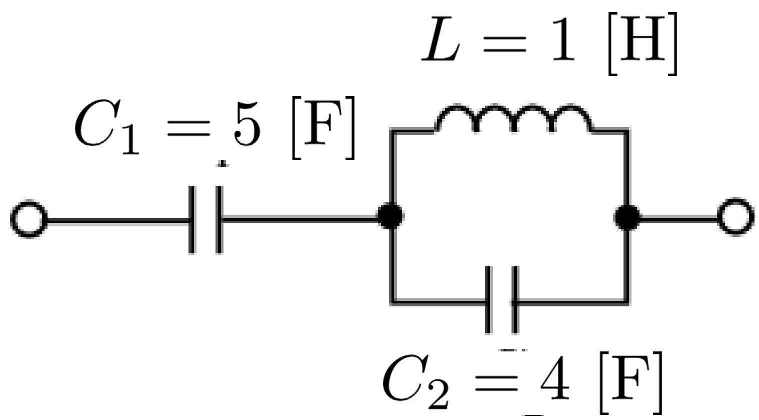
【問題1】



$$Z(s) = \frac{1}{sC_1} + \frac{sL\frac{1}{sC_2}}{sL + \frac{1}{sC_2}}$$

$$= \frac{1}{sC_1} + \frac{sL}{s^2LC_2 + 1}$$

$$= \frac{(s^2LC_2 + 1) + s^2LC_1}{sC_1(s^2LC_2 + 1)}$$

$$= \frac{L(C_1 + C_2)s^2 + 1}{sC_1(s^2LC_2 + 1)}$$

$$= \frac{L(C_1 + C_2)}{LC_1C_2}\frac{s^2 + \frac{1}{L(C_1+C_2)}}{s(s^2 + \frac{1}{LC_2})} = \frac{C_1 + C_2}{C_1C_2}\frac{s^2 + \frac{1}{L(C_1+C_2)}}{s(s^2 + \frac{1}{LC_2})}$$

$$= \frac{5 + 4}{5 \times 4}\frac{s^2 + \frac{1}{1(5+4)}}{s(s^2 + \frac{1}{4})} = \frac{9}{20}\frac{s^2 + \frac{1}{9}}{s(s^2 + \frac{1}{4})}$$

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

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

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

$$s = 0,$$

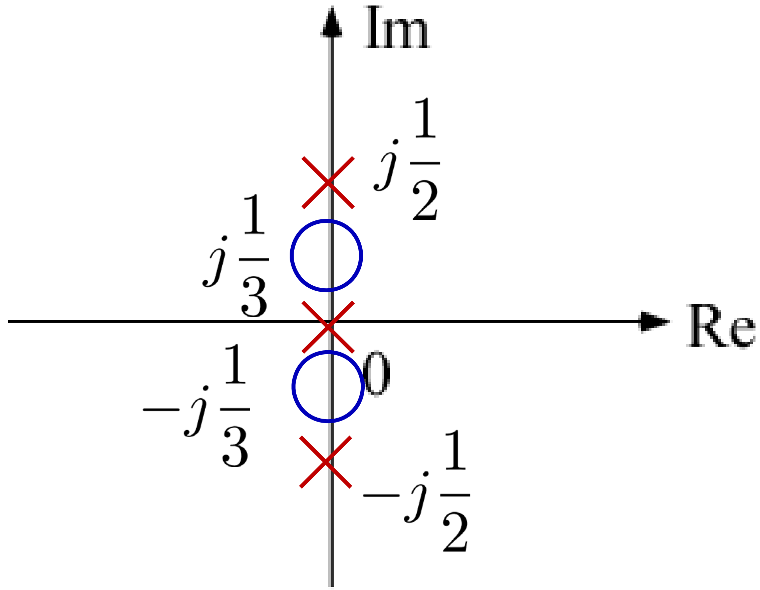
$$s = \pm j\frac{1}{\sqrt{4}} = \pm j\frac{1}{2}$$

