RECOMMENDATION ITU-R BS.775-1*

MULTICHANNEL STEREOPHONIC SOUND SYSTEM WITH AND WITHOUT ACCOMPANYING PICTURE

(Question ITU-R 79/10)

(1992-1994)

The ITU Radiocommunication Assembly,

considering

a) that it is widely recognized that a two-channel sound system has serious limitations and improved presentation is necessary;

b) that the requirements of cinema presentation differ from those that apply in the home, particularly with respect to room and screen size and distribution of listeners, but that the same programmes may be reproduced in either the cinema or the home;

c) that broadcast HDTV signals, and those delivered by other media, should be capable of giving appropriate sound quality with a wide range of domestic loudspeaker configurations, including compatibility with two-channel stereophonic and monophonic listening;

d) that for multichannel sound it is desirable to separate the requirements of production, delivery and domestic presentation, though these are mutually interacting;

e) that investigations about multichannel sound transmission and reproduction associated and not associated with accompanying picture are being carried out with the basic requirements as laid down in Annex 2;

f) that one universal multichannel sound system applicable to both sound and television broadcasting would be beneficial to the listener;

g) that compromises may be necessary to ensure that the system is as universal and as practical as possible;

h) that a hierarchy of compatible sound systems for broadcasting, cinema and recordings is useful for programme exchange and up- and down-mixing depending on the programme material;

j) that ancillary services such as those for the visually impaired and hearing impaired are desirable;

k) that advances in digital audio coding currently allow the delivery of multiple audio channels in an efficient manner,

recommends

1. one universal multichannel stereophonic sound system, with or without accompanying picture, within a hierarchy given in Annex 1;

2. the following reference loudspeaker arrangement (see Fig. 1):

- three front loudspeakers combined with two rear/side loudspeakers (Note 1);
- the left and right frontal loudspeakers are placed at the extremities of an arc subtending 60° at the reference listening point (Notes 2 and 3);

  Where for reasons of available space, it is preferred to place the frontal loudspeakers on a straight line base, then it may be necessary to introduce compensating time delays in the signal feed of the centre loudspeaker;

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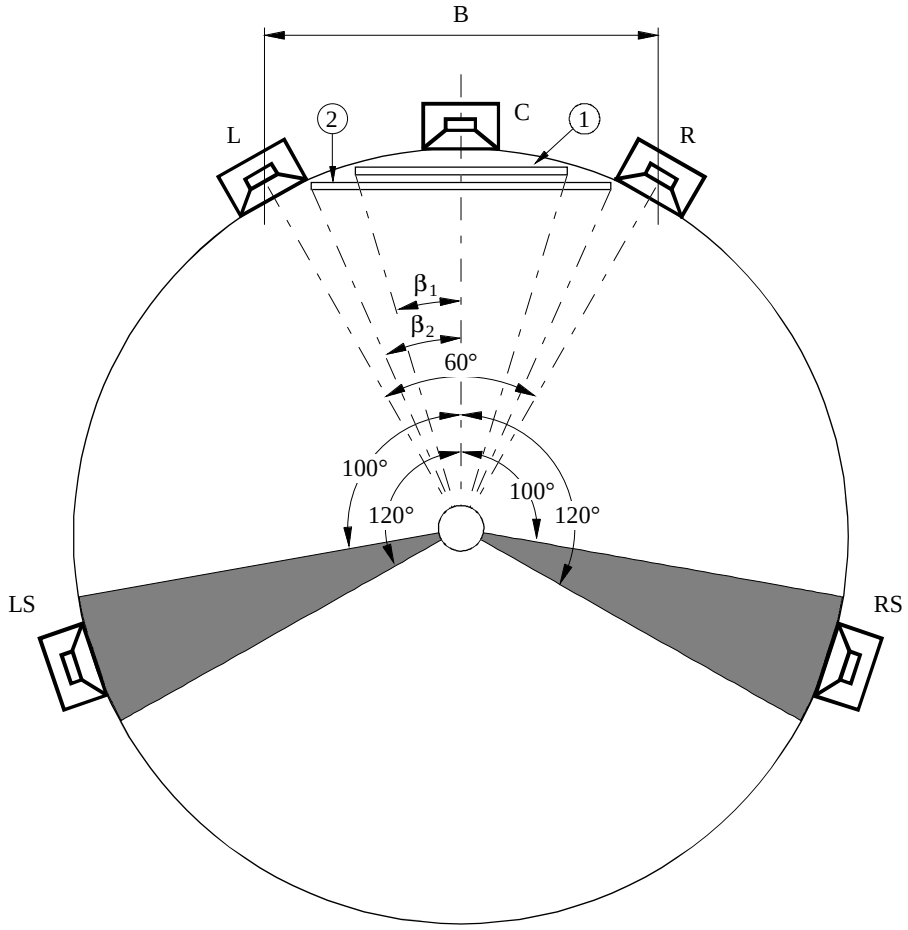
* This Recommendation should be brought to the attention of the International Electrotechnical Commission (IEC) and the Society of Motion Picture and Television Engineers (SMPTE).

