เฉลย วิศวกรรมไฟฟ้า ปริญญาตรี

1/2558

ข้อ ①

$$z_1 = 40 + j30\ \Omega = 50\angle 36.87^\circ\ \Omega$$

$$z_2 = j(80-40)$$

$$z_2 = 0 + j40 = 40\angle 90^\circ\ \Omega$$

$$z_3 = 0 + j(40-50) = 0 - j10 = 10\angle -90^\circ\ \Omega$$

$$z_4 = 100 + j0 = 100\angle 0^\circ$$

$$\bar{Y}_T = \bar{Y}_1 + \bar{Y}_2 + \bar{Y}_3 + \bar{Y}_4$$

$$= \frac{1}{\bar{z}_1} + \frac{1}{\bar{z}_2} + \frac{1}{\bar{z}_3} + \frac{1}{\bar{z}_4}$$

$$\bar{Y}_T = \frac{1}{50\angle 36.87^\circ} + \frac{1}{40\angle 90^\circ} + \frac{1}{10\angle -90^\circ} + \frac{1}{100\angle 0^\circ}\ \mho$$

$$\bar{Y}_T = 0.02\angle -36.87 + 0.025\angle -90 + 0.1\angle 90 + 0.01\angle 0^\circ$$

$$\bar{Y}_T = 0.0154 - j0.0120 + 0 - j0.025 + 0 + j0.1 + 0.01 + j0$$

$$\bar{Y}_T = 0.0254 + j0.063\ \mho = 0.0681\angle 67.85^\circ$$

ดังนั้น $\bar{Y}_T = G_T + jB_C = G_T + j\omega C$

$= G_T + j2\pi fC$

$\therefore B_C = 0.063$ ℧

$\therefore 2\pi fC = 0.063$

$C = \frac{0.063}{2\pi f}$ F.

ที่ความถี่ $f = 60$ Hz

$C = \frac{0.063}{2\pi \times 60} = 1.671 \times 10^{-4}$ F.

$C = 167.1$ μF

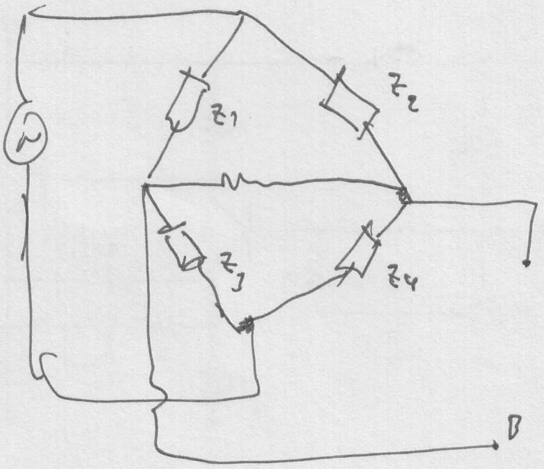
ค่าของ สมดุล $\bar{Z}_{eq} = 216.9 \angle 12.53^\circ \ \Omega$

ข้อ ② วงจรบริดจ์

$$\bar{X}_C = -j\frac{1}{2\pi f C}$$

$$= -j\frac{1}{\omega C}$$

$$\bar{X}_L = j\omega L = j2\pi f L$$



สมดุล $V_{AB} = 0\ V$

ไม่สมดุล $V_{AB} \neq 0\ V$.

ในสภาวะสมดุลย์ $\dfrac{Z_1}{Z_3} = \dfrac{Z_2}{Z_4}$ —— ①

หรือ $\dfrac{Z_1}{Z_2} = \dfrac{Z_3}{Z_4}$ —— ②

หรือ $\dfrac{\bar{Z}_3}{\bar{Z}_1} = \dfrac{\bar{Z}_4}{\bar{Z}_2}$ —— ③

ตามสูตร $\bar{Z}_1 = 200 + j0 = 200 \angle 0^\circ$

$$\bar{Z}_2 = -j\frac{1}{\omega C} = -j\frac{1}{2\pi f C}$$

$$\omega = 2\pi f = 1000$$

$$f = \frac{1000}{2\pi} = 159.15\ Hz$$

$$\bar{Z}_2 = -j\frac{1}{2\pi \times 159.15 \times 1.25 \times 10^{-6}}\ \Omega$$

$$\bar{Z}_2 = -j\,800\ \Omega = 0 - j\,800\ \Omega$$

$$\bar{Z}_2 = 800\angle -90^\circ\ \Omega$$

$$\bar{Z}_3 = +j2\pi fL = +j(2\times\pi\times 159.15\times 0.1)$$

$$\bar{Z}_3 = j\,99.99 = 0 + j100\ \Omega = 100\angle +90^\circ$$

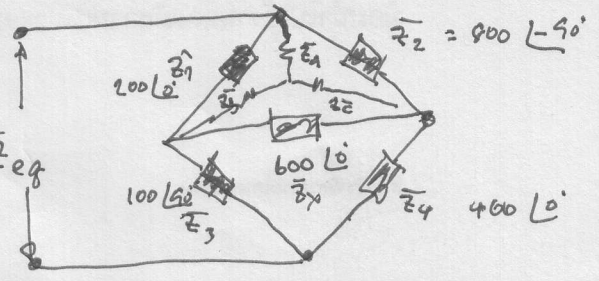
$$\bar{Z}_4 = 400 + j0 = 400\angle 0^\circ\ \Omega$$

