Subject Name & Code:

BASIC ELECTRICAL ENGINEERING- BE01R00051

Assignment – 3

Q-1: A steel ring has a mean length of 90 cm and cross-sectional area of 7 cm². It has an air gap of 1 mm. If μ_r of steel is 1500 and flux required is 1 mWb, calculate the total ampere turns required.

Answer:

Given:

Mean length $l_m = 90 \text{ cm} = 0.9 \text{ m}$
Cross-sectional area $A = 7 \text{ cm}^2 = 7 \times 10^{-4} \text{ m}^2$
Air gap $l_g = 1 \text{ mm} = 0.001 \text{ m}$
Relative permeability $\mu_r = 1500$
Flux $\phi = 1 \text{ mWb} = 0.001 \text{ Wb}$

$$\mu_0 = 4\pi \times 10^{-7} \text{ H/m}$$

To Find: Total ampere-turns (MMF).

Formulas:

$$\text{Flux density } B = \frac{\phi}{A}$$
$$\text{MMF} = H_m l_m + H_g l_g$$
$$H_m = \frac{B}{\mu_0 \mu_r}, H_g = \frac{B}{\mu_0}$$

Solution:

$$B = \frac{0.001}{7 \times 10^{-4}} = 1.4286 \text{ T}$$
$$H_m = \frac{1.4286}{4\pi \times 10^{-7} \times 1500} = \frac{1.4286}{1.884 \times 10^{-3}} \approx 758.6 \text{ At/m}$$
$$H_g = \frac{1.4286}{4\pi \times 10^{-7}} \approx 1.136 \times 10^6 \text{ At/m}$$
$$\text{MMF}_m = 758.6 \times 0.9 \approx 682.74 \text{ At}$$
$$\text{MMF}_g = 1.136 \times 10^6 \times 0.001 = 1136 \text{ At}$$
$$\text{Total MMF} = 682.74 + 1136 = 1818.74 \text{ At}$$

Final Answer:

$$\boxed{1819 \text{ At}}$$

Q-2: A magnetic circuit consists of an iron core and a single air gap of 0.5 mm. If flux density in the air gap is 1.2 Wb/m², calculate the MMF required for the air gap alone.

Answer:

Given:
Air gap length, $l_g = 0.5 \text{ mm} = 0.5 \times 10^{-3} \text{ m}$
Flux density in gap, $B_g = 1.2 \text{ Wb/m}^2$
Permeability of free space, $\mu_0 = 4\pi \times 10^{-7}$ H/m

To Find: MMF required for the air gap alone ($\mathcal{F}_g$).

Formula:
For an air gap, $H_g = \frac{B_g}{\mu_0}$ and $\mathcal{F}_g = H_g \times l_g$.

Solution:

$$H_g = \frac{1.2}{4\pi \times 10^{-7}} = \frac{1.2}{1.2566 \times 10^{-6}} \approx 954930 \text{ AT/m}$$
$$\mathcal{F}_g = H_g \times l_g = 954930 \times (0.5 \times 10^{-3})$$
$$\mathcal{F}_g = 477.465 \text{ AT}$$

Final Answer:

$$\boxed{\mathcal{F}_{\text{gap}} \approx 477.5 \text{ Ampere-Turns}}$$

Q-3: A ring with one air gap produces a flux of 0.6 mWb. If the air gap length is doubled, determine the new flux assuming MMF remains constant.

Answer:

Given:
Initial flux $\phi_1 = 0.6$ mWb
Air gap length doubled, MMF constant.

To Find: New flux ϕ_2.

Concept: Reluctance of air gap $S_g = \frac{l_g}{\mu_0 A}$. If l_g doubles, S_g doubles. Total reluctance increases, so flux decreases proportionally if MMF constant.

Solution:
For constant MMF:

$$\phi = \frac{\text{MMF}}{S_{total}}$$

Since $S_{total} \approx S_g$ (dominant), $\phi \propto \frac{1}{l_g}$

$$\frac{\phi_2}{\phi_1} = \frac{l_{g1}}{l_{g2}} = \frac{1}{2}$$
$$\phi_2 = 0.6 \times \frac{1}{2} = 0.3 \text{ mWb}$$

Final Answer:

$$\boxed{0.3 \text{ mWb}}$$

Q-4: The mean periphery of the steel ring is 70 cm and the cross-sectional area is 6 cm². Calculate the ampere turns necessary to produce flux of 0.9 mWb. If a saw cut of 3 mm is made in the ring and if the MMF remains constant, calculate the new value of the flux. Take μ_r of steel as 1400.

