

SURROUND SOUND FORUM

Eine Gemeinschaftsinitiative von VDT, IRT und SRT



RECOMMENDED PRACTICE SSF – 02.1-E-2002

MULTICHANNEL RECORDING IN 3/2 FORMAT

Parameters for Program Interchange and Archiving,
Alignment of Reproduction Equipment



Schule für Rundfunktechnik

PREFACE

This “Recommended Practice” was published by the “SURROUND SOUND FORUM”, an interdisciplinary and supraregional working group that was founded in 1996 at the 19th Tonmeistertagung (Convention of Sound Design of the Association of German Tonmeisters, VDT). This forum is also supported by the IRT, Institute of Broadcast Engineering, and the SRT, School of Broadcast Engineering, and is open for anyone interested. In conjunction with other committees and institutions as well as the relevant industry, the SSF wishes to coordinate the development of multichannel stereophony, to take control of further standardizations, and especially, to support a move for fair practice in this field as well as encouraging an exchange of information and experience.

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This document replaces the former “Recommended Practice SSF-02/1-E-2 (1999). Herewith proposals of the member of the SSF are considered as well as results of discussions with the working group “Multichannel Audio” of the AES. Moreover, printing errors are amended and editorial improvements have been made. The amendments are in yellow color. This designation is removed after acceptance by the SSF at 2003-08-01.

1. Introduction / Scope

This recommendation is intended for the purposes of studios (sound broadcasting, television, film and mastering studios). It should also be valid, to a large extent, for consumer equipment. It concerns parameters of recording and reproduction for storage media as well as transmission formats for multichannel sound in discrete 3/2 format, e.g. the 8-channel format Audio-Hi8. It can easily be adapted for the Matrix 3/1 format.

A loudspeaker set up in accordance with the figure 1, page 5, is assumed, which is in agreement with the reference set-up in the international recommendations ITU-R BS.775-1 [1]. If a loudspeaker set-up on the circumference of a circle is not possible, the loudspeakers inside this circumference should be delayed accordingly. Details can be found in the “Recommended Practice” document, SSF 01.1-E-2002 (“Listening Conditions and Reproduction set-up for Multichannel Stereophony”) [11].

A special “Recommended Practice” document (SSF-03) is planned for multichannel replay through headphones.

2. Parameters for Program Interchange and Archiving

2.1 Track Allocation¹ in an Eight Channel Recording Format.

International recommendations [1]...[10] are the basis of the determination of the following recording characteristics, particularly ITU-R BS.775-1 [1], ITU-R BS.1116-1 [4], as well as ITU-R BS. [Doc.10/10] [2].

Track	Signal	Comments	Color ⁴
1	L Left		Yellow
2	R Right		Red
3	C Centre		Orange
4	LFE Low Frequency Enhancement	Additional sub-bass and effects signal for subwoofer, optional ²	Grey
5	LS Left Surround	- 3dB in the case of Mono Surround (MS = -3dB)	Blue
6	RS Right Surround	- 3dB in the case of Mono Surround (MS = -3dB)	Green
7	In program exchange free use ³	Preferably left signal of a 2/0 stereo mix	Violet
8	In program exchange free use ³	Preferably right signal of a 2/0 stereo mix	Brown

In individual cases designated uses of tracks 4, 7, and 8 are stated on the recording medium.

Note 1:

In many film studios a different order of track allocation or listening buttons is being used as the normal practice, namely L – C – R – LS - RS. However, new mixing desks follow the general allocation as recommended above, in accordance with ITU-R [2]. After ongoing debate over the practices of the International Organizations of the ITU-R, this recommendation was formed, and is binding for sound broadcasting and television, but not for film studios.

¹ The term “track” is used to denote either tracks on magnetic tape, or virtual tracks on other storage media where no real tracks exist.

