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Demonstration of Lissajous Figures in the Study of Physics

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ABSTRACT – *The article describes a very simple device for laser demonstrationof Lissajous figures with a ratio of oscillation frequencies 1:1. Also the electric circuit for quick and convenient demonstration on the screen of an oscilloscope of Lissajous figures with different ratios of oscillation frequencies is described.*
KEYWORDS - *physics course; demonstration of experiments; figures of Lissajous.*

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I. Introduction

When studying the addition of harmonic oscillations, it is useful to demonstrate the so-called Lissajous figures. These figures are the pattern produced by the intersection of two sinusoidal curves, the axes of which are at right angles to each other [1]. The simplest figure is obtained by adding two harmonic oscillations of the same frequency. In the general case it is an ellipse that at a certain difference of oscillation phases can turn into a straight line. At other ratios of oscillation frequencies, the Lissajous figures have a more complex forms [2].

The first part of this article describes a simple device for demonstrating the Lissajous figures with a frequency ratio of 1:1. The second part shows the electrical circuit of the device, intended to be used with an oscilloscope. This device simplifies the demonstration of Lissajous figures on the oscilloscope screen for various ratios of oscillation frequencies.

II. The Device for Demonstrating the Lissajous Figures with a Ratio ofOscillation Frequencies1:1

The device consists of a spring, one end of which is fixed to the post. A small flat mirror is attached to another end of the spring. A beam from of a small-sized laser of visible light reflects from the mirror, which is oscillating together with the spring, and gives a certain picture on the screen.

The appearance of this simple device is shown in Fig.1.

Fig.1 The appearance of device

Suppose that we made the spring to oscillate along direction 1 (see Fig.2).

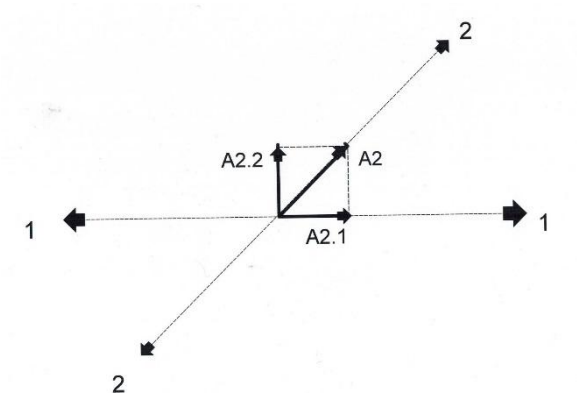

Fig. 2. Theoscillationalongtwomutuallyperpendiculardirections (see the text).

Due to the random deviation, the spring will also oscillate (with a small amplitude) along some direction 2. Suppose that the elastic properties of the spring are the same in all directions. Then the oscillation frequency in direction 2 is the same as in the direction 1. The oscillations along the direction 2 can be decomposed along two mutually perpendicular directions 2.1 and 2.2. The 2.1. component affects only the amplitude of the oscillations along the direction 1. Thus, there remain two oscillations of one frequency in two mutually perpendicular directions 1 and 2.2. As a result, the end of the spring oscillates in the general case along an ellipse. Since the oscillations are damped, the dimensions of the ellipse decrease with time. Because of the randomly changing phases and amplitudes of two oscillations, elongation of the ellipse and its position change. In the particular case, it can turn into a streight line. All this can be seen on short videos [3,4].

III. Construction of the Device For Observation of the Lissajous Figures with Different Ratios of Oscillation Frequencies on the Oscilloscope Screen

Usually two separate adjustable sinusoidal generators are used to observe the Lissajous figures on the oscilloscope screen. Their outputs are connected to the inputs "X" and "Y" of the oscilloscope. The following electrical circuit of a simple device already contains two harmonic oscillations generators. One of the generators is tuned to a fixed frequency, and the second can be switched discretely so that the oscillation frequency ratios are 1:1; 1:1,5; 1:2.0....and so on. It is convenient and saves time for demonstration of various Lissajous figures.

The electrical circuit (see Fig.3) consists of the following parts: a main transformer Tr1, a rectifier VD1 and a voltage stabilizer based on LM350 microchip. The output voltage of the stabilizer is set by a trimmer R2. The LED HL1 indicator shows once the device is switched on. Two harmonic voltage generators are identical. Both are assembled on the XR2206 microchip [5]. The voltage at the generator outputs (approximately 2V) is set by selecting the values of the resistors R7 and R12. The frequency of generator №1 is constant and is approximately equal to 250 Hz. It is set by selecting of a resistor R8. The frequency of generators №2 is discretely switched by the switch SA2. In our case this switch has five positions that correspond to the following frequency ratios of generators №1 and №2: 1:1; 1:1.5; 1:2.0, 1:2.5 and 1:3.0. To fine-tune the frequency of the second generator, potentiometer R14 is applied. Resistors R15 .... R19 are selected during the adjustment of the device. Other ratios of frequencies of the two generators can be selected by selecting these resistors (and potentiometer R14).

IV. Conclusion

Schematically, both devices are very simple and easily reproducible. It can be noted that the teaching of physics proves these devices to be useful and convenient for demonstration of the Lissajous figures at lectures.

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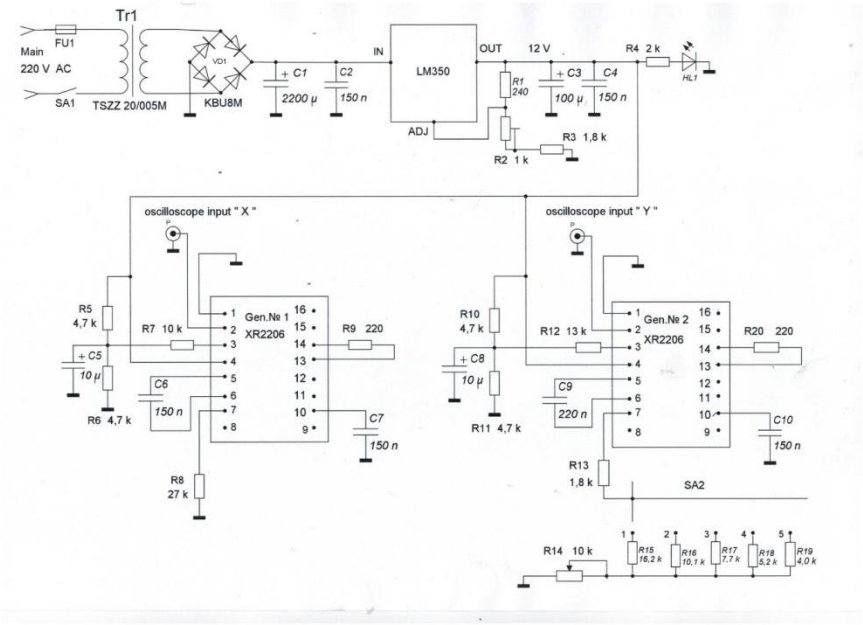

Fig. 3 The electrical circuit of thedeviceforobservation of variousLissajous figures.

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