– both side/rear loudspeakers should be placed within the sectors from 100° to 120° from the centre front reference. Precise location is not necessary. Side/rear loudspeakers should be no closer to the listener than the frontal loudspeakers, unless compensating time delay is introduced (Note 4);

– the frontal loudspeakers should ideally be at a height approximately equal to that of the listener's ears. This implies an acoustically transparent screen. Where a non-acoustically transparent screen is used, the centre loudspeaker should be placed immediately above or below the picture. The height of side/rear loudspeakers is less critical.

FIGURE 1

Reference loudspeaker arrangement with loudspeakers L/C/R and LS/RS



Screen 1 HDTV – Reference distance = 3 H ($2\beta_1 = 33°$)

Screen 2 = 2 H ($2\beta_2 = 48°$)

H: height of screen

B: loudspeaker base width

Loudspeaker	Horizontal angle from centre (degrees)	Height (m)	Inclination (degrees)
C	0	1.2	0
L, R	30	1.2	0
LS, RS	100 ... 120	≥ 1.2	0 ... 15 down

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3. the use of five reference recording/transmission signals for left (L), right (R), centre (C), channels for the front, and left surround (LS) and right surround (RS) channels for the side/rear. Additionally the system may include a low frequency extension signal for a low frequency extension (LFE) channel (see Annex 7);

In circumstances where transmission capacity or other constraints apply, the three front signals can be combined with one (mono surround, MS) or zero rear/side signals. In the case of mono surround, the MS signal is fed to both LS and RS loudspeakers (see Fig. 1);

4. compatibility, if required, with existing and low cost receivers by using one of the methods given in Annex 3;

5. down-mixing capability, if required, for reduction of the number of channels, either prior to transmission or at the receiver, by employing the down-mixing equations given in Table 2;

6. upward conversion where an increase in the number of channels is desired, either prior to transmission or at the receiver, by employing upwards-conversion techniques described in Annex 5;

7. overall quality to the requirements of Annex 2;

8. provision (but see also § 9 below) for the following if necessary:

- alternate multiple language principal services;
- one or more independent channels carrying descriptive information for the visually impaired;
- one or more independent channels for the purpose of supplying improved intelligibility to the hearing impaired;

9. additional data transmitted with the audio to enable the flexible use of the data capacity allocatable to audio signals (see Annex 6).

Note 1 – Optionally, there may be an even number of more than two rear/side loudspeakers which may provide a larger optimum listening area and greater envelopment.

Note 2 – Optimum sound reproduction requires use of wide angular spacing between the left and right loudspeakers of two or three front loudspeaker channel stereophonic systems (see Fig. 1). It is recognized that the television pictures accompanying stereophonic sound having such an angular width cannot, with current techniques, be displayed to the same wide angles, but are often restricted to 33° horizontal subtended angle at the reference distance, although cinema images may be displayed at such angles (see Fig. 1). The resulting mismatch between picture and sound image width leads to differences in mixing technique for cinema and television. It is expected that larger television displays will lead to better compatibility of mixes for cinema and television display.

