

A Device For Demonstration Of Lissajous Figures Using Document Camera

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Abstract – The article describes in detail a device for demonstration of Lissajous figures on a large screen using a document camera and projector. Carrying out the specified experiment using this device does not take long. The device itself, containing two sine-wave generators and a miniature oscilloscope, is small and easy to use.

Keywords—*physics course; demonstration of experiments; Lissajous figures.*

I. INTRODUCTION

Studying the addition of harmonic oscillation in the physics course, the experiment with the demonstration of Lissajous figures is often used. These figures arise when two harmonic oscillations are added, occurring in two mutually perpendicular directions [1]. The figures represent the trajectories of a point which participates in two oscillations simultaneously. Closed figures are demonstrated most often. They are formed in case the frequencies of added oscillations relate to each other as whole numbers.

Usually, two sine-wave generators and an oscilloscope are used to demonstrate Lissajous

figures [2]. Due to small size of an oscilloscope screen it is not convenient if the demonstration of the experience takes place in a large lecture hall. Installation and tuning of these devices also takes quite a long time. This article provides a detailed description of a small-size design uniting the functions of these three instruments. The device does not require presetting. It is designed to display Lissajous figures through a document projector on a large screen.

II. DEVICE STRUCTURE

The device is designed to be installed horizontally under the lens of the document camera. All the required attributes to be displayed on the screen are located on the top horizontal side. It contains a miniature two-channel oscilloscope, all switches and regulators. Area of the upper side is 200x220 mm (the height of device is 70 mm).

Two sine-wave generators necessary in the device are assembled on XR2206 chip [3]. These chips were developed a long time ago, but due to their popularity they are still used today. Designing a generator on this chip requires minimum of external parts. It is also convenient to set the required frequency.

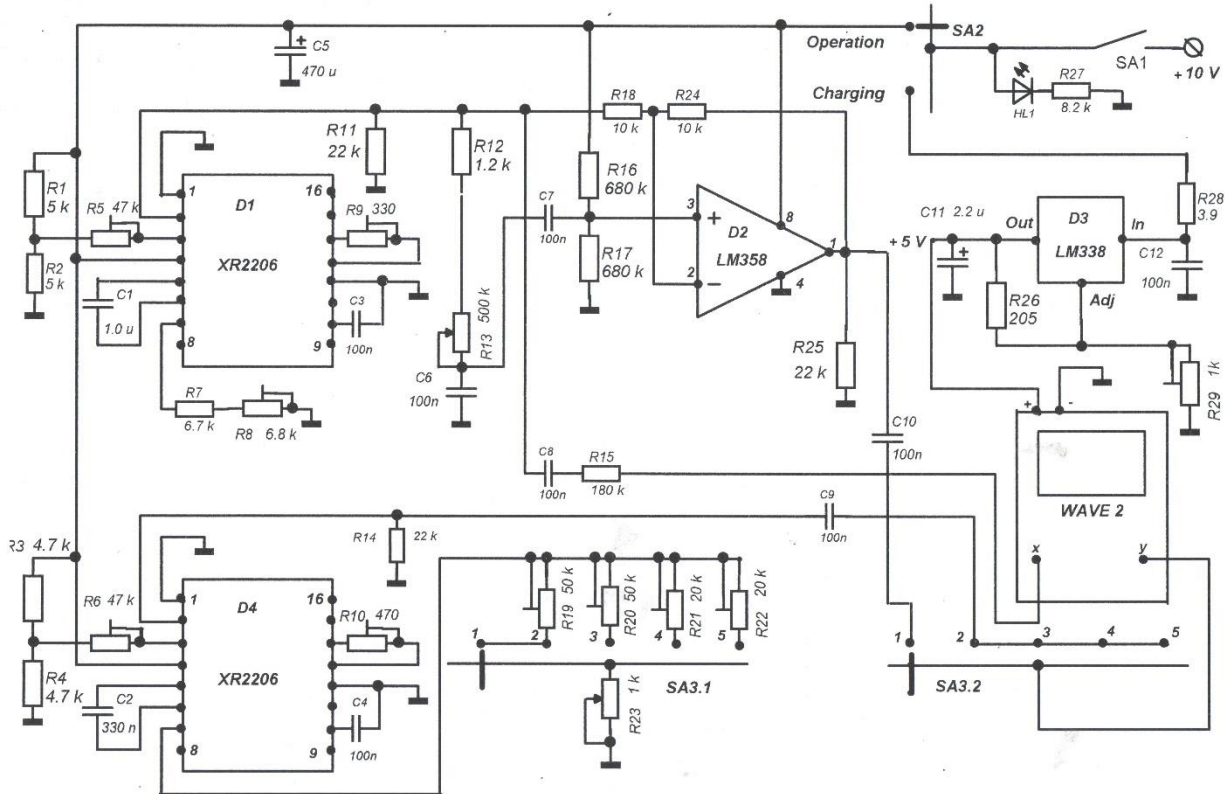


Fig. 1. Electrical circuit of the device.

