8. AC-Technik (Frequenzverhalten) – Teil 2

8.1) <u>Geg.:</u>

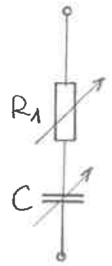
a1) $C = 250\,pF$; $f = 50\,kHz$; $R_1 = 10\,k\Omega,\ 50\,k\Omega,\ 100\,k\Omega$;

a2) $R_1 = 50\,k\Omega$; $f = 50\,kHz$; $C = 50\,pF,\ 100\,pF,\ 250\,pF$;

a3) $R_1 = 50\,k\Omega$; $C = 250\,pF$; $f = 10\,kHz,\ 20\,kHz,\ 50\,kHz$;

<u>Ges.:</u> $\underline{Z}$ - Ortskurven

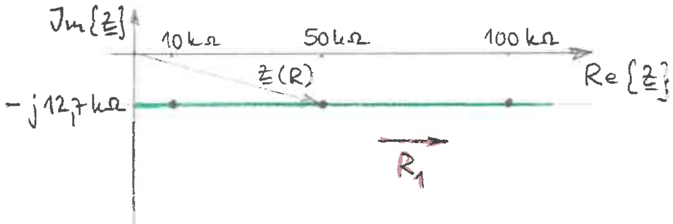
<u>Lös.:</u> a) $\boxed{\underline{Z}} = R_1 + X_c = R_1 + \frac{1}{j\omega C} = \boxed{R_1 - j\frac{1}{\omega C}}$;



Maßstab : $10\,k\Omega \mathrel{\hat{=}} 0{,}5\,cm$

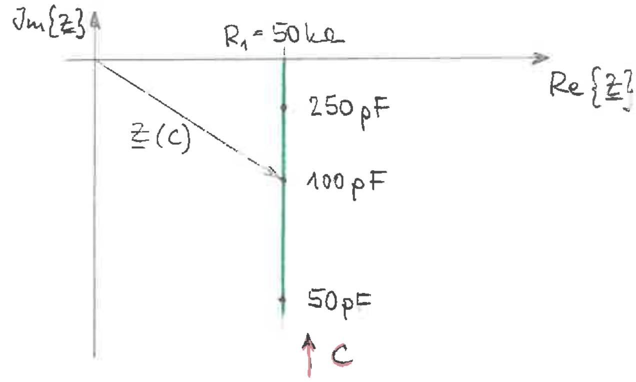
a1) $\underline{Z}(R)$ - Ortskurve : $Im\{\underline{Z}\} = const.$

R_1	$-Im\{\underline{Z}\}$
10 kΩ	12,73 kΩ
50 kΩ	12,73 kΩ
100 kΩ	12,73 kΩ



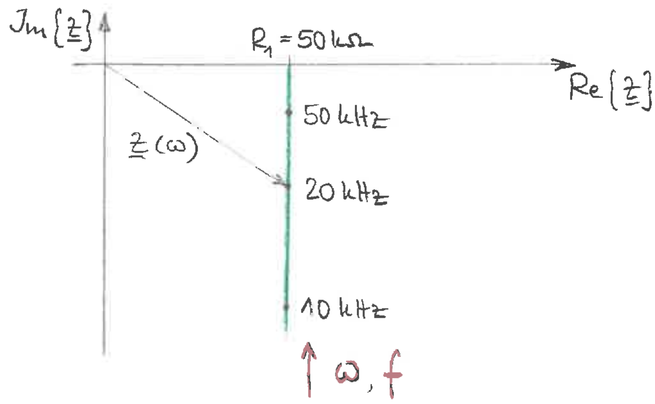
a2) $\underline{Z}(C)$ - Ortskurve : $Re\{\underline{Z}\} = const. = R_1$

C	$-Im\{\underline{Z}\}$
50 pF	63,66 kΩ
100 pF	31,83 kΩ
250 pF	12,73 kΩ



a3) $\underline{Z}(\omega)$ - Ortskurve : $Re\{\underline{Z}\} = const. = R_1$

f	ω	$-Im\{\underline{Z}\}$
10 kHz	$62{,}8 \cdot 10^3\ \frac{1}{s}$	63,66 kΩ
20 kHz	$125{,}7 \cdot 10^3\ \frac{1}{s}$	31,83 kΩ
50 kHz	$314{,}1 \cdot 10^3\ \frac{1}{s}$	12,73 kΩ



8. AC-Technik (Frequenzverhalten) – Teil 2

8.1) Geg.: b1) $L = 10\,mH$; $f = 50\,kHz$; $R_2 = 1\,k\Omega, 5\,k\Omega, 10\,k\Omega$;

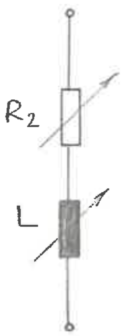
b2) $R_2 = 5\,k\Omega$; $f = 50\,kHz$; $L = 1\,mH, 5\,mH, 10\,mH$;

b3) $R_2 = 5\,k\Omega$; $L = 10\,mH$; $f = 5\,kHz; 25\,kHz; 50\,kHz$;

Ges.: $\underline{Z}$ – Ortskurven

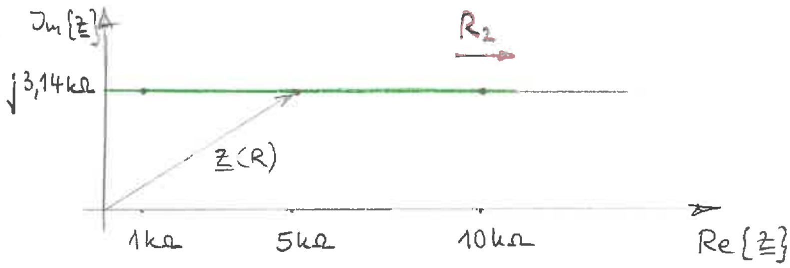
Lös.: b) $\boxed{\underline{Z}} = R_2 + X_L = \boxed{R_2 + j\omega L}$;

Maßstab: $1\,k\Omega \mathrel{\widehat{=}} 0{,}5\,cm$



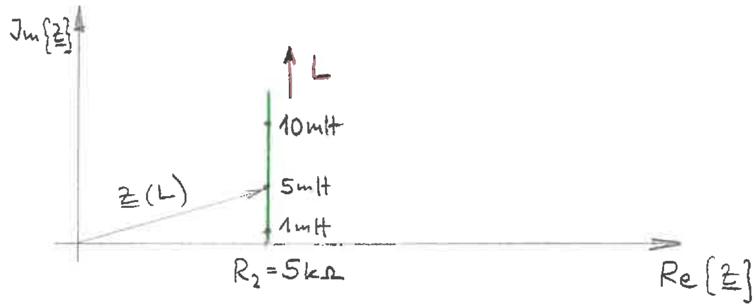
b1) $\underline{Z}(R)$ – Ortskurve: $Im\{\underline{Z}\} = const.$

R_2	$+Im\{\underline{Z}\}$
$1\,k\Omega$	$3{,}14\,k\Omega$
$5\,k\Omega$	$3{,}14\,k\Omega$
$10\,k\Omega$	$3{,}14\,k\Omega$



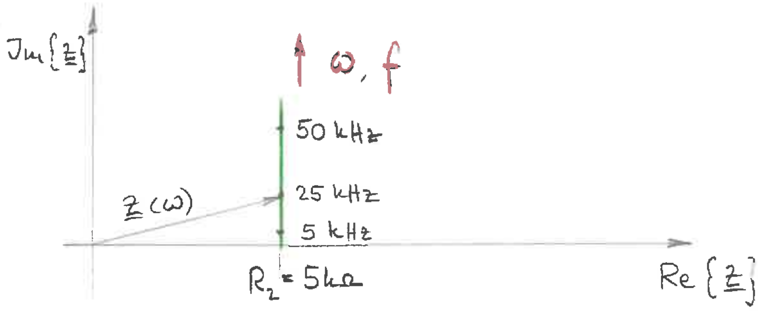
b2) $\underline{Z}(L)$ – Ortskurve: $Re\{\underline{Z}\} = const. = R_2$

L	$+Im\{\underline{Z}\}$
$1\,mH$	$314\,\Omega$
$5\,mH$	$1.570\,\Omega$
$10\,mH$	$3.140\,\Omega$



b3) $\underline{Z}(\omega)$ – Ortskurve: $Re\{\underline{Z}\} = const. = R_2$

f	ω	$+Im\{\underline{Z}\}$
$5\,kHz$	$31{,}4 \cdot 10^3\,\frac{1}{s}$	$314\,\Omega$
$25\,kHz$	$157 \cdot 10^3\,\frac{1}{s}$	$1.570\,\Omega$
$50\,kHz$	$314 \cdot 10^3\,\frac{1}{s}$	$3.140\,\Omega$



8. AC-Technik (Frequenzverhalten) – Teil 2

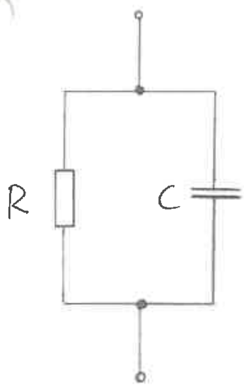
8.2) Geg.: $R = 1\,k\Omega$; $C = 10\,nF$; $f = 10\,kHz$, $20\,kHz$, $50\,kHz$;

Ges.: a) $\underline{Y}(\omega)$-Ortskurve, Grenzfrequenz f_g berechnen u. einzeichnen

b) $\underline{Z}(\omega)$-Ortskurve

Lös.:

$$\boxed{\underline{Y} = G + B_C = \frac{1}{R} + \frac{1}{X_C} = \underbrace{\frac{1}{R}}_{Re\{\underline{Y}\}} + \underbrace{j\omega C}_{Jm\{\underline{Y}\}}}$$



f	ω	$G = \frac{1}{R}$	$+Jm\{\underline{Y}\}$
10 kHz	$62{,}8 \cdot 10^3\,\frac{1}{s}$	1 mS	0,63 mS
20 kHz	$125{,}7 \cdot 10^3\,\frac{1}{s}$	1 mS	1,26 mS
50 kHz	$314{,}1 \cdot 10^3\,\frac{1}{s}$	1 mS	3,14 mS

Grenzfrequenz f_g:

(bei Phasenwinkel $\varphi = 45°$)

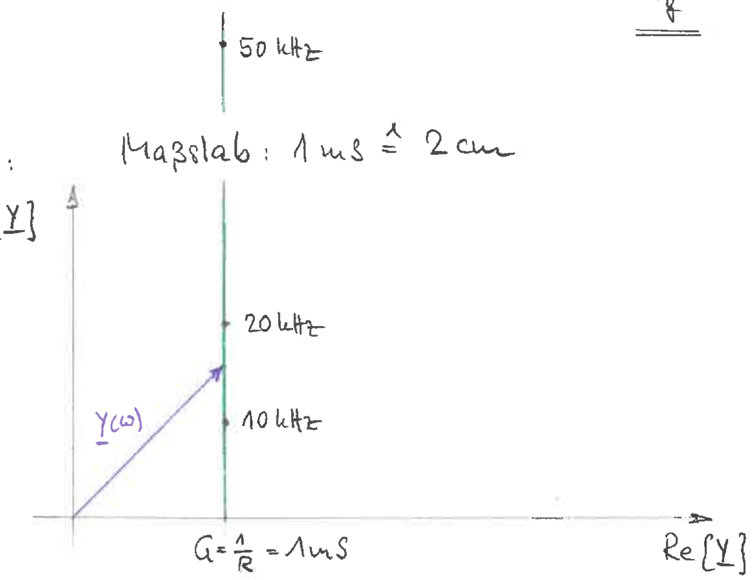
$\rightarrow |Re\{\underline{Y}\}| = |Jm\{\underline{Y}\}|$

$$1\,mS = 2\pi \cdot f \cdot C$$

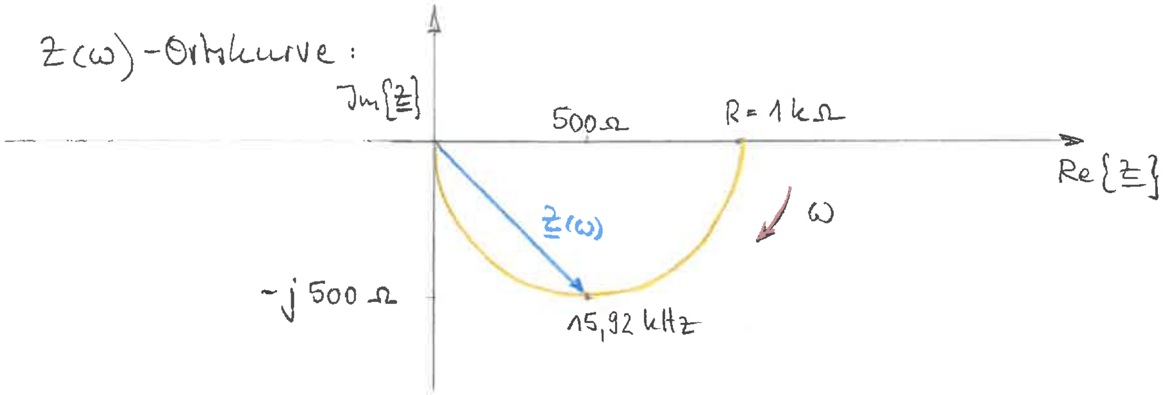
$$\underline{\underline{f_g}} = \frac{1 \cdot 10^{-3}\,\frac{A}{V}}{2 \cdot \pi \cdot 10 \cdot 10^{-9}\,\frac{A}{V}s} = \underline{\underline{15{,}92\,kHz}};$$

$\underline{Y}(\omega)$-Ortskurve:

Maßstab: $1\,mS \mathrel{\hat{=}} 2\,cm$



$\underline{Z}(\omega)$-Ortskurve:



8. AC-Technik (Frequenzverhalten) – Teil 2

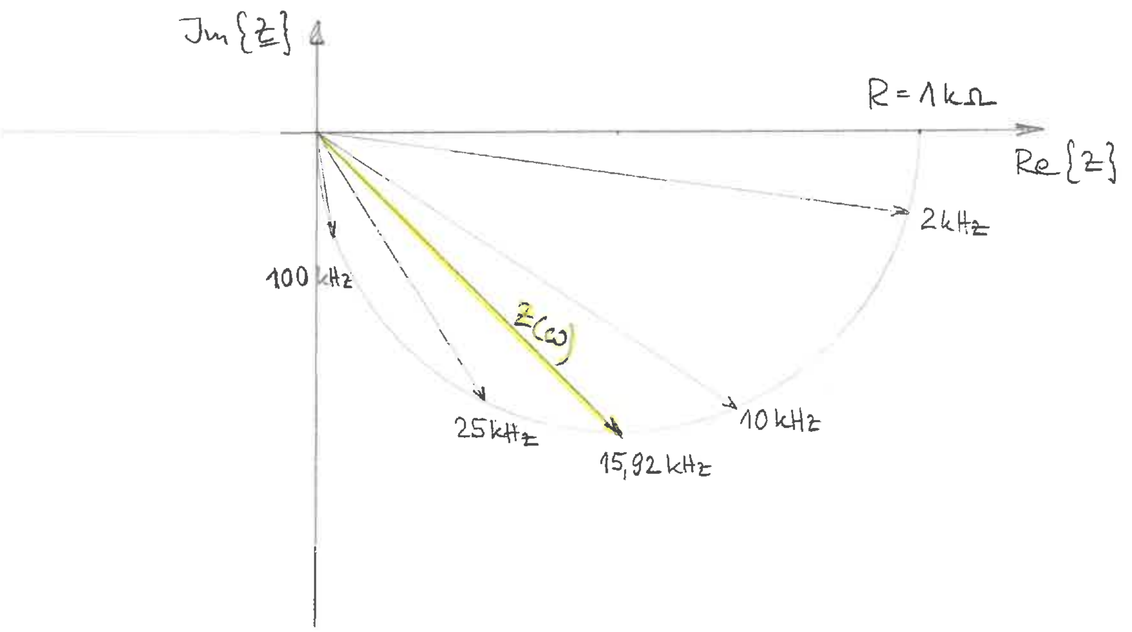
zu Aufg. 8.2

Frequenz f	R	Xc	Z	Phasen-winkel φ	*Re{Z}*	*Im{Z}*	Z	Zeigerlänge von Z
0,05 kHz	1 kΩ	318,310 kΩ	1,000 kΩ	-0,18°	*999,990 Ω*	*-3,142 Ω*	*999,995 Ω*	4,000 cm
1 kHz	1 kΩ	15,915 kΩ	0,998 kΩ	-3,60°	*996,068 Ω*	*-62,585 Ω*	*998,032 Ω*	3,992 cm
2 kHz	1 kΩ	7,958 kΩ	0,992 kΩ	-7,16°	*984,454 Ω*	*-123,710 Ω*	*992,197 Ω*	3,969 cm
5 kHz	1 kΩ	3,183 kΩ	0,954 kΩ	-17,44°	*910,170 Ω*	*-285,938 Ω*	*954,028 Ω*	3,816 cm
10 kHz	1 kΩ	1,592 kΩ	0,847 kΩ	-32,14°	*716,957 Ω*	*-450,477 Ω*	*846,733 Ω*	3,387 cm
15 kHz	1 kΩ	1,061 kΩ	0,728 kΩ	-43,30°	*529,587 Ω*	*-499,124 Ω*	*727,727 Ω*	2,911 cm
16 kHz	1 kΩ	1,000 kΩ	0,707 kΩ	-45,00°	*500,000 Ω*	*-500,000 Ω*	*707,107 Ω*	2,828 cm
20 kHz	1 kΩ	0,796 kΩ	0,623 kΩ	-51,49°	*387,727 Ω*	*-487,232 Ω*	*622,677 Ω*	2,491 cm
25 kHz	1 kΩ	0,637 kΩ	0,537 kΩ	-57,52°	*288,400 Ω*	*-453,018 Ω*	*537,029 Ω*	2,148 cm
50 kHz	1 kΩ	0,318 kΩ	0,303 kΩ	-72,34°	*92,000 Ω*	*-289,025 Ω*	*303,314 Ω*	1,213 cm
100 kHz	1 kΩ	0,159 kΩ	0,157 kΩ	-80,96°	*24,705 Ω*	*-155,223 Ω*	*157,177 Ω*	0,629 cm
200 kHz	1 kΩ	0,080 kΩ	0,079 kΩ	-85,45°	*6,293 Ω*	*-79,077 Ω*	*79,327 Ω*	0,317 cm
500 kHz	1 kΩ	0,032 kΩ	0,032 kΩ	-88,18°	*1,012 Ω*	*-31,799 Ω*	*31,815 Ω*	0,127 cm
1.000 kHz	1 kΩ	0,016 kΩ	0,016 kΩ	-89,09°	*0,253 Ω*	*-15,911 Ω*	*15,913 Ω*	0,064 cm
10.000 kHz	1 kΩ	0,002 kΩ	0,002 kΩ	-89,91°	*0,003 Ω*	*-1,592 Ω*	*1,592 Ω*	0,006 cm
100.000 kHz	1 kΩ	0,000 kΩ	0,000 kΩ	-89,99°	*0,000 Ω*	*-0,159 Ω*	*0,159 Ω*	0,001 cm

$$Y = \sqrt{G^2 + B_c^2}$$

$$\left(\frac{1}{Z}\right)^2 = \left(\frac{1}{R}\right)^2 + \left(\frac{1}{X_c}\right)^2 \quad \rightsquigarrow \quad Z = \sqrt{\frac{1}{\left(\frac{1}{R}\right)^2 + (2\pi f \cdot C)^2}} \; ;$$

$$\varphi = \arctan \frac{X_c}{R} - 90° \; ;$$

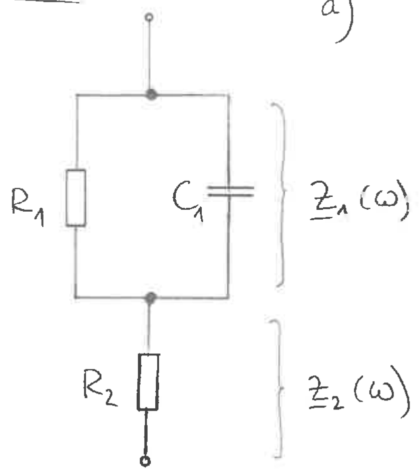


8. AC – Technik (Frequenzverhalten) – Teil 2

8.3) Geg.: Reihenschaltung von $R_1 \| C_1$ mit $\underline{Z}_2$; $\underline{Z}_2 = R_2$;

Ges.: prinzip. Verlauf der $\underline{Z}(\omega)$-Ortskurve u. Diskussion der Frequenzpunkte $\omega = 0$ u. $\omega = \infty$;

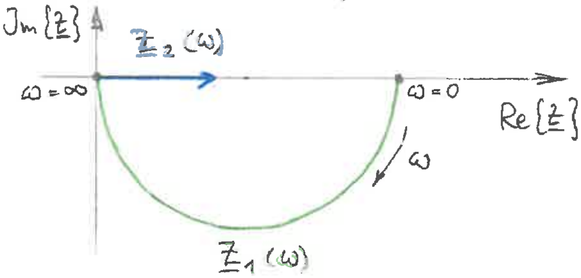
Lös.:



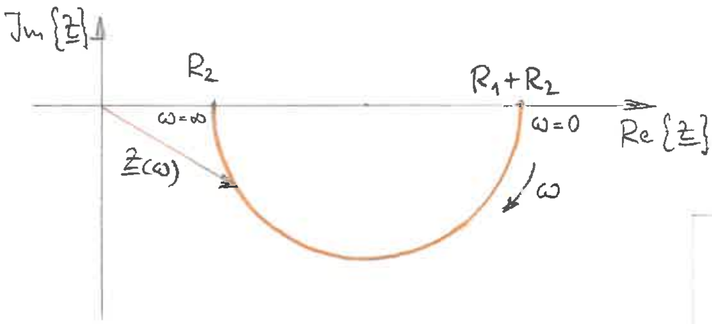
a) Der konstante komplexe Widerstand $\underline{Z}_2(\omega)$ ist hier ein reeler Widerstand R_2, dessen Ortskurve $\underline{Z}_2(\omega)$ als eine Gerade in der reelen Achse liegt.
Die $\underline{Z}_1(\omega)$-Ortskurve der $R_1 \| C_1$-Schaltung hat die Form eines Halbkreises im 4. Quadranten und den Durchmesser R_1.

$\Longrightarrow$ Durch Verschiebung der $\underline{Z}_1(\omega)$-Ortskurve um R_2 ergibt sich die resultierende $\underline{Z}(\omega)$-Ortskurve

Einzelortskurven $\underline{Z}_1(\omega)$ u. $\underline{Z}_2(\omega)$:



Resultierende $\underline{Z}(\omega)$-Ortskurve:



b) Betrachtung der Frequenzpunkte $\omega = 0$ u. $\omega = \infty$:

$$\underline{Y}_1 = \frac{1}{R_1} + j\omega C_1$$

$$\rightsquigarrow \underline{Z}_1 = \frac{1}{\frac{1}{R_1} + j\omega C_1} = \frac{R_1}{1 + j\omega R_1 \cdot C_1}$$

u. $\underline{Z}_2 = R_2$

$$\rightsquigarrow \boxed{\underline{Z} = \underline{Z}_1 + \underline{Z}_2 = R_2 + \frac{R_1}{1 + j\omega R_1 \cdot C_1}}$$

$$\omega = 0 : \quad \underline{Z}(\omega) = R_2 + \frac{R_1}{1+0} = R_1 + R_2 ,$$

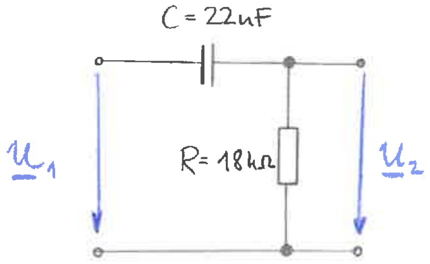
$$\omega = \infty : \quad \underline{Z}(\omega) = R_2 + 0 = R_2 ;$$

8. AC-Technik (Frequenzverhalten) – Teil 2

8.4) <u>Geg.:</u> RC-Hochpass; $f_n = 10\,\text{Hz},\ 100\,\text{Hz},\ 400\,\text{Hz},\ 1\,\text{kHz},\ 10\,\text{kHz}$;
$R = 18\,k\Omega$ u. $C = 22\,nF$

<u>Ges.:</u> Amplituden- u. Phasengang für die Frequenzen f_n

<u>Lös.:</u>



$$\frac{\underline{U}_2}{\underline{U}_1} = \frac{R}{R + \frac{1}{j\omega C}} = \frac{1}{1 - j\frac{1}{\omega RC}}$$

$$\boxed{\frac{U_2}{U_1} = \frac{1}{\sqrt{1 + \left(\frac{1}{\omega RC}\right)^2}}}$$

−3 dB-Grenzfrequenz:

$$\omega_g = \frac{1}{R \cdot C} \sim f_g = \frac{1}{2\pi R \cdot C}$$

normierte Frequenz:

$$\boxed{\Omega} = \frac{\omega}{\omega_g} = \frac{\omega}{\frac{1}{RC}} = \boxed{\omega RC}$$

$$;\ \omega_g = \frac{1}{RC} = \frac{1}{18 \cdot 10^3 \frac{V}{A} \cdot 22 \cdot 10^{-9} \frac{As}{V}} = 2.525{,}25\,\frac{1}{s};$$

$(f_g = 401{,}9\,\text{Hz})$

Darstellung des Amplitudenganges:

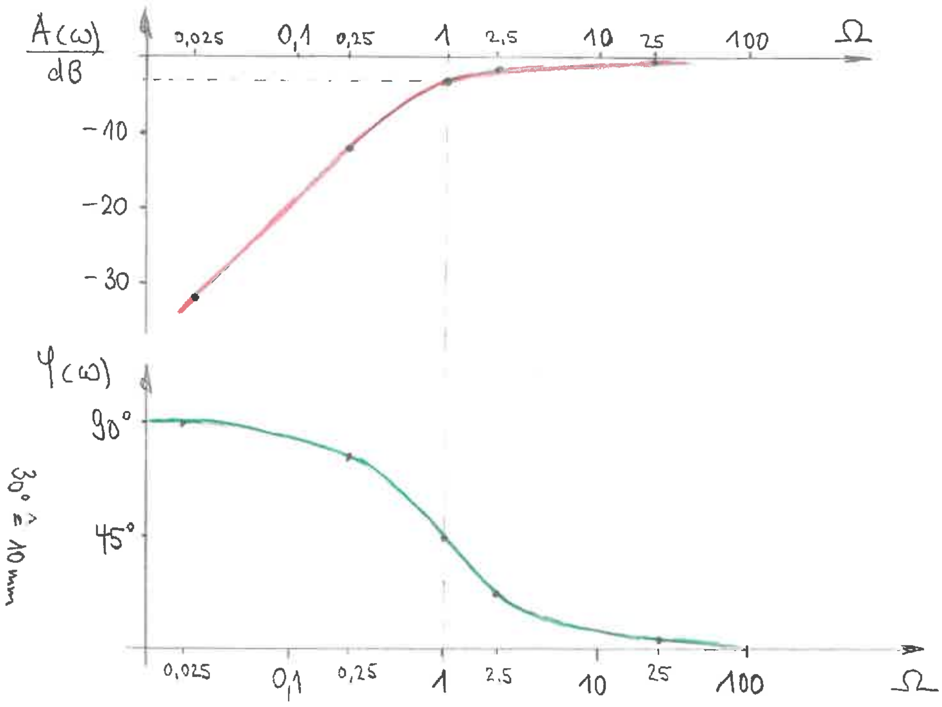
$$\boxed{\frac{A(\omega)}{dB} = 20 \cdot \lg \frac{U_2}{U_1}}$$

f in Hz	ω in s^{-1}	$\Omega = \frac{\omega}{\omega_g}$	$\frac{U_2}{U_1}$	$A(\omega)$	$\varphi(\omega)$
10	62,83	0,025	0,025	−32 dB	88,6°
100	628,3	0,25	0,25	−12 dB	75,9°
400	2.513	0,995	0,705	−3 dB	45°
1.000	6.283	2,488	0,928	−0,65 dB	21,9°
10.000	62.832	24,88	0,999	−0,007 dB	2,3°

für Hochpass gilt:

$$\varphi(\omega) = \arctan \frac{\omega_g}{\omega}$$

$$\sim \boxed{\varphi(\omega) = \arctan \frac{1}{\Omega}}$$

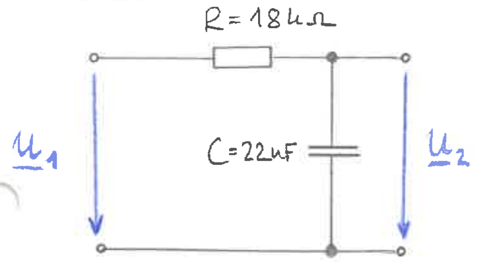


8. AC-Technik (Frequenzverhalten) – Teil 2

8.5) Geg.: RC-Tiefpass ; $f_n = 10\,Hz,\ 100\,Hz,\ 400\,Hz,\ 1\,kHz,\ 10\,kHz$;
$R = 18\,k\Omega$ u. $C = 22\,nF$

Ges.: Amplituden- u. Phasengang für die Frequenzen f_n

Lös.:



$$\frac{u_2}{u_1} = \frac{\frac{1}{j\omega C}}{\frac{1}{j\omega C} + R} = \frac{1}{1 + j\omega RC}$$

$$\boxed{\frac{u_2}{u_1} = \frac{1}{\sqrt{1 + (\omega RC)^2}}}$$

–3 dB – Grenzfrequenz:

$$\omega_g = \frac{1}{R \cdot C} \curvearrowright f_g = \frac{1}{2\pi \cdot R \cdot C}$$

normierte Frequenz:

$$\boxed{\Omega = \frac{\omega}{\omega_g} = \frac{\omega}{\frac{1}{RC}} = \omega RC} \;;\quad \omega_g = \frac{1}{RC} = \frac{1}{18 \cdot 10^3 \frac{V}{A} \cdot 22 \cdot 10^{-9} \frac{As}{V}} = 2.525{,}25\,\frac{1}{s};$$

$(f_g = 401{,}9\ Hz)$

Darstellung des Amplitudenganges:

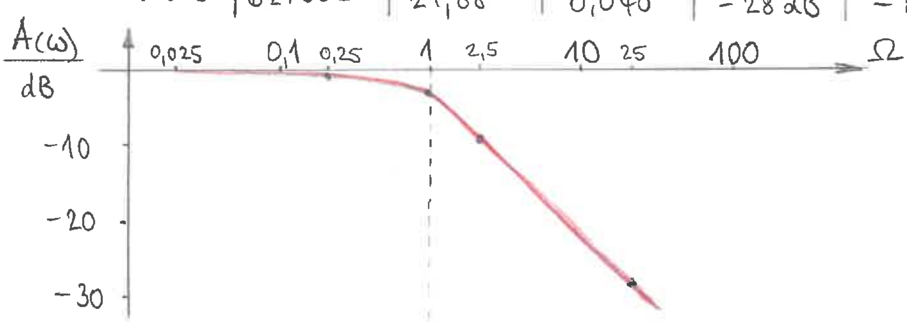
$$\boxed{\frac{A(\omega)}{dB} = 20 \cdot \lg \frac{u_2}{u_1}}$$

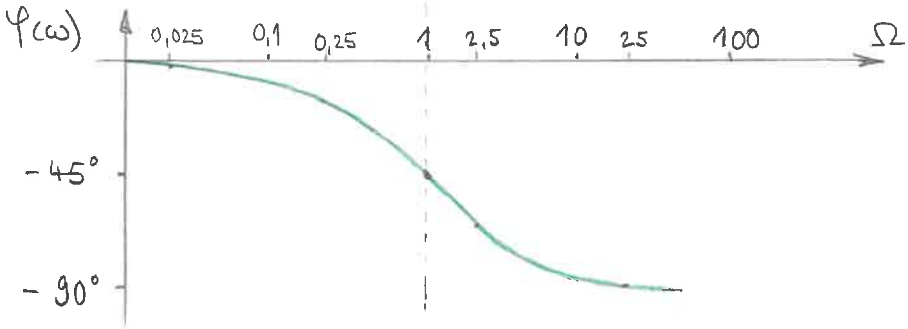
f in Hz	ω in s^{-1}	$\Omega = \frac{\omega}{\omega_g}$	$\frac{u_2}{u_1}$	$A(\omega)$	$\varphi(\omega)$
10	62,83	0,025	0,999	–0,003 dB	–1,4°
100	628,3	0,25	0,970	–0,26 dB	–14°
400	2.513	0,995	0,709	–3 dB	–45°
1.000	6.283	2,488	0,373	–9 dB	–68°
10.000	62.832	24,88	0,040	–28 dB	–88°

für Tiefpass gilt:

$$\varphi(\omega) = -\arctan \frac{\omega}{\omega_g}$$

$$\curvearrowright \boxed{\varphi(\omega) = -\arctan \Omega}$$





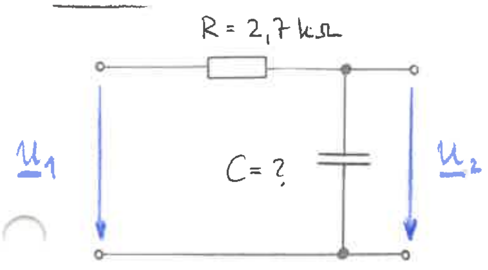
8. AC-Technik (Frequenzverhalten) – Teil 2

8.6) Geg.: bei $f = 1{,}8$ kHz Dämpfung 20 dB ; $R = 2{,}7\,k\Omega$;

Ges.: a) $C = ?$; b) ω_g u. f_g ? , c) $L = ?$

d) Amplituden- u. Phasengang

Lös.:



a) $$\frac{U_2}{U_1} = \frac{\frac{1}{j\omega C}}{\frac{1}{j\omega C} + R} = \frac{1}{1 + j\omega RC}$$

$$\frac{U_2}{U_1} = \frac{1}{\sqrt{1 + (\omega RC)^2}}$$

$$-20\,dB = 20 \cdot lg \frac{U_2}{U_1}$$

$$-1 = lg \frac{U_2}{U_1} \curvearrowright \frac{U_2}{U_1} = 10^{-1} = 0{,}1 ;$$

$$0{,}1 = \frac{1}{\sqrt{1 + (\omega RC)^2}}$$

$$1 + (\omega RC)^2 = 100 \curvearrowright (\omega RC)^2 = 99$$

$$\underline{C} = \frac{\sqrt{99}}{2\pi \cdot f \cdot R} = \frac{\sqrt{99}}{2\pi \cdot 1{,}8 \cdot 10^3 \frac{1}{s} \cdot 2{,}7 \cdot 10^3 \frac{V}{A}} = \underline{325{,}8\,nF} ;$$

b) $$\frac{U_2}{U_1} = \frac{1}{\sqrt{2}} = \frac{1}{\sqrt{1 + (\omega RC)^2}}$$

$$\curvearrowright 1 = \frac{2}{1 + (\omega_g \cdot R \cdot C)^2}$$

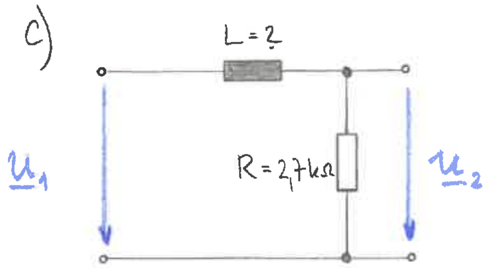
$$1 + (\omega_g \cdot R \cdot C)^2 = 2$$

$$\omega_g \cdot R \cdot C = 1$$

$$\curvearrowright \underline{\omega_g} = \frac{1}{RC} = \frac{1}{2{,}7 \cdot 10^3 \frac{V}{A} \cdot 325{,}8 \cdot 10^{-9} \frac{As}{V}} = \underline{1.136{,}8 \frac{1}{s}} ,$$

$$\underline{f_g} = \frac{\omega_g}{2\pi} = \frac{1.136{,}8 \frac{1}{s}}{2\pi} = \underline{180{,}9\,Hz} ;$$

c)



$$\frac{U_2}{U_1} = \frac{R}{R + j\omega L} = \frac{1}{1 + j\frac{\omega L}{R}}$$

$$\frac{U_2}{U_1} = \frac{1}{\sqrt{1 + \left(\frac{\omega L}{R}\right)^2}} ; \quad \frac{U_2}{U_1} = \frac{1}{\sqrt{2}}$$

$$\Rightarrow 1 = \frac{2}{1 + \left(\frac{\omega_g \cdot L}{R}\right)^2} \curvearrowright 1 + \left(\frac{\omega_g \cdot L}{R}\right)^2 = 2 \curvearrowright \omega_g = \frac{R}{L} \text{ bzw. } \underline{L} = \frac{R}{\omega_g} = \frac{2{,}7 \cdot 10^3 \frac{V}{A}}{1.136{,}8 \frac{1}{s}} =$$

$$= 2{,}38 \frac{Vs}{A} = \underline{2{,}38\,H} ;$$

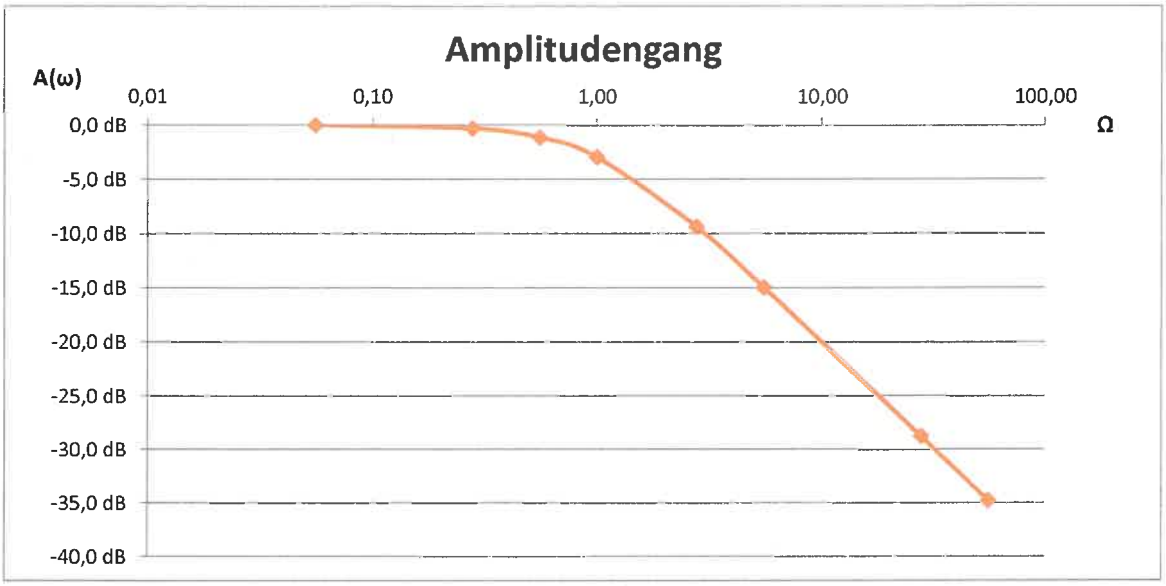
8. AC-Technik (Frequenzverhalten) – Teil 2

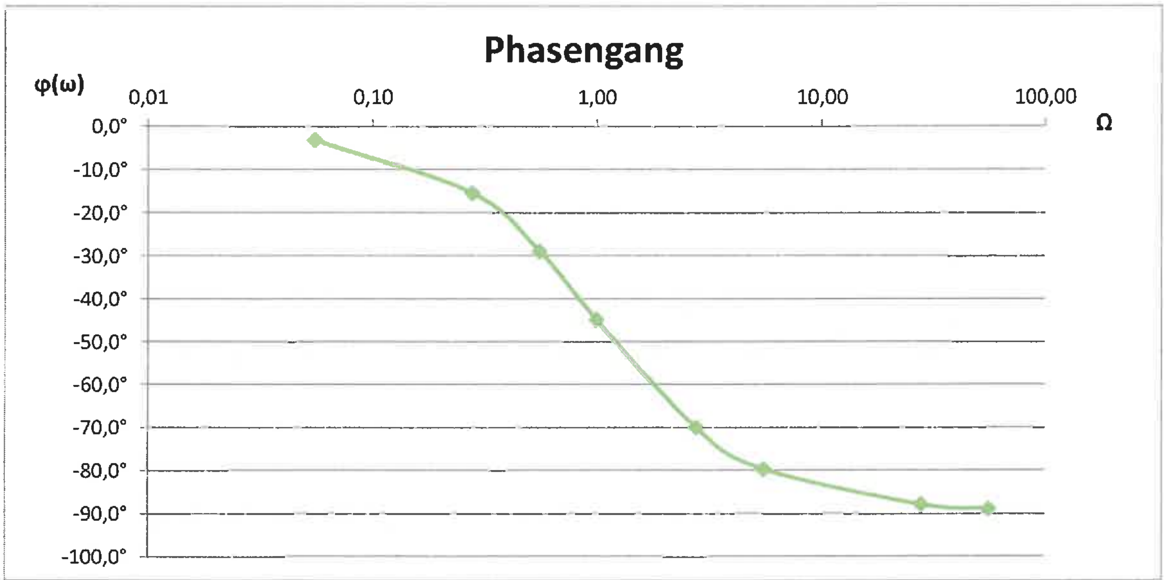
Aufg. 8.6: RC-Tiefpass

f in Hz	ω in s^{-1}	$\Omega = \omega/\omega_g$	U_2/U_1	A(ω)	φ(ω)	C= 325,84 nF
10 Hz	62,83	0,055	0,998	-0,013 dB	-3,2°	
50 Hz	314,16	0,276	0,964	-0,320 dB	-15,4°	
100 Hz	628,32	0,553	0,875	-1,158 dB	-28,9°	
180 Hz	1.130,97	0,995	0,709	-2,988 dB	-44,9°	
500 Hz	3.141,59	2,764	0,340	-9,364 dB	-70,1°	
1.000 Hz	6.283,19	5,527	0,178	-14,990 dB	-79,7°	
5.000 Hz	31.415,93	27,635	0,036	-28,835 dB	-87,9°	
10.000 Hz	62.831,85	55,271	0,018	-34,851 dB	-89,0°	

Aufg. 8.6: RL-Tiefpass

f in Hz	ω in s^{-1}	$\Omega = \omega/\omega_g$	U_2/U_1	A(ω)	φ(ω)	L= 2,375 H
10 Hz	62,83	0,055	0,998	-0,013 dB	-3,2°	
50 Hz	314,16	0,277	0,964	-0,321 dB	-15,5°	
100 Hz	628,32	0,554	0,875	-1,162 dB	-29,0°	
180 Hz	1.130,97	0,997	0,708	-2,997 dB	-44,9°	
500 Hz	3.141,59	2,769	0,340	-9,380 dB	-70,1°	
1.000 Hz	6.283,19	5,539	0,178	-15,007 dB	-79,8°	
5.000 Hz	31.415,93	27,693	0,036	-28,853 dB	-87,9°	
10.000 Hz	62.831,85	55,385	0,018	-34,869 dB	-89,0°	



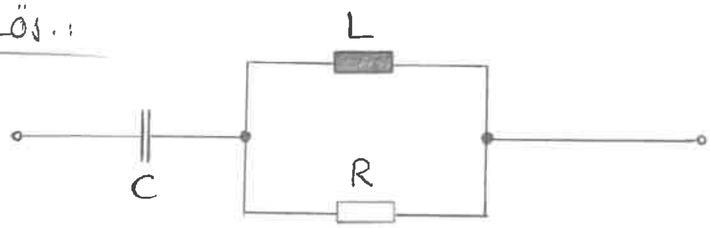


8. AC-Technik (Frequenzverhalten) - Teil 2

8.7) <u>Geg.:</u> $C = 1{,}25\,\mu F$; $L = 10\,mH$; $R = 125\,\Omega$;

<u>Ges.:</u> Resonanzfrequenz $f_0 = ?$

<u>Lös.:</u>



$$X_C = \frac{1}{j\omega C} \;;$$

$$X_L = j\omega L$$

$$\underline{Z} = -jX_C + \frac{jX_L \cdot R}{jX_L + R}$$

$$\underline{Z} = -jX_C + \frac{jX_L \cdot R \cdot (R - jX_L)}{(R + jX_L)\cdot(R - jX_L)} = -jX_C + \frac{jX_L \cdot R^2 + X_L^2 \cdot R}{R^2 + X_L^2}$$

$$\underline{Z} = \frac{-jX_C \cdot (R^2 + X_L^2) + jX_L \cdot R^2 + X_L^2 \cdot R}{R^2 + X_L^2}$$

$$\underline{Z} = \underbrace{\frac{X_L^2 \cdot R}{R^2 + X_L^2}}_{Re\{\underline{Z}\}} + j\underbrace{\frac{X_L \cdot R^2 - X_C \cdot R^2 - X_C \cdot X_L^2}{R^2 + X_L^2}}_{Im\{\underline{Z}\}}$$

$$Im\{\underline{Z}\} = 0 = \frac{X_L \cdot R^2 - X_C \cdot R^2 - X_C \cdot X_L^2}{R^2 + X_L^2}$$

$$\curvearrowright \quad 0 = X_L \cdot R^2 - X_C \cdot R^2 - X_C \cdot X_L^2$$

$$0 = 2\cdot\pi\cdot f_0 \cdot L \cdot R^2 - \frac{R^2}{2\cdot\pi\cdot f_0 \cdot C} - \frac{(2\cdot\pi\cdot f_0 \cdot L)^2}{2\cdot\pi\cdot f_0 \cdot C}$$

$$0 = \frac{(2\cdot\pi\cdot f_0)^2 \cdot L \cdot C \cdot R^2 - R^2 - (2\cdot\pi\cdot f_0 \cdot L)^2}{2\cdot\pi\cdot f_0 \cdot C}$$

8. AC-Technik (Frequenzverhalten) – Teil 2

8.7)

$$0 = \frac{(2\cdot\pi\cdot f_0)^2\cdot L\cdot C\cdot R^2-(2\cdot\pi\cdot f_0\cdot L)^2-R^2}{2\cdot\pi\cdot f_0\cdot C}$$ ← Zähler = 0 !

$$0 = f_0^2\cdot(4\cdot\pi^2\cdot L\cdot C\cdot R^2-4\cdot\pi^2\cdot L^2)-R^2$$

$$f_0^2 = \frac{R^2}{4\cdot\pi^2\cdot L\cdot C\cdot R^2-4\cdot\pi^2\cdot L^2}$$

$$\boxed{f_0 = \frac{R}{\sqrt{4\cdot\pi^2\cdot L\cdot C\cdot R^2-4\pi^2\cdot L^2}}} = \boxed{\frac{R}{2\cdot\pi\cdot\sqrt{L\cdot C\cdot R^2-L^2}}}$$

$C = 1{,}25\,\mu F = 1{,}25\cdot 10^{-6}\,\frac{As}{V}$; $L = 10\,mH = 10\cdot 10^{-3}\,\frac{Vs}{A}$; $R = 125\,\frac{V}{A}$;

$$f_0 = \frac{125\,\frac{V}{A}}{2\cdot\pi\cdot\sqrt{10\cdot 10^{-3}\,\frac{Vs}{A}\cdot 1{,}25\cdot 10^{-6}\,\frac{As}{V}\cdot\left(125\,\frac{V}{A}\right)^2-\left(10\cdot 10^{-3}\,\frac{Vs}{A}\right)^2}} = 2{,}038\cdot 10^3\,\frac{1}{s} =$$

$$= \underline{2.038\ Hz} \ ;$$