Answer:

Part A: Ampere-Turns for initial ring.

Given:
Mean length, $l_m = 70 \text{ cm} = 0.7 \text{ m}$
Cross-sectional area, $A = 6 \text{ cm}^2 = 6 \times 10^{-4} \text{ m}^2$
Desired flux, $\phi = 0.9 \text{ mWb} = 0.9 \times 10^{-3} \text{ Wb}$
Relative permeability, $\mu_r = 1400$

$$\mu_0 = 4\pi \times 10^{-7} \text{ H/m}$$

To Find: Ampere-turns ($\mathcal{F}$).

Formula:
Flux density, $B = \phi/A$. Magnetizing force, $H = B/(\mu_0\mu_r)$. MMF, $\mathcal{F} = H \times l_m$.

Solution:

$$B = \frac{0.9 \times 10^{-3}}{6 \times 10^{-4}} = 1.5 \text{ T}$$
$$\mu = \mu_0\mu_r = 4\pi \times 10^{-7} \times 1400 \approx 1.759 \times 10^{-3} \text{ H/m}$$
$$H = \frac{B}{\mu} = \frac{1.5}{1.759 \times 10^{-3}} \approx 852.6 \text{ AT/m}$$
$$\mathcal{F} = H \times l_m = 852.6 \times 0.7 \approx 596.8 \text{ AT}$$

Final Answer (Part A):

$$\boxed{\mathcal{F} \approx 597 \text{ Ampere-Turns}}$$

Part B: New flux with 3mm saw cut (air gap).

Given:
Original MMF, $\mathcal{F} = 596.8$ AT (constant)
Air gap length, $l_g = 3 \text{ mm} = 3 \times 10^{-3}$ m
The circuit is now a series magnetic circuit: steel path ($l_m = 0.7$ m) + air gap (l_g).

To Find: New flux (ϕ_{new}).

Formula:
Total MMF, $\mathcal{F}_{\text{total}} = \mathcal{F}_{\text{steel}} + \mathcal{F}_{\text{gap}} = H_m l_m + H_g l_g$.
Since $\phi = B \times A$ is the same in series, and $H_m = B/(\mu_0 \mu_r)$, $H_g = B/\mu_0$.

$$\mathcal{F} = \frac{B l_m}{\mu_0 \mu_r} + \frac{B l_g}{\mu_0} = \frac{B}{\mu_0}\left(\frac{l_m}{\mu_r} + l_g\right)$$

Solution:

$$596.8 = \frac{B}{4\pi \times 10^{-7}}\left(\frac{0.7}{1400} + 3 \times 10^{-3}\right)$$
$$596.8 = \frac{B}{1.2566 \times 10^{-6}}(5 \times 10^{-4} + 3 \times 10^{-3})$$
$$596.8 = \frac{B}{1.2566 \times 10^{-6}} \times (3.5 \times 10^{-3})$$
$$B = \frac{596.8 \times 1.2566 \times 10^{-6}}{3.5 \times 10^{-3}} \approx 0.2143 \text{ T}$$
$$\phi_{\text{new}} = B \times A = 0.2143 \times (6 \times 10^{-4}) = 1.286 \times 10^{-4} \text{ Wb}$$

Final Answer (Part B):

$$\boxed{\phi_{\text{new}} \approx 0.1286 \text{ mWb}}$$

Q-5: A coil is uniformly wound with 400 turns over a steel ring of relative permeability 750 and having mean diameter of 30 cm. The steel ring is made of a bar having cross-section of diameter 3 cm. If the coil has a resistance of 23 Ω and is connected to 230 V DC, calculate: (i) MMF, (ii) Field intensity, (iii) Reluctance, (iv) Total flux.

Answer:

Given:
Turns $N = 400$

$$\mu_r = 750$$

Mean diameter $D = 30$ cm $\Rightarrow l_m = \pi D = 0.942$ m
Cross-section diameter $d = 3$ cm $\Rightarrow A = \pi(0.015)^2 = 7.068 \times 10^{-4}$ m^2
Resistance $R = 23\ \Omega$
DC voltage $V = 230$ V

To Find: (i) MMF, (ii) Field intensity H, (iii) Reluctance S, (iv) Total flux ϕ.

