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Method for

Expression of the properties of cathode-ray oscilloscopes —

Part 1: General

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- British Industrial Measuring and Control Apparatus Manufacturers Association
- Department of Industry (British Calibration Service)
- Department of Industry (National Physical Laboratory)
- Technical expert

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National foreword

This Part of this British Standard, published under the direction of the Electronic Equipment Standards Committee, is identical with IEC Publication 351-1 “*Expression of the properties of cathode-ray oscilloscopes. Part 1: General*” published in 1976 by the International Electrotechnical Commission (IEC).

This Part of BS 4739:1979, together with Part 2, is a revision of BS 4739:1971 “*Specification for the interpretation of the data relating to cathode ray oscilloscopes*”, which is to be withdrawn.

Part 2 of this standard is identical with IEC Publication 351-2 “*Expression of the properties of cathode-ray oscilloscopes. Part 2: Storage oscilloscopes*”.

Terminology and conventions. The text of the International Standard has been approved as suitable for publication, without deviation, as a British Standard. Some terminology and certain conventions are not identical with those used in British Standards; attention is especially drawn to the following.

In some places the unit symbols dB and min and their numerical values are printed in italic type instead of roman (upright) type as required by convention.

In **9.6.5** and **9.9.2**, under “Units”, “M Ω /pF” should be read as “M Ω and pF”; in **9.9.2**, under “Units”, where “ Ω /pF” occurs it should be read as “ Ω and pF”.

Scope. Clause 1 (General) of the International Standard is not presented in the way which is customary for the scope of a British Standard. Clause 1 should be read as the following, which makes no change in the technical meaning and is essentially a re-arrangement of the existing text.

This standard gives rules for the standardization of methods of expression of the properties of cathode-ray oscilloscopes and defines special terminology and catalogue data related to such apparatus. The conditions and methods for testing cathode-ray oscilloscopes are specified so that compliance with properties claimed or specified by the manufacturer of the apparatus may be verified.

Safety requirements are specified in IEC Publication 348:1979.

This standard is applicable to the following types of cathode-ray oscilloscope.

- a) General-purpose cathode-ray oscilloscopes (hereinafter called “oscilloscopes”) for measuring electrical quantities and containing
 - a cathode-ray tube,
 - a vertical deflection device, and
 - a time base and/or a horizontal deflection device.
- b) Multitrace oscilloscopes as defined in **2.1.4** and containing all three items listed in a).
- c) Complete assemblies of oscilloscopes with detachable or incorporated parts, e.g. probes or interchangeable plug-in units.
- d) 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.

This standard is concerned with the qualities of cathode-ray tubes only when these are necessary for the evaluation of oscilloscopes. The intrinsic qualities of cathode-ray tubes are not the subject of this standard.

By special agreement between the manufacturer and the user some portions of this standard may be regarded as applicable to observation or special-purpose oscilloscopes, e.g. sampling oscilloscopes (see also BS 5788:1979 “*Method for expression of the properties of sampling oscilloscopes*”), and also to characteristic curve tracers, vectorscopes, radial deflection oscilloscopes, and storage oscilloscopes (see also Part 2 of this standard); but this standard is not directly applicable to such units.

Cross-references

International Standard ^a	Corresponding British Standard
IEC 348:1979	BS 4743:1979 <i>Safety requirements of electronic measuring apparatus</i> (Identical)
IEC 359:1971	BS 4889:1973 <i>Method for specifying the performance of electronic measuring equipment</i> (Technically equivalent)

^a Undated in the text.

At present there is no corresponding British Standard for IEC 106:1974. The technical committee has reviewed the provisions of IEC 106:1974 and has decided that they are acceptable for use in conjunction with this standard.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 50, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 General

1.1 Scope

1.1.1 This standard applies to general-purpose cathode-ray oscilloscopes (hereinafter called “oscilloscopes”) for measuring electrical quantities, containing at least:

- a cathode-ray tube,
- a vertical deflection device,
- a time base and/or a horizontal deflection device.

1.1.2 This standard is also applicable to:

- multitrace oscilloscopes (Sub-clause **2.1.4**) when they comply with Sub-clause **1.1.1**,
- complete assemblies of oscilloscopes with detachable or incorporated parts, e.g. probes or interchangeable plug-in units.

1.1.3 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.

1.1.4 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.

1.1.5 Some portions of this standard may be applicable, by special agreement between manufacturer and user, to observation or special-purpose oscilloscopes, e.g.:

- sampling oscilloscopes,
- characteristic curve tracers,
- vectorscopes;
- radial deflection oscilloscopes,
- storage oscilloscopes.

