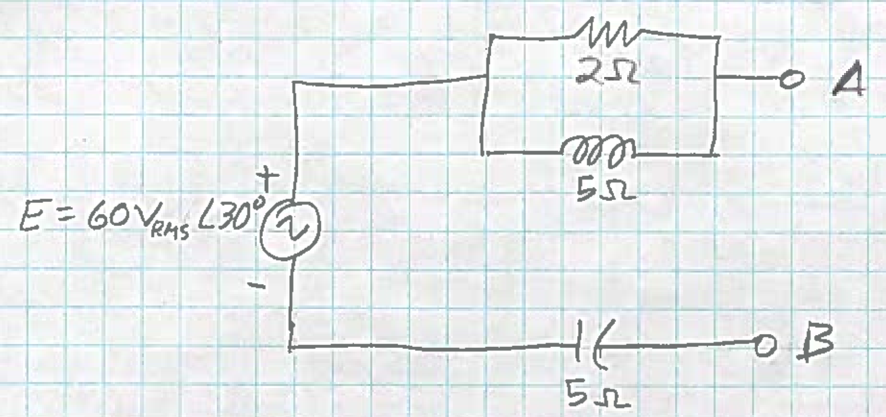
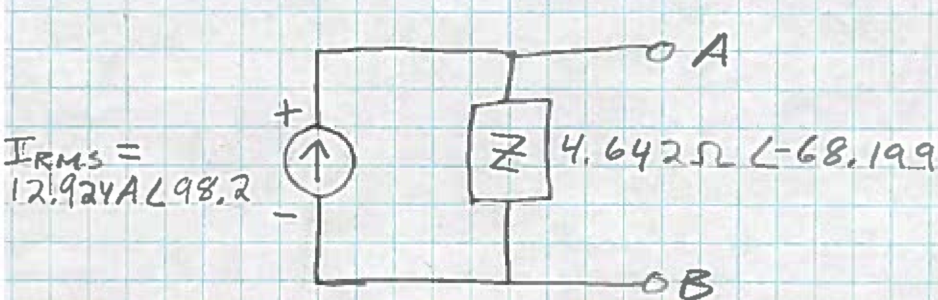
18-2 Convert the voltage source to a current source

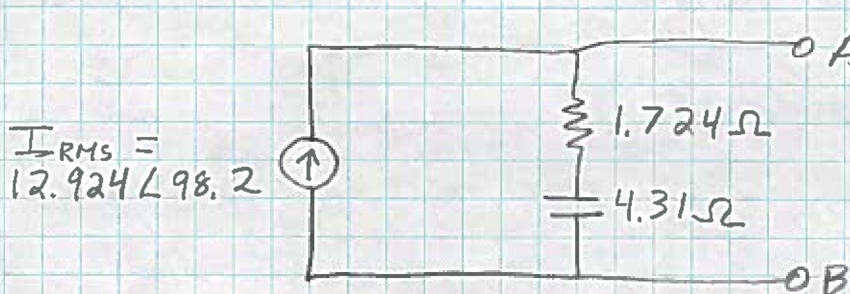


$$Z = 5\Omega\angle{-90} + 2\Omega\angle 0 \,//\, 5\Omega\angle 90$$
$$= 5\Omega\angle{-90} + 1.857\Omega\angle 21.80 = 4.642\Omega\angle{-68.199}$$