এখন ব্রিজের শর্ত $\dfrac{\bar{Z}_1}{\bar{Z}_2} = \dfrac{\bar{Z}_3}{\bar{Z}_4}$

$$\frac{200\angle 0^\circ}{800\angle -90^\circ} = \frac{100\angle +90^\circ}{400\angle 0^\circ}$$

$$0.25\angle 90^\circ = 0.25\angle 90^\circ$$

ব্রিজটি সমতুল্য



$$\omega \quad \bar{Z}_a = \frac{\bar{Z}_1 \bar{Z}_2}{\bar{Z}_1 + \bar{Z}_2 + \bar{Z}_x}$$

$$\bar{Z}_a = \frac{200\angle 0^\circ \times 800\angle -90^\circ}{200\angle 0^\circ + 800\angle -90^\circ + 600\angle 0^\circ}$$

$$= \frac{160\text{k}\angle -90^\circ}{200 + j0 + 0 - j800 + 600 + j0}$$

$$= \frac{160\text{k}\angle -90^\circ}{800 - j800} = \frac{160\text{k}\angle -90^\circ}{1131.37\angle -45^\circ}\ \Omega$$

$$\bar{Z}_a = 141.42\angle -45^\circ\ \Omega$$

$$\bar{Z}_b = \frac{\bar{Z}_1 \times \bar{Z}_x}{\bar{Z}_1 + \bar{Z}_2 + \bar{Z}_x} = \frac{200\angle 0^\circ \times 600\angle 0^\circ}{1131.37\angle -45}$$

$$\bar{Z}_b = \frac{120\text{k}\angle 0^\circ}{1131.37\angle -45^\circ} = 106.06\angle 45^\circ\ \Omega$$

$$\bar{Z}_c = \frac{\bar{Z}_2 \times \bar{Z}_x}{\bar{Z}_1 + \bar{Z}_2 + \bar{Z}_x} = \frac{800\angle -90^\circ \times 600\angle 0^\circ}{1131.37\angle -45^\circ}$$

$$\bar{Z}_c = \frac{480\text{k}\angle -90^\circ}{1131.37\angle -45^\circ} = 424.26\angle -45^\circ\ \Omega$$

$$\bar{Z}_{T_1} = \bar{Z}_b + \bar{Z}_3 = 106.06 \angle 45^\circ + 100 \angle 90^\circ$$

$$\bar{Z}_{T_1} = 74.99 + j74.99 + 0 + j100$$

$$= 74.99 + j174.99$$

$$\bar{Z}_{T1} = 190.38 \angle 66.80^\circ \quad \Omega$$

$$\bar{Z}_{T_2} = \bar{Z}_c + \bar{Z}_4 = 424.26 \angle -45^\circ + 400 \angle 0^\circ$$

$$\bar{Z}_{T_2} = 299.99 - j299.99 + 400 + j0$$

~~$\bar{Z}_{T_2} = 300 - j300$~~ ~~700~~

$$\bar{Z}_{T_2} = 700 - j300 \quad \Omega$$

$$\bar{Z}_{T_2} = 761.57 \angle -23.19^\circ$$

$$\bar{Z}_{T_3} = \bar{Z}_{T1} \,//\, \bar{Z}_{T_2} = \frac{\bar{Z}_{T_1} \times \bar{Z}_{T_2}}{\bar{Z}_{T_1} + \bar{Z}_{T_2}}$$

$$\bar{Z}_{T_3} = \frac{190.38 \angle 66.80^\circ \times 761.57 \angle -23.19^\circ}{190.38 \angle 66.80^\circ + 761.57 \angle -23.19}$$

$$\bar{Z}_{T_3} = \frac{144.98 \angle 43.61^\circ}{74.99 + j174.99 + 700 - j300} \quad \Omega$$

$$\bar{Z}_{T_3} = \frac{144.98 \angle 43.61^\circ}{774.99 - j125.01} = \frac{144.98 \angle 43.61^\circ}{785.00 \angle -9.163}$$

$$\bar{Z}_{T_3} = 0.1846 \angle 52.773 \; \Omega$$

$$\bar{Z}_{eq} = \bar{Z}_a + \bar{Z}_{T_3} = 141.42 \angle -45^\circ + 0.1846 \angle 52.773$$

