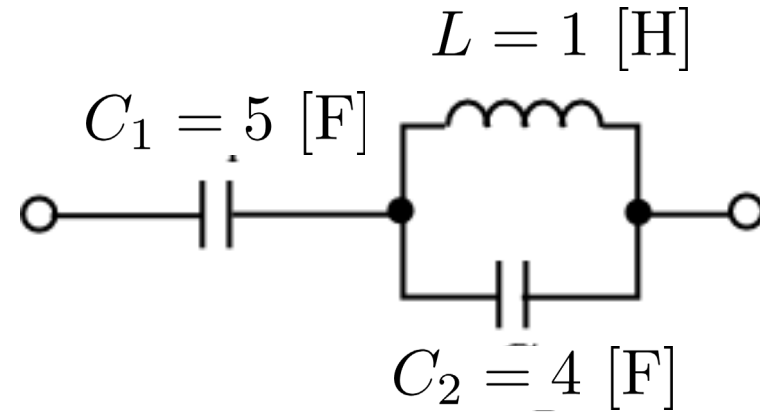


【問題1】

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



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

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

$$s = 0,$$

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

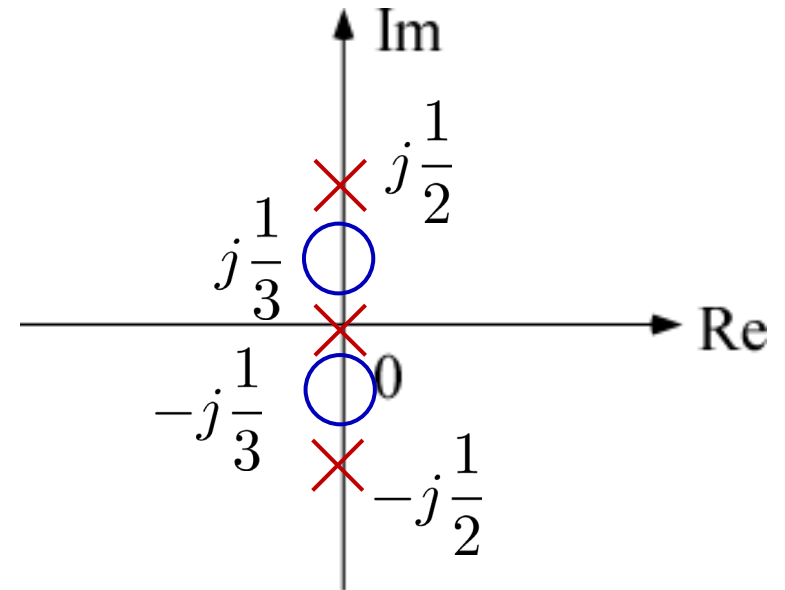
$$\omega_0 = 0, \quad \omega_2 = \frac{1}{2}$$

零点: $s^2 + \frac{1}{9} = 0$

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

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

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



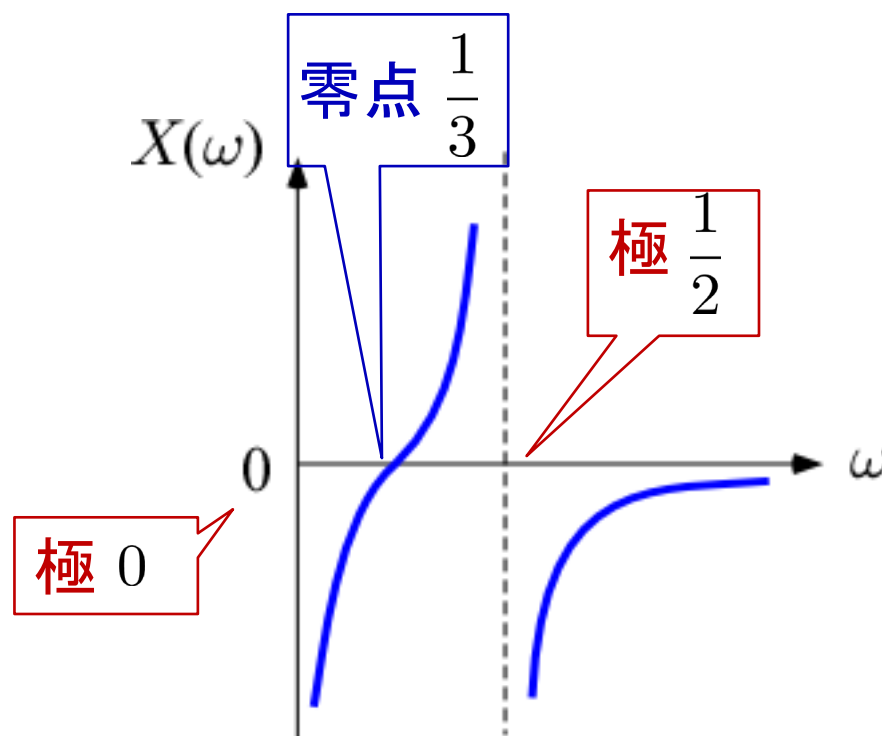
$$Z(s) = \frac{9}{20} \frac{s^2 + \frac{1}{9}}{s(s^2 + \frac{1}{4})}$$

