Task VI. Analysis of the signals

Required knowledge: Human voice; Electrical phenomena and living systems; Electric properties of tissues

1. Measuring the voltage and frequency of electric signals with the oscilloscope

Main task:
To learn a oscilloscope operation and its using for voltage and frequency measurement of alternate electric signals.

Needs for measurement:
Two-channel oscilloscope, generator of alternating voltage (further only "generator"), junction cables.

Procedure:
1) By means of junction cables connect the generator with the oscilloscope, i.e. the generator output with the input of the oscilloscope vertical amplifier (channel A or B).
2) Switch on the oscilloscope, adjust optimum brightness and track focusing and test the vertical and horizontal track shifts, switching over and continuous regulation the deflection factor and the time base. Knobs for continuous control of the deflection factor and the time base (red control elements) must be set in the right position throughout all measurements!!!
3) Switch on the generator. Adjust knobs for continuous control and changeover switches of voltage setting in arbitrary positions.
4) With the changeover switch of the deflection factor of the oscilloscope (on the channel with the fed-on signal) adjust the maximum height of the track on the screen, but within the limits of the grating. With the changeover switch of the time base of the oscilloscope adjust the position in which the number of periods of the displayed signal will be well and quickly assessable (e.g. 5 – 10 periods).
5) With the knob for the vertical track shift adjust the track position of the displayed signal and record its HEIGHT in divisions of the grating (Y) and the adjusted deflection factor (S) into the prepared table. With the knob for vertical shift adjust the position of the displayed signal and record the number of whole periods of signal (N), the corresponding number of the horizontal grating divisions (X) and the value of the time base in s/division (T) into the table. (Time base values on the left hands of the time base changeover are in ms/division, on the right hand are in the μs/division – necessary convert!)
6) Repeat the procedure described in points 3) through 5) four more times for other distinctively altered voltages and frequencies of output signal of the generator.
7) a) Calculate peak-to-peak voltage U for each measured signal with equation

$$U = Y \,.\, S \qquad /V/$$

where Y means the number of vertical divisions of the grating corresponding to the track height of the displayed courses, and S is the deflection factor (V/division) adjusted with the corresponding changeover switch.

b) Calculate the frequency f for each measured signal with equation

$$f = \frac{N}{X.T} \qquad /Hz/$$

where N denotes the number of selected periods of the displayed courses, X is the number of horizontal divisions of the grating corresponding to the number N of selected periods, and T denotes the value of the time base (s/division) adjusted with the corresponding changeover switch.

8) Create a table with measured and calculated values for five different signals:

a) values of height of track (Y), values of deflection factor (S) and calculated voltage values of measured signals (U)

b) numbers of whole periods of signal (N), corresponding numbers of the horizontal grating divisions (X) and the values of the time base in s/division (T) and calculated frequency values (f) of measured signals

2. Analysis of acoustic elements of human voice

Main task:

Oscillographic analysis of vowels.

Needs for measurement:

Two-channel oscilloscope, generator of alternating voltage (further only "generator"), junction cables, microphone, audio amplifier, tuning fork (as source of fixed frequency, hammer unit.

