Probing a resonant circuit with a PC sound card

W. C. Magno, A. E. P. de Araújo, M. A. Lucena, E. Montarroyos, and C. Chesman

Citation: *Am. J. Phys.* **75**, 161 (2007); doi: 10.1119/1.2423038

View online: <http://dx.doi.org/10.1119/1.2423038>

View Table of Contents: <http://ajp.aapt.org/resource/1/AJPIAS/v75/i2>

Published by the American Association of Physics Teachers

Related Articles

Laboratory Investigation of Noise-Canceling Headphones Utilizing “Mr. Blockhead”
Phys. Teach. **51**, 332 (2013)

The use of dc glow discharges as undergraduate educational tools
Am. J. Phys. **81**, 663 (2013)

Resistivity in Play-Doh: Time and Color Variations
Phys. Teach. **51**, 351 (2013)

Corrected Launch Speed for a Projectile Motion Laboratory
Phys. Teach. **51**, 359 (2013)

Improving the quantification of Brownian motion
Am. J. Phys. **81**, 485 (2013)

Additional information on Am. J. Phys.

Journal Homepage: <http://ajp.aapt.org/>

Journal Information: http://ajp.aapt.org/about/about_the_journal

Top downloads: http://ajp.aapt.org/most_downloaded

Information for Authors: <http://ajp.dickinson.edu/Contributors/contGenInfo.html>

ADVERTISEMENT

American Association of **Physics Teachers**

Explore the **AAPT Career Center** –
access hundreds of physics education and
other STEM teaching jobs at two-year and
four-year colleges and universities.

<http://jobs.aapt.org>

Probing a resonant circuit with a PC sound card

W. C. Magno^{a)} and A. E. P. de Araújo

Instituto de Física "Gleb Wataghin," Universidade Estadual de Campinas, CP 6165, Campinas, SP, Brazil

M. A. Lucena and E. Montarroyos

Departamento de Física, Universidade Federal de Pernambuco, 50670-901 Recife, PE, Brazil

C. Chesman

Departamento de Física—CCET, Universidade Federal do Rio Grande do Norte, C.P. 1634, Natal, PE, Brazil

(Received 24 July 2003; accepted 22 November 2006)

We discuss an inexpensive experimental system that enables us to generate and acquire electronic signals using only a personal computer and its sound card to study the resonance of an RLC oscillator circuit. © 2007 American Association of Physics Teachers.
[DOI: 10.1119/1.2423038]

I. INTRODUCTION

The response of a system to an AC excitation can provide us with information about the system. For instance, we can determine the speed of sound in a vibrating bar¹ or carry out electronic experiments.² Some investigations have shown the importance of a microcomputer in the generation and acquisition of electronic signals.^{3–5}

In this paper we present a low-cost system for the generation and acquisition of electronic signals where a personal computer plays a key role as a probe in a resonant circuit. The system consists only of a computer and a sound card for simple electronic experiments in physics teaching laboratories.

II. EXPERIMENTAL RESULTS

The line-in channel of the sound card can receive different electronic signals. A wave generator was built using the simple schematics depicted in Fig. 1. A square-wave signal was produced directly from the computer motherboard at point A in the circuit. This signal originates in a circuit of transistors and resistors and is useful for buffering the input signal from the resonant oscillator circuit that we studied. We used our own software to produce an audio signal at the

output of the circuit, as shown in Fig. 1 (point B), with adjustable frequencies in the audible range and constant amplitude ($V_0=5$ V).

We studied the resonance of a linear RLC circuit consisting of a resistor in series with a parallel arrangement of an inductor L and a capacitor C . The nominal values of the components are $R=200\ \Omega$, $L\approx 1$ mH, and $C=2.2\ \mu\text{F}$. For the acquisition of electronic signals we used a program that simulates a virtual oscilloscope.⁶ The input voltage $V_{\text{in}}(t)$ is at point B, shown in Fig. 1, and the output voltage $V_{\text{out}}(t)$ corresponds to the potential between the terminals of the parallel components. The RLC circuit can help students understand concepts such as impedance, reactance, phasors, electromagnetic resonance, bandwidth, and the quality factor. The LC bandpass circuit is often used to amplify a particular radio frequency, when the angular frequency ω of the voltage source equals the resonant frequency, $\omega_0=1/\sqrt{LC}$.