² Preferably, used in film sound, but is optional for home reproduction, see note 2 in § 2.2. If no LFE signal is being used, track 4 can be used freely, e.g. for commentary, in accordance with [2] or for a further surround signal. In some regions a mono surround signal MS = LS + RS is applied, where the levels of LS and RS are decreased by 3 dB.

³ Tracks 7 and 8 can be used alternatively, for example, for commentary, for additional surround-signals, or for half-left/half-right front signal (e.g. for special film format), or rather for the matrix format sum signal Lt/Rt.

⁴ This color coding is at present a proposal of the Surround Sound Forum, and not yet internationally standardized.

2.2 Recording Levels

The alignment guidelines of the EBU-Recommendations 64 and 68 as well as the level definitions in ITU-R BS.645-2 [3], are taken into account here.

	Analogue Recording	Digital Recording ⁴ (for Program Interchange / Live Work / Radio / TV)	Digital Recording ⁴ (for Mastering and other things)
L_{PMS} (Permitted Maximum Signal Level) with a 1kHz sinus tone.	0 dB ^{5, 8} Relative to respective nominal studio level	-9 dB ^{5, 8, 9} Relative to digital clip level 0 dBFS	0 dB ⁶ Relative to digital clip level 0 dBFS
L_{AS} (Alignment Signal Level) with a 1kHz sinus tone.	- 9 dB ^{5, 8} Relative to respective nominal studio level	-18 dB ^{5, 7} Relative to digital clip level 0 dBFS	-18 dB ^{5, 6, 7} Relative to digital clip level 0 dBFS



Note 2:

For reproduction of film sound the sound pressure level of the LFE signal should normally be raised about 10 dB higher than the reproduction sound level of other individual channels. (Details about this can be found in Recommendation SSF – 01 [11] as well in [12]). For measurement conditions see Appendix 1; for further explanations see Appendix 2.

⁴ In linear digital recording, with at least 16-bits and 48kHz Sampling Frequency, with no pre-emphasis. For special applications in the consumer domain, also 44.1 kHz is permitted.

⁵ Measured with an IEC Quasi PPM ($\tau = 10\text{ms}$). When controlling the levels using $\tau < 0.1\text{ms}$ and with short impulses, this maximum signal level will be exceeded.

⁶ Measured with true PPM ($\tau < 0.1 \text{ ms}$) and with respecting short time impulses for the economical use of the full word-length and dynamic range with CD/DVD productions etc.

⁷ In regions which follow SMPTE guidelines, the level alignment rules given in SMPTE RP 155 should be used as $- 20 \text{ dBrel FS}$.

⁸ The nominal studio level can differ in various broadcasting organizations and private studios from +4 dBu to 12 dBu; but in this connection only the standardized difference to the limit value of the storage medium is of interest. The indication value depends also on the use of the relevant program meter (normally IEC types as Type 1 (DIN); Type 2a (UK) ; Type 2b (for EBU transmission points with +9 dBu); etc.).

⁹ In UK/BBC the L_{PMS} is at + 8dBu0 (i.e. $- 10 \text{ dB}$ relative o clipping).

2.3 Checking Section [2, 5]

Before the program section of the recording, a level checking section is to be recorded, with two reference signals for each track used. These signals should be recorded with alignment level L_{AS} :

- a) 1-kHz sinus tone to check the alignment signal level
- b) Random noise, non-correlated, to check the sound pressure levels (see following note 3 and note 1).

Note 3:

The recording of the noise signal is superfluous, if measurement and test recordings (e.g., SSF Test-DVD) in accordance with Appendix 1 are used as a standard method. At present, because of varying international standards, measurement signals and therefore the resulting sound pressure levels are not uniformly handled. Therefore the following tables give the most frequently occurring relationships to the usual reference listening level $L_{LISTref} = 78$ dB (A) per individual channel (excluding LFE channel):

Measurement signals

Signal	PPM level with $t < 0.1\text{ms}$ /dB	QPPM level with $t = 10\text{ms}$ /dB	RMS level /dB
1-kHz Sine wave	-18	-18	-18
Pink Noise, 20 Hz – 20 kHz	-9	-13	-18
Pink Noise, 200 Hz – 20 kHz	-11	-15	-20