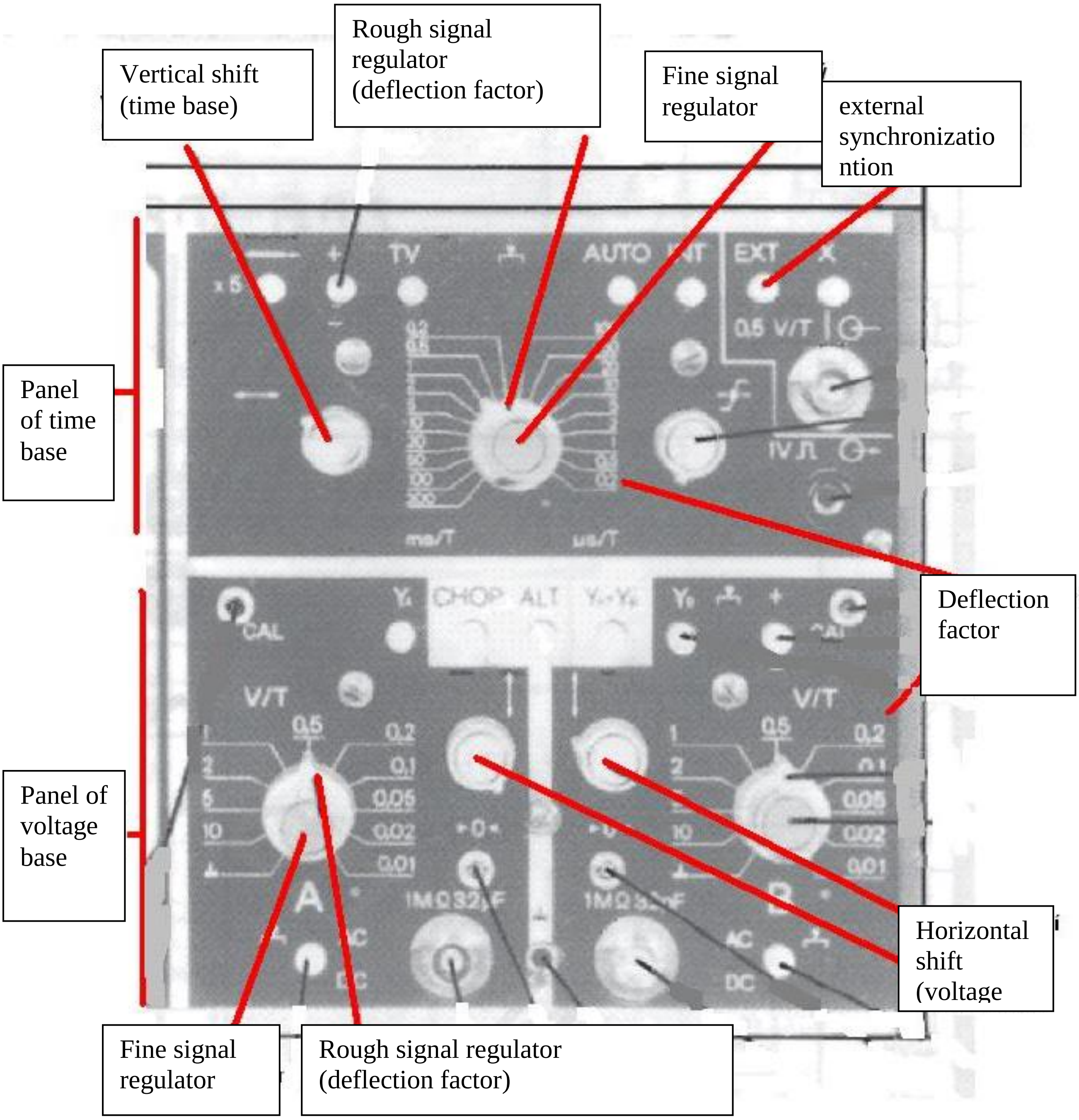
Procedure:

1) Carry out the electro-acoustic chain: the microphone connect to the amplifier, the amplifier trough the switch panel to the oscilloscope. Switch on the amplifier, the oscilloscope and the generator.
2) At first realize the imaging and determine the frequency of the vowels. The switch on the switch panel set in position Z. Intone a vowel into the microphone and at the same time adjust the oscilloscope: with the changeover switch of the deflection factor of the oscilloscope (on the channel with the fed-on signal) adjust the maximum height of the track on the screen, but within the limits of the grating, with the changeover switch and by fine control of the time base set a suitable number of oscillations on the screen (2-3). This curve of vowel draw in record. The switch on the switch panel set in position G. The knobs on the oscilloscope no change, the frequency of the generator signal change so long until the same number of sinusoidal oscillations is displayed on the screen as is the number of oscillations of the intoned vowel. This frequency write in record.
3) The point 2) repeat for all vowels.
4) Choose any of the previously measured vowels (i.e. “a”) and intone a vowel by lowest tone as is possible. Measure the frequency of this vowel by the generator (due point 2) and record the frequency value. Repeat measurements with the same vowel intonation by highest tone as is possible and record again its frequency.
5) Now determine the frequency of two tuning forks. Keep the tuning fork grip on the end, by means of hammer unit clang the tuning fork and set it nearly the microphone. With the changeover switch and by fine control of the time base again set a suitable number of oscillations on the screen (2-3). The switch on the switch panel set in position G. The knobs on the oscilloscope no change, the frequency of the generator signal change so long until the same number of sinusoidal oscillations is displayed on the screen as is the number of oscillations of the tuning fork. Compare this generator frequency with frequency written on the tuning forks and write it in record.

Plot the waveform of individual vowels and their corresponding frequency. Give the frequency for selected vowels intone by lowest and highest tone. Plot the waveform of tuning forks and their corresponding frequency. Make sure that the found frequencies

correspond approximately to the actual frequency of used tuning forks. Discuss possible discrepancies.

