

Methods of

Measuring and expressing the performance of television receivers —

**Part 1: General considerations and
electrical measurements other than
those at audio-frequencies**

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The Electronic Equipment Standards Committee, under whose direction this British Standard was prepared, consists of representatives from the following Government department and scientific and industrial organizations:

- British Broadcasting Corporation*
- British Electrical and Allied Manufacturers' Association (BEAMA)
- British Radio Equipment Manufacturers' Association*
- Cable and Wireless Limited
- Cable Television Association of Great Britain*
- Electrical, Electronic, Telecommunications and Plumbing Union
- Electricity Supply Industry in England and Wales
- Electronic Components Industry Federation*
- Electronic Engineering Association*
- Institution of Electronic and Radio Engineers*
- Ministry of Defence
- Post Office*
- Post Office Engineering Union
- Scientific Instrument Manufacturers' Association

The organizations marked with an asterisk in the above list, together with the following, were directly represented on the committee entrusted with the preparation of this British Standard:

- Consumers' Association
- Consumer Standards Advisory committee of BSI
- Home Office
- Institution of Electrical Engineers
- Radio Society of Great Britain
- Science Research Council — Radio and Space Research Station
- Society of Cable Television Engineers

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National foreword

This British Standard has been prepared under the direction of the Electronic Equipment Standards Committee and is the first part of a revision of BS 3549 which was first issued in 1963. It is identical with Publication 107-1 (second edition — 1977) “*Recommended methods of measurement on receivers for television broadcast transmissions*” Part 1 “*General considerations and electrical measurements other than those at audio-frequencies*”, published by the International Electrotechnical Commission (IEC)

This revision of this standard extends the 1963 edition to cover measurements on colour television receivers as well as monochrome receivers. It does not specify performance limits for receivers.

The standard will be divided into four Parts, of which this is Part 1. The other Parts will be as follows:

- *Part 2: Audio-frequency measurements;*
- *Part 3: Colorimetric and photometric measurements;*
- *Part 4: Additional measurements.*

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.

The comma has been used in some places as the decimal marker. In British Standards it is current practice to use a full point on the baseline as the decimal marker.

Wherever the word “standard” appears, referring to this standard, it should be interpreted as “British Standard”.

Cross-references

International Standard	Corresponding British Standard
IEC 68	BS 2011 <i>Basic environmental testing procedures</i>
Part 1:1968	Part 1.1 <i>General</i> : 1977 (Identical)
Part 2	Part 2.1 <i>Tests</i> (Identical)
IEC 86	BS 397 <i>Specification for primary cells and batteries</i> : 1976 (Related)
IEC 107	BS 3549 <i>Methods for measuring and expressing the performance of television receivers</i>
Part 2 ^a	Part 2 <i>Audio-frequency measurements</i> ^a
Part 3 ^a	Part 3 <i>Colorimetric and photometric measurements</i> ^a

^a In course of preparation.

At present there is no corresponding British Standard for the remaining International Standard referred to.

A copy of the CCIR Recommendation referred to in this British Standard is available for consultation in the BSI Library, 2 Park Street, London W1A 2BS.

Copies of CCIR publications can be purchased from the International Telecommunications Union, Place des Nations, 1211 — Geneva — 20, Switzerland.

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.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i to xii, pages 1 to 106, 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.

Chapter I. General

Section 1. Introduction

1 Object

The object of this standard is to standardize the conditions and methods for the measurements to be used for the study of a receiver for television broadcasting so as to make possible the comparison of the results of measurements. Specifying limiting values of the various quantities for acceptable performance is not an object of this standard.

The standard constitutes a catalogue of selected measurements recommended for assessing the essential properties of receivers of a given type. It is neither mandatory nor limiting; a choice of measurements can be made in each particular case and, if necessary, additional measurements may be carried out.

The recommended methods are designed to make possible the assessment of the performance of the complete receiver, without going into more than a minimum of detail and without giving its components separate consideration.

It should be realized that the measurements proposed are subject to future improvements as methods are refined and with the development of receiver techniques.

2 Scope

The methods of measuring the electrical, acoustic and optical properties described in this standard apply more particularly to broadcast television receivers designed for monochrome and colour vision reception with accompanying sound of the systems of the C.C.I.R.¹⁾ recommendations and reports, due regard being given to national transmission standards.

Section 2. General explanation of terms

3 Definitions

The following general definitions apply for the purpose of this standard.

3.1

voltage and *current* mostly imply in television technique “peak-to-peak” values; this is indicated by p-p. Without such indication, voltage and current imply r.m.s. values unless otherwise specified. A fully modulated radio-frequency signal is a radio-frequency signal modulated to white level in accordance with the standard of the television system used. By convention, the signal strength is considered to be equal to the r.m.s. value of an unmodulated radio-frequency signal having the same peak amplitude as the modulated signal has at the peak of modulation. This corresponds to white level for systems using positive modulation and synchronizing level for systems using negative modulation as shown in Figure 1a and Figure 1b, page 66

NOTE 1 Greater modulation depths can occur with colour signals, see Sub-clauses 3.2 and 3.3.

NOTE 2 The true r.m.s. value of a modulated signal will be different from this value, the magnitude of the difference depending on the depth of modulation and its waveform. In the tests in which a sine-wave modulated carrier can be used, the factor for conversion to peak values is given in the appropriate figures.

3.2

picture modulation percentage

picture modulation percentage is expressed on a linear scale to indicate the picture signal level at any given instant

0 % picture modulation corresponds to the black level, and

100 % picture modulation corresponds to the white level as defined for the system used

values below 0 % and above 100 % can occur with colour signals

intermediate values correspond to intermediate levels of the picture signal (see Figure 1a and Figure 1b)

¹⁾ C.C.I.R.: International Radio Consultative Committee.

3.3

envelope level

the envelope level is expressed on a linear scale to indicate the level of the vision radio-frequency signal at any given instant

100 % envelope level corresponds to highest carrier level for a monochrome signal, and

0 % envelope level corresponds to the zero carrier level

with negative modulation, 100 % envelope level corresponds to the radio-frequency signal level at the top of the synchronizing pulses. With positive modulation 100 % envelope level corresponds to the radio-frequency signal level at white level (100 % picture modulation) (see Figure 1a and Figure 1b). This value can be exceeded for colour signals

3.4

the relative radio-frequency signal levels of the picture and associated sound are those defined for the system in use by the appropriate C.C.I.R. reports and recommendations, due regard being given to national transmission standards

3.5

the *bel* is the fundamental division of a logarithmic scale used to express the ratio of two specified or implied amounts of power, the number of bels denoting such a ratio being the logarithm to the base 10 of this ratio

NOTE With P_1 and P_2 designating two amounts of power and N the number of bels denoting their ratio:

$$N = \log_{10} \frac{P_1}{P_2} \text{ bels}$$

3.6

the *decibel* is one-tenth of a bel, the number of decibels denoting the ratio of two specified or implied amounts of power being 10 times the logarithm to the base 10 of this ratio. The symbol dB is commonly used for the term decibel. It is also used to express voltage and current ratios, the relations being:

$$\text{number of decibels} = 20 \log_{10} \frac{U_1}{U_2} \text{ or } 20 \log_{10} \frac{I_1}{I_2}$$

by definition, these formulae are applicable when the impedances at the reference points, at which the voltages and currents occur, are identical. However, it has long become customary to use the decibel notation in an extended sense, to express numerical ratios in general on a logarithmic basis. In such cases, it is recommended that a note be made of the special use of the decibel notation and if possible information added about the impedances to which the ratio values refer

3.7

decibel suffixes

a decibel ratio related to a specified reference quantity will define the level of a new quantity. The reference quantities used in expressing the levels of power, voltage, current or field strength may be indicated by means of a suffix associated with dB

commonly used references and their suffixes are:

Quantity	Reference	Abbreviation
Power	1 milliwatt	dB(mW)
Voltage	1 volt	dB(V)
Current	1 ampere	dB(A)
Field strength	1 volt per metre	dB(V/m)

3.8

luminance (L) in a given direction is the luminous intensity per unit of projected area of any surface as viewed from that direction

the luminance value is expressed in candela per square metre. ($1 \text{ cd/m}^2 = 1 \text{ nit} = 0.0001 \text{ stilb} = 0.292 \text{ foot lamberts} = \pi \text{ apostilb}$)

3.9

brightness is the subjective impression of the luminance

3.10

supply mains denotes any power source with an operating voltage of more than 24 V that is not used solely to supply television receivers

3.11

battery operation denotes operation on accumulator and/or dry batteries irrespective of the application of d.c. voltage-transforming device

3.12

terminal device denotes any device for connecting external conductors or apparatus

3.13

artificial aerial denotes a network which replaces the receiving aerial and its associated transmission line when taking measurements

3.14**composite video signal**

a composite video signal is a signal consisting of picture information, luminance and, where appropriate, chrominance (produced for instance by a camera or a pattern generator) and the complete synchronizing information. The signal should comply with the standards of the television system for which the receiver is designed

3.15**television signal**

a television signal is a radio-frequency signal containing both vision and sound information in accordance with the standards of the television system used

3.16**test patterns**

a test pattern is used for checking the complete television system. It comprises a combination of monochrome or monochrome and colour signal components that offer as much information as possible on the performance of the system. Such a pattern should include at least the following items:

- 1) Vertical and horizontal definition wedges in the centre and in the four corners of the picture area, calibrated in "number of lines". The wedges should enable definition to be checked up to the theoretical maximum of the system. The definition is always referred to the corresponding number of horizontal scanning lines, the same figure indicating the same definition, both vertically and horizontally. The video frequency corresponding to each "number of lines" may be calculated for the television system under consideration.
- 2) Patterns for linearity and colour registration or convergence checks, consisting of a pattern of equidistant horizontal and vertical lines and/or dots. Circles may be included to facilitate adjustment of picture size and geometry.
- 3) A marking to check the aspect ratio.
- 4) Marks to facilitate centring of the picture even when the mask partly cuts the corners.
- 5) A known brightness scale of from 5 to 10 brightness steps for gradation checks.
- 6) Alternate black and white blocks at the vertical edges of the picture to check synchronizing quality. These may be combined with the linearity patterns and the aspect-ratio marking.
- 7) Special patterns, such as single vertical bars of different widths and suitable horizontal blocks giving black-white and white-black transitions, for checking overshoot, reflections (ghosts) and low-frequency response.
- 8) Coloured areas to check decoding operation, colour transitions and luminance/chrominance time equalization.
- 9) Areas at white level and black level to check drive levels, beam current limiting and intercarrier sound.

some of the features may be provided by the inclusion of an area of colour bar signal (see C.C.I.R. Recommendation 471, XIIIth Plenary Assembly, Geneva, 1974)

the mean brightness of the patterns should correspond to a mean picture modulation percentage of approximately 50 %

3.17

field

a field is that part of the picture which is scanned in the interval between two successive vertical synchronizing impulses

3.18

picture

a picture consists of two consecutive fields (see Sub-clause 3.17)

3.19

chromaticity

colour quality of a colour stimulus definable by its chromaticity co-ordinates or by its dominant (or complementary) wavelength and its purity taken together. Chromaticity co-ordinates can be x and y of the CIE²⁾ (1931) standard colorimetric system or u and v of the CIE (1960) uniform chromaticity system

3.20

colour bar signals

colour bar signals are electronically generated patterns and usually consist of vertical bands of colours in order of descending luminance, left to right. Colour bar signals referred to in this publication, unless otherwise stated, are those of the examples in Recommendation 471 of the C.C.I.R. XIIIth Plenary Assembly, Geneva, 1974

3.21

hanover blind effect

spurious variation in luminance level, hue or saturation in the reproduced picture signal, line by line due to effects associated with the chrominance signal

3.22

an example of a *representative number of channels* where measurements are not carried out on all channels in which a receiver is designed to operate is:

2 channels in band 1 — the lowest and the highest;

2 channels in band 3 — the lowest and the highest;

3 channels each in bands 4 and 5 — one near each end of the band and one in the middle.

3.23

unacceptable performance

performance may be considered unacceptable when one or more of the following phenomena occur:

loss of synchronization;

cross-modulation of sound and picture;

loss of resolution;

distortion of grey scale;

noise effects in picture or sound;

errors of colour reproduction;

spurious colour effects;

spurious interlined differences;

spurious colour killing;

sound distortion.

²⁾ CIE: International Commission on Illumination.

Chapter II. General notes on measurements

Section 3. General conditions

4 Introduction

All measurements shall, unless specified otherwise, be carried out under the conditions specified in the relevant clauses, whilst the following points shall also be taken into consideration.

In all measurements on a television receiver, it is assumed that both the sound and the picture sections are operating, so that any influence one section may have on the other will be present during the measurements, except where otherwise stated. For instance, an A.G.C. circuit operated by the vision signal may influence the sound channel circuits and the reverse may be the case. One of the signals may be omitted from the composite television input signal only when it has been ascertained that this does not affect the results of the measurement in question.

For most measurements, it is important that the scanning circuits be properly synchronized.

5 Measuring conditions

A description of the condition under which the measurement has been made should be added to the results, including the set-up of the measuring equipment, external circuit elements, the applied signal levels and the applicable environmental conditions.

6 Accuracy of measuring instruments

The accuracy of the measuring instruments used, if known, shall either be stated as a percentage or in decibels as appropriate. Alternatively, the accuracy class may be quoted as laid down in the relevant publications (under consideration).

7 Presentation of results

If the results of measurements are presented graphically, the points which have been obtained experimentally shall always be indicated on the graph, together with other specifically required data of the measurements. If a continuous record has been made, this shall be stated.

8 Deviations

If deviations from the recommended methods are adopted, they shall be explicitly stated with the results.

Section 4. Environmental conditions

9 Introduction

Unless otherwise specified, the following standard atmospheric conditions apply for the purposes mentioned in Clauses 10, 11 and 12 (in accordance with IEC Publication 68-1, Basic Environmental Testing Procedures, Part 1: General [Third edition]).

Other environmental conditions are referred to in Clause 13.

10 Standard reference conditions

If the quantities to be measured depend on temperature and/or air pressure and the law of dependence is known, the values are measured under the conditions given in Clause 12 and, if necessary, corrected by calculation to the following reference values:

temperature: + 20 °C;

air pressure: 101 300 Pa (1 Pa = 10⁻⁵ bar).

NOTE No requirements for relative humidity are given here, because a correction by calculation is generally not possible.

11 Standard referee conditions

If the quantities to be measured depend on temperature, humidity and air pressure and the law of dependence is unknown, the measurements may be made, by mutual agreement, under one of the following conditions.

Temperature	Relative humidity	Air pressure
+ 20 ± 1 °C	63 % – 67 %	86 000 Pa – 106 000 Pa
+ 23 ± 1 °C	48 % – 52 %	86 000 Pa – 106 000 Pa
+ 25 ± 1 °C	48 % – 52 %	86 000 Pa – 106 000 Pa
+ 27 ± 1 °C	63 % – 67 %	86 000 Pa – 106 000 Pa
		(1 Pa = 10 ⁻⁵ bar)

When the temperature of measurement differs from 20 °C or such other temperature as may be prescribed in the relevant specification, suitable limits for the characteristic values shall be agreed between user and manufacturer.

The test report shall give the actual values of temperature, relative humidity and air pressure during the measurements.

For large equipment or test rooms, where temperature, relative humidity and air pressure limits as indicated above are difficult to maintain, wider tolerances are allowed, subject to mutual agreement. The actual values shall be given in the test report.

