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Machines Assignment 3

Q:1

$S_{b1} = 1000\text{ KVA}$, $S_{b2} = 1000\text{KVA}$, $S_{b3} = 1000\text{KVA}$

$V_{b1} = 480\text{ V}$, $V_{b2} = 14400\text{ V}$, $V_{b3} = 480\text{ V}$

$V_\phi = \frac{480}{\sqrt{3}} = 277\text{V}$, $V_\phi = 8313.84\text{V}$, $V_\phi = 277\text{V}$

$Z_{b1} = \frac{3\times(V_\phi)^2}{S_{b1}}$, $Z_{b2} = \frac{3\times(V_\phi)^2}{S_{b2}}$, $Z_{b3} = \frac{3\times(V_\phi)^2}{S_{b3}}$

$Z_{b1} = 0.23\,\Omega$, $Z_{b2} = 207.4\,\Omega$, $Z_{b3} = 0.23\,\Omega$

a

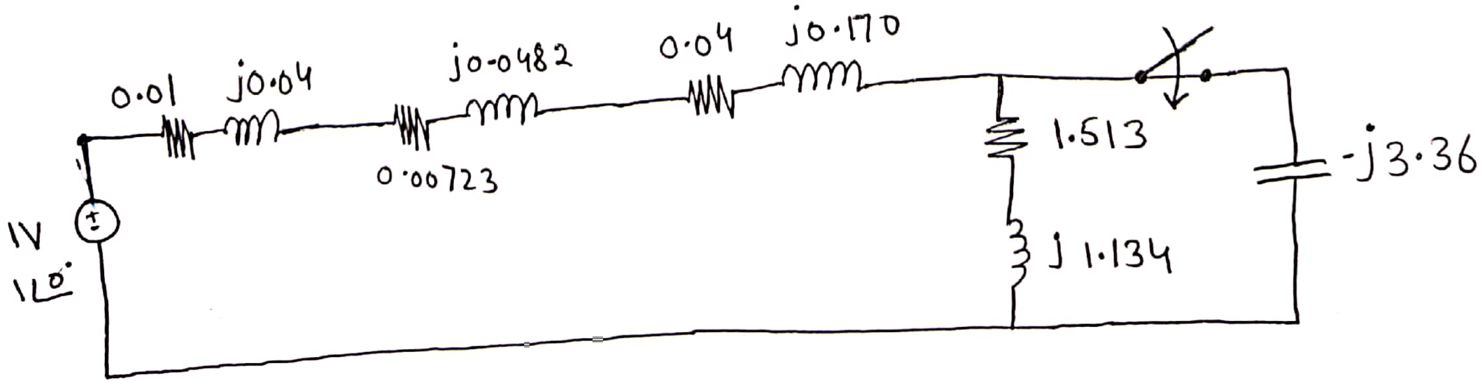
$R_{1pu} = 0.01$, $X_{1pu} = 0.04$

$R_{2pu} = (0.02)\left[\frac{(8314)^2}{(8314)^2} \times \frac{1000\text{KVA}}{500\text{KVA}}\right] = 0.04$, $X_{2pu} = (0.085)(02) = 0.170$

$Z_{line\ pu} = \frac{Z_L}{Z_{b2}} = \frac{(1.5+j10)}{207.4} = 0.00723 + j0.0482$

$Z_{load1\ pu} = \frac{0.45\angle 36.87^\circ}{0.23} = 1.513 + j1.134$

$Z_{load2\ pu} = \frac{-j0.8}{0.23} = -j3.36$



(b) $Z_{eq} = (0.01 + j0.04) + (0.00723 + j0.0482) + (0.04 + j0.170) + (1.513 + j1.134)$

$\boxed{Z_{eq} = 2.1 \angle 41.6^\circ}$

$I_{Total} = \frac{V}{Z_{eq}} = \frac{1}{2.1\angle 41.6}$, $\boxed{I = 0.4765 \angle -41.6^\circ}$

$V_{Load} = (I)(Z_{Load}) = (0.4765\angle -41.6^\circ)(1.513 + j1.134) = 0.9 \angle -4.7^\circ$