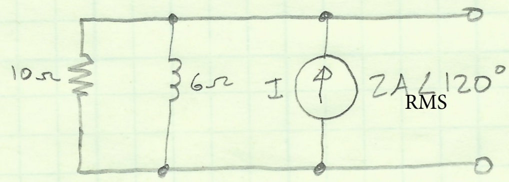
$$I = \frac{E}{Z} = \frac{60V_{RMS}\angle 30^\circ}{4.642\Omega\angle{-68.199}} = 12.924A\angle 98.199$$



$$Z = 4.642\Omega\angle{-68.199} = (1.724 - j4.31)\Omega$$

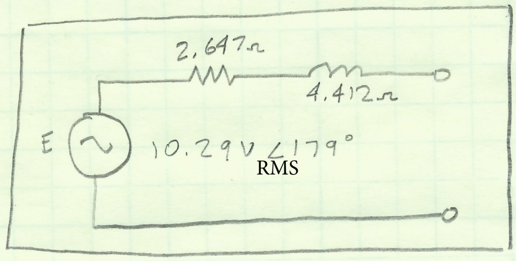


③ Convert the current source to a voltage source

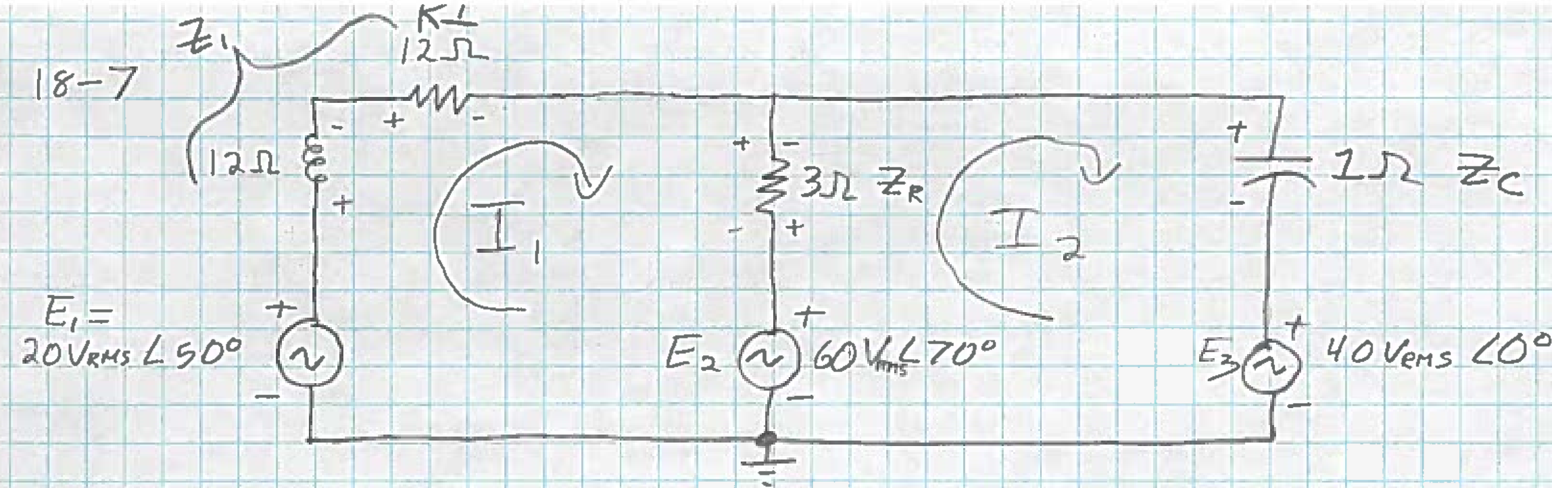


$$Z_T = 10\Omega \,//\, j6\Omega = (2.647 + j4.412)\Omega$$

$$E_{th} = I \cdot Z_T = (2.647 + j4.412)\Omega \cdot (2A_{RMS}\angle 120°) = (10.29V_{RMS}\angle 179°)$$



18-7



Write the mesh equations and determine the current through R1.

