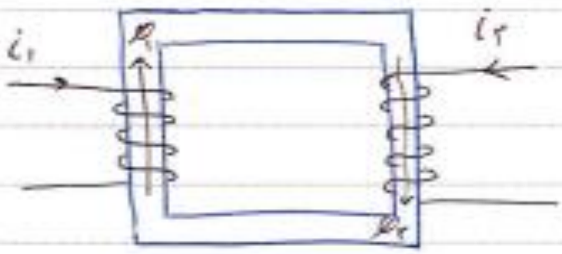
ترنفورمیچ

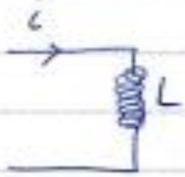


بر حسب هانری

$M = k\sqrt{L_1 L_2}$ القای متقابل

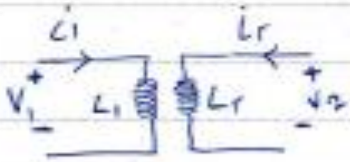
ضریب کوپلاژ

تغییرات جریان نسبت به زمان باعث ولتاژ القایی می‌شود.

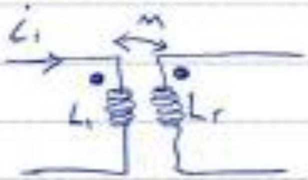


$$V_L = L\frac{di}{dt}$$ ولتاژ القایی

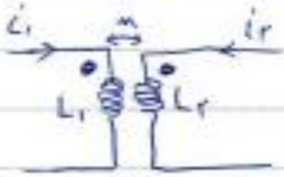
$$V_L = j\omega L i$$ " "



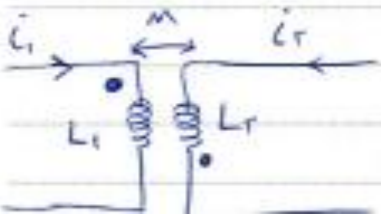
$$V_1 = j\omega L_1 i_1$$
$$V_2 = j\omega L_2 i_2$$



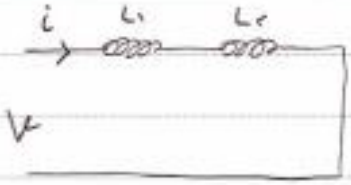
$$V_1 = j\omega L_1 i_1$$
$$V_2 = j\omega M i_1$$



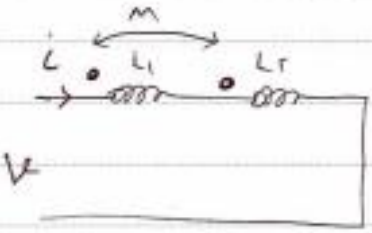
$$V_1 = j\omega L_1 i_1 + j\omega M i_2$$
$$V_2 = j\omega L_2 i_2 + j\omega M i_1$$



$$V_1 = j\omega L_1 i_1 - j\omega M i_2$$
$$V_2 = j\omega L_2 i_2 - j\omega M i_1$$



