Electrical Machines

Answer Keys and Explanations

1. **[Ans. B]**
(Transformer B has more weight than A)
Since, both are connected to the same bus bar so both will have same voltage, 'V' applied
$V \propto \phi$, so flux is also constant in both transformers
Now, $\phi = B.A$, $B \rightarrow$ filux density
$A \rightarrow$ Area of come
$B \propto \frac{1}{A} . \because \phi = \text{Constant}$
$\therefore$ Area of transformer A come is less than that of B. So weight of transformer B is more than A.

2. **[Ans. C]**

3. **[Ans. *] Range: 0.955 to 0.965**
Number of slots per pole per phase =g'=3.
With 3 phase, number of slots per pole $= g\ 3 \times 3 = 9$. Slot pitch $\Psi = \frac{180°}{9} = 20°$ elec
For 60° phase spread double layer winding, distribution factor is given by
$k_d = \frac{\sin g^1 \frac{\Psi}{2}}{g^1 \sin \frac{\Psi}{2}} = \sin \frac{\frac{3 \times 20°}{2}}{3 \sin \frac{20°}{2}} = \frac{\sin 30°}{3 \sin 10°} = 0.96$

4. **[Ans. *] Range 600 to 600**
For convenience let the slope of the linear portion of OCC=m.
m is directly proportional to the speed of the rotor. Operating as a shunt generator, m must be greater than or equal to the filed circuit resistance for buildup, the quality giving the critical speed at 1500 RPM, m=250 (given)
For $m = 100$, Speed $= \frac{100}{250} \times 1500 = 600$ RPM

5. **[Ans. D]**
Method 1:
Supply voltage $V_1 = 800V$
Primary turns $N_1 = 1250$
Secondary turns $N_2 = 800$
Secondary voltage $V_2 = V_1 \times \frac{N_2}{N_1} = 250 \times \frac{800}{1250} = 160V$
Method 2:
EMF per turn $= \frac{V_1}{N_1} = \frac{250}{1250} = 0.2V$
And secondary voltage V_2 = EMF per turn × secondary turns $= 0.2 \times 800 = 160V$

6. **[Ans. *] Range 210 to 212**

Main winding impedance, $Z_m = (4.5 + j3.7)\Omega$ or $5.826\angle 39.43°\Omega$

Main winding current, I_m lags behind the applied V by 39.43°

Auxiliary winding impedance, $Z_a = (9.5 + j3.5)\Omega$

Since, time phase angle between auxiliary winding current I_a is 90°, so auxiliary winding current I_a must lead the applied voltage by$(90° - 39.43°)$or 50.57 °.

If X_c is the capacitive reactance of the capacitor connected in series with the auxiliary winding, then impedance of the auxiliary winding will be given as

$Z_a = (9.5 + j3.5 - jX - c)$or $[9.5 + j(3.5 - X_c)]$ohm

For auxiliary winding,

$$\tan\phi_m = \frac{3.5 - X_c}{9.5}$$

$$\Rightarrow X_c = 3.5 - 9.5\tan\phi_a = 3.5 - 9.5\tan(-50.57)°$$

$$= 3.5 + 11.553 = 15.053\Omega$$

$$\text{Capaitance, } C = \frac{1}{2\pi f X_c} = \frac{1}{2\pi \times 50 \times 15.053} = 211.5\mu F$$

7. **[Ans. D]**

$T_s = 1.5T_f$

$T_{max} = 2T_f$

For maximum torque, $s_{mT} = \frac{r_2}{x_2}$

$$\frac{T_s}{T_{max}} = \frac{1.5T_f}{2T_f} = \frac{2s_{mT}}{1 + s_{mT}^2}$$

i.e., $1.5\, s_{mT}^2 4s_{mT} + 1.5 = 0$

$\therefore s_{mT} = 0.45$

also, $\frac{T_f}{T_{max}} = \frac{T_f}{2T_f} = \frac{2s_{mT}}{s_{mT}^2 + s^2}$

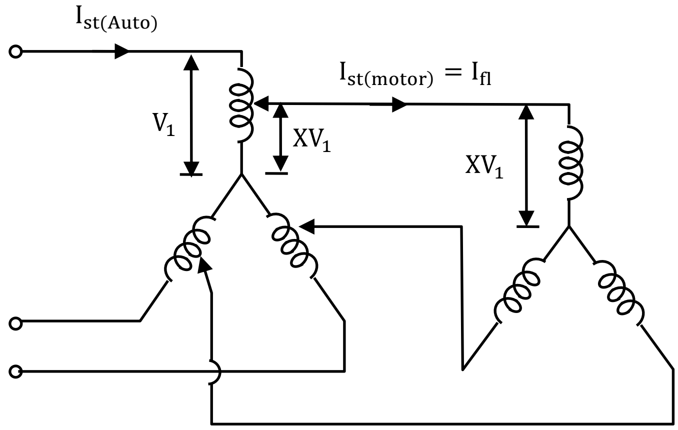
at $s_{mT} = 0.45$,

$s^2 - 4s_{mT}s + s_{mT}^2 = 0$

$\Rightarrow s^2 - 4(0.45)s + (0.45)^2 = 0$

$s = 0.12$

8. **[Ans. *] Range 141 t0 143**



$x = 60\% = 0.6$

$I_{fl(motor)} = \frac{50 \times 10^3}{\sqrt{3} \times 440} = 65.61a$

$I_{st(motor)} = 6I_{fl} = 6 \times 65.61\text{ A} = 393.65a$

$I_{st(Auto)} = x^2 I_{st(motor)}$

$= (0.6)^2 \times 393.65a$

$= 141.71A$

9. **[Ans. *] Range 15to 16**

$N_s = \frac{120f_1}{P} = \frac{120 \times 50}{6} = 1000\text{rpm}$

$s = \frac{f_2}{f_1} = \frac{1.5}{50} = 0.03 \text{ or } 3\%$

$N_r = (1 - s)N_s = (1 - 0.03) \times 1000 = 970\text{ rpm}$

$\omega_r = 2\pi N_r = \frac{2\pi \times 970}{60}\ 101.58\text{ rad/s}$

Shaft power output $P = T\omega_r$

$= 150 \times 101.58 = 15236W = 15.236\text{ kW}$

10. **[Ans. A]**

$f_1 = \frac{PN_s}{120}$

$50 = \frac{6 \times N_s}{120}, N_s = \frac{120 \times 50}{6} = 1000\text{ rpm}$

$s = \frac{N_s - N_r}{N_s} = \frac{1000 - 960}{1000} = 0.04\text{p.u.}$

Rotor copper loss $= \frac{s}{1 - s} \times$ Mechanical power developed

$3I_2^2R_2 + 250 = \frac{0.04}{1 - 0.04}(25 \times 746 + 1000)$

$3 \times 35^2R_2 = 818.75 - 250$

$R_2 = \frac{568.75}{3 \times 35^2} = 0.154\Omega$