Department of Electrical and Computer Engineering
Howard University 2008

NET1LAB Hybrid Class (202&208) **Dr. Charles Kim**

Mobile Studio (MS)-08 - RLC Transient Circuits

1. Series RLC circuit powered by a DC voltage source.

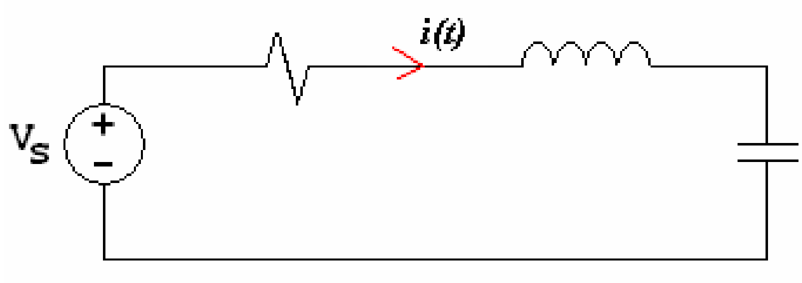


FIG. 1

The loop KVL equation for the current of the above circuit is:

$$-V_s + Ri + \frac{1}{C}\int_{t_o}^{t} i(x)dx + L\frac{di}{dt} = 0 \rightarrow Ri + \frac{1}{C}\int_{t_o}^{t} i(x)dx + L\frac{di}{dt} = V_s$$

By derivation with respect to time *t*, we have:

$$L\frac{d^2 i}{dt^2} + R\frac{di}{dt} + \frac{i}{C} = 0 \rightarrow \frac{d^2 i}{dt^2} + \frac{R}{L}\frac{di}{dt} + \frac{i}{LC} = 0$$

Since damping condition is determined by the damping coefficient (α) and the natural frequency (w_o), we have the following possible damping behaviors:

i) critically damping, if $\left(\frac{R}{2L}\right)^2 = \frac{1}{LC}$

ii) overdamping, if $\left(\frac{R}{2L}\right)^2 > \frac{1}{LC}$

iii) underdamping with oscillation frequency of $w_d = \sqrt{\frac{1}{LC} - \left(\frac{R}{2L}\right)^2}$, if $\left(\frac{R}{2L}\right)^2 < \frac{1}{LC}$,

Therefore, by observing the current of the circuit, we can guess the relationship among R, L, and C values of the circuit.

2. Parallel RLC circuit

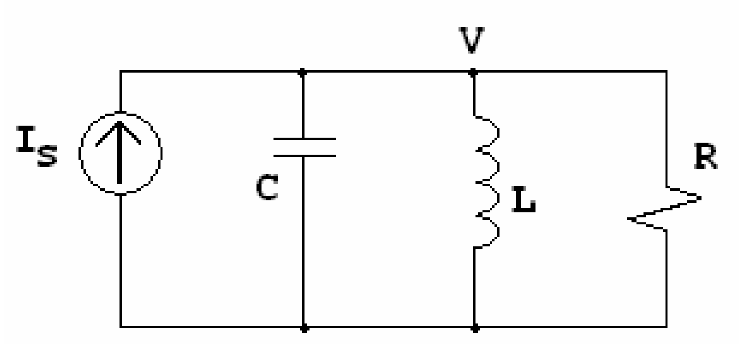


FIG.2

The node voltage equation for the above circuit is:

$$-I_s + \frac{v}{R} + \frac{1}{L}\int_{t_o}^{t} v\,dx + C\frac{dv}{dt} = 0 \rightarrow \frac{v}{R} + \frac{1}{L}\int_{t_o}^{t} v\,dx + C\frac{dv}{dt} = I_s$$

By derivation with respect to time *t*, we have:

$$C\frac{d^2v}{dt^2} + \frac{1}{R}\frac{dv}{dt} + \frac{v}{L} = 0 \quad \text{or} \quad \frac{d^2v}{dt^2} + \frac{1}{RC}\frac{dv}{dt} + \frac{v}{LC} = 0$$