1.1.6 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.

1.2 Object

The object of this standard is the standardization of methods of expression of the properties of cathode-ray 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 compliance with properties claimed or specified by the manufacturer.

2 Terminology

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 to I.E.V. Group 07 or 20.

2.1 Types of oscilloscopes

2.1.1

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

2.1.2

measuring oscilloscope

an oscilloscope which, by means of scales or calibrated switch positions associated with the controls of deflection and time coefficients, is suitable for measuring with defined accuracy

NOTE A measuring oscilloscope may, or may not, have built-in calibrating devices. It is further necessary to distinguish between oscilloscopes in which measurement is made by a calibrated graticule and oscilloscopes in which the graticule is not used directly, except as a means of referring to another calibrated control.

2.1.3

observation oscilloscope

an oscilloscope which is suitable only for the qualitative observations of varying quantities, being without defined accuracy

NOTE Some observation oscilloscopes have sufficient linearity and stability of performance to permit their use for measuring purposes after calibration by external means.

2.1.4

multitrace oscilloscope

an oscilloscope with which it is possible to measure or observe simultaneously several electrical phenomena, each phenomenon being displayed on a separate trace

NOTE This result may be obtained by:

- a tube with several guns (multi-beam),
- a tube with one divided beam (split-beam),
- one beam and electronic switching (displayed alternately or chopped),
- an oscilloscope with several tubes (multi-tube).

2.2 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).

2.2.1

cathode-ray tube size

the overall dimensions 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)

2.2.2

screen

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

2.2.3 Spot

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

2.2.3.1

spot size and focus

under consideration

2.2.4

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.

2.3 General terms

2.3.1 Amplifiers and attenuators

2.3.1.1

amplifier

the circuitry which provides amplification of the voltage applied to the input terminals to obtain a deflection or other function

2.3.1.2**attenuator**

a device which provides the attenuation of a voltage according to defined ratios

2.3.2 Accessory parts**2.3.2.1****plug-in unit**

a removable part of an oscilloscope, adapted by plug and socket connection to compose a set intended to perform a particular function

examples of plug-in units:

- high sensitivity amplifier,
- wide-band amplifier,
- difference amplifier,
- electronic beam switching.

2.3.2.2**probe**

an input device of an oscilloscope made as a separate unit and connected by a flexible cable which transmits, in a suitable manner, the measuring quantity to the oscilloscope

2.3.3 Terms concerning waveform**2.3.3.1****departures from a sine-wave**

the distortion of a sine-wave is defined by the difference between the peak value and/2 times the r.m.s. value and/or by limits as specified by value β of the formula:

$$y = a (1 \pm \beta) \sin \omega t$$

2.3.3.2**square wave**

a periodic wave that alternately for equal lengths of time assumes two fixed values, the time of transition being negligible in comparison with that length

2.3.3.3**rectangular pulse**

a waveform having a profile approximately rectangular, the rise and fall times being sufficiently short in comparison with the pulse duration

2.4 Terms concerning preparation of tests**2.4.1****warm-up time**

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

2.4.2**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.

2.4.3**centring**

the process by which the spot (or the base line drawn by the spot) is positioned to the centre of the screen

2.5 Terms related to accuracy

2.5.1 Quantities related to the function of the oscilloscope and terms related to conditions of operation, transport and storage

2.5.1.1

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 2.5.1.2).

2.5.1.2

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 2.5.3.5).

2.5.1.3

reference value

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

2.5.1.4

reference range

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

2.5.1.5

reference conditions

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

2.5.1.6

rated range of use

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

2.5.1.7

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

2.5.1.8

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 The limit conditions will, in general, include overload.

2.5.1.9

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

2.5.2 Values related to quantities

2.5.2.1 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.

2.5.2.1.1**rated vertical (horizontal) deflection**

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

2.5.2.2**rated range**

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

2.5.2.3**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)

2.5.3 Terms related to the specification of performance**2.5.3.1****performance**

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

2.5.3.2 Error**2.5.3.2.1****absolute error**

the error expressed algebraically, in the unit of the measured or supplied 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.

NOTE 1 The true value of a quantity is the 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.

NOTE 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.

2.5.3.2.2**relative error**

the ratio of the absolute error to a stated value

2.5.3.2.3**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.

