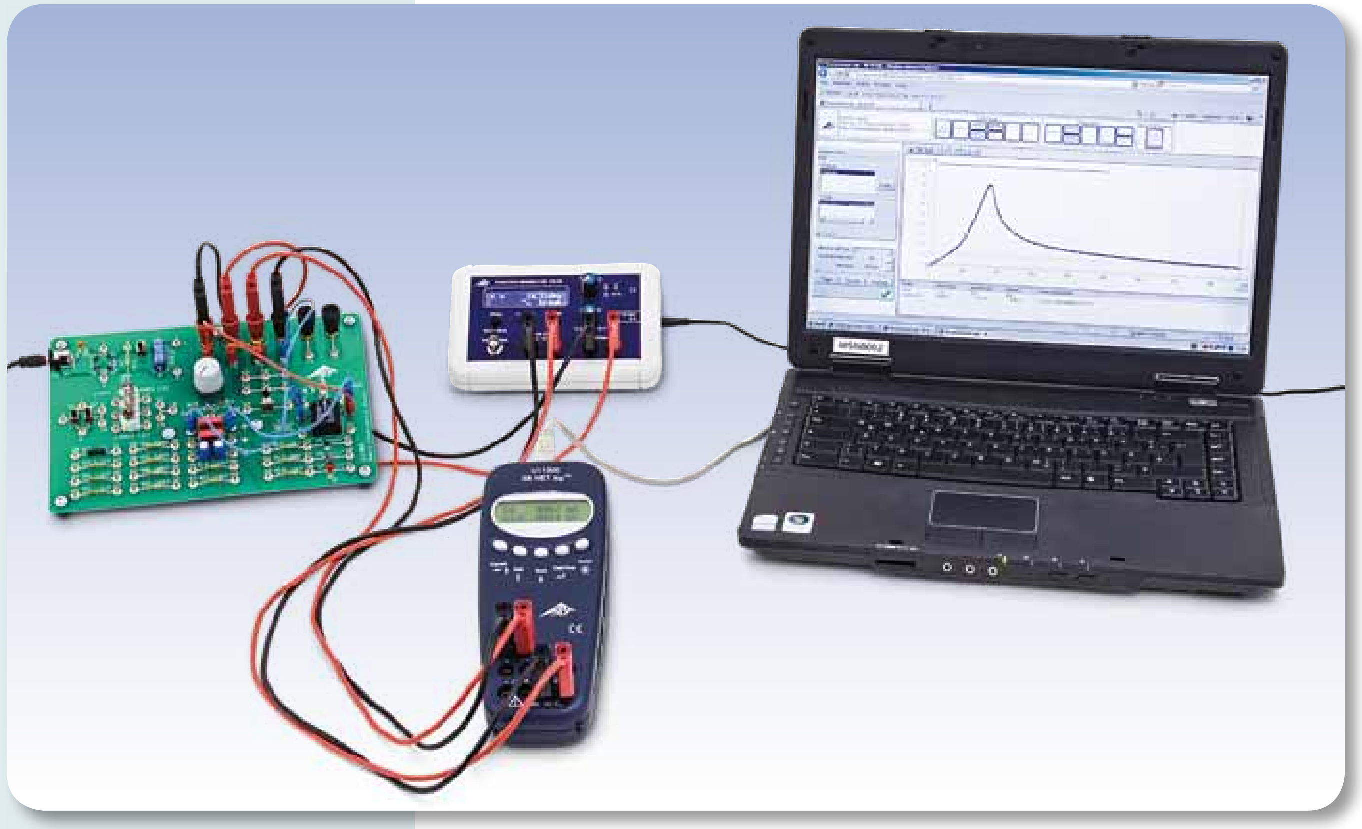
LC RESONANT CIRCUITS



EXPERIMENT PROCEDURE

- **Record an amplitude resonance curve for a series LC resonant circuit with various degrees of damping.**
- **Determine the resonant frequency of the series LC resonant circuit.**

OBJECTIVE

Investigate the resonance response of a series LC resonant circuit.

SUMMARY

An electric resonant (also resonance or tuned) circuit is a circuit which is capable of resonating at a specific frequency. It comprises an inductor and a capacitor. In this experiment an AC voltage is generated with the help of a function generator and fed to a series resonant circuit. What will be measured is the amplitude resonance curve, i.e. the current as a function of the frequency at a constant voltage amplitude. If the capacitance is known, it is possible to calculate the unknown inductance of the circuit.

