Recommendation R27-1993
Audio automatic measurement equipment

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1. Introduction

This Technical Recommendation sets out the requirements for equipment for the automatic measurement of the quality of audio circuits. These requirements have been determined as a result of discussions between broadcasters and representatives of the telecommunication administrations. The Recommendation outlines the parameters to be measured and the facilities that must be offered by the equipment, but does not specify in detail how the measurements are to be made and the results processed. Thus, manufacturers are free to adopt any appropriate design that will furnish the desired results. However, it is evident that it would be advantageous to control the measurement sequence by stored programs, thus permitting the use of several different measuring sequences, each suited to the requirements of individual users and individual applications. On the other hand, it is emphasised that extreme sophistication should be avoided since the equipment should be relatively inexpensive to facilitate its widespread introduction. *Appendix 1* defines the measurement sequence required by the EBU for measurements on wide-band audio circuits.

2. General

The automatic measurement equipment shall consist of either two units:

- sending unit;
- receiving unit

or

- a combined sending and receiving unit of modular construction to permit send-only or receive-only facilities.

It must be capable of measuring the following parameters of audio circuits:

1) received level (insertion gain);
2) frequency/attenuation distortion (frequency response);
3) harmonic distortion:
4) signal-to-noise ratio unweighted, and weighted in accordance with ITU-R Recommendation BS.468-3 [1];
5) interchannel gain and phase difference;
6) interchannel crosstalk and circuit transposition;
7) compander linearity;
8) expanded noise.

These parameters are further defined in *Section 4*.

As implied by 5) and 6), the equipment must provide for measurements on pairs of circuits as used for stereophonic transmissions, but the physical design should preferably be such that this capability is provided by optional plug-in units thus making it possible to have:

a) a monophonic system for the measurement of a single circuit;

b) a stereophonic system for the simultaneous measurement of pairs of circuits;

c) user conversion between a) and b) by the addition of the appropriate plug-in modules and, possibly, minor internal wiring changes.

3. Start/source programme identification signal

The sequence of audio test signals shall be preceded by a start/source/programme identification signal which will instruct the receiving unit to start the measurement sequence, will identify the source of the test signals and will indicate which of the stored measurement programmes is to be used. This signal shall be sent by frequency- shift keying at 110 baud in the IS0-7 code with one even parity bit and two stop bits. The mark frequency shall be 1650 Hz and the space frequency 1850 Hz. The start/source/programme identification signal shall consist of the character SOH (start of heading) followed by four alphanumeric characters for source identification plus one character for special signalling, followed by a number from 00 to 99 for measurement programme identification, followed by ETX (end of text). The mark frequency shall be transmitted for at least 18 ms (two bits) before the start bit of the SOH character. The end of the second stop bit of the ETX character defines the start of the measurement sequence. The start/source/programme identification signal shall be sent at a level 12 dB below TEST level[1].

4. Parameters

4.1. Received level (insertion gain)

1020 Hz is sent at TEST level; the received level shall be measured and the result expressed in dB with reference to TEST level.

4.2. Frequency/attenuation distortion (frequency response)

The received level shall be measured at a number of discrete frequencies. These frequencies are defined in the individual measurement program. The sending level shall be 12 dB below TEST level.

The results shall be displayed in dB relative to the received level at 1020 Hz sent at 12 dB below TEST level.

It is not considered acceptable to use the level received from parameter described in *Section 4.1*.

4.3. Distortion

Total harmonic distortion shall be measured at 60 Hz and 1020 Hz.

Second harmonic distortion (K_2) shall be measured at 1020 Hz.

Third harmonic distortion (K_3) shall be measured at 60 Hz.

The sending level shall be 9 dB above TEST level. The receiving instrument shall give an RMS indication of the harmonic content and the results shall be expressed in dB with respect to the received levels of the fundamentals.

Note: The frequency of l020 Hz has been chosen not to be a sub-multiple of a digital sampling rate.