2.5.3.2.4**relative error of a deflection (time) coefficient**

the ratio of the absolute error of a deflection (time) coefficient to the rated value

2.5.3.2.5**percentage error**

the relative error expressed as a percentage

2.5.3.2.6**relative linearity error of a coefficient**

relative linearity error of a coefficient is given by whichever of the following two expressions has the greater value without regard to sign:

$$\frac{K_a - K_b}{K_a} \text{ or } \frac{K_a - K_c}{K_a}$$

where:

- K_a = the average deflection coefficient measured over the central 80 % region of the rated deflection
- K_b and K_c = the average deflection coefficient for each of the two extreme 10 % regions of the rated deflection.

NOTE This definition of linearity is intended solely for oscilloscopes and takes account of the fact that departures from linearity are generally negligible in the central 80 % of the rated deflection but become significant in the extreme 10 % regions.

2.5.3.3**intrinsic error**

the error determined under reference conditions

2.5.3.4**operating error**

the error determined under rated operating conditions (Sub-clause 2.5.1.7)

2.5.3.5**influence error**

the error determined when one influence quantity assumes any value within its rated range of use (or an influencing performance characteristic assumes any value within its effective range), all others being at reference condition

NOTE When over the whole rated range of use a substantially linear relationship exists between the influence error and the effect causing it, the relationship may be conveniently expressed in coefficient form.

2.5.3.6**limits of error**

the maximum values of error assigned by the manufacturer to a measured or supplied quantity of an oscilloscope operating under specified conditions

2.5.3.7**limits of error of a deflection (time) coefficient**

the maximum values of error assigned by the manufacturer to a deflection (time) coefficient of an oscilloscope operating under specified conditions

2.5.4**variation**

the difference between the values of a measured or supplied quantity when one influence quantity assumes successively two specified values within its rated range of use, the others being at reference conditions

NOTE A variation may be considered as absolute or relative in the same way as an error.

2.6 Terms related to vertical (horizontal) deflection**2.6.1 Vertical (horizontal) deflection**

The deflection of the spot when a signal is applied to the vertical (horizontal) input, the horizontal (vertical) system being non-operative.

2.6.1.1**vertical (horizontal) deflection coefficient**

the ratio between the voltage and the length of vertical (horizontal) deflection produced by this voltage

NOTE Deflection coefficients are expressed in the dimension voltage (or current) per unit length, and a coefficient of 5 V/cm is larger than 5 mV/cm. This means, accordingly, that the sensitivity with a coefficient of 5 V/cm is smaller than with a coefficient of 5 mV/cm.

2.6.2 Instability of the spot position

This term comprises the following three phenomena which occur whether a signal is present or not.

2.6.2.1 drift

the (unwanted) generally slow and continuous deviation of the spot as a function of time

a) *Long-term drift*

Maximum deviation of the spot recorded during 1 h.

b) *Short-term drift*

Maximum deviation of the spot recorded during the most unfavourable minute within 1 h total recording.

NOTE Drift has, in general, vertical and horizontal components which can be measured separately, the values of the influence quantities being held constant in every case.

2.6.2.2 periodic and/or random deviations (PARD)

unwanted deflections of a periodic (hum, ripple, etc.) and/or random (noise, fluctuation, etc.) nature due to various causes and appearing on the screen in the absence of a signal or added to the display of an input signal

2.6.2.3 zero shift

the movement of the spot or of the trace without any signal due to the effect of a prescribed change in a specified influence quantity

NOTE The zero shift is generally not instantaneous. The maximum value of this shift shall be determined during a specified time interval.

2.6.3 Pulse and frequency responses

2.6.3.1 frequency response: – 3 dB bandwidth

band of frequencies within which the value of the reciprocal of the deflection coefficient does not differ by more than – 3 dB from its value at reference frequency

NOTE This definition does not take into account any rise or other irregularity in the frequency response between reference frequency and the – 3 dB points, as this would cause irregularities concerning pulse response defined in Sub-clauses 2.6.3.2, 2.6.3.3 and 2.6.3.4.