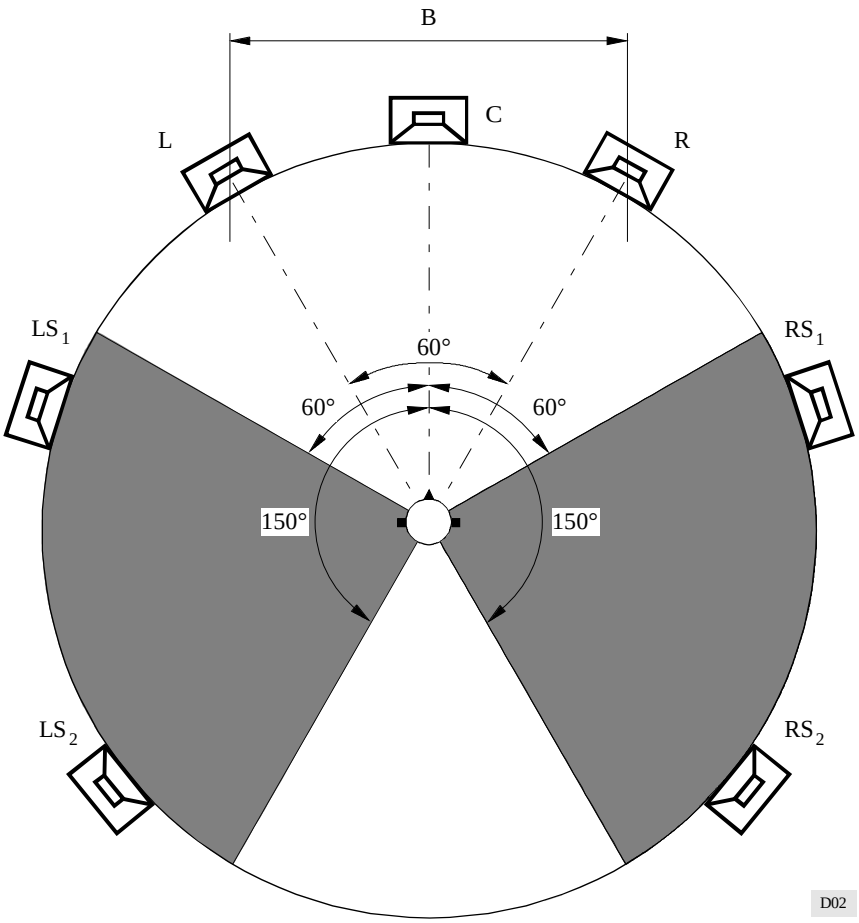
Note 3 – The size of the loudspeaker basewidth, B (see Fig. 1), is defined for reference listening test conditions in Recommendation ITU-R BS.1116 “Methods for the subjective assessment of small impairments in audio systems including multichannel sound systems”.

Note 4 – If more than two rear/side loudspeakers are used, then the loudspeakers should be disposed symmetrically and at equal intervals on the arc which measures from 60° to 150° from the centre front reference (see Fig. 2).

Note 5 – If more than two rear/side loudspeakers are used, the LS signal should be fed to each of the side/rear loudspeakers on the left side of the room and the RS signal should be fed to each of the side/rear loudspeakers on the right side of the room. In doing so, it will be necessary to reduce the signal gain such that the total power emitted by the loudspeakers carrying the LS (or RS) signal is the same as if that signal had been reproduced over a single loudspeaker. For large room reproduction, it may also be necessary to delay, or otherwise decorrelate, the feeds to some or all of the side/rear loudspeakers. Further studies on such decorrelation is necessary.

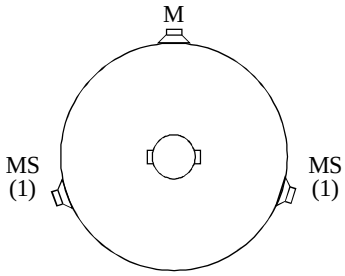
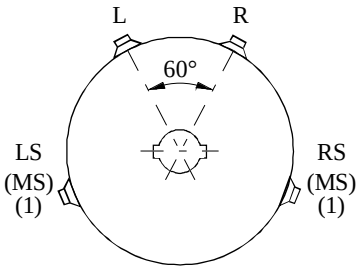
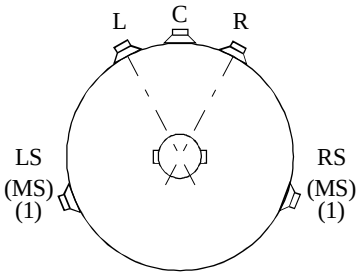
FIGURE 2

