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SERIES O: SPECIFICATIONS FOR MEASURING EQUIPMENT

Automatic and semi-automatic measuring systems

AUTOMATIC EQUIPMENT FOR RAPIDLY MEASURING STEREOPHONIC PAIRS AND MONOPHONIC SOUND-PROGRAMME CIRCUITS, LINKS AND CONNECTIONS

Reedition of CCITT Recommendation O.33 published in the Blue Book, Fascicle IV.4 (1988)

NOTES

1 CCITT Recommendation O.33 was published in Fascicle IV.4 of the *Blue Book*. This file is an extract from the *Blue Book*. While the presentation and layout of the text might be slightly different from the *Blue Book* version, the contents of the file are identical to the *Blue Book* version and copyright conditions remain unchanged (see below).

2 In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Recommendation O.33

AUTOMATIC EQUIPMENT FOR RAPIDLY MEASURING STEREOPHONIC PAIRS AND MONOPHONIC SOUND-PROGRAMME CIRCUITS, LINKS AND CONNECTIONS

(Malaga-Torremolinos, 1984; amended at Melbourne, 1988)

1 General

An automatic measuring equipment for sound-programme circuits must be capable of rapidly measuring all relevant parameters necessary for checking the quality of such circuits. The parameters to be measured and the facilities that must be offered by the equipment are outlined in this specification but neither the measurement method nor the processing of the results are specified in detail. Manufacturers are thus free to adopt any appropriate design that will fulfil the requirements of this specification. However, it is evident that it would be advantageous to control the measurement sequence by stored programs. The use of different measuring sequences, each suited to the requirements of individual users and individual applications should be possible.

It should be noted that the equipment will meet the requirements of Recommendations N.12 [1] and N.13 [2]. However, measurement of every parameter specified in Recommendations N.10 [3], N.21 [4] and N.23 [5] is not possible, e.g., group delay/frequency response.

2 Basic design

The equipment shall consist of either two units, send and receive, or a combined sending and receiving unit of modular construction permitting a send-only or receive-only facility.

The measurement results should be made available by a direct display via a storage mechanism to permit a long-term display of any measured parameter.

The results of the measurements are not only to permit an immediate decision by the staff in the field, but also to provide the basis for later exact evaluation by the responsible transmission engineer. It is preferred that the results be available also as a 110- and 300-baud ISO-7 bit serial data output [6] at a standard RS 232-C [7] interface, selectable between 110 and 300 bauds, or optionally, at a standard IEEE 488/IEC 625 [8] interface.

In each case, the parameters measured must be clearly identified and the source code given (see § 2.1).

The equipment must be capable of measuring at least the following parameters:

a) received level (insertion gain);

b) frequency/attenuation distortion (frequency response);

c) harmonic distortion (nonlinear distortion);

d) signal-to-noise ratio unweighted, and weighted in accordance with CCIR Recommendation 468 [9];

e) compandor linearity;

f) programme modulated noise and expanded noise.

These parameters are further defined in § 4.

In addition, the equipment must be capable of measuring in channels A and B at least the following parameters:

g) interchannel difference in gain and phase;

h) interchannel crosstalk and circuit transposition.

The stereo parameters are further defined in § 5.

The physical design should preferably be such that this capability is provided by user conversion of the monophonic equipment by the addition of appropriate plug-in units and, possibly, minor internal wiring changes.

The equipment will be required to send audio test signals at amplitudes consistent with that required at the user's test point. Since the nominal working levels vary from broadcasting organization to broadcasting organization, and from PTT Administration to Administration, it is not desirable to specify absolute levels. “TEST” level has therefore been defined as the level 9 dB below the maximum permitted level at the point at which the measurement is made. TEST level corresponds to an absolute value of 0 dBm0 when measured at a point of zero relative level (0 dBr) [10]. Manufacturers of automatic measurement equipment should therefore choose to make TEST level equal to a convenient level (e.g. 0 dBm0).

At this fixed level, the send frequency amplitudes in the programme measurement sequences will conform to the definitions for permitted maximum level (+9 dBm0s), alignment level (0 dBm0s) and measuring level (–12 dBm0s) given in Recommendation N.15 [11].

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 r.m.s. This switch must be protected, particularly for absolute values greater than 0 dBm0, against unintentional operation, e.g. by mounting it inside the instrument. Consideration should also be given to providing –20 dB with respect to 0.775 V r.m.s.