$$\bar{Z}_{eq} = + 100 - j100 + 0.1116 + j0.1469$$

$$\bar{Z}_{eq} = 100.1116 - j99.88 \; \Omega$$

$$\bar{Z}_{eq} = 141.41 \angle -44.93 \; \Omega$$

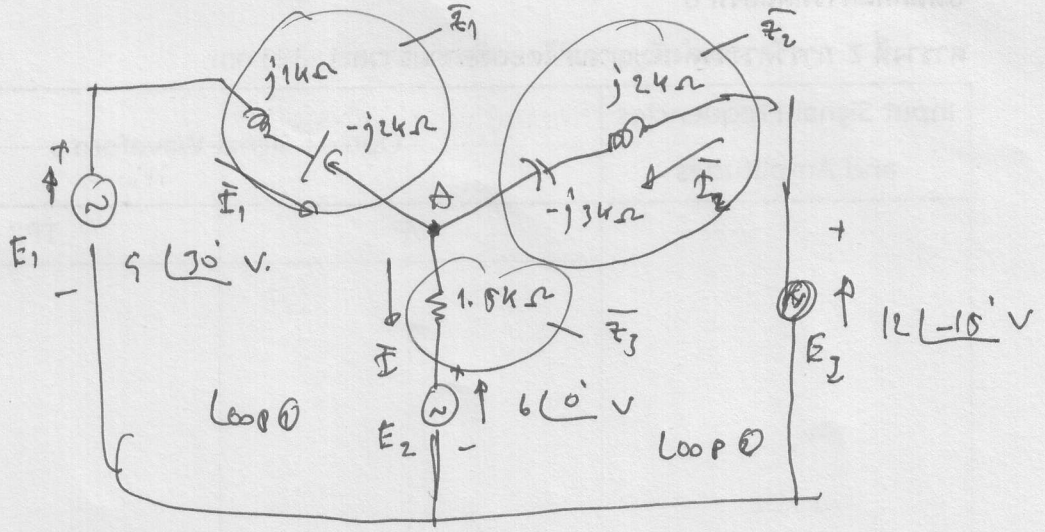
$$\bar{Z}_{eq} = 916.9 \angle 12.53^\circ = (Z_1 + Z_3) \,//\, (\bar{Z}_2 + \bar{Z}_4)$$

ข้อที่ 600∠0°

บริดจ์สมดุล

$\bar{I} = 8.82 \angle 8.94°$ mA

วิธี ① ออก $\bar{I}$



วิธีอื่นๆ $\bar{Z} \to k\Omega \to \bar{I} \to mA$.

Node A

$$\bar{I}_1 + \bar{I}_2 = \bar{I} \qquad \text{——— ①}$$

$$\bar{Z}_1 = 0 + j(1-2) = 0 - j = 1 \angle -90° \ k\Omega$$

$$\bar{Z}_2 = 0 + j(2-3) = 0 - j = 1 \angle -90° \ k\Omega$$

$$\bar{Z}_3 = 1.5 \angle 0° \ k\Omega = 1.5 + j0 \ k\Omega$$

Loop ①

$$-5 \angle 30° + \bar{I}_1 \bar{Z}_1 + \bar{I} \bar{Z}_3 + 6 \angle 0° = 0$$

แทน $\bar{I} = \bar{I}_1 + \bar{I}_2$

$$-5 \angle 30° + \bar{I}_1 \bar{Z}_1 + (\bar{I}_1 + \bar{I}_2)\bar{Z}_3 + 6 \angle 0° = 0$$

$$(\bar{Z}_1 + \bar{Z}_3)\bar{I}_1 + \bar{Z}_3 \bar{I}_2 = 5 \angle 30° - 6 \angle 0°$$

$$(0 - j + 1.5 + j0)\bar{I}_1 + (1.5 + j0)\bar{I}_2 = 7.754 + j4.5 - (6 + j0)$$

$$(1.5 + -j)\,\bar{I}_1 + (1.5 + j0)\,\bar{I}_2 = 1.794 + j4.5$$

$$1.802\angle -33.69^\circ\,\bar{I}_1 + 1.5\angle 0^\circ\,\bar{I}_2 = 4.844\angle 68.26^\circ \quad \text{——} (1)$$

Loop (2)

$$-6\angle 0^\circ - \bar{Z}_3\bar{I} - \bar{Z}_2\bar{I}_2 + 12\angle -15^\circ = 0$$

$$-\bar{Z}_3(\bar{I}_1 + \bar{I}_2) - \bar{Z}_2\bar{I}_2 = -12\angle -15^\circ + 6\angle 0^\circ$$

$$-\bar{Z}_3\bar{I}_1 + (-\bar{Z}_3 - \bar{Z}_2)\bar{I}_2 = -12\angle -15^\circ + 6\angle 0^\circ$$

$$-\bar{Z}_3\bar{I}_1 - (\bar{Z}_3 + \bar{Z}_2)\bar{I}_2 = -12\angle -15^\circ + 6\angle 0^\circ$$

$$-(1.5 + j0)\bar{I}_1 - (1.5 + j0 + 0 - j)\bar{I}_2 =$$

$$(-1.5 - j0)\bar{I}_1 - (1.5 - j)\bar{I}_2 = -(11.59 - j3.1) + 6 + j0$$

$$= -11.59 + j3.1 + 6 + j0$$

$$= -5.59 + j3.1$$

$$1.5\angle 180^\circ\,\bar{I}_1 + (-1.5 + j)\bar{I}_2 = -5.59 + j3.1$$

$$1.5\angle 180^\circ\,\bar{I}_1 + 1.802\angle 146.3^\circ\,\bar{I}_2 = 6.34\angle 151^\circ \quad \text{——} (2)$$