Reference listening level $L_{LISTref}$ at the recommended listening position

Signal	SPL/dB, slow	SPL/dB(A), slow
Pink Noise, 20 Hz – 20 kHz	82	78
Pink Noise, 200 Hz – 20 kHz	80	78

3. ALIGNMENT OF REPRODUCTION EQUIPMENT

The use of measurement and test recordings (e.g. the Test-DVD of the SSF) is assumed when aligning reproduction equipment. The conditions for this are part of this document.

The recording comprises two parts:

- 1: Subjective monitoring of the multichannel reproduction
- 2: Objective testing of the reproduction equipment by measurement

The track allocations and the recording levels correspond with paragraphs 2.1 and 2.2 respectively.

Details and advice on this are given in Appendix 1.

4. REFERENCES

- [1] ITU- Recommendation ITU-R BS.775-1: Multichannel Stereophonic Sound System with and without accompanying Picture (Geneva, 1992-1994).
- [2] ITU- Recommendation ITU-R BS.1384: Parameters for International Exchange of Multichannel Sound Recordings, Geneva, 1998.
- [3] ITU- Recommendation ITU 645-2: Test Signals and Metering to be used on International Sound Program Connections (Geneva, 1986-1992).
- [4] ITU Recommendation ITU-R BS. 1116: Methods for the Subjective Assessment of Small Impairments in Audio Systems including Multichannel Sound Systems (Geneva, 1994).
- [5] EBU- Recommendation: Exchange of Sound Programs as digital Tape Recordings. EBU Technical Recommendation R 64 - 1993.
- [6] EBU- Recommendation: Alignment Level in digital Audio Production Equipment and in digital Audio Recorders. EBU Technical Recommendation R 68 - 1992.
- [7] EBU- Recommendation: Track allocations and recording levels for the exchange of multichannel audio signals. EBU Technical Recommendation R 91-1998.
- [8] SMPTE Recommended Practice: Loudspeaker Arrangements for Audio Monitoring in Television Productions (SMPTE RP 173 - 19).
- [9] SMPTE Recommended Practice: Audio Levels for digital Audio Records on digital Television Tape Recorders (SMPTE RP 155 - 1995).
- [10] Proposed SMPTE Standard for Television: Channel Assignments and Levels on Multichannel Audio Media. ITU Information Document ITU-R 10C/11 and 10-11R/24; 16 March 1998 (E).
- [11] Surround-Sound-Forum: Recommended Practice SSF-01.1-2002: Listening Conditions and Reproduction Arrangements for Multichannel Stereophony [Hoerbedingungen und Wiedergabeanordnungen fuer Mehrkanal-Stereophonie]
- [12] AES Information Document AESTD1001.1.01-10: Multichannel Sound Systems and Operations, 2002.