12 Standard testing conditions

Measurements and mechanical tests are normally carried out at any existing combination of temperature, humidity and air pressure within the following limits:

temperature: + 15 °C to + 35 °C;

relative humidity: 45 % to 75 %;

air pressure: 86 000 Pa to 106 000 Pa (1 Pa = 10⁻⁵ bar).

In addition, for receivers intended for operation over a wider temperature range such as portable and motor vehicle receivers, the temperature range may be extended further, covering one of the ranges specified in IEC Publication 68-1.

The temperature and relative humidity shall be substantially constant during a series of measurements carried out as a part of one test on one equipment.

Where it is impracticable to carry out measurements under these standard atmospheric conditions for testing, a note to this effect, stating the actual conditions, shall be added to the test report.

13 Other environmental conditions

When, by mutual agreement, the essential properties of receivers have to be assessed in environmental conditions other than those laid down in Clauses 11 and 12, the measurements shall be made during or after subjection of equipment to such conditions as laid down in IEC Publication 68-2, Part 2: Tests, and as required according to the relevant specification sheets.

Section 5. Precautions during measurements

14 Damage to equipment

When carrying out measurements on a receiver, all test conditions or operations which may lead to damage to the receiver and/or its tubes, valves or semiconductor devices, shall be avoided. This applies particularly to sensitive solid state devices such as integrated circuits and similar constructions.

15 Safety arrangements

If a protecting cover is removed and parts which are directly connected to the mains (e.g. the chassis) become accessible, it is recommended, for the safety of personnel performing measurements that equipment be connected to the a.c. mains via a safety transformer, the secondary winding of which is insulated in accordance with the principle of double insulation.

It shall be ascertained that the use of a safety transformer does not influence the receiver properties to be measured. In particular, the internal impedance of the safety transformer shall be sufficiently low, for the behaviour of the receiver to be the same as when connected directly to the mains supply. If a safety transformer is not used, the safety aspect shall be taken care of by other means (see also IEC Publication 284, Rules of Behaviour with Respect to Possible Hazards when Dealing with Electronic Equipment and Equipment Employing Similar Techniques, First edition).

Section 6. Power supply

16 Types of power supply and relevant measuring conditions

The following ways of operation with regard to power supply are defined:

Mains: operation from any centralized a.c. or d.c. power source with a nominal operating voltage of more than 24 V.

Batteries: operation on accumulators, primary batteries or any similar energy source, e.g. solar batteries, thermo-electric cells, etc.

Accumulators, primary batteries, and/or other similar energy sources of the type, voltage and internal resistance, as specified for use with the receiver, shall be employed; other sources, which sensibly simulate the characteristics of those specified, may also be used and the substitute arrangements stated with the results.

Receivers intended for use on more than one type of power supply shall be measured by connecting the receiver to each type of power supply in turn.

NOTE In this respect, a.c. mains and d.c. mains are considered different types of power supply.

The normal measuring conditions, as laid down in Clauses 17, 19 or 21, whichever are applicable, shall apply for all measurements.

Receivers designed to operate over a wide range of voltages without adjustment are tested under the conditions laid down in Clauses 24 and 25.

To determine the influence of variations in the supply voltages on various characteristics of a receiver, supplementary measurements shall, unless otherwise specified, be carried out. Where a rated voltage but no tolerance is given or where a rated voltage with a tolerance is given, supplementary measurements shall be carried out at overvoltages and undervoltages, whichever are applicable, deviating from the chosen rated values, and as laid down in Clauses 18, 20, 22 and 23.

The conditions chosen shall be stated. See also Table I.

17 Mains-operated receivers, normal conditions

The rated voltage at the rated frequency shall be applied to the mains terminal device.

For receivers with more than one rated operating voltage or frequency, a specified rated voltage, at a rated frequency, shall be applied to the mains terminal device.

If the receiver has to operate on a mains supply with a rated frequency differing considerably from the field frequency of the television system, e.g. 50 Hz and 60 Hz, all measurements should be made under these conditions, special attention being paid to measurements where the difference of frequency may give rise to spurious effects.

18 Mains-operated receivers, overvoltages and undervoltages

An overvoltage of + 10 % or the given tolerance and an undervoltage of – 10 % or the given tolerance at a rated frequency shall be applied to the mains terminal device.

For receivers with more than one rated operating voltage or frequency, the highest overvoltage at the lowest rated frequency and the lowest undervoltage at the highest rated frequency, shall be applied to the mains terminal device; where tapplings for the range of voltages are provided, the appropriate range shall be selected for the measurements.

19 Accumulator-operated receivers, normal conditions

The normal operating voltage for accumulator batteries is fixed at 2.0 V per cell for lead batteries not under charge, 2.2 V per cell for lead batteries under charge and 2.4 V per cell for car batteries, measured at the terminals of the battery. If accumulators other than lead accumulators are used, these voltages per cell shall be chosen accordingly and stated with the results (see also Table I).

20 Accumulator-operated receivers, overvoltages and undervoltages

The undervoltage for lead accumulators is fixed at 1.8 V per cell. The overvoltages for lead accumulators of motor-cars is fixed at 2.6 V per cell. If accumulators other than lead accumulators are used, the undervoltage and overvoltage per cell shall be chosen accordingly and stated with the results (see also Table I).

NOTE For batteries in vehicles, switching peaks of very short duration and nearly double the normal operating voltage may occur, whilst at low operating temperatures higher battery voltages may be encountered.

21 Primary battery-operated receivers, normal conditions

The normal operating voltages for primary batteries are generally to be found in the relevant IEC Publication 86, Primary Cells and Batteries. The normal operating voltage for primary batteries of the Leclanché type is fixed at 1.5 V per cell; if other voltages apply, these shall be stated with the results.

22 Primary battery-operated receivers, overvoltages and undervoltages

The test overvoltage corresponding to that possibly occurring with new Leclanché cells shall be 1.65 V per cell, obtained from a voltage source of negligible internal resistance. The tests at this overvoltage shall be of sufficient duration to check that operation is normal and without instability, but shall be kept short, in order to avoid possible excessive power dissipation.

The test undervoltage on load for primary batteries of the Leclanché type shall be of 1.10 V per cell.

Normally, undervoltages shall be obtained by using adjustable resistors in series with fresh batteries or any other sources of the rated voltages having negligible internal resistance. Under the conditions of the particular test in progress, the series resistor shall be adjusted once and for all, to obtain the specified undervoltages on full load of the receiver. It is to be noted that the addition of a series resistance to a source of negligible internal impedance does not simulate a partially discharged battery perfectly, the impedance of which may be non-linear.

Alternatively, under special circumstances, the undervoltage may be obtained in a similar way using an initial voltage source of a specified percentage, e.g. 20 % below the rated voltage value, with an appropriately smaller value for the series resistance; this deviation from the normal procedure shall be explicitly stated with the results.

23 Additional information

Table I gives a survey of the different overvoltages and undervoltages for various types of operation.

If the undervoltage is to be obtained by an adjustable resistor in series with an adjustable constant voltage source, as prescribed in Clause 22, it is convenient to apply first the relevant undervoltage directly, with the adjustable series resistor set at zero resistance, and to adjust the various parameters of the receiver as required. Then, without changing these parameters, the normal operating voltage is applied, the adjustable resistor being set at maximum resistance, after which the resistance shall be gradually decreased until the same chosen undervoltage is reached. The series resistance shall be kept constant during further tests with the same equipment.

If, during operation at the extreme voltages specified in this section, the receiver ceases to give useful operation, measurements shall be made at less extreme voltages. A clear statement of these conditions shall be added to the results.