2.6.3.2 rise (fall) time

time interval within which the current or voltage of the edge of a rectangular pulse passes from 10 % to 90 % (from 90 % to 10 %) of its steady-state amplitude (Figure 1, page 32)

NOTE In the case of amplifiers having a proper pulse response, the following relationship between rise time (t_r), expressed in nanoseconds, and the upper limit of the – 3 dB bandwidth (B), expressed in megahertz, is approximately true:

$$t_r = \frac{350}{B}$$

2.6.3.3 overshoot

that part of the initial response which exceeds the steady-state value of the response to a rectangular (square) pulse (Figure 1). It is expressed as a percentage of the steady-state value

2.6.3.4 pulse tilt

the relative difference between the initial and final amplitude of the representation of a rectangular pulse (Figure 2a, page 33) or of a square wave (Figure 2b, page 33) ignoring overshoot and other distortions (see Sub-clause 2.6.3.2). It is expressed as a percentage of the initial amplitude and for a specified time period:

$$\text{pulse tilt} = \frac{\Delta A}{A} 100 \text{ (Figure 2a).}$$

NOTE When tests for pulse tilt are performed with a symmetrical square wave, the formula:

$$\text{pulse tilt} = \frac{\Delta A}{A} 100 \text{ (Figure 2b).}$$

may be used for convenience.

2.6.3.5

other pulse distortions

distortions other than those defined in Sub-clauses **2.6.3.2**, **2.6.3.3** and **2.6.3.4** are identified by the titles to Figure 3a to Figure 3g, pages 34 and 36; verbal descriptions are not given, as the diagrams are sufficient in themselves for the effects to be identified. These distortions may appear on the display either singly, in groups or combined, depending on the selected time coefficient

when these distortions have durations comparable to the rise time t_r , the diagrams show the rise time as having finite magnitude. Conversely, when the distortions can occupy time durations up to several orders of magnitude greater than the rise time, the diagrams show the rise time as zero. This is particularly so in the case of Figure 3g, Defect of sustained step response, when the effects are thermal in origin

2.6.4

positioning

the vertical or horizontal movement of the trace obtained by actuating the appropriate control

2.6.5

input impedance

the impedance measured between the input terminals of the oscilloscope

NOTE It is represented by the values of a resistor and a capacitor, connected in parallel, which produce an equivalent impedance.

2.6.6 Interaction between circuits of an oscilloscope

2.6.6.1

interaction between the circuits of a multitrace oscilloscope

the influence of the voltage at one input on the deflection of a beam which is normally intended to display the voltage of another input

2.6.6.2

interaction between x and y signals

under consideration

2.6.6.3

decoupling factor

quantity defining the suppression of interaction between any two channels of an oscilloscope. It is the ratio between the unwanted deflection coefficient (i.e. the ratio between the amplitude of the signal of the disturbing channel to the unwanted deflection at the other channel) and the deflection coefficient of the disturbed channel

NOTE The size of the decoupling factor is, therefore, in inverse ratio to the size of the disturbance. Decoupling factor is a number larger than 1. This means, accordingly, that the interaction corresponding to a factor of 10 000 is smaller than that corresponding to a factor of 1 000.

To simplify the interpretation of this definition, the following example is given: if the two channels are numbered 1 and 2, and have individual deflection coefficients of x V/cm and y V/cm respectively, then if channel No. 1 is considered as being the disturbing one and the magnitude of the display on trace No. 1 is A cm and if the magnitude of the display on trace No. 2 is B cm, the decoupling factor is given by the expression:

$$\frac{Ax}{By}$$

where normally $x > y$ and $A > B$.

2.6.6.4

phase difference between displays of a multitrace oscilloscope

phase difference (unwanted) observed between any two displays of a multitrace oscilloscope when the same signal is applied to both inputs

NOTE 1 This difference may result from:

- different phase angle of the amplifiers,
- different linearity errors of the separate time bases,
- different geometrical structures of deflection plates.

NOTE 2 For test purposes, it is convenient to measure the phase difference in terms of time by applying the same pulse signal to both inputs.

2.6.6.5**common-mode rejection factor for difference amplifiers**

relation between the deflection coefficient determined when a voltage is applied between the input terminals of the deflection circuit and the deflection coefficient determined when a voltage is applied between the input terminals, joined together, and the earth terminal of the oscilloscope

NOTE The common-mode rejection factor is a measure of the ability of a circuit to reject interference and its size is, therefore, in inverse ratio to the size of the disturbance. Common-mode rejection factor is a number larger than 1, and a common-mode rejection factor of 10 000 is larger than 1 000. This means, accordingly, that the interaction with a common-mode rejection factor of 10 000 is smaller than with a common-mode rejection factor of 1 000.

2.6.7 Delay line

A transmission line having distributed or lumped constants intended to delay the signal.

NOTE The value of the delay is such that its duration is sufficient to allow the sweep to start and the spot to be unblanked before the signal is displayed.