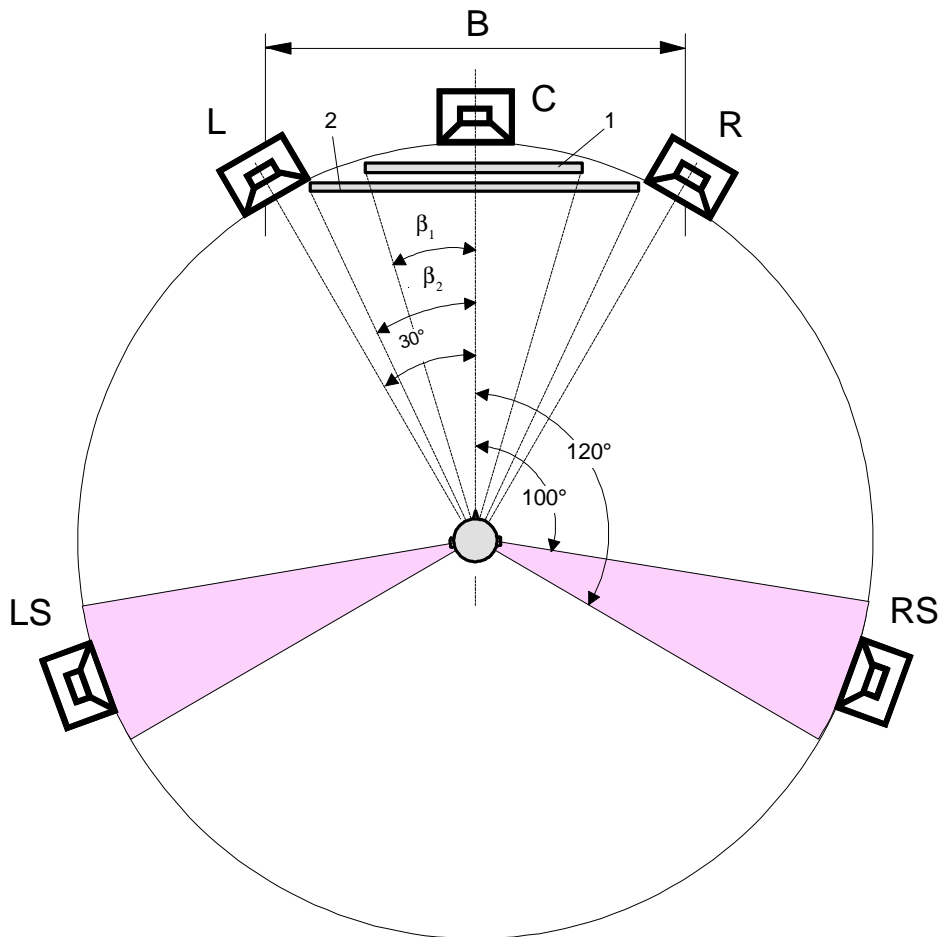


Fig. 1: Reference Loudspeaker Setup
(3/2 format in accordance with ITU-R BS.775-1)

Screen 1: Listening distance = 3H ($2 \beta_1 = 33^\circ$)
 Screen 2: Listening distance = 2H ($2 \beta_2 = 48^\circ$)
 H: Screen height
 B: Loudspeaker basis width

Acoustical centre	Angle	Height	Tilt
C	0°	1,2m*)	0°*)
L, R	+/- 30°	1,2m	0°
LS, RS	+/- (100...120)°	>1,2m	≤15°

*) depending on the shape and size of the screen

For the exclusive reproduction of surround signals the LS and RS speakers can alternatively be positioned outside the designated radius.
 For deviations to the inside of the circle, see paragraph 1.

Appendix 1

MEASUREMENT AND TEST RECORDING FOR THE ALIGNMENT OF REPRODUCTION EQUIPMENT FOR DISCRETE 3/2 MULTICHANNEL STEREOPHONY

(Track allocation and recording levels are as stated in paragraphs 2.1 and 2.2 respectively, of this document)

Part 1: Introduction and explanations

Part 2: Subjective checking of the reproduction equipment at the reference listening position

The loudness of announcements and test signals are set using the loudness of an orchestral recording as a reference.

- a) Channel Identification: Checking of Track and Channel allocations using announcements on each channel
- b) Frequency response test of the stereo loudspeakers using a sweep tone from 20 Hz to 20 kHz.
Frequency response test of the Subwoofer (LFE channel) using a sweep tone from 20 Hz to 200 Hz.
- c) Level comparison between each two replay channels using noise impulses.
Level comparison between subwoofer and stereo loudspeakers
- d) Checking for correct phase through the use of announcements (Comparing: in phase signal – out of phase signal – in phase signal). The phase must be judged for each pair of loudspeakers by listening facing the midpoint between the relevant speakers (thus not facing the center loudspeaker). Then follow the pairs C+L, C+R, R+RS, L+LS.
- e) Re-checking of the above alignments with selected listening examples.
- f) Digital "0".