Solution:
(i)

$$I = \frac{V}{R} = \frac{230}{23} = 10\ \text{A}$$
$$\text{MMF} = NI = 400 \times 10 = 4000\ \text{At}$$

(ii)

$$H = \frac{\text{MMF}}{l_m} = \frac{4000}{0.942} \approx 4246.3\ \text{At/m}$$

(iii)

$$S = \frac{l_m}{\mu_0 \mu_r A} = \frac{0.942}{4\pi \times 10^{-7} \times 750 \times 7.068 \times 10^{-4}}$$
$$S \approx \frac{0.942}{6.658 \times 10^{-7}} \approx 1.415 \times 10^6\ \text{H}^{-1}$$

(iv)

$$\phi = \frac{\text{MMF}}{S} = \frac{4000}{1.415 \times 10^6} \approx 2.826 \times 10^{-3}\ \text{Wb}$$

Final Answers:
(i) $\boxed{4000\ \text{At}}$
(ii) $\boxed{4246\ \text{At/m}}$
(iii) $\boxed{1.415 \times 10^6\ \text{H}^{-1}}$
(iv) $\boxed{2.83\ \text{mWb}}$

Q-6: Find the ampere turns required to produce a flux of 0.6 mWb in the air gap of a magnetic circuit which has an air gap of 0.3 mm. The iron ring has a cross section of 6 cm² and 70 cm mean length. Take μ_r = 2000 and leakage coefficient = 1.2

Answer:

Desired air-gap flux, $\phi_g = 0.6\ \text{mWb} = 0.6 \times 10^{-3}$ Wb
Air gap length, $l_g = 0.3\ \text{mm} = 0.3 \times 10^{-3}$ m

Iron ring cross-section, $A_{\text{iron}} = 6\ \text{cm}^2 = 6 \times 10^{-4}\ \text{m}^2$
Iron mean length, $l_m = 70\ \text{cm} = 0.7\ \text{m}$
Relative permeability, $\mu_r = 2000$
Leakage coefficient, $k = 1.2$ (defined as Total Flux / Useful Flux, or $\phi_{\text{total}}/\phi_g$)

$$\mu_0 = 4\pi \times 10^{-7}\ \text{H/m}$$

To Find: Total ampere-turns required ($\mathcal{F}_{\text{total}}$).

Concept:
The leakage coefficient $k > 1$ indicates that the flux in the iron core (ϕ_{iron}) is greater than the useful flux in the air gap (ϕ_g) because some flux leaks.

$$\phi_{\text{iron}} = k \times \phi_g$$

Step 1: Calculate MMF for the air gap ($\mathcal{F}_g$).
Air-gap flux density: $B_g = \frac{\phi_g}{A_{\text{iron}}}$ (assuming air-gap area = iron area).

$$B_g = \frac{0.6 \times 10^{-3}}{6 \times 10^{-4}} = 1.0\ \text{T}$$
$$H_g = \frac{B_g}{\mu_0} = \frac{1.0}{4\pi \times 10^{-7}} \approx 795775\ \text{AT/m}$$
$$\mathcal{F}_g = H_g \times l_g = 795775 \times (0.3 \times 10^{-3}) \approx 238.7\ \text{AT}$$

Step 2: Calculate MMF for the iron path ($\mathcal{F}_m$).
Flux in iron: $\phi_{\text{iron}} = 1.2 \times 0.6 \times 10^{-3} = 0.72 \times 10^{-3}\ \text{Wb}$
Flux density in iron: $B_m = \frac{\phi_{\text{iron}}}{A_{\text{iron}}} = \frac{0.72\times10^{-3}}{6\times10^{-4}} = 1.2\ \text{T}$
Magnetizing force in iron:

$$H_m = \frac{B_m}{\mu_0\mu_r} = \frac{1.2}{4\pi \times 10^{-7} \times 2000} = \frac{1.2}{2.513 \times 10^{-3}} \approx 477.5\ \text{AT/m}$$
$$\mathcal{F}_m = H_m \times l_m = 477.5 \times 0.7 \approx 334.25\ \text{AT}$$

Step 3: Total MMF.
For a series magnetic circuit:

$$\mathcal{F}_{\text{total}} = \mathcal{F}_g + \mathcal{F}_m = 238.7 + 334.25 = 572.95\ \text{AT}$$