I_1) $0 = E_1 - I_1 Z_1 - I_1 Z_R + I_2 Z_R - E_2$

$-E_1 + E_2 = -I_1(Z_1 + Z_R) + I_2 Z_R$

$-20V_{RMS}\angle 50° + 60V_{RMS}\angle 70° = +I_1(-15 - j12) + I_2(3)$

$41.77\,V_{RMS}\angle 79.425°$

I_2) $0 = E_2 - I_2 Z_R + I_1 Z_R - I_2 Z_C - E_3$

$-E_2 + E_3 = I_1 Z_R - I_2(Z_R + Z_C)$

$-60V_{RMS}\angle 70° + 40V_{RMS}\angle 0° = I_1(3) + I_2(-3 + j1)$

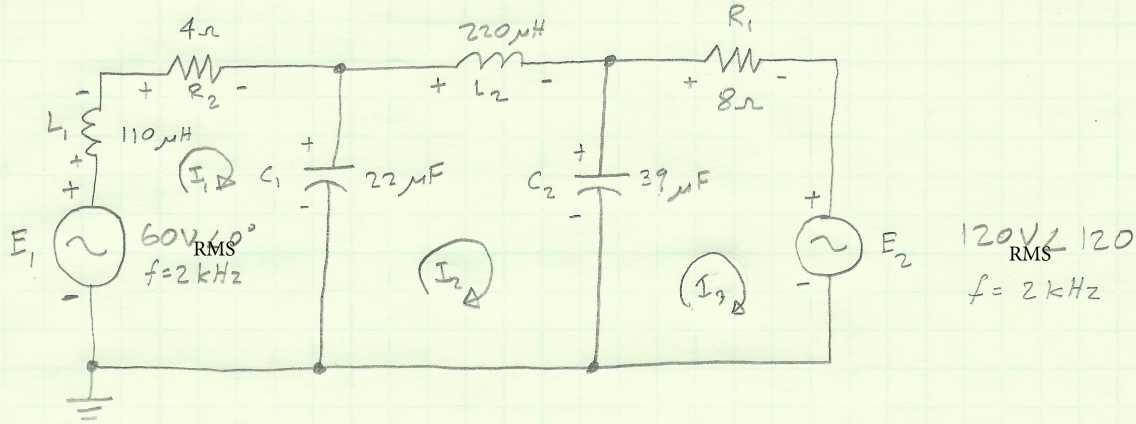
$59.652\,V_{RMS}\angle -70.941$

$$I_1 = \frac{\begin{vmatrix} 41.77V\angle 79.425 & 3\angle 0 \\ 59.652V\angle -70.941 & -3+j1 \end{vmatrix}}{\begin{vmatrix} -15-j12 & 3\angle 0 \\ 3 & -3+j1 \end{vmatrix}}$$

$$= \frac{(41.77V\angle 79.425)(-3+j1) - (59.652V\angle -70.941)(3\angle 0)}{(-15-j12)(-3+j1) - (3)(3\angle 0)}$$

$$= \frac{133.72\angle 156.355}{52.393\angle 23.629} = \boxed{2.55\,A_{RMS}\angle 132.73°}$$

⑧ Write the mesh equations for the network below. Find the current through R_1.



$$E_1 = V_{L_1} + V_{R_2} + V_{C_1} = I_1 X_{L_1} + I_1 R_2 + (I_1 - I_2) X_{C_1}$$

$$0 = -V_{C_1} + V_{L_2} + V_{C_2} = -(I_1 - I_2) X_{C_1} + I_2 X_{L_2} + (I_2 - I_3) X_{C_2}$$

$$-E_2 = -V_{C_2} + V_{R_1} = I_3 R_1 - (I_2 - I_3) X_{C_2}$$

$$\boxed{\begin{aligned} E_1 &= (X_{L_1} + R_2 + X_{C_1}) I_1 + (-X_{C_1}) I_2 + 0 I_3 \\ 0 &= (-X_{C_1}) I_1 + (X_{C_1} + X_{L_2} + X_{C_2}) I_2 + (-X_{C_2}) I_3 \\ -E_2 &= 0 I_1 + (-X_{C_2}) I_2 + (X_{C_2} + R_1) I_3 \end{aligned}}$$

$X_{L_1} = 1.382\,\Omega$ $X_{C_1} = 3.617\,\Omega$ $X_{L_2} = 2.765\,\Omega$ $X_{C_2} = 2.04\,\Omega$

