Out of Syllabus Solved problems

Q + Q1. The equation for an alternating current is given by $I = 77 \sin 314t$. Find the peak value, frequency, time period and instantaneous value at $t = 2ms$.

Sol. Given that,

Equation of an alternating current, $I = 77 \sin 314t$ → (1)

Time, $t = 2ms = 2\times10^{-3}$ sec

To determine,

1. Peak value = ? 2. Frequency = ? 3. Time period = ?

4. Instantaneous value = ?

We know that

The general equation for alternating current is

$I = I_m \sin \omega t$ — (2)

On comparing equation (1) & (2), we get

1. peak value ($I_m$)

$I_m = 77A$

2. Frequency ($f$)

$\omega = 2\pi f \Rightarrow f = \frac{\omega}{2\pi}$

$f = \frac{314}{2\times3.14} = 50Hz$

3. Time period.

$T = \frac{1}{f} = \frac{1}{50} = 0.02s$

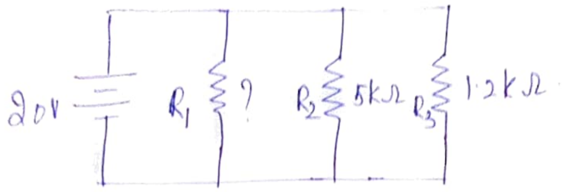
4. Instantaneous value.

At $t = 2ms$.

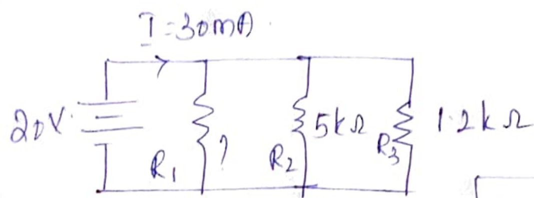
$I = 77 \sin(314\times2\times10^{-3})$

$I = 45.23A$.

Q2 Calculate the necessary resistor size for $R_1$ to make the total circuit current equal to 30 milli amps:



Sol Given circuit shown in fig (1).



Also given total current in circuit, $I = 30mA$

From fig (1), it is clear that, resistors $R_2$ & $R_3$ are connected in parallel

$$\therefore R_2 \parallel R_3 = \frac{R_2 R_3}{R_2 + R_3} = \frac{5 \times 1.2}{5 + 1.2} = 0.967\,k\Omega$$

Now, fig (1), will be modified as shown in fig (2).

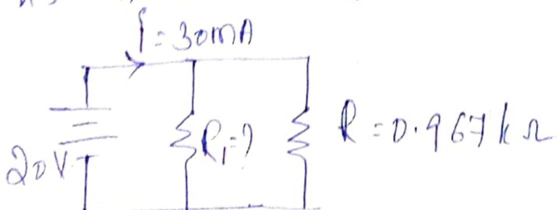


fig (2)

From figure (2); resistors $R$ & $R_1$ are parallel

$$R_{eq} = R \parallel R_1 = \frac{0.967 \times R_1}{0.967 + R_1}\,k\Omega$$

We know that

$$V = I R_{eq}$$

$$\therefore R_{eq} = \frac{V}{I}$$

$$\Rightarrow \frac{0.967 \times 10^3 R_1}{(0.967 \times 10^3) + R_1} = \frac{20}{30 \times 10^{-3}}$$

$$\Rightarrow 0.967 \times 30 \times R_1 = 20(0.967 \times 10^3 + R_1)$$

$$\Rightarrow 29.031 R_1 = 19.354 \times 10^3 + 20 R_1$$

$$\Rightarrow (29.031 - 20) R_1 = 19.354 \times 10^3$$

$$\Rightarrow 9.03 R_1 = 19.354 \times 10^3$$

$$\Rightarrow R_1 = \frac{19.354}{9.03} \times 10^3 = 2.143\,k\Omega$$

$$\boxed{R_1 = 2.143\,k\Omega}$$

Q: A Transformer is rated at 100kVA. At full load the Copper loss is 1200W & its Iron losses is 960W. Calculate

(i) The efficiency at full load, O.P.F (unity power factor)

(ii) Efficiency at half load, 0.8 p.f

(iii) The Efficiency at 75% of full load, 0.7 p.f lag.