4.4. Signal-to-noise ratio

The sending unit shall suitably terminate the input to the circuit under test and the receiving unit shall measure the highest quasi-peak value, either weighted or unweighted, over a period of eight seconds, consistent with ITU-R Recommendation BS.468-3. The results shall be given in dB with respect to the received TEST level at 1020 Hz or at maximum permitted level (+ 9 dBm0). Selection of the weighted or unweighted characteristic and the level reference shall be made by a manually operated switch on the receiving unit. The switch shall be protected against unintentional operation and its position shall be indicated in the results. The normal position will correspond to the weighted characteristics.

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1. Since the nominal working levels vary from broadcaster to broadcaster, and from PTT Administration to Administration, it is not desirable to specify absolute levels. The EBU has therefore defined TEST level as the level 9 dB below the maximum permitted level at the point at which the measurement is made. Manufacturers of automatic audio measurement equipment should therefore choose to make TEST level equal to a convenient fixed level (e.g. 0 dBm0). Switching should be provided so that TEST level may be set to +6 dB, 0 dB or -3 dB with respect to 0.775 V_{RMS}. This switch must be protected against unintentional operation. For PTT use, consideration should also be given to providing - 20 dB with respect to 0.775 V_{RMS}.

4.5. Compander linearity

800 Hz tone is sent during three consecutive time intervals, at + 6 dB, - 6 dB and + 6 dB with respect to TEST level.

The receiving unit shall indicate the levels as received.

4.6. Expanded noise

The test element used for the measurement of distortion at 60 Hz may be used for the measurement of expanded noise. A high-pass filter (f_o v 400 Hz, *a* w 60 dB at 60 Hz) is used to eliminate second- and third-order harmonics. The remaining noise will be measured, either weighted or unweighted, with a quasi-peak response.

Stereo measurements

In addition to the parameters defined in *Sections 4.1.* to *4.6.*, the following parameters shall also be measured.

4.7. Interchannel gain and phase difference

level between the signals present at its two inputs A and B. Measurements shall be made at all frequencies specified for the measurement of freqency/attenuation distortion. The instrument shall preferably indicate the polarity of the error.

The results shall be expressed in dB and degrees, taking the A channel as reference.

4.8. Interchannel crosstalk and circuit transposition

The transmitter shall send a tone at 2040 Hz at a level of 12 dB below TEST level, first from output A and then from output B, the unused circuit being correcly terminated. The receiver shall measure the level of the unwanted signal in the terminated circuit. The results shall be expressed in dB relative to the level in the used circuit. The crosstalk test signal shall be used to test for circuit transposition and an indication shall be given if there is an error.

5. Equipment characteristics - sending unit

Output impedance:	t 10 W
Level error:	t 0.2 dB
Frequency error:	t 1%
Total harmonic distortion at maximum output level (+ 21 dB)	
except at 60 Hz and 1020 Hz:	t 0.5%
at 60 Hz and 1020 Hz:	t 0.1%
Signal-to-noise ratio (weighted):	w 80 dB
Level difference between outputs 1 and 2:	t 0.2 dB
Phase difference between outputs 1 and 2:	t 2°

All durations and timings related to the beginning of the sequence must not deviate by more than 10 ms from the values given in *Appendix 1.*

6. Equipment characteristics - receiving unit

Input impedance		u 20 kW
Minimum accuracy and range:		
Level measurements:		
Range:	Signal:	+ 20 dB to - 45 dB
	Noise:	- 20 dB to - 70 dB
		with respect to 0.775 V_{RMS}

Error:	v + 0.2 dB over the range + 15 to - 20 dB v + 0.5 dB over the range - 20 to - 50 dB v + 1.0 dB over the range - 50 to - 60 dB v + 3.0 dB over the range - 60 to - 70 dB with appropriate CCIR band-limiting filters
Frequency range:	20 Hz to 50 kHz
Phase measurement:	
Range:	± 180°
Error:	v 2° over whole range

7. Environmental performance

The characteristics specified in *Sections 5* and *6* are to be maintained over a temperature range of 0–C to + 40–C and with mains supply variations of ±10% from nominal voltage.

8. Modes of operation

It shall be possible to operate the equipment in automatic or manual modes.

8.1. Automatic mode

In the automatic mode, the sending unit shall cycle once through a complete programmed test sequence on receipt of a start signal given either by push-button on the sending unit or by the momentary closing of a remote pair of contacts. The receiver shall, on receipt of the start/identification signal from the sending unit, cycle once through the complete programmed measurement sequence, storing and/or printing the results for subsequent examination.