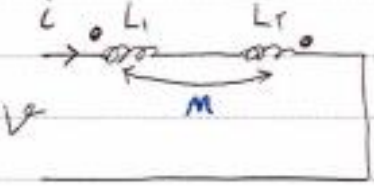
$$V = j\omega L_1 i + j\omega L_2 i$$



$$V_1 = j\omega L_1 i + j\omega M i$$

$$V_2 = j\omega L_2 i + j\omega M i$$

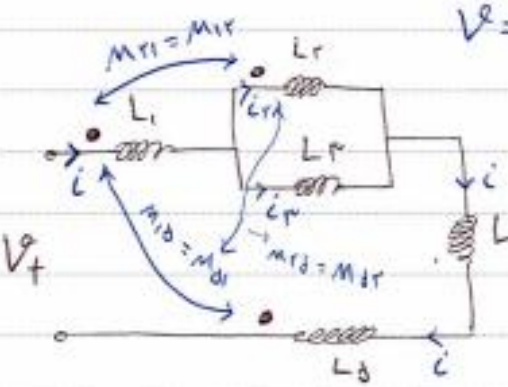
$$V = V_1 + V_2$$



$$V_1 = j\omega L_1 i - j\omega M i$$

$$V_2 = j\omega L_2 i - j\omega M i$$

$$V = V_1 + V_2$$



$$V_1 = j\omega L_1 i + j\omega M_{12} i_2 - j\omega M_{10} i$$

$$V_2 = j\omega L_2 i_2 + j\omega M_{12} i - j\omega M_{20} i$$

$$V_2 = j\omega L_2 i_2$$

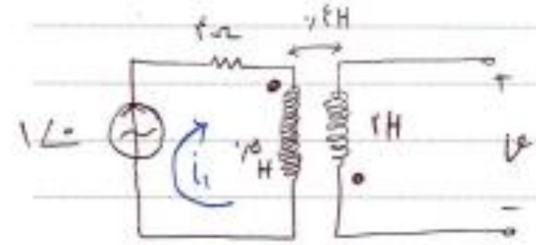
$$V_E = j\omega L_E i$$

$$V_0 = j\omega L_0 i - j\omega M_{10} i - j\omega M_{20} i_2$$

$$V_T = V_1 + V_2 + V_C + V_E + V_0$$

مثال : سوال ۸ ص ۳۹

الف :



$f = 50\,Hz \Rightarrow \omega = 314$

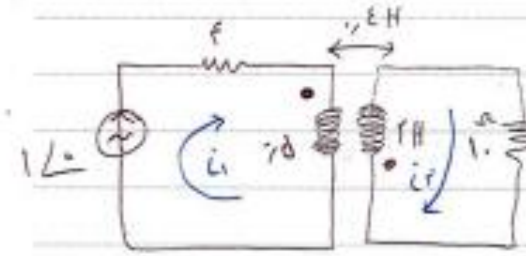
$M = K\sqrt{L_1 L_2} = 0.4$

$$\begin{cases} i_1 = 1\angle 0 \\ V = j\omega M i_1 \Rightarrow V = j(314)(0.4)(1) \end{cases}$$

$V = 125.6j$ حوزه فرکانس

حوزه زمان $V(t) = 125.6\cos(314t + 90^\circ)$

ب :

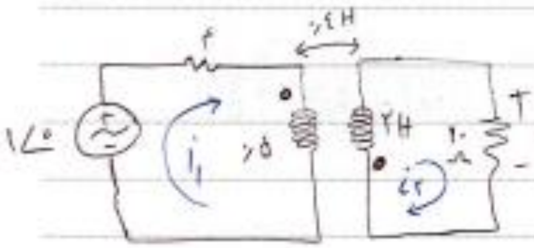


$$\begin{cases} i_1 = 1\angle 0 \\ 10 i_2 + j(314)(2) i_2 + j(314)(0.4) i_1 = 0 \end{cases}$$

$10 i_2 + j628 i_2 = -125.6j \Rightarrow$

$\Rightarrow i_2 = \dfrac{-125.6j}{10 + j628} = 0.2\angle -179^\circ$

$V = 10 i_2 \Rightarrow V = 2\angle -179^\circ \Rightarrow \boxed{V_t = 2\cos(314t - 179^\circ)}$



ج :

$$\begin{cases} -1\angle 0 + 4 i_1 + j(314)(0.5) i_1 + j(314)(0.4) i_2 = 0 \\ 10 i_2 + j(314)(2) i_2 + j(314)(0.4) i_1 = 0 \end{cases}$$

$$\begin{cases} (4 + j157) i_1 + 125.6j\, i_2 = 1 \\ 125.6j\, i_1 + (10 + j628) i_2 = 0 \end{cases}$$

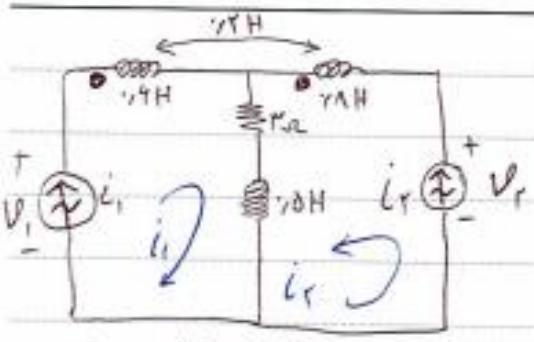
$$i_2 = \frac{\begin{vmatrix} 4+j157 & 1 \\ j125.6 & 0 \end{vmatrix}}{\begin{vmatrix} 4+j157 & 125.6j \\ 125.6j & 10+j628 \end{vmatrix}} = \frac{-j125.6}{82881\angle 177.1}$$

$i_2 = 1.5\times 10^{-3}\angle 92.9^\circ \Rightarrow \boxed{V = 15\times 10^{-3}\angle 92.9^\circ}$

$V_t = 15\times 10^{-3}\cos(314t + 92.9^\circ)$

Year . Month . Date .

