

**Izražanje lastnosti vzorčevalnih osciloskopov**

Expression of the properties of sampling oscilloscopes

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Expression des qualités des oscillographes  
à échantillonnage

Expression of the properties of sampling  
oscilloscopes  
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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**EXPRESSION OF THE PROPERTIES OF SAMPLING OSCILLOSCOPES**

FOREWORD

- 1) The formal decisions or agreements of the IEC on technical matters, prepared by Technical Committees on which all the National Committees having a special interest therein are represented, express, as nearly as possible, an international consensus of opinion on the subjects dealt with.
- 2) They have the form of recommendations for international use and they are accepted by the National Committees in that sense.
- 3) In order to promote international unification, the IEC expresses the wish that all National Committees should adopt the text of the IEC recommendation for their national rules in so far as national conditions will permit. Any divergence between the IEC recommendation and the corresponding national rules should, as far as possible, be clearly indicated in the latter.

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PREFACE

This standard has been prepared by Sub-Committee 66B, Oscilloscopes, of IEC Technical Committee No. 66, Electronic Measuring Equipment. [SIST IEC 60548:2005](https://standards.iteh.ai/catalog/standards/sist/92b3802e-0324-428e-95f6-d01e6a31aa/sist-iec-60548-2005)

A first draft was discussed at the meeting held in Baden-Baden in 1972. As a result of this meeting, a draft, Document 66B(Central Office)5, was submitted to the National Committees for approval under the Six Months' Rule in March 1972. Amendments, Document 66B(Central Office)11, were submitted to the National Committees for approval under the Two Months' Procedure in April 1975.

The following countries voted explicitly in favour of publication:

Belgium	Japan
Brazil	Netherlands
Canada	Poland
Czechoslovakia	Sweden
Denmark	Switzerland
Finland	Turkey
France	Union of Soviet Socialist Republics
Hungary	United States of America
Israel	
Italy	

*Other IEC publications quoted in this standard:*

Publications Nos. 106: Recommended Methods of Measurement of Radiated and Conducted Interference from Receivers for Amplitude-modulation, Frequency-modulation and Television Broadcast Transmissions.

348: Safety Requirements for Electronic Measuring Apparatus.

351-1: Expression of the Properties of Cathode-ray Oscilloscopes, Part 1: General.

359: Expression of the Functional Performance of Electronic Measuring Equipment.

## EXPRESSION OF THE PROPERTIES OF SAMPLING OSCILLOSCOPES

### 1. Scope

1.1 This standard applies to equivalent-time sampling oscilloscopes for measuring electrical quantities.

*Note.* — At lower sweep rates some equivalent-time sampling oscilloscopes may operate in a real-time sampling mode.

1.2 This standard is also applicable to:

- multi-trace sampling oscilloscopes when they comply with Sub-clause 1.1;
- complete assemblies comprising sampling oscilloscopes with detachable or incorporated parts, e.g. probes or interchangeable plug-in units.

1.3 This standard applies also to oscilloscopes for measuring non-electrical quantities when it is possible to express their performance in terms of an electrical quantity which represents the non-electrical quantity.

1.4 This standard is concerned with the qualities of the cathode-ray tubes only when these are necessary for the evaluation of oscilloscopes. The intrinsic qualities of cathode-ray tubes will be dealt with in another standard.

1.5 Some portions of this standard may be applicable by special agreement between manufacturer and user, to the other types of sampling oscilloscopes, for instance, real-time sampling oscilloscopes or those using digital displays or programmable units.

### 2. Object

The object of this standard is the standardization of methods of expression of the properties of sampling oscilloscopes and more particularly:

- the definition of special terminology and catalogue data related to these types of apparatus;
- the specification of conditions and methods for testing these types of apparatus in order to verify their compliance with properties claimed or specified by the manufacturer.

2.1 Safety requirements are not dealt with in this standard. Unless otherwise agreed upon, devices such as those in Clause 1 shall comply with IEC Publication 348, Safety Requirements for Electronic Measuring Apparatus.

## SECTION ONE — DEFINITIONS

For the purpose of this standard, it has been agreed that the special meanings contained in the following clauses shall apply. Definitions taken from the International Electrotechnical Vocabulary are shown by the reference I.E.V.

### 3. Types of oscilloscopes

#### 3.1 Cathode-ray oscilloscope

An apparatus for measurement or observation purposes which uses the deflection of one or more electron beams to produce a display which represents the instantaneous value of functions of varying quantities, one of them in general being time.

#### 3.2 Sampling oscilloscope

An oscilloscope which employs signal sampling together with means for constructing a coherent display from the samples taken.