2.1 *Start/source/program identification*

The measurement sequence will be chosen to suit the requirements of individual applications. Defined measurement programs are annexed to this Recommendation. The sequence of operations of the measurement program together with the associated time units are shown.

The sequence of audio test signals is to be preceded by a start/source/program identification signal which will:

- instruct the receiving unit to start the measurement sequence;
- identify the source of the test signals;
- indicate which of the stored measurement programs is to be used.

The start/source/program identification signal using the ISO-7 [6] code with one even parity bit and two stop bits, is to be sent by frequency-shift keying with a mark frequency of 1650 Hz and a space frequency of 1850 Hz, at a transmission rate of 110 bauds.

The message structure of the identification signal is formed by the following order of characters:

- Start of heading (character “SOH”);
- Source identification (four alphanumeric characters);
- Special signalling (one character);
- Start of text (character “STX”);
- Measurement program identification (two numeric characters 00—99);
- End of text (character “ETX”).

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/program identification signal shall be set at 12 dB below TEST level.

2.2 *Modes of operation*

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

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

2.2.2 *Manual mode*

2.2.2.1 *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 output shall be adjustable within the range –12 dB to +15 dB with respect to 0.775 V r.m.s. 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 0.775 V r.m.s.

2.2.2.2 *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.

2.2.3 *Remote control*

Both the sending and receiving units should optionally offer the possibility of remote control. This could be either the RS 232-C [7] or IEEE 488/IEC 625 [8] interface.

3 Design and construction

It should be noted 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 only after sufficient time has been allowed for the received waveform to stabilize.

In general, the design and construction of the equipment shall conform to national and international provisions, especially in relation to safety requirements and protection against electric shock [12].

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 the parameter in § 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 given an r.m.s. indication of the harmonic content and the results shall be expressed in dB with respect to the received levels of the fundamentals.

In order to avoid overload of carrier-frequency transmission systems, the sending of test frequencies at the maximum permitted level should be strictly in accordance with the prescriptions of Recommendation N.21 [4]. Programs which include distortion measurements should therefore limit the duration of transmission to a single time interval (1 s) and a pause of at least one interval must be allowed when successive distortion measurements are to be made.

It shall be possible to insert the test cycle, the measurement of nonlinearity distortion by either duplication of the stored programmes with and without this measurement or by the use of a non-locking switch.

Note – The frequency of 1020 Hz has been chosen to avoid using 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 CCIR Recommendation 468 [9]. 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 characteristic.

4.5 *Compandor linearity*

820 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 time interval used for the measurement of distortion at 60 Hz may also be used for the measurement of expanded noise. A high-pass filter (f_0 ≤400 Hz, and ≥60 dB/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.

5 Stereo parameters

5.1 *Interchannel difference in gain and phase*

When the stereo modules are used, the equipment shall measure simultaneously the difference in phase and level between the signals present at its two inputs A and B. Measurements shall be made at all frequencies specified for the measurement of frequency/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.

Equipment not employing simultaneous measurement techniques may be acceptable if it can be established that they provide results equivalent to those obtained with simultaneous measurement. The caution given in Recommendation N.21, § 3.8 [4], on avoiding certain frequencies should be observed.

5.2 *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 correctly 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 the channels are interchanged.

6 Equipment characteristics – sending unit

Output impedance[1]:	< 10 ohms
Level error:	< 0.2 dB
Frequency error:	< 1%
Total harmonic distortion at maximum output level,	
(+21 dB): except 60 Hz and 1020 Hz	< 0.5%
at 60 Hz and 1020 Hz	< 0.1%
Weighted noise level output:	≤ –80 dBq0ps
Level difference between outputs A and B:	< 0.2 dB
Phase difference between outputs A and B:	< 2°

[1] Value does not take account of any transformer needed to comply with the requirements of Recommendation N.11 [13] in regard to impedance and balance with respect to earth.

7 Equipment characteristics 2 receiving unit

7.1 *Input impedance*[2]*:* > 20 kohms

7.2 *Minimum accuracy and range*

7.2.1 *Level measurements*

Range:

Signal: +20 dB to –45 dB
Noise: –20 dB to –70 dB
with respect to 0.775 V r.m.s.

Error:

≤ ± 0.2 dB over the range +15 to –20 dB
≤ ± 0.5 dB over the range –20 to –50 dB
≤ ± 1.0 dB over the range –50 to –60 dB
≤ ± 3.0 dB over the range –60 to –70 dB

Note – Noise measurements are band limited to comply with the frequency response given in Annex 1, CCIR Recommendation 468 [9].

