PRACTICE LAB 3-1

EXAMINATION OF SIGNAL GENERATORS

The purpose of this laboratory exercise is to enhance the skills of learners to check the metrological characteristics of signal generators, to examine the internal resistance, amplitude-frequency characteristics, accuracy of outgoing signals' parameters and also acquiring practical skills for equipment exploitation.

1. Theoretical introduction.

The signal generators, used for measurement, present sources of different electrical and electromagnetic waveforms with the possibility to alter the frequency, amplitude and power to some limitations. These limitations define the equipment's capabilities, and the Class of accuracy define the metrological characteristics.

The most important signal generator parameters, used for measurements, are:

- **frequency range** – this is the frequency interval f_{min} - f_{max} , in which the outgoing signal follows all requirements of accuracy;
- **carrier frequency error** – depends of frequency stability during duty intervals. The absolute carrier frequency error is presented by:

$$\Delta f = \pm(\varepsilon . f + f_{err})$$

where f_{err} is the absolute methodical scale grading error, and $\boldsymbol{\varepsilon}$ represents the main relative error in the working frequency interval. Common values are: ε=0,1÷3% and f_{err} =1÷3 Hz;

- **frequency deviation** – this is the relative instability of carrier frequency. It is described with δ as:

$$\delta = \frac{\Delta f}{f}.$$

Factors, affecting frequency destabilization are changes of environment temperature, alternations in power supply, humidity, etc. The relative frequency instability for a time interval is presented by:

$$\delta_t = \frac{f_2 - f_1}{f_1}.100\ \%$$

where f_2 and f_1 are respectively the maximum and the minimum measured frequencies;

- **amplitude stability** – this is the capability of a generator to maintain the amplitude of the outgoing signal in a constant value for interval of time, despite the changes in environment. Factors affecting amplitude stability are: changes in temperature, changes in frequency, power supply instabilities. Automatic gain control (AGC) solutions are applied for improving the amplitude stability in some cases;

- **nonlinear distortions** – those are frequency components in the outgoing signal that are not part of the input. There are two main types of nonlinear distortions: **harmonic distortions** and **noise distortions**. The **brum** is part of the noise distortions, which is activated by the 50HZ power supply AC-current frequency.

2. Practice tasks:

2.1. Learn the connection circuit, working principles and the control and regulation of the signal generator used for measurement.
2.2. Measure the output resistance R_{out} of the generator.
2.3. Define the error in the frequency scale when setting up the work frequency.
2.4. Define the error in the value of the generator output voltage while setting the output signal amplitude.
2.5. Plotting the frequency to voltage relevancy.
2.6. Report writing containing the performed measurements.

The connection circuit should contain the following equipment:

- signal generator used for measurement – 1 pc.;
- cathode ray tube (CRT) oscilloscope – 1 pc.;
- electronic voltmeter – 1 pc.;
- digital frequency counter – 1 pc.;
- standard reference resistance (R_{ref} = 1,5kΩ);
- high-frequency connecting cables – 3 pcs.;
- interconnecting triple – 1 pc.

3. Practice lab instructions:

Students are obligatory to learn the theoretical aspects before performing this practice. On fig. 1 the connection circuit for examination of signal generators is depicted.

For task 2.2., the outgoing resistance R_{out} of the generator is a parameter equivalent to its power payload. To perform this measure, a switch and a reference resistance is predicted.

With the key switched to position 1 the outgoing voltage of the generator $U_1=U=E_{gen}$ is measured by the voltmeter, which has sufficient ingoing resistance. After this measure, the generator is loaded with the reference resistance R_{ref} by switching the key to position 2 and the outgoing voltage $U_2 = I.R_{ref}$ is measured. For the key in position two it can be written: $E_{gen}=I.(R_{out} + R_{ref})$