*Note.* — Sampling oscilloscopes may use sequential sampling or random sampling (see Sub-clauses 4.2 and 4.3) and the display may be represented in equivalent time or in real time (see Sub-clauses 4.4 and 4.5).

#### 3.3 X-Y sampling oscilloscope

A sampling oscilloscope in which two components of a phenomenon are sampled by two channels; the first determines the vertical deflection of the dots, the other the horizontal deflection.

### 4. Terms fundamental to the sampling process

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#### 4.1 Sampling

A process of sensing and storing one or more instantaneous values of a signal for further processing or display.

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#### 4.2 Sequential sampling

A sampling process in which samples are taken at successively later (or earlier, according to the process involved) times relative to the trigger recognition point (see Sub-clause 7.6).

#### 4.3 Random sampling

A sampling process allowing a significant time-interval uncertainty between the signal and sample-taking operation. Also the process of coherent display construction from such randomly taken samples.

#### 4.4 Equivalent-time sampling

A sampling process in which no more than one sample is taken during one occurrence of that portion of the input signal which is to be displayed. The real duration of the sweep is equal to the time required for several repetitions of the input signal.

#### 4.5 Equivalent-time sampling display

A display constructed by means of equivalent-time sampling.

#### 4.6 Equivalent-time

The time scale associated with a display constructed by an equivalent-time sampling process.



#### 4.7 *Real-time sampling*

A sampling process in which more than one sample is taken during each occurrence of that portion of the input signal which is to be displayed. The real duration of the sweep is equal to the real duration of that portion of the input signal.

#### 4.8 *Real time*

The time scale associated with a display constructed by a real-time sampling process.

#### 4.9 *Sample*

That part of the input signal which is taken during the operation of the sampling gate (see Sub-clause 6.3).

#### 4.10 *Feed-through sampler*

A signal-path configuration in which the input signal is conducted past the sampling gate to be made available for further use or external termination.

#### 4.11 *Sample distribution*

In a random sampling oscilloscope, a mathematical function of equivalent time which describes how the density of randomly placed samples varies along the trace.

#### 4.12 *Probability distribution of samples*

The average number of samples that fall left of a chosen point on the equivalent time axis, divided by the total average number of samples, both being averaged for the same length of real time.

*Note.* — The probability distribution of samples is a function of the equivalent time; it starts from zero, ends at unity and has only positive or zero slopes.

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#### 4.13 *Probability density of samples*

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The average number of samples falling within a relatively narrow (in comparison with the length of equivalent time for which it is averaged) equivalent-time interval, divided by the total average number of samples, both being averaged for the same length of real time.

*Note.* — The probability density of samples generally depends on where the chosen narrow interval lies on the equivalent-time axis and is, therefore, a function of the equivalent time. Mathematically, it is the derivative of the probability distribution function, and the area under the curve is equal to unity.

#### 4.14 *Dot transient response*

The ability of a sampling oscilloscope to display a change in two successively sampled values of the input signal.

*Note.* — Dot transient response depends on smoothing (see Sub-clause 6.13).

### 5. **Cathode-ray tube**

#### 5.1 *Cathode-ray tube*

An electron-beam tube in which the beam can be focused to a small cross-section on a surface and varied in position and intensity to produce a pattern either visible or otherwise detectable (I.E.V. 07-30-090).

## 5.2 Cathode-ray tube size

The overall dimension of the face of the cathode-ray tube (external diameter of tubes with a circular face, the height and width of tubes having a rectangular face).

## 5.3 Screen

The surface of the tube upon which the visible pattern is produced (I.E.V. 07-30-145).

## 5.4 Spot

The small area of the screen surface instantaneously affected by the impact of the electron beam (I.E.V. 07-30-160).

## 5.5 Spot size and focus

*Under consideration.*

## 5.6 Measuring area

That part of the screen within which measurements can be made with defined accuracy.

*Note.* — This is not necessarily the whole screen area within which a display can be obtained.

## 6. Terms related to the sampling loop

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### a) Terms related to sampling loop techniques

#### 6.1 Feedback sampler

A sampling system employing a feedback sampling loop.

#### 6.2 Sampling loop

The feedback system which is established to improve linearity and accuracy by operating the sampling gate as a null detector.

*Note.* — The sampling loop, in general, will consist of those items defined in Sub-clauses 6.3, 6.4, 6.5, 6.6, 6.7 and 6.8.

#### 6.3 Sampling gate

A switch, usually electronic, which operates briefly upon command for the purpose of sampling the input signal.

#### 6.4 Balanced sampling gate

A type of sampling gate arranged symmetrically so that the strobe signals are balanced.

#### 6.5 Forward attenuator

A circuit which determines forward gain and is normally ganged with the feedback attenuator.

