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British Standard Method for

Expression of the properties of signal generators

Méthode d'expression des qualités des générateurs de signaux

Verfahren zur Beschreibung der Eigenschaften von Signalgeneratoren

National foreword

This British Standard has been prepared under the direction of the Electronic Equipment Standards Committee. It is identical with IEC Publication 716 'Expression of the properties of signal generators', published in 1981 by the International Electrotechnical Commission (IEC).

It supersedes the following British Standards, which are withdrawn.

BS 4980 : 1973 Method for specifying the performance of audio frequency generators

BS 5133 : 1975 Method for specifying the performance of frequency-modulated signal generators

BS 5134 : 1975 Method for specifying the performance of amplitude-modulated signal generators

BS 5826 : 1979 Method of expression of performance of microwave signal generators

Terminology and conventions. The text of the international standard has been approved as suitable for publication as a British Standard without deviation. Some terminology and certain conventions are not identical with those used in British Standards.

Cross-references

International standard	Corresponding British Standard
IEC 278 : 1968 } IEC 278A : 1974 }	BS 4308 : 1979 Specification for documentation to be supplied with electronic measuring apparatus (Identical)
IEC 348 : 1978	BS 4743 : 1979 Specification for safety requirements for electronic measuring apparatus (Identical)
IEC 359 : 1971	BS 4889 : 1973 Method for specifying the performance of electronic measuring apparatus (Technically equivalent)
IEC 469-1 : 1974	BS 5698 Guide to pulse techniques and apparatus Part 1 : 1979 Pulse terms and definitions (Identical)
IEC 624 : 1978	BS 5813 : 1979 Guide for expression of the performance of pulse generators (Identical)
IEC *625-1 : 1979	BS 6146 An interface system for programmable measuring instruments (byte serial, bit parallel) Part 1 : 1981 Specification for functional, electrical and mechanical requirements, system applications and requirements for the designer and user (Identical)
IEC *625-2 : 1980	Part 2 : 1981 Guide for code and format conventions (Identical)

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

*In clause 2 appears a general reference to IEC 625.

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British Standard Method for

Expression of the properties of signal generators

1. Scope

This standard is applicable to signal generators supplying, to a rated load, signals of sine-wave and or square-wave form *either* with amplitude and frequency unmodulated, *or* frequency modulated, amplitude modulated and/or on/off pulse modulated, *or* frequency swept.

This standard is applicable to traditional signal generators using tunable oscillators, to synchronizers for use with these, and to synthesizers and sweep generators.

Throughout this standard, the term “generators” includes all these.

This standard is not applicable to pulse generators. *

The generators have the following characteristics:

- a) The range of amplitude of the output is calibrated and marked in terms of voltage and/or output power and/or decibels relative to a certain reference level. Where generators are calibrated in terms of voltage, the manufacturer may choose either source e.m.f. or matched output voltage or both. The preferred markings for voltage are source e.m.f. for audio frequencies, and output voltage for higher frequencies; and for power, decibels relative to 1 mW.

Note. — Throughout this standard, the term “amplitude” relating to the value of the output signal means source e.m.f. or matched output voltage or power, as appropriate to the method of calibration.

- b) The output impedance is marked on the generator and should have one of the values: 50 Ω , 60 Ω , 75 Ω , 150 Ω , 200 Ω or 600 Ω . The preferred values are 50 Ω or 75 Ω for a coaxial output and 150 Ω or 600 Ω for a symmetrical output.
- c) If amplitude, frequency or on/off pulse modulation is incorporated in the generator, it is possible for the output signal to be modulated at least at 1000 Hz, and it is possible to switch off the modulation. The modulation may be produced using either an internal or an external source of modulating signal. For amplitude modulation it is possible to modulate with sinewaves at least at a factor of 0.3.
- d) Within the limits of their effective ranges, the amplitude, frequency, modulation and sweep characteristics are adjustable to values which are indicated on the generator or in the instruction manual.
- e) The power supply required is a.c. or d.c. mains or batteries.

Note. — Some kinds of generator do not provide all the possibilities described in this standard. Therefore, if this standard is used for them, all irrelevant clauses are automatically to be disregarded.

* For pulse generators, see IEC Publication 624: Expression of the Performance of Pulse Generators.

2. Object

The object of this standard is:

- to state the requirements intended for evaluating the electrical properties of signal generators;
- to establish the essential definitions relating to these types of generators;
- to establish a selection of standard performance characteristics from which the manufacturer shall or may state the requirements;
- to specify the tests necessary to verify that generators comply with the relevant requirements.

