Determining the signal frequency by Lissajous curves and beats observation

Equipment:

1. Generator G1
2. Reference Generator G2
3. Oscilloscope with the ability to freeze the image

Exercise:

I Direct measurement

1. Check if the G1 generator is connected to the input *1*, G2 generator to the input *2*.
2. Turn on the oscilloscope and the G1 generator. Wait until the oscilloscope completes the self-testing process. The following fields should be highlighted on the oscilloscope: "A", "RFR", "TR", CHI "and" AC "(in the case of other settings, ask the teacher)
3. Using the potentiometer *8* move the signal so that it is placed in the center of the screen. Then, using the potentiometer on the G1 generator, set the amplitude of the voltage signal on the oscilloscope so that the height is 4 cm.
4. Using the switch number *6* select the minimum time base T_C value (its current value is displayed in the upper left corner of the screen), for which the oscilloscope screen displays the full period of the signal coming from the G1 generator.
5. Measure in centimeters the distance *L* corresponding to one period of examined signal. During measurement you can change the position of the signal with potentiometers *8* and *10*.
6. Calculate the signal period from the G1 generator:
$$T_1 = LT_C,$$
its frequency:
$$f_1 = \frac{1}{T_1}$$
and angular frequency:
$$\omega_1 = 2\pi f_1.$$

II. Measurement by the observation of Lissajous curves

7. Turn on the G2 generator. Press button number *5*. Use the potentiometer to move the signal so that it is in the center of the screen. Then, with the "AMPLITUDE" potentiometer on the G2 generator, set the amplitude of the voltage signal so that the height on the oscilloscope is 4 cm. On the G2 generator, set the reference frequency f_1 calculated in point 6.
8. Press button *4* and hold it down for about 2 seconds. At the screen an ellipse should appear. Switch button number *6* to set the sampling rate to 100 kS /s (its current value is displayed in the upper left corner of the screen).
9. Adjust the frequency of the signal from the G2 generator so that the Lissajous curve on the screen is as stable and the obtained picture is not blurred. Record the frequency f_2 set on the G2 generator.
10. Stop the Lissajous curve by pushing the button *7* briefly. **Redraw the image from the oscilloscope screen with a graph paper**. Press button *7* again.

11. Repeat steps performed in the in the previous point. **Redraw the Lissajous curves for a different phase shift value.**

12. Repeat steps 9-11 for 3 higher frequencies and 3 lower frequencies than f_1. After completing the measurements, the Lissajous curve on the screen should be moving.
13. Calculate for each frequency f_2 the number of intersections of the Lissajous curve with the N_x and N_y axes. Calculate the frequency

$$f_1 = \frac{N_y}{N_x} f_2$$

and the angular frequency

$$\omega_1 = 2\pi f_1$$

of the signal from the generator G1.

14. Calculate the average frequency $\overline{f_1}$ of the signal from the G1 generator and its standard deviation.

III. Measurement by the observation of beats

15. Set the G2 reference generator at a frequency around 50 Hz lower than f_1 frequency calculated in point 6.
16. Press button *4*. Check whether the amplitudes of both signals are the same and equal to 4 cm.
17. Press buttons *4* and *5* simultaneously. Set the time base (using *6*) to $T_C = 5$ ms. The image of beat will appear on the screen.
18. Stop the beat image with the button *7*. Save the frequency set to the G2 generator. Save the time base value T_{Cb} and the length of the period of beating L_b. During the measurement the position of the signal can be changed using potentiometers *8* and *10*
19. Press the button *11* briefly to decrease the time base value tenfold. Save the time base value T_{Cr} and the length of an resultant period L_r. During the measurement the position of the signal can be changed using potentiometers *8* and *10*.
20. Press in turn the button *11* and then the button *7*.
21. Perform the steps described in paragraphs 18-20 for two other frequencies below f_1 frequency and three above the f_1 frequency.
22. Redraw the beating image for one selected f_2 frequency.
23. After completing the measurements, release the beat image with the button *7.*
24. Press button *3* so that the oscilloscope screen only has a signal from G1 generator (the "CHI" field above switch *4* is highlighted).
25. Turn off the oscilloscope and both generators.
26. Based on each of the measurements made, determine:

- number of vibrations of the resultant wave falling on one beating period T_b

$$n = \frac{L_b T_{Cb}}{L_r T_{Cr}}$$

- frequency

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

- when the frequency f_2 of the signal from the G2 generator is larger than the frequency f_1 determined by direct measurement

or

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

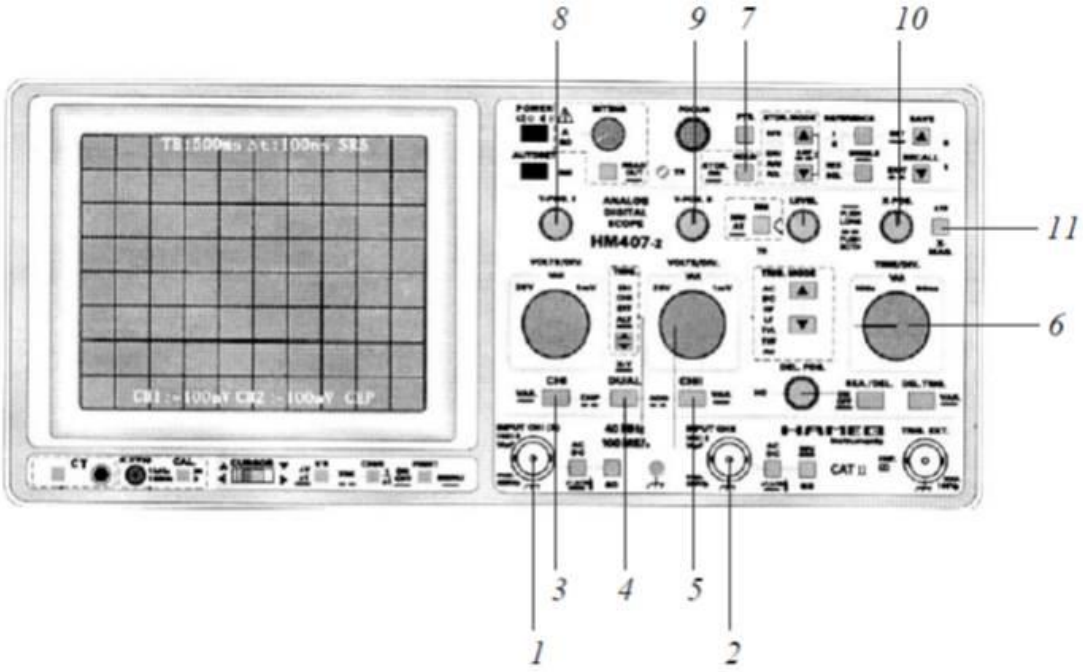
- when the frequency f_2 of the signal from the G2 generator is lower than the frequency f_1 determined by direct measurement

– angular frequency

$$\omega_1 = 2\pi f_1$$

of signal from G1 generator

27. Calculate the average frequency $\overline{f_1}$ of the signal from the G1 generator and its standard deviation.
28. Compare the frequency values f_1 obtained by all the methods.
29. Formulate conclusions.



Tables:

I Direct measurement

T_C [...s/cm]	L [cm]	T_1 [s]	f_1 [Hz]	ω_1 [Hz]

II. Measurement by the observation of Lissajous curves

f_2 [Hz]	N_x [–]	N_y [–]	f_1 [Hz]	ω_1 [Hz]

$$\overline{f_1} = (..... \pm .....) Hz$$

III. Measurement by the observation of beats

f_2 [Hz]	T_{Cb} [...s/cm]	L_b [cm]	T_b [s]	T_{Cr} [...s/cm]	L_r [cm]	T_r [s]	n [–]	f_1 [Hz]	ω_1 [Hz]

$$\overline{f_1} = (..... \pm .....) Hz$$