



A TEACHING MATERIAL FOR LEARNING ALTERNATING CURRENT CIRCUIT USING SOUNDCARD OSCILLOSCOPE -EXPERIMENTS FOR THE ELECTRICAL RESONANCE-

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Abstract

Nowadays, the lack of a facility is one of the main problems in physics education for developing countries. To solve the problem by use of the modern technology which develops around the world apparently, a teaching material in learning alternating current (AC) circuit as one of the most difficult theories in physics for secondary school students have been investigated using a soundcard oscilloscope with the laptop computer. Experiments for the electrical resonance in LCR circuits have been investigated using the sound card oscilloscope; experimental results were compared to that measured by the conventional oscilloscope system. As expected, the investigated soundcard oscilloscope experiments show a good performance; the magnitude of electrical current as a frequency response proves the effectiveness of the teaching material in physics education that shows kind of limited function of soundcard oscilloscope that utilizes as a benefit in a simple experiment. For the further work, the teacher can utilize and develop this software for the other teaching materials. For example, something that related to traditional music or traditional apparatus which tend to find around students' home or school; therefore, students can understand more deeply about the concept of alternating current in many cases, and more interesting classes can be created.

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INTRODUCTION

The strains toward the feature of the higher education requirements to be improved to create a quality output and to ready to plummet into the employee market and to meet national as well as international standards (Setyawarno & Prasetyo, 2016). To achieve this goal, teachers as an essential part of education need to ensure the creatively based on the situation for each school. This paper aims to let teachers know that the limited facility and funding for education can be solved in many ways by using modern technologies.

In the case of physics education, alternating current is one of the most difficult parts to be understood for secondary school students (Rusilowati, 2006). In some developing countries, students have to learn the phenomena in AC without any experiments due to the lack of or inadequate apparatus (Djamal, 2013). Almost every school has only one conventional oscilloscope; it makes teachers tend to avoid doing experiments in science class and to use so-called traditional teaching methods which make students read and listen to the explanation. There is a few current class that can improve knowledge, skill, and creative thinking of students as well.

Nowadays, development of technology is around the world obviously. The questions are how the technology can create efficiencies in the classroom and how the subsequent changes should be added to our curriculum (Miyazaki et al., 2017).

Furthermore, in the learning process using developed teaching material by taking the benefits of low-cost apparatus can help the student to understand without limitation of time, limitation of apparatus quantity, and limitation of funding. The importance of them is creating the spirit of the whole people in the class that can support more activities, and teacher and students can communicate actively (Widiyatmoko & Nurmasitah, 2013) (Wantoro et al., 2016).

Therefore, based on the problem that teachers and students face in their school and the benefit of developed teaching material, we have investigated and finally, conduct experiments related to the phenomenon of the electric resonance using a free soundcard oscilloscope with a laptop computer as a low-cost system for the generation and acquisition of electronic signals. The performance of this teaching material has been checked using a conventional apparatus with a commercially

available digital oscilloscope and a signal generator. In this report, the experimental results for the electric resonance in the *LCR* circuit with the both oscilloscopes will be presented, and the applicability of the free soundcard oscilloscope to the AC circuit experiments will be discussed.

ELECTRICAL RESONANCE

Resonance is the tendency of a system to oscillate with great amplitude at some frequencies than at others. Resonance frequency ω_0 or f_0 is the frequency at which the response amplitude is relative maximum. Electrical resonance occurs in any circuit that has at least one inductor and one capacitor. The condition of the *LCR* circuit in which the reactance of capacitor *C* coincides with that of the indicator in magnitude results in a purely resistive impedance.

The series *LCR* circuit represents the input impedance *Z* is given by ratio between input voltage v_{in} and current *I* as follow,

$$Z = \frac{v_{in}}{I} = R + X_L + X_C = R + j\omega L + \frac{1}{j\omega C} \quad (1)$$

Where *R*, X_L , and X_C are the electrical resistance, reactance of coil and that of the capacitor, respectively. *L* and *C* are the inductance of the coil and the capacitance of the capacitor. Electrical resonance takes place when the imaginary part of the transfer function (1) is zero, i.e.