سوال ۱۴ صفحه ۳۹



$is_1 = 2\cos 1.t$

$is_2 = 1.2\cos 1.t$

$$\begin{cases} -V_1 + j(1.)(0.2)(2\angle 0^\circ) - j(1.)(0.2)(1.2\angle -0^\circ) + 3(2\angle 0^\circ + 1.2\angle -0^\circ) + j(1.)(0.5)(2\angle 0^\circ + 1.2\angle -0^\circ) = 0 \\ -V_2 + j(1.)(0.8)(1.2\angle -0^\circ) - j(1.)(0.2)(2\angle 0^\circ) + 3(2\angle 0^\circ + 1.2\angle -0^\circ) + j(1.)(0.5)(2\angle 0^\circ + 1.2\angle -0^\circ) = 0 \end{cases}$$

(ω, L, i_1, M, i_2)

$V_1 = 12j - 2.4j + 9.6 + j12 \Rightarrow V_1 = 9.6 + j25.6 = 27.3\angle 69.4^\circ \Rightarrow v_{1(t)} = 27.3\cos(1.t + 69.4^\circ)$

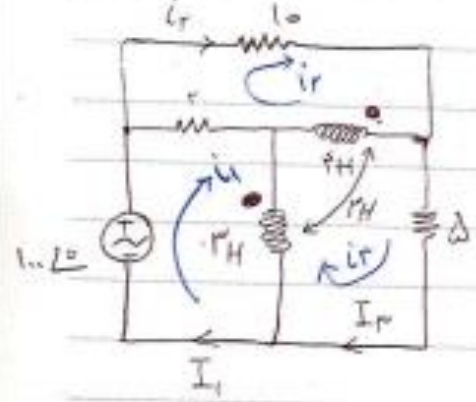
$V_2 = 9.6j - j4 + 9.6 + j12 \Rightarrow V_2 = 9.6 + j21.6 = 23.6\angle 66^\circ \Rightarrow v_{2(t)} = 23.6\cos(1.t + 66^\circ)$

منبع $S_1 = \frac{1}{2} V_1 \cdot I_1^* = \frac{1}{2}(9.6 + j25.6)(2) = 9.6 + j25.6 \Rightarrow P_{av_{s_1}} = 9.6\ W$

منبع $S_2 = \frac{1}{2} V_2 \cdot I_2^* = \frac{1}{2}(9.6 + j21.6)(12) = 57.6 + j129.6$

$\Rightarrow P_{av_2} = 57.6\ W$

حل ۳۹ سوال ۴



$f = 50\,Hz$

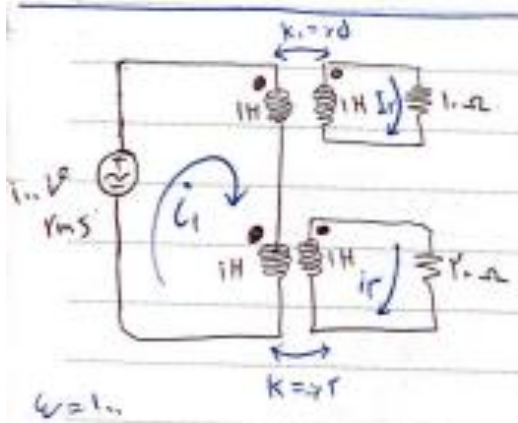
$\omega = 314$

$$\begin{cases} -100 + 2(i_1 - i_2) + j(314)(3)(i_1 - i_3) + j(314)(2)(i_1 - i_2) = 0 \\ 10 I_2 + j(314)(4)(i_2 - i_3) + j(314)(2)(i_2 - i_1) + 2(i_2 - i_1) = 0 \\ 5 i_3 + j(314)(3)(i_3 - i_1) + j(314)(2)(i_3 - i_2) + j(314)(4)(i_3 - i_2) + j(314)(2)(i_3 - i_1) = \end{cases}$$