Table I — Survey of voltages for various types of power supply

1	2	3	4	5
Type of power supply for television receivers	Rated voltage (V)	Operating voltage		
		Normal (V)	Maximum (V)	Minimum (V)
Mains	U	U	$U + 10\%$ or $U + X^c$	$U - 10\%$ or $U - Y^c$
Primary battery ^a	1.5	1.5	1.65	1.10
Accumulator ^a				
Lead accumulators	2.0	2.0	—	1.8 ^b
— under charge	—	2.2	—	—
— for car receivers	—	2.4	2.6	—
Nickel-cadmium accumulators with incorporated gas-vent	1.2	1.2	—	1.1
— under charge	—	1.4	—	—
— for car receivers	—	—	1.6	—
Nickel-cadmium accumulators of the sealed type	1.2	1.2	—	1.1
— under charge	—	1.35	—	—
— for car receivers	—	—	1.4	—

^a Voltage per cell.
^b Where manufacturers define a higher minimum voltage than 1.8 V, this higher voltage should be considered to be the minimum value.
^c X and Y correspond to the given tolerance (if other than 10 %) see Clause 18.

24 Receivers designed to operate over a moderate range of voltages without adjustment

The voltage range of operation is defined as follows:

$$U_1 < U_2 < 1.5 U_1$$

where U_1 is the lower voltage limit of the range of operation and U_2 is the higher voltage limit of the range of operation.

An example of such a range is 190 – 260 V.

Normal conditions are defined as $\frac{U_1 + U_2}{2}$.

The overvoltage is U_2 .

The undervoltage is U_1 .

See also Notes 1 and 2 of Clause 25.

25 Receivers designed to operate over a wide range of voltages without adjustment

The voltage range of operation is defined as follows:

$$U_2 \geq 1.5 U_1$$

where U is the lower voltage limit of the range of operation and U_2 is the higher voltage limit of the range of operation.

An example of such a range is 95 – 255 V.

Normal conditions are defined as $U_2 - 20\%$.

The overvoltage is U_2 .

The undervoltage is U_1 .

NOTE 1 Where a wide range of operation is obtained by an automatic switching arrangement, the receiver shall be tested over a narrow range of voltages within which the switch operates. This is to ensure that no instability over this range occurs.

NOTE 2 The values of U_1 and U_2 are the absolute values outside which operation should not be attempted in any circumstances.

26 Power and current consumption of receivers

The power and/or current consumption of receivers shall be measured under normal measuring conditions (see Clause 17, Clause 19 and/or Clause 21), for each of the following conditions:

- a) without a radio-frequency input signal;
- b) with a radio-frequency input signal using a suitable test pattern and sound modulated 30 % at the standard reference frequency, the receiver delivering the reference audio output power³⁾ (see Section 4, IEC Publication 107-2).
- c) as b) but delivering 40 % of the reference audio output power;
- d) as b) but delivering maximum useful audio output power, obtained, if necessary, by increasing the modulation factor up to 100 %;
- e) as b) but in the two extreme conditions of minimum and maximum setting of the brightness control.

27 Maximum power and current consumption of receivers

The maximum power and/or current consumption of receivers shall be measured under the input signal conditions and setting of user and externally adjustable controls that, while maintaining usable picture and sound give maximum power and/or current consumption. When carrying out this measurement due care should be taken to avoid damage to the receiver under test.

Section 7. Radio-frequency input signals

28 General

To facilitate the comparison of results, the selection of radio-frequency input signals with regard to frequencies and input signal levels used for measurements shall preferably be restricted to a minimum. However, the appropriate measurements shall be made using channels at the extreme ends and distributed within all of the frequency bands for which the receiver is designed. The frequencies used shall conform to the standards of the country or countries in which the receiver is intended to be used. Additional measurements shall be made using any channel showing or expected to show anomalous response or receiver behaviour. The video and audio modulating signals are defined in each section describing a particular measurement or groups of related measurements.

Section 8. Radio-frequency input arrangements

29 Introduction

Depending on the type of receiver, the radio-frequency signal normally enters the radio-frequency input circuit by an unbalanced or balanced cable with a characteristic impedance equal to the specified source impedance for which the receiver has been designed, or through a (in some cases built-in) magnetic aerial. The following clauses describe the way in which measuring signals from a radio-frequency signal generator are applied to receivers of these various types. Great care must be taken in the construction of the matching networks in order that results are reliable at the high frequencies used for television channels.

30 Matching networks for providing a specified source impedance for the receiver requiring such impedances

The specified source impedance for which the receiver has been designed (R_p), is not to be confused with the actual input impedance of the receiver, as measurable at the aerial input terminals.

A receiver with a balanced or an unbalanced input circuit for a specified source impedance shall be measured with a signal source having a balanced output e.m.f. or having an unbalanced one, respectively, its internal impedance (R_i) matched to the specified source impedance (R_p).

If the specified source impedance R_p and the internal resistance of the signal source R_i are unequal, a suitable matching network shall be inserted between the signal source and the receiver.

³⁾ The reference output power is defined as a power 10 dB below the level of the relevant maximum useful output power.

Care shall be taken that connecting cables in the relevant parts of the circuit have characteristic impedances R_r and R_i as appropriate.

If a balanced signal source is not available, a suitable unbalanced-to-balanced transformer (balun) shall be used; its influence on the input signal shall be taken into account in connection with the calculation of the actual value of this level.

Figure 2, pages 67 and 68, gives examples of matching networks for providing specified source impedances for various cases, including also a balanced-to-unbalanced transformer.

31 Combining networks

For the application to two- or multi-signal measuring methods, suitable combining networks shall be applied when coupling various signal generators.

Figure 3, pages 69 and 70, gives the following examples of combining networks for measuring methods using more than one signal generator:

- a) unbalanced network for combining two signals;
- b) unbalanced network for combining n signals.

In cases of combination of a symmetrical and an asymmetrical signal generator, a suitable balanced-to-unbalanced transformer (balun) shall be used; its influence on the input signal level, from the relevant signal generator shall be taken into account in calculating the actual value of this level.

A combining network may be followed by a matching network or a transformer, according to the application; its influence on the input signal level shall be taken into account.

Instead of combining several networks, reducing the output resistance of the different generators to that of an equivalent generator and adapting this equivalent generator to the receiver, other networks can be used to adapt the generators to the receivers.

32 Balanced radio-frequency input circuit

Some types of receivers are provided with a balanced radio-frequency input circuit, e.g. to reduce certain types of interference, especially those entering in an asymmetrical mode.

This effect may or may not have been enhanced by applying a form of electrical screening between the actual input coil and the rest of the radio-frequency circuit.

The efficacy of a balanced input circuit is determined by the unbalance ratio, which represents the ability of the circuit to increase the immunity of the receiver to incoming unbalanced signals (asymmetrical mode).

As the unbalance ratio is usually expressed in decibels, it is necessary to specify, apart from the specified source impedance R_r for which the receiver has been designed, the source impedance R_{un} of the unbalanced system to which the receiver input circuit is connected. R_{un} will generally be equal to the characteristic impedance of the unbalanced system, formed by the balanced feeder, as a whole, and earth.

33 Method of measurement of the unbalance ratio

The unbalance ratio is determined by measuring the available power (see Clause 36) of an asymmetrical signal that produces a specified value of output signal and the available power of a normal balanced signal that produces the same value of signal output, the ratio between the two values of available power being expressed in decibels.

Care shall be taken that the measurement is not influenced by the effects of an A.G.C.-system or a limiting device. For other special cases, see the relevant part covering the radio-frequency properties of the receiver under test.

The asymmetrical signal shall be applied through a resistive network to the radio-frequency input terminal device of the receiver, as shown in Figure 4, page 71.

The configuration of this network is based on the assumption that the input impedance for the asymmetric mode is very high compared with the value of R_{un} , and is not necessarily applicable if this condition is not met.

The value of R_{un} in practice depends upon the installation, but a value of 600 Ω is representative of this parameter.

The symmetrical signal shall be applied according to Figure 2, pages 67 and 68, Items a), c) or e).

Both signals shall be applied, and the necessary available power calculated in accordance with the relevant clauses of this section (see Clause 30).

NOTE The accuracy of the method of measurement is limited, particularly at the higher frequencies used for television and care must be taken in interpreting the results.