$$\Delta = \begin{vmatrix} 1.802\angle -33.69^\circ & 1.5\angle 0^\circ \\ 1.5\angle 180^\circ & 1.802\angle 146.3^\circ \end{vmatrix} = (3.247\angle 112.61^\circ) - (2.25\angle 180^\circ)$$

$$\Delta = -1.248 + j2.997 - (-2.25 + j0)$$

$$\Delta = -1.248 + j2.997 + 2.25 - j0$$

$$\Delta = 1.005 + j2.997 = 3.16\angle 71.46^\circ$$

$$\bar{I}_1 = \frac{\begin{vmatrix} 4.844\angle 68.26^\circ & 1.5\angle 0^\circ \\ 6.34\angle 151^\circ & 1.802\angle 146.3^\circ \end{vmatrix}}{\Delta}$$

$$= \frac{8.728\angle 214.56^\circ - (5.585\angle 151^\circ)}{3.16\angle 71.46^\circ}$$

$$= \frac{-7.187 - j4.95 - (-8.38 + j4.646)}{1.004 + j2.997}$$

$$= \frac{-7.187 - j4.95 + 8.38 - j4.646}{3.16\angle 71.46^\circ}$$

$$\bar{I}_2 = \frac{1.193 - j\,5.596}{3.16\,\angle 71.46^\circ} = \frac{5.66\,\angle -82.91^\circ}{3.16\,\angle 71.46^\circ}$$

$$\bar{I}_1 = 3.056\,\angle -154.87^\circ \quad A$$

$$\bar{I}_2 = \frac{\begin{vmatrix} 1.802\,\angle -33.65^\circ & 4.844\,\angle 66.26^\circ \\ 1.5\,\angle 180^\circ & 6.35\,\angle 151^\circ \end{vmatrix}}{3.16\,\angle 71.46^\circ}$$

$$\bar{I}_2 = \frac{11.514\,\angle 117.31 - (7.266\,\angle 248.26)}{3.16\,\angle 71.46^\circ}$$

$$= \frac{-5.28 + j10.23 - (-2.65 - j6.795)}{3.16\,\angle 71.46^\circ}$$

$$= \frac{-5.28 + j10.23 + 2.65 + j6.795}{3.16\,\angle 71.46^\circ}$$

$$= \frac{-2.65 + j16.595}{3.16\,\angle 71.46^\circ} = \frac{19.175\,\angle 98.67}{3.16\,\angle 71.46^\circ}$$

$$\bar{I}_2 = 5.435\,\angle 29.21$$

$$\bar{I}_t = \bar{I}_1 + \bar{I}_2 = 3.056 \angle -154.89^\circ + 5.438 \angle 27.21^\circ$$

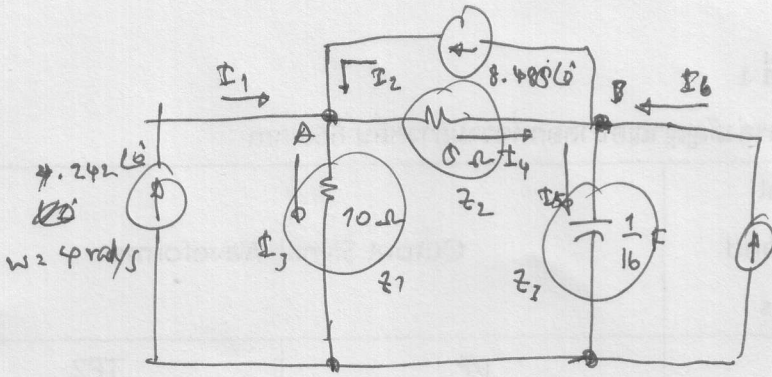
$$\bar{I}_t = -2.766 - j\,1.299 + 4.833 + j\,2.485$$

$$\bar{I} = 2.069 + j\,1.188$$

$$\bar{I} = 2.384 \angle 29.88^\circ \text{ mA}$$

$$V_B = 15\angle -135^\circ \text{ V}$$

(4)



$$Z_1 = 10\,\Omega = 10\angle 0^\circ\ \Omega$$

$$Z_2 = 5\,\Omega = 5\angle 0^\circ\ \Omega$$

$$Z_3 = -j\frac{1}{\omega C} = -j\frac{1}{2\pi f C}$$

$$\omega = 4 \text{ rad/s} = 2\pi f$$

$$f = \frac{4}{2\pi} = 0.6366 \text{ Hz}$$

$$Z_3 = -j\frac{1}{2\pi \times 0.6366 \times \frac{1}{16}} = -j4\ \Omega$$

$$Z_3 = 4\angle -90^\circ\ \Omega$$

Node A

$$I_1 + I_2 = I_3 + I_4$$

$$4.242\angle 0^\circ + 8.485\angle 0^\circ = \frac{V_A}{Z_1} + \frac{V_A - V_B}{Z_2}$$

$$4.242 + j0 + 8.485 + j0 = \frac{V_A}{10\angle 0^\circ} + \frac{V_A}{5\angle 0^\circ} - \frac{V_B}{5\angle 0^\circ}$$

