T3: Measurements with a digital instruments

**1. Introduction**

Digital instruments are characterized by a number of beneficial properties comparing to analog devices, including:

- great readability, because there is no reading error (parallax)

- high speed of measurement

- usually more accuracy

- low price of popular instruments,

- the ability to automate measurements - many instruments are equipped with an interface.

The digital device is equipped with the display field with n decimal positions. It is a rule that more accurate instruments have more displays (digital indicators) in the reading field.

2. Ways to record the accuracy of digital instruments

The accuracy of the digital device, specifying its limit error, can be represented by an expression with two components:

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| --- |
| ±(a% measuring value + b digits) |

The first component represents the so-called analog component of error with relative value a%, second - the digital component of the error is an absolute value. Depending on the needs, the expression is used to calculate the absolute value of the limit error or its relative value.

How to understand the component "b digits"? This is the value resulting from the multiplication of b times the resolution of the digital instrument - ΔrX, i.e.

|  |
| --- |
| b digits ≡ b ΔrX |

Resolution is a feature of all instruments and determines their ability to distinguish between close values of the measured quantity. For digital devices the resolution is determined by the value of the unit (quantum) of the measured quantity, indicated by the last read-out field indicator. For multi-range instruments, the resolution depends on the measuring range on which the measurement is performed:i.e. for reading 126,6V the device has a resolution ΔrU=0,1V;

for reading 75,36mV the device has a resolution ΔrU = 0,01mV = 10μV.

It is a rule that the smaller the measurement range, the "higher" the resolution (the smaller the value is distinguished).

The maximum permissible error expressed in absolute value is calculated from the dependence:



The maximum permissible error expressed by the relative value (percentage) is calculated from the dependence:



Example 1. Accuracy of the instrument is shown by the dependence: 0.5% Ux + 2 digits. The measurement was carried out on the 2,000V measuring range; the reading was Ux = 1.658V. Give the boundary errors of the device in this measurement.

For the measurement made, the resolution was , , therefore:



The second way of recording the error of the digital device presents the expression:

|  |
| --- |
| ± (a% reading + c % range) |

Therefore, calculation formulas for maximum permissible errors have the form

- for absolute value 

- for relative value 

It is worth noting that in the measurement of values close to the range in the boundary error, the analog component dominates, while in measurements of small values in relation to the range, the digital component of the error prevails. Hence, as in analog instruments, the measurements should be made with the fullest "filling in" of the reading field. In other words, the selection of the proper measuring range of a digital instrument is just as important as in analog instruments.

**Example 2.** The accuracy of the device is represented by: ****.

The reading was 102.3 mV and was made on the 200mV range.

Absolute and relative error errors are:



3. Technique of measuring with digital devices

It does not deviate from measurements with analogue devices. Before switching the voltmeter on to the circuit with the measured voltage:

- turn on the voltmeter to the network and wait a few minutes to "warm up" the device (electronic instruments get their full efficiency after a few or several minutes from the moment of switching on)

- then check the "electrical zero" of the voltmeter.

The check consists in shorting the input, setting the DC voltage measurement function and switching on the most sensitive measuring range. If after this the indication is not zero, then it should be brought to zero using the potentiometer available on the front panel.

After determining the full efficiency of the device, the appropriate settings of switches should be made, including

- select the measuring function (measured quantity),

- choose the appropriate measuring range,

- select other measuring functions (they are different for different types of digital instruments).

After these operations, you can turn on the voltmeter to the circuit under test and after reading the indications, make a reading.

Exercise program

* learn about the properties of the instruments available on laboratory stand,
* make a list of used instruments,
* measure the voltage of the sources indicated by the lecturer,
* calculate measurement results.

Tab. 1. Voltage measurement from source: , type ...........................

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| --- | --- | --- | --- | --- | --- | --- | --- |
| Instrument type | Readings | | | | Measurement result | | comments |
| Un  V | U  V | Instrument error formula | ΔrU  V | U ± U(U), p=...  V | Ur(U)  % |
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**5. Example of measurement result calculation**

The DT-380 digital multimeter was used to measure the current at the measuring range of 200mA, obtaining a reading of 126.5mA. The accuracy of the meter was expressed as. Calculate the measurement result taking into account the measurement uncertainty at the confidence level p = 0.95

* absolute error 
* standard uncertainty 
* extended uncertainty 
* measurement result ****
* relative uncertainty 