The value of the output sinusoidal voltage of the generator D1 is set by the trimmer resistor R5, and for second generator D4 - by the trimmer resistor R6 (see Fig.1). For both generators, the effective output voltage is set at approximately 1V. The maximum reduction in the distortion of the output voltages is achieved by adjusting the trimmer resistors R9 and R10.

In our device the frequency of the voltage generated by the first generator (D1) is 90 Hz. It is installed with a R8 trimmer. The voltage from the output of this generator is applied to a phase shifter assembled on an operational amplifier D2. In this case, the LM358 chip is used in which only one of two operational amplifier is engaged. The use of this chip is not critical. It can be replaced by many others (for example LM158, LM258, TS912, TS922 etc.). With the help of such a phase shifter, using a variable resistor, one can change the voltage phase within the limits approx. 0° 180° [4]. In our device, the voltage phase can be changed with the R13 potentiometer within the range of 0° 170° . Potentiometer R13 is used with a logarithmic characteristic (A type). For better linearity of the phase adjustment, it is necessary to experimentally choose which terminals of this potentiometer need to connect resistor R12 and capacitor C6. It may be

necessary to select resistor R12 and slightly change the frequency of the generated voltage with the resistance of trimmer resistor R8 in order to obtain the mentioned range of phase change.

Directly from the output of the generator D1, the voltage through the circuit C8, R15 is applied to X – input of the oscilloscope. From the output of the phase shifter, the voltage through the capacitor C10 is applied to Y – input of the oscilloscope. This occurs only in the „1:1. Stab.“ position of the switch SA3 (which consists of double switches SA3.1 and SA3.2). In this case, two voltages of exactly the same frequency are applied to both inputs of the oscilloscope, the phase shift between them can be adjusted. For this case the Lissajous figure is motionless. Its appearance at various values of the phase difference of oscillations in the interval 0° 170° can be observed by changing the resistance of the potentiometer R13 (see Fig. 2-4). Resistor R15 is turned on so that the voltages applied to the inputs of the oscilloscope are approximately the same. The value of this resistor is selected while adjusting.

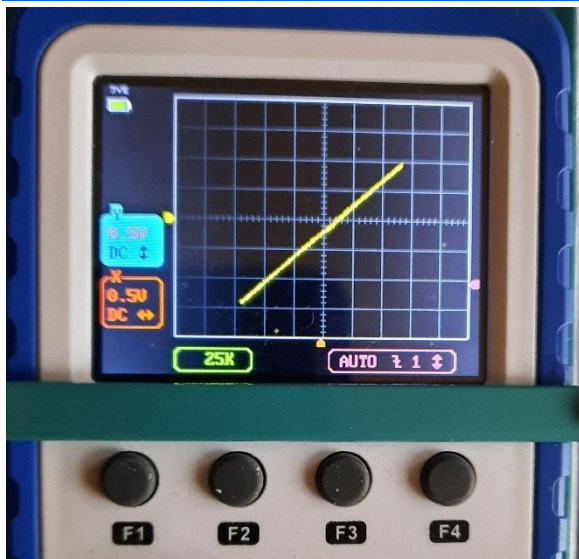


Fig.

2. Phase difference of the oscillations is 0° .

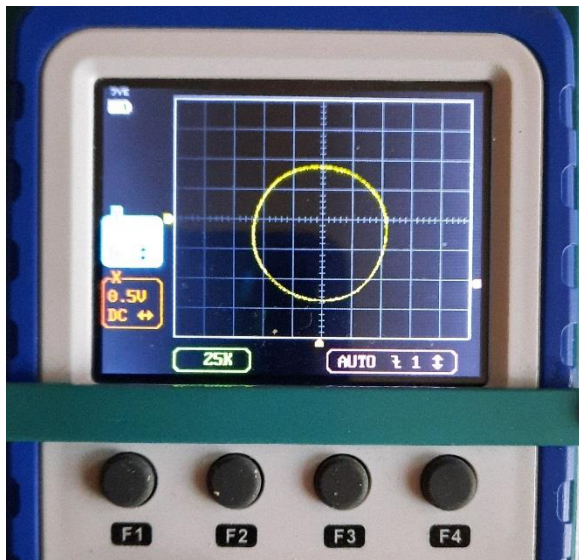


Fig. 3. Phase difference of the oscillations is 90° .

