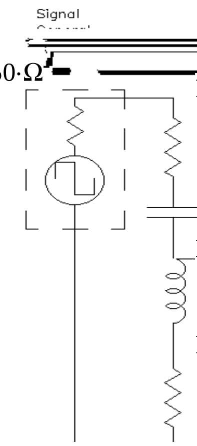
Appendix, Calculations

Series RLC Circuit

$R_T := R + R_s + R_{sub}$



$R_s := 50\cdot\Omega$ $R_{sub} := 0\cdot\Omega$ $C := 0.001\cdot\mu F$ $L := 3.3\cdot mH$ $R := 100\cdot\Omega$

For transient analysis, use the LaPlace s instead of jω for the impedances.
Remember that the LaPlace s = α + jω

Transfer function: $H(s) = \dfrac{R}{Ls + R_T + \dfrac{1}{C\cdot s}} = R\cdot\dfrac{s}{L\cdot s^2 + R_T\cdot s + \dfrac{1}{C}} = \dfrac{R}{L}\cdot\dfrac{s}{s^2 + \dfrac{R_T}{L}\cdot s + \dfrac{1}{L\cdot C}}$

voltage divider

If you take the denominator of the transfer function and set it equal to zero, you get the characteristic equation:

Characteristic equation: $0 = s^2 + \dfrac{R_T}{L}\cdot s + \dfrac{1}{L\cdot C}$

Solve the characteristic equation for s values, using the quadradic equation:

$s_1 := \dfrac{\dfrac{-R_T}{L} + \sqrt{\left(\dfrac{R_T}{L}\right)^2 - \dfrac{4}{L\cdot C}}}{2}$ $s_2 := \dfrac{\dfrac{-R_T}{L} - \sqrt{\left(\dfrac{R_T}{L}\right)^2 - \dfrac{4}{L\cdot C}}}{2}$

$s_1 = -2.273\bullet 10^4 + 5.5\bullet 10^5 j \bullet\dfrac{1}{sec}$ $s_2 = -2.273\bullet 10^4 - 5.5\bullet 10^5 j \bullet\dfrac{1}{sec}$

s = α + jω , so: $\alpha := \dfrac{-R_T}{2\cdot L}$ $\alpha = -22727\bullet\dfrac{1}{sec}$ and: $\omega := \dfrac{1}{2}\cdot\sqrt{\dfrac{4}{L\cdot C} - \left(\dfrac{R_T}{L}\right)^2}$ $\omega = 5.5\bullet 10^5 \bullet\dfrac{1}{sec}$

$f := \dfrac{\omega}{2\cdot\pi}$ $f = 87.5\bullet kHz$

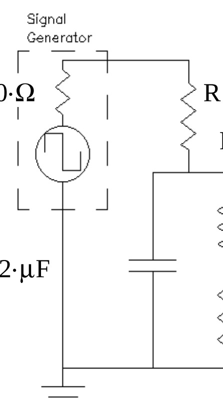
$e^{\alpha\cdot t}$ is a decaying exponential

The time constant is: $\tau := -\dfrac{1}{\alpha}$ $\tau = 44\bullet\mu s$

Compare these to what you measured.

Critcal Damping happens when the part of s under the radical is 0: $\left(\dfrac{R_T}{L}\right)^2 = \dfrac{4}{L\cdot C}$ $R_T = \sqrt{\dfrac{L\cdot 4}{C}} = 3633\bullet\Omega$

Parallel RLC Circuit



$R_s := 50\cdot\Omega$ $R_1 := 1\cdot k\Omega$ $R := 1050\cdot\Omega$ $L := 3.3\cdot mH$ $C := 0.22\cdot\mu F$ $R_L := 5\cdot\Omega$

R_L could be neglected above, but not here

Impedance of C, L, & R_L: $Z(s) = \dfrac{1}{C\cdot s + \dfrac{1}{L\cdot s + R_L}}$

Transfer function:

$$H(s) = \frac{Z(s)}{Z(s) + R} = \frac{1}{1 + \dfrac{R}{Z(s)}} = \frac{1}{1 + R\cdot\left(C\cdot s + \dfrac{1}{L\cdot s + R_L}\right)}$$

$$= \frac{1}{1 + R\cdot C\cdot s + \dfrac{R}{L\cdot s + R_L}}\cdot\left(\frac{L\cdot s + R_L}{L\cdot s + R_L}\right) = \frac{L\cdot s + R_L}{L\cdot s + R_L + R\cdot C\cdot s\cdot(L\cdot s + R_L) + R}$$

$$= \frac{L\cdot s + R_L}{R\cdot C\cdot L\cdot s^2 + (L + R\cdot C\cdot R_L)\cdot s + (R_L + R)}\cdot\frac{\left(\dfrac{1}{R\cdot C\cdot L}\right)}{\left(\dfrac{1}{R\cdot C\cdot L}\right)} = \frac{\dfrac{1}{R\cdot C}\cdot s + \dfrac{R_L}{R\cdot C\cdot L}}{s^2 + \left(\dfrac{1}{R\cdot C} + \dfrac{R_L}{L}\right)\cdot s + \left(\dfrac{R_L}{R\cdot C\cdot L} + \dfrac{1}{C\cdot L}\right)}$$

characteristic equation: $0 = \left[s^2 + \left(\dfrac{1}{R\cdot C} + \dfrac{R_L}{L}\right)\cdot s + \left(\dfrac{R_L}{R\cdot C\cdot L} + \dfrac{1}{C\cdot L}\right)\right]$

Find solutions to the characteristic eq. as above $s = -\dfrac{1}{2}\cdot\left(\dfrac{1}{R\cdot C} + \dfrac{R_L}{L}\right) \pm \dfrac{1}{2}\cdot\sqrt{\left(\dfrac{1}{R\cdot C} + \dfrac{R_L}{L}\right)^2 - 4\cdot\left(\dfrac{R_L}{R\cdot C\cdot L} + \dfrac{1}{C\cdot L}\right)}$

$\alpha := -\dfrac{1}{2}\cdot\left(\dfrac{1}{R\cdot C} + \dfrac{R_L}{L}\right)$ $\tau = -\dfrac{1}{\alpha} = 0.342\bullet ms$ $\omega := \dfrac{1}{j}\cdot\dfrac{1}{2}\cdot\sqrt{\left(\dfrac{1}{R\cdot C} + \dfrac{R_L}{L}\right)^2 - 4\cdot\left(\dfrac{R_L}{R\cdot C\cdot L} + \dfrac{1}{C\cdot L}\right)}$ $f = \dfrac{\omega}{2\cdot\pi} = 5.9\bullet kHz$