$$12.729 + j0 = \left(\frac{1}{10\angle 0^\circ} + \frac{1}{5\angle 0^\circ}\right) V_A - \frac{1}{5\angle 0^\circ} V_B$$

$$= \left[(0.1 + 0.2) + j0\right] V_A - 0.2\angle 0^\circ V_B$$

$$12.729\angle 0^\circ = 0.3\angle 0^\circ V_A - 0.2\angle 0^\circ V_B \quad \text{---} (1)$$

$$0.2\angle 0^\circ V_B = 0.3\angle 0^\circ V_A - 12.729\angle 0^\circ$$

$$V_B = \frac{0.3\angle 0^\circ}{0.2\angle 0^\circ} V_A - \frac{12.729\angle 0^\circ}{0.2\angle 0^\circ}$$

$$V_B = 1.5\angle 0^\circ V_A - 63.635\angle 0^\circ \quad \text{---} (2)$$

At Node B

$$I_4 + I_6 = I_2 + I_5$$

$$I_6 - I_2 = I_5 - I_4$$

$$1.414\angle -45^\circ - (8.485\angle 0^\circ) = \frac{V_B}{Z_3} - \frac{(V_A - V_B)}{Z_2}$$

$$0 - j1.414 - (8.485 + j0) = \frac{V_B}{4\angle -45^\circ} - \frac{(V_A - V_B)}{5\angle 0^\circ}$$

$$0 - j1.414 - 8.485 - j0 = \frac{V_B}{4\angle -45^\circ} - \frac{V_A}{5\angle 0^\circ} + \frac{V_B}{5\angle 0^\circ}$$

$$-8.485 - j1.414 = 0.25\angle 45^\circ V_B - 0.2\angle 0^\circ V_A + 0.2\angle 0^\circ V_B$$

$$8.602\angle -170.53^\circ = (0.25\angle 45^\circ + 0.2\angle 0^\circ) V_B - 0.2\angle 0^\circ V_A$$

$$0.2\angle 0^{\circ} V_A = [0 + j0.25 + 0.2 + j0] V_B - (8.602\angle 170.55^{\circ})$$

$$0.2\angle 0^{\circ} V_A = [0.2 + j0.25] V_B - (-8.485 - j1.414)$$

$$0.2\angle 0^{\circ} V_A = (0.2 + j0.25) V_B + (8.485 + j1.414)$$

$$0.2\angle 0^{\circ} V_A = 0.320\angle 51.34^{\circ} V_B + 8.602\angle 9.461^{\circ}$$

$$V_A = \frac{0.320\angle 51.34^{\circ}}{0.2\angle 0^{\circ}} V_B + \frac{8.602\angle 9.461^{\circ}}{0.2\angle 0^{\circ}}$$

$$V_B = 1.6\angle 51.34^{\circ} V_B + 43.01\angle 9.461^{\circ} \quad \text{---} (2)$$

Using (2) in (1)

$$V_B = 1.5\angle 0^{\circ}\left[1.6\angle 51.34^{\circ} V_B + 43.01\angle 9.461^{\circ}\right] - 63.635\angle 0^{\circ}$$

$$V_B = 2.4\angle 51.34^{\circ} V_B + 64.515\angle 9.461^{\circ} - 63.635\angle 0^{\circ}$$

$$(1 - 2.4\angle 51.34^{\circ}) V_B = 64.515\angle 9.461^{\circ} - 63.635\angle 0^{\circ}$$

$$[1 + j0 - (1.499 + j1.896)] V_B = 63.637 + j10.6 - (63.635 + j0)$$

$$[1 - j0 - 1.455 - j1.894]\, V_B = 63.637 + j10.6 - 63.637 - j0$$

$$(-0.455 - j1.894) V_B = j10.6$$

$$1.939 \angle -104.51^\circ \; V_B = 10.6 \angle 90^\circ$$

$$V_B = \frac{10.6 \angle 90^\circ}{1.939 \angle -104.51^\circ}$$

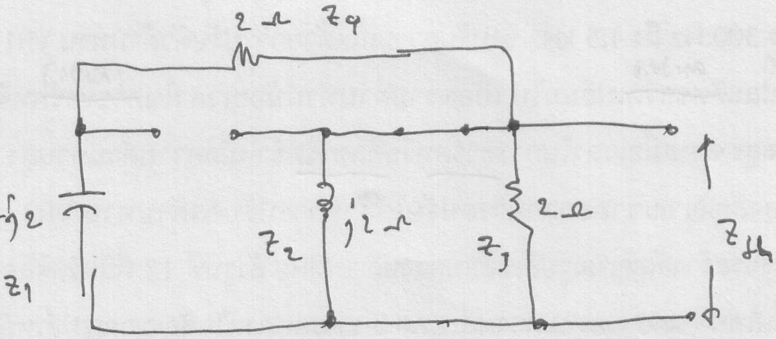
$$V_B = 5.46 \angle 194.51^\circ \; V.$$

now $V_0 = 5.66 \angle -45^\circ$ V

wb (b)