Similarly, we have the following damping conditions:

i) critically damping, if $\left(\frac{1}{2RC}\right)^2 = \frac{1}{LC}$

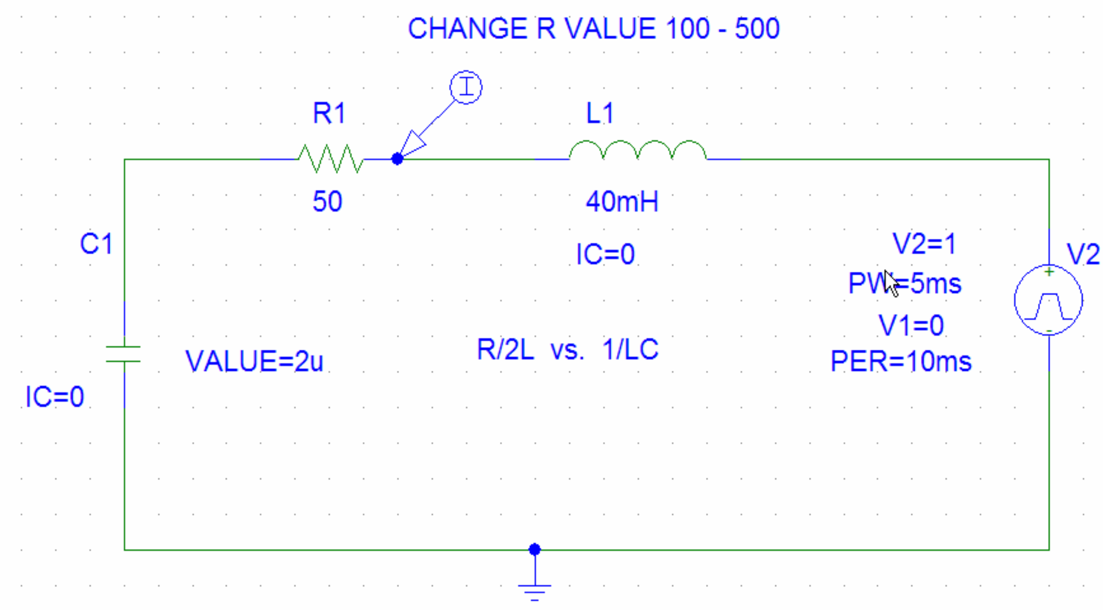
ii) overdamping, if $\left(\frac{1}{2RC}\right)^2 > \frac{1}{LC}$

iii) underdamping with oscillation frequency $w_d = \sqrt{\frac{1}{LC} - \left(\frac{1}{2RC}\right)^2}$, if $\left(\frac{1}{2RC}\right)^2 < \frac{1}{LC}$,

Therefore, by observing the current of the circuit, we can guess the relationship among R, L, and C values of the circuit.

