 + 1 \Rightarrow \boxed{I_a = 21A}$

(ii) $E_g = ?$; $E_g = V + I_a R_a$.

$E_g = 250 + 21(0.24)$

$\boxed{E_g = 255.04\ V}$

$A = 2$ (wave winding)

(iii) ϕ/pole = ? ; $E_g = \frac{\phi P Z N}{60 A} \Rightarrow \phi = \frac{E_g \times 60 \times A}{P \times Z \times N}$

$\phi = \frac{255.04 \times 60 \times 2}{8 \times 778 \times 500}$

$\boxed{\phi = 0.00983\ Wb = 9.83\ mWb}$

(3) A 4 pole DC generator having wave wound armature has 50 slots and 25 conductors per slot. Find the generated EMF, if it is driven at 25 rpm & useful flux per pole in the machine is 0.03 wb?

Sol: $P = 4$; $\phi = 0.03$ wb; $A = 2$ (wave winding); $N = 25$

Total conductors = No. of slots × conductors per slot

$$Z = 50 \times 25$$

$$Z = 1250 \quad ; \quad E_g = ?$$

$$E_g = \frac{\phi P Z N}{60 A} = \frac{0.03 \times 1250 \times 4 \times 25}{60 \times 2}$$

$$\boxed{E_g = 31.25\,V}$$

(4) A 220V DC machine supplies 20A at 200V as a Generator the armature resistance is 0.2 ohms. If the machine is now operated as a motor at the same terminal voltage and current but with flux increased by 10 percentage, calculate the ratio of motor speed to generator speed.

Sol Given,

(i) DC Generator; $R_a = 0.2$

$V = 200V$

(ii) DC Motor; $R_a = 0.2$

$V = 200V$

Find $\frac{N_2}{N_1} = ?$

Flux increased in motor by 10% compared to Generator

$\phi_2 = 1.1 \phi_1$

How? Flux of Generator ~~Assume~~ = 100%

Flux of Motor = 110%

$\phi_2 = 1.1 \phi_1$

→ In case of Generator,

E_g = Terminal voltage + voltage drop

$E_g = V_t + I_a R_a$

$E_g = 200 + 20(0.2) = 204\,V$

→ In case of motor,

$E_b = V_t - I_a R_a$

$E_b = 200 - (0.2)\,20 = 196\,V$

Turns ratio: $\frac{N_2}{N_1} = \frac{E_2}{E_1} \times \frac{\phi_2}{\phi_1}$ $[E = N\phi]$

$\frac{N_2}{N_1} = \frac{196}{204} \times \frac{1.1\phi_1}{\phi_1}$

$\boxed{\frac{N_2}{N_1} = 0.87}$

⑤ A 440V DC shunt motor takes a no load current of 2.5A. The resistance of shunt field and the armature are 550 Ω and 1.2 Ω respectively. The full load line current is 32 A. Find the full load output and the efficiency of the motor.

Sol: 440V; $I_{No\ load} = 2.5A$; $R_{sh} = 550\Omega$; $R_a = 1.2\Omega$

$I_{Full\ load} = 32A$; o/p & Efficiency = ?

Input power = Voltage × $I_{full\ load}$

$\Rightarrow 440 \times 32 = 14080\,W$

Output power = Voltage × $I_{full\ load}$

$\Rightarrow 440 \times 32 = 14080\,W$

$$\text{Efficiency} = \frac{\text{output power}}{\text{Input power}} \times 100$$

$$\eta = \frac{14080}{14080} \times 100$$

$$\boxed{\eta = 100\%}$$

⑥ A three-phase, 20 hp, 208 V, 60 Hz, six pole, wye connected induction motor delivers 15 kW at a slip of 5 percentage. Calculate (i) synchronous speed (ii) Rotor speed (iii) Frequency of rotor speed

Sol: Given; poles = 6; frequency = 60; slip = 5 %

= 0.05

(i) $n_s = \frac{120f}{P} = \frac{120 \times 60}{6} = 1200$ rpm

$\boxed{n_s = 1200 \text{ rpm}}$

(ii) $n_r = (1-s)\, n_s = (1-0.05) \times 1200$

$\boxed{n_r = 1140 \text{ rpm}}$

(iii) $f_r = s f_s$

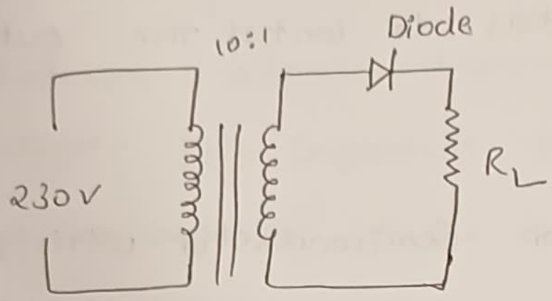
$f_r = 0.05\,(60)$

$\boxed{f_r = 3 \text{ Hz}}$

CIE-II PART-A

Q1) An AC Supply of 230V is applied to a half wave rectifier circuit Through a transformer of turn ratio 10:1. Find (i) the output dc voltage.

