INTERNATIONAL TELECOMMUNICATION UNION

ITU-T

J.21

(ex CMTT.505-4)

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

(08/94)

TELEVISION AND SOUND TRANSMISSION

PERFORMANCE CHARACTERISTICS OF 15 kHz-TYPE SOUND-PROGRAMME CIRCUITS – CIRCUITS FOR HIGH QUALITY MONOPHONIC AND STEREOPHONIC TRANSMISSIONS

ITU-T Recommendation J.21

(Formerly Recommendation ITU-R CMTT)

FOREWORD

The ITU-T (Telecommunication Standardization Sector) is a permanent organ of the International Telecommunication Union (ITU). The ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Conference (WTSC), which meets every four years, establishes the topics for study by the ITU-T Study Groups which, in their turn, produce Recommendations on these topics.

The approval of Recommendations by the Members of the ITU-T is covered by the procedure laid down in WTSC Resolution No. 1 (Helsinki, March 1-12, 1993).

ITU-T Recommendation J.21 was revised by ITU-T Study Group 9 (1993-1996) and was approved under the WTSC Resolution No. 1 procedure on the 22nd of August 1994.

NOTE

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

CONTENTS

SUMMARY

This Recommendation contains design objectives for equipment to be developed for the transmission of high-quality type sound-programmes. It gives the parameters to be envisaged and appropriate quality values. Measuring methods for several parameters are specified.

Recommendation J.21[1)]

PERFORMANCE CHARACTERISTICS OF 15 kHz-TYPE SOUND-PROGRAMME CIRCUITS – CIRCUITS FOR HIGH QUALITY MONOPHONIC AND STEREOPHONIC TRANSMISSIONS[2)]

(1974; revised 1978, 1982, 1986, 1990 and 1994)

The ITU-T,

considering

(a) that it is necessary to set transmission standards for sound-programme circuits;

(b) that quality requirements for the hypothetical reference circuit are established for analogue sound programmes;

(c) that advantage should be taken of the technical evolution made possible by the introduction of digital techniques, particularly for mixed analogue and digital circuits,

recommends

that, with due regard to the application constraints, equipment for new circuits shall meet the requirements laid out below.

1 Application

This Recommendation applies to homogeneous analogue or mixed analogue-and-digital circuits.

The requirements below apply to the hypothetical reference circuit (HRC) defined in Recommendation J.11 (formerly ITU-R Recommendation CMTT.502).

For estimation of the performance of circuits shorter or longer than the HRC, see ITU-T Recommendation CMTT.605.

NOTES

1 For all-digital circuits, a separate Recommendation might be envisaged after further study.

2 For further information, ITU-R Report CMTT.496 may be consulted. This Report also draws attention to certain differences between CCIR and OIRT Recommendations.

2 Interface characteristics

2.1 Test conditions

When circuit performance is to be measured, the system output shall be terminated by a balanced test load, nominally 600 Ω resistive.

2.2 Impedance

System input impedance	600 Ω balanced[3)]
System output impedance, provisionally	Low, balanced

---

1) Formerly ITU-R Recommendation CMTT.505-4.

2) For the definition of absolute power, relative power and noise levels, see ITU-R Recommendation V.574.

3) The tolerance, permitted reactance and degree of unbalance need further study.

The open-circuit output level shall not decrease more than 0.3 dB within the nominal frequency range, if the output is terminated by the specified test load.

The reactive part of the source impedance must be restricted to 100 Ω maximum (provisional value) within the nominal frequency range.

This clause alone would however, not rule out a large difference in the reactive parts of the output impedances of a stereophonic pair, and this in turn could lead to difficulties in meeting 3.2.2. This aspect needs further study.

2.3 Levels

Input maximum programme level	+9 dBm0s
Insertion gain (1 kHz at –12 dBm0s)	0 dB
Adjustment error, within	± 0.5 dB
Variation over 24 hours not to exceed	± 0.5 dB
Relative level (see Recommendation J.14)	+6 dBrs

If broadcasting organizations wish to have closer tolerances, it is necessary for the receiving broadcasting organization to insert additional trimming attenuators.

