14.) 1.) Zer berechnen:

$$\frac{\left(sL+\frac{1}{sC_2}\right)\cdot\frac{1}{sC_1}}{sL+\frac{1}{sC_2}+\frac{1}{sC_1}} = \frac{\frac{sLC_2+1}{s^2C_1C_2}}{\frac{s^3C_1C_2L+sC_1+sC_2}{s^2C_1C_2}} = \frac{s^2LC_2+1}{s^3C_1C_2L+sC_1+sC_2} = Zer$$

2.) Spannungsteiler für gesamte Schaltung

$$\frac{U_c}{U_e} = \frac{Zer}{R+Zer} \Rightarrow \frac{Zer}{R+Zer}\cdot U_e = U_c$$

3.) Spannungsteiler für Zer

$$\frac{U_a}{U_c} = \frac{U_e}{U_e\cdot\frac{Zer}{Zer+R}} = \frac{\frac{1}{sC_2}}{\frac{1}{sC_2}+sL} \Rightarrow$$

$$\frac{U_a}{U_e} = \frac{\frac{1}{sC_2}}{\frac{1}{sC_2}+sL}\cdot\frac{Zer}{R+Zer} = \frac{(s^2C_2L+1)\cdot Zer}{R+Zer}$$

$$\Rightarrow \frac{U_a}{U_e} = \frac{1}{(s^2C_2L+1)}\cdot\frac{(s^2C_2L+1)}{R+\frac{s^2C_2L+1}{s^3C_1C_2L+sC_1+sC_2}}$$

$$\Rightarrow \frac{U_a}{U_e} = \frac{1}{R\cdot(s^3C_1C_2L+sC_1+sC_2)+s^2C_2L+1} = \frac{1}{\underbrace{s^3C_1C_2RL}_{1}+s\cdot\underbrace{(C_1R+C_2R)}_{2}+\underbrace{s^2LC_2}_{1}+1}$$

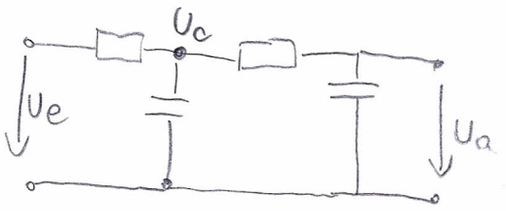
$$H(s) = \frac{1}{s^3+2s+s^2+1}$$

14.) Betrag:

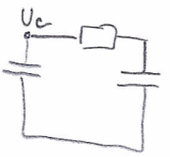
$$H(s) = \frac{1}{s^3 + s^2 + 2s + 1} \qquad s = j\omega$$

$$|H(j\omega)| = \frac{1}{\sqrt{(-\omega^2 + 1)^2 + (2j\omega - j\omega^3)^2}} = \frac{1}{\sqrt{-\omega^6 + 4\omega^4 - 6\omega^2 + 1}}$$

16.)



1.) Zer berechnen



$$Z_{er} = \frac{\left(R+\frac{1}{sC}\right)\cdot\frac{1}{sC}}{\frac{1}{sC}+\frac{1}{sC}+R} = \frac{\frac{sCR+1}{s^2C^2}}{\frac{2+sCR}{sC}} = \frac{sCR+1}{sC\cdot(2+sCR)}$$

2.) Spannungsteiler für gesamte Schaltung

$$\frac{U_c}{U_e} = \frac{Z_{er}}{Z_{er}+R} \Rightarrow U_c = U_e \cdot \frac{Z_{er}}{Z_{er}+R}$$

3.) Spannungsteiler für Zer

$$\frac{U_a}{U_c} \Rightarrow \frac{U_a}{U_e\cdot\frac{Z_{er}}{Z_{er}+R}} = \frac{\frac{1}{sC}}{R+\frac{1}{sC}} \Rightarrow \frac{U_a}{U_e} = \frac{1\cdot Z_{er}}{(sCR+1)\cdot(Z_{er}+R)}$$

$$\frac{U_a}{U_e} = \frac{1}{sCR+1}\cdot\frac{\frac{sCR+1}{sC\cdot(2+sCR)}}{\frac{(sCR+1)+sCR\cdot(2+sCR)}{sC\cdot(2+sCR)}}$$

$$\frac{U_a}{U_e} = \frac{1}{sCR+1+2sCR+s^2C^2R^2} = \frac{1}{s^2C^2R^2+3sCR+1}$$

$$\Rightarrow \frac{U_a(s)}{U_e(s)} = \frac{1}{s^2+3s+1}$$