Optional 3/4 loudspeaker arrangement (3 front and 4 surround)



ANNEX 1

Hierarchy of compatible multichannel sound systems for broadcasting and recording

System	Channels	Code	Loudspeaker arrangement
Mono channel system	M	1/0	
Mono plus mono surround	M/MS	1/1	
Two-channel stereo	L/R	2/0	
Two-channel stereo plus 1 surround	L/R/MS	2/1	
Two-channel stereo plus 2 surround	L/R/LS/RS	2/2	
Three-channel stereo	L/C/R	3/0	
Three-channel stereo plus 1 surrond	L/C/R/MS	3/1	
Three-channel stereo plus 2 surround	L/C/R/LS/RS	3/2	

(1) In the case of mono surround the signal feeding LS and RS should preferably be decorrelated.

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ANNEX 2

Basic requirements

The following requirements are related to the specified multichannel sound system with and without accompanying picture.

1. The directional stability of the frontal sound image shall be maintained within reasonable limits over a listening area larger than that provided by conventional two-channel stereophony.

2. The sensation of spatial reality (ambience) shall be significantly enhanced over that provided by conventional two-channel stereophony. This shall be achieved by the use of side and/or rear loudspeakers.

3. It is not required that the side/rear loudspeakers should be capable of the prescribed image locations outside the range of the front loudspeakers.

4. Downward compatibility with sound systems providing lower number of channels (down to stereophonic and monophonic sound systems) shall be maintained (see Annex 1).

5. Real-time mixing for live broadcast shall be practicable.

6. In cases where the number of delivered signals is smaller than the number of reproduction channels upward conversion should be ensured to an acceptable degree (see Annex 5).

7. The basic audio quality of the sound reproduced after decoding must be subjectively indistinguishable from the reference for most types of audio programme material. Using the triple stimuli with hidden reference test implies grades consistently higher than four on the ITU-R impairment 5-grade scale. The most critical material must not be graded lower than four.

8. For the objective quality parameters Recommendations ITU-R BS.644 and ITU-R BS.645 shall be the basis, superseded by new measuring methods for digital techniques. (These matters are under study by the ITU-R.)

9. Listening test conditions are currently under study in the ITU-R.

10. For subjective assessments see Recommendation ITU-R BS.1116.

11. The synchronization of sound and vision signals are currently under study in the ITU-R.

12. Optimum economy shall be pursued in all respects, including both cost and transmission bandwidth.

ANNEX 3

Compatibility

1. Backward compatibility with existing receivers

In the case that an existing 2/0 channel format is extended to a 3/2 channel format, two methods have been identified to assure backward compatibility with existing receivers.

One method is to continue providing the existing 2/0 channel service and to add the new 3/2 channel service. This approach is referred to as a simulcasting operation. The advantage of this approach is that the existing 2/0 service could be discontinued at some point in the future.

Another method is the use of compatibility matrices. The matrix equations shown in Table 1 may be used to provide compatibility with existing receivers. In this case, the existing Left and Right emission channels are used to convey the compatible A and B matrix signals. Additional emission channels are used to convey the T, Q_1, and Q_2 matrix signals. The advantage of this approach is that less additional data capacity is required to add the new service.

TABLE 1

Five channel surround: encoding and decoding equations

Encoding equations					
	L	R	C	LS	RS
A =	1.0000	0.0000	0.7071	0.7071	0.0000
B =	0.0000	1.0000	0.7071	0.0000	0.7071
T =	0.0000	0.0000	0.7071	0.0000	0.0000
Q_1 =	0.0000	0.0000	0.0000	0.7071	0.7071
Q_2 =	0.0000	0.0000	0.0000	0.7071	–0.7071