سوال ۱۹ : $P_{1\Omega}, P_{2\Omega}, P_s = ?$

ضریب کوپلاژ مغناطیسی $= ?$

$M = k\sqrt{L_1 L_2}$



$\omega = 100$

$$\begin{cases} -100 + j(100)(1) i_1 - j(100)(0.25) i_2 + j(100)(1) i_1 - j(100)(0.2) i_3 = 0 \\ 10 i_2 + j(100)(1) i_2 - j(100)(0.25) i_1 = 0 \\ 2 i_3 + j(100)(1) I_3 - j(100)(0.2) i_1 = 0 \end{cases}$$

Poopak

۱۰۴

$$\begin{cases} j200\, i_1 - j50\, i_2 - j20\, i_3 = 100 \\ -j50\, i_1 + (10 + j10)\, i_2 = 0 \\ -j20\, i_1 + (20 + j10)\, i_3 = 0 \end{cases}$$

$$i_1 = \frac{\begin{vmatrix} 100 & -j50 & -j20 \\ 0 & 10+j10 & 0 \\ 0 & 0 & 20+j10 \end{vmatrix}}{\begin{vmatrix} j200 & -j50 & -j20 \\ -j50 & 10+j10 & 0 \\ -j20 & 0 & 20+j10 \end{vmatrix}} = \frac{1024 \angle 129^\circ}{1750 \angle 102.8^\circ} = 0.58 \angle -19^\circ$$

$$i_2 = \frac{j50\,(0.58 \angle -19^\circ)}{10 + j10} = 0.28 \angle -83.2^\circ$$

$$i_3 = \frac{j20\,(0.58 \angle -19^\circ)}{20 + j10} = 0.11 \angle -77.4^\circ$$

$$\begin{aligned} i_1 &= 0.58\sqrt{2}\cos(10t - 19^\circ) \\ i_2 &= 0.28\sqrt{2}\cos(10t - 83.2^\circ) \\ i_3 &= 0.11\sqrt{2}\cos(10t - 77.4^\circ) \end{aligned}$$

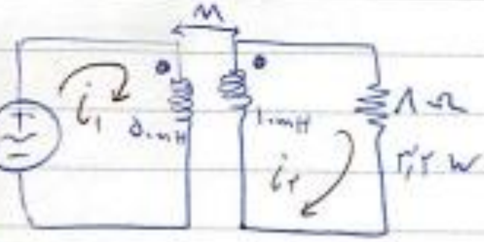
معادلات جریان

$$P_{10\Omega} = R I_1^2 = 10\,(0.28)^2 = 0.78\ \text{W}, \quad P_{4\Omega} = R I_3^2 = 20\,(0.11)^2 = 0.24\ \text{W}$$

Poopak

$$\text{منبع } S = V I^* = (10\angle 0)(0.58 \angle 19^\circ) = 5.5 + j1.9 \quad (P_S = 5.5\ \text{W})$$

(۱۰۵)



$P_L = R_L I_2^2 \Rightarrow I_2 = \sqrt{\frac{P_L}{R_L}}$

$I_2 = \sqrt{\frac{3.2}{8}} = 0.63\ A$

$f = 160\ Hz \quad M = ?$

$\omega = 1005\ Rad/s$

$$\begin{cases} -20 + j(1005)(50\times10^{-3})\, i_1 - j(1005)(M)(0.63) = 0 \\ 8(0.63) + j(1005)(100\times10^{-3})(0.63) - j(1005)(M)\, i_1 = 0 \end{cases}$$

$$\begin{cases} 50.25\, j\, i_1 - j633M = 20 \\ j1005\, i_1 M = 5.04 + j6.33 \Rightarrow i_1 = \frac{5.04 + j6.33}{j1005M} = \frac{8.05\angle -38.5}{1000M} \end{cases}$$

$\hookrightarrow (50.25j)\left(\frac{8.05\angle -38.5^\circ}{1000M}\right) - j633M = 20$

$M^{\times}$ می‌کنیم.

$-j633M^2 - 20M + 0.4\angle 51.5^\circ = 0$

$\downarrow$

Δ

$M_1 = 41.91\ mH$

$M_2 = 15.24\ mH$

M هرگز منفی نمی‌شود.

K حداکثر ۱ می‌باشد.

$M_1 \Rightarrow K_1 = \frac{M_1}{\sqrt{L_1 L_2}} = 1.87 > 1$ غیر قابل قبول

$M_2 \Rightarrow K_2 = 0.68 < 1$ قابل قبول

امتحان: ۵ سوال ← ۱۵ نمره

(104)

RL و RC ص ۱۷ تا ۲۲

۵ سوال از ... ۲۴ و ۲۸

Poopak