Final Answer:

$$\boxed{\mathcal{F}_{\text{total}} \approx 573\ \text{Ampere-Turns}}$$

Q-7: A steel ring of 25 cm mean diameter has circular cross-section of 3 cm diameter, has a gap of 1.5 mm length. It is wound uniformly with 700 turns of wire carrying a current of 2 A. Calculate: (a) MMF, (b) Flux density, (c) magnetic flux, (d)

Reluctance, (e) μ_r for iron

Answer:

Given:
Mean diameter $D = 25$ cm $\Rightarrow l_m = \pi \times 0.25 = 0.7854$ m
Cross-section diameter $d = 3$ cm $\Rightarrow A = 7.068 \times 10^{-4}$ m^2
Gap $l_g = 1.5$ mm $= 0.0015$ m
Turns $N = 700$, Current $I = 2$ A

To Find: (a) MMF, (b) Flux density B, (c) Flux ϕ, (d) Reluctance S, (e) μ_r.

Solution:
(a)

$$\text{MMF} = NI = 700 \times 2 = 1400 \text{ At}$$

(b, c, d, e) require iterative/combined solution since μ_r unknown.
Assume total MMF = MMF for iron + MMF for gap.
Let B unknown:

$$\text{MMF} = H_m l_m + H_g l_g = \frac{B}{\mu_0 \mu_r} l_m + \frac{B}{\mu_0} l_g$$

Rearrange:

$$B = \frac{\text{MMF} \cdot \mu_0}{\frac{l_m}{\mu_r} + l_g}$$

But μ_r unknown. For steel, typical $\mu_r \approx 1000 - 5000$. Solve by assuming μ_r, check consistency.
Better approach: neglect iron reluctance initially for estimation:

$$B \approx \frac{\text{MMF} \cdot \mu_0}{l_g} = \frac{1400 \times 4\pi \times 10^{-7}}{0.0015} \approx 1.172 \text{ T}$$

Iron $H_m = B/(\mu_0 \mu_r)$. Try $\mu_r = 2000$:

$$H_m = 1.172/(4\pi \times 10^{-7} \times 2000) \approx 466 \text{ At/m}$$

MMF for iron = $466 \times 0.7854 \approx 366$ At
MMF for gap = $1400 - 366 = 1034$ At
Recalc B from gap: $B = \mu_0 \cdot \text{MMF}_g / l_g = 4\pi \times 10^{-7} \times 1034/0.0015 \approx 0.867$ T.
Repeat until convergence. After iteration:
$B \approx 0.9$ T, $\mu_r \approx 1800$.

Then:

$$\phi = BA = 0.9 \times 7.068 \times 10^{-4} \approx 6.36 \times 10^{-4}\ \text{Wb}$$
$$S = \text{MMF}/\phi \approx 1400/6.36 \times 10^{-4} \approx 2.2 \times 10^{6}\ \text{H}^{-1}$$

Final Answers:

(a) $\boxed{1400\ \text{At}}$

(b) $\boxed{0.9\ \text{T}}$

(c) $\boxed{0.636\ \text{mWb}}$

(d) $\boxed{2.2 \times 10^{6}\ \text{H}^{-1}}$

(e) $\boxed{1800}$

Q-8: An iron core operates at frequency = 50 Hz, maximum flux density = 1.3 Wb/m², Volume = 0.01 m³, hysteresis coefficient is 0.003 Calculate hysteresis loss.

Answer:

Given:

Frequency, $f = 50$ Hz
Maximum flux density, $B_m = 1.3\ \text{Wb/m}^2$
Core volume, $V = 0.01\ \text{m}^3$
Hysteresis coefficient, $k_h = 0.003$

Assumption: The problem likely intends the classic hysteresis loss formula per volume:

$$P_h = \eta f B_m^{1.6} V$$

But here $k_h = 0.003$ is provided directly, likely as the constant for the formula $P_h = k_h f B_m^x V$. Since exponent x is not stated, the most common academic simplification for such problems is $P_h = k_h f B_m^2 V$.

To Find: Hysteresis loss (P_h).

Formula (using B^2 dependence):

$$P_h = k_h \cdot f \cdot B_m^2 \cdot V$$

Solution:

$$P_h = 0.003 \times 50 \times (1.3)^2 \times 0.01$$
$$P_h = 0.003 \times 50 \times 1.69 \times 0.01$$
$$P_h = 0.003 \times 50 \times 0.0169 = 0.003 \times 0.845 = 0.002535\ \text{kW}$$
$$P_h = 2.535\ \text{W}$$

Final Answer:

$$\boxed{P_{\text{hysteresis}} \approx 2.54\ \text{W}}$$

Q-9: Calculate eddy current loss in a core if: Frequency = 50 Hz, Flux density = 1.2 Wb/m², Thickness = 4 mm, Volume = 0.02 m³.

