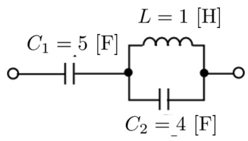
【問題1】



$$Z(s) = \frac{1}{sC_1} + \frac{sL\frac{1}{sC_2}}{sL + \frac{1}{sC_2}}$$
$$= \frac{1}{sC_1} + \frac{sL}{s^2LC_2 + 1}$$
$$= \frac{(s^2LC_2+1) + s^2LC_1}{sC_1(s^2LC_2+1)}$$
$$= \frac{L(C_1+C_2)s^2 + 1}{sC_1(s^2LC_2+1)}$$
$$= \frac{L(C_1+C_2)}{LC_1C_2}\frac{s^2 + \frac{1}{L(C_1+C_2)}}{s(s^2+\frac{1}{LC_2})} = \frac{C_1+C_2}{C_1C_2}\frac{s^2 + \frac{1}{L(C_1+C_2)}}{s(s^2+\frac{1}{LC_2})}$$
$$= \frac{5+4}{5\times 4}\frac{s^2+\frac{1}{1(5+4)}}{s(s^2+\frac{1}{4})} = \frac{9}{20}\frac{s^2+\frac{1}{9}}{s(s^2+\frac{1}{4})}$$

$$F(s) = K\frac{(s^2+\omega_1^2)(s^2+\omega_3^2)\cdots(s^2+\omega_{2n-1}^2)}{s(s^2+\omega_2^2)(s^2+\omega_4^2)\cdots(s^2+\omega_{2n-2}^2)}$$

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$$Z(s) = \frac{9}{20}\frac{s^2+\frac{1}{9}}{s(s^2+\frac{1}{4})}$$

極: $s\left(s^2 + \frac{1}{4}\right) = 0$

$s = 0,$

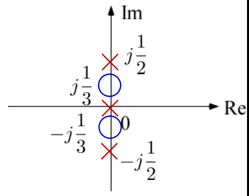
$s = \pm j\frac{1}{\sqrt{4}} = \pm j\frac{1}{2}$

$\omega_0 = 0, \quad \omega_2 = \frac{1}{2}$

零点: $s^2 + \frac{1}{9} = 0$

$s = \pm j\frac{1}{\sqrt{9}} = \pm j\frac{1}{3}$

$\omega_1 = \frac{1}{3}$



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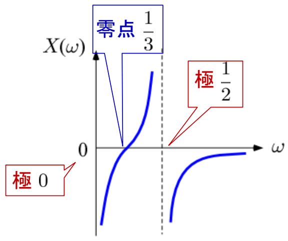
$$Z(s) = \frac{9}{20}\frac{s^2+\frac{1}{9}}{s(s^2+\frac{1}{4})}$$
$$Z(j\omega) = \frac{9}{20}\frac{-\omega^2+\frac{1}{9}}{j\omega(-\omega^2+\frac{1}{4})}$$
$$X(\omega) = -\frac{9}{20}\frac{-\omega^2+\frac{1}{9}}{\omega(-\omega^2+\frac{1}{4})}$$

タイプ4

$X(+0) = -\infty, \quad X(\infty) = 0$



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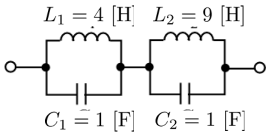
【問題2】



$$Z(s) = \frac{sL_1\frac{1}{sC_1}}{sL_1 + \frac{1}{sC_1}} + \frac{sL_2\frac{1}{sC_2}}{sL_2 + \frac{1}{sC_2}}$$
$$= \frac{sL_1}{1+s^2L_1C_1} + \frac{sL_2}{1+s^2L_2C_2}$$
$$= \frac{sL_1(1+s^2L_2C_2) + sL_2(1+s^2L_1C_1)}{(1+s^2L_1C_1)(1+s^2L_2C_2)}$$
$$= \frac{1}{L_1C_1L_2C_2}\frac{s((L_1+L_2) + s^2L_1L_2(C_1+C_2))}{(\frac{1}{L_1C_1}+s^2)(\frac{1}{L_2C_2}+s^2)}$$
$$= \frac{L_1L_2(C_1+C_2)}{L_1C_1L_2C_2}\frac{s\left(s^2 + \frac{L_1+L_2}{L_1L_2(C_1+C_2)}\right)}{(s^2+\frac{1}{L_1C_1})(s^2+\frac{1}{L_2C_2})}$$
$$= \frac{C_1+C_2}{C_1C_2}\frac{s\left(s^2 + \frac{L_1+L_2}{L_1L_2(C_1+C_2)}\right)}{(s^2+\frac{1}{L_1C_1})(s^2+\frac{1}{L_2C_2})}$$