#### 6.6 Sample-and-hold gate

A switch, usually electronic, between a sample-and-hold circuit and its driving amplifier.

### 6.7. *Sample-and-hold circuit*

A circuit which stores the vertical (or horizontal) co-ordinate value of a sample.

### 6.8. *Feedback attenuator*

A circuit which determines attenuation of the feedback signal in the sampling loop.

#### b) *Terms relating to sampling loop performance*

### 6.9. *Loop gain*

The product of sampling gate efficiency, forward gain and feedback attenuation.

### 6.10. *Forward gain*

The effective gain between the sampling gate output and the sample-and-hold output.

### 6.11. *Feedback attenuation*

In a sampling loop, the effective attenuation in the signal path between sample-and-hold output and sampling gate.

### 6.12. *Sampling gate efficiency*

The ratio of the gate output voltage change between the instant before sampling ( $t^-$ ) and the instant after sampling ( $t^+$ ) to the difference between the gate input voltage ( $E_i$ ) and gate output voltage ( $E_o$ ) at the instant before sampling ( $t^-$ ) expressed as a percentage.

$$\text{Sampling gate efficiency} = \frac{E_o(t^+) - E_o(t^-)}{E_i(t^-) - E_o(t^-)} \times 100\%$$

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### 6.13. *Smoothing*

A process affecting dot transient response wherein sampling loop gain is purposely made to be less than unity in order to reduce the effects of random noise and horizontal jitter.

## 7. **Terms related to the slewing process** (see Figure 1, page 92)

### 7.1. *Slewing*

The process of causing successive samples to be taken at different instants relative to the trigger recognition point. This term also applies to sequential sampling and to random sampling.

### 7.2. *Scanning*

The process by which slewing is controlled.

*Note.* — The function performed is the association of the time function of the input signal with the horizontal position function of the spot. In an equivalent-time sampling oscilloscope, it is governed by the scanning signal.

### 7.3. *Scanning signal (scanning ramp, slow ramp)*

A staircase, ramp or other changing voltage which governs the horizontal deflection of the spot and directly or proportionately interacts with the slewing ramp.

7.4 *Slewing ramp (fast ramp)*

A linear ramp which interacts with the scanning signal to cause slewing.

7.5 *Trigger recognition*

The process of responding to a suitable triggering signal (see Sub-clause 14.6 and Figure 1, page 92).

7.6 *Trigger recognition point*

The point in time at which trigger recognition occurs, also that point on a display waveform representing the instant of trigger recognition (see Sub-clause 14.6).

7.7 *Sampling command*

A general term relating to a trigger or other electrical signal intended to cause sampling.

7.8 *Strobe*

A pulse of short duration which directly operates the sampling gate.

7.9 *Slewing interval*

The particular equivalent-time interval over which the scanning signal allows sampling to occur.

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8. Terms related to the presentation of the display

8.1 *Dot*

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A spot, the position of which indicates the horizontal and vertical co-ordinates of a particular sample.

8.2 *Dot density*

The number of dots per centimetre without input signal.

8.3 *Coherent display*

A display in which the time function of the input signal is preserved. A coherent display may be produced by either random or sequential sampling.

8.4 *False display*

A sampling display allowing faulty or ambiguous interpretation, usually caused by insufficient dot density, improper triggering, or improper setting of the controls.

8.5 *Magnified display (expanded display)*

When associated with sweep timing or horizontal deflection, a display whose time per division has been decreased. Usually produced either by attenuation of the scanning signal or by amplification of the horizontal deflection signal.

8.6 *Display window*

The equivalent-time interval represented within the limits of the rated horizontal deflection.

### 8.7 Time positioning

The process of moving the display window by, for example, offsetting the d.c. level of the scanning signal or of the slewing ramp.

### 8.8 Time position range

The equivalent-time interval over which the display window can be moved by time positioning.

## 9. General terms concerning waveform

### 9.1 Departures from a sinewave

The distortion of a sinewave is defined by its crest factor and/or by limits  $\beta$  defined by the formula:

$$y = a(1 - \beta) \sin \omega t < y < a(1 + \beta) \sin \omega t$$

*Note.* — When the value assigned to the quantity  $\beta$  is especially significant, it is necessary, in addition, to establish a limit for the difference between the peak value and  $\sqrt{2}$  times the r.m.s. value.

### 9.2 Square wave

A periodic wave that alternately assumes two fixed values for equal lengths of time, the time of transition being negligible in comparison with the half-length (I.E.V. 55-35-090).

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### 9.3 Rectangular pulse

A waveform having a profile approximately rectangular, the rise and fall times being sufficiently short in comparison with the pulse duration (from I.E.V. 55-35-085).

