Musterprotokoll Versuch Schwingkreis

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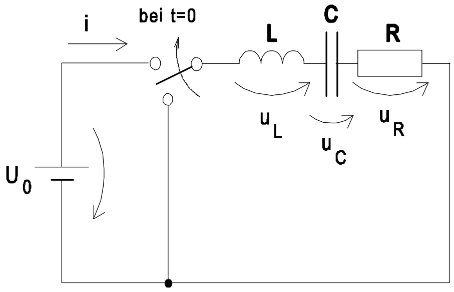
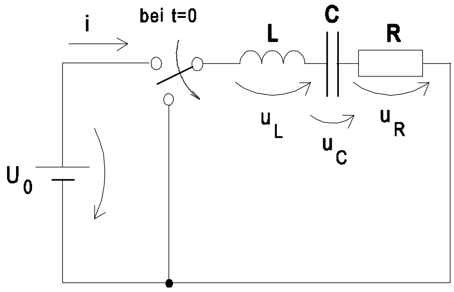
Schaltung des Reihenschwingkreises:
L=300 mH, C=0,22 µF, R=300, 1600 und 5000 Ω bei U_0=10 V





1. Periodischer Fall (R=300 Ω)

Theorie:

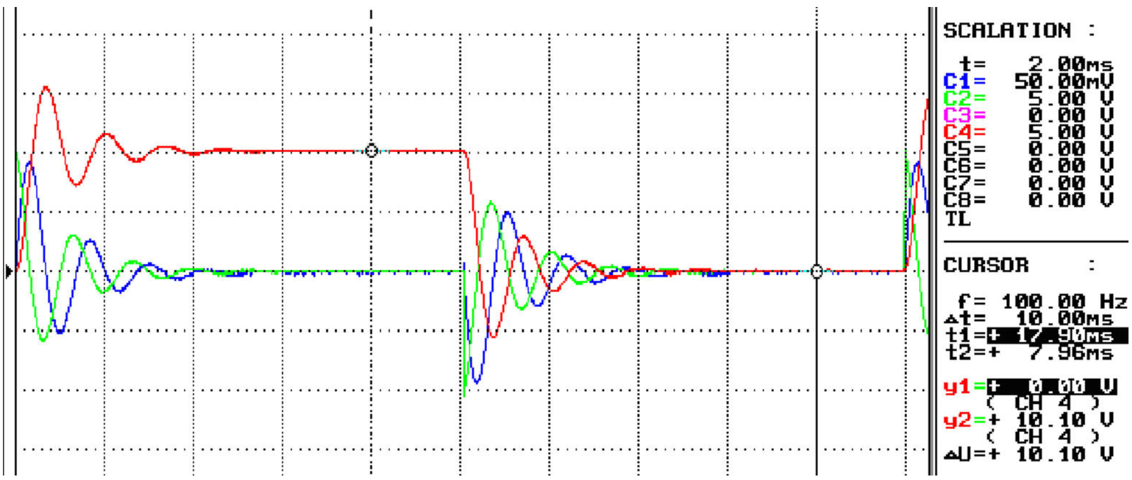
$$i = \frac{U_0}{\omega_e L} \sin \omega_e t\, e^{-\delta t} \qquad\qquad i = -\frac{U_0}{\omega_e L} \sin \omega_e t\, e^{-\delta t}$$

$$u_R = \frac{U_0 R}{\omega_e L} \sin \omega_e t\, e^{-\delta t} \qquad\qquad u_R = -\frac{U_0 R}{\omega_e L} \sin \omega_e t\, e^{-\delta t}$$

$$u_L = U_0 (\cos \omega_e t - \frac{\delta}{\omega_e} \sin \omega_e t) e^{-\delta t} \qquad\qquad u_L = -U_0 (\cos \omega_e t - \frac{\delta}{\omega_e} \sin \omega_e t) e^{-\delta t}$$

$$u_C = U_0 - U_0 (\cos \omega_e t + \frac{\delta}{\omega_e} \sin \omega_e t) e^{-\delta t} \qquad\qquad u_C = U_0 (\cos \omega_e t + \frac{\delta}{\omega_e} \sin \omega_e t) e^{-\delta t}$$

mit $\delta = R/2L$, $\omega_0^2 = 1/LC$ und $\omega_e^2 = \omega_0^2 + \delta^2$



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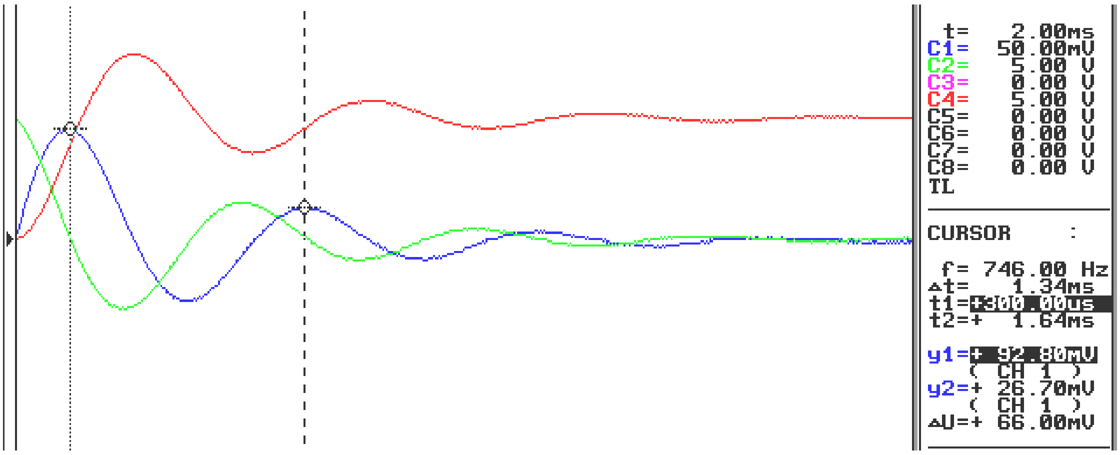

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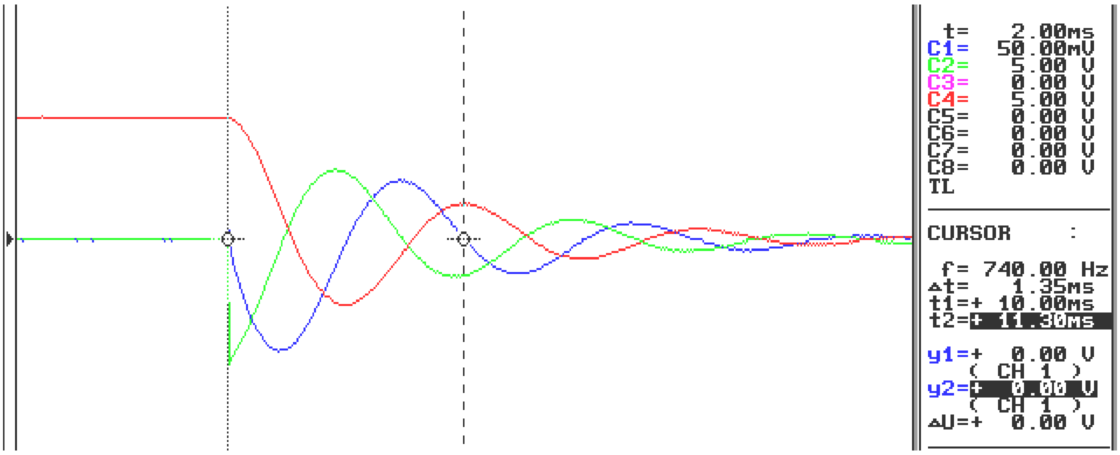


Werte aus den Messkurven:

i_{max1} = 9,87 mA $\qquad$ i_{max2} = 2,67 mA $\qquad$ $T_e = \Delta t$ =1,35 ms $\qquad$ U_0 = 10,1 V

Berechnung der Parameter aus den Messwerten: $\qquad$ Vergleich:

$\delta = \frac{1}{T_e} \ln \frac{i_{max\,1}}{i_{max\,2}}$	= 965 1/s		
$\omega_e = 2\pi/T_e$	= 4 654 1/s	⇒740 Hz	
$\omega_0 = \sqrt{\omega_e^2 + \delta^2}$	= 4 753 1/s	⇒756 Hz	
$L = \frac{U_0}{\omega_e\, i_{max\,1}} \sqrt[4]{\frac{i_{max\,2}}{i_{max\,1}}}$	= 160 mH		300 mH bei 50 Hz
$C = 1/\omega_0^2 L$	= 0,27 µF		0,22 µF
$R = \delta\, 2L$	= 308 Ω		300 Ω

2. Aperiodischer Grenzfall (R=1600 Ω)

Theorie:

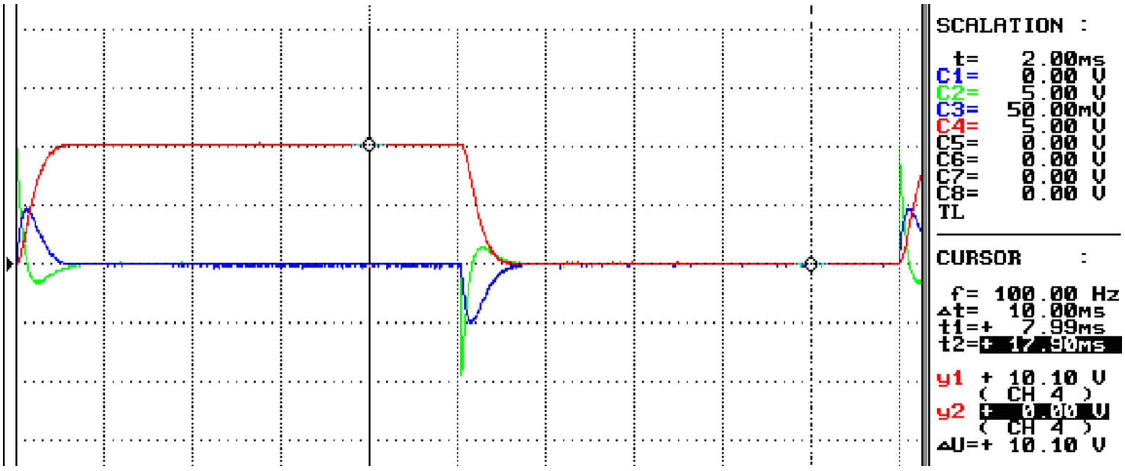
$$i = \frac{2U_0}{R} \delta t\, e^{-\delta t} \qquad\qquad i = -\frac{2U_0}{R} \delta t\, e^{-\delta t}$$

$$u_R = U_0 2\, \delta t\, e^{-\delta t} \qquad\qquad u_R = -U_0 2\, \delta t\, e^{-\delta t}$$

$u_L = U_0(1-\delta t)e^{-\delta t}$ $u_L = -U_0(1-\delta t)e^{-\delta t}$

$u_C = U_0 - U_0(1+\delta t)e^{-\delta t}$ $u_C = U_0(1+\delta t)e^{-\delta t}$

mit $\delta^2 = (R/2L)^2 = \omega_0^2 = 1/LC$ und $\omega_e = 0$



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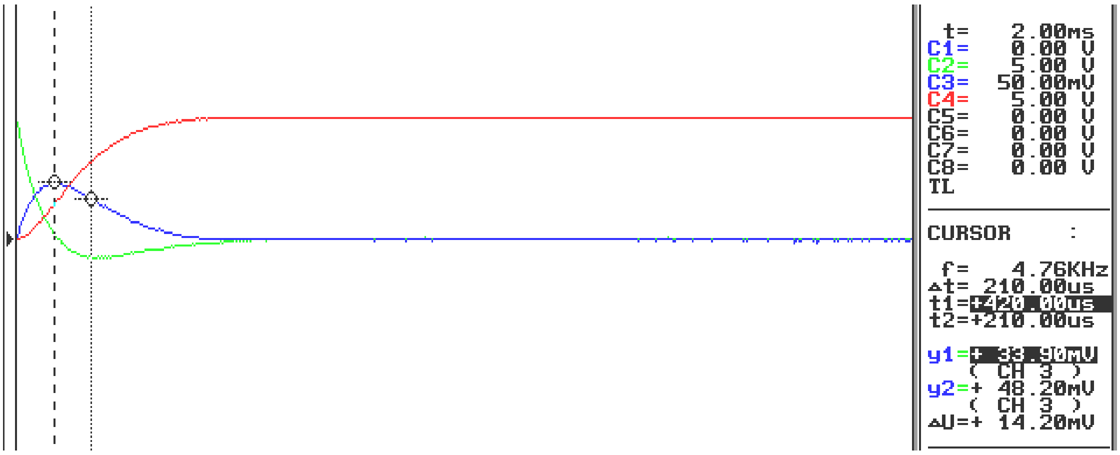

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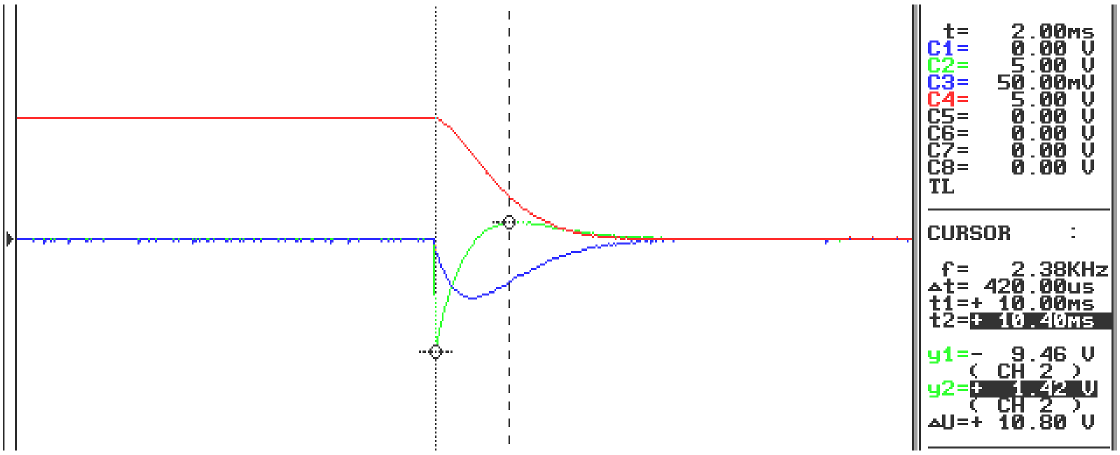


Werte aus den Messkurven:

$i_{max} = 4{,}82$ mA $t_{max} = \Delta t = 210$ µs $U_0 = 10{,}1$ V

Berechnung der Parameter aus den Messwerten:			Vergleich:
$\delta = 1/t_{max} = \omega_0$	$= 4\,761$ 1/s	$\Rightarrow$757 Hz	
$R = 2U_0/i_{max}\, e$	$= 1\,541\ \Omega$		$1\,600\ \Omega$
$L = R/2\delta$	$= 160$ mH		300 mH bei 50 Hz
$C = 1/\delta^2 L$	$= 0{,}27\ \mu$F		$0{,}22\ \mu$F

3. Aperiodischer Fall (R=5000 Ω)

Theorie:

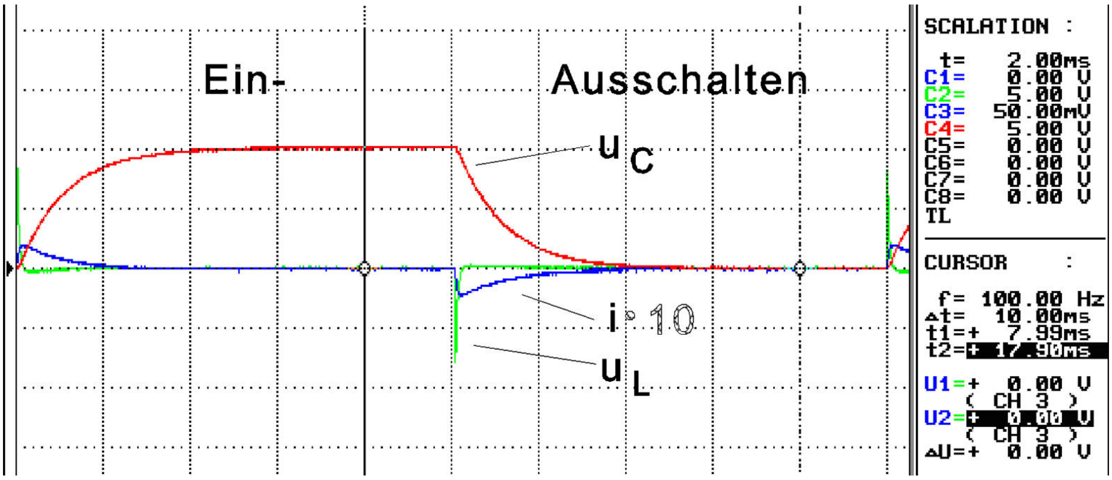
$$i = \frac{U_0}{R}\frac{\delta}{\sqrt{\delta^2-\omega_0^2}}(e^{-\delta_1 t}-e^{-\delta_2 t}) \qquad i = -\frac{U_0}{R}\frac{\delta}{\sqrt{\delta^2-\omega_0^2}}(e^{-\delta_1 t}-e^{-\delta_2 t})$$

$$u_R = U_0\frac{\delta}{\sqrt{\delta^2-\omega_0^2}}(e^{-\delta_1 t}-e^{-\delta_2 t}) \qquad u_R = -U_0\frac{\delta}{\sqrt{\delta^2-\omega_0^2}}(e^{-\delta_1 t}-e^{-\delta_2 t})$$

$$u_L = \frac{U_0}{2\sqrt{\delta^2-\omega_0^2}}(\delta_2 e^{-\delta_2 t}-\delta_1 e^{-\delta_1 t}) \qquad u_L = \frac{-U_0}{2\sqrt{\delta^2-\omega_0^2}}(\delta_2 e^{-\delta_2 t}-\delta_1 e^{-\delta_1 t})$$

$$u_C = \frac{U_0}{2\sqrt{\delta^2-\omega_0^2}}[\delta_1(e^{-\delta_2 t}-1)+\delta_2(1-e^{-\delta_1 t})] \qquad u_C = \frac{U_0}{2\sqrt{\delta^2-\omega_0^2}}[\delta_2 e^{-\delta_1 t}-\delta_1 e^{-\delta_2 t}]$$

mit $\delta_{1/2} = \delta \mp \sqrt{\delta^2-\omega_0^2}$ oder $\tau_{1/2} = 1/\delta_{1/2}$, $\delta = R/2L$ und $\omega_0^2 = 1/LC$



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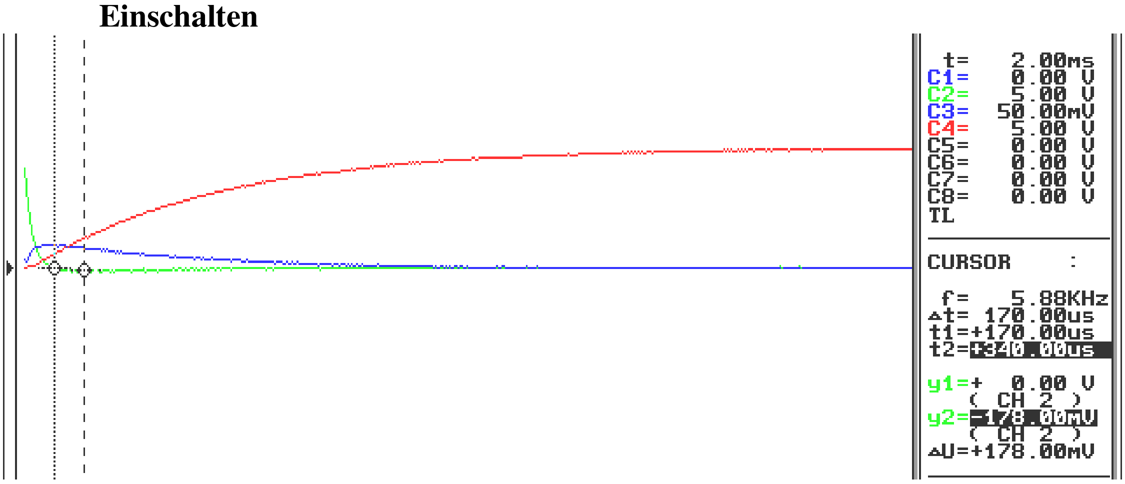

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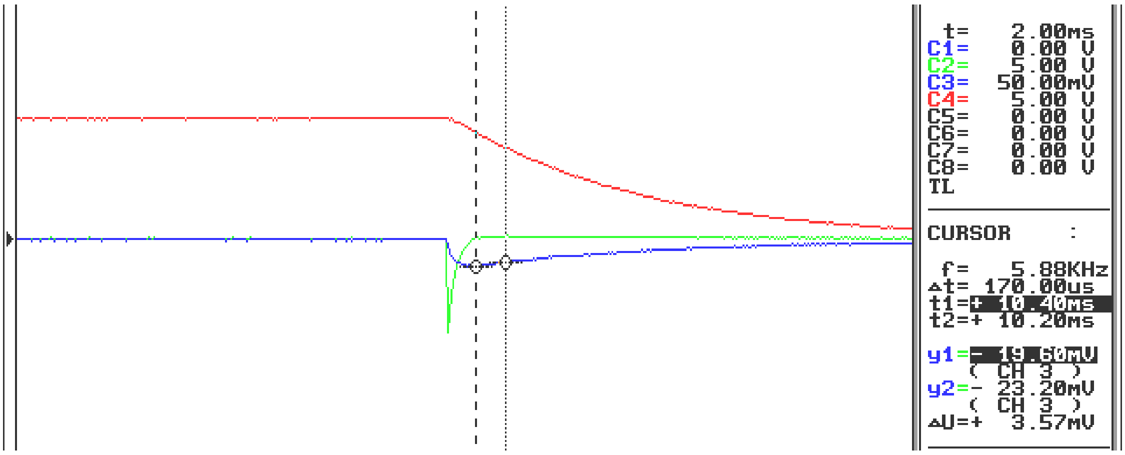

Werte aus den Messkurven: i_{max1} = 2,32 mA t_{max} = 170 µs U_0=10,1 V

i_{max2} = 1,96 mA u_{Lmax2} = -178 mV

Berechnung der Parameter aus den Messwerten: Vergleich:

$\delta = \frac{1}{2 t_{max}} \ln \frac{U_0}{-u_{Lmax2}}$	= 11 900 1/s	
$R = \frac{i_{max2} U_0}{i_{max1}^2}$	= 3 700 Ω	5 000 Ω
$L = R/2\delta$	= 160 mH	300 mH bei 50 Hz
$C = \frac{i_{max1}^2 L}{-u_{Lmax2} U_0}$	= 0,48 µF	0,22 µF
$\omega_0 = 1/\sqrt{LC}$	= 3 600 1/s ⇒575 Hz	

(Genauigkeit: Beachte, dass 1 Bildpunkt = 178 mV bzw. 1,7 mV ist!)