Decoding equations											
	A	B	T	Q_1	Q_2		L	R	C	LS	RS
L′ =	1.0000	0.0000	–1.0000	–0.5000	–0.5000	=	1.0000	0.0000	0.0000	0.0000	0.0000
R′ =	0.0000	1.0000	–1.0000	–0.5000	0.5000	=	0.0000	1.0000	0.0000	0.0000	0.0000
C′ =	0.0000	0.0000	1.4142	0.0000	0.0000	=	0.0000	0.0000	1.0000	0.0000	0.0000
LS′ =	0.0000	0.0000	0.0000	0.7071	0.7071	=	0.0000	0.0000	0.0000	1.0000	0.0000
RS′ =	0.0000	0.0000	0.0000	0.7071	–0.7071	=	0.0000	0.0000	0.0000	0.0000	1.0000

2. Downward compatibility with low-cost receivers

Two methods have been identified which provide downward compatibility with low receiver complexity. The first requires the use of the matrix process described in § 1. A low-cost receiver then only requires the A- and B-channels as in the case of the 2/0 system i.e. a system which does not use a backwards compatibility matrix.

The second method is applicable to the discrete 3/2 delivery system. The delivered signals are digitally combined using the equations in Annex 4, which enable the required number of signals to be provided. In the case of low bit-rate source coded signals, the downward mixing of the 3/2 signals may be performed prior to the synthesis portion of the decoding process (where the bulk of the complexity lies).

ANNEX 4

Downward mixing of multichannel audio signals

1. 3/2 source signals

Table 2 shows a set of equations that may be used to mix the five signals of the 3/2 system down to the formats: 1/0; 2/0; 3/0; 2/1; 3/1; 2/2.

TABLE 2

Downward mixing equations for 3/2 source material

Mono – 1/0 format		L	R	C	LS	RS
	C′ =	0.7071	0.7071	1.0000	0.5000	0.5000
Stereo – 2/0 format		L	R	C	LS	RS
	L′ =	1.0000	0.0000	0.7071	0.7071	0.0000
	R′ =	0.0000	1.0000	0.7071	0.0000	0.7071
Three channels – 3/0 format		L	R	C	LS	RS
	L′ =	1.0000	0.0000	0.0000	0.7071	0.0000
	R′ =	0.0000	1.0000	0.0000	0.0000	0.7071
	C′ =	0.0000	0.0000	1.0000	0.0000	0.0000
Three channels – 2/1 format		L	R	C	LS	RS
	L′ =	1.0000	0.0000	0.7071	0.0000	0.0000
	R′ =	0.0000	1.0000	0.7071	0.0000	0.0000
	S′ =	0.0000	0.0000	0.0000	0.7071	0.7071
Four channels – 3/1 format		L	R	C	LS	RS
	L′ =	1.0000	0.0000	0.0000	0.0000	0.0000
	R′ =	0.0000	1.0000	0.0000	0.0000	0.0000
	C′ =	0.0000	0.0000	1.0000	0.0000	0.0000
	S′ =	0.0000	0.0000	0.0000	0.7071	0.7071
Four channels – 2/2 format		L	R	C	LS	RS
	L′ =	1.0000	0.0000	0.7071	0.0000	0.0000
	R′ =	0.0000	1.0000	0.7071	0.0000	0.0000
	LS′ =	0.0000	0.0000	0.0000	1.0000	0.0000
	RS′ =	0.0000	0.0000	0.0000	0.0000	1.0000

It should be noted that the overall effect of such downward mixing equations (and compatibility matrixing, see Annex 3) will depend on other factors, such as the panning equations and microphone characteristics. It is recommended that further studies on such interactions be carried out (see Annex 8).

ANNEX 5

Upwards conversion

Upwards conversion is needed in cases where the number of production channels is smaller than the number of channels available for reproduction. A typical example is a 2-channel stereo programme (2/0) that is to be presented over a 3/2 reproduction system.

Upwards conversion involves the generation of the "missing" channels somewhere in the broadcast chain. When performing upwards conversion, the following guidelines should normally be respected in order that the programme makers have a reference arrangement. These guidelines do not exclude the possibility, for receiver manufacturers, of the implementation of more sophisticated techniques.

1. Frontal channels

1.1 When a monophonic programme is to be presented over a reproduction system with three frontal loudspeakers, the mono signal should be presented over the centre loudspeaker only. When two frontal loudspeakers are only available, the mono signal should be presented over both left and right loudspeakers with an attenuation of 3 dB.