in Z_{th}

$V \to 0$ Load R 2Ω in Z_{th}



$$\bar{Z}_{th} = (\bar{Z}_2 \parallel \bar{Z}_3) \parallel (\bar{Z}_1 + \bar{Z}_4)$$

$$\bar{Z}_1 = 0 - j2 = 2 \angle -90^\circ \ \Omega$$

$$\bar{Z}_2 = 0 + j2 = 2 \angle 90^\circ \ \Omega$$

$$\bar{Z}_3 = 2\Omega = 2 + j0 = 2 \angle 0^\circ \ \Omega$$

$$\bar{Z}_4 = 2 + j0 = 2 \angle 0^\circ \ \Omega$$

$$\bar{Z}_2 \parallel \bar{Z}_3 = \frac{2\angle 90^\circ \times 2\angle 0^\circ}{2\angle 90^\circ + 2\angle 0} = \frac{4\angle 90^\circ}{0+j2+2+j0} = \frac{4\angle 90^\circ}{2+j2} = \frac{4\angle 90^\circ}{2.828\angle 45^\circ}$$

$$\bar{Z}_2 \parallel \bar{Z}_3 = 1.414 \angle 45^\circ \ \Omega$$

$$\bar{Z}_1 + \bar{Z}_4 = 0 - j2 + (2 + j0) = 2 - j2 = 2.828 \angle -45^\circ$$

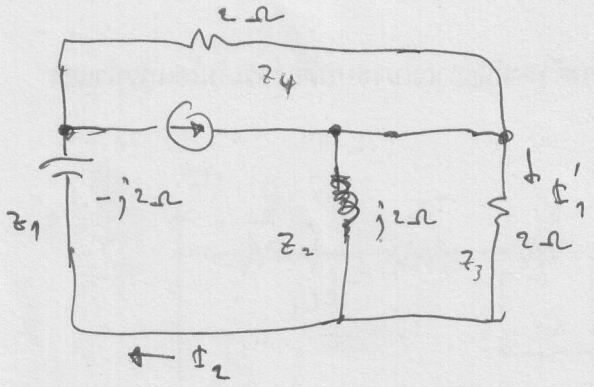
$$Z_{th} = \frac{1.414\angle 45^\circ \times 2.828\angle -45^\circ}{1.414\angle 45^\circ + 2.828\angle -45^\circ}$$

$$Z_{th} = \frac{3.998\angle 0^\circ}{0.999 + j0.99 + 1.999 - j1.999}$$

$$Z_{th} = \frac{3.998\angle 0^\circ}{2.998 - j} = \frac{3.998\angle 0^\circ}{3.16\angle -18.44}$$

$$Z_{th} = 1.265\angle 18.44^\circ \ \Omega$$

Using superposition principle to find I_1'



$$\bar{Z}_{T1} = \bar{Z}_2 // \bar{Z}_3 = 1.414\angle 45^\circ$$

$$\bar{Z}_{T2} = \bar{Z}_{T1} + \bar{Z}_1 = 1.414\angle 45^\circ + 0 - j2 = 0.99 + j0.99 + 0 - j2$$

$$\bar{Z}_{T2} = 0.99 - j1.01 \ \Omega = 1.414\angle -45^\circ$$

$$I_2^* = \frac{4\angle 0^\circ \times 2\angle 0^\circ}{2\angle 0^\circ + 1.414\angle -45^\circ} = \frac{8\angle 0^\circ}{2 + j0 + 0.99 - j1}$$

$$\Phi_2 = \frac{8\angle 0^\circ}{2.99 - j1} = \frac{8\angle 0^\circ}{3.152\angle -18.44^\circ} = 2.538\angle 18.44^\circ \ A$$

$$\bar{I}_{\uparrow} = \frac{12\angle 0^{\circ}}{2\angle -53.1^{\circ}} = 6\angle +53.1^{\circ} \text{ A}$$

$$\bar{I}_1'' = \frac{\bar{I}_{\uparrow} \times \text{parallel}(2-j2)}{2\angle 0^{\circ} + 2.828\angle -45^{\circ}} = \frac{6\angle 53.1 \times 2.828\angle -45^{\circ}}{2\angle 0^{\circ} + 2.828\angle -45^{\circ}}$$

$$\bar{I}_1'' = \frac{16.968\angle 8.1^{\circ}}{2+j0+2-j2} = \frac{16.968\angle 8.1^{\circ}}{4-j2} = \frac{16.968\angle 8.1^{\circ}}{4.472\angle -26.56}$$

$$\bar{I}_1'' = 3.794\angle 34.66 \text{ A}$$

$$\bar{I}_{2\Omega} = \bar{I}_1' + \bar{I}_1'' = 1.768\angle 63.45 + 3.794\angle 34.66^{\circ}$$

