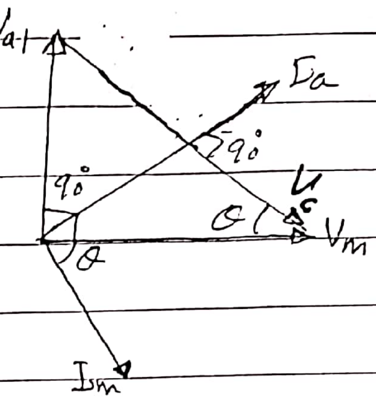
Q6)



For balanced conditions, the voltage across the auxiliary winding V_{a1} is

$V_{a1} = V_m - V_c = ja V_m$

$P = V_m I_m \cos\theta$

$1.25 \times 10^3 = 250 \times 12.5 \cos\theta$

$\cos\theta = 0.4$

$\theta = 66.42°$

$\tan\theta = a = \frac{V_{a1}}{V_m}$

$a = \tan 66.42 = 2.29$

$a = \frac{N_a}{N_m} \Longrightarrow N_a = a N_m = 2.29 \times 600$

$N_a = 1374$ turns

For balanced condition

$I_b = I_m + ja I_a = 0$ (only I_f exists)

$I_m = -ja I_a$

$|I_m| = a |I_a|$

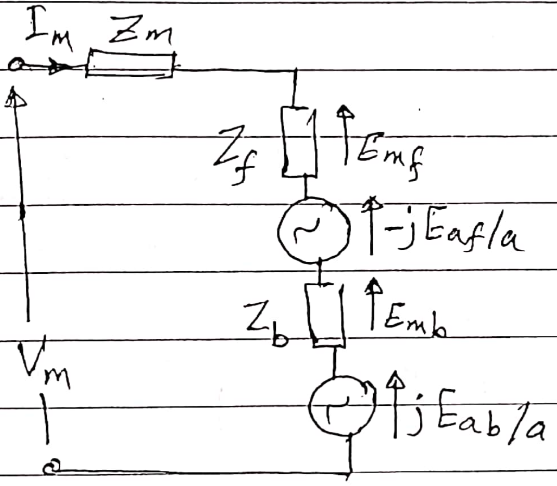
$|I_a| = \frac{|I_m|}{a} = \frac{12.5}{2.29} = 5.45$ A

$\cos\theta = \frac{V_m}{V_c}$

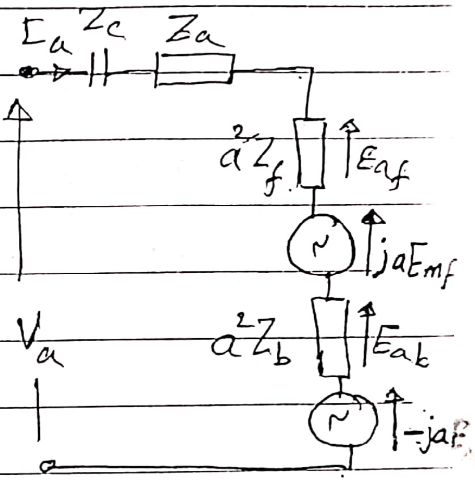
$V_c = \frac{V_m}{\cos\theta} = \frac{250}{0.4} = 625$ V

$VA = V_c I_a = 625 \times 5.45 = 3.40$ KVA

Q7) A) The equivalent circuits through main and auxiliary windings for operation with both windings, assuming the slip is "s" are shown below.



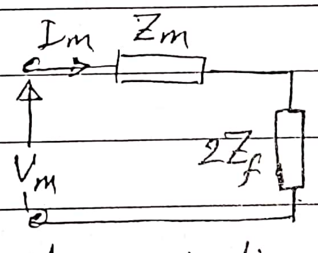
Main winding circuit



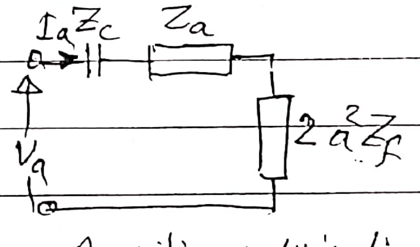
Auxiliary winding circuit.

for $s=1$ $Z_f = Z_b$, $E_{mf}=E_{mb}$, and $E_{af}=E_{ab}$

The equivalent circuits are simplified.