2.6.7.1**apparent signal delay**

the time which elapses between the moment of the appearance of the sweep and the moment when the signal trace reaches 10 % of the final amplitude

NOTE The apparent signal delay is not to be mistaken for the actual signal delay which is the time elapsing between the application of a signal voltage at the input of the oscilloscope and the time of the appearance of the signal display on the screen.

2.6.8**switching rate (of multitrace oscilloscopes or associated plug-in units)**

the repetition frequency of the switching processes in oscilloscopes or associated plug-in units which employ electronic beam switching to produce multitrace displays. This frequency may have a fixed or adjustable value (chopped display) or may be controlled by the repetition rate of the time base and triggering (alternate display)

2.7 Terms related to the time base**2.7.1 Time base**

The circuitry by which a spot displacement depending upon time is obtained.

NOTE The term "sweep" is reserved for the spot displacement produced by the time base.

2.7.1.1**free running time base**

a time base running periodically, even in the absence of a signal

NOTE A free running time base may be synchronized either externally or internally.

2.7.1.2**triggered time base**

a time base which, for each single sweep, is initiated by a trigger pulse. The repetition rate is not necessarily periodic

NOTE In this mode, any value of time coefficient can be chosen independently of the period of the observed quantity, and without affecting the stability of the display.

2.7.1.3**single sweep operation**

the operation of a time base in which one sweep only is triggered. Further sweeps are prevented until the sweep circuits have been externally reset

2.7.1.4**hold-off circuit**

a circuit incorporated in the time base which prevents the sweep from being re-triggered until the spot has returned to its rest position and the circuit elements have completely relaxed

2.7.1.5**delayed sweep**

a sweep which is started after a defined interval of delay following a triggering pulse

2.7.1.6**delaying sweep**

a sweep produced by one time base of an oscilloscope when it is used to delay the start of another sweep (delayed sweep) produced by a second time base

2.7.1.7

delayed sweep operation

an oscilloscope function involving both a delaying sweep and a delayed sweep

NOTE A common use of delayed sweep operation follows the normal display of a signal using a particular time base. A special circuit enables the delayed sweep to be started at any (adjustable) point in time during the sweep of the first time base. A change in the operating mode of the time base then enables the signal to be displayed on a time scale, provided by the delayed sweep which may well have a much smaller sweep coefficient.

2.7.1.8

spot unblanking (or bright-up)

the process by which the spot is kept visible during the sweep time only and is suppressed during flyback and the rest time

NOTE Suppression may be achieved by beam current cut-off or by deflecting the spot off the screen.

2.7.1.9

brightness

under consideration

2.7.1.10

luminance

under consideration

2.7.1.11

information writing speed

the display characteristic which is an indication of the maximum number of trace widths per second that can be photographically recorded and identified

2.7.2

time coefficient

the ratio between the time and the length of spot displacement, produced by the time base, occurring during this time

NOTE Time coefficients are expressed in the dimension time per unit length. This means, accordingly, that a sweep with a coefficient of 2 s/cm is slower than with a coefficient of 2 ms/cm.

2.7.3

expansion (or magnification)

the process enabling the sweep to be increased in such a manner that a part of the display can be expanded so as to cover the whole rated horizontal deflection

NOTE In general, this expansion is obtained by increasing the gain of the horizontal amplifier. The display will normally need to be recentred.

2.8 Terms related to display stabilization

2.8.1

display stabilization

the process by which the sweep is made dependent on the observed phenomenon or on another related phenomenon, so as to bring the display to a standstill

2.8.2 Modes of stabilization

2.8.2.1

synchronized sweep

a recurrent sweep synchronized so as to maintain the sweep period equal to a period or multiple of the period of the observed quantity

NOTE Synchronization is normally maintained for small changes in the period of the observed quantity.

2.8.2.2

triggered sweep

the mode of operation of a triggered time base in which the beginning of every sweep coincides with a predetermined point of the displayed quantity, thus producing a stable display on the screen

NOTE In triggered sweep modes, the internal trigger pulse can be produced corresponding to any predetermined level of the signal on either negative or positive going slopes.