34 Input arrangements for built-in aerials

If a receiver is provided with a built-in aerial or is intended to be connected to an external aerial in the close vicinity of the receiver, the input signal should be provided by means of a radio-frequency field. The various methods of producing such fields which are at present available are not valid for the full range of frequencies for which the need to make measurements exists. This clause, therefore, remains for the time being under consideration.

Section 9. Recommended values for radio-frequency input signal levels

35 Introduction

Depending on the type of receiver under consideration and the different input arrangements, various ways of expressing the radio-frequency input level are recommended.

For amplitude-modulated signals (a.m.) and for frequency-modulated signals (f.m.), the electromotive force E' shall be expressed as the r.m.s. value of the unmodulated carrier. For television signals (t.v.), the electromotive force E' shall be expressed as the r.m.s. value at the peak amplitude of the unmodulated signal.

For receivers with input circuits for specified source impedances, the input signal level is expressed in decibels (microvolts), in terms of the apparent signal source e.m.f. E' .

To facilitate the direct comparison of receivers for which different source impedances are specified, it is useful to compare the input signal levels in terms of the available power at the output terminals of the relevant network. The available power is the power which would be delivered by the signal generator and its associated network to a matched load.

It is equal to:

$$\frac{E'^2}{4 R_r}$$

where, measured between the output terminals of the network (see Figure 2 and Figure 3, pages 67 to 70), the apparent signal source e.m.f. E' is equal to the open-circuit voltage caused by the signal generator and R_r is the source impedance of the network, which shall be equal to the specified value (see Clause 30). The available power is preferably expressed in decibels (milliwatts).

Where the input signal level to a receiver is expressed in terms of power, it should be clearly understood that the figure refers to the available power, and if it is expressed in terms of voltage, the source e.m.f. is the value referred to. The actual input power may be less than the figure quoted.

For tests requiring the application of very low input signal levels, care shall be taken that interfering signals entering the receiver, in any spurious way, do not influence the results of the measurements. Relative values for maximum permissible interference signal levels are given in the relevant part covering the radio-frequency properties of the receiver under test.

36 Input signal levels, expressed in terms of the available power

If it is deemed desirable to express the values of input signal levels related to the available power, $\frac{E'^2}{4 R_r}$

values indicated in Table II are recommended, of which those given in the first column are preferred values.

In the last two columns approximate values of source e.m.f. E' for two different values of the specified source impedance R_r are given. Corresponding values may be calculated for other impedance values (see Clause 35).

As a first choice, a value of -50 dB(mW) is considered to be convenient.

Table II

Input signal level, expressed in terms of available power			Equivalent source e.m.f. E'	
Recommended values			Approximate values	
Preferred values dB(mW)	Intermediate values dB(mW)	Equivalent available power $\frac{E'^2}{4 R_r}$	For $R_r = 300 \Omega$	For $R_r = 75 \Omega$
- 110	- 120	0.001 pW ^a	1.1 μ V	0.55 μ V
		0.01 pW ^a	3.5 μ V	1.7 μ V
- 90	- 100	0.1 pW ^a	11 μ V	5.5 μ V
		1 pW	35 μ V	17 μ V
- 70	- 80	10 pW	110 μ V	55 μ V
		100 pW	350 μ V	170 μ V
- 50	- 60	1 nW	1.1 mV	550 μ V
		10 nW	3.5 mV	1.7 mV
- 30	- 40	100 nW	11 mV	5.5 mV
		1 μ W	35 mV	17 mV
- 10	- 20	10 μ W	110 mV	55 mV
		100 μ W	350 mV	170 mV
	0	1 mW	1.1 V	550 mV

^a These values may also be expressed in femtowatts (1 fW = 10^{-15} W).

Section 10. Tuning methods

37 General methods of tuning

Tuning shall be carried out using a signal having a test pattern as vision modulation and a suitable audio-frequency tone, for instance 1 kHz sine-wave tone at 30 % modulation depth as sound modulation. The signal shall be of such a level as to give substantially noise-free reproduction, a convenient initial figure being - 50 dB(mW).

If the receiver has a calibrated scale or a channel selection switch marked with channel identification, this is first adjusted to correspond to that of the input signal.

The fine tuning method depends upon both the electrical and mechanical aspects of the design. If the manufacturer's instructions are available, these should be followed.

In the absence of such instructions, the criteria listed below may be used. It is unlikely that all the criteria will be fulfilled for a given tuning condition, so a compromise aimed at optimum performance must usually be adopted.

If an automatic frequency control circuit is included, its effect must be considered when tuning, particularly if it is possible to switch it manually out of operation (see Clause 42).

Tuning criteria:

- tuning indicator;
- picture sharpness;
- colour reproduction;
- rejection of co-channel sound and adjacent channel signals from the picture circuits;
- satisfactory sound reproduction;
- intermediate frequency picture carrier set at the nominal value or the value stated by the manufacturer.

NOTE For each tuning method the difference from the nominal value or the value stated by the manufacturer of the intermediate frequency picture carrier should be measured and recorded. However, in some receiver designs this may not be possible as the intermediate frequency signal may not be accessible.

Where the tuning control is not calibrated, care must be taken to distinguish between the true or possible spurious responses. The spurious responses will not normally meet the above criteria or will be excessively noisy for reasonable input signal levels.

38 Frequency limits of the tuning ranges

Signals shall be applied to the receiver to establish the range of channels in each band to which it is capable of being tuned or to confirm that the extreme channels in the various bands are within its tuning ranges.

Section 11. Tuning sensitivity

39 Definition

The tuning sensitivity is the extent by which the receiver tuning may deviate from the correct condition in order to give rise to a just noticeable effect according to the criteria of Clause 37.

40 Method of measurement

The receiver is set at a chosen channel near the centre of each band as accurately as possible. A signal generator providing a signal of this same channel with test pattern and sound modulation and (unless otherwise specified due to receiver sensitivity), with a signal level of -50 dB(mW) is tuned to the actual operating frequency of the receiver following the procedure specified in Clause 37. The applied method or methods of tuning shall be stated and the actual operating vision carrier frequency determined, e.g. by means of a digital frequency meter.

The frequency of the signal generator is gradually detuned until a just noticeable mistuning has occurred according to the criteria of Clause 37. The detuning process being carried out for both higher and lower frequencies.

The signal generator is then detuned lower in frequency so that a recognizable signal is not received and the reference frequency gradually approached. The signal generator frequency, at which the criteria of Clause 37 are met, is noted and the process repeated approaching the reference frequency from the high-frequency side.

41 Presentation of results

The results of the measurements are presented in the form of a table showing the deviations of frequency in a direction away from the reference frequency for which correct operation is maintained and the frequencies at which correct operation is achieved approaching the reference frequency from both directions. The particular criteria of Clause 37 that are not complied with when detuning are to be noted.

Section 12. Automatic frequency control performance characteristics

42 Introduction

Automatic frequency control (A.F.C.) means a device which automatically tunes a receiver very closely to the frequency of a sufficiently strong signal if the operating frequency (see Clause 48) of the receiver itself, in the absence of any control, would deviate from the frequency of the signal within certain limits. From measurements, the values of frequency errors, pull-in range, hold-in range, etc., can be determined.

The method of measurement described in Clauses 43 and 44 is used where the receiver design is such that an i.f. signal can be conveniently injected. However, in some designs the appropriate terminals are not available, in which case a measurement of tuning sensitivity is carried out as described in Section 11.

43 Method of measurement

The receiver is set at a chosen channel near the centre of each band, as accurately as practicable.

A signal generator, providing a signal on this same channel, with test pattern and sound modulation and (unless otherwise specified, due to receiver sensitivity) with a signal level of -50 dB(mW), is tuned to the actual operating frequency of the receiver, following a procedure specified in Clause 37, the applied method or methods of tuning to be stated and the actual operating vision-carrier frequency being determined e.g. by means of a digital frequency meter.