$$\bar{I}_{2\Omega} = 0.787 + j1.578 + 3.12 + j2.157$$

$$\bar{I}_{2\Omega} = 3.907 + j3.735 = 5.40\angle 43.7$$

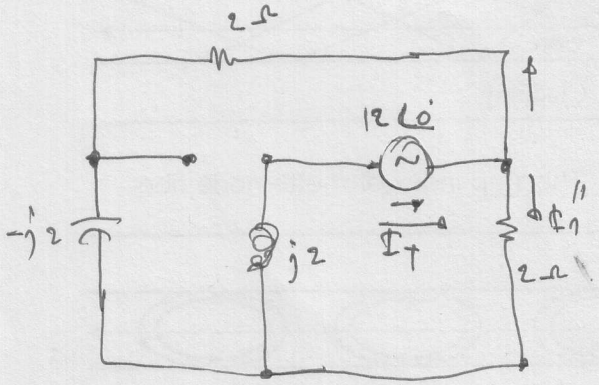
$$\bar{V}_0 = \bar{I}_{2\Omega} \times 2\Omega = 5.40\angle 43.7 \times 2\angle 0^{\circ}$$

$$\bar{V}_0 = 10.8\angle 43.7^{\circ} \text{ V}$$

$$I_1' = \frac{I_2 \times j2}{0+j2+2+j0} = \frac{2.538\angle 18.45^\circ \times 2\angle 90^\circ}{2+j2}$$

$$I_1' = \frac{5\angle 108.45^\circ}{2.828\angle 45^\circ} = 1.768\angle 63.45^\circ \quad A.$$

En I_2''



$$\bar{Z}_{T3} = 2+j0+0-j2 = 2-j2 = 2.828\angle -45^\circ \ \Omega$$

$$\bar{Z}_{T4} = 2\angle 0^\circ \,//\, \bar{Z}_{T3} = \frac{2\angle 0^\circ \times 2.828\angle -45^\circ}{2\angle 0^\circ + 2.828\angle -45^\circ}$$

$$\bar{Z}_{T4} = \frac{5.656\angle -45^\circ}{2+j0+1.55-j1.55} = \frac{5.656\angle -45^\circ}{3.55-j1.55}$$

$$\bar{Z}_{T4} = \frac{5.656\angle -45^\circ}{4.454\angle -26.5^\circ} = 1.268\angle -18.5 \ \Omega$$

$$\bar{Z}_T = 0+j2+\bar{Z}_{T4} = 0+j2+1.20-j0.40$$

$$\bar{Z}_T = 1.20-j1.6 = 2\angle -53.1 \ \Omega$$

$$\bar{I}_{\uparrow} = \frac{12\angle 0^{\circ}}{2\angle -53.1^{\circ}} = 6\angle +53.1^{\circ} \text{ A}$$

$$I_1'' = \frac{I_{\uparrow} \times \text{parallel}(2-j2)}{2\angle 0^{\circ} + 2.828\angle -45^{\circ}} = \frac{6\angle 53.1 \times 2.828\angle -45^{\circ}}{2\angle 0^{\circ} + 2.828\angle -45^{\circ}}$$

$$I_1'' = \frac{16.968\angle 8.1^{\circ}}{2+j0+2-j2} = \frac{16.968\angle 8.1^{\circ}}{4-j2} = \frac{16.968\angle 8.1^{\circ}}{4.472\angle -26.56}$$

$$I_1'' = 3.794\angle 34.66 \text{ A}$$

$$I_{2\Omega} = I_1' + I_1'' = 1.768\angle 63.45^{\circ} + 3.794\angle 34.66^{\circ}$$

$$I_{2\Omega} = 0.787 + j1.578 + 3.12 + j2.157$$

$$I_{2\Omega} = 3.907 + j3.735 = 5.40\angle 43.7$$

$$\bar{V}_0 = I_{2\Omega} \times 2\Omega = 5.40\angle 43.7 \times 2\angle 0^{\circ}$$

$$\bar{V}_0 = 10.8\angle 43.7^{\circ} \text{ V}$$

$$\bar{Z}_A = \bar{Z}_B = \bar{Z}_C = 60 + j20\ \Omega = 63.24 \angle 18.43^\circ$$

$$Y \rightarrow V_{line} = \sqrt{3}\, V_{phase}$$

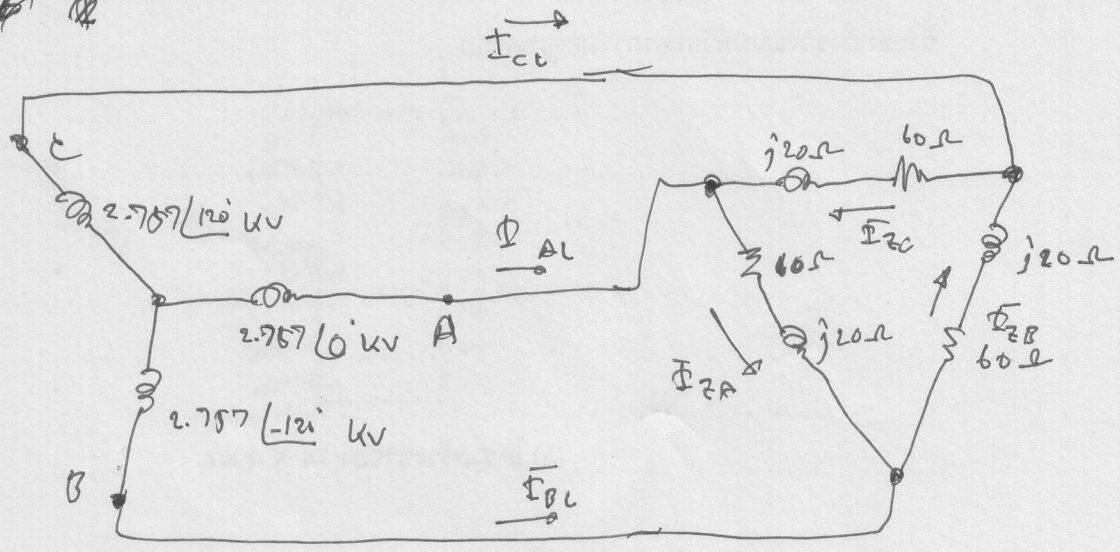
$$\bar{E}_{AB} = \sqrt{3}\, E_p \angle 30^\circ$$