Safety requirements are dealt with in IEC Publication 348: Safety Requirements for Electronic Measuring Apparatus.

Requirements for control of programmable characteristics are dealt with in IEC Publication 625: An Interface System for Programmable Measuring Instruments (Byte Serial, Bit Parallel).

Requirements for electromagnetic compatibility in various situations are dealt with in the relevant IEC and C.I.S.P.R. publications.

General requirements for specifying and testing are given in IEC Publication 359: Expression of the Functional Performance of Electronic Measuring Equipment.

SECTION ONE — DEFINITIONS

Some of the following definitions have been taken from those given in the International Electrotechnical Vocabulary (I.E.V.), from IEC Publication 359 and from IEC Publication 469-1: Pulse Techniques and Apparatus, Part 1: Pulse Terms and Definitions.

Certain modifications of I.E.V. definitions have been made in this standard in order to facilitate their understanding.

3. General terms related to generators

3.1 *Signal generator*

Screened (shielded) source of sinusoidal and/or square waveform electric signals, the frequency, amplitude and modulation characteristics (if applicable) of which can be set at fixed or variable values, within specified limits.

Note. — The output signal may consist of a single frequency, obtained from a traditional tunable oscillator, or a synthesized frequency. In the latter case, the equipment is usually described as a synthesizer.

3.1.1 *Synthesizer (synthesized signal generator)*

A signal generator in which the frequency of the output signal is arithmetically derived, from (normally internal) reference frequency(ies).

3.1.2 *Sweep generator*

A signal generator equipped with wideband frequency modulation using a waveform, usually a low-frequency sawtooth, which can provide the frequency axis for an X-Y video display of changes, with respect to frequency, in a characteristic of a device under test.

3.2 *Synchronizer*

A device (usually an accessory) for improving the frequency accuracy of a signal generator. It provides a control voltage to lock a tunable oscillator in the generator to a reference oscillator which is normally part of the synchronizer.

3.3 *Accessory*

A device (terminated or unterminated r.f. transmission line, matching transformer, matched load, etc.) or an apparatus (modulator, attenuator, etc.) which is associated with the generator, either permanently and essential for its operation, or temporarily and required only for the purpose of modifying its characteristics in a prescribed way.

3.3.1 *Interchangeable accessory*

An accessory having its own properties and accuracy, these being independent of those of the generator with which it may be associated.

3.3.2 *Non-interchangeable accessory*

An accessory which has been adjusted to take into account the electrical characteristics of one particular generator. The requirements of this standard are then applicable to the combination of generator and accessory.

4. **Values and ranges**

4.1 *Rated value*

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

4.2 *Rated range*

The range of a quantity to be supplied or set which the manufacturer has assigned to the generator.

4.3 *Effective range (measuring range)*

That part of the rated range where measurements can be made or quantities can be supplied within the stated limits of error.

5. Terms related to the expression of performance

5.1 *Performance*

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

5.2 *Performance characteristic*

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

Note. — The term “performance characteristic” does not include influence quantities.

5.3 *Influence quantity*

Any quantity generally external to a generator which may affect the performance of the generator.

Note. — Where a change of a performance characteristic affects another performance characteristic, it is referred to as an *influencing characteristic*.

5.4 *Error*

5.4.1 *Absolute error*

The error expressed algebraically in the unit of the measured or supplied quantity. The error with which the generator indicates the quantity supplied is the indicated or pre-set value minus the true value.

Note. — 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 should be traced to standards agreed upon by the manufacturer and the user or to national standards. Whichever is chosen, the uncertainty of the conventionally true value shall be stated.

5.4.2 *Relative error*

The ratio of the absolute error to a stated value.

5.4.3 *Percentage error*

The relative error expressed as a percentage, such as per cent of full-scale (the maximum value of the effective range), per cent of the indicated or pre-set value or of the rated value.

5.5 *Fiducial value*

A value to which reference is made in order to specify the percentage error, for example, the maximum value of the effective range or another clearly stated value.

5.6 *Intrinsic error*

The error determined under reference conditions.

5.7 *Operating error*

The error determined under rated operating conditions (Sub-clause 6.3).

5.8 Influence error

The error determined when one influence quantity (except time) assumes any value within its rated range of use (or an influencing characteristic assumes any value within its effective range), all others being at reference conditions.

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.

5.9 Stability

The ability of the generator to maintain the supplied value of the relevant performance characteristic during a specified time, other conditions remaining constant.

5.10 Stability error (drift)

The error which occurs in the supplied value of the relevant performance characteristic of a generator during a specified time, other conditions remaining constant. See Figure 1.