$$\text{Im}(Z) = \omega L - \frac{1}{\omega C} = 0 \quad (2)$$

The value of ω that satisfies this condition is called the resonate frequency ω_0 . Thus, the resonant condition is described by $\omega_0 L = 1/\omega_0 C$; the resonance angular frequency ω_0 and resonance frequency $f_0 = 1/\omega_0$ are given by

$$\omega_0 = \frac{1}{\sqrt{LC}} \quad \text{and} \quad f_0 = \frac{1}{2\pi\sqrt{LC}} \quad (3)$$

respectively. Further, the circuit's current magnitude is given by

$$I = \frac{V}{Z} = \frac{1}{\sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}} \quad (4)$$

In the series resonance circuit, the *LC* combination acts as a short circuit, and the

entire voltage is across R . Consequently, the impedance is purely resistive, $Z = R$; the voltage V and the current I are in phase. Hence the power factor is unity; the inductor voltage and capacitor voltage can be more than the source voltage (Serway & Jewett, 2010).

In the measurement of electrical resonance in the alternating current circuit, the waveform observation is important to realize the amplitude or phase difference between voltage and current. Hence, a simple experimental apparatus has been prepared; waveforms observation and the measurement of signal amplitude have been conducted using two oscilloscope systems. One is the conventional digital oscilloscope, and another one is a soundcard oscilloscope with a laptop computer.

METHODS

Apparatus

Schematic diagram of the electrical circuit for the conventional oscilloscope experiment is shown in Figure 1.

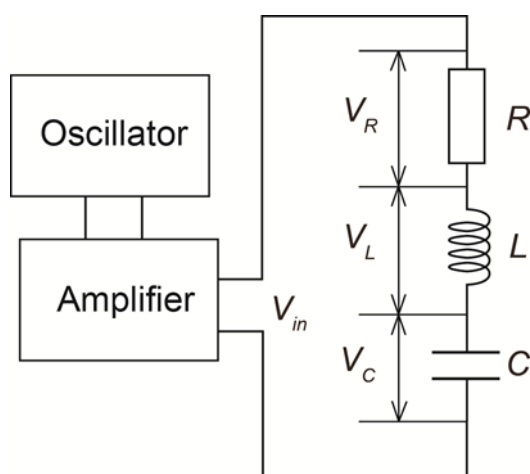


Figure 1. Electrical circuit and setup for LCR resonance experiment

The alternating current signal is generated by the oscillator and provided to the LCR circuit after the amplification. The oscillator changes the oscillation frequency; the electrical current I is determined from the voltage V_R using the relationship $I = V_R/R$ measured as a function of frequency. A conventional experimental setup is shown in Figure 2. Components for the AC circuit experiments using soundcard oscilloscope are shown in Figure 3.

In more detail, there are apparatus that be used to complete the circuit, they are:

- Interface Circuit as a voltage divider
- Laptop computer
- Audio Stereo Capture
- Probe
- Multimeter
- Resistor $R = 20\ \Omega, 40\ \Omega, 60\ \Omega$
- Inductor $L = 0.051\text{H}$
- Capacitor $C = 0.334\mu\text{F}$

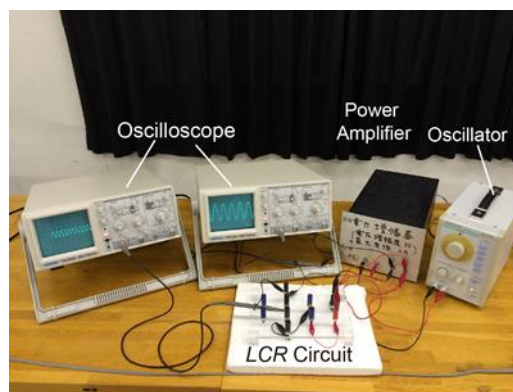


Figure 2. Experimental setup for the electrical resonance measurement by use of conventional oscilloscope

In this study, the main apparatus is a laptop computer, stereo capture, and a voltage divider. The voltage divider is created using OP-amplifier LM358N, two capacitors $100\mu\text{F}$, two capacitors 10.10^4pF , two resistors $1\text{K}\Omega$, two resistors $1\text{M}\Omega$, and adaptor 9 volts (Hartley & Misell, 1987). It can be used for keeping our laptop computer soundcard from high voltage. As we know, the soundcard of every single laptop computer has a limited frequency around 100KHz .



Figure 3. Experimental apparatus

Another main apparatus is stereo capture that used on the laptop computer which has an only mono audio port. It is needed because the signal from LCR circuit will send a stereo audio signal to the software oscilloscope.

Ceramic disk capacitors are recommended in this experiment because they are insensitive to polarity (non-polarized), inexpensive, and durable. Avoid capacitors with any polarity marking, as these will be destroyed when powered by AC.