REQUIRED APPARATUS

Quantity	Description	Number
1	Basic Experiment Board (230 V, 50/60 Hz)	**1000573 or**
	Basic Experiment Board (115 V, 50/60 Hz)	**1000572**
1	3B NET*log*™ (230 V, 50/60 Hz)	**1000540 or**
	3B NET*log*™ (115 V, 50/60 Hz)	**1000539**
1	3B NET*lab*™	**1000544**
1	Function Generator FG 100 (230 V, 50/60 Hz)	**1009957 or**
	Function Generator FG 100 (115 V, 50/60 Hz)	**1009956**
1	Set of 15 Experiment Leads, 75 cm 1 mm²	**1002840**

BASIC PRINCIPLES

An electric resonant circuit is a circuit consisting of an inductor with inductance *L* and a capacitor with capacitance *C*. The periodic transfer of energy between the magnetic field of the coil and the electric field of the capacitor results in oscillation of the electric circuit. This transfer results in alternating instances where there is maximum current through the coil or maximum voltage across the capacitor.

If the resonant circuit is not oscillating freely, but is excited by an external sine-wave signal, it oscillates at the same frequency as the excitation signal and the amplitude of the current and voltage across the individual components are dependent on the frequency. The current *I* can be deduced from Ohm's law as follows:

(1) $$I = \frac{U}{Z} = \frac{U_0 \cdot e^{i\omega t}}{Z}.$$

U: sinusoidal input voltage
U_0: amplitude, ω: angular frequency
Z: total impedance

In a series circuit, the total impedance is made up of the sum of the impedances of the individual components. In addition there is an ohmic resistance R, which covers the losses which inevitably occur in a real resonant circuit and which may also have any external resistance added to it. The following expression therefore arises:

(2) $$Z = R + i\omega L + \frac{1}{i\omega C}.$$

From equation (1) and (2) the current is given by

(3) $$I(\omega) = \frac{U_0 \cdot e^{i\omega t}}{R + i\left(\omega L - \frac{1}{\omega C}\right)}.$$

The magnitude of the current corresponds to its amplitude, which is frequency-dependent:

(4) $$I_0(\omega) = \frac{U_0}{\sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}}.$$

This reaches its maximum value at the resonant frequency

(5) $$f_r = \frac{\omega_r}{2\pi} = \frac{1}{2\pi \cdot \sqrt{L \cdot C}}$$

At that point, its magnitude is

(6) $$I_0(\omega_r) = \frac{U_0}{R}.$$

Therefore, in the case of resonance, the resonant circuit behaves as if it consisted solely of an ohmic resistance. In particular, an inductor and capacitor and capacitor connected in series act as if they were a short circuit when resonance is occurring.

This experiment involves an AC voltage generated by a function generator being used to excite the tuned circuit. The current *I* is measured as a function of the frequency *f* while the amplitude of the voltage remains constant. The current is measured using a measuring interface and recorded by means of measurement and evaluation software which allows it to be displayed graphically. The amplitude resonance curve of the current, i.e. the way the amplitude of the current depends on the frequency, is recorded automatically.

EVALUATION

The resonant frequency f_r can be read off from the amplitude resonance curve. Since the capacitance *C* is known, it is possible to calculate the size of the inductor being used by means of equation (5):

$$L = \frac{1}{4\pi^2 \cdot f_r^2 \cdot C}$$

Using equation (6), the ohmic resistance *R* can be calculated from the amplitude of the resonance curve. If no external resistor is connected, *R* represents the ohmic losses inherent in a real resonant circuit.

$$R = \frac{U_0}{I_0(\omega_r)}$$

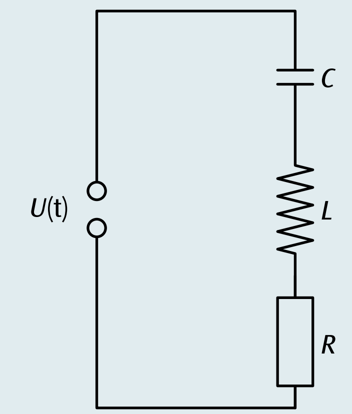


Fig. 1: Circuit diagram sketch for series LC resonant circuit

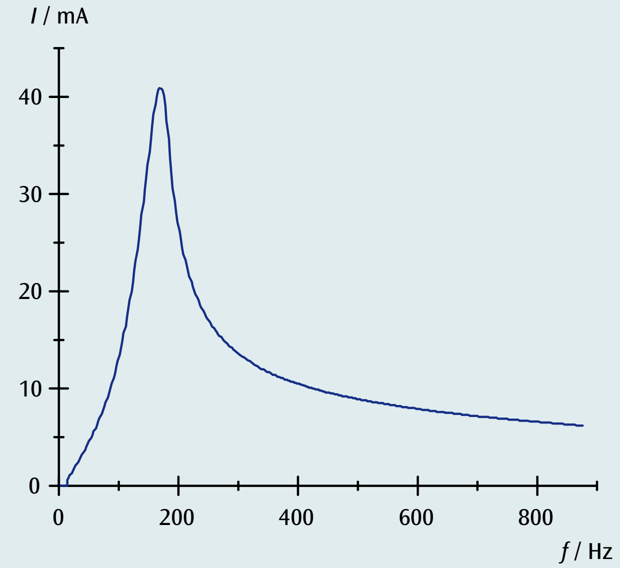


Fig. 2: Amplitude resonance curve of the current (R_{ext} = 0)