Note. — The rate of drift over a long period is known as the *ageing rate*.

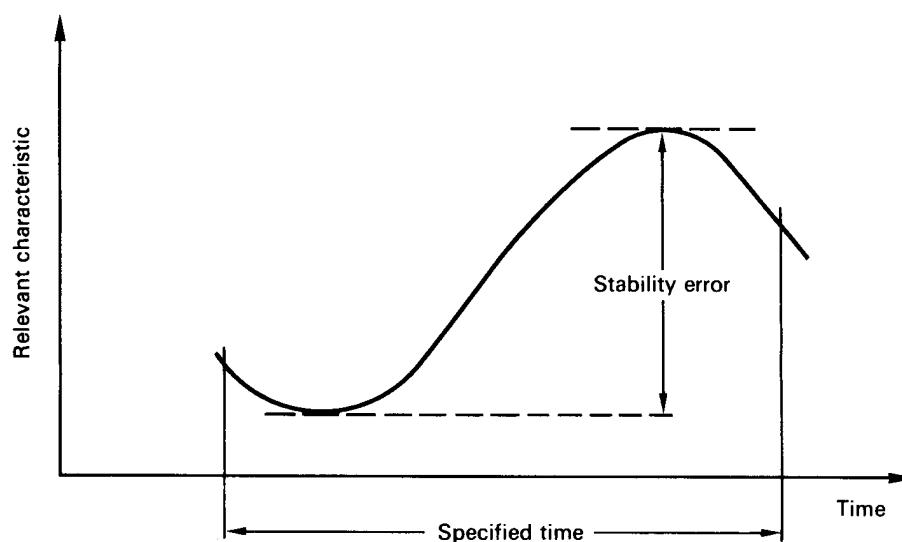


FIGURE 1

5.11 Recovery time

The time interval between the occurrence of a step change of any frequency or amplitude and the moment when the value of the frequency or amplitude enters and remains within the limits of operating error.

5.12 Limits of error

The maximum values of error assigned by the manufacturer to a supplied quantity of a generator operating under specified conditions.

6. Terms related to conditions of operation, transport and storage

6.1 *Reference conditions*

A set of values with tolerances or a set of restricted ranges, fixed for influence quantities and for influencing characteristics if any, specified for making comparison and calibration tests.

6.2 *Rated range of use*

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

6.3 *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 generator is specified.

6.4 *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 a generator can function without resulting in damage or degradation of performance when it is afterwards operated under rated operating conditions.

Note. — Attention is drawn to Sub-clause 28.1g).

6.5 *Conditions of storage and transport*

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

7. Terms related to frequency

7.1 *Effective frequency range*

The range of frequencies of the carrier wave produced by the generator, either continuously, or in bands, or by a series of discrete frequencies, within which the generator meets all accuracy requirements.

7.2 *Frequency band*

A part of the frequency range over which the frequency can be adjusted continuously or in steps.

7.3 *Band overlap*

A part of the frequency range common to two adjacent frequency bands for the purpose of ensuring continuity of the effective frequency range.

7.4 *Additional frequency coverage*

A range of frequency continuing above or below the effective frequency range, but in which the requirements of this standard do not apply.

7.5 *Incremental frequency range*

The width of the band of frequencies covered by the incremental frequency control (fine frequency control) above or below the frequency values set by the frequency control (coarse frequency control).

7.6 *Phase lock*

The control of frequency obtained by establishing phase coherence between a reference signal and the output signal of the generator.

7.7 *Frequency switching time*

The time interval between the initiation of a frequency change and the frequency approaching and remaining within a specified offset from its final value.

Note. — This is often stated for a number of progressively smaller offset frequencies and may also be repeated for a number of sizes of frequency step.

8. **Terms related to output amplitude**

8.1 *Matched output voltage*

The value of the voltage (potential difference) at the specified output terminal of the generator across a load impedance equal to the rated source impedance, the carrier being unmodulated. The value of the voltage is expressed as an r.m.s. value for sine-waves, and as a peak-to-peak value for square-waves.

8.2 *Source e.m.f.*

Twice the value of the matched output voltage.

8.3 *Output power*

That power which is supplied by the generator into the rated load impedance.

8.4 *Attenuation*

The ratio, expressed either in decibels or as a voltage (power) ratio, of any output relative to the reference level given by the manufacturer.

8.5 *Output amplitude switching time*

The time interval between the initiation of an amplitude change and the amplitude approaching and remaining within a specified error relative to the rated value of the new amplitude selected.