A second signal generator, coupled loosely to the receiver, is adjusted to the intermediate frequency until the beat-note observed on the video signal, oscillographically or on the picture display screen, has reached zero. The frequency of the first signal generator (the signal frequency) is then detuned slightly and the change in intermediate frequency is determined by readjusting the second signal generator. This process is repeated, measurements being made for both increasing and decreasing signal frequency, because the relation between the departure of the latter frequency from the initial operating frequency and the resulting change in the intermediate frequency is, as a rule, irreversible.

Measurements are normally carried out at a frequency near the middle of each of the tuning ranges of the receiver. The measurements may be repeated at other frequencies and input signal levels.

Where a tuning indicator, coupled to the automatic frequency control, is provided, this shall be used to carry out the initial adjustment according to Clause 37.

Where no such tuning indicator is provided, but a switch is incorporated to disconnect the automatic frequency control, the initial adjustment shall be made with the switch in the "off" position.

44 Presentation of results

The results of the measurements by the first method are presented graphically by plotting as abscissa the difference between the signal frequency and the reference frequency, plus or minus being indicated, and as ordinate the frequency error, corresponding to the change in i.f. frequency. Both scales shall be linear, and the frequency expressed in megahertz or kilohertz. Arrows point in the direction in which the change in signal frequency takes place.

As a reference, the initial operating frequency shall be chosen.

An example of such a curve, representative for automatic frequency control, is shown in Figure 5, page 71.

Section 13. Operating frequency and its stability

45 Introduction

The operating frequency is the actual value, at any time, of the frequency at which the receiver operates, according to a specified method of tuning (see Clause 37). This frequency may differ from the one to which the receiver was tuned originally.

This section deals with measurements of the variation of the operating frequency of a receiver with respect to time, temperature, supply voltage and input signal level. The sign of the variation of operation frequency relative to any reference operating frequency shall be included in the results, since the effect upon the receiver performance may be different.

The operating frequency may be influenced by the operation of an automatic frequency control if present; its performance characteristics are assessed according to Section 12.

Various measurements can only be adequately performed when the operating frequency of the receiver is reasonably stable; in case of doubt, it is advisable to check the operating frequency stability and to measure the period of initial variation of operating frequency before proceeding to other measurements.

See Clause 47 and following clauses.

46 Method of measurement

The operating frequency is measured by tuning a signal generator, the tuning controls of the receiver remaining in a fixed position, following a procedure specified in Clause 37.

The operating frequency is subsequently determined by assessing the frequency of the signal generator with a suitable frequency measuring device.

The chosen method of tuning shall be stated with the results.

47 Variation of operating frequency with time

If no other influence is present, the variation of the operating frequency with time is mainly due to the temperature dependence of the component characteristics and the internal heating of the receiver. It is expressed as the frequency difference including its sign, in kilohertz, between the actual operating frequency and an arbitrary reference frequency, as a function of time.

48 Method of measurement

The value of the variation of the operating frequency with time shall be derived from a series of measurements of the operating frequency in a specified period, under constant supply voltage, ambient temperature and relative humidity, without touching the tuning controls.

If the receiver is provided with a switchable automatic frequency control device, the measurements should be carried out with it both operative and inoperative.

NOTE Where the automatic frequency control device is automatically switched off during manual tuning and automatically becomes operative at the end of the tuning procedure, the receiver shall not be considered to be provided with switchable A.F.C.

If applicable, it is recommended that the measurement be repeated at the lowest and the highest values of the ambient temperature to be encountered in practice. Measurements may also be repeated for a range of ambient temperatures.

49 Period of initial variation of operating frequency

The period of initial variation of operating frequency is the time elapsing between initial switching on and the establishment of a condition in which the frequency stays within a specified tolerance. The initial variation of operating frequency has two values, corresponding to the upper and lower limits of the frequency variation with respect to the reference operating frequency.

50 Method of measurement

Before the commencement of the measurements, the receiver shall be switched off for a sufficiently long period for all parts of the receiver to attain approximately the test-room temperature.

The duration and the extent of the initial variation of operating frequency shall be derived from the results of a series of measurements of the operating frequency.

Time is measured from the moment of switching on, but the frequency measurements begin as soon as these are performable.

51 Presentation of results

The variation in frequency is plotted as a function of time in a curve having, as abscissa, the time in minutes on a logarithmic scale and, as ordinate, the frequency change in kilohertz on a linear scale.

As reference, the operating frequency at 1 min or, where necessary, 5 min after the initial switching on may be chosen.

An example of curves showing the initial variation of operating frequency Δf_i , its duration, t_i , is given in Figure 6, page 72.

52 Operating frequency as a function of the supply voltage

A variation in the supply voltage may result in a change of the operating frequency of a receiver. The operating frequency is determined according to Clause 46 as a function of the supply voltage, the latter being varied within the limits of overvoltages and undervoltages as laid down in Section 6.

This measurement shall not be performed during the period of initial variation of operating frequency.

53 Presentation of results

Curves representing the operating frequency as a function of the supply voltage are plotted with the frequency variation as ordinate, expressed in kilohertz, on a linear scale, the frequency at nominal supply voltage being chosen as reference point. The supply voltage variation is expressed as a percentage on a linear horizontal scale.

An example of a curve showing the operating frequency as a function of the supply voltage is given in Figure 7, page 72.

54 Operating frequency as a function of the input signal level

A variation in the input signal level may result in a change of the operating frequency of a receiver. The operating frequency is determined according to Clause 46 as a function of the radio-frequency input signal level, the signal applied being varied over the full range of recommended values, in accordance with Section 9.

The measurement shall not be performed during the period of initial variation of operating frequency.

NOTE For practical reasons, and if applicable, this measurement may be combined with the A.G.C. measurement in accordance with Clause 118.

55 Presentation of results

Curves representing the operating frequency as a function of the input signal level are plotted with the frequency variation, expressed in kilohertz, as ordinate on a linear scale, the recommended reference value depending on the receiver sensitivity being that obtained with an input signal level of -50 dB(mW). The input signal is expressed in decibels on a horizontal linear scale.

An example of a curve showing the operating frequency as a function of the input signal level is given in Figure 8, page 73.

Section 14. General mechanical properties of tuning systems

56 Introduction

The following general properties determine the quality of the mechanical part of the tuning system.

They apply to manually tuned receivers, to receivers with presettable tuning systems, and to the process of tuning such presettable systems to the required channel.

57 Mechanical tuning characteristic

The mechanical tuning characteristic of a receiver is understood to mean the travel, for a certain change in frequency, of a point on the periphery of the part of the tuning control normally handled. It is expressed in millimetres per kilohertz or megahertz depending upon the frequency band and total control range.

This measurement shall preferably be made at the measuring frequencies specified in Section 7. Care shall be taken that the results of the measurements are not influenced by play in the tuning mechanism (see Clause 60) and that allowance is made for the effect of any automatic frequency control system. If such a system is available and switchable, measurements shall be made for both conditions.

58 Tuning dial characteristic

The tuning dial characteristic of a receiver is understood to mean the dial length corresponding to a certain change in frequency. It is expressed in millimetres per kilohertz, megahertz or by channel numbers.

These measurements shall preferably be made at the measuring frequencies specified in Section 7.

59 Calibration error

The difference between the operating frequency of a receiver and the indication read on its dial is the calibration error of the receiver at that operating frequency. It is expressed in kilohertz or megahertz and its maximum value for each tuning range shall be stated, together with the chosen method of tuning, as described in Clause 37, using a signal of known frequency, its accuracy being stated with the results.

The calibration error shall preferably be determined at the measuring frequencies specified in Section 7 and unless otherwise specified at an input signal level of -50 dB(mW).

Care shall be taken that the results of the measurement are not influenced by play in the tuning mechanism (see Clause 60).

If necessary, the calibration error shall be determined by tuning the receiver in both directions of the frequency scale.

The receiver shall have reached its steady temperature state before measurements are started.