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

零点： $$s^2 + \frac{1}{9} = 0$$

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

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



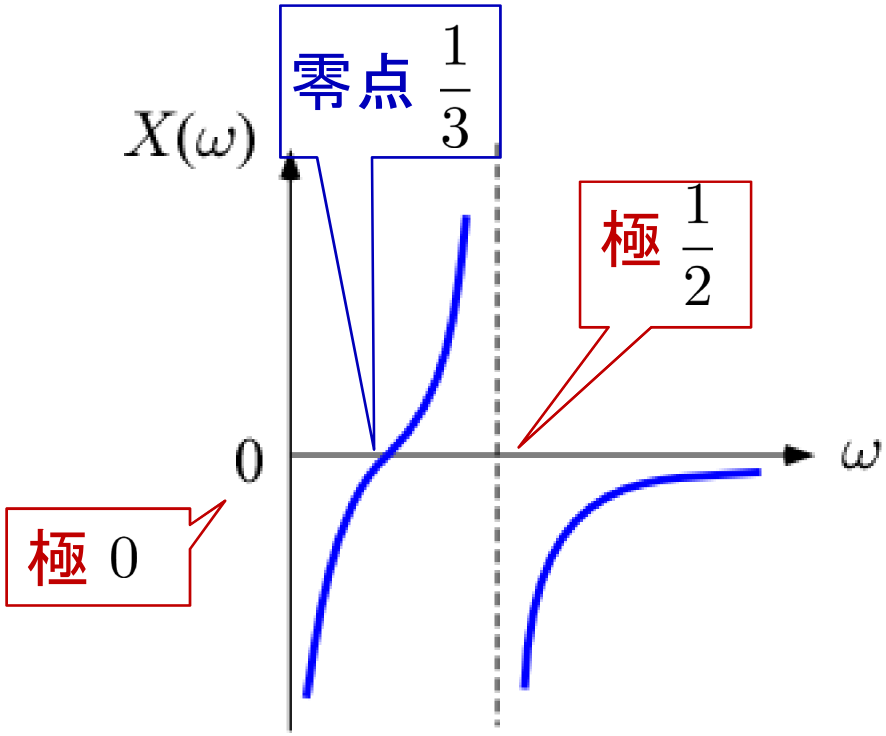
$$Z(s) = \frac{9}{20}\frac{s^2 + \frac{1}{9}}{s(s^2 + \frac{1}{4})}$$

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

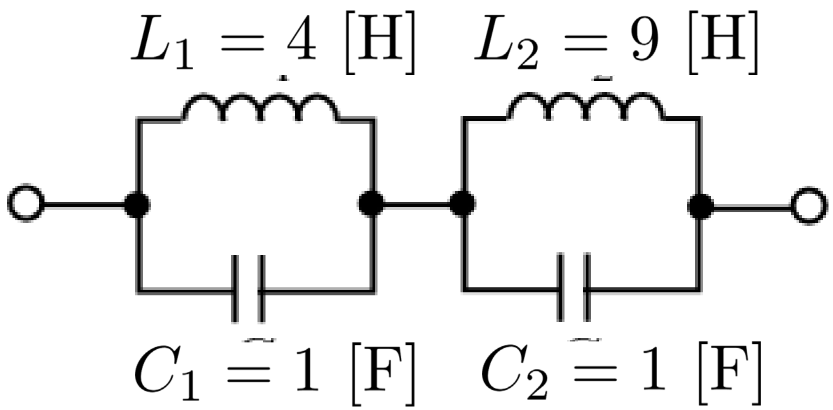
$$X(\omega) = -\frac{9}{20}\frac{-\omega^2 + \frac{1}{9}}{\omega(-\omega^2 + \frac{1}{4})}$$

タイプ4

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



【問題2】



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

$$= \frac{sL_1}{1 + s^2 L_1 C_1} + \frac{sL_2}{1 + s^2 L_2 C_2}$$

$$= \frac{sL_1(1 + s^2 L_2 C_2) + sL_2(1 + s^2 L_1 C_1)}{(1 + s^2 L_1 C_1)(1 + s^2 L_2 C_2)}$$