9. Terms related to the impedance at the outlet

9.1 Source impedance

The internal impedance of the generator, when the source e.m.f. is held at a constant value independent of the load.

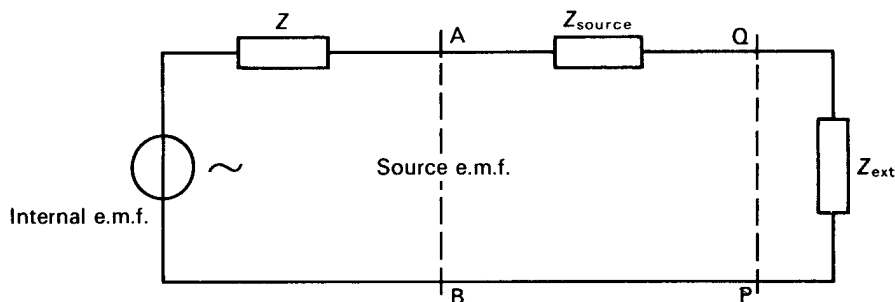


FIGURE 2

Notes 1. — The generator can be considered as an internal e.m.f. with series impedances Z and Z_{source} connected to a load Z_{ext} according to Figure 2.

When the source e.m.f. between A and B is held constant, the part of the circuit which is to the left of AB simulates zero impedance and the source impedance of the generator is equal to Z_{source} .

The matched output voltage appears across the terminals P and Q, if Z_{ext} is equal to the rated source impedance.

When the voltage between P and Q is held constant, the generator simulates zero source impedance.

However, looking into the terminals P and Q, the output impedance (see Sub-clause 9.2) is $Z + Z_{\text{source}}$.

2. — In many practical cases the quantity Z in the figure has a negligible value.

3. — It is not important whether the source e.m.f. is held at a constant value automatically or by manual adjustment.

9.2 Output impedance

The impedance ($Z + Z_{\text{source}}$) appearing at the outlet (terminals Q and P in Figure 2) looking back into the generator.

Notes 1. — The source impedance is the main definition since it expresses the impedance when the apparatus is working as a generator feeding a linear load. For non-linear or tuned loads, especially when fed by a modulated signal, the magnitude of Z modifies the voltages delivered by the generator. For these applications Z should be as close to zero as possible. Output impedance may be greater than source impedance, especially when no attenuation is in the output circuit of the generator (i.e. at high output levels).

2. — The error of the impedances is often expressed in terms of voltage standing wave ratio (VSWR) or may be expressed more precisely in terms of reflection factor.

3. — In the case of waveguide output, output impedance is a meaningless measurement. It is appropriate to specify the waveguide dimensions and the VSWR or reflection factor.

4. — During the measurement of output impedance, the generator should be under specified operating conditions.

9.3 *Rated load impedance*

- a) For generators intended for use with a matched load, the rated value of the source impedance.
- b) For generators intended for use under substantially open-circuit conditions, the minimum value for which the generator meets the accuracy requirements.

10. Terms related to signal waveforms, distortions and noise

10.1 *Sine-wave*

A voltage or current which varies according to a sinusoidal function of time.

10.2 *Square-wave*

A voltage or current which alternately assumes two values for equal durations, in comparison with which the transition durations are negligible.

10.3 *Total distortion factor (of a sine-wave at audio frequencies)*

The ratio, expressed as a percentage, of the r.m.s. value of a distorted sinusoidal signal without its fundamental component, to the r.m.s. value of the complete signal. The distorted sinusoidal signal includes harmonically related components, supply ripple and non-harmonically related components.

10.4 *Relative harmonic content (of a carrier wave)*

The ratio of the r.m.s. (or power) value of a stated harmonic output signal or of a stated group of harmonics to the r.m.s. (or power) value of the fundamental of the carrier wave, expressed as a percentage or as decibels below the carrier level.

Note. — The relative harmonic content for r.m.s. values is given by:

$$\frac{\sqrt{F_2^2 + F_3^2 + F_4^2 + \dots}}{F_1} \times 100 \text{ (expressed in \%)}$$

where F_n is the voltage of the n^{th} harmonic.

The relative harmonic content for power is given by:

$$10 \log \frac{P_2 + P_3 + P_4 + \dots}{P_1} \text{ dB}$$

where P_n is the power of the n^{th} harmonic.

10.5 *Relative sub-harmonic content (of a carrier wave)*

The ratio of the power value of a stated sub-harmonic* output signal to the power value of the fundamental of the carrier wave, expressed as decibels below the carrier level.