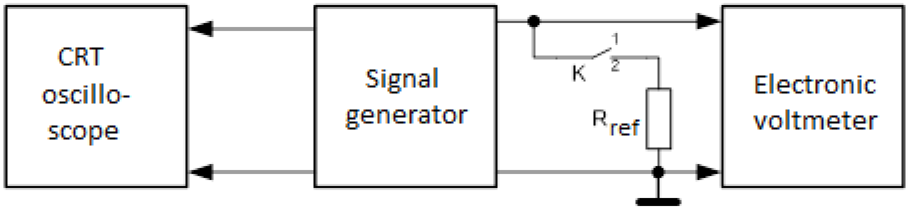

Fig. 1 – Connection circuit

Using the mentioned equations, for the output resistance of the generator we have:

$$R_{out} = R_{ref}\left(\frac{U_2}{U_1}\right).$$

Usually, the outgoing resistance is in the range of number of kiloohms. The measured values of the two voltages U_1 and U_2 should be written in Table 1, after which, the signal generator output resistance R_{out} is manually calculated. The frequency, in which the values are measured, should be in the middle of its subrange.

Table 1.

Frequency subrange / Parameter	I subrange	II subrange	III subrange	IV subrange
U_1, V				
U_2, V				
R_{out} , kΩ				

For task 2.3., frequency error check is done by the means of direct measurement with digital reference frequency counter. The frequency counter is caught to the output of the signal generator. The frequency error check is performed:

- in generators with subranges, containing more than 3 frequencies;
- in generators without frequency subranges, to more than 5 equally distributed frequencies similar to 10, 20, 50, 100, 200, 500 Hz; 1, 5, 10, 20, 50, 100, 200, 500 kHz; 1,5,10, 20, 50, 100, 200, 500 MHz;
- in generators with decad scale – at least 3 points for each decad, usually it is the start, middle and end of decad.

In generators, working with the principle of sound adjust, the settings should be done prior frequency error check. The absolute frequency error Δf measured in

Hertz, and relative error δ_f measured in percentage, for the main scale, are calculated by the formula:

$$\Delta f = f_{nom} - f_o$$

$$\delta_f = \frac{f_{nom} - f_o}{f_o} .100\%$$

f_{nom} – the nominal value set for the signal generator frequency;

f_0 – the frequency, measured with the reference frequency counter when the settings switch is set to 0.

The obtained measurement results should be written in Table 2.

Table 2

Frequency subrange / Parameter	I subrange			II subrange			III subrange			IV subrange		
	start	middle	end	start	middle	end	start	middle	end	start	middle	end
f_{nom}, Hz												
f_0, Hz												
δ_f, %												

For task 2.4., the error of output voltage amplitude is checked with reference voltmeter while attenuator is turned off, and generator payload is equivalent to its technical documentation sheet, mostly 50Ω. If the scale is one row (voltage or decibels), this check is performed for more than 5, digit-labelled, points. This is done while frequency is fixed. If the scale is multi-row, the check should be performed for more than 5, digit-labelled, points for each scale row. The obtained measurement results should be written in Table 3.

Table 3

Digital scale stripes / Parameter	1	2	3	4	5	6	7	8	9	10
U_{nom}, V										
U_{ref}, V										
U_{last}, V										
$\delta_{пр}$, %										
δ, %										

To define the accuracy of output voltage in the embedded measurement system, the relative error should be calculated by the formula:

$$\delta_{np} = \frac{U_{nom} - U_0}{U_{end}} .100\%$$

where: U_{nom} – the voltage nominal value, set according to the reference scale;

U_0 – the voltage value measured by the reference voltmeter;

U_{end} – voltage value of the last digit-labelled point in the scale row.

For task 2.5., the amplitude-frequency domain should be plotted. The amplitude-frequency domain characteristics describe whether the generator is able to maintain constant amplitude (constant signal level) when frequency is altered. The amplitude-frequency characteristics are taken by setting a constant voltage value of the output signal and frequency alternation on equal points for each subrange. The obtained measurement results should be written in Table 4.

Table 4

Frequency subrange / Parameter	I subrange			II subrange			III subrange			IV subrange		
	start	middle	end	start	middle	end	start	middle	end	start	middle	end
f, Hz												
U_{out}, V												

For task 2.6., students have to fill in a report and draw graphics using data in tables 1÷4. The reports should contain conclusions for all tasks.

4. Control questions:

4.1. What are the technical requirements for signal generators used for measurement?

4.2. Point some generator output devices used for different frequency ranges?

4.3. Are you able to draw basic LC generator circuits?