## 10. Terms concerning preparation of tests

### 10.1 Warm-up time

The time interval after switching on the oscilloscope under reference conditions necessary for it to comply with all accuracy requirements.

### 10.2 Adjustment

The operation by means of which certain adjusting parts are set according to the manufacturer's directions, so as to cause the oscilloscope to conform with the specified accuracy.

*Note.* — This process is termed *preliminary adjustment* when it is carried out before tests, and *readjustment* during tests.

With oscilloscopes having built-in calibrating devices, calibration may form a part of preliminary adjustments.

### 10.3 Centring

The process by which the spot (or the base line drawn by the spot) is adjusted to a definite place on the screen.

## 11. Terms related to accuracy

a) *Quantities related to the function of the oscilloscope and terms related to conditions of operation, transport and storage*

### 11.1 *Performance characteristic*

One of the quantities assigned to an oscilloscope in order to define by values, tolerances, ranges, etc., the performance of the oscilloscope.

*Note.* — The term “performance characteristic” does not include influence quantities (see Note to Sub-clause 11.2).

### 11.2 *Influence quantity*

Any quantity, generally external to an oscilloscope, which may affect the performance of the oscilloscope.

*Note.* — Where a change in a performance characteristic affects another performance characteristic, it is referred to as an *influencing characteristic* (see Sub-clause 11.23).

### 11.3 *Reference value*

A single value of an influence quantity at which the oscilloscope (or accessory) complies with the requirements concerning intrinsic errors.

### 11.4 *Reference range*

A range of values of an influence quantity within which the oscilloscope (or accessory) complies with the requirements concerning intrinsic errors.

### 11.5 *Reference conditions*

A set of values with tolerances (reference values), or of restricted ranges (reference ranges) of influence quantities and, if necessary, of influencing characteristics, specified for making comparison and calibration tests.

### 11.6 *Rated range of use*

The range of values for an influence quantity within which the requirements concerning operating error are satisfied.

### 11.7 *Rated operating conditions*

The whole of the effective ranges for performance characteristics and rated ranges of use for influence quantities within which the performance of the apparatus is specified.

### 11.8 *Limit conditions of operation*

The whole of the ranges of values for influence quantities and performance characteristics (beyond the rated ranges of use and effective ranges respectively) within which an apparatus can function without resulting damage or degradation of performance when it is afterwards operated under rated operating conditions.

*Note.* — These limit conditions will, in general, include overload.

### 11.9 *Conditions of storage and transport*

The whole of the conditions of temperature, humidity, air pressure, vibration, shock, etc., within which the apparatus may be stored or transported in an inoperative condition, without resulting damage or degradation of performance when it is afterwards operated under rated operating conditions.

b) *Values related to quantities*

11.10 *Rated value*

The value (or one of the values) of a quantity to be measured, observed, supplied or set, which the manufacturer has assigned to the oscilloscope.

11.11 *Rated vertical (horizontal) deflection*

Distance measured in the vertical (horizontal) direction between the limits of the measuring area.

11.12 *Rated range*

The range of a quantity to be measured, observed, supplied or set, which the manufacturer has assigned to the oscilloscope.

11.13 *Effective range*

That part of the rated range where measurements can be made or quantities be supplied within the stated limits of error (I.E.V. 20-40-035, modified).

c) *Terms related to the specification of performance*

11.14 *Performance*

The degree to which the intended functions of an oscilloscope are accomplished.

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*Errors*

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11.15 *Absolute error*

The error expressed algebraically, in the unit of the measured quantity.

a) For a measuring apparatus, the error is the indicated value of the measured quantity minus its true value.

b) For a supply apparatus, the error is the true value of the quantity supplied minus its rated, indicated or preset value.

*Notes 1.* — The *true value* of a quantity is the ideal value that would be measured by a measuring process having no error.

In practice, since this true value cannot be determined by measurement, a *conventionally true* value, approaching the true value as closely as necessary (having regard to the error to be determined), is used in place of the true value. This value may be traced to standards agreed upon by the manufacturer and the user, or to national standards. In both cases, the uncertainty of the conventionally true value shall be stated.

2. — The above definitions do not apply to deflection coefficients or time coefficients of an oscilloscope as these coefficients are neither measured nor supplied quantities.

11.16 *Relative error*

The ratio of the absolute error to a stated value.

11.17 *Absolute error of a deflection (time) coefficient*

The difference between the measured value and the rated value of a deflection (time) coefficient.

*Note.* — The measured value of a coefficient is the value that is calculated from the deflection measured on the screen when a known signal is applied to input terminals.