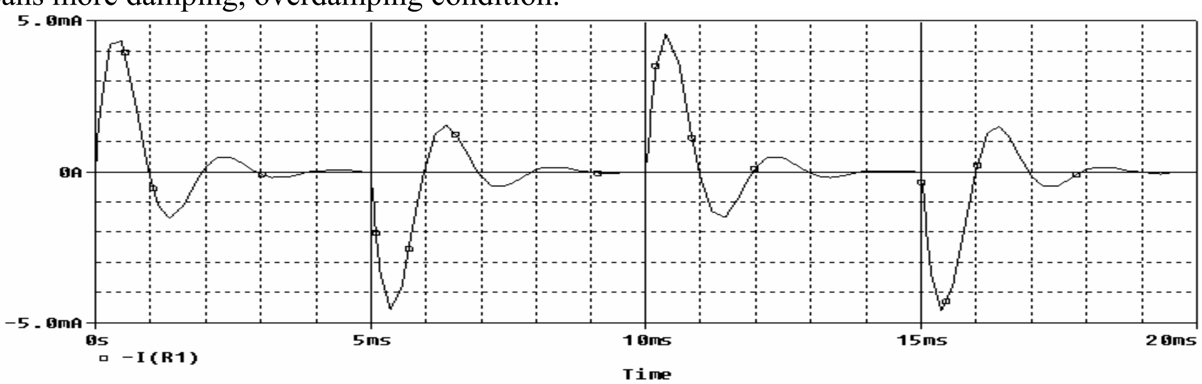
MS-08 RLC Transient Circuits

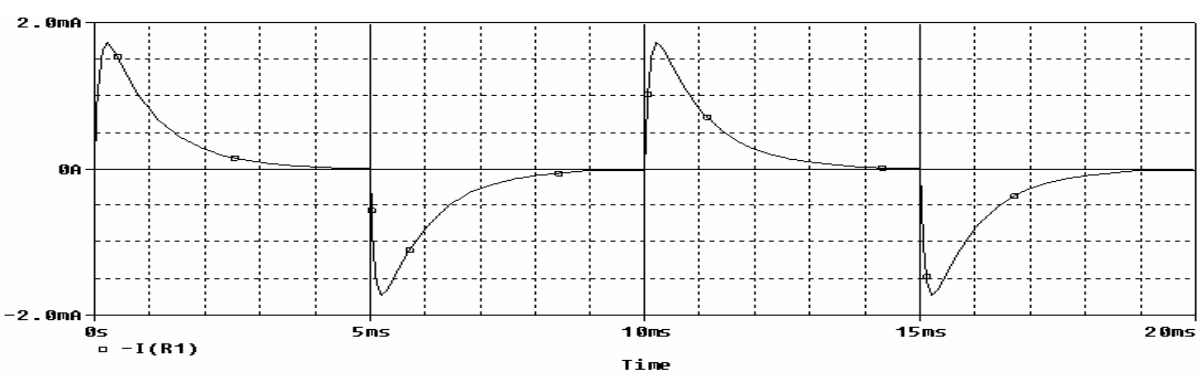
1. Simulate the circuit (**FIG. 1**) with R=50 ohm, C=2uF, and L=40mH, with VPulse source with V1=0, V2=1, PW=5ms and PER=10ms. Get the I probe at the R. Note that IC=0 (in C) and IC=0 (in L) indicate that there are no initial charges in the capacitor and inductor.



FIG,3

Check if you can make three damping conditions by changing the value of R between 100 and 500 ohm. Remember that $[R/2L]^2$ vs. $[1/LC]$ determines the damping condition. Bigger $[R/2L]^2$ means more damping, overdamping condition.





2. Simulation of Parallel RLC as in FIG.2 can be changed in the following schematic by applying source transformation. We can do it without change in PSpice, but since we are doing the same thing using Mobile Studio which does not have current source, it would be better work with voltage source circuit with series resistance instead of current source with parallel resistance.

We will keep the capacitor and inductor the same, and the source of VPulse is also the same. So, build the circuit as below, and get the voltage probe for voltage transient behavior.

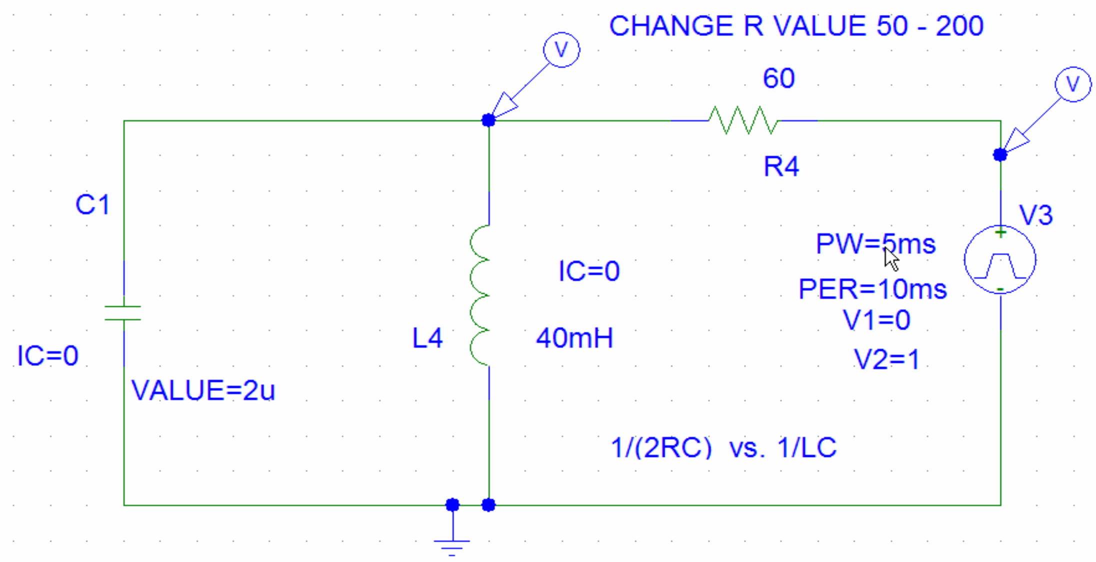
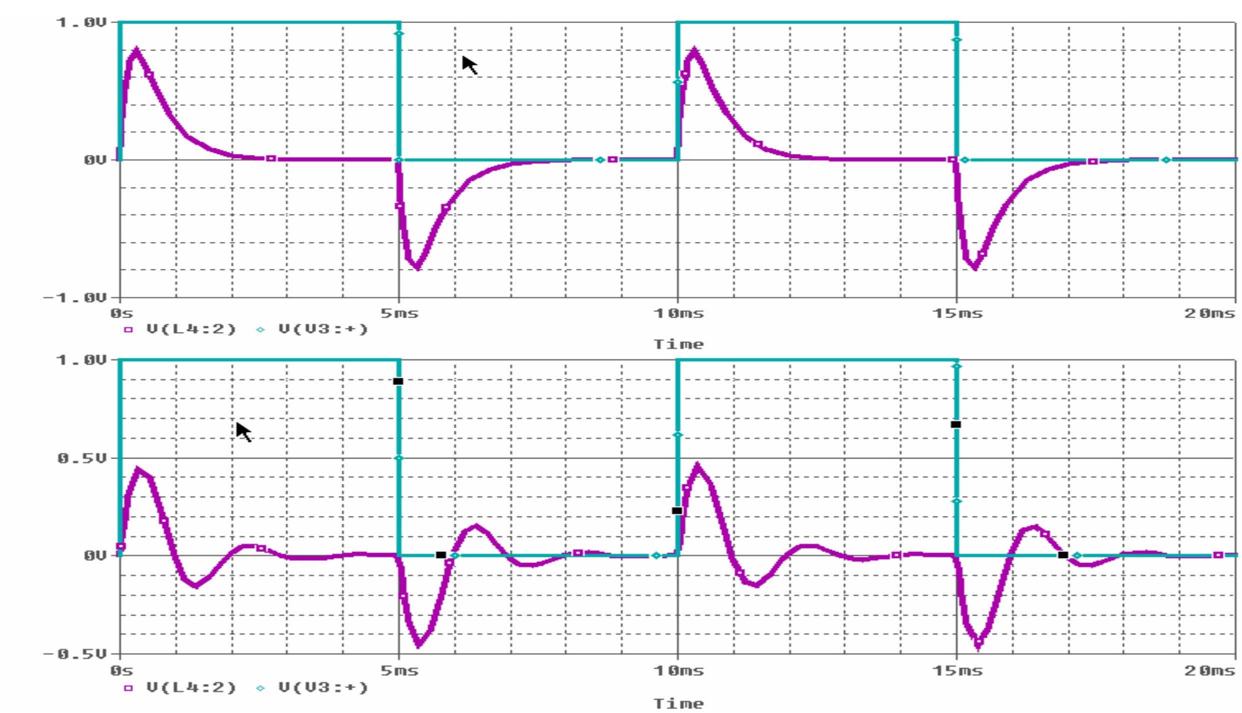