(ii) The Peak inverse voltage (Assume the diode to be ideal).



Sol Given data; $V_{rms} = 230V$ (ac supply)

Turns ratio $= \frac{N_1}{N_2} = 10$.

To find (i) $V_{dc} = ?$

(ii) Peak inverse voltage.

primary to Secondary turns ratio is.

RMS primary Voltage = 230V

max. primary voltage is $V_{pm} = (\sqrt{2}) \times V_p (rms)$.

Note: $V_{rms} = \frac{V_m}{\sqrt{2}}$

$V_p(max) = \sqrt{2} \times 230 = \cancel{325.3V}$ 460V

$V_m = \sqrt{2}\, V_{rms}$

Max. Secondary voltage is

$V_s(max) = V_{p(max)} \times \frac{N_2}{N_1}$ $\left(\frac{V_1}{V_2} = \frac{N_1}{N_2}\right)$

$\Rightarrow \cancel{325.3}$ 460 $\times \frac{1}{10} = \cancel{32.53V}$ 46V

(i) the output d.c voltage

$$I_{d.c} = \frac{I_m}{\pi}$$

$$V_{d.c} = \frac{I_m}{\pi} \times R_L = \frac{V_{s\,(max)}}{\pi}$$

$$\Rightarrow \frac{\cancel{32.53}\ 46}{\pi} = \cancel{10.36V}\ 14.64V$$

$$\boxed{V_{d.c} = \cancel{10.36V}\ 14.64V}$$

(ii) During the negative half cycle of a.c supply the reverse biased and hence conducts no current the secondary voltage appears across the diode.

$$\boxed{\therefore \text{Peak Inverse voltage} = \cancel{32.53V}\ 46V.}$$

Note:
$PI_V = V_m$

Q2) A half wave rectifier is used to supply 50V dc to a resistive load of 800 Ω. The diode has a resistance of 25 Ω. Calculate a.c voltage required.

Ans Given data:

Output dc voltage $(V_{dc}) = 50V$

Diode resistance $r_f = 25\ \Omega$

Load resistance $= 800\ \Omega$

$$\left[I_m = \frac{V_m}{r_f + R_L} \right]$$

solution:

$$V_{dc} = I_{dc} \times R_L = \frac{I_m}{\pi} \times R_L$$

$$= \frac{V_m}{\pi (r_f + R_L)} \times R_L$$

$$50 = \frac{V_m}{\pi(25+800)} \times 800$$

$$V_m = \frac{\pi \times 825 \times 50}{800} = 162\ V$$

Hence a.c voltage of maximum value 162 V is required

Q3) A full wave rectifier uses two diodes, the Internal resistance of each diode may be assumed constant at 20 Ω. The transformer rms secondary voltage from centre tap to each end of secondary is 50 V and load resistance is 980 Ω. Find.

(i) the mean load current

(ii) the rms value of load current.

Sol Given data:

diode resistance, $r_f = 20\ \Omega$; $R_L = 980\ \Omega$, $V_{rms} = 50V$

Max. AC voltage $V_m = 50 \times \sqrt{2}$

$= 70.7V$

Max. load current $I_m = \frac{V_m}{r_f + R_L} = \frac{70.7}{(20+980)}$

$= 70.7\ mA$

(i) Mean load current $I_{d.c} = \frac{2 I_m}{\pi} = \frac{2 \times 70.7}{\pi}$

$= 45\ mA$

$$\boxed{I_{d.c} = 45\ mA}$$

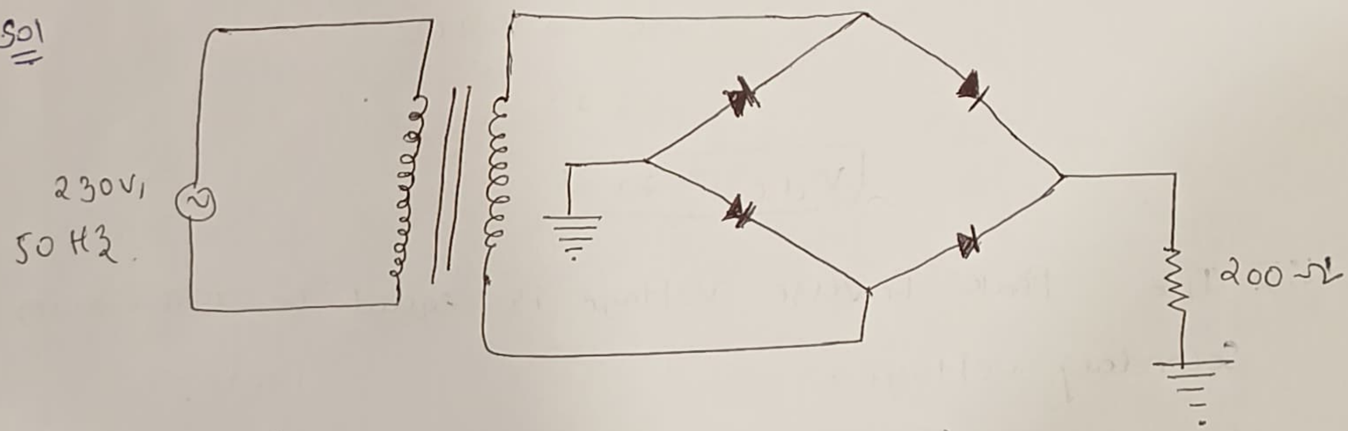
(iii) RMS value of load current is

$$I_{rms} = \frac{I_m}{\sqrt{2}} = \frac{70.7}{\sqrt{2}} = 50\,mA$$

$$\boxed{I_{rms} = 50\,mA}$$

Q4). An a.c supply of 230v is applied to a bridge type Rectifier circuit through a transformer of turns ratio 4:1. Find (i) d.c out voltage.
(ii) Peak inverse voltage.
(iii) Output frequency. Assume the diodes are ideal.

Sol



Turns ratio $\frac{N_1}{N_2} = \frac{4}{1}$

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

RMS Primary voltage = 230 v

RMS Secondary voltage $= 230 \times \frac{N_2}{N_1}$

$= 230 \times \frac{1}{4}$

$= 57.5\,V$

Maximum voltage across secondary is

$$V_{max} = 57.5 \times \sqrt{2}$$

$$= 81.3 V.$$

$$\boxed{V_{max} = 81.3 V.}$$

Note

$V_{max} = \sqrt{2} \times V_{rms}$

(i) Average current $I_{dc} = \frac{2 V_m}{\pi R_L}$

Note

$I_{d.c} = \frac{2 I_m}{\pi}$

$I_m = \frac{V_m}{R_L}$

$$I_{d.c} = \frac{2 \times 81.3}{\pi \times 200} = 0.26 A$$

d.c output voltage $V_{d.c} = I_{d.c} \times R_L$

$$= 0.26 \times 200$$

$$= 52 V.$$

$$\boxed{V_{d.c} = 52 V}$$

(ii). The Peak Inverse Voltage is equal to maximum Secondary voltage.

Note;

$PIV = V_{max}$

$$\boxed{PIV = 81.3 V}$$

(iii) In full wave rectification, there are two output pulses for each complete cycle of the input a.c voltage.

$$f_{out} = 2 \times f_{in}$$

$$= 2 \times 50$$

$$= 100 Hz$$

$$\boxed{f_{out} = 100 Hz}$$

5) An Half wave rectifier has a load of 3.5 KΩ. If the diode resistance and secondary coil resistance together have a (11) resistance of 800 Ω and the input voltage has a signal voltage of peak value 240. Calculate

(a) Peak, average and rms values of current flowing.

(b) dc power output.

(c) a.c power input.

(d) efficiency of the rectifier.

Ans Given data : , $R_L = 3.5 K\Omega$

$R_s + R_f = 800\Omega$ and $V_m = 240V$.

(a) Peak value of current $I_m = \frac{V_m}{R_f + R_s + R_L}$

$$= \frac{240}{800 + 3 * 500}$$

$$\boxed{I_m = 55.81 mA}$$

Average value of current $I_{dc} = \frac{I_m}{\pi} = \frac{55.81}{\pi}$

$$\boxed{I_{dc} = 17.77 mA}$$

Rms value of current $I_{rms} = I_m/2$

$$= \frac{55.81 \times 10^{-3}}{2}$$

$$= 27.9 mA$$

$$\boxed{I_{rms} = 27.9 mA}$$

(b) d.c power output $P_{dc} = I^2_{dc} R_L$

$$= (17.77 \times 10^{-3})^2 \times 3500$$

$$= 1.105 W$$

$$\boxed{P_{dc} = 1.105 W}$$

(c.) A.c Input power $P_{AC} = I^2_{rms} \times (R_f + R_L + R_s)$

$$= (27.905 \times 10^{-3})^2 \times (3500 + 800)$$

$$= (27.9 \times 10^{-3})^2 \times 4300$$

$$\boxed{P_{AC} = 3.348 \omega}$$

(d) Efficiency $(\eta) = \frac{P_{d.c}}{P_{a.c}}$

$$\eta = \frac{1.105}{3.348} \times 100$$

$$\boxed{\eta = 33\%}$$

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