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

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

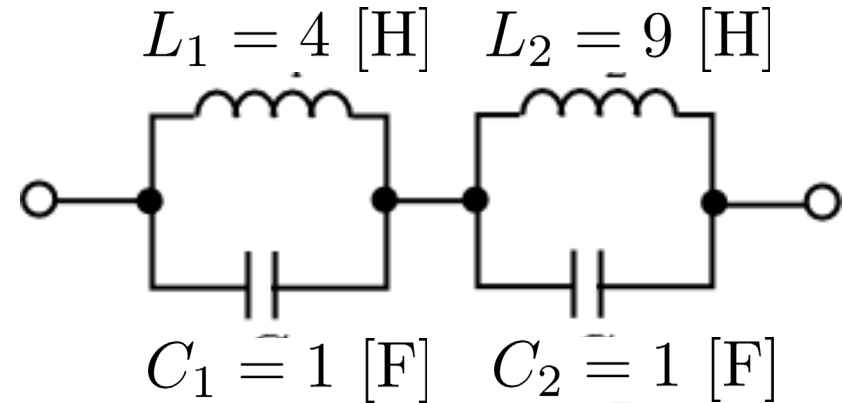
タイプ4

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

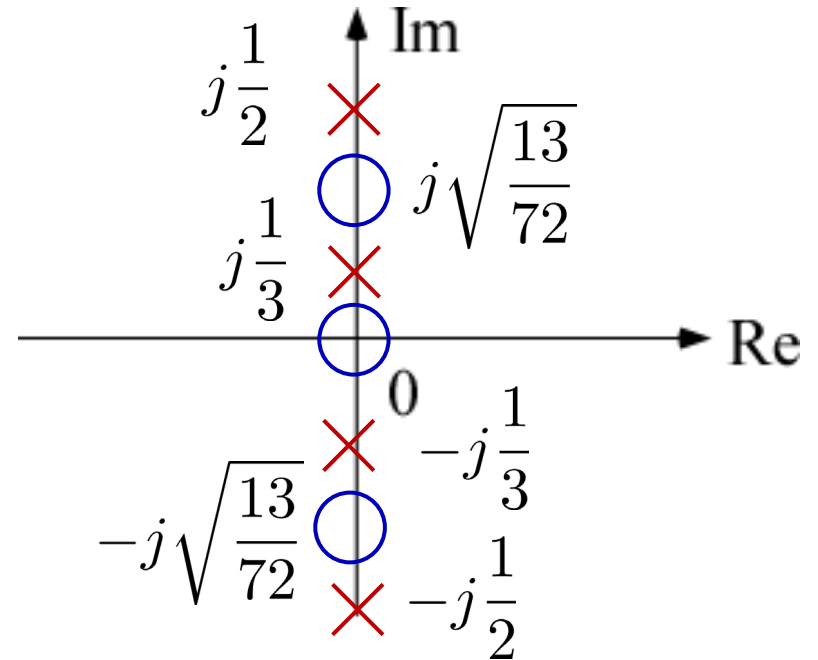


【問題2】

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



$$\begin{aligned}
 Z(s) &= \frac{C_1 + C_2}{C_1 C_2} \frac{s \left(s^2 + \frac{L_1 + L_2}{L_1 L_2 (C_1 + C_2)} \right)}{\left(s^2 + \frac{1}{L_1 C_1} \right) \left(s^2 + \frac{1}{L_2 C_2} \right)} \\
 &= \frac{1 + 1}{1 \times 1} \frac{s \left(s^2 + \frac{4 + 9}{4 \times 9 (1 + 1)} \right)}{\left(s^2 + \frac{1}{4 \times 1} \right) \left(s^2 + \frac{1}{9 \times 1} \right)} \\
 &= 2 \frac{s \left(s^2 + \frac{13}{72} \right)}{\left(s^2 + \frac{1}{4} \right) \left(s^2 + \frac{1}{9} \right)}
 \end{aligned}$$



