Time Constants for an RC Circuit and an LR Circuit

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1 Abstract/Procedure/Conclusion

In this lab, we measured the time constants, τ, for three RC and three LR circuits. Each RC circuit was set up as in Figure 1. The first had a resistor with a resistance of 100 Ω and a capacitor with a capacitance of 330 μF. The second had a resistor with a resistance of 10 Ω and a capacitor with a capacitance of 100 μF. The first had a resistor with a resistance of 10 Ω and a capacitor with a capacitance of 100 μF. The LR circuits were set up as shown in Figure 2. They all used the same inductor with an inductance of 8.2 mH and a resistance of 6.5 Ω. The first had a resistor with a resistance of 10 Ω. The second had a resistor with a resistance of 33 Ω. The third had a resistor with a resistance of 100 Ω. The power source was a signal generator set to create a square wave with a frequency around 1 kHz and an amplitude of 5 V.

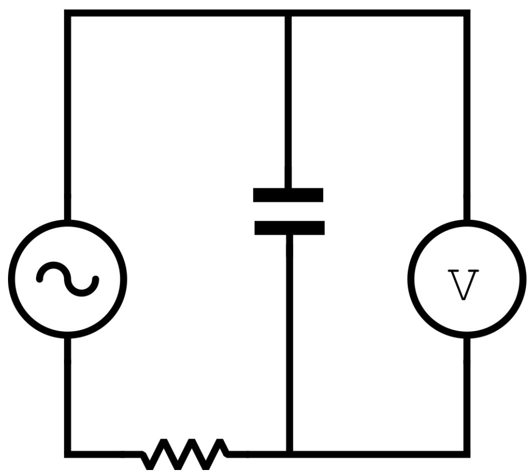

Figure 1: RC circuit: Experimental setup

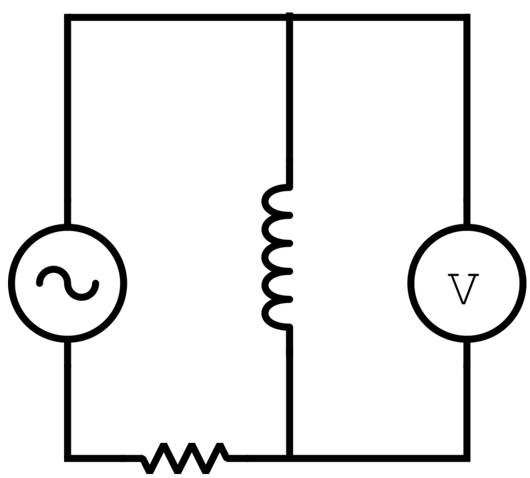

Figure 2: LR circuit: Experimental setup

2 Data

	C (μF)	R (Ω)	τ (s)	τ_{meas} (s)
1	330	100	0.033	0.036
2	100	10	0.0010	0.0011
3	100	33	0.0033	0.0036

Table 1: RC circuit: Capacitance and resistance.

	L (H)	R (Ω)	τ (s)	τ_{meas} (s)
1	0.0082	16.5	0.000497	0.000078
2	0.0082	39.5	0.00021	0.00021
3	0.0082	106.5	0.000077	0.00051

Table 2: LR circuit: Inductance and resistance.

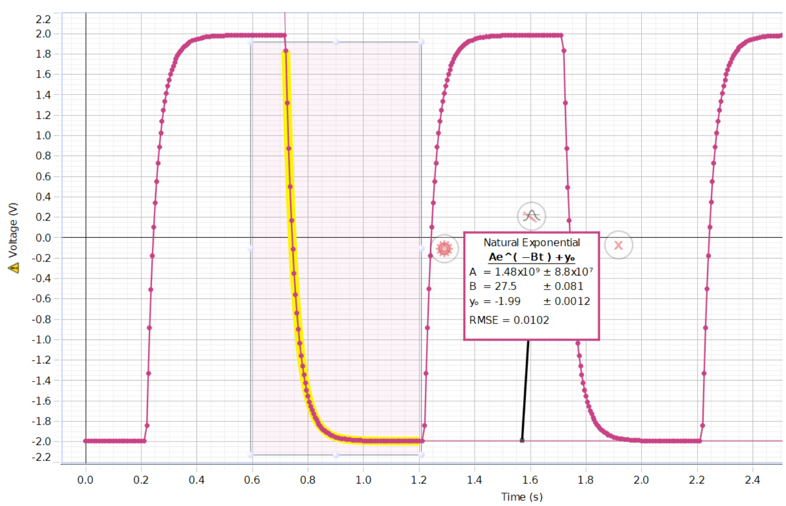

Figure 3: RC circuit 1 plot.

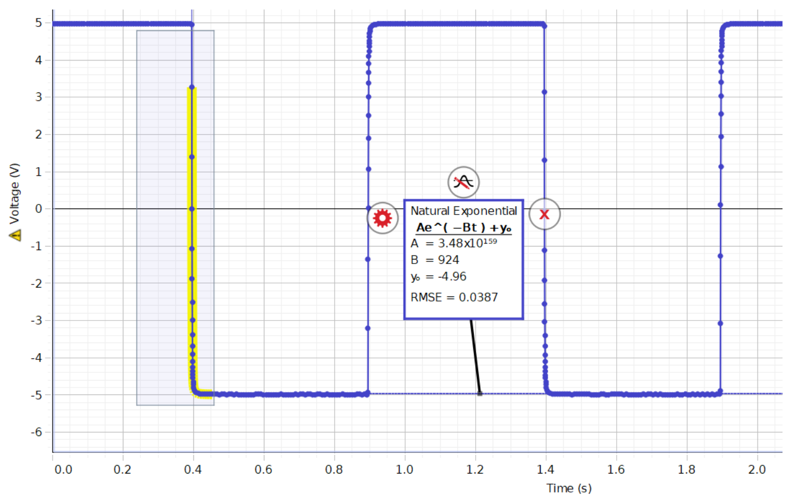

Figure 4: RC circuit 2 plot.

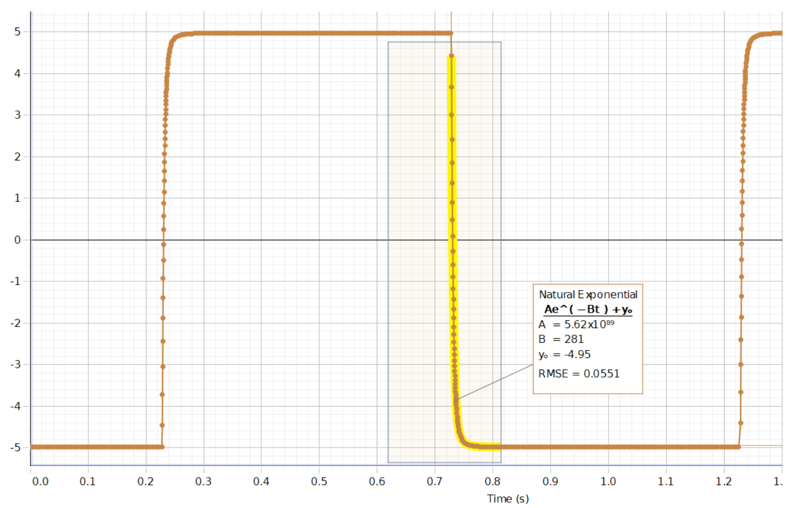

Figure 5: RC circuit 3 plot.

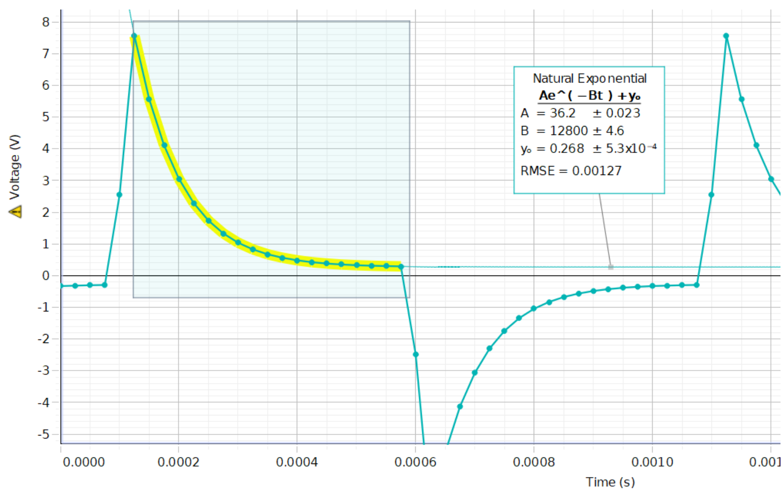

Figure 6: LR circuit 1 plot.

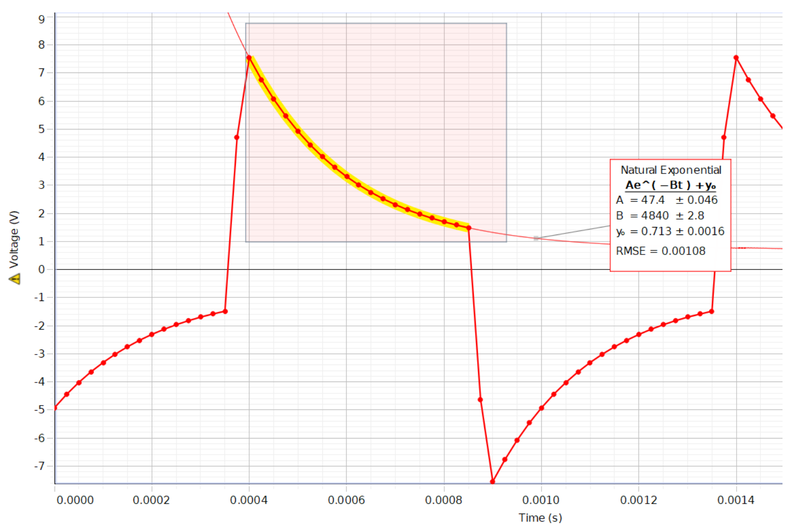

Figure 7: LR circuit 2 plot.