FIG.4.

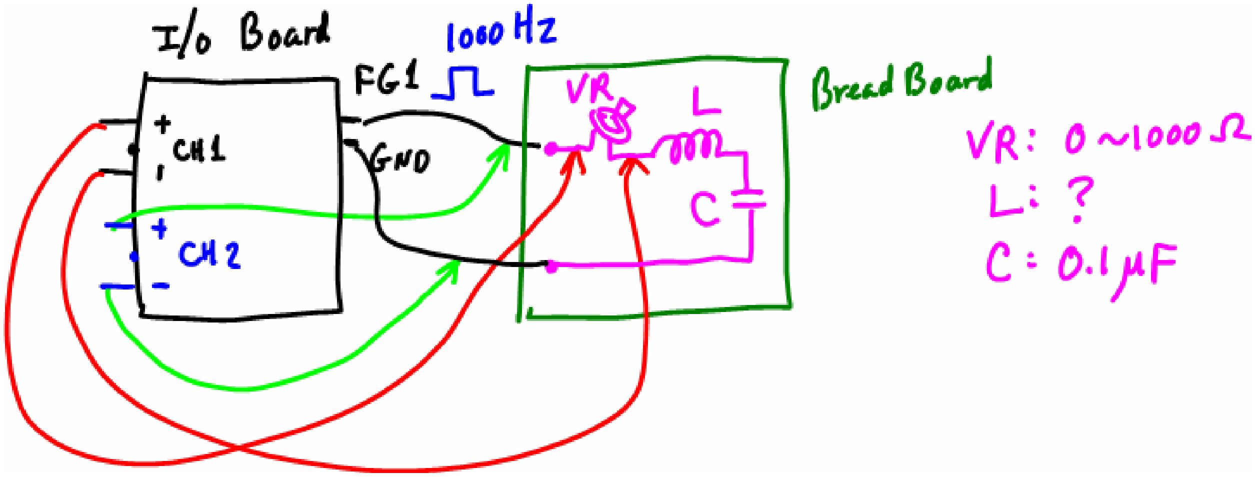
Check if you can make three damping conditions by changing the value of R between 50 and 200 ohm. Remember that $[1/2RC]^2$ vs. [1/LC] determines the damping condition. Bigger $[1/2RC]^2$ means more damping, overdamping condition.