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

$$s = 0$$

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

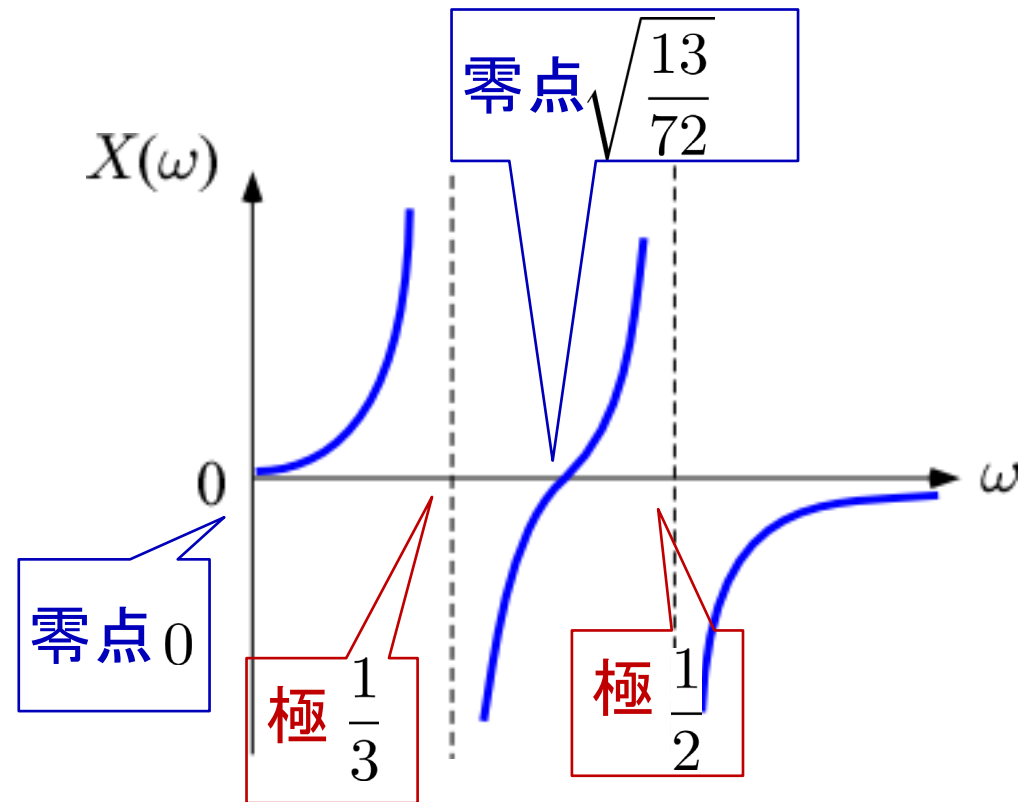
$$\frac{1}{3} = \frac{1}{\sqrt{9}} = \frac{\sqrt{8}}{\sqrt{72}}$$

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

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

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

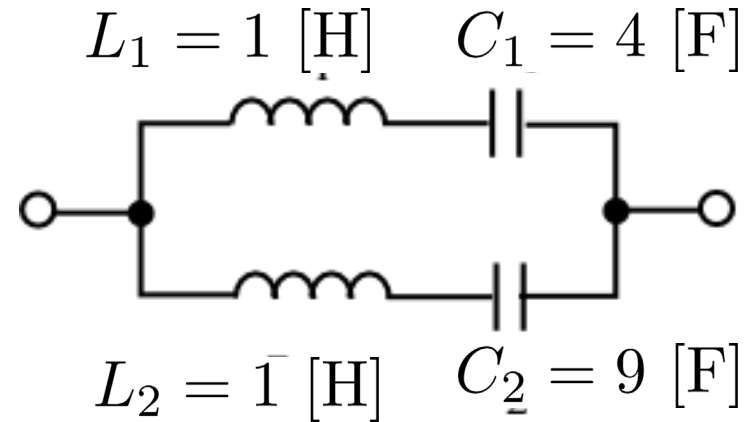
$$X(\omega) = 2 \frac{\omega \left(-\omega^2 + \frac{13}{72} \right)}{\left(-\omega^2 + \frac{1}{4} \right) \left(-\omega^2 + \frac{1}{9} \right)}$$