3 Overall performance

3.1 Common parameters

3.1.1 Gain/frequency response

See Table 1.

Reference frequency:	1 kHz (nominal value)
The response shall be measured at:	–12 dBm0s

If broadcasting organizations wish to have closer tolerances, it is necessary for the receiving broadcasting organization to insert additional equalizers.

TABLE 1/J.21

Frequency (kHz)	Response (dB)
$0.04 \leq f < 0.125$	+0.5 to –2
$0.125 \leq f \leq 10$	+0.5 to –0.5
$10 < f \leq 14$	+0.5 to –2
$14 < f \leq 15$	+0.5 to –3

3.1.2 Group delay variation

Differences between the value of group delay at the following frequencies and the minimum value are:

kHz	Δτ (ms)
0,04	55
0,075	24
14	8
15	12

Between the points defined above, the tolerance limit varies linearly on a linear-delay/logarithmic-frequency diagram.

3.1.3 Noise

See Table 2.

TABLE 2/J.21

Noise	Transmission system	
	Analogue	Digital (3 codecs cascaded)
Idle channel noise, maximum (dBq0ps)	–42	–51
Programme-modulatd noise, maximum (dBq0ps)	–30	–39

The measurement to be made with an instrument conforming to ITU-R Recommendation BS.468.

For radio-relay systems, the requirements shall be met for at least 80% of the total time of any 30-day period. For 1% of the time an additional impairment of 4 dB, and for 0.1% of the time an additional impairment of 12 dB is acceptable.

Programme-modulated noise usually only occurs on sound-programme circuits which are equipped with compandors (e.g. types of circuits corresponding to ITU-T Recommendation J.31).

This noise value may be measured with the aid of an auxiliary sinusoidal test signal +9 dBm0s/60 Hz which has to be suppressed by a high-pass filter ($f_o \leq 400$ Hz, $a \geq 60$ dB/60 Hz) before the measuring set.

ITU-R Report CMTT.493 indicates that if a compandor is used, an improved signal-to-noise ratio is necessary to avoid objectional effects with some programme material.

NOTE – For further information on digital systems see ITU-R Report CMTT.647.

3.1.4 Single tone interference

Level of any individual tone:

$$\leq -(73 + \psi) \qquad \text{dBm0s}$$

where ψ is the weighting filter response factor (positive or negative) as given in ITU-R Recommendation BS. 468 at the particular frequency.

For sound-programme transmissions over carrier systems, occurrence of carrier leaks can be expected. For this reason, stop filters may be provided in the carrier frequency path which can be switched in, if required, to suppress the tones otherwise audible in the upper frequency range from 8 to 15 kHz. For a hypothetical reference circuit, it is recommended that the stop filters should have a 3 dB bandwidth of less than 3% referred to the mid-frequency. The use of stop filters which affect frequencies below 8 kHz should be avoided.

3.1.5 Disturbing modulation by power supply

The level of the strongest unwanted side component due to modulation caused by low-order interference components from 50 Hz or 60 Hz mains shall be less than –45 dBm0s with a test signal of 1 kHz at alignment level 0 dBm0s.

3.1.6 Non-linear distortion

Requirements for non-linear distortion are given below in 3.1.6.1 and 3.1.6.2. However, for the measurement of non-linearity in the upper frequency range some problems are described. More information can be found in Annex A.

3.1.6.1 Harmonic distortion

The harmonic distortion shall be measured with the input signal at +9 dBm0s for frequencies up to 2 kHz, and at +6 dBm0s for frequencies above 2 kHz up to 4 kHz.

The duration for which a single tone is to be transmitted at these levels should be restricted in accordance with ITU-T Recommendations N.21 and N.23.