(iv) Load kVA at which maximum efficiency occurs.

Sol Given that.

Rating of a transformer = 100kVA.

Full load Copper losses, $W_{Cu}$ = 1200W.

Iron losses $W_i$ = 960W.

(i) Full load Efficiency at unity power factor

We have,

Output = Rating × p.f × Desired load

= 100 × 1 × 1 = 100kW

Total losses = Iron losses + Full load Copper losses

= $W_i + W_{Cu}$ = 960 + 1200 = 2160W = 2.16kW.

⇒ Input = output + losses = 100 + 2.16 = 102.16 kW

Efficiency $\eta = \frac{\text{output}}{\text{Input}} \times 100 = \frac{100}{102.16} \times 100$

$\eta$ = 97.88%

(ii) Efficiency at Half load at 0.8 p.f

Output Rating x p.f x Desired load

: $100 \times 0.8 \times \frac{1}{2} = 40 kw$.

Iron loss $W_i$ : 960W (Same at all load)

Copper loss at half load.

$W_{Cu}$ : $(\frac{1}{2})^2 \times$ Full load Copper loss

: $[\frac{1}{2}]^2 \times 1200 : 300 W$

Total losses = $W_i + W_{Cu} = 960 + 300 = 1260 W$

$= 1.26 kw$

=> Input = Output + losses = $40 + 1.26 = 41.26 kw$

Efficiency $\eta = \frac{\text{Output}}{\text{Input}} \times 100 = \frac{40}{41.26} \times 100 = 96.95\%$

(iii) Efficiency at 75% of full load, 0.7 p.f.

Output = Rating x p.f x Desired load

: $100 \times 0.7 \times 0.75 = 52.5 kW$

Iron loss = 960W.

Copper loss $W_{Cu}$ at 75% of full load Copper loss

$W_{Cu}$ $(0.75)^2 \times$ Full load Copper loss

$= (0.75)^2 \times 1200 = 675 W$

Total losses $W_i + W_{Cu}$ : $960 + 675 = 1.635 kw$.

Input = Output + losses : $52.5 + 1.635 = 54.135 kw$

∴ Efficiency $\eta = \frac{\text{Output}}{\text{Input}} \times 100 = \frac{52.5}{54.135} \times 100 = 96.98\%$

(iv) Load kVA at which maximum Efficiency occurs.

Load kVA Corresponding to maximum efficiency is given by Load kVA = Full load kVA × $\sqrt{\frac{\text{Iron Loss}}{\text{Full load Cu}}}$

$= 100 \times \sqrt{\frac{960}{1200}}$

$= 89.44$ kVA

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Q) A 8 pole lap wound DC Generator has 120 slots having 4 Conductors per slot. If each Conductor Can Carry 250A and if flux/pole is 0.05 wb, Calculate the Speed of generator for giving 240V on open Circuit. If the voltage drops to 220V on full load, find the rated output of the machine.

Sol Given that,

A lap wound D.C generator

No. of poles, $P = 8$

Since it is a lap wound generator, Therefore

No. of parallel paths in armature, $A = P = 8$.

No. of Slots = 120.

No. of Conductors/slot = 4

Current across each Conductor, $I = 250A$

Flux, $\phi = 0.05\,Wb$.

Generated voltage, $E_g = 240V$.

Full load voltage, $V = 220V$.

To determine,

(i) Speed of the generator, $N = ?$

(ii) Rated output of the machine, $P = ?$

(i) Speed of Generator

The Emf Equation of a DC Generator is given as,

$$E_g = \frac{\phi Z N P}{60A} \quad \text{——} \quad (1).$$

Since we know that,

Total no. of Conductors $Z$ = number of slots $\times$ no. of Conductors / slot

$\therefore Z = 120 \times 4 = 480$

Substitute given values in eqn (1), we get

$$\Rightarrow 240 = \frac{0.05 \times 480 \times N \times \cancel{8}}{60 \times \cancel{8}} = \frac{240 \times 60}{480 \times 0.05} = N$$

$N = 600\,rpm$.

(ii) Rated output of the machine.