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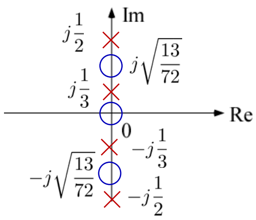
$$Z(s) = \frac{C_1+C_2}{C_1C_2}\frac{s\left(s^2 + \frac{L_1+L_2}{L_1L_2(C_1+C_2)}\right)}{(s^2+\frac{1}{L_1C_1})(s^2+\frac{1}{L_2C_2})}$$
$$= \frac{1+1}{1\times 1}\frac{s\left(s^2+\frac{4+9}{4\times 9(1+1)}\right)}{(s^2+\frac{1}{4\times 1})(s^2+\frac{1}{9\times 1})}$$
$$= 2\frac{s\left(s^2+\frac{13}{72}\right)}{(s^2+\frac{1}{4})(s^2+\frac{1}{9})}$$



極: $\left(s^2+\frac{1}{4}\right)\left(s^2+\frac{1}{9}\right) = 0$

$s = \pm j\frac{1}{\sqrt{4}} = \pm j\frac{1}{2}$

$s = \pm j\frac{1}{\sqrt{9}} = \pm j\frac{1}{3}$

零点: $s\left(s^2+\frac{13}{72}\right) = 0$

$s = 0$

$s = \pm j\sqrt{\frac{13}{72}} > \frac{1}{3}$

$$\frac{1}{3} = \frac{1}{\sqrt{9}} = \frac{\sqrt{8}}{\sqrt{72}}$$

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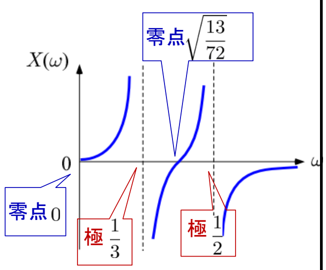
$$F(s) = K\frac{(s^2+\omega_1^2)(s^2+\omega_3^2)\cdots(s^2+\omega_{2n-1}^2)}{s(s^2+\omega_2^2)(s^2+\omega_4^2)\cdots(s^2+\omega_{2n-2}^2)}$$

$$Z(s) = 2\frac{s\left(s^2+\frac{13}{72}\right)}{(s^2+\frac{1}{4})(s^2+\frac{1}{9})}$$
$$Z(j\omega) = 2\frac{j\omega\left(-\omega^2+\frac{13}{72}\right)}{(-\omega^2+\frac{1}{4})(-\omega^2+\frac{1}{9})}$$
$$X(\omega) = 2\frac{\omega\left(-\omega^2+\frac{13}{72}\right)}{(-\omega^2+\frac{1}{4})(-\omega^2+\frac{1}{9})}$$



タイプ2 $X(0) = 0, \quad X(\infty) = 0$

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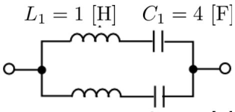
【問題3】

$L_1 = 1$ [H]　$C_1 = 4$ [F]



$L_2 = 1$ [H]　$C_2 = 9$ [F]

$$Z(s) = \frac{\left(sL_1 + \frac{1}{sC_1}\right)\left(sL_2 + \frac{1}{sC_2}\right)}{\left(sL_1 + \frac{1}{sC_1}\right) + \left(sL_2 + \frac{1}{sC_2}\right)}$$

$$= \frac{(s^2L_1C_1 + 1)(s^2L_2C_2 + 1)}{sC_2(s^2L_1C_1 + 1) + sC_1(s^2L_2C_2 + 1)}$$

$$= \frac{(s^2L_1C_1 + 1)(s^2L_2C_2 + 1)}{s(s^2L_1C_1C_2 + C_2 + s^2L_2C_2C_1 + C_1)}$$

$$= \frac{(s^2L_1C_1 + 1)(s^2L_2C_2 + 1)}{s(C_1C_2(L_1 + L_2)s^2 + (C_1 + C_2))}$$

$$= \frac{L_1\cancel{C_1}L_2\cancel{C_2}}{\cancel{C_1}\cancel{C_2}(L_1 + L_2)} \frac{\left(s^2 + \frac{1}{L_1C_1}\right)\left(s^2 + \frac{1}{L_2C_2}\right)}{s\left(s^2 + \frac{C_1+C_2}{C_1C_2(L_1+L_2)}\right)}$$

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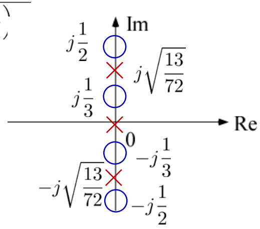
$$Z(s) = \frac{L_1L_2}{L_1 + L_2} \frac{\left(s^2 + \frac{1}{L_1C_1}\right)\left(s^2 + \frac{1}{L_2C_2}\right)}{s\left(s^2 + \frac{C_1+C_2}{C_1C_2(L_1+L_2)}\right)}$$

$$= \frac{1 \times 1}{1 + 1} \frac{(s^2 + \frac{1}{4\times1})(s^2 + \frac{1}{9\times1})}{s\left(s^2 + \frac{4+9}{4\times9(1+1)}\right)}$$

$$= \frac{1}{2} \frac{(s^2 + \frac{1}{4})(s^2 + \frac{1}{9})}{s\left(s^2 + \frac{13}{72}\right)}$$