Frequency range: 20 Hz-50 kHz

7.2.2 *Distortion measurement*

Range: down to 0.3% (–50 dB)
Error: (± 1 dB)

7.2.3 *Phase measurement*

Range: ± 180
Error: +2 over whole range

8 Operating equipment

The electrical performance requirements shall be met when operating at the climatic conditions as specified in Recommendation O.3, § 2.1.

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[2] Value does not take account of any transformer needed to comply with the requirements of Recommendation N.11 [13] in regard to impedance and balance with respect to earth.

ANNEX A

(to Recommendation O.33)

Measurement sequence for monophonic sound-programme circuits

Time interval (seconds)	Sending unit		Programme number: 00
	Frequency (Hz)	Level (dBm0)	Measuring function
1	1650/1850	−12	Start/source/programme identification
1	1 020	0	Received level
1	1 020	−12	Frequency response
1	40	−12	
1	80	−12	
1	200	−12	
1	500	−12	
1	820	−12	
1	1 900	−12	
1	3 000	−12	
1	5 000	−12	
1	6 300	−12	
1	9 500	−12	
1	11 500	−12	
1	13 500	−12	
1	15 000	−12	
1	1 020	+9	Total harmonic distortion
1 [a)]	–	–	
1	60	+9	
1	820	+6	Compandor test
1	820	−6	
1	820	+6	
8	–	–	Signal-to-noise ratio

[a)] Waiting interval.

ANNEX B

(to Recommendation O.33)

Measurement sequence for stereophonic pairs of sound-programme circuits

Time interval	Channel A Sending unit		Channel B Sending unit		Programme number: 01
Seconds	Frequency (Hz)	Level (dBm0)	Frequency (Hz)	Level (dBm0)	Measuring function
1	1650/1850	−12	–	–	Start/source/programme identification
1	1 020	0	1 020	0	Received level
1	1 020	−12	1 020	−12	Frequency response interchannel Gain and phase
1	40	−12	40	−12	
1	80	−12	80	−12	
1	200	−12	200	−12	
1	500	−12	500	−12	
1	820	−12	820	−12	
1	1 900	−12	1 900	−12	
1	3 000	−12	3 000	−12	
1	5 000	−12	5 000	−12	
1	6 300	−12	6 300	−12	
1	9 500	−12	9 500	−12	
1	11 500	−12	11 500	−12	
1	13 500	−12	13 500	−12	
1	15 000	−12	15 000	−12	
1	1 020	+9	1 020	+9	Total harmonic distortion
1 [a]	–	–	–	–	
1	60	+9	60	+9	
1	2 040	−12	–	–	Crosstalk and circuit transposition
1	–	–	2 040	−12	
1	820	+6	820	+6	Compandor test
1	820	−6	820	−6	
1	820	+6	820	+6	
8	–	–	–	–	Signal-to-noise ratio

[a] Waiting interval.

ANNEX C

(to Recommendation O.33)

Measurement sequence for medium band sound-programme circuits

Time interval (Secs.)	Sending unit		Programme number: 02
	Frequency (Hz)	Level (dBm0)	Measuring function
1	1650/1850	−12	Start/source/programme identification
1	1 020	0	Received level
1	1 020	−12	Frequency response
1	40	−12	
1	80	−12	
1	200	−12	
1	300	−12	
1	500	−12	
1	820	−12	
1	1 400	−12	
1	3 000	−12	
1	5 000	−12	
1	6 300	−12	
1	7 400	−12	
1	8 020	−12	
1	10 000	−12	
1	1 020	+9	Total harmonic distortion
1	–	–	
1	60	+9	
1	820	+6	Compandor test
1	820	−6	
1	820	+6	
8	–	–	Signal-to-noise ratio

ANNEX D

(to Recommendation O.33)

Measurement sequence for narrow-band (telephone type) circuits

Time interval (Secs.)	Sending unit		Programme number: 03
	Frequency (Hz)	Level (dBm0)	Measuring function
1	1650/1850	−12	Start/source/programme identification
1	1 020	0	Received level
1	1 020	−10	Frequency response
1	200	−10	
1	300	−10	
1	400	−10	
1	600	−10	
1	820	−10	
1	1 400	−10	
1	1 900	−10	
1	2 400	−10	
1	2 700	−10	
1	2 900	−10	
1	3 000	−10	
1	3 100	−10	
1	3 400	−10	
1	1 020	+9	Total harmonic distortion
8	–	–	Signal-to-noise ratio