Answer:

Given:
$f = 50$ Hz, $B_m = 1.2$ T, $t = 4$ mm $= 0.004$ m, $V = 0.02$ m^3
Eddy current loss formula: $P_e = K_e f^2 B_m^2 t^2 V$
Assume $K_e = 1$ for simplicity (typical constant depends on material).

Solution:

$$P_e = (1) \times (50)^2 \times (1.2)^2 \times (0.004)^2 \times 0.02$$
$$= 2500 \times 1.44 \times 1.6 \times 10^{-5} \times 0.02$$
$$= 2500 \times 1.44 \times 3.2 \times 10^{-7}$$
$$= 2500 \times 4.608 \times 10^{-7} = 1.152 \times 10^{-3} \text{ W}$$

Final Answer:

$$\boxed{1.15 \text{ mW}}$$

Q-10: A single-phase transformer has 400 primary turns and 100 secondary turns. If primary voltage is 240 V, calculate: (a) Secondary voltage, (b) Turns ratio

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Answer:

Given:
Primary turns, $N_1 = 400$
Secondary turns, $N_2 = 100$
Primary voltage, $V_1 = 240$ V

To Find:
(a) Secondary voltage (V_2)
(b) Turns ratio (a)

Formulas:
For an ideal transformer:
Turns ratio, $a = \frac{N_1}{N_2}$

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

Solution:
(a)

$$V_2 = V_1 \times \frac{N_2}{N_1} = 240 \times \frac{100}{400} = 240 \times 0.25 = 60 \text{ V}$$

(b)

$$a = \frac{N_1}{N_2} = \frac{400}{100} = 4$$

(The turns ratio is 4:1, step-down transformer).

Final Answer:

$$\boxed{(a)\ V_2 = 60\ \text{V}(b)\ \text{Turns Ratio} = 4}$$

Q-11: A 10 kVA, 230/115 V transformer supplies full load at 0.8 power factor. Calculate: (a) Primary current, (b) Secondary current

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Answer:

Given:
$S = 10$ kVA, $V_1 = 230$ V, $V_2 = 115$ V, pf $= 0.8$

Formulas:

$$I_1 = \frac{S}{V_1}, I_2 = \frac{S}{V_2}$$

(pf not needed for magnitude of current in VA rating)

Solution:

$$I_1 = \frac{10000}{230} \approx 43.48\ \text{A}$$
$$I_2 = \frac{10000}{115} \approx 86.96\ \text{A}$$

Final Answers:
(a) Primary current: $\boxed{43.5\ \text{A}}$
(b) Secondary current: $\boxed{87.0\ \text{A}}$

Q-12: The iron loss of a transformer is 300W and copper loss at full load is 400W. Calculate efficiency at full load and 0.8 power factor.

Answer:

Given:
Iron loss (constant loss), $P_i = 300$ W

Full-load copper loss, $P_{c(FL)} = 400$ W
Full load, $x = 1$
Load power factor, $\cos\,\phi = 0.8$

To Find: Efficiency at full load (η_{FL}).

Formula:

$$\eta = \frac{xS\cos\,\phi}{xS\cos\,\phi + P_i + x^2 P_{c(FL)}} \times 100\%$$

Assumption: $S = 5000$ VA

Solution:
Full-load output power:

$$P_{\text{out(FL)}} = S\cos\,\phi = 5000 \times 0.8 = 4000\text{ W}$$

Total losses at full load:

$$P_{\text{loss}} = P_i + P_{c(FL)} = 300 + 400 = 700\text{ W}$$

Efficiency:

$$\eta_{FL} = \frac{4000}{4000 + 700} \times 100\% = \frac{4000}{4700} \times 100\% \approx 85.11\%$$

Final Answer (with assumption $S = 5$ kVA):

$$\boxed{\eta_{\text{full load}} \approx 85.1\%}$$

Q-13: A transformer delivers 5 kW at 0.9 power factor. If losses are 600 W, determine the efficiency.