$V_{Load} = (480)(0.9)$, $\boxed{V_{Load} = 432\ V}$

$P_{Load} = (S_b)(I^2)(R_{load}) = (1000000)(0.4765^2)(1.513) \Rightarrow \boxed{344\ KW}$

$P_{supplied} = (V)(I)\cos(\theta) = (1)(0.4765)\cos(41.6^\circ) \Rightarrow 0.356\ pu$

$P_{supplied} = (0.356)(1000000) \Rightarrow \boxed{356\ KW}$

$Q = (S_b)(VI\sin\theta) = (1000000)(1)(0.4765\sin(41.6^\circ)) \Rightarrow \boxed{316\ KVAR}$

$S = (S_b)(V)(I) = (1000000)(1)(0.4765) \Rightarrow \boxed{476.5\ KVA}$

$PF = \cos\theta = \cos(41.6^\circ) = \boxed{0.748 \text{ lagging}}$

(c) $Z_{eq} = (0.01 + j0.04) + (0.00723 + j0.0482) + (0.04 + j0.170) + \left[\frac{(1.513 + j1.134)(-j3.36)}{1.513 + j1.134 - j3.36}\right]$

$\boxed{Z_{eq} = 2.443 \angle 8.65^\circ}$

$I = \frac{V}{Z_{eq}} = \frac{1}{2.443\angle 8.65^\circ} \Rightarrow \boxed{0.409 \angle -8.65^\circ}$

$V_{Load} = (V_{b3})(I)(Z_{load}) = (480)(0.409\angle -8.65)(2.358 + j0.109)$

$\boxed{V_{load} = 464\ V}$

$P_{load} = (S_b)(I^2)(R_{load}) = (1000000)(0.409^2)(2.358) = \boxed{394\ KW}$

$P_{supp} = (VI\cos\theta) \times (S_b) = (1)(0.409)\cos(6.08^\circ) \Rightarrow \boxed{407\ KW}$

$Q = (VI\sin\theta)(S_b) = (1)(0.409)\sin(6.08)(1000000) \Rightarrow \boxed{42.8\ KVAR}$

$S = (S_b)(V)(I) = (1000000)(1)(0.409) \Rightarrow \boxed{409\ KVA}$

$PF = \cos\theta = \cos(6.08^\circ) \Rightarrow \boxed{0.995 \text{ lagging}}$

(d) $P_{line} = (S_b)(I_T^2)(R_{line}) = (1000000)(0.4765^2)(0.00723)$

$\boxed{P_{line} \Rightarrow 1.64\ KW}$ → line loss with switch open

$P_{line} = (S_b)(I)(R_{line}) \Rightarrow (1000000)(0.409)(0.00723)$

$\boxed{P_{line} \Rightarrow 1.21\ KW}$

As computed in part (c), adding a capacitor at the load has increased / improved the power factor. Hence less line losses will take place by the addition of capacitor

$1.21\ KW < 1.64\ KW$

Q:- 2

$B = 0.4 T$ $\quad$ $V_B = 48V$

$l = 0.5 m$ $\quad$ $R = 0.4 \Omega$

$r = 0.25 m$ $\quad$ $\omega = 500 \, rad s^{-1}$

(a)

$$e_{ind} \Rightarrow 2rlB\omega = 2(0.25)(0.5)(0.4)(500)$$

$$\boxed{e_{ind} \Rightarrow 50 V}$$

as $e_{ind} > V_B$, so the machine is operating as a generator.

(b) $$i = \frac{e_{ind} - V_B}{R} = \frac{50-48}{0.4} , \quad \boxed{i = 5A}$$

$$P = V_B \times i = (48)(5) = 240 W$$

$$P = e_{ind} \times i = (50)(5) = 250 W$$

$$P = (i^2)(R) = (5^2)(0.4) = 10 W$$

(c) $\omega = 550 \, rad s^{-1}$

$$i = \frac{e_{ind} - V_B}{R} = \frac{(2rlB\omega - V_B)}{R} = \frac{(2(0.25)(0.5)(0.4)(550-48))}{0.4}$$

$$\boxed{i = 17.5A}$$

if ω increases, current (i) also increases.