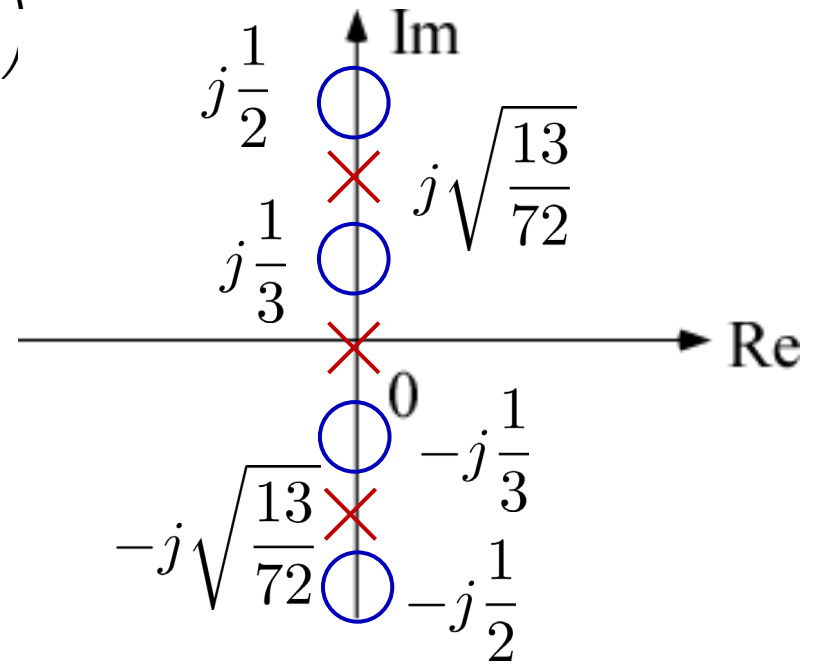
タイプ2 $X(0) = 0, X(\infty) = 0$

【問題3】

$$\begin{aligned}
 Z(s) &= \frac{\left(sL_1 + \frac{1}{sC_1}\right) \left(sL_2 + \frac{1}{sC_2}\right)}{\left(sL_1 + \frac{1}{sC_1}\right) + \left(sL_2 + \frac{1}{sC_2}\right)} \\
 &= \frac{(s^2L_1C_1 + 1)(s^2L_2C_2 + 1)}{sC_2(s^2L_1C_1 + 1) + sC_1(s^2L_2C_2 + 1)} \\
 &= \frac{(s^2L_1C_1 + 1)(s^2L_2C_2 + 1)}{s(s^2L_1C_1C_2 + C_2 + s^2L_2C_2C_1 + C_1)} \\
 &= \frac{(s^2L_1C_1 + 1)(s^2L_2C_2 + 1)}{s(C_1C_2(L_1 + L_2)s^2 + (C_1 + C_2))} \\
 &= \frac{\cancel{L_1}\cancel{C_1}\cancel{L_2}\cancel{C_2}}{\cancel{C_1}\cancel{C_2}(L_1 + L_2)} \frac{\left(s^2 + \frac{1}{L_1C_1}\right) \left(s^2 + \frac{1}{L_2C_2}\right)}{s \left(s^2 + \frac{C_1+C_2}{C_1C_2(L_1+L_2)}\right)}
 \end{aligned}$$



$$\begin{aligned}
 Z(s) &= \frac{L_1 L_2}{L_1 + L_2} \frac{\left(s^2 + \frac{1}{L_1 C_1}\right) \left(s^2 + \frac{1}{L_2 C_2}\right)}{s \left(s^2 + \frac{C_1 + C_2}{C_1 C_2 (L_1 + L_2)}\right)} \\
 &= \frac{1 \times 1}{1 + 1} \frac{\left(s^2 + \frac{1}{4 \times 1}\right) \left(s^2 + \frac{1}{9 \times 1}\right)}{s \left(s^2 + \frac{4 + 9}{4 \times 9 (1 + 1)}\right)} \\
 &= \frac{1}{2} \frac{\left(s^2 + \frac{1}{4}\right) \left(s^2 + \frac{1}{9}\right)}{s \left(s^2 + \frac{13}{72}\right)}
 \end{aligned}$$



