

# Audio uređaji i signali

*SURROUND ZVUK*

# Počeci i razvoj surround zvuka na filmu

Prvi komercijalno prihvatljivi vešekanalni formati reprodukcije zvuka razvijni su početkom 1950-tih godina za film (Nagli razvoj filmske industrije zbog konkurencije televizije)

Na bazi ovih iskustava sedamdesetih i osamdesetih godina prošlog veka usavršavaju se na filmu analogni Surround formati (Dolby stereo, Dolby SR)

Početkom devedesetih – digitalni Surround formati (CDS, Dolby Digital, DTS, SDDS)



# Analogni formati na filmu

## Prvi formati višekanalnog tona na filmu

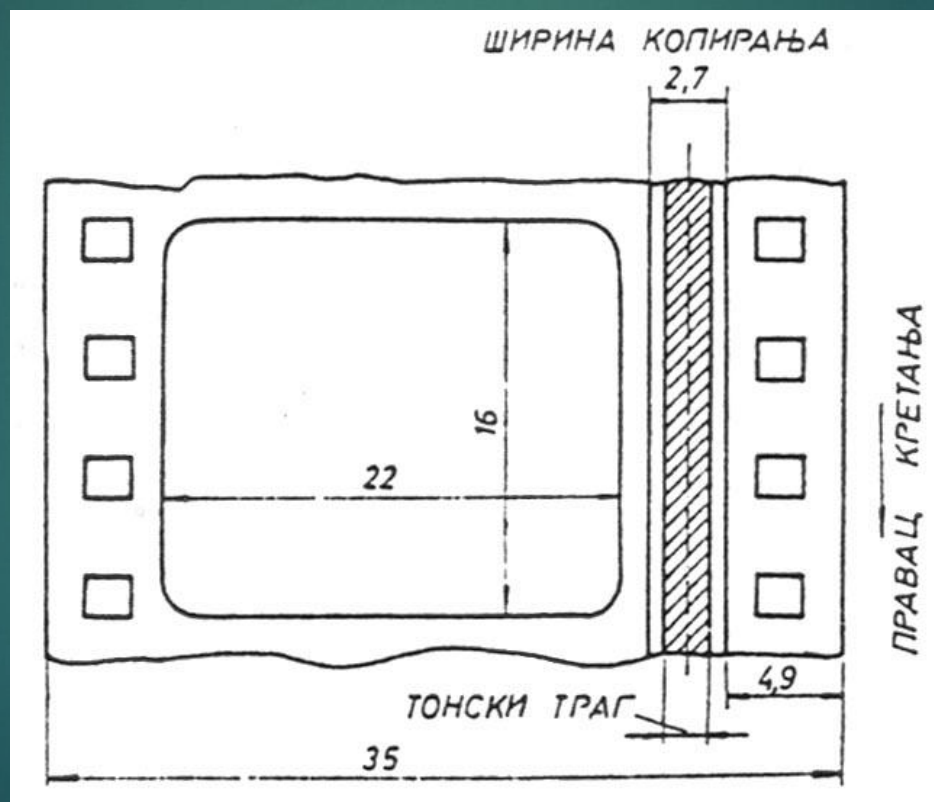
Jednokanalni ton: svetlosni zapis

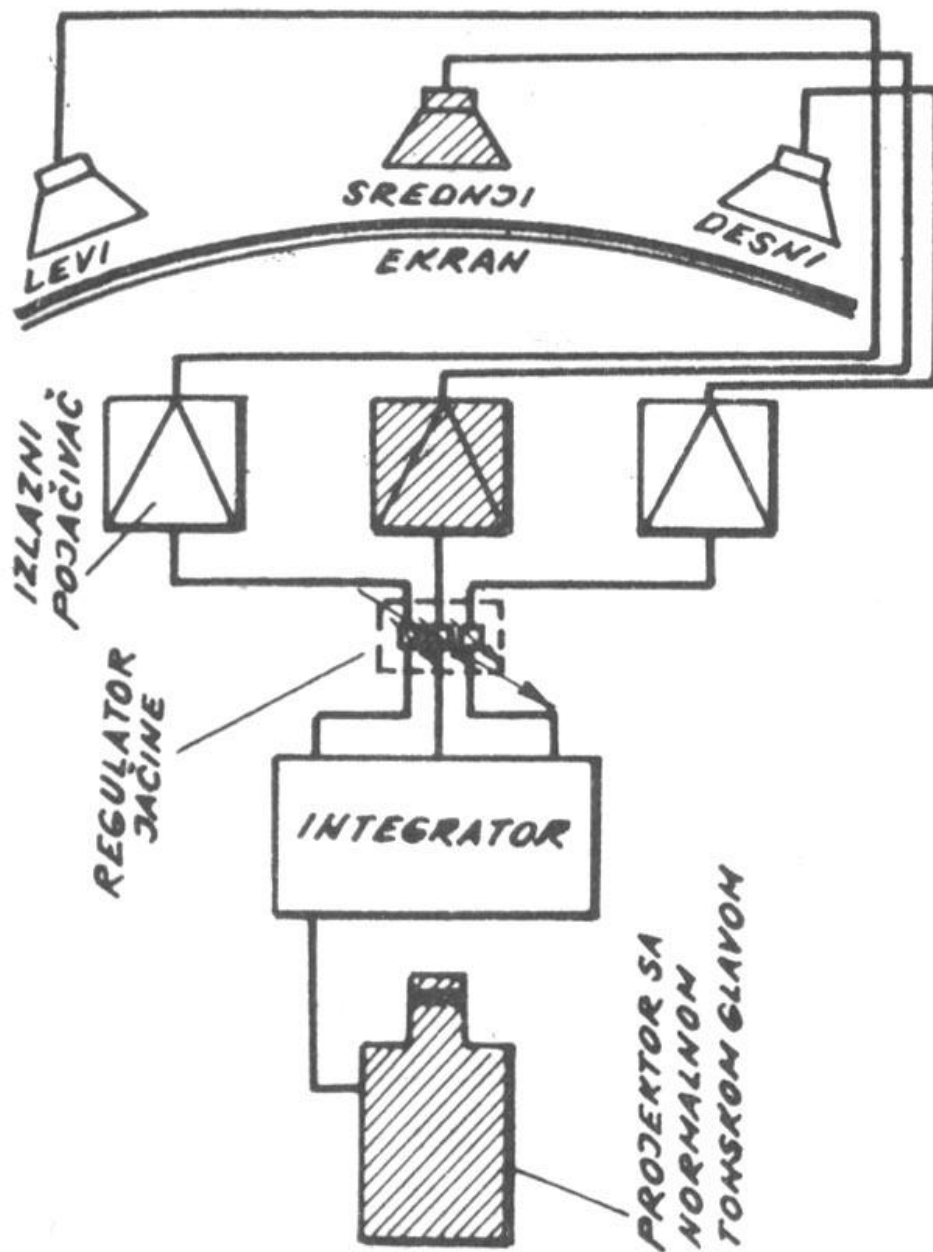
Pseudo – stereofonski ton (perspekta ton): svetlosni zapis

Sinema Scope – (35 mm): 4 kanala, magnetni zapis

Todd-AO – