Physics Department

Physics 112

Experiment #8

DAMPED OSCILLATIONS

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Section:- 18

Date:12/4/2017

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Abstract:

The aim of the experiment: *is to find out* $t_{1/2}$ *and decing constant (λ) (lambda) for the three cases,*
and to study the natural response of the RLC-circuit.

The method used is: by measuring the voltage difference across the capacitor's plates using the DCO.

<u>The Main Result:</u>

1- Over damping:

$t_{1/2} = 40\ \mu s$

Vmax=19 volt

$\lambda = 1.7250*10^4\ s^{-1}$

2- Critical damping:

$t_{1/2} = 28\ \mu s$

Vmax=19.4 volt

$\lambda = 1*10^5$

3- Under damping:

R=97Ω

$t_{1/2} = 28\mu s.$

Vmax=28 volt

$$\delta = \frac{R}{2L} = \frac{97}{20\times 10^{-3}} = 4850$$

Theory:

The equation:

, is the equation that describes the charge on $Q(t) = A_1 e^{\lambda_+ t} + A_2 e^{\lambda_- t}$ *.....1*

the capacitor's plates in the DC powered RLC circuit, where A_1 *and* A_2 *are constants, and*

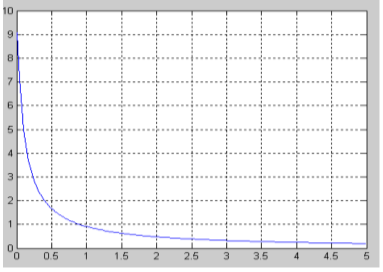
$$\lambda_+ = -\frac{R}{2L} + \sqrt{\left(\frac{R}{2L}\right)^2 - \frac{1}{LC}}$$

(2)

$$\lambda_- = -\frac{R}{2L} - \sqrt{\left(\frac{R}{2L}\right)^2 - \frac{1}{LC}}$$

And this leads us to talk about this three interesting cases.

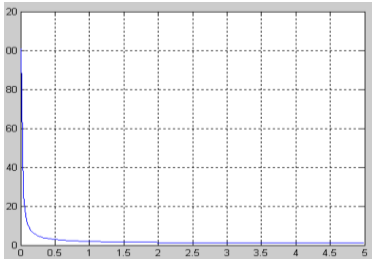
<u>Over damping:</u>



If $\left(\frac{R}{2L}\right)^2 > \frac{1}{LC}$ *then, both terms in the first equation decay exponentially with time and the voltage across the capacitor is said to be over damped, as shown in fig.2.*

Critical damping:

If $\left(\frac{R}{2L}\right)^2 = \frac{1}{LC}$ *then, the terms under the square root in equation 2 vanishes and* $\lambda_+ = \lambda_- = -\frac{R}{2L}$



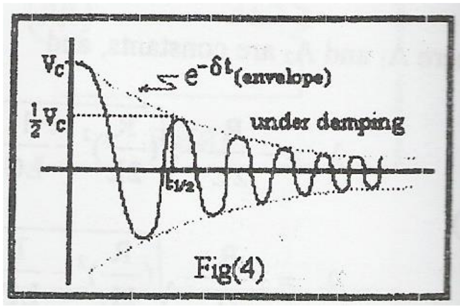
And so the charge on the capacitor's plates takes the following form:

where A and B are constants. $Q(t) = A_1 e^{-\frac{R}{2L}t} + Bte^{-\frac{R}{2L}t}$

And again the charge and the voltage across the capacitor's plates decay exponentially with time, as shown in fig.3. And this case is called critical damping.

Under damping:

If $\left(\frac{R}{2L}\right)^2 < \frac{1}{LC}$ *then the terms under the square root becomes negative.*



Fig(4)

, $Q(t) = Q_o e^{-\delta t}\cos(\omega' t + \theta_o)$

where $\delta = \frac{R}{2L}$,

and $\omega' = \sqrt{\frac{1}{LC} - \left(\frac{R}{2L}\right)^2}$.

This case is called under damping.

is the time at which the amplitude $Q_o e^{-\delta t}$ *falls to half the initial value* $t_{1/2}$ Q_o.

$$\frac{Q_o}{2} = Q_o e^{-\delta t_{1/2}}$$

$$t_{1/2} = \frac{(2L)\ln(2)}{R}$$

Analysis of results:

As we can see from the results the theoretical $t_{1/2}$ *is some how equal to the practical* $t_{1/2}$ *in the under damping case and this difference is due to the resistances of wires, capacitor and inductor. and the decay constant of the critical damping case is the largest so it decays faster.*