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

$$s = 0$$

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

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

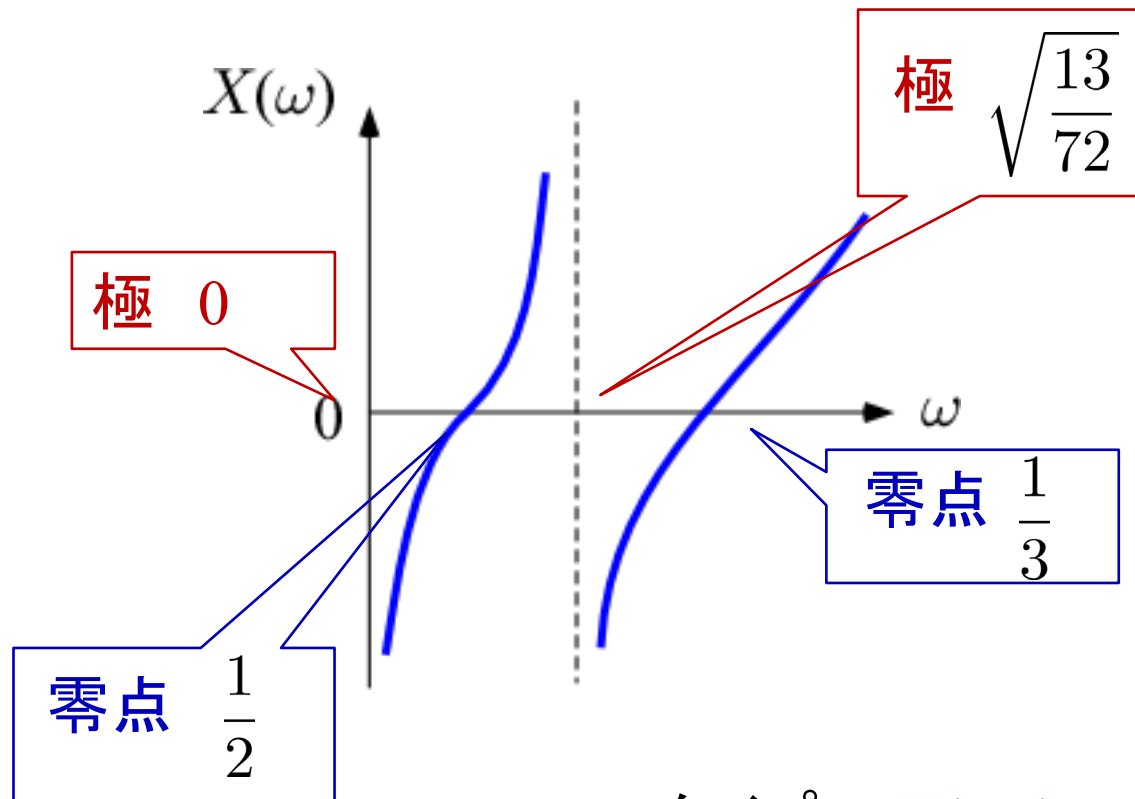
$$s = \pm j \frac{1}{\sqrt{4}} = \pm j \frac{1}{2}$$

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

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

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

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



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

【問題4】

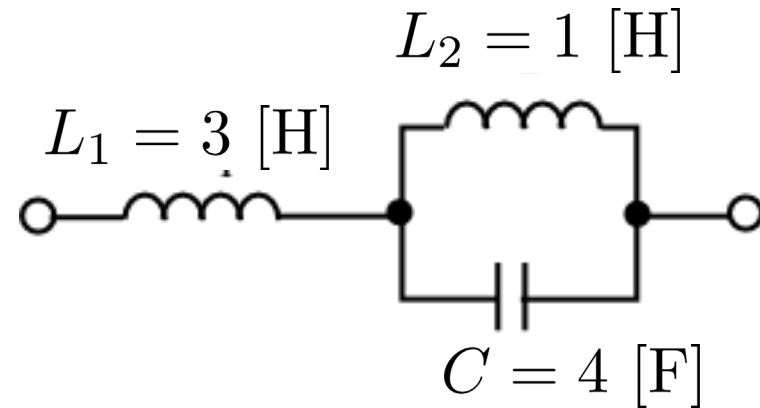
$$Z(s) = L_1 s + \frac{sL_2 \frac{1}{sC}}{sL_2 + \frac{1}{sC}}$$
$$= L_1 s + \frac{sL_2}{1 + s^2 L_2 C}$$