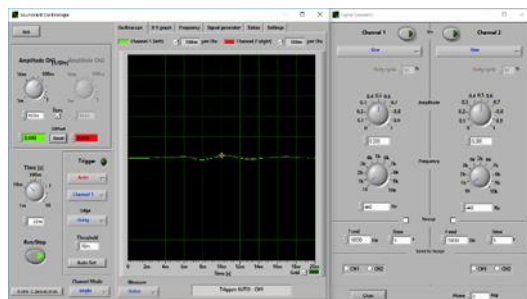


Figure 4. Soundcard Oscilloscope and Signal Generator

In the case of software oscilloscope, meanwhile, there are a lot of software oscilloscopes nowadays, some are free, others require a license but have a free trial, and others have optional licenses.

Therefore, the researcher tries to test and compare to find the most appropriate that can support experiment for secondary school. These include BIP Electronics Lab Oscilloscope, Zelscope, Xoscope, Virtins Sound Card Oscilloscope, and Soundcard Oscilloscope. Given several software oscilloscopes, the decision was that the soundcard oscilloscope. This software is arranged like a conventional oscilloscope with the frequency analysis functionality and additional signal generator which was the best choice. The delightful by this product is that Soundcard Oscilloscope is free for public education purposes (Long & Hartas, 2005; Wild & Swan, 2011; Wild et al., 2011; Zeitnitz, 2015).

Experimental Methodology

In this study, researchers try to develop teaching material related to Alternating Current Circuit. It aims to solve the problem of limited facility and funding for education in some developing countries.

In the case of the common experiment, researchers use the apparatus that observed through figure 2. A conventional oscilloscope can see the differences with the separated oscillator as well as a power amplifier. On the developed experiment, researchers utilize a laptop computer for oscilloscope software and signal generator, a voltage divider (Interface circuit) as a choice, stereo capture, plate circuit, probe, cable connection, resistor,

inductor, capacitor, and multimeter as you can see in figure 5. Furthermore, researchers connect the components on the plate circuit in series. Then, from the plate circuit, we connect laptop computer again as a signal generator to *LCR* circuit using an audio cable connection.

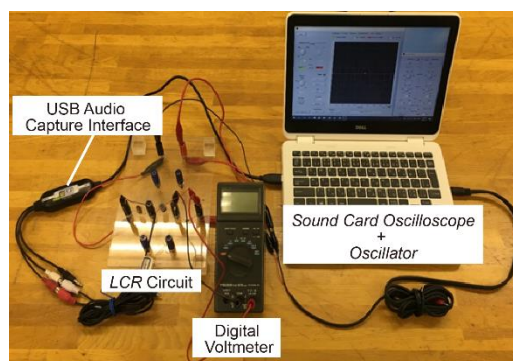


Figure 5. Experimental setup for data collection of frequency response using soundcard oscilloscope

After that, researchers connect the *LCR* circuit to the interface circuit using the probe, and it will be as a filter for the high voltage and manage to the stereo capture, and it will deliver the signal to the laptop computer, and the oscilloscope software will show the signal through the sinusoidal wave. Meanwhile, we can change the variable that oscilloscope software read which depends on what we want to measure. In this case, varying the frequency can be determined by the signal generator and the amplitude voltages V_R , V_L , and V_C at each frequency was measured and recorded using a multimeter.

Lastly, we can take a note for the frequency, voltage, and current using Microsoft Excel and frequency versus current was plotted. The resonance frequency, the frequency at which the maximum voltage (V_R) occurs was determined.

RESULTS AND DISCUSSION

The graphs show the data collected from the measurement of the amplitude voltage for different values of R varying the frequency. The left graph is the result of measurement using a conventional oscilloscope (CO) and the right graph used soundcard oscilloscope (SO). As the frequency increases, the amplitude current for each resistance also increases and reaches its maximum when the frequency is around 1250

Hz using DO and around 1200 Hz for SO as explained that characteristics of both oscilloscopes are the same. Keeping increase the frequency the amplitude current I_{R1} , I_{R2} , and I_{R3} now decreases. It also seems that at this frequency the inductor and capacitor amplitude voltage is equal in magnitude. From the theory, the resonance is the condition in which the inductor and capacitive voltage amplitude are equal in magnitude resulting in purely resistive amplitude, and the phase is 100% different. Thus, we can conclude that in this experiment, using three different resistances, the resonance phenomenon

occurs when the frequency is 1250 Hz and 1200 Hz as shown in Figure 6 that can be different because of damping factor. Theoretical calculation of resonance frequency shown 7661.9 rad/s, meanwhile, experimental calculation of resonance frequency using conventional oscilloscope shown 7859.8 rad/s (Herieta, 2015). Meanwhile, the experimental calculation of resonance frequency using soundcard oscilloscope shows around 7536 rad/s.