$$\bar{E}_{AB} = \sqrt{3}\, E_p \angle 30^\circ = \sqrt{3} \times 2.757 \angle 30^\circ = 4.775 \angle 30^\circ \text{ kV}$$

$$\bar{E}_{AB} = 4.775 \angle 30^\circ \text{ kV} \quad \text{——— (1)}$$

$$\bar{E}_{BC} = \sqrt{3} \times (2.757) \angle -90^\circ = 4.775 \angle -90^\circ \text{ kV} \quad \text{——— (2)}$$

$$\bar{E}_{CA} = \sqrt{3} \times (2.757) \angle 150^\circ = 4.775 \angle 150^\circ \text{ kV} \quad \text{——— (3)}$$



$$\bar{I}_{zA} = \frac{\bar{E}_{AB}}{\bar{Z}_A} = \frac{4.795\angle 30^\circ}{63.24\angle 18.43^\circ} = 75\angle 11.57^\circ \text{ A} \quad \text{---} (4)$$

$$\bar{I}_{zB} = \frac{\bar{E}_{BC}}{\bar{Z}_B} = \frac{4.795\angle -90^\circ}{63.24\angle 18.43^\circ} = 75\angle -108.43^\circ \text{ A} \quad \text{---} (5)$$

$$\bar{I}_{zC} = \frac{\bar{E}_{CA}}{\bar{Z}_C} = \frac{4.795\text{ kV}\angle 150^\circ}{63.24\angle 18.43^\circ} = 75\angle 131.55 \text{ A} \quad \text{---} (6)$$

กระแสที่ไหลในสายเส้นที่ 2 คือ

$$\bar{I}_{AL} = \bar{I}_{zA} - \bar{I}_{zC}$$

$$= 75\angle 11.57^\circ - 75\angle 131.55 \text{ A}$$

$$= 73.47 + j15.062 - (-45.74 + j56.128)$$

$$= 73.47 + j15.062 + 45.74 - j56.128$$

$$= 123.21 - j41.066 \text{ A}$$

$$= 129.97\angle -18.46^\circ \text{ A}$$

$$\bar{I}_{BL} = \bar{I}_{zB} - \bar{I}_{zA}$$

$$= 75\angle -108.43 - 75\angle 11.57$$

$$= -23.71 - j71.15 - (73.47 + j15.042)$$

$$= -23.71 - j71.15 - 73.47 - j15.042$$

$$=$$

$$\bar{I}_{BL} = -57.18 - j86.152 \quad A$$

$$\bar{I}_{BL} = 129.896 \angle -138.42 \quad A$$

$$\bar{I}_{CL} = \bar{I}_{BC} - \bar{I}_{ZB}$$

$$= 75\angle 131.55 - 75\angle -108.43 \quad A$$

$$= -49.74 + j56.128 - (-23.71 - j71.15)$$

$$= -49.74 + j56.128 + 23.71 + j71.15$$

$$= -26.03 + j127.27 \quad A$$

$$\bar{I}_{CL} = 129.50\angle 101.55 \quad A$$

ที่หม้อแปลงของ load 3 เฟส แบบ Δ เขียนได้ว่า

$$\bar{S}_T = 3\bar{V}_p\bar{I}_p$$

$$\bar{S}_T = 3 \times 4.775\,kV\angle -30^\circ \times 75\angle 11.57^\circ \quad A$$

$$\bar{S}_T = 1.0743\angle -18.43^\circ \quad MVA$$

$$\bar{S}_T = P_T + jQ_T$$

$$S_T = 1.014 - j0.339 \quad MVA$$

$$P_T = 1014 \quad kW$$

กำลังไฟฟ้ารวม $\bar{S}_T = 1,074$ kVA

กำลังไฟฟ้าจริง $\bar{P}_T = 1.015$ MWatt $= 1015$ kWatt

กำลังไฟฟ้าปฏิกิริยา $\bar{Q}_T = 355$ kVar

$$\cos\theta = \text{p.f.} = \frac{\bar{P}_T}{\bar{S}_T} = \frac{1015}{1074} = 0.948$$

มุมเฟส

$$\theta = \cos^{-1} 0.948$$

$$\theta = 18.55^\circ$$