Determining the signal frequency by Lissajous curves and beats observation

Objectives:

- Familiarization with the phenomenon of superposition of simple harmonic oscillations mutually parallel and perpendicular.
- Determinantion of signal frequency based on direct observation of oscillations and by beats and Lissajous curves observation.

Questions and problems to solve:

- Equation describing simple harmonic oscillation.
- Discuss the principle of measuring the period and frequency of alternating voltage using an oscilloscope.
- Formation and characteristic features of the Lissajous curves.
- The principle of determining the signal frequency by Lissajous curves observation.
- Formation of beats. What is the beating period and the resultant period? How depends value of these periods on the frequency of waves creating observed beating?
- The principle of determining the frequency of the signal based on beats observation.

Short description:

To determine the frequency of the signal coming from the tested generator, we use an oscilloscope and a second, standard generator. The unknown frequency of the signal is determined by the direct measurement method, observation of Lissajous curves and beats observations.

Direct measurement

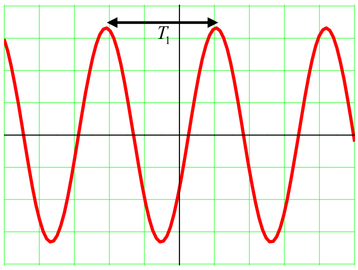


Fig.1. Image of sinusoidal voltage

The signal from the generator of unknown frequency is connected to the oscilloscope. After obtaining a stable image of harmonic oscillations on the screen, we determine the period of oscillations T_1. The signal frequency f_1 is calculated from the relation:

$$f_1 = \frac{1}{T_1}. \tag{1}$$

Lissajous Curves:

The signal from the tested generator is connected to the oscilloscope input *X*, and the signal from the second - the standard generator - is connected to the input *Y*. We turn off the time base and set the standard generator to the frequency determined in the previous measurement. By adjusting the frequency f_2 of the signal from this generator, we obtain an ellipse image on the screen. We redraw the image of the resulting Lissajous curve for several different phase shifts.

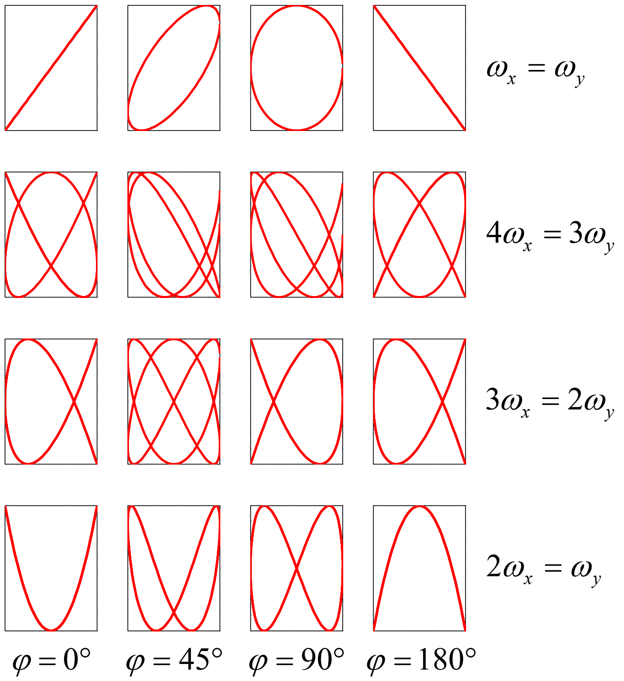
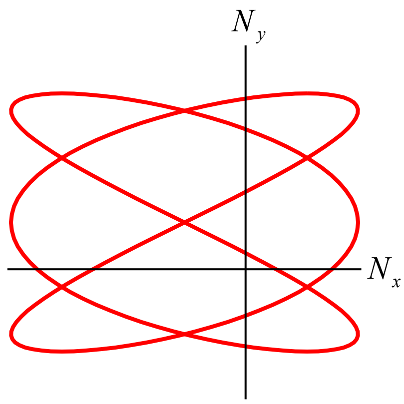


Fig. 2. Examples of the Lissajous curves



$$\frac{\omega_x}{\omega_y} = \frac{N_y}{N_x} = \frac{6}{4} = \frac{3}{2}$$

Fig. 3. Determining the frequency ratio of two oscillations forming the Lissajous curve

Similar measurements are made for other signal frequencies from the reference generator, for which a stable image of the Lissajous curve is created on the screen.

For each observed curve, we determine the number N_x of intersections of the Lissajous curve with the horizontal axis and the number N_y of intersections of the Lissajous curve with the vertical axis. We determine the frequency f_1 of the signal coming from the examined generator:

$$f_1 = \frac{N_y}{N_x} f_2. \tag{2}$$

Beats:

We turn on the time base. On the reference generator, set the frequency f_2, lower than the frequency f_1 of the tested generator by approximately 50 Hz. The frequency ω_2 is then adjusted so that a stable image of beats is obtained on the screen.

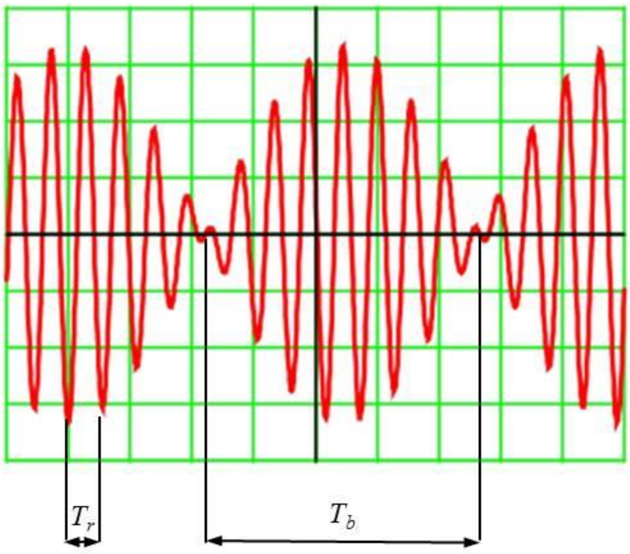


Fig. 4. Image of beats

We determine the resultant period T_r and the period of beats T_b. We repeat the measurement for several other values f_2 below and above the frequency f_1. We redraw the beat image for one selected frequency f_2.

We estimate the number n of the oscillations of the resultant wave per one beat period

$$n = \frac{T_b}{T_r} \tag{3}$$

The frequency f_1 of the signal from the examined generator is determined from the dependence

$$f_1 = \frac{2n-1}{2n+1} f_2 \tag{4}$$

– when the frequency f_2 of the signal from the G2 generator is greater than the frequency f_1 determined by direct measurement, or

$$f_1 = \frac{2n+1}{2n-1} f_2 \tag{5}$$

– when the signal frequency f_2 from the G2 generator is lower than the frequency f_1 determined by direct measurement.

We compare the frequencies f_1 obtained in the three ways.

Literature:

1. Resnick R., Halliday D., Walker J., *Fundamentals of Physics*, John Wiley & Sons, INC. (available editions)