Part 3: Objective testing of the reproduction equipment at the reference listening position by measurement

Warning!

Listening level for level checking in section a) must be reduced by at least 20 dB!

- a) Level checking with 1 kHz sine wave signal (-18 dB, -9dB, 0dB).
- b) Alignment of the reference listening level for each reproduction channel in accordance with Appendix 2 (pink noise, band pass filtered 200 Hz – 20 kHz).
- c) Alignment of the resulting reference listening levels $L_{LISTref} = 85$ dBA (non-coherent pink noise, band pass filtered 200 Hz – 20 kHz).
- d) Measurement of the individual loudspeaker/room transfer curve for each channel (operational sound level curve) (pink noise, band pass filtered 200 Hz – 20 kHz).
- e) Measurement of the resulting loudspeaker/room transfer curve (non-correlated pink noise, band pass filtered 20 Hz – 20 kHz).
- f) Level adjustments between subwoofer and stereo loudspeakers with different crossover frequencies.

**Part 1:
Introduction and explanations**

Track	Channel	Content	Comments
10	C	Introduction	Announcement
10	C	Introduction	Announcement

Part 2:

Subjective checking of the reproduction equipment at the reference listening position

20	C	Channel Identification	Announcement
	L	Speech	left channel
	C	Speech	center channel
	R	Speech	right channel
	RS	Speech	right surround channel
	LS	Speech	left surround channel
	C	Low Frequency Channel	Announcement
	LFE	Low frequency impulse	
30	C	Frequency response of the main speakers	Announcement
	L	Sweep 20 Hz – 20 kHz	
	C	Sweep 20 Hz – 20 kHz	
	R	Sweep 20 Hz – 20 kHz	
	RS	Sweep 20 Hz – 20 kHz	
	LS	Sweep 20 Hz – 20 kHz	
	C	Frequency response test for the subwoofer at LFE output	Announcement
	LFE	Sweep 20 Hz – 200 Hz	
40	C	Loudness comparison between each pair of channels	Announcement
	C-L	Noise impulse	
	C-R	Noise impulse	
	C-RS	Noise impulse	
	C-LS	Noise impulse	
50	C	Loudness comparison between subwoofer and main speakers	Announcement
	L+C+R+LS+RS	Low frequency noise impulse	80 Hz crossover frequency
51	L+C+R+LS+RS	Low frequency noise impulse	100 Hz crossover frequency
52	L+C+R+LS+RS	Low frequency noise impulse	120 Hz crossover frequency
53	L+C+R+LS+RS	Low frequency noise impulse	160 Hz crossover frequency
54	L+C+R+LS+RS	Low frequency noise impulse	200 Hz crossover frequency
60	C	Phase test	Announcement
	C+L	Speech	
	C+R	Speech	
	R+RS	Speech	
	L+LS	Speech	
70	C	Selected listening examples	Announcement
	L+C+R+LS+RS	Mahler, 9th Symphony, 3. + 4. movement (Excerpt)	
	L+C+R+LS+RS	Background noise from Ice Hockey / Thunder Storm- Rain	
	L+C+R+LS+RS	Film production: Schlafes Bruder (Excerpt)	
	L+C+R+LS+RS	Mendelssohn – Bartholdy, Italian Symphony, 2. Movement (Excerpt)	
80	L+C+R+LS+RS	Digital "0" / Silence	Perceptibility of noise from the reproduction equipment

Part 3:

Objective testing of the reproduction equipment at the reference listening position by measurement