NOTE This measurement is significant only if the dial has a graduated and calibrated scale.

60 Play in the tuning mechanism

Play in the tuning mechanism is separated into play of the tuning knob and play of the indicator.

Measurement of play shall be made by tuning the receiver twice to the same frequency, turning the tuning knob first in one direction and then in the opposite direction. The two adjustments to the same operating frequency shall be ascertained by the criteria of Clause 37 or by the method using an auxiliary generator tuned to the intermediate-frequency of the receiver, analogous to that of Clause 43. In case of play, two different positions of the tuning knob and likewise two different positions of pointer will be found.

The play of the tuning knob is defined as the angular difference between the positions of the tuning knob found by tuning in opposite directions to the same frequency. The travel between the two positions of the knob may be translated to kHz at any operating frequency of the receiver and the results compared, with the mechanical tuning characteristic in accordance with Clause 57.

The play of the indicator is defined as the ratio of the difference between the two indicated positions, found by tuning in opposite directions to the total movement of the pointer. Also, in this case, the difference between the two positions may be converted into kHz and the results compared, with the tuning dial characteristic in accordance with Clause 58.

Section 15. Performance characteristics of pre-settable tuning systems

61 Introduction

Pre-settable tuning systems can be divided into three groups:

- a) mechanical systems, in which one of a number of pre-selected frequencies is chosen, either in a purely mechanical way, or by means of a suitable mechanism, such as an electric motor;
- b) electrical systems, in which one of a number of pre-selected frequencies is chosen by means of presettable switches, either directly, by actuating a motor-driven switching system, or applying a pre-selected potential to a voltage-dependent reactor;
- c) systems using a combination of both methods.

Any system may or may not be equipped with a correcting system of automatic frequency control, according to Section 12.

The tuning errors that may occur and their dependence on various conditions shall be determined.

62 Methods of measurement

Receivers with a presettable tuning system which are not provided with automatic frequency control shall initially be tuned according to the manufacturers instructions to one of the recommended frequencies of Section 7, this being the operating frequency.

Method (a)

During the following frequency measurements, no radio-frequency input signal shall be applied.

The oscillator frequency f_{00} , corresponding to the operating frequency, shall be measured and used as the reference frequency for this series of measurements.

A starting position, corresponding to a different frequency from that chosen for measurement is selected. That chosen for measurement is now selected and the resulting oscillator frequency measured. This procedure is repeated until a sufficient number of frequency measurements has been obtained, but at least ten times, resulting in e.g. ten, possibly different, frequencies f_{01} to f_{010} .

The differences between these frequencies are the tuning errors, which shall be presented in the following way:

- a) The individual tuning error:

$$\Delta f_i = f_{0i} - f_{00} \text{ (kHz)}$$

$$i = 1 \dots n$$

- b) The mean tuning error for n measurements:

$$\overline{\Delta f_{(n)}} = \frac{1}{n} \sum_{i=1}^{i=n} \Delta f_i \text{ (kHz)}$$

c) The standard deviation from the mean tuning error for n measurements:

$$S_{(n)} = \pm \sqrt{\frac{1}{n-1} \sum_{i=1}^{i=n} (\Delta f_i - \overline{\Delta f_{(n)}})^2} \text{ (kHz)}$$

If the mean tuning error or the standard deviation depends on the magnitude and sense of the difference between the frequency of the starting position and the chosen operating frequency, the dependence of the values of the mean tuning error and the standard deviation can be determined and given in graphical form.

The measurements shall be repeated with another combination of selections, from which the most unfavourable performance shall be derived and stated with the results.

The measurements shall also be repeated at other frequencies described in Section 7.

If the accuracy of tuning depends on the force with which a button is pressed or on the voltage applied to the driving mechanism, these values shall be varied between their permissible limits and quoted with the resulting tuning errors at these limits.

Method (b)

In some cases, it may be inconvenient or impossible to measure the oscillator frequency, in which case after tuning the receiver to the selected operating frequency, the radio-frequency input signal shall remain connected.

A starting position, corresponding to a different frequency from that chosen for measurement is selected. That chosen for measurement is now selected and the sound and picture reproduction noted for compliance with the criteria of Clause 37. This procedure is repeated until a sufficient number of observations has been made, at least ten, resulting in, e.g. ten, possibly different, tuning conditions. Measurements shall also be repeated at other frequencies as described in Section 7.

If the accuracy of tuning depends on the force with which a button is pressed or the voltage applied to the driving mechanism, these values shall be varied between their permissible limits and quoted with the resulting observations at these limits.

63 Presentation of results

Method (a)

In case the mean tuning error or the standard deviation depends on the sense and the frequency spacing between the frequency of the starting position and the chosen operating frequency, these relations shall be presented graphically by plotting, as abscissa, the difference between the frequency of the starting position and the chosen operating frequency, plus or minus being indicated, and, as ordinate, the corresponding mean tuning error $\overline{\Delta f_{(n)}}$ with its sign, and the standard deviation $|S_{(n)}|$. Both scales shall be linear, frequency being expressed in kilohertz. The operating frequency corresponding to the reference frequency f_{00} and the number of measurements n shall be given with the results.

Figure 9, page 73, shows an example of curves giving the mean tuning error and the standard deviation for a presettable tuning system, as functions of the difference between the frequency of the starting position and the chosen operating frequency.

Method (b)

The number and proportion of the observations in which the criteria of Clause 37 are met should be tabulated, and the effects recorded for the occasions when the criteria are not met.

Chapter III. Geometrical properties of the picture

Section 16. Picture size

64 Definition

The picture size as given by the dimensions of the available picture reproduction area is defined by the following three quantities, maximum picture height in centimetres, maximum picture width in centimetres, and effective picture area in square centimetres. It is assumed that under standard measuring conditions, the visible part of this area is completely filled with the television picture.

65 Method of measurement

The maximum picture height and width are determined by means of a sliding gauge, cathetometer or other suitable device. To ascertain the effective picture area, a photograph of the picture reproduction area may be taken from a point situated on the optical axis of this area at a distance of ten times the maximum picture height. From this photograph the effective picture area may be determined.

66 Presentation of results

The results shall include a note of which method of measurement has been used. This is because the results obtained by the photographic method are not directly comparable with those obtained by means of a gauge or similar device.

Section 17. Curvature of picture screen

67 Definition

The curvature of the picture screen is defined by the ratio between the picture depth and the maximum picture height or maximum picture width, whichever has the greatest curvature, only the selected one being stated with the result. The picture depth is defined as the distance between two geometrical planes, both perpendicular to the optical axis, one going through the point nearest to the observer and the other going through the most distant points of the visible reproduction area.

68 Method of measurement

The picture depth may be measured with the aid of a travelling microscope or other suitable means.

Section 18. Geometrical distortion

69 Introduction

Any deviation in the reproduced picture from the transmitted signal relationship between time and the co-ordinates of the picture elements is a geometrical distortion. Geometrical distortions can be divided into three categories; these are described in Clauses 70, 73 and 76.

70 Influence of mains supply related effects on geometrical distortion

A part of the total geometrical distortion may be caused by effects related to the mains supply. These are most noticeable when the mains supply frequency differs slightly from the field frequency.

71 Method of measurement

The receiver is operated from a mains supply differing by approximately 1 Hz from the field frequency. The excursion of the points in the picture where the greatest vertical or horizontal displacements are observed and the displacements are measured.

72 Presentation of results

The displacements measured are expressed as a percentage of the active horizontal or vertical scan periods as appropriate.

73 Non-linearity of scanning

Distinction is made between horizontal and vertical non-linearity.

Horizontal non-linearity is evaluated by means of the relative deviation of the horizontal velocity of the scanning spot projected orthogonally on to the tangential plane through the centre of the picture reproduction area. The relative deviation is the difference between the instantaneous velocity and the mean velocity, expressed as a percentage of the mean velocity of the scanning spot and is given in a graph representing the deviation as a function of time.