3. RLC Series Circuit with Mobile Studio Lab.

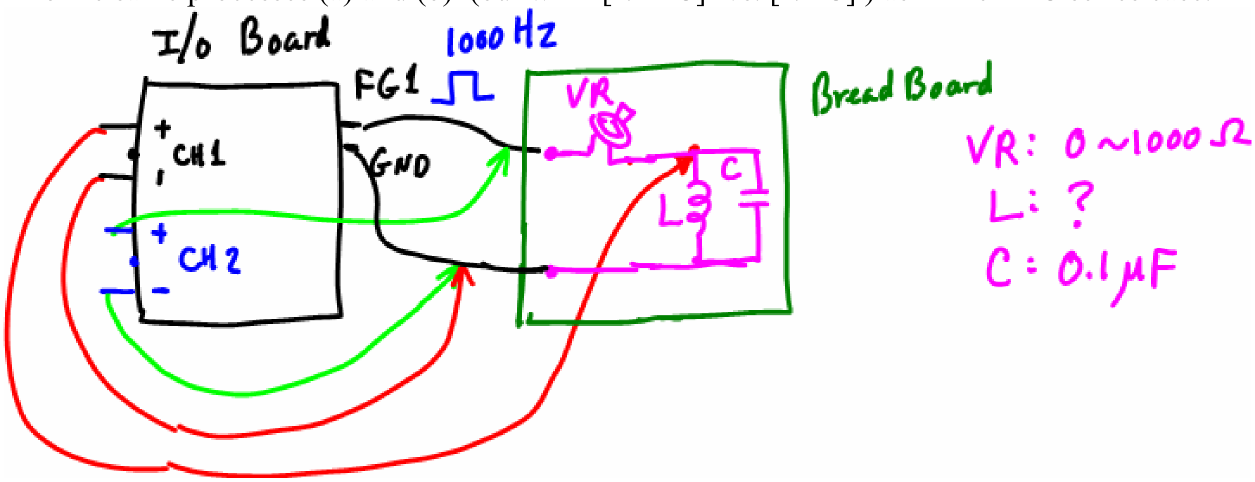
(a) Implement the circuit of FIG.1 with C=0.1uF, a variable resistor (0 – 1000 ohm), and an inductor with unknown value. For the Vpulse source, connect 1000 Hz square wave form from the function generator terminal of the instrumentation board. And measure the voltage across the variable resistor (which gives you the current through the resistor). Check the damping condition of the voltage across the variable resistor by wheeling the wiper of the resistor.

(b) Now, the question is "Can you guess the inductance of the inductor?". Make three different damping condition by changing the variable resistance, and, using DMM, measure the resistance of the circuit at each damping condition. By using the $[R/2L]^2$ vs. [1/LC] condition for damping. If your measured values at 3 different damping conditions match very well, you get the inductance of the inductor.



4. Parallel RLC case as in FIG.4 using Mobile Studio Lab.

Do the same processes (a) and (b) (but with $[1/2RC]^2$ vs. [1/LC]) as in the RLC series case.



5. From step 3, what is the inductance?
6. From step 4, what is the inductance?
7. What is the inductance of the inductor?

Turn over for Survey --- This is all I need from the lab. Thanks.
-Dr. Kim

Today's Date: ___________________, 2008

SURVEY - Part 1

(a) Overall, what was most frustrating in the Mobile Studio class?

(b) Overall, what was most interesting in the class?

(c) Which subject(s) of the Network Analysis could you understand better only after Mobile Studio lab?

(d) Do you believe the Mobile Studio has a good potential to reinforce your learning of the Network Analysis concepts?

(e) Have you enjoyed the Mobile Lab and had some fun?

SURVEY - Part 2
Using the scale below, please check mark your level of agreement or disagreement with the statements regarding the use of the Mobile Studio Lab in the course. *(Check one response per item)*

	SA: Strongly Agree A: Agree N: I don't know (neutral) D: Disagree SD: Strongly Disagree	Indication of Agreement/Disagreement				
#	**The Hybrid Class with Mobile Studio Lab increased my:**	SA	A	N	D	SD
A	Understanding of the lecture					
B	Ability to apply the theory					
C	Knowledge of the subject matter					
D	Attention to the lecture					
E	Interest in the subject matter					
F	Class attendance					
G	Motivation in class					
H	Participation in class					
I	Interaction with the instructor					
J	Interaction with other students					

Thanks.

Submit this to me by next week. -Dr. Kim