We measured the resonance curve for the RLC circuit with the fast Fourier transform (FFT) spectrum of the output signal as a function of the driving frequency around ω_0 . Figure 2 shows the response curve of the oscillator circuit at reso-

Fig. 1. Experimental setup for generating a square-wave from a computer's sound output.

Fig. 2. Response curve of the oscillator circuit at resonance.

Fig. 3. Magnetization curves as a function of the external magnetic field H (mT). The data corresponds to the susceptibility integral, which is shown in the insets: (a) an amorphous ferromagnetic ribbon and (b) a ferrite nucleus.

nance (in arbitrary units) as a function of angular frequency ω of the voltage source. The solid curve is a fit to the measured data.

From the linear RLC circuit we can build a simple magnetometer with the acquisition system. If there is ferromagnetic material in the nucleus of the coil, its magnetic permeability $\mu(H) = dM/dH$ changes with the external field. The change of magnetic permeability with the applied field alters the inductance (magneto-inductance), given in SI units⁷ by $L(H) = \mu(H) / \pi^2 \epsilon_0$. Therefore, applying a magnetic field will also change the resonance frequency of the circuit. When we measure the dependence of the resonant frequency on the magnetic field, we find $\omega_0(H) = 1 / \sqrt{L(H)C}$. The magnetic permeability of different samples introduced into the solenoid is given by $\mu(H) = \pi^2 \epsilon_0 / [C \omega_0^2(H)]$. If we use an amorphous ferromagnetic CoFeSiB ribbon and a ferrite bar, we can demonstrate how this system can be used to obtain magnetization curves, $M(H)$. The external magnetic field was generated by a Helmholtz coil and a power supply. In addition, we used a calibrated commercial Hall sensor to measure the field amplitude. Figure 3(a) (inset) shows the magnetic permeability of the amorphous ribbon as a function of H . The square points depict the integral of $\mu(H)$, which results in the magnetization curve $M(H)$ of the ferromagnetic ribbon. We normalize the magnetization by its value in the saturation field, M_s . Figure 3(b) (inset) shows the magnetic per-

meability for the ferrite nucleus and the corresponding magnetization curve. We observe that the amorphous ribbon has a very low saturation field of 1.5 mT, whereas the ferrite has a saturation field of about 10 mT. Our results for permeability show a dynamic magnetization process; the tilted plateau in the amorphous ribbon demonstrates the displacement of a wall domain, while low ferrite permeability is associated with its ferrimagnetic origin. We can apply this experiment to investigate the differences among magnetic properties of ferromagnetic, ferrimagnetic, and paramagnetic materials.

^aElectronic mail: victor@ifi.unicamp.br

¹T. Key, R. Smidrovskis, and From Milton, "Measuring the speed of sound in a solid," *Phys. Teach.* **38**, 76–77 (2000).

²J. Guzman and M. Alvarado, "Nueva forma de enseñanza de circuitos eléctricos y electrónicos," *Rev. Mex. Fis.* **44**(3), 321–325 (1998).

³R. Wisman and M. Forinash, "Discount interfacing with the IBM parallel printer port," *Am. J. Phys.* **57**, 561–562 (1989).

⁴A. Henriquez, P. B. Gil, and M. Alvarez, "High resolution ADC through an IBM parallel printer port," *Am. J. Phys.* **62**, 568–569 (1994).

⁵T. J. Bensky and S. E. Frey, "Computer sound card assisted measurements of the acoustic Doppler effect for accelerated and unaccelerated sound sources," *Am. J. Phys.* **69**, 1231–1236 (2001).

⁶Winscope, Oscilloscope for Windows, version 2.51, (<http://www.zelscope.com>). This program turns a personal computer into a virtual digital oscilloscope.

⁷J. D. Jackson, *Classical Electrodynamics*, 3rd ed. (Wiley, New York, 1999).