Answer:

Given:
Output $P_{out} = 5$ kW $= 5000$ W, pf $= 0.9$
Losses $P_{loss} = 600$ W

Formula:

$$\eta = \frac{P_{out}}{P_{out} + P_{loss}} \times 100\%$$

Solution:

$$\eta = \frac{5000}{5000 + 600} \times 100 = \frac{5000}{5600} \times 100 \approx 89.29\%$$

Final Answer:

$$\boxed{89.3\%}$$

Q-14: A transformer has no-load loss of 200 W and full-load copper loss of 300 W. At what load will the transformer have maximum efficiency?

Answer:

Given:
No-load loss (iron loss), $P_i = 200$ W
Full-load copper loss, $P_{c(FL)} = 300$ W

To Find: The load (as fraction of full load, x) at which maximum efficiency occurs.

Concept:
Maximum efficiency occurs when **variable losses = constant losses**, i.e.,

$$x^2 P_{c(FL)} = P_i$$

Formula:

$$x = \sqrt{\frac{P_i}{P_{c(FL)}}}$$

Solution:

$$x = \sqrt{\frac{200}{300}} = \sqrt{\frac{2}{3}} \approx \sqrt{0.6667} \approx 0.8165$$

Final Answer:

$$\boxed{\text{Maximum efficiency occurs at about } 81.65\% \text{ of full load.}}$$

Q-15: A transformer has equivalent resistance of 0.5 Ω and reactance of 1.2 Ω referred to secondary. If rated current is 10 A at 0.8 lagging power factor, calculate voltage regulation.

Answer:

Given:
$R_{eq} = 0.5\ \Omega$, $X_{eq} = 1.2\ \Omega$ (referred to secondary)
Rated current $I_2 = 10$ A, pf $= 0.8$ lagging

Formula:

$$\%\text{VR} = \frac{I_2(R_{eq}\cos\ \phi + X_{eq}\sin\ \phi)}{V_2} \times 100$$

Need V_2: not given. Assume rated secondary voltage = base voltage (typically 115V from earlier, but here unspecified). Let's denote V_2 as base. Use per-unit approach:

$$\%\text{VR} = I_2(R_{eq}\cos\ \phi + X_{eq}\sin\ \phi) \times 100/V_2$$

If V_2 unknown, express in terms of V_2:
$\cos\ \phi = 0.8$, $\sin\ \phi = 0.6$

$$\%\text{VR} = \frac{10 \times (0.5 \times 0.8 + 1.2 \times 0.6)}{V_2} \times 100$$
$$= \frac{10 \times (0.4 + 0.72)}{V_2} \times 100 = \frac{11.2}{V_2} \times 100$$

If $V_2 = 115$ V (typical for such rating):

$$\%\text{VR} = \frac{1120}{115} \approx 9.74\%$$

Final Answer:

$$\boxed{9.74\%\ (\text{for } V_2 = 115V\ )}$$

Q-16: Find the percentage regulation of a transformer supplying a unity power factor load if secondary induced voltage is 220 V and terminal voltage is 210 V.

Answer:

Given:
Secondary induced voltage (no-load voltage), $E_2 = 220$ V
Secondary terminal voltage on load, $V_2 = 210$ V
Load power factor = 1 (unity)

To Find: Percentage regulation (% Reg).

Formula:
Voltage regulation is defined as the change in secondary terminal voltage from no-load to full-load, expressed as a percentage of the no-load voltage:

$$\%\text{Reg} = \frac{E_2 - V_2}{V_2} \times 100\% (\text{often uses } E_2 \text{ in denominator})$$

The more common and precise definition:

$$\%\text{Reg} = \frac{E_2 - V_2}{E_2} \times 100\%$$

Solution:

$$\%\text{Reg} = \frac{220 - 210}{220} \times 100\% = \frac{10}{220} \times 100\% \approx 4.545\%$$

Final Answer:

$$\boxed{\%\text{Regulation} \approx 4.55\%}$$

Q-17: A practical transformer has efficiency of 95% at full load. If output is 4 kW, calculate total losses.

Answer:

Given:
Efficiency $\eta = 95\%$ at full load
Output $P_{out} = 4 \text{ kW} = 4000 \text{ W}$

Formula:

$$\eta = \frac{P_{out}}{P_{out} + P_{loss}}$$
$$0.95 = \frac{4000}{4000 + P_{loss}}$$
$$4000 + P_{loss} = \frac{4000}{0.95} \approx 4210.53$$
$$P_{loss} = 4210.53 - 4000 \approx 210.53 \text{ W}$$

Final Answer:

$$\boxed{210.5 \text{ W}}$$

Q18. Two sinusoidal currents of equal magnitude and frequency but phase displaced by 90° are applied to two stator windings. If the maximum flux produced by each winding is 0.04 Wb, determine the magnitude of the resultant rotating magnetic flux.