Track	Channel	Content	Sound level at the reference listening position		Signal level			Remarks
			SPL/ dB	<u>SPL</u> / dBA	PPM/ dB t < 0.1 ms	PPM/ dB t < 10 ms	RMS / dB	
90	C	Objective Testing						Announcement
100	+LC+R+LS+RS	1-kHz sine wave			-18	-18	-18	
	+C+R+LS+RS	1-kHz sine wave			-9	-9	-9	
	+C+R+LS+RS	1-kHz sine wave			0	0	0	
110	L	Pink noise 200 Hz – 20 kHz	80	78	-11	-15	-20	Alignment of the reference listening levels for each replay channel $L_{LISTref} = 78$ dBA
	C	Pink noise 200 Hz – 20 kHz	80	78	-11	-15	-20	
	R	Pink noise 200 Hz – 20 kHz	80	78	-11	-15	-20	
	RS	Pink noise 200 Hz – 20 kHz	80	78	-11	-15	-20	
	LS	Pink noise 200 Hz – 20 kHz	80	78	-11	-15	-20	
111	L+C+R+LS+RS	Pink noise 200 Hz – 20 kHz non coherent	87	85	-11	-15	-20	Alignment of the total reference listening level $L_{LISTref} = 85$ dBA
120	L	Pink noise 20 Hz – 20 kHz	82	78	-9	-13	-18	Measurement of the loudspeaker / room transfer curves for each channel $L_{LISTref} = 78$ dBA
	C	Pink noise 20 Hz – 20 kHz	82	78	-9	-13	-18	
	R	Pink noise 20 Hz – 20 kHz	82	78	-9	-13	-18	
	RS	Pink noise 20 Hz – 20 kHz	82	78	-9	-13	-18	
	LS	Pink noise 20 Hz – 20 kHz	82	78	-9	-13	-18	
121	L+C+R+LS+RS	Pink noise 20 Hz – 20 kHz non coherent	89	85	-9	-13	-18	Measurement of the total loudspeaker / room transfer curves $L_{LISTref} = 85$ dBA
130	L+C+R+LS+RS	Band pass filtered, octave band, non coherent pink noise $F_{m\ 3rd} = 25 - 50$ Hz and $125 - 250$ Hz						Level adjustment between subwoofer and main speakers Crossover frequency 80 Hz
131	L+C+R+LS+RS	Band pass filtered, octave band, non coherent pink noise $F_{m\ 3rd} = 31.5 - 63$ Hz and $160 - 320$ Hz						Crossover frequency 100 Hz
132	L+C+R+LS+RS	Band pass filtered, octave band, non coherent pink noise $F_{m\ 3rd} = 40 - 80$ Hz and $200 - 400$ Hz						Crossover frequency 120 Hz
133	L+C+R+LS+RS	Band pass filtered, octave band, non coherent pink noise $F_{m\ 3rd} = 50 - 100$ Hz and $250 - 500$ Hz						Crossover frequency 160 Hz
134	L+C+R+LS+RS	Band pass filtered, octave band, non coherent pink noise $F_{m\ 3rd} = 63 - 125$ Hz and $315 - 630$ Hz						Crossover frequency 200 Hz

Appendix 2

1. EXPLANATION OF THE USE OF THE LFE SIGNALS

For recordings which are produced chiefly for use in the cinema, the LFE channel is used for the films low frequency signals. In the cinema, this low frequency signal will be replayed constantly through a separate subwoofer channel. The LFE channel can therefore be used during mixing of the film sound track, to convey low frequency effects.

In consumer audio systems the LFE channel is considered only optional in reproductions with 5.1 format. Therefore, productions which conform to this standard should be prepared in such a way that they sound satisfactory with the 3/2 format even if the LFE channel is not reproduced.

It is important that any low frequency sounds that are very significant to the integrity of the content of the film are not assigned to the LFE channel. The LFE channel should be reserved for parts of the program with extra low frequencies or with very high levels less than 120 Hz. This ensures that if the LFE channel is not reproduced this will not impair the artistic completeness of the recording [10].

The reproduction level of the LFE signal should normally be raised about 10 dB higher than the reproduction level of the other individual channels. In accordance with SMPTE [10] this should not be achieved by raising the recording level, but by raising the level of the LFE reproduction channel.⁹

2. CONCEPTS AND DEFINITIONS

MS = monophonic surround signal

M/S = middle and side signals – as in recording techniques and processing of two channel stereo.