1.2 When a stereophonic programme is to be presented over a reproduction system with three frontal loudspeakers, the left and right signals of the stereo programme should be presented respectively over the left and right loudspeakers only.

2. Surround channels

2.1 When there is no surround signal in a programme, surround loudspeakers should not be activated.

2.2 When a given surround signal is to be reproduced over more than one loudspeaker, decorrelation between each loudspeaker signal should be performed. Furthermore, proper attenuation should be applied to each loudspeaker signal so that the combined sound pressure level produced by these loudspeakers should match that of a single frontal loudspeaker if fed by the same signal at a given reference listening position.

3. Data channel

Auxiliary information describing the mode of transmission (number and type of transmitted channels) should be transmitted periodically in a special data channel in parallel with the programme. This information will be needed to perform upwards conversion in receivers.

ANNEX 6

Additional data*

It is necessary that some additional data are sent to the multichannel sound receiver, to enable it to identify the multichannel sound configuration in use, and provide the loudspeakers with the required signals. Implicit in the ability to reconfigure a multichannel sound system is the ability to use the available sound channels flexibly, so that a wide range of applications can be covered.

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* Further studies and contributions from administrations are necessary.

The details of the additional data (bit rate, data format, etc.) have yet to be determined. However, the following applications, which would need to be signalled in the data channel, have been identified:

– the signalling and controlling of different multichannel sound configurations for the main programme and conversion (e.g. 5-channel, 3-channel, 2-channel, mono) to other configurations;

– indicating a special sound signal for listeners with impaired hearing;

– indicating a special sound signal for viewers with impaired sight;

– indicating a separate audio programme (SAP);

– conveying dynamic range control information, to compress or expand the dynamic range;

– conveying characters for a text service;

– flexible usage of the data capacity allocated for audio signals.

ANNEX 7

Subwoofer channel or low frequency extension channel (LFE)

The purpose of this optional channel is to enable listeners, who choose to, to extend the low frequency content of the reproduced programme in terms of both frequency and level. In this way it is the same as the subwoofer channel proposed by the film industry for their digital sound systems.

In the film industry the subwoofer channel carries high level, low frequency sound effects which are intended to be fed to (a) specific low frequency loudspeaker(s). In that way the magnitude of the low frequency content of the other channels is restricted so that the main loudspeakers are not required to handle these special effects signals. The main film sound channels carry normal low frequency sounds but not at such high levels. They are therefore sufficient on their own if these special effects are not required by the user. This combination has the other benefit that the coding of the high level signals in the subwoofer channel can be optimized without affecting the coding of the main channels.

Although it is recognized that the number of domestic consumers who will choose to use a subwoofer channel is likely to be restricted, it is also recognized that there are other future applications of the HDTV sound system under discussion that will make more use of this option, e.g. distribution of signals to cinemas.

The subwoofer channel should not, however, be used for the entire low frequency content of the multi-channel sound presentation. The subwoofer channel is an option, at the receiver, and thus should only carry the additional enhancement information.

(In a similar way, the surround channels should carry their own low frequency information rather than it being mixed into the front channels. This forward mixing of the low frequency sounds is an option, at the receiver, to decrease the requirements on the surround loudspeakers.)

The subwoofer channel should be capable of handling signals in the range 20-120 Hz.

The level at which the subwoofer channel should be reproduced, relative to the main channels, is still to be studied. It is noted, however, that the film industry is currently coding the subwoofer channel such that a positive gain of 10-12 dB is required on reproduction. A common standard on this point will obviously be beneficial.

The coding of the main channels should not place any reliance on masking provided by the subwoofer channel. The coding of the subwoofer channel may, however, assume masking due to sounds reproduced from the main channels.

ANNEX 8

Compatibility matrixing and downward mixing

Methods for providing backward compatibility and downward compatibility are described in Annex 3. Annex 4 contains downward mixing equations for 3/2 source material.

However, it is recognized that the alternative down-mix coefficients for the surround signals LS/RS are desirable, depending on the type of the programme material.

Four alternative surround signal down-mix coefficients should be indicated by the broadcaster.

0.7071

0.5000

0.0000

Reserved

Additional data should be transmitted to indicate which coefficient should be used.

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