Given:
$\phi_1\_max = \phi_2\_max = 0.04$ Wb
Phase difference = 90°

To Find:
Resultant rotating magnetic flux magnitude

Formula:
For two fluxes displaced by 90° in time and space:
$\phi\_resultant\_max = \sqrt{(\phi_1\_max^2 + \phi_2\_max^2)}$

Solution:
$\phi\_resultant\_max = \sqrt{(0.04^2 + 0.04^2)}$
$= \sqrt{(0.0016 + 0.0016)}$
$= \sqrt{(0.0032)}$
$= 0.05657$ Wb

Final Answer:

$$\boxed{0.0566\ Wb}$$

Q19. A two-phase stator produces fluxes $\phi_1 = 0.03 \sin \omega t$, $\phi_2 = 0.03 \cos \omega t$. Find the value of the resultant flux and comment on its nature.

Given:
$\phi_1 = 0.03 \sin \omega t$
$\phi_2 = 0.03 \cos \omega t$

To Find:
Resultant flux magnitude and nature

Formula:
$\phi\_resultant = \sqrt{(\phi_1^2 + \phi_2^2)}$

Solution:
$\phi\_resultant = \sqrt{[(0.03 \sin \omega t)^2 + (0.03 \cos \omega t)^2]}$
$= 0.03 \sqrt{(\sin^2\omega t + \cos^2\omega t)}$
$= 0.03 \times 1$
$= 0.03$ Wb (constant)

Comment:
The resultant flux is **constant in magnitude** (0.03 Wb) and **rotates** in space at angular speed ω. This is the principle of a **rotating magnetic field** in a two-phase induction motor.

Final Answer:

$$\boxed{0.03\ Wb}$$

Nature: Constant magnitude, rotating magnetic field.

Q20. A rotating magnetic field is produced by two stator windings carrying currents of 6 A each and displaced by 90°. If the flux per ampere is 0.005 Wb/A, calculate the maximum value of the resultant flux.

Given:
$I_1 = I_2 = 6$ A
Flux per ampere = 0.005 Wb/A
Phase displ. = 90°

To Find:
Maximum resultant flux

Formula:
Flux per winding = Flux per ampere × Current
$\phi_{max\_per\_winding} = 0.005 \times I$
Then $\phi_{R\_max} = \sqrt{\phi_1^2 + \phi_2^2}$

Solution:
$\phi_{1\_max} = \phi_{2\_max} = 0.005 \times 6 = 0.03$ Wb
$\phi_{R\_max} = \sqrt{0.03^2 + 0.03^2} = 0.03 \times \sqrt{2} = 0.04243$ Wb

Final Answer:

$$\boxed{0.04243\ Wb}$$

Q21. In a split-phase motor, the main winding carries a current of 8 A and the auxiliary winding carries 5 A with a phase difference of 30°. Calculate the resultant starting current.

Given:
$I_m = 8$ A, $I_a = 5$ A, phase angle $\theta = 30°$

To Find:
Resultant starting current I_s

Formula:
$I_s = \sqrt{I_m^2 + I_a^2 + 2 \cdot I_m \cdot I_a \cdot \cos\theta}$

Solution:
$I_s = \sqrt{8^2 + 5^2 + 2 \times 8 \times 5 \times \cos 30°}$
$\cos 30° = 0.866$
$= \sqrt{64 + 25 + 80 \times 0.866}$
$= \sqrt{89 + 69.28}$
$= \sqrt{158.28}$
$= 12.58$ A

Final Answer:

$$\boxed{12.58\ A}$$

Q22. A split-phase induction motor has main winding impedance of (6 + j4) Ω and auxiliary winding impedance of (10 + j3) Ω. Supply voltage = 230 V. Calculate:

(a) Current in main winding
(b) Current in auxiliary winding
(c) Phase angle between the two currents.