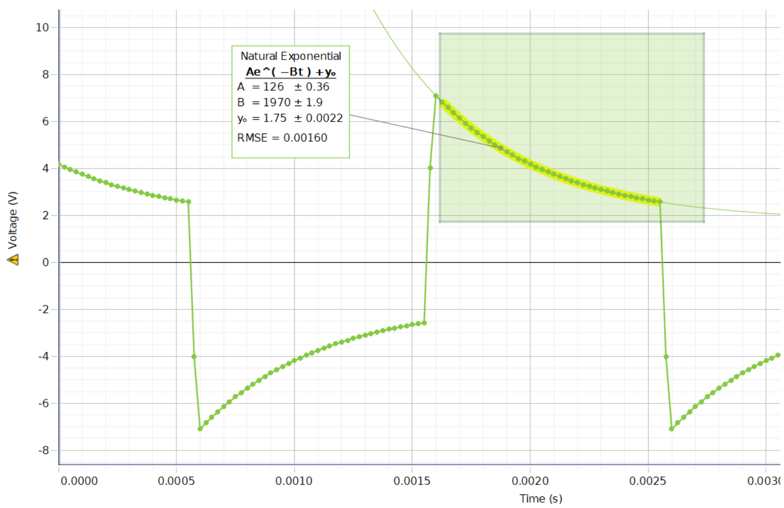

Figure 8: LR circuit 3 plot.

3 Calculations

$$
\begin{aligned}
(1) \qquad Q &= C\Delta V_c \\
(2) \qquad \sigma_{R_1} &= 5\ \Omega \\
\sigma_{R_2} &= 1.65\ \Omega \\
\sigma_{R_3} &= 0.5\ \Omega \\
\frac{\sigma_{R_1}}{R_1} &= \frac{5\ \Omega}{100\ \Omega} \\
\frac{\sigma_{R_2}}{R_2} &= \frac{1.65\ \Omega}{33\ \Omega} \\
\frac{\sigma_{R_3}}{R_3} &= \frac{0.5\ \Omega}{10\ \Omega} \\
\frac{\sigma_{R_1}}{R_1} &= \frac{\sigma_{R_2}}{R_2} = \frac{\sigma_{R_3}}{R_3} \\
&= 5\% \\
\sigma_{C_1} &= 66\ \mu\text{F} \\
\sigma_{C_2} &= 20\ \mu\text{F} \\
\frac{\sigma_{C_1}}{C_1} &= \frac{66\ \mu\text{F}}{330\ \mu\text{F}}
\end{aligned}
$$

$$
\begin{aligned}
\frac{\sigma_{C_2}}{C_2} &= \frac{20\ \mu\text{F}}{100\ \mu\text{F}} \\
\frac{\sigma_{C_1}}{C_1} &= \frac{\sigma_{C_2}}{C_2} \\
&= 20\% \\
\text{(3)} \qquad \overline{\tau_1} &= 330\ \mu\text{F} \cdot 100\ \Omega \\
&= 0.033\ \text{s} \\
\tau_{1,R} &= 330\ \mu\text{F} \cdot (100 + 5)\ \Omega \\
&= 0.03465\ \text{s} \\
\tau_{1,C} &= (330 + 66)\ \mu\text{F} \cdot 100\ \Omega \\
&= 0.0396 \\
\sigma_{\tau_1} &= 0.0068\ \text{s} \\
\text{(4)} \qquad \sigma_{R_4} &= 0.825\ \Omega \\
\sigma_{R_5} &= 1.975\ \Omega \\
\sigma_{R_6} &= 5.325\ \Omega \\
\frac{\sigma_{R_4}}{R_4} &= \frac{0.825\ \Omega}{16.5\ \Omega} \\
\frac{\sigma_{R_5}}{R_5} &= \frac{1.975\ \Omega}{39.5\ \Omega} \\
\frac{\sigma_{R_6}}{R_6} &= \frac{5.325\ \Omega}{106.5\ \Omega} \\
\frac{\sigma_{R_4}}{R_4} &= \frac{\sigma_{R_5}}{R_5} = \frac{\sigma_{R_6}}{R_6} \\
&= 5\% \\
\text{(5)} \qquad \overline{\tau_4} &= \frac{0.0082\ \text{H}}{16.5\Omega} \\
&= 0.000497\ \text{s} \\
\tau_{4,R} &= \frac{0.0082\ \text{H}}{(16.5 + 0.825)\Omega} \\
&= 0.000473\ \text{s} \\
\sigma_{\tau_4} &= \overline{\tau_4} - \tau_{4,R} \\
&= 0.000497\ \text{s} - 0.000473\ \text{s} \\
&= 0.000024\ \text{s}
\end{aligned}
$$