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

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

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

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



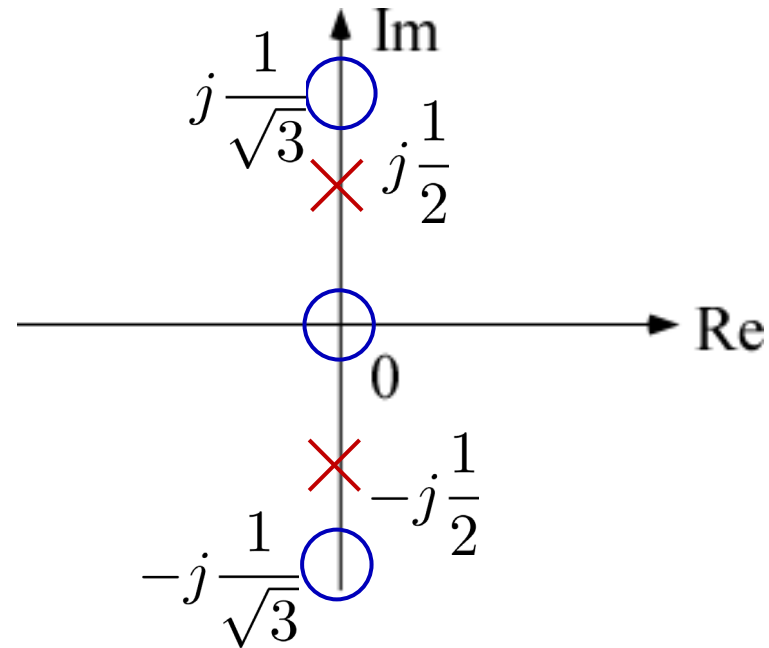
$$Z(s) = 3 \frac{s \left(s^2 + \frac{1}{3} \right)}{s^2 + \frac{1}{4}}$$

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

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

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

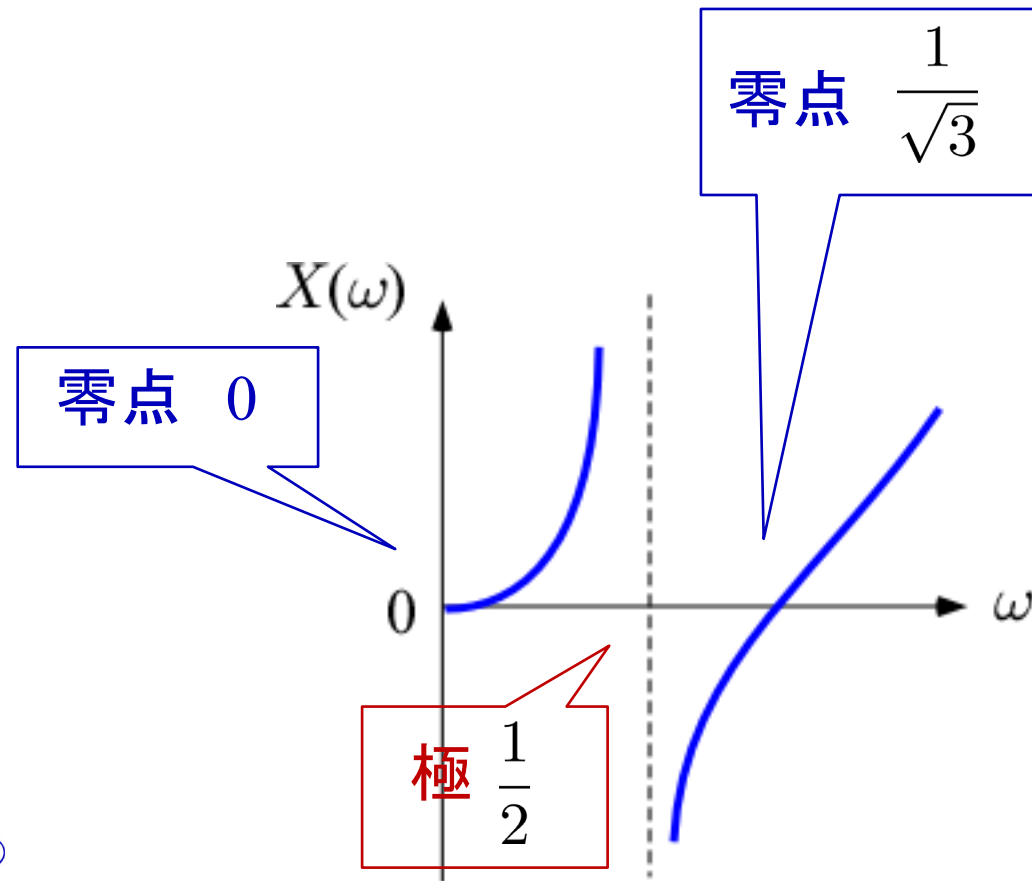
$$s = 0, \pm j \frac{1}{\sqrt{3}}$$



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

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

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



タイプ1

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