Main winding circuit



Auxiliary winding circuit.

From the above simplified circuits

$$I_m = \frac{V_m}{Z_m + 2Z_f}, \text{ and } I_a = \frac{V_a}{Z_c + Z_a + 2a^2 Z_f}$$

B) For single phase induction motor,

$V_a = V_m = V$,

$$\frac{I_m}{I_a} = \frac{\frac{V}{Z_m + 2Z_f}}{\frac{V}{Z_c + Z_a + 2a^2 Z_f}} = \frac{Z_c + Z_a + 2a^2 Z_f}{Z_m + 2Z_f}.$$

$$Z_f = Z_b = jX_m/2 \,//\, \left(\frac{r_2}{2} + j\frac{X_2}{2}\right)$$

$$= j20 \,//\, (2+j2) = \frac{(2+j2)\times j20}{2+j2+j20} = \frac{2.82\angle 45^\circ \times 20\angle 90^\circ}{22.09\angle 84.8^\circ}$$

$$= 2.55\angle 50.2^\circ = 1.63 + j1.95$$

For balanced condition $I_b = I_m + jaI_a = 0$

$I_m = -jaI_a$

$\therefore \frac{I_m}{I_a} = -ja$

$$\frac{I_m}{I_a} = -ja.8 = \frac{Z_c + (3+j3) + 2\times 0.8^2 (1.63 + j1.95)}{(5+j6) + 2(1.63 + j1.95)}$$

$$-j0.8 = \frac{Z_c + 5.08 + j5.49}{8.26 + j9.9}$$

$$Z_c + 5.08 + j5.49 = -j6.6 + 7.92$$

$$Z_c = -j12.09 + 2.84$$

$$X_c = \frac{1}{2\pi f c} \Rightarrow C = \frac{1}{X_c \times 2\pi f} =$$

$$C = \frac{1}{12.09 \times 2\pi \times 50} = 263\ \mu F$$

c) $Z_c = (2.84 - j12.09)\,\Omega$

Q8) a) $I_m = 15A$, $I_a = 10A$, $\alpha = 60^\circ$ and $a = 1.5$

$T_f = I_f^2 R_f$, $T_b = I_b^2 R_b$ ($R_f = R_b$ at starting).

$$\frac{T_f}{T_b} = \frac{[|I_m|^2 + a^2|I_a|^2 + 2a|I_a||I_m|\sin\alpha]\cancel{R_f}}{[|I_m|^2 + a^2|I_a|^2 - 2a|I_a||I_m|\sin\alpha]\cancel{R_b}}$$

$$\frac{T_f}{T_b} = \frac{15^2 + 1.5^2 \times 10^2 + 2\times 1.5\times 15\times 10 \sin 60}{15^2 + 1.5^2 \times 10^2 - 2\times 1.5\times 15\times 10 \sin 60}$$

$$\frac{T_f}{T_b} = \frac{839.711}{60.2885} = 13.9782$$

(b) $$\frac{T_f}{T_s} = \frac{T_f}{T_f - T_b} = \frac{[|I_m|^2 + a^2|I_a|^2 + 2a|I_m||I_a|\sin\alpha]\cancel{R_f}}{4a|I_a||I_m|\sin\alpha\,\cancel{R_f}}$$

$\therefore T_s = 2a|I_a||I_m|(R_f + R_b)\sin\alpha$, but $R_f = R_b \Rightarrow T_s = 4a|I_a||I_m|R_f\sin\alpha$

$$\frac{T_f}{T_s} = \frac{|I_m|^2 + a^2|I_a|^2 + 2a|I_a||I_m|\sin\alpha}{4a|I_a||I_m|\sin\alpha} = \frac{I_f^2 R_f}{I_f^2 R_f - I_b^2 R_b}$$

$$\frac{T_f}{T_s} = \frac{839.711}{799.423} = 1.05$$