The total harmonic distortion when measured with a true r.m.s. metre shall not be greater than the values in Table 3:

NOTE – If a companding system is used, the selective measuring method should be applied in order to avoid any influence of the programme-modulated noise on the measured values.

TABLE 3/J.21

Input frequency (kHz)	Total harmonic distortion (THD)	Second and third harmonic measured selectively
$0.04 \leq f < 0.125$	1% (–31 dBm0s)	0.7 (–34 dBm0s)
$0.125 \leq f \leq 2.0$	0.5% (–37 dBm0s)	0.35 (–40 dBm0s)
$2.0 < f \leq 4.0$	0.5% (–40 dBm0s)	0.35 (–43 dBm0s)

3.1.6.2 Intermodulation

With input signals of 0.8 kHz and 1.42 kHz, each at a level of +3 dBm0s, the third order difference tone at 0.18 kHz shall be less than 0.5% (–43 dBm0s).

NOTE – Attention is drawn to the fact that in transmission systems using compandors, a third order difference-frequency may occur which exceeds the specified limit of 0.5%. This may occur when the difference between the two fundamental frequencies is less than 200 Hz. Thus, the components due to third order distortion will have frequencies which correspond to the difference between the two test frequencies. However, in these cases the subjective masking is such that a distortion up to 2% is acceptable.

For 15 kHz systems, intended for baseband transmissions on physical circuits only, and on modulation equipment in local loops, assuming no pre-emphasis, the additional requirements of Table 4 apply.

TABLE 4/J.21

Input signals at +3 dBm0s each	Maximum difference-tone level at 1.6 kHz
5.6 kHz and 7.2 kHz	0.5% (–43 dBm0s) (second order)
4.2 kHz and 6.8 kHz	0.5% (–43 dBm0s) (third order)

3.1.7 Error in reconstituted frequency (applies only to FDM systems)

The error should not be greater than 1 Hz. Recommendation O.111 specifies the essential characteristics of instruments for measuring the frequency shift caused by carrier transmission and the use of sinusoidal test frequencies having a 2:1 harmonic ratio for this purpose.

NOTE – A maximum error of 1 Hz is in principle acceptable where there is only a single transmission path between the signal source and the listener.

Where the broadcast network can involve two or more parallel paths, e.g. commentary and separate sound channels, or radio broadcast from different transmitters on the same frequency, unacceptable beats may occur unless zero error can be assured. The ITU-T is studying methods of effecting this in all recommended systems.

3.1.8 Intelligible cross-talk ratio

3.1.8.1 The intelligible near-end and far-end cross-talk ratios between sound-programme circuits, or from a telephone circuit (disturbing) into a sound-programme circuit (disturbed) shall be measured selectively in the disturbed circuit at the same frequencies as those of the sinusoidal test signal applied to the disturbing circuit, and shall not be less than the values of Table 5:

TABLE 5/J.21

Frequency (kHz)	Cross-talk attenuation
$f = 0.04$	50 dB
$0.04 < f < 0.05$	Oblique straight-line segment on linear-decibel and logarithmic-frequency scales
$0.05 \leq f \leq 5$	74 dB
$5 < f < 15$	Oblique straight-line segment on linear-decibel and logarithmic frequency scales
$f = 15$	60 dB

3.1.8.2 The near-end and far-end cross-talk attenuations between a sound-programme circuit (disturbing circuit) and a telephone circuit (disturbed circuit) shall be at least 65 dB.

NOTES

1 It is understood that this value is defined between the relative levels applicable to telephone circuits. Administrations are invited to submit contributions on methods for measuring this parameter.

2 The attention of Administrations is drawn to the fact that in some cases it may be difficult or impossible to meet these limits. This may occur when unscreened pairs are used for a long audio-frequency circuit (e.g. about 1000 km or longer), or in certain carrier systems on symmetric pair cables, or at low frequencies (e.g. below about 100 kHz) on certain coaxial cable carrier systems. If sub-standard performance is to be avoided, such systems or parts of systems must not be used for setting up programme channels.