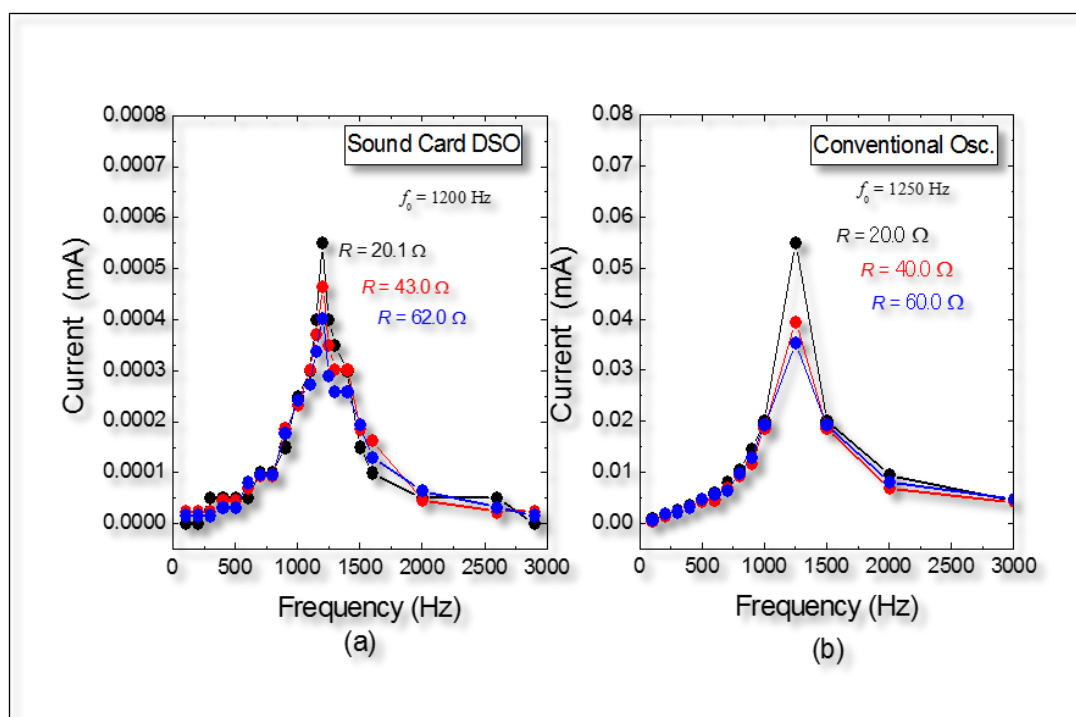


Figure 6. Current as a function of frequency in series circuit

The result values from the theoretical calculation and experimental measurement in both oscilloscopes are in good agreement, and the resonance frequency is the same for the circuits but still found different magnitude frequency which means this software oscilloscope as the available one can work effectively as well as conventional oscilloscope as a commercial apparatus.

The difference of this study with the conventional one is the voltage divider that is provided by the researcher to keep the soundcard of the laptop computer from the high voltage as well as stereo capture that uses in an experiment, and it is proved by the result that is explained before.

Meanwhile, one of the competencies that the students must develop in this topic is to be able to account for the phenomenon of resonance in electronics. By using this low-cost apparatus which is already developed, it may generate new knowledge on electrical oscillations and resonance and at the same time developed competencies that are required for the topic that can be used to study alternating current in high school physics as well as higher education. In general, the benefit of using advanced technology in the learning process especially in physics can encourage the student to ask, curious because there will be new things that they find and catch their interest (Blasco-Arcas, 2013; Henderson et al., 2017).

CONCLUSION

In this research, a soundcard oscilloscope can be used as an effective apparatus supported by the signal generator, a voltage divider, and stereo capture. For the further work, the researcher wishes that this soundcard oscilloscope can be used for another school-based curriculum. The teacher can utilize and develop this software for the other teaching materials for example related to traditional music or traditional apparatus which tend to find around students' home or school; therefore, students can understand more deeply about the concept of alternating current in many cases and more interesting classes can be created.

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