The total current at full load, I = current in each parallel path $\times$ No. of parallel paths

$= 250 \times 8 = 2000\,A$ [$\because$ No. of parallel paths $= 8$]

The Rating of the machine $P = VI = 220 \times 2000$

$= 440000\,W = 440\,kW$

Q: A 440V 3-phase, 50Hz supply is fed to three coils, star connected each having a resistance of 25 Ω and inductive reactance of 20Ω. Calculate (a) line current (b) power factor (c) power supplied

Sol Given that

A 3-phase star connected network

Line voltage, $E_L = 440V$.

Frequency, $f = 50Hz$.

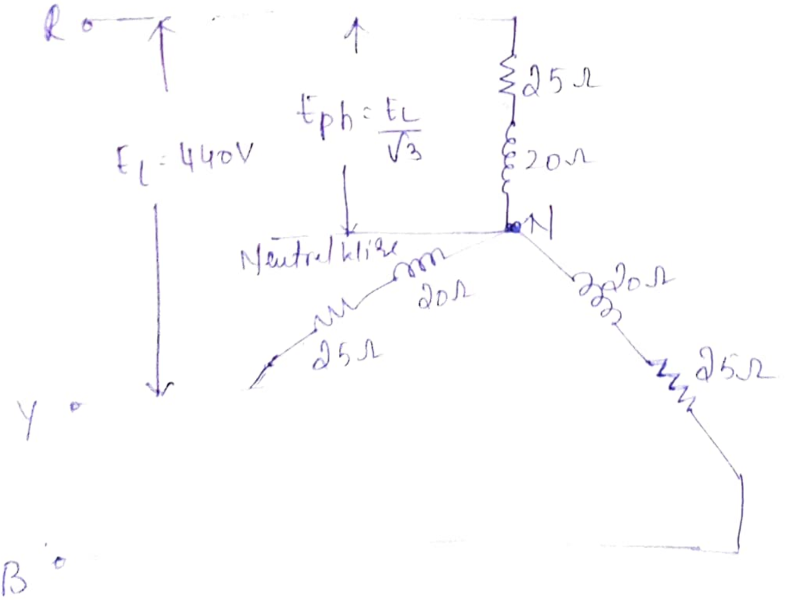
Resistance per phase, $R_{ph} = 25Ω$

Reactance per phase, $X_{ph} = 20Ω$

To determine

(i) line current = ? (ii) power factor = ? (iii) power supplied = ?

The 3-phase star connected network is shown in fig




Impedance per phase is given by

$$Z_{ph} = \sqrt{R_{ph}^2 + X_{ph}^2} = \sqrt{(25)^2 + (20)^2} = 32Ω$$

phase voltage, $E_{ph} = \frac{E_L}{\sqrt{3}} = \frac{440}{\sqrt{3}} = 254V.$

phase Current, $I_{ph} = \frac{E_{ph}}{Z_{ph}} = \frac{254}{32} = 7.93 \simeq 8A$

(i) Line Current

We know that, in star Connection

Line Current = phase Current

∴ Line Current, $I_L = I_{ph} = 8A$

(ii) power factor (pf)

power factor $\cos\phi = \frac{R_{ph}}{Z_{ph}} = \frac{25}{32} = 0.78$ (lag)

(iii) power supplied

power $P = \sqrt{3} E_L I_L \cos\phi = \sqrt{3} \times 440 \times 8 \times 0.78$

$P = 4755.5W$

Q A 3-$\phi$, 50Hz Induction motor has 4 poles, If the slip is 3% at a certain load, Determine Speed of the rotor and frequency of the induced emf in the rotor

Sol Given that

A 3-$\phi$ induction motor

frequency, $f = 50Hz$

poles $P = 4$;

slip, $s = 3\% = 0.03$

To determine,

Speed of the rotor, $N = ?$

frequency $f = ?$

We know that,

Synchronous Speed, $N_s = \frac{120f}{P} = \frac{120 \times 50}{4} = 1500 rpm$

Slip, $s = \frac{N_s - N_r}{N_s} = 1 - \frac{N_r}{N_s}$.

$$0.03 = 1 - \frac{N_r}{1500}$$

$$\frac{N_r}{1500} = 1 - 0.03 \Rightarrow N_r = 1500(1-0.03)$$

$\therefore$ Rotor Speed, $N_r = 1455$ rpm.

$$f_r = sf = 0.03 \times 50$$

$$= 1.5 Hz.$$