極: $s\left(s^2 + \frac{13}{72}\right) = 0$

$s = 0$

$s = \pm j\sqrt{\frac{13}{72}} > \frac{1}{3}$

零点: $\left(s^2 + \frac{1}{4}\right)\left(s^2 + \frac{1}{9}\right) = 0$

$s = \pm j\frac{1}{\sqrt{4}} = \pm j\frac{1}{2}$

$s = \pm j\frac{1}{\sqrt{9}} = \pm j\frac{1}{3}$

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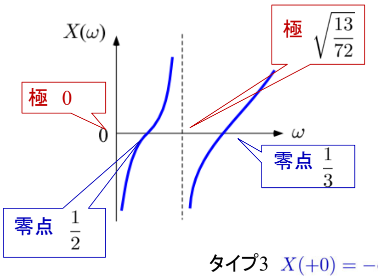
$$F(s) = K\frac{(s^2 + \omega_1^2)(s^2 + \omega_3^2)\cdots(s^2 + \omega_{2n-1}^2)}{s(s^2 + \omega_2^2)(s^2 + \omega_4^2)\cdots(s^2 + \omega_{2n-2}^2)}$$

$$Z(j\omega) = \frac{1}{2} \frac{(-\omega^2 + \frac{1}{4})(-\omega^2 + \frac{1}{9})}{j\omega\left(-\omega^2 + \frac{13}{72}\right)}$$

$$X(j\omega) = -\frac{1}{2} \frac{(-\omega^2 + \frac{1}{4})(-\omega^2 + \frac{1}{9})}{\omega\left(-\omega^2 + \frac{13}{72}\right)}$$



タイプ3　$X(+0) = -\infty$,　$X(\infty) = \infty$

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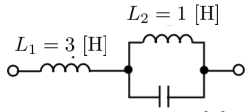
【問題4】

$L_2 = 1$ [H]

$L_1 = 3$ [H]



$C = 4$ [F]

$$Z(s) = L_1s + \frac{sL_2\frac{1}{sC}}{sL_2 + \frac{1}{sC}}$$

$$= L_1s + \frac{sL_2}{1 + s^2L_2C}$$

$$= \frac{L_1s(1 + s^2L_2C) + sL_2}{1 + s^2L_2C} = \frac{s((L_1 + L_2) + L_1L_2Cs^2)}{L_2Cs^2 + 1}$$

$$= \frac{L_1L_2C}{L_2C} \frac{s\left(s^2 + \frac{L_1+L_2}{L_1L_2C}\right)}{s^2 + \frac{1}{L_2C}} = L_1\frac{s\left(s^2 + \frac{L_1+L_2}{L_1L_2C}\right)}{s^2 + \frac{1}{L_2C}}$$

$$= L_1\frac{s\left(s^2 + \frac{3+1}{3\times1\times4}\right)}{s^2 + \frac{1}{1\times4}} = L_1\frac{s\left(s^2 + \frac{4}{12}\right)}{s^2 + \frac{1}{4}}$$

$$= 3\frac{s\left(s^2 + \frac{1}{3}\right)}{s^2 + \frac{1}{4}}$$

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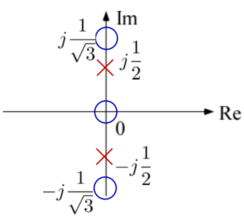
$$Z(s) = 3\frac{s\left(s^2 + \frac{1}{3}\right)}{s^2 + \frac{1}{4}}$$

極: $\left(s^2 + \frac{1}{4}\right) = 0$

$s = \pm j\frac{1}{\sqrt{4}} = \pm j\frac{1}{2}$

零点: $s\left(s^2 + \frac{1}{3}\right) = 0$

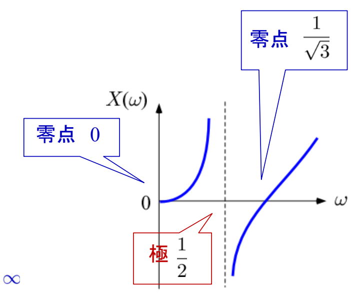
$s = 0,\ \pm j\frac{1}{\sqrt{3}}$



$$Z(s) = 3\frac{s\left(s^2 + \frac{1}{3}\right)}{s^2 + \frac{1}{4}}$$

$$Z(j\omega) = 3\frac{j\omega\left(-\omega^2 + \frac{1}{3}\right)}{-\omega^2 + \frac{1}{4}}$$

$$X(\omega) = 3\frac{\omega\left(-\omega^2 + \frac{1}{3}\right)}{-\omega^2 + \frac{1}{4}}$$



タイプ1

$X(0) = 0$,　$X(\infty) = \infty$

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