PRACTICE LAB 3-3

MEASUREMENT OF FREQUENCIES AND TIME INTERVALS

The purpose of this practice is students to get familiar with methodologies of low and high frequency measurements and to acquire skills for accuracy check.

1. **Theoretical introduction**.

The signal frequency is one of the main signal parameters, characterizing an electric harmonic process, and it is defined by the number of periods over sample of time (most often it is related to one second). In human industrial practice, the frequency domain is extremely huge starting from 10^{-4} Hz leveraging to up to 10^{15} Hz. The contemporary measurement equipment has accuracy equal approximately to 10^{-10}. This high accuracy is the key for different kinds of signal parameters measurements, conducted after their conversion to frequency.

The main methods of frequency measurements are:

- low frequency measurements – methods of acoustic vibes (акустични биения) comparisons, method of CRT (Cathode Ray Tube), method of capacitor recharge, absolute method (counting method);
- high frequency measurements – methods of comparison, capacitor method, method of the heterodyne, absolute method;
- superhigh frequency measurements – resonance method.

For the low and for the high frequencies the methods are similar. The absolute method is performed by electronic digital frequency counter (device example is „Ч3-XX“).

The capacitor reload method.

The principle of this method is represented in figure 1. There, the signal with unknown frequency f_x switches the electronic key, who’s function is to switch between positions 1 and 2. This leads to capacitor inclusion and exclusion from the one of the two electric current circuits. Inclusion and exclusions lead to charging and discharging the capacitor form voltage source E_{stab} respectively. For the time of the first semi period of the unknown frequency f_x, the capacitor C is charged by the source E_{stab} through the resistance R_{charg} , and for the second semi period, C is discharged through resistance R_{disch} and Current measurer (galvanometer) G. The capacitor charging constant $\tau_{charg} = R_{charg}.C$ and the discharging constant $\tau_{disch} = (R_{disch} + R_G).C$ are chosen extremely small in comparison with the semi period of the highest measured frequency. The value of momentum current is calculated by:

$$i = \frac{E_{stab}}{R_{disch} + R_G} e^{-\frac{t}{\tau_{disch}}} \approx \frac{E_{stab}}{R_{disch}} e^{-\frac{t}{\tau_{disch}}}$$

Nevertheless, the Current measurer G reacts only on Current mean value $I_{mean}=I_0$ for which we have:

$$I_{mean} = \frac{1}{T}\int_0^T i.dt = f_x.E_{stab}.C\left(1 - e^{-\frac{T}{\tau_{disch}}}\right) \approx f_x.E_{stab}.C,$$

where $e^{-\frac{T}{\tau_{disch}}} \approx 0$ since $T>>\tau_{disch}$ and $T = \frac{1}{f_x}$ is the period of the measured frequency.

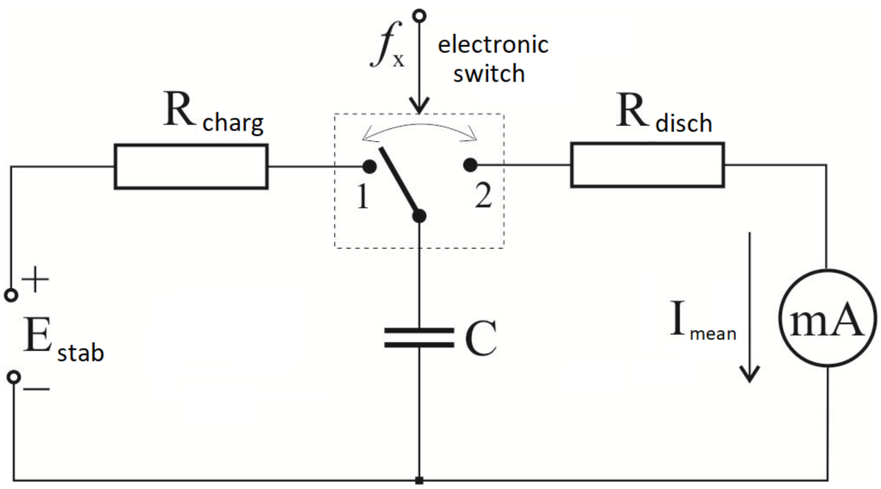

Fig. 1

If the product $E_{stab}.C$ is a constant value, indications on G will be proportional to the measured frequency f_x and its scale can be marked as drawn sector lines, but taken in mind a transfer coefficient K_F :

$$K_F = \frac{F_{max}}{N_{max}}, \; [Hz/sector] \quad \Rightarrow \quad f_x = K_F N \quad ,$$

where N is the number of drawn sector lines.

A block-scheme of an electronic digital frequency counter, working on the principle of capacitor charge is depicted on figure 2.

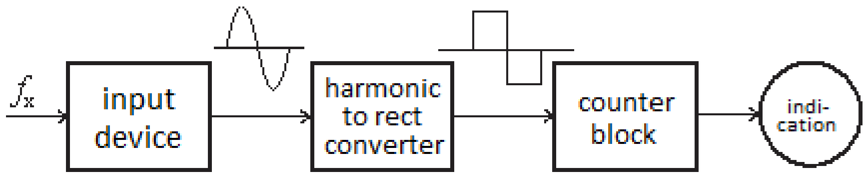

Fig. 2

2. asdasd

3. asd

4. asd

5. asd

6. asd