2.8.2.3**internal synchronization (or triggering)**

the synchronization (triggering) obtained when the signal which controls the time base is supplied by an internal circuit affected by the observed quantity

2.8.2.4**external synchronization (or triggering)**

the synchronization (or triggering) obtained when the signal which controls the time base is applied externally and independently of the internal circuit affected by the observed quantity

2.8.3**synchronization (or triggering) frequency range**

the frequency range for which the internal or external synchronization (or triggering) circuits permit a stable display to be obtained

2.8.4**synchronization or triggering threshold**

the minimum value of the synchronizing or trigger signal (external) or the minimum value of the vertical deflection (internal) which is necessary to obtain a stable display

2.8.5**time base jitter**

an (unwanted) fluctuation in the position of the display or a part of it, in a direction parallel to the sweep

NOTE This fluctuation may result from:

- a) an unwanted change in the trigger delay;
- b) an unwanted modulation of the spot velocity.

2.9 Miscellaneous**2.9.1 Geometry and orthogonality errors and phase difference****2.9.1.1****geometry distortion**

a distortion appearing as a deformation of the boundary of a display, as related to the limits of the measuring area. The distortion shall be contained between the limits of the measuring area and a concentric rectangle of which the dimensions are given by the manufacturer

2.9.1.2**orthogonality error**

the complement to 90 degrees of the angle formed by a vertical and a horizontal trace, measured at the centre of the measuring area

2.9.1.3**parallelism error of multitrace oscilloscopes**

with cathode-ray tubes having at least two completely separated deflection systems, it is the angle between two horizontal axes and between two vertical axes measured at the centre of the measuring area

2.9.1.4**phase difference between vertical and horizontal axes**

difference in the phase response of the vertical and horizontal deflection circuits of an oscilloscope, resulting in a departure from a purely straight line display when a sinusoidal wave is applied simultaneously to these circuits

2.9.2**direct connections to tube**

method of connection from the outside of the oscilloscope to the vertical (horizontal) deflection plates or to the electrode intended for intensity modulation

2.9.3**windowing facilities**

under consideration

3 General test requirements

3.1 General

3.1.1 Statement of limits of errors

3.1.1.1 Limits of operating error (which apply under rated operating conditions) shall be stated.

3.1.1.2 Limits of intrinsic error (which apply under reference conditions) may be stated. In the absence of a statement, they are considered to be equal to the limits of the operating error.

3.1.1.3 Limits of influence error may be stated. It is particularly useful to state these limits when one influence quantity or influencing characteristic causes an important part of the operating error. It may also be of interest to state that certain environmental conditions do not contribute to the operating error.

3.1.1.4 Limits of variation may be stated when this standard explicitly permits it.

3.1.2 Performance characteristics and performances to be verified

The tests described in this standard are to be performed in order to verify compliance with the manufacturer's stated data. These tests apply to:

- vertical and horizontal deflection coefficients (Clause 5),
- time coefficients (Clause 6),
- display stabilization (Clause 7),
- other miscellaneous qualities (Clause 8).

The clauses specify the conditions under which tests shall be performed, such as values of influence quantities, voltages to be used, switch positions of amplifiers, attenuators, etc., as well as whether these tests are mandatory or not. Recommended test methods for the determination of errors in deflection and time coefficients and for determining the displacement of the display form the object of Appendix A and Appendix B.

3.2 Combinations of an oscilloscope with different accessories

3.2.1 When an oscilloscope can take one or more plug-in devices, the assembly comprising the given plug-in devices and the oscilloscope itself is considered as a whole and shall comply with the relevant requirements for errors and variations, as stated in the following clauses. When another plug-in device is substituted, the new assembly shall also comply with the relevant requirements for errors and variations.

NOTE Plug-in devices for special purposes, such as curve tracers, etc., are subject to a special agreement between manufacturer and user.

3.2.2 When an oscilloscope is supplied with a probe, the combination of oscilloscope and probe shall comply with all requirements stated in the following clauses.

When probes are supplied as separate items and are intended to be used in combination with various types of oscilloscopes, separate specifications for the probes and for the oscilloscopes are required, and these specifications should define the properties of any combination of probe and oscilloscope recommended by the manufacturer.

3.3 Reference waveforms

3.3.1 Reference sine-waves

The following sinusoidal waves are used, generally at reference frequency, for test purposes.

- a) A sine-wave for which the coefficient β , as defined in Sub-clause **2.3.3.1**, is equal to 0.01.
- b) A sine-wave for which the coefficient β , as defined in Sub-clause **2.3.3.1**, is equal to 0.05 but having a peak value not differing by more than 1 % from $\sqrt{2} \times$ the r.m.s. value.
- c) A sine-wave for which the coefficient β , as defined in Sub-clause **2.3.3.1**, is equal to 0.05 and having no special requirement concerning the peak value.