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

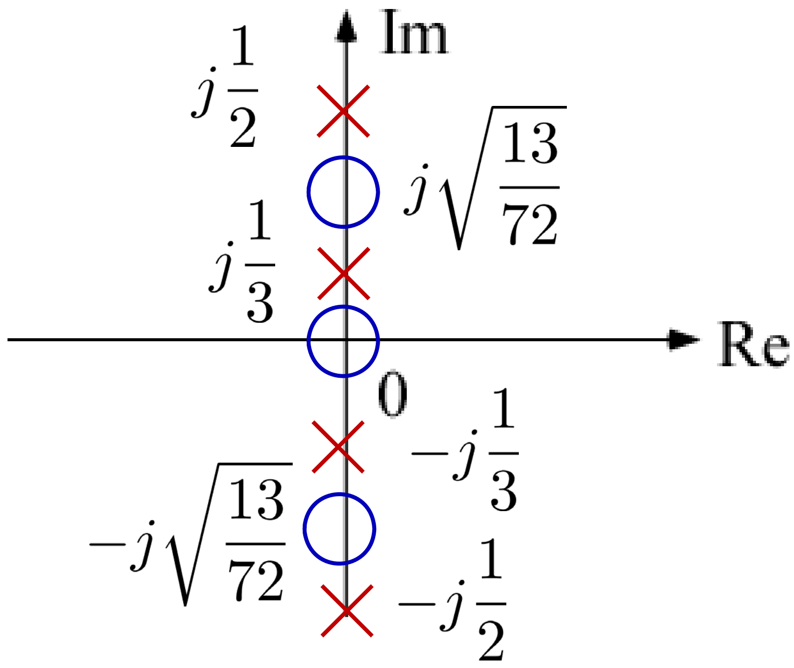
$$= \frac{\cancel{L_1} \cancel{L_2} (C_1 + C_2)}{\cancel{L_1} C_1 \cancel{L_2} C_2} \frac{s\left(s^2 + \frac{L_1 + L_2}{L_1 L_2 (C_1 + C_2)}\right)}{(s^2 + \frac{1}{L_1 C_1})(s^2 + \frac{1}{L_2 C_2})}$$

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

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

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

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



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:

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

$$s = 0$$

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

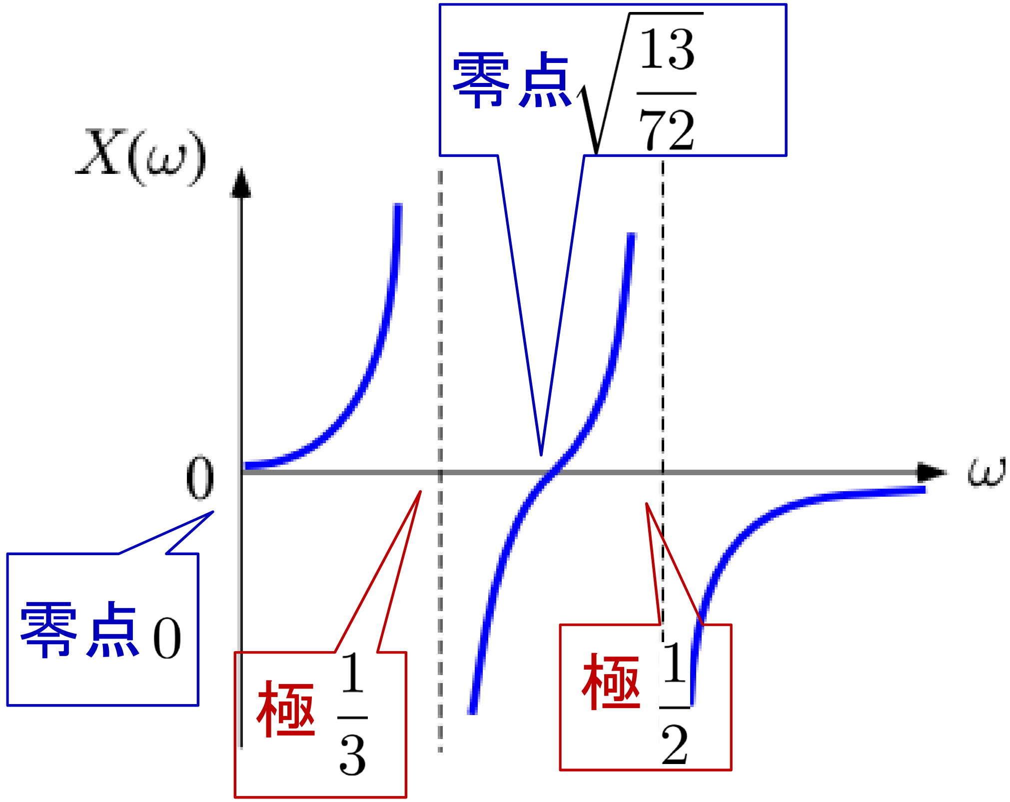
$$\frac{1}{3} = \frac{1}{\sqrt{9}} = \frac{\sqrt{8}}{\sqrt{72}}$$

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

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

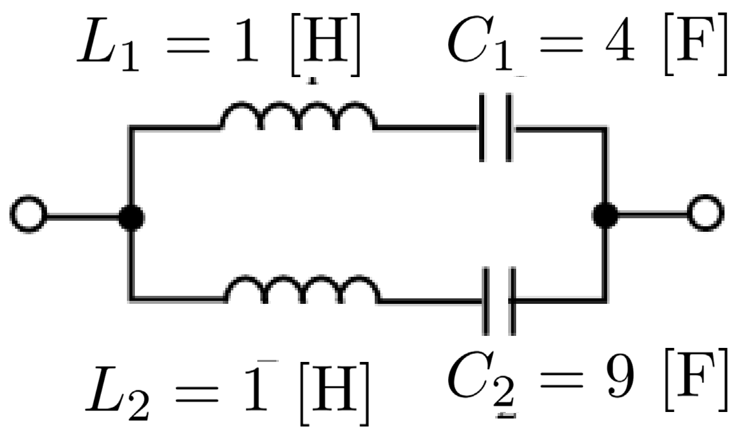
$$Z(j\omega) = 2\frac{j\omega\left(-\omega^2+\frac{13}{72}\right)}{(-\omega^2+\frac{1}{4})(-\omega^2+\frac{1}{9})}$$

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



タイプ2　$X(0) = 0, \quad X(\infty) = 0$

【問題3】



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

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

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

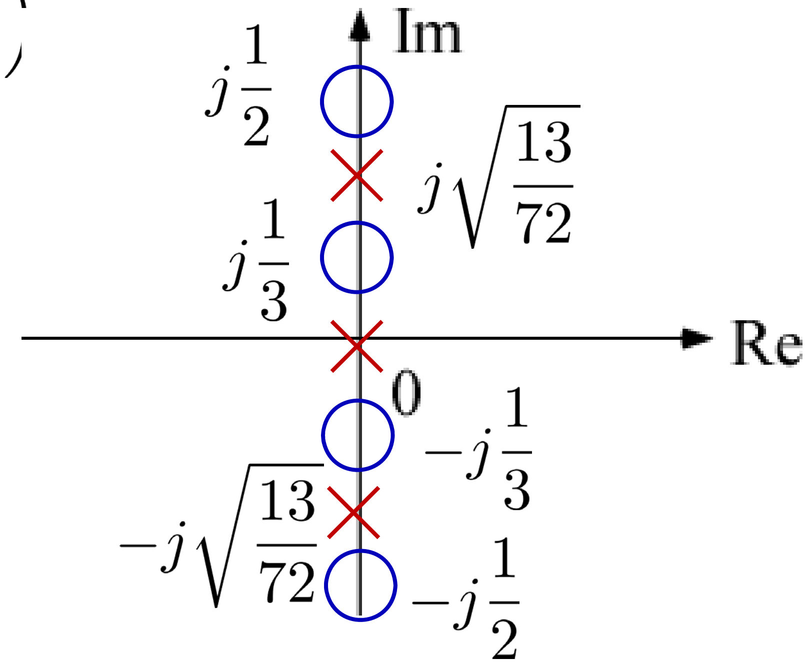
$$= \frac{\left(s^2L_1C_1 + 1\right)\left(s^2L_2C_2 + 1\right)}{s\left(C_1C_2(L_1 + L_2)s^2 + (C_1 + C_2)\right)}$$

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

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

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

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



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

$$s = 0$$

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

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

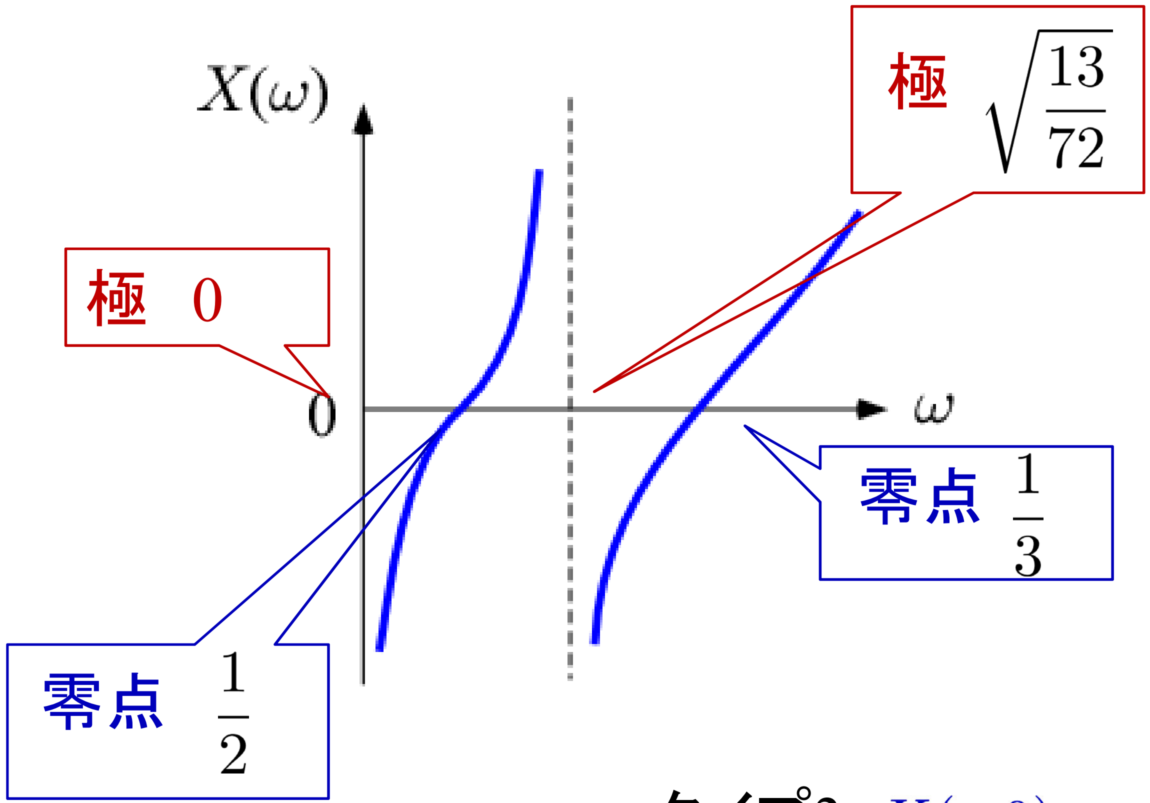
$$s = \pm j\frac{1}{\sqrt{4}} = \pm j\frac{1}{2}$$

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

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

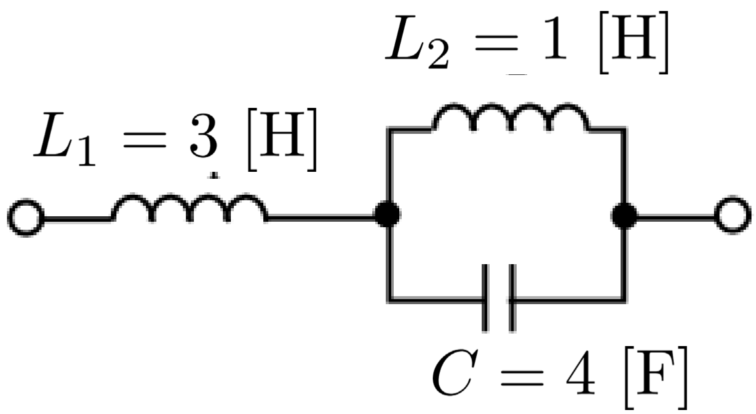
$$Z(j\omega) = \frac{1}{2}\frac{(-\omega^2+\frac{1}{4})(-\omega^2+\frac{1}{9})}{j\omega\left(-\omega^2+\frac{13}{72}\right)}$$

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



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

【問題4】



$$Z(s) = L_1 s + \frac{sL_2 \frac{1}{sC}}{sL_2 + \frac{1}{sC}}$$

$$= L_1 s + \frac{sL_2}{1 + s^2 L_2 C}$$

$$= \frac{L_1 s(1 + s^2 L_2 C) + sL_2}{1 + s^2 L_2 C} = \frac{s((L_1 + L_2) + L_1 L_2 C s^2)}{L_2 C s^2 + 1}$$

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

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

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

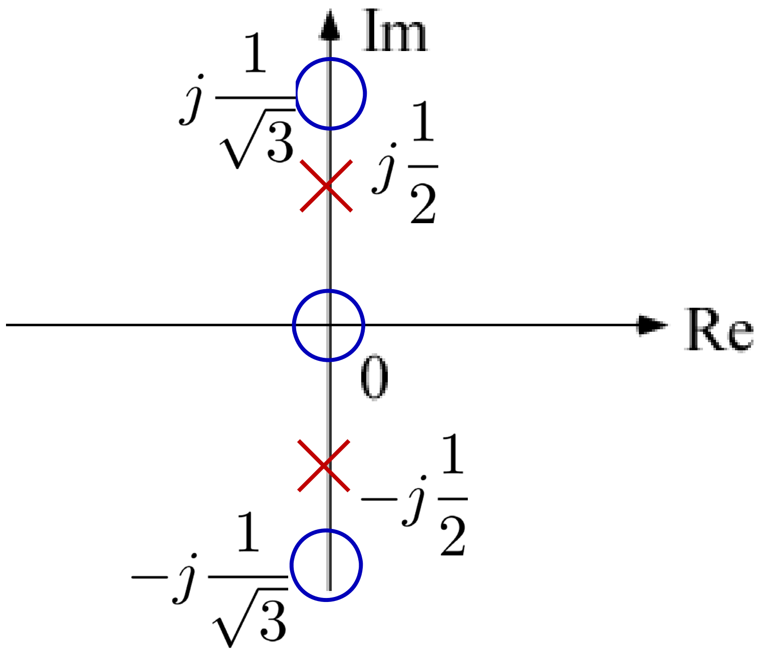
$$Z(s) = 3\frac{s\left(s^2+\frac{1}{3}\right)}{s^2+\frac{1}{4}}$$

极： $\left(s^2+\dfrac{1}{4}\right)=0$

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

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

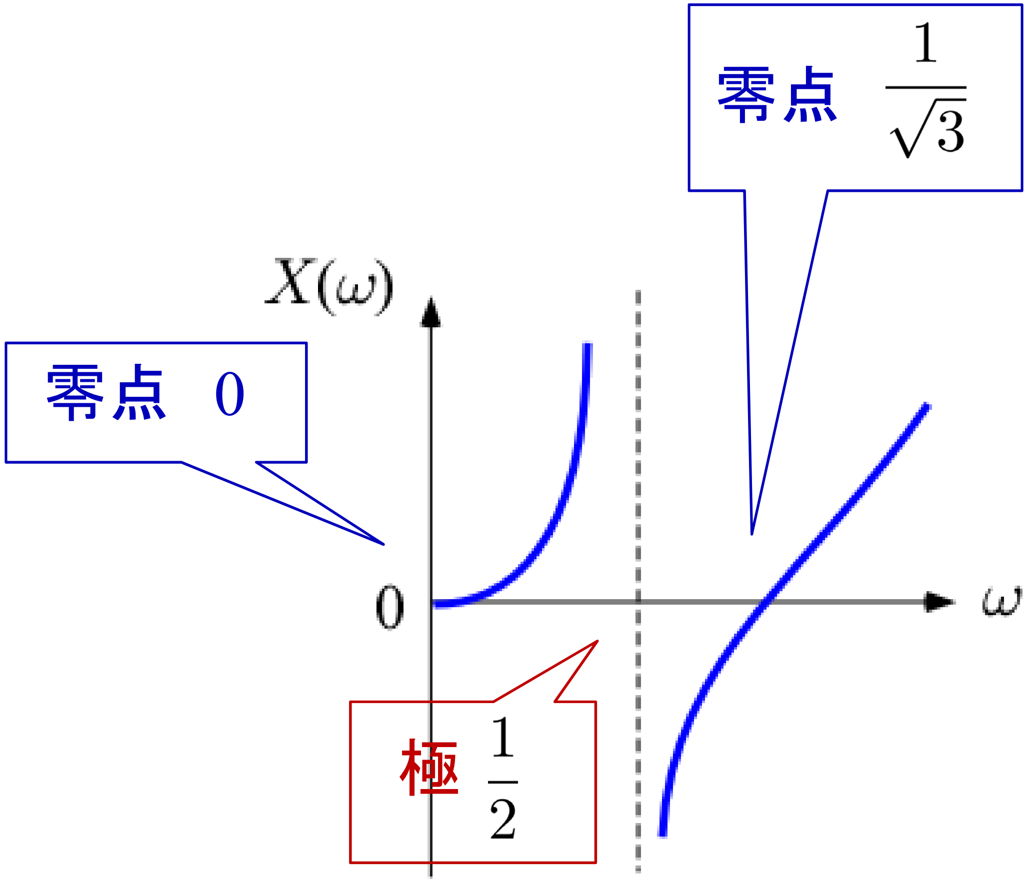
$$s=0,\ \ \pm j\frac{1}{\sqrt{3}}$$



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

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

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



タイプ1

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