3 When 4000 pW0p or more noise is continuously present in the telephone channel (this may be the case in satellite systems, for example), a reduced cross-talk ratio of 58 dB between a sound-programme circuit and a telephone circuit is acceptable.

4 The attention of Administrations is drawn to the fact that, because of cross-talk which may occur in terminal modulating and line equipment, special precautions may have to be taken to meet the above cross-talk limits between two sound-programme circuits, simultaneously occupying the go and return channels respectively, of a carrier system (the most economical arrangement). This is because under these circumstances they occupy the same position in the line-frequency band (see ITU-T Recommendation J.18).

5 The value indicated is based on the assumption that sine wave test signals are used. The use of the test signal as described in ITU-T Recommendation J.19 is under study.

6 The effect of cross-talk from a sound-programme circuit into a telephone circuit is not a question of secrecy, but rather of subjective disturbance by an interfering signal whose character is noticeably different from random noise or multiple cross-talk (babble).

The frequency offset adopted for some sound-programme equipment allows a reduction of cross-talk from a telephone circuit into a sound-programme circuit. However, in the reverse direction, this reduction of cross-talk remains only for speech material but is practically ineffective for music material.

3.1.9 Amplitude linearity

When a 1 kHz input signal is stepped from –6 dBm0s to +6 dBm0s or vice versa, the output level shall change accordingly by 12 ± 0.5 dB.

3.2 Additional parameters for stereophonic programme transmission

3.2.1 The difference in gain between A and B channels shall not exceed the values of Table 6.

TABLE 6/J.21

Frequency (kHz)	Gain difference (dB)
$0.04 \leq f < 0.125$	1.5
$0.125 \leq f \leq 10$	0.8
$10 < f \leq 14$	1.5
$14 < f \leq 15$	3.0

3.2.2 The phase difference between the A and B channels shall not exceed the values of Table 7.

TABLE 7/J.21

Frequency (kHz)	Phase difference
$f = 0.04$	30°
$0.04 < f < 0.2$	Oblique straight-line segment on linear-degree and logarithmic-frequency scales
$0.2 \leq f \leq 4$	15°
$4 < f < 14$	Oblique straight-line segment on linear-degree and logarithmic-frequency scales
$f = 14$	30°
$14 < f < 15$	Oblique straight-line segment on linear-degree and logarithmic-frequency scales
$f = 15$	40°

3.2.3 The cross-talk ratio between the A- and B- channels shall not be less than the following limits: Intelligible cross-talk ratio, measured with sinusoidal test signal 0.04 to 15 kHz: 50 dB.

3.2.3.1 Total cross-talk ratio predominantly caused by intermodulation: 60 dB

This value is ascertained by loading one of the two channels with the sound-programme simulating signal, defined in ITU-T Recommendation J.19 (formerly ITU-R Recommendation CMTT.571). In the other channel, the noise contribution due to intermodulation shall not be higher than –51 dBq0ps.

This leads to an increase of noise depending on the idle channel noise value. The tolerable increase is given in Table 8.

TABLE 8/J.21

Idle channel noise (dBq0ps)	–60	–57	–54	–51	–48	–45	–42
Tolerable increase of noise (dB)	9.5	7	4.8	3	1.8	1.0	0.5

3.3 Additional requirements for digital systems

3.3.1 If a test signal is harmonically related to the sampling frequency, measuring difficulties may arise. In this case, the nominal 1 kHz test signal must be offset. Recommendation O.33 recommends 1020 Hz.

3.3.2 Unbalance of the limitation level

The difference between the levels which lead to a limitation of the positive or negative half-wave of the test signal, shall not exceed 1 dB.

3.3.3 Intermodulation with the sampling signal

Intermodulation products (f_d) caused by non-linearities may occur in the sound channel when the sampling signal (f_o) is combined with the in-band audio signals (f_i) or out-of-band interfering signals (f_a).

3.3.3.1 In-band intermodulation

The following combination rule applies:

$$f_d = f_o - nf_i$$

Only values with $n = 2$ or 3 are of importance.