Similarly, vertical non-linearity is evaluated by means of the relative deviation of the vertical velocity of the scanning spot.

Both horizontal and vertical non-linearity should be measured in terms of geometrical distortions along a horizontal and a vertical line approximately through the centre of the picture area.

If the relative phase between the mains supply and the received signal vertical scan synchronization significantly influences the non-linearity of scanning, the measurements should be made with the test signal generator not locked to the mains supply frequency but with the difference frequency suitably low.

74 Method of measurement

An electronically generated test pattern may be used consisting of a system of horizontal and vertical lines, both equidistant in time, dividing the picture area into elementary areas of approximately square shape. It is preferable but not essential that these dividing bars themselves be visible but at least the corners of the elementary areas (intersection points of the lines) must be visible. It is desirable to use at least ten dividing bars because the information given by the measurements increases with the number of dividing bars. If desired, the horizontal and vertical lines may be used separately for these measurements. To ascertain the non-linearity, a photograph of the reproduced pattern may be taken under the same conditions as mentioned in Clause 65.

A cathetometer or other suitable means may also be used, as an alternative, but only if the picture is sufficiently stable.

The distance between two adjacent intersection points of the projected pattern is used to determine the instantaneous velocity.

The total distance traversed divided by the number of intervals is used to determine the mean velocity.

75 Graphic representation

The non-linearity is plotted on a linear time scale as abscissa and a linear-percentage scale as ordinate. The equal time intervals corresponding to the divisions of the picture area by the line pattern are marked on the abscissa.

The difference between the instantaneous velocity and the mean velocity is plotted as a percentage of the mean velocity at the centre of each time interval on the abscissa.

In the graph of Figure 11, page 74, short-time non-linearity of scanning, such as results from scan ringing, does not necessarily appear. To measure such deviations, a finer pattern may be necessary, but to reduce measurement errors, measurements may be taken over groups of lines.

76 Picture outline distortion

Picture outline distortions are deviations from a true rectangle of the largest completely visible contour of approximately the correct aspect ratio formed by the test pattern.

77 Method of measurement

An electronically generated test pattern as described in Clause 74 may be used.

If desired, the horizontal and vertical lines may be used separately for these measurements. To ascertain the picture outline distortions, a photograph of the reproduced pattern may be taken under the conditions specified in Clause 65.

The distorted reproduction of the contour of the largest completely visible rectangle formed by the test pattern and having approximately the correct aspect ratio is traced (see Figure 12b, page 75) on this photograph, or a similar projection of the reproduced pattern, on a plane perpendicular to the optical axis.

This contour is normally adequate and should be reproduced with the results. If one form of distortion predominates, it may be measured in accordance with the following methods.

The corner points A, B, C and D are marked and the auxiliary lines AB, BC, CD, DA, KF and HE are then drawn so that AE = EB, BF = FC, CH = HD, DK = KA (see Figure 12b).

The distance between AB and the point of the contour lying farthest away from AB inside the quadrilateral ABCD is called a_1 .

The greatest distance between the line AB and that part of the contour between A and B lying outside the quadrilateral ABCD is called a_2 .

The distances b_1 , b_2 , c_1 , c_2 , d_1 and d_2 are similarly defined.

It is possible to specify the following distortion percentages:

horizontal trapezium distortion

$$T_H = \frac{AD - BC}{AD + BC} \cdot 100 \%$$

and:

vertical trapezium distortion

$$T_V = \frac{AB - DC}{AB + DC} \cdot 100 \%$$

If the contours AB and DC lie completely outside the quadrilateral ABCD, only a_2 and b_2 can be measured and the

horizontal barrel distortion

$$B_H = 2 \cdot \frac{a_2 + b_2}{AD + BC} \cdot 100 \%$$

If the contours AB and DC lie completely within the quadrilateral ABCD, only a_1 and b_1 can be measured and the

horizontal pincushion distortion

$$C_H = 2 \cdot \frac{a_1 + b_1}{AD + BC} \cdot 100 \%$$

similarly if only c_2 and d_2 can be measured the

vertical barrel distortion

$$B_V = 2 \cdot \frac{c_2 + d_2}{AB + CD} \cdot 100 \%$$

and if only c_1 and d_1 can be measured the

vertical pincushion distortion

$$C_V = 2 \cdot \frac{c_1 + d_1}{AB + CD} \cdot 100 \%$$

Parallelogram distortion is expressed by the angle α in degrees.

Ripple distortion of the contour is present when the contours AB, CD, BC and DA show undulations (see Figure 12b, page 75).

If desired, the peak-to-peak value of such undulations or oscillations can be expressed as a percentage of picture height or width (Figure 12C, Figure 12d and Figure 12e, pages 75 and 76), the values being taken from the contour reproduction.

Greater distortions of picture outline may occur nearer the centre of the screen than that defined by the largest completely visible rectangle of the test pattern. In this case, the measurements should be repeated for smaller rectangles and the sizes of all the rectangles used recorded with the results.

Since the picture outline distortion may also be influenced by beam current, additional measurements may be made by increasing the background level of the pattern. The background level or levels used should be recorded with the results as a percentage of the signal voltage difference between black level and white level.

Section 19. Overall geometrical distortion alternative method of measurement

78 Definition

This measurement procedure provides an overall indication of the scanning non-linearity and picture outline distortion. It may be used to give more rapid results than the separate methods described in Section 18.

79 Method of measurement

A grill pattern is applied to the receiver having at least 14 horizontal lines and 19 vertical lines.

The vertical lines shall be of approximately sine-squared form with a duration at the half amplitude points of 0.2 μ s to 0.3 μ s. The amount of signal drive applied to the picture tube must be such that any defocusing that may occur does not affect the accuracy of measurement.

Each horizontal line shall consist of a pair of spacially adjacent lines, one in each of the pair of interlaced fields.

The peaks of the horizontal and vertical lines shall be at white level and the background normally at black level. In order to ascertain the effect of beam current, the background should be adjustable in level.

The point of intersection of the horizontal and vertical lines nearest to the geometrical centre of the picture is defined. The mean vertical line spacing is determined by measuring the distance between the second vertical line to the left and the second vertical line to the right of the centre intersection and dividing by 4.

The mean horizontal line spacing is determined in the same way with the second horizontal lines above and below the centre intersection.

Using the mean spacing as a reference, the horizontal displacements of the vertical lines from their theoretically correct positions along all the horizontal lines are measured. The process is then repeated for the vertical scan direction by measuring the vertical displacements of the horizontal lines along all of the vertical lines.

The measurements may be conveniently carried out by photographing the pattern. Where the picture is sufficiently stable, measurements may be carried out using a sliding gauge, cathetometer, or other suitable device.

80 Presentation of results

The displacements of the intersections of the pattern are to be expressed as a percentage of the maximum picture width and height respectively (see Section 16). They are to be tabulated identifying the intersections by assigning a pair of co-ordinates obtained by numbering the lines in the direction of scan, the first representing the vertical scan direction and the second, the horizontal scan direction (see Figure 12f, page 77).

Section 20. Convergence errors

81 Definition

Convergence errors are the extent to which all three electron beams of a colour display tube fail to converge upon a common phosphor triad over the entire screen area.

82 Method of measurement

A grill pattern is applied to the receiver having at least 14 horizontal lines and 19 vertical lines.

The vertical lines shall be of approximately sine-squared form with a duration at the half amplitude points of 0.2 μ s to 0.3 μ s. The amount of signal drive applied to the picture tube must be such that any defocusing that may occur does not affect the accuracy of measurement.

Each horizontal line shall consist of a pair of spacially adjacent lines, one in each of the pair of interlaced fields.

The background of the patterns shall be at black level and the peaks of both horizontal and vertical lines shall be at white level.

The vertical and horizontal separation between the red and green components and the vertical and horizontal separation between the blue and green components is measured along the vertical and horizontal lines at their intersections (see Figure 12f).