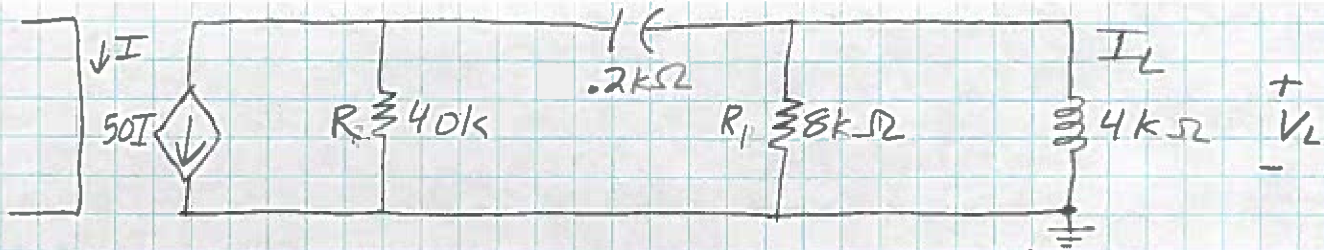
... and then a miracle happens...

$I_1 = 6.667\,A_{RMS} \angle -63.1°$

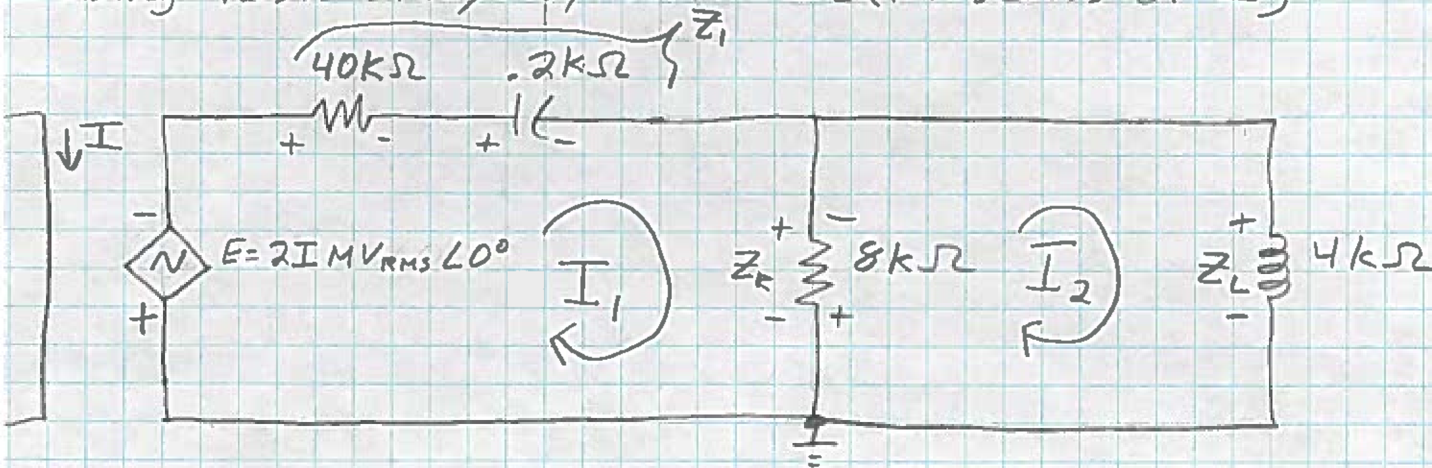
$I_2 = 18.91\,A_{RMS} \angle -63.5°$

$$\boxed{I_3 = 14.99\,A_{RMS} \angle -63.82° = I_{R_1}}$$

18-13



Using mesh analysis, find I_L (in terms of I)