Given:
$Z_m = 6 + j4\ \Omega$, $Z_a = 10 + j3\ \Omega$, $V = 230\angle 0°$ V

To Find:
I_m, I_a, phase difference

Formula:
$I = V / Z$, Phase angle $= \tan^{-1}(\text{Imag/Real})$

Solution:

(a) $|Z_m| = \sqrt{(6^2 + 4^2)} = \sqrt{(36+16)} = \sqrt{52} = 7.211\ \Omega$
$I_m = 230 / 7.211 = 31.90$ A
$\theta_m = \tan^{-1}(4/6) = \tan^{-1}(0.6667) = 33.69°$ lagging
So $I_m = 31.90\angle -33.69°$ A

(b) $|Z_a| = \sqrt{(10^2 + 3^2)} = \sqrt{(100+9)} = \sqrt{109} = 10.44\ \Omega$
$I_a = 230 / 10.44 = 22.03$ A
$\theta_a = \tan^{-1}(3/10) = \tan^{-1}(0.3) = 16.70°$ lagging
So $I_a = 22.03\angle -16.70°$ A

(c) Phase angle between I_m and $I_a = \theta_m - \theta_a$ (since same reference)
$= 33.69° - 16.70° = 16.99°$ lag of main w.r.t auxiliary

Final Answer:

$$\boxed{I_m = 31.90\ A,\ I_a = 22.03\ A, \text{Phase difference} = 16.99°}$$

Q23. A capacitor-start motor uses a capacitor of 150 μF at 50 Hz with a supply of 230 V. Calculate:

(a) Capacitive reactance
(b) Capacitor current

Given:
$C = 150\ \mu F = 150 \times 10^{-6}$ F, $f = 50$ Hz, $V = 230$ V

To Find:
X_C, I_C

Formulas:
X_C = 1 / (2πfC)
I_C = V / X_C

Solution:
X_C = 1 / (2 × 3.1416 × 50 × 150×10^{-6})
= 1 / (0.047124) = 21.22 Ω
I_C = 230 / 21.22 = 10.84 A

Final Answer:

$$\boxed{X_C = 21.22\,\Omega,\ I_C = 10.84\,A}$$

Q24. A capacitor start-capacitor run motor delivers 1.5 kW output at an efficiency of 75%. Calculate input power and input current at 230 V.

Given:
P_out = 1.5 kW = 1500 W, η = 75% = 0.75, V = 230 V

To Find:
P_in, I_in

Formulas:
η = P_out / P_in ⇒ P_in = P_out / η
P_in = V × I × p.f. (Assuming p.f. = 1 for simplicity if not given)

Solution:
P_in = 1500 / 0.75 = 2000 W
Assuming unity power factor:
I_in = P_in / V = 2000 / 230 = 8.696 A

Final Answer:

$$\boxed{P_{in} = 2000\,W,\ I_{in} = 8.70\,A}$$

Q25. A single-phase motor driving a water pump delivers 1.1 kW output with efficiency of 70%. Calculate input power and current drawn from 230 V supply.

Given:
P_out = 1.1 kW = 1100 W, η = 70% = 0.70, V = 230 V

Solution:
P_in = 1100 / 0.70 = 1571.43 W

Assuming p.f. = 1 (not given):
I_in = 1571.43 / 230 = 6.83 A

Final Answer:

$$\boxed{P_{in} = 1571.43\ W,\ I_{in} = 6.83\ A}$$

Q26. A refrigerator motor draws 2.8 A from a 230 V supply at 0.85 power factor. Calculate input power.

Given:
I = 2.8 A, V = 230 V, p.f. = 0.85

Formula:
P_in = V × I × p.f.

Solution:
P_in = 230 × 2.8 × 0.85 = 230 × 2.38 = 547.4 W

Final Answer:

$$\boxed{547.4\ W}$$

Q27. A ceiling fan motor consumes 75 W of power at rated conditions. If efficiency is 65%, calculate mechanical output power.

Given:
P_in = 75 W, η = 65% = 0.65

Formula:
P_out = η × P_in

Solution:
P_out = 0.65 × 75 = 48.75 W

Final Answer:

$$\boxed{48.75\ W}$$

Q28. A BLDC motor operates from a 48 V DC supply and draws 12 A. Calculate electrical input power.

Given:
V = 48 V, I = 12 A (DC)

Formula:
$P\_in = V \times I$

Solution:
$P\_in = 48 \times 12 = 576$ W

Final Answer:

$$\boxed{576\,W}$$

Q29. A BLDC motor has efficiency of 88% and electrical input of 900 W. Calculate mechanical output power.

Given:
$\eta = 88\% = 0.88$, $P\_in = 900$ W

Formula:
$P\_out = \eta \times P\_in$

Solution:
$P\_out = 0.88 \times 900 = 792$ W

Final Answer:

$$\boxed{792\,W}$$

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