The level difference between a 0 dBm0s signal (f_i) and the intermodulation products (f_d) shall not be less than 40 dB.

A restriction to the f_i and f_d values in Table 9 is sufficient.

TABLE 9/J.21

	$n = 2$		$n = 3$	
f_i (kHz)	9	13	7	11
f_d (kHz)	14	6	11	1

3.3.3.2 Out-of-band intermodulation

The following combination rule applies:

$$f_d = nf_o + f_a$$

Only values with $n = 1$ or 2 are of importance.

The level difference between a 0 dBm0s signal (f_a) and the intermodulation products (f_d) shall not be less than 60 dB.

A restriction to the f_a and f_d values in Table 10 is sufficient.

TABLE 10/J.21

	$n = 1$		$n = 2$	
f_a (kHz)	31	33	63	65
f_d (kHz)	1			

3.3.4 Further parameters

Characteristics for bit errors, clicks, jitter, etc. are under study (see ITU-R Report CMTT.647).

NOTE – ITU-T Recommendation J.66 (formerly ITU-R Recommendation CMTT.572) deals with the transmission of one sound-programme associated with an analogue television signal by means of time-division multiplex in the line synchronizing pulse. The system recommended is a digital one, using pulse code modulation. A sound-programme bandwidth of 14 kHz is provided.

Annex A

The measurement of non-linearity in the upper frequency range

(This annex forms an integral part of this Recommendation)

In a bandwidth-limited system such as a transmission channel, harmonic distortion measurements are not suitable for testing the amplitude linearity of the system.

For instance, in a 15 kHz channel, the measurement of third harmonic distortion above 5 kHz becomes meaningless.

Experience has shown that non-linearities may occur at high frequencies, even if the level of the signal is kept within permitted limits (slew-rate limitations in operational amplifiers for example).

The non-linearity measurement at high frequencies may be performed by means of "difference-frequency distortion" methods which consists of simultaneously sending two sinusoidal signals. The frequencies, f_1 and f_2 ($f_2 > f_1$), are normally of the same order of magnitude and the amplitude levels are usually identical.

The particular difference components at frequencies $f_2 - f_1$ and $2f_1 - f_2$, which fall within the system bandwidth, are used to reflect the second and third order non-linearities, respectively.

Table A.1 summarizes several methods for the non-linearity measurement. The first method A is the method specified in the main text of this Recommendation. Method B uses two measuring frequencies very close together. Method C uses frequencies further apart. Method D is described in Annex V to ITU-R Recommendation BS.644.

The measuring equipment may use either selective filters to improve the protection against noise, or a low-pass filter to measure simultaneous distortions of various orders including other intermodulation components (e.g. intermodulation with PCM sampling frequencies, or in FDM multiplex).

TABLE A.1/J.21

Proposed methods of measurement

Method	Frequencies (Hz)		Proposed sending level of each tonel (Note 1) (N_n)	Second order term		Third order term	
	f_1	f_2		Frequency (Hz)	Reference level (Note 2)	Frequency (Hz) (Note 2)	Reference level
A (ITU-T Recommenda-tion J.21)	5 600 7 200	7 200 6 800	+3 dBm0s +3 dBm0s	1 600	+3 dBm0s (N_0)	1 600	+3 dBm0s (N_0)
B	13 960	14 040	–9 dBm0s	80	+9 dBm0s (N_0 + 18 dB)	13 880	+3 dBm0s (N_0 + 12 dB)
C	10 400	13 400		3 000	N_0 + 3 dB	7 400	N_0 + 3 dB
D (UIT-R Recommandation BS.644)	8 000	11 950		3 950	N_0	4 050	N_0

NOTES

1 These levels depend significantly on the pre-emphasis used. In method A, the levels quoted are for no pre-emphasis. In method B, the levels quoted are for 50 μs pre-emphasis.

2 The level to which the distortion components are referred.