Definition for test level in accordance with [3]:

Alignment signal level L_{AS} :

1 kHz sine-tone (or to be precise 1020Hz in accordance with CCITT-Rec 0.33) used for the alignment of recording / transmission equipment should be at –9 dBr (relative to nominal studio level) or respectively –18dB relative to digital clip level 0 dBFS, measured with an IEC QPPM (Quasi Peak Program Meter) ($\tau=10ms$)¹⁰.

Permitted maximum signal level L_{PMS} :

1 kHz sine-tone (1020 Hz to be precise) which is 9 dB higher than the alignment signal level L_{AS} . In the analogue domain this corresponds to the normal studio level 0 dBr; in the digital domain this is –9 dBFS.

For measurements made with metering equipment in accordance with IEC publication 268.10 with a 10ms integration time for the display of –1dBr, the maximum momentary amplitude may occasionally exceed the permitted maximum signal level PMS. When the quasi peak value is measured, impulses of less than 10ms will not reach the clip level (0dB_{FS} in the digital domain). When measured with an integration time of fewer than 1ms, all short impulses will be registered; consequently the maximum signal level is always under 0dB_{FS}.

⁹ It seems to be necessary to come here to an agreement with the DVD standards (Software Book)

¹⁰ In the alignment of international sound program connections this level is in accordance with the level dBuOs, i.e., 0.775 V r.m.s. at a zero relative level point.

Reference listening level $L_{LISTref}$

The reference listening level $L_{LISTref}$ allows the specified listening level, or volume, to be set correctly during reproduction of program material under specified reproduction conditions, as well as during the reproduction of the same program material under different conditions. The reference listening level is in dB with reference to a 0dB level in each loudspeaker channel.

3. ALIGNMENT OF THE REFERENCE LISTENING LEVEL $L_{LISTref}$

The measurement takes place for each individual reproduction channel, from the reference listening position. Each channel should be played through one fader and one monitor loudspeaker one at a time.

The measuring signal used to set each channel is pink noise, band pass filtered to 200 Hz – 20 kHz. Non coherent noise, bands pass filtered to 200 Hz – 20 kHz is used when all five channels are set simultaneously. (Appendix 1, Section 3, tracks 100 – 111).

The level of the each reproduction channel is set so that the sound level (RMS slow) at the reference listening position is:

$$L_{LISTref} = 85 - 10 \log n \text{ (dBA).}$$

Where n is the number of reproduction channels in the relevant configuration. So if one channel has a reference listening level $L_{LISTref} = 78 \text{ dBA}$, then the five combined channels of the 3/2 multichannel stereo configuration have a resulting reference listening level $L_{LISTref} = 85 \text{ dBA}$.

The level difference between any two channels should not exceed 1dB.

When listening to special program material the listening level may be adapted individually to suit the content of the program (for example by using a multichannel level fader). The value set can be given with reference to the reference listening level, and must be stated on the recording medium.

For example, the replay of a special program over a 3/2-stereo configuration with a level of –10 dB with reference to the reference listening level, means that the total level from all five replay channels measured at the reference listening position, using a non coherent pink noise signal, will be 75dB(A) (Appendix 1, part 3, track 111).

With the LFE-channel within the 80-Hz band pass range - or another band pass range – a + 10 dB higher level should result compared with the other channels. Because of the limited band width therefore the reproduction level of the LFE channel is also band limited to + 10 dBrel compared with the other individual channels, measured with a frequency analyzer and/or test recording according to this recommendation.

Note:

With measurements for two-channel stereo reproduction (2/0) the measuring reception level is then 82 dBA and/or 84 dB(lin) for an individual channel according this measuring condition. With compatibility tests and changing program content - especially within the surround channels - loudness differences between 2/0 and 3/2 configurations have to be observed.