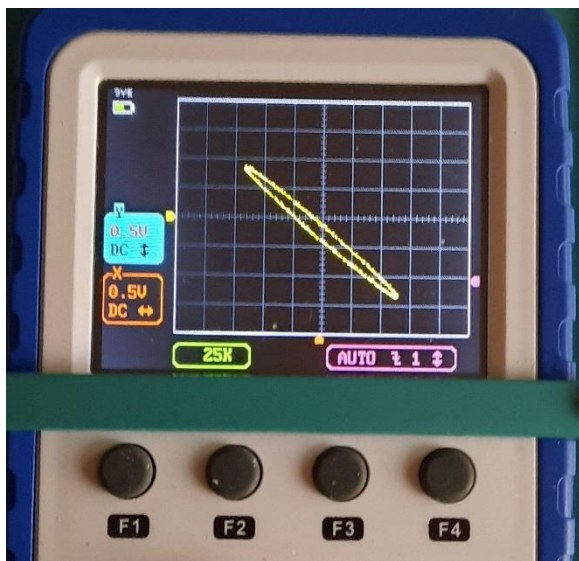


Fig. 4. Phase difference of the oscillations is 170° .

The second oscillator (D4) generates, depending of the subsequent positions of switch SA3, a voltage with frequencies 90 Hz, 135 Hz, 180 Hz and 270 Hz. At a frequency of the first generator of 90 Hz, they correspond to the ratios of the frequencies of the two oscillations 1:1, 2:3, 1:2 and 1:3. These frequencies are selected using trimmer resistors R19...R22. Potentiometer R23 („Tuning“) is used for precise frequency setting. Usually, when observing these figures, due to the inaccurate coincidence of the frequencies of the two generators, the phase difference changes all the time. This causes the observed figures to rotate. However, by adjusting the resistance of the „Tuning“ potentiometer, you can get closer to the exact coincidence of frequencies and, accordingly, slow down the rotation speed of the observed figures until they stop for a short time.

Thus, in position 1:1 of switch SA3 we can observe the Lissajous figure for a frequency ratio of 1:1. In general case, this is an ellipse, which on the screen will slowly rotate due to the continuously changing phase difference, changing its position and eccentricity (up to the case when the ellipse turns into a straight line segment). Recall that in the position of the switch „1:1. Stab.“ we observe a motionless Lissajous figure with different phase differences, which can be changed with the regulator „Phase“.

With the following positions of the switch SA3, you can observe Lissajous figures for frequency ratios 2:3 , 1:2 and 1:3. As an example, Fig.5 shows the first of them.

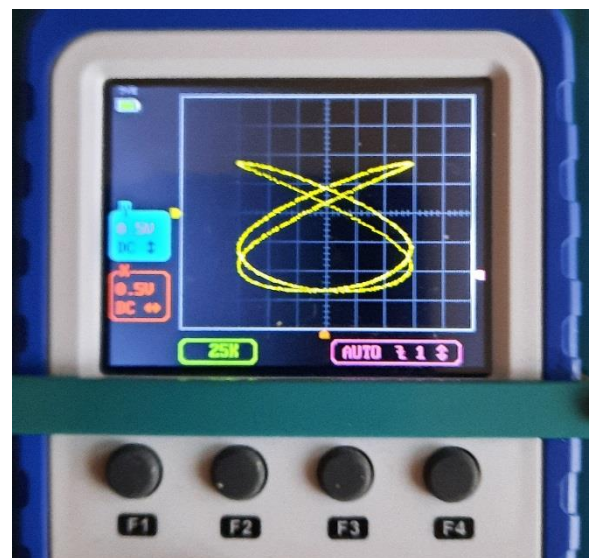


Fig. 5. Oscillations frequency ratio is 2:3.

The device is powered from the DC 10V 1A adapter. The current consumption is 24mA (in the charging mode of the battery built into the oscilloscope – 110 mA).

The miniature two-channel oscilloscope WAVE2 used in device is powered by a built-in lithium battery. The operating time of an oscilloscope with a fully charged battery reaches several hours. The oscilloscope comes with a USB cable for charging. In this device, charging is performed from the same adapter through a voltage stabilizer D3. To do this, two wires from the USB cable are connected to the output of the stabilizer (plus – red wire and minus – black). Stabilizer is assembled on chip LM338. The 5 V output voltage is set using a trimmer resistor R29. The power reserve of the used chip is much higher than the required one, so less powerful chips LM350 or LM317 can be used instead.

The device is operated in the position „Operation“ of the switch SA2 and the battery is charged in the „Charging“ position.

The appearance of the device from the upper horizontal side is shown in Fig. 6.



Fig. 6. The appearance of the device.

IV. CONCLUSION

In our opinion, this device can be successfully used in physics lectures to demonstrate Lissajous figures on the screen. It is small in size and requires a little time when using document camera with a projector to prepare and demonstrate the experiment. Working with this device is a visual „live“ experience, a „live“ alternative to finding a video on the same topic in the Internet and showing it on the screen.

REFERENCES

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