10.6 *Relative non-harmonic content (of a carrier wave)*

The ratio of the power value of a stated non-harmonic output signal to the power value of the fundamental of the carrier wave, expressed as decibels below the carrier level.

Note. — This definition does not include non-harmonics due to:

- unwanted modulation in an intentionally unmodulated condition (see Sub-clauses 14.3 and 14.5);
- modulation distortion (see Sub-clauses 11.5 and 11.9).

* Otherwise known as *fractional-harmonic*.

10.7 *Spot noise (spot noise to carrier ratio)*

The ratio of the power value of the noise in a 1 Hz bandwidth to the power value of the fundamental of the carrier wave.

Notes 1. — This is usually specified for a number of offset frequencies from the carrier. It is expressed in decibels.

2. — This is applicable to single-sideband noise if the a.m. noise is negligible compared with the phase noise in a 1 Hz bandwidth.

10.8 *Noise floor*

Spot noise measured at a stated frequency offset from the carrier, beyond which its value is substantially constant.

10.9 *Phase noise (phase noise to carrier ratio)*

The ratio of the power value of the unwanted phase modulation sidebands measured in a 30 kHz equivalent noise bandwidth centred on the carrier, excluding a 1 Hz bandwidth centred on the carrier, to the power value of the fundamental of the carrier. It is expressed in decibels.

Note. — This definition is applicable for those signal generators whose output frequency is derived from a fixed reference frequency and whose long-term stability and frequency may be expressed as M/N times that reference frequency (M and N both being integers).

11. **Terms related to modulation**

11.1 *Amplitude modulation*

The process by which the carrier amplitude is varied following a given law.

11.2 *Amplitude modulation factor (for sinusoidal modulation)*

The ratio of half the difference of the maximum and minimum amplitudes to the mean value of these amplitudes.

Note. — Amplitude modulation factor may be expressed as a percentage and is then known as modulation depth.

11.3 *Effective amplitude modulation factor*

The ratio of the peak voltage value of the fundamental component of the modulating frequency to the d.c. component at the output of a linear detector to which the output signal of the generator is applied.

11.4 *Envelope of the amplitude modulated signal*

The upper and lower boundary lines of that area which is swept by the carrier wave when plotted against time, while the phase of the modulating signal is varied continuously through 360 degrees.

Note. — For a high ratio of carrier frequency to modulating frequency, the following definition produces a good approximation: the curve followed by the peaks of an amplitude modulated carrier wave.

11.5 *Amplitude modulation distortion (for sinusoidal amplitude modulating signal)*

Distortion of the waveform at the output of a linear detector, connected to the generator

output, when a sinusoidal amplitude modulating signal is applied to the generator to obtain an amplitude modulated signal.

Notes 1. — This is sometimes called “envelope distortion”.

2. — The distortion is the higher of the two values found when the polarity of the detector is reversed.

11.6 *Frequency modulation*

The process by which the carrier frequency is varied following a given law.

11.7 *Frequency deviation (for sinusoidal modulation)*

One half of the total excursion (peak-to-peak) of the carrier frequency during one cycle of pure sinusoidal modulation.

11.8 *Effective frequency deviation*

The value of deviation which gives, with pure sinusoidal frequency modulation, the same amplitude of the fundamental of the modulation frequency in the output of a linear discriminator (to which the frequency modulated wave is applied) as is obtained with distorted modulation.

11.9 *Frequency modulation distortion (for sinusoidal frequency modulating signal)*

Distortion of the waveform at the output of a linear discriminator, connected to the generator output, when a sinusoidal frequency modulating signal is applied to the generator to obtain a frequency modulated signal.

11.10 *Average frequency (of a frequency modulated carrier)*

The frequency of an unmodulated carrier which gives the same direct voltage output from a linear symmetrical discriminator as the modulated carrier.

Note. — The difference between the average frequency and the frequency of the unmodulated carrier is called “*carrier frequency shift*”.

11.11 *On/off pulse modulation*

The process of forming carrier pulses, by which the carrier is switched on and off between its unmodulated level and zero level, the repetition following a given law.

11.12 *Square-wave modulation*

For the purpose of this standard, a kind of on/off pulse modulation in which the duty factor is 0.5 (50%).

12. **Pulse terms**

Some basic pulse terms, used in these definitions but not otherwise defined themselves, will be found in IEC Publication 469-1.

12.1 *Pulse amplitude*

The algebraic difference between the top magnitude and the base magnitude.

Note. — For a carrier pulse (on/off pulse modulated carrier), these magnitudes relate to the envelope of the pulse.