Oscilloscope



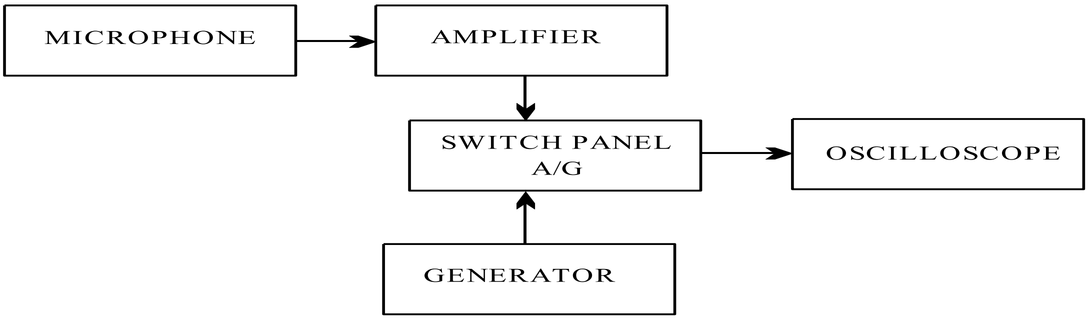


Diagram of the electroacoustic chain

2. Frequency dependence of tissue impedance and tissue model

Main tasks:
To acquaint with the function of passive electric elements in alternate current network with variable frequency, its use as a tissue model and low-pass filter.
To verify a impedance tissue character in alternate current network with variable frequency.

Task 1
Frequency dependence circuits with electrical elements for tissue models.

Needs for measurement:
Generator of alternating voltage (further only "generator"), two-channel oscilloscope, interconnecting module, junction cables, 3 exchangeable connectors containing together with known resistor always this next part: tissue model (parallel connection the resistor and capacitor), separated resistor and separated capacitor.

Procedure:
1) Attach to the interconnecting module (according to symbols on the module) junction from the generator, from the two-channels A and B of the vertical oscilloscope amplifier (in the earthing clips of module ($\perp$) connect green eventually black earthing plugs of cables from the generator and oscilloscope). To corresponding receptacle push in connector with separated resistor for resistance measurement of tissue model (R_u). The truth of connection compare with schematic task diagram. Put in operation the oscilloscope and the generator. For channel A of the oscilloscope vertical amplifier adjust the deflecting factor 0.5V/T (i.e. half a volt per one division of the measuring grating).
2) On the generator choose the frequency of 500Hz and by the regulation knob of its output voltage adjust the height of the displayed track for channel A of the oscilloscope to 2 divisions of the measuring grating (U_g = 1V).
3) According to the voltage magnitude of the displayed signal on channel B of the oscilloscope set the suitable deflecting factor for the exact reading of the height. Into the prepared table record the frequency of the measured voltage, the height of the track in channel B in divisions of the measuring grating and the set value of the deflecting factor (for determining voltage U_r).
4) On the generator set gradually further frequencies: 5kHz, 50kHz and 500kHz. After each adjustment of frequency check and/or correct the output voltage of the generator in channel A of the oscilloscope (1V) and repeat the procedure described in point 3. Adapt the frequency of the oscilloscope time base to the voltage frequency from the generator for the purpose of accurate reading of the track height on the screen.
5) Gradually use the connector with separated capacitor (labelled X_u) and connector with whole tissue model (labelled Z_u - resistor and capacitor connected). By these measurements

the capacitance and the impedance of the tissue model repeat the procedure included in points 2), 3) and 4).

6) The magnitude of the unknown resistance R_u (capacitance X_c, model impedance Z) calculate from voltage $U_{r\,u}$ (U_c , U_z), which is the difference of the output voltage of the generator and voltage across the known resistor R, and from current $I_{r\,u}$ (I_{xc} , I_z), which flows through the whole circuit (it is calculated from the voltage across the known resistor R and from its resistance – this is in table by task). For calculations use the following equations:

$$Ru = \frac{Uru}{Iru} = \frac{Ug - Ur}{\frac{Ur}{R}} \qquad Xc = \frac{Uxc}{Ixc} = \frac{Ug - Ur}{\frac{Ur}{R}} \qquad Z = \frac{Uz}{Iz} = \frac{Ug - Ur}{\frac{Ur}{R}} \quad /\Omega/$$

The symbols used are explained in the circuitry below.

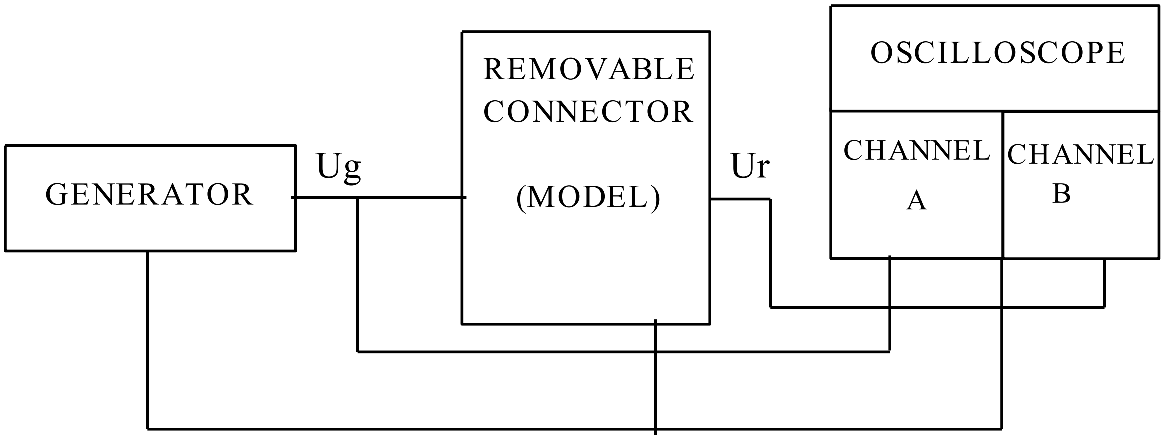
7) Create two tables with these measured and calculated values for each measured tissue models:

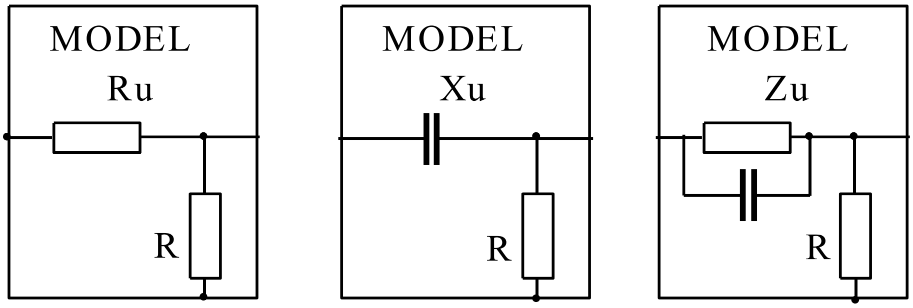
a) values of height of track (Y), values of deflection factor (S) and calculated voltage values (U_r) for each measured frequency

b) values of calculated resistance, capacitance and tissue model impedance for each measured frequency with graphic presentation in one graph

Circuit diagram for measuring resistance, capacitance and tissue impedance models

- overall circuitry (upper part)
- connection of electrical elements in individual connectors (lower part)





Task 2

Frequency dependence of impedance of human organism tissues

<u>Needs for measurement:</u>

Generator of alternating voltage (further only "generator"), two-channel oscilloscope, interconnecting module with known resistor, skin attachment electrodes, cellulose wadding, ECG gel, ether, junction cables.

<u>Procedure:</u>

1) Attach to the interconnecting module (according to symbols on the module) junction from the generator, from the two-channels A and B of the vertical oscilloscope amplifier (in the earthing clips of module (⏊) connect green eventually black earthing plugs of cables from the generator and oscilloscope). To corresponding receptacle insert the connector with cables going to the skin electrodes. (The truth of connection compare with schematic task diagram.)

2) On the upper extremity, best on the lower arm, fasten by means of the fastening rubber band the two electrodes (on the dorsal and the volar sides) to sites that have been degreased with ether and spread with ECG gel. By means of banana pins attach cables from the connector inserted in the interconnecting module to the electrodes.

3) Put in operation the oscilloscope and the generator. For channel A of the oscilloscope vertical amplifier adjust the deflecting factor 0.5V/T (i.e. half a volt per one division of the measuring grating). On the generator select the frequency of 100Hz and by regulating its output voltage adjust the height of the displayed track on channel A of the oscilloscope to 2 divisions of the measuring grating. This peak-to-peak voltage Ug (1V) must be constant throughout the whole measurement.

4) According to the voltage magnitude of the displayed signal on channel B of the oscilloscope adjust the suitable deflecting factor for the accurate reading of the track height. Into the prepared table record the frequency of the measured voltage, the height of the track in channel B in divisions of the measuring grating and the adjusted value of the deflecting factor (for determining voltage U_R).

5) On the generator adjust gradually further frequencies: 250, 500, 750Hz, 1, 2, 4, and 8kHz. After each adjustment of frequency check or adjust the output voltage of the generator on channel A of the oscilloscope (1V) and repeat the procedure included in point 4. Adapt the frequency of the time base of the oscilloscope to the voltage frequency from the generator in order to read exactly the height of the tracks on the screen.

6) The magnitude of the tissue impedance Z for each frequency calculate from voltage U_z occuring on it (it is the difference of the output voltage of the generator U_g and voltage drop U_r across the known resistor R, and from current I_z through the whole circuit (it is calculated from the voltage drop U_r across resistor R and from its resistance (this is in table by task). For calculations use the following equation:

$$Z = \frac{Uz}{Iz} = \frac{Ug - Ur}{\frac{Ur}{R}} \qquad /\Omega/$$

The symbols used are explained in the circuitry below.

7) Create the table with tissue impedance values (Z) calculated for each measured frequency, create the graph with the dependence of measured tissue impedance on frequency

Circuit diagram for measuring tissue impedance