ANNEX E

(to Recommendation O.33)

Measurement sequence for narrow-band (telephone-type) circuits used for sound-programme transmissions which are fitted with compandors

Time interval (Secs.)	Sending unit		Programme number: 04
	Frequency (Hz)	Level (dBm0)	Measuring function
1	1650/1850	−12	Start/source/programme identification
1	1 020	0	Received level
1	1 020	−10	Frequency response
1	200	−10	
1	300	−10	
1	400	−10	
1	600	−10	
1	820	−10	
1	1 400	−10	
1	1 900	−10	
1	2 400	−10	
1	2 700	−10	
1	2 900	−10	
1	3 000	−10	
1	3 100	−10	
1	3 400	−10	
1	1 020	+9	Total harmonic distortion
1	820	+6	Compandor test
1	820	−6	
1	820	+6	
8	–	–	Signal-to-noise ratio

ANNEX F

(to Recommendation O.33)

Measurement sequence for the CMTT three-level test signals (without station announcement) for the alignment of international sound-programme connections

Time interval	Channel A sending unit		Channel B sending unit		Programme number: 05
Seconds	Frequency (Hz)	Level (dBm0)	Frequency (Hz)	Level (dBm0)	Measuring Function
1	1650/1850	−12	–	–	Start/Source/Programme identification
1	–	–	–	–	Pause
1	1 020	−12	1 020	−12	Measurement level (ML)
1	1 020	−12	1 020	−12	
1	1 020	0	1 020	0	Alignment level (AL)
1	1 020	0	1 020	0	
1	1 020	0	1 020	0	
1	1 020	0	1 020	0	
1	1 020	0	1 020	0	
1	1 020	0	1 020	0	
1	1 020	0	1 020	0	
1	1 020	0	1 020	0	
1	1 020	0 [a]	–	–	Permitted maximum [a] level (PML)
1	1 020	0 [a]	–	–	
1	–	–	–	–	Pause
1	–	–	–	–	
1	–	–	–	–	
1	–	–	1 020	0 [a]	Permitted maximum [a] level (PML)
1	–	–	1 020	0 [a]	

[a] Provisionally 0 dBm0 level is to be used. The resulting two-level test signal is required until all transmission systems are capable of carrying sinusoidal signals at +9 dBm0s without producing excessive channel loading or crosstalk into other channels. The active incorporation of the +9 dBm0 level into this sequence will need to be confirmed by CMTT and CCITT.

References

[1] CCITT Recommendation *Measurements to be made during the line-up period that precedes a sound-programme transmission*, Vol. IV, Rec. N.12.

[2] CCITT Recommendation *Measurements to be made by the broadcasting organizations during the preparatory period*, Vol. IV, Rec. N.13.

[3] CCITT Recommendation *Limits for the lining-up of international sound-programme links and connections*, Vol. IV, Rec. N.10.

[4] CCITT Recommendation *Limits and procedures for the lining-up of a sound-programme circuit*, Vol. IV, Rec. N.21.

[5] CCITT Recommendation *Maintenance measurements to be made on international sound-programme circuits*, Vol. IV, Rec. N.23.

[6] CCITT Recommendation *International Alphabet No. 5*, Vol. VIII, Rec. T.50, and International Organization for Standardization *ISO 7-bit serial data output*.

[7] CCITT Recommendation *List of definitions for interchange circuits between data terminal equipment and data circuit terminating equipment*, Vol. VIII, Rec. V.24, and Electronic Industries Association (EIA) Standard RS-232-C *Interface between data terminal equipment and data communication equipment employing serial binary data interchange*.

[8] International Electrotechnical Commission *Interface system for programmable measuring instruments*, IEC Publications 625, 625-1 and 625-2.

[9] CCIR Recommendation *Measurement of audio-frequency noise in sound broadcasting*, Vol. X, Rec. 468, ITU, Geneva, 1986.

[10] CCITT Recommendation *Relative levels and impedances on an international sound-programme connection*, Vol. III, Rec. J.14.

[11] CCITT Recommendation *Maximum permissible power during an international sound-programme transmission*, Vol. IV, Rec. N.15.

[12] European Broadcasting Union (EBU) *Guiding principles for the design of electronic equipment*, Document TECH 3215.

[13] CCITT Recommendation *Essential transmission performance objectives for international sound-programme centres (ISPC)*, Vol. IV, Rec. N.11.

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