(d) $\omega = 450 \text{ rad s}^{-1}$

$$i = \frac{e_{ind} - V_B}{R} = \frac{2(0.25)(0.5)(0.4)(450) - 48}{0.4}$$

$\boxed{i = -7.5 \text{ A}}$ $\boxed{i = 7.5 \text{ A}}$

it means the direction of the current will be reversed by slowing down the speed of rotor to 450 rad s^{-1}.

Q:- 3

(1) $m = 2$, Poles $= P = 8 = 8$

coils $= 64$, 10 turns / coil, 2 conductors / turn

(a) $E = K\phi\omega = \frac{ZP}{2\pi a} \times \phi\omega$

$$120 = \frac{[(64)(10)(2)][8] \times \phi \times (3600)(2\pi)}{(2\pi)(2)(8) \times (60 \text{ seconds})}$$

$$120 = 38400\phi$$

$$\boxed{\phi = 3.125 \text{ mWb}}$$

(b) $I = ?$

$$I = \frac{P}{V \times a} = \frac{P}{V \times mP} = \frac{25\ KW}{(120)(2)(8)}$$

$$\boxed{I = 13.02\ A}$$

(c) Induced Torque $= \tau_{ind} = ?$

$$\tau_{ind} = \frac{ZP \times \phi \times I \times a}{2\pi a} = \frac{(1280)(8)(0.003125)(13.02)\cancel{(16)}}{2\pi \times \cancel{(2)}\cancel{(8)}}$$

$$\boxed{\tau_{ind} = 66.31\ Nm}$$

(d) A DC generator having a duplex lap wound armature must have 8 brushes in the motor and each brush must be wide enough to strech across 2 complete commutator segments.

(e)
$$R_A = \frac{N_P \times 0.011}{a} = \quad = \frac{(64)(10)(0.011)}{a \times a}$$

$$R_A = 0.0275\ \Omega$$

$$\boxed{R_A = 27.5\ m\Omega}$$

Q3

(2) $P = 8$, Λ $I_A = 120\,A$

(a) $I = \dfrac{I_A}{a} = \dfrac{120}{(8)(1)}$ $\boxed{I = 15A}$

(b) $I = \dfrac{I_A}{a} = \dfrac{120}{(8)(2)}$ $\boxed{I = 7.5A}$

(c) $I = \dfrac{I_A}{2m} = \dfrac{120}{2\times 1}$ $\boxed{I = 60A}$

Q:- 4

(1) $P = 2$, Coils $= 8$, 10 turns / coil

$\phi_p = 0.006\,Wb$

(a) at no load $V_T = E_A = K\phi\omega$, $\omega = \dfrac{E_A}{K\phi}$

$K = \dfrac{ZP}{2\pi a} = \dfrac{[(6)(4)(2)][2]}{(2\pi)(2)} = 7.64$

$\omega = \dfrac{12V}{(7.64)(0.006)}$, $\boxed{\omega = 262 \text{ rads}^{-1}}$

$n = (\omega)(\frac{1}{2\pi})(60)$, $\boxed{n = 2502 \text{ radian/min}}$

(b) If the positive terminal of the battery is connected with the right most brush then the current will flow (into the page) under the south pole face and the motor will start rotating.

(c) $P = 600 \text{ W}$

$$I = \frac{P}{V_B} = \frac{600}{12} = \boxed{50A = I}$$

$$\tau = K\phi I = (7.64)(0.006)(50)$$

$$\boxed{\tau = 2.3 \text{ Nm}}$$

Q4

(2) $P = 20$

(a) $a = mP = (1)(20)$ $\boxed{a = 20 \text{ paths}}$

(b) $a = 2m = (2)(2) = \boxed{4 \text{ Paths}}$

(c) $a = mp = (3)(20) = \boxed{a = 60 \text{ paths}}$

(d) $a = 2m = (2)(4) = \boxed{8 \text{ paths}}$