UNIVERSIDADE da MADEIRA

Experimental Science
P11: Forced RLC circuit oscillations

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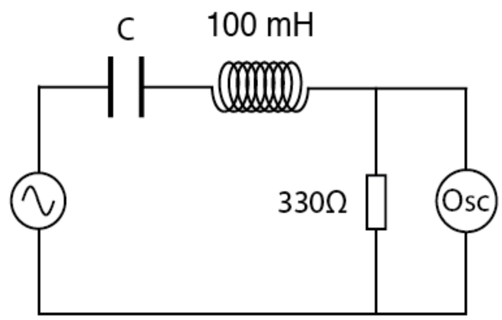
1. Purpose

- Experimental verification of a power dependency between two physical quantities.
- Perform numerical evaluations.
- Observe the phenomenon of resonance.

2. Introduction

On this study, a sinusoidal signal is imposed on a series circuit formed by three components: a capacitor, an inductor and a resistor.



The group formed by the capacitor and the inductor behaves as an oscillating pair which interacts the following way: when the capacitor discharges, does so through the inductor; the inductor reacts by sending the electric charge back to the capacitor.

This charge exchange is attenuated by the resistor (330 Ω) and oscillates with a proper period that depends on the component's parameters (capacity and inductance) as was seen on the previous experimental study (P10 – free oscillations).

On this study, the LC set is forced to oscillate at the signal generator's frequency. We will observe that the current intensity flowing through the resistor will be at its maximum only when the imposed signal's period coincides with the LC set's proper period:

$$T = 2\pi\sqrt{LC}$$

This is called the *Resonance effect*.

Our main purpose is to verify experimentally that the relation between *T* e *C* is in accordance with the previous equation.

The voltage at the resistor's terminals provides an indirect measurement of the current intensity running through it. This voltage will be measured with an oscilloscope.

To further understand this study let's resort to an analogy.

When air flows into a flute we are imposing a group of various frequencies. However the sound produced by the flute is a musical note with a well-defined frequency. Of all the present frequencies, one of them was intensified relative to the others. The effect occurring inside the flute is the *resonance effect*.

Inspired on this musical instrument we will scan the imposed signal frequencies until we find a maximum amplitude.

3. Previous questions

1. What type of relation is there between the resonance period and the capacitor's capacitance?
2. Propose a method to confirm experimentally the dependence mentioned on the previous question.
3. This activity involves the use of 11 capacitors. Determine the RLC circuit resonance frequency obtained for each one.

4 Experimental activity

4.1 Material

1 oscilloscope, 1 signal generator, 1 multimeter, 11 capacitors (10 nF, 22 nF, 47 nF, 68 nF, 100 nF, 150 nF, 330 nF, 470 nF, 680 nF, 1 μF and 1.5 μF), 1 resistor (330 Ω), 1 inductor (100 mH), connection wires, crocodile connectors, breadboard.

4.2 Additional information

All amplitude measurements are made peak to peak.

Don't forget that all measurements have an associated experimental error and that a measurement without an experimental error estimate is useless.

4.3 Procedure

1. Assemble the figure's RLC circuit. Before you close the circuit ask the teacher to confirm the connections.
2. This study involves the use of several capacitors. Organize your circuit so it is easy to replace them.
3. Measure the components physical parameters (resistance, capacity) with the multimeter. Add an extra column to the table to write the capacitor codes.
4. Sort the capacitors.
5. If possible measure also the inductor's inductance (ask the teacher).

6. Connect the two oscilloscope probes to the circuit so you can measure the input (signal generator) and output (resistor terminals) signals. To ensure a greater signal stability of the measured signal set the oscilloscope trigger source to the input signal.
7. Choose the channels so that the output signal is measured on the horizontal direction in the XY mode.
8. Use to oscilloscope to set the signal generator to a sinusoidal signal with a peak to peak voltage of 2 V and a period as close as possible to the previously calculated resonance period for the current capacitor. The input amplitude value should be confirmed on the oscilloscope **with the voltage applied to the circuit.**
9. Change to the XY mode and measure the maximum amplitude by varying the input signal period around the calculated resonance period.
10. Change to the YT mode and measure the period (T_R) as well as the output signal amplitude (A_S). Record the values into a table with the following headline:

C (nF)	T_R (ms)	A_S (V)

10. Replace the circuit capacitor with the next and repeat the procedure from point 9 until all capacitors have been used.

Measure the resonance curve experimental points for the 100 nF circuit. That is, measure the output signal amplitude for the following periods: 0.300 ms, 0.400 ms, 0.50 ms, 0.60 ms, 0.70 ms, 0.80 ms, 0.90 ms e 1.00 ms.

Record your measurements into a table with the following headline:

T (ms)	A_S (V)