8.2. Manual mode

a) Sending unit

In the manual mode, it shall be possible to cycle the sending unit through the measuring sequence to any chosen test element, upon which the appropriate test signal will be sent continuously. This mode should thus permit the sending unit to operate with manual measuring equipment. It shall also be possible to manually adjust the output signal to any frequency within the range 40 to 15 000 Hz to a resolution of better than 5 Hz. The level shall be adjustable within the range - 12 dB to + 15 dB with respect to TEST level with a resolution of 0.2 dB. The instrument shall indicate the output frequency and level. A flashing warning light shall operate when the output level exceeds TEST level.

b) Receiving unit

In the manual mode, it shall be possible to cycle the receiving unit through the measuring sequence to any chosen parameter measurement to permit the instrument to be used with manual sending equipment. It would be advantageous to display the frequency of the incoming signal.

8.3. Remote control

Both the sending and receiving units should optionally offer the possibility of remote control. This could be either the RS 232 or IEEE 488/IEC 625 interface.

9. Output of results

The results should be made available by one of the following:

a) by direct display via a storage mechanism to permit long-term display of any of the measured characteristics;

b) as a 110 and 300 baud ISO-7 serial data output at a standard RS 232-C interface, selectable between 110 and 300;

c) preferably, a combination of a) and b);

d) optionally, at a standard IEEE 488/IEC 625 interface.

In each case, the parameters measured shall be clearly identified and the source code given. In particular, an indication must be given of whether the signal-to-noise ratio is weighted or unweighted.

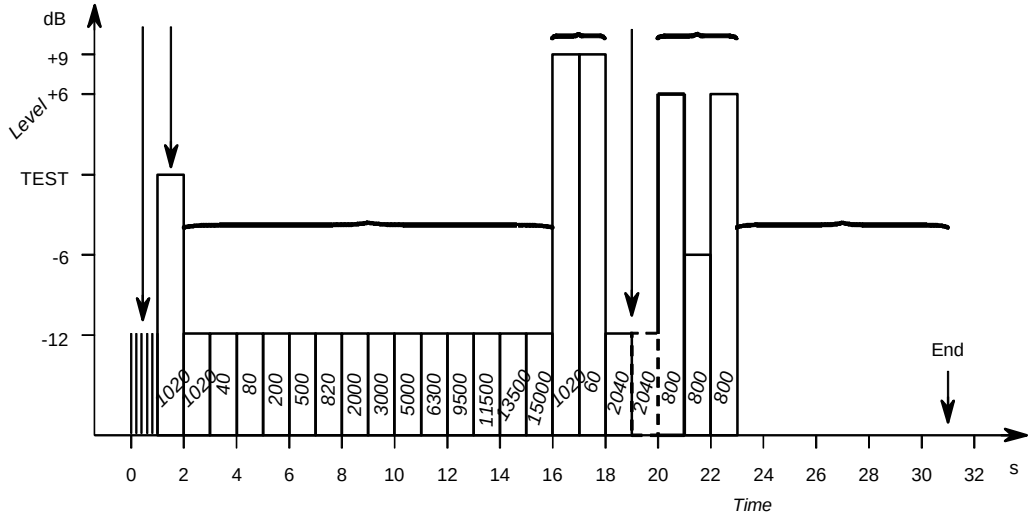
10. Design and construction

In general, the design and construction of the equipment shall conform to the provisions of EBU document Tech. 3215 [2].

It should be noted, however, that the group delay encountered on long circuits may lead to measurement error, particularly at low frequencies. The design of measurement circuits should therefore be such that measurements are made during the last 100 ms of each burst to allow time for the received waveform to stabilise.

Appendix 1
EBU measurement sequence for wide-band audio circuits

The individual test elements shall be arranged as shown in *Fig. 1.*



* The mark frequency shall be transmitted for at least 18 ms before the beginning of the sequence.

Fig. 1 - Test sequence

Bibliography

[1] ITU-R Recommendation BS.468-4: **Measurement of audio-frequency noise voltage level in sound broadcasting**.

[2] EBU document Tech. 3215 (2nd edition, 1980): **Guiding principles for the design of electronic equipment**