$E = 50I \cdot 40k\Omega = 2I\ MV_{RMS}\angle 0$

$I_1)$ $0 = -E - I_1 Z_1 - I_1 Z_R + I_2 Z_2$

$E = I_1(-Z_1 - Z_R) + I_2 Z_2$

$2I\ MV\angle 0° = I_1(-48k + j200) + I_2(8k)$

$I_2)$ $0 = -I_2(Z_R) + I_1(Z_R) - I_2(Z_L)$

$0 = I_1(Z_R) + I_2(-Z_R - Z_L)$

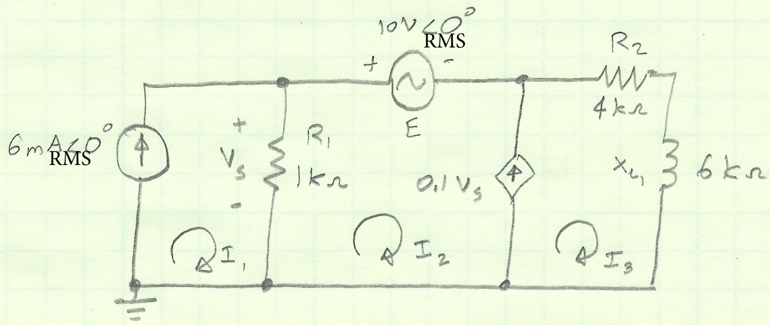
$0 = I_1(8k) + I_2(-8k - j4k)$

$$I_2 = \frac{\begin{vmatrix} -48k + j200 & 2I\ MV\angle 0° \\ 8k & 0 \end{vmatrix}}{\begin{vmatrix} -48k + j200 & 8k \\ 8k & -8k - j4k \end{vmatrix}}$$

$$= \frac{(-48k + j200)(0) - (2I\ MV\angle 0°)(8k)}{(-48k + j200)(-8k - j4k) - (8k)(8k)}$$

$$= \frac{16 \times 10^9 \cdot I}{320.8 \times 10^6 + j190.4 \times 10^6} = \boxed{42.89\,I\ A_{RMS}\angle -30.69°}$$

(16) Write the mesh equations for the network below. Determine the current through the inductive element.



$Z_1 = R_1 + X_{L_1} = (4k\Omega + j6k\Omega)$

$I_1 = 6\,mA \angle 0°$ $\qquad$ $V_S = (I_1 - I_2) R_1$

$\boxed{① \; -V_S + E - I_3 Z_1 = 0}$ $\qquad$ $\boxed{② \; 0.1 V_S = I_3 - I_2}$

$-(I_1 - I_2)R_1 + E - I_3 Z_1 = 0$ $\qquad$ $I_3 = I_2 + 0.1 R_1 (I_1 - I_2)$

$-R_1 I_1 + R_1 I_2 + E - I_3 Z_1 = 0$ $\qquad$ $I_3 = I_2 + 0.1 R_1 I_1 - 0.1 R_1 I_2$

$E = R_1 I_1 - R_1 I_2 + I_3 Z_1$ $\qquad$ $I_3 = 0.1 R_1 I_1 + (1 - 0.1 R_1) I_2$

$E = R_1 I_1 - R_1 I_2 + Z_1 \left[0.1 R_1 I_1 + (1 - 0.1 R_1) I_2 \right]$

$E = R_1 I_1 - R_1 I_2 + 0.1 Z_1 R_1 I_1 + Z_1 (1 - 0.1 R_1) I_2$

$Z_1 (1 - 0.1 R_1) I_2 - R_1 I_2 = E - R_1 I_1 - 0.1 Z_1 R_1 I_1$

$$I_2 = \frac{E - R_1 I_1 - 0.1 Z_1 R_1 I_1}{Z_1 (1 - 0.1 R_1) - R_1} = 6.053\,mA \angle 0.111°$$

$$I_{X_{L_1}} = I_3 = 0.1 R_1 (I_1 - I_2) + I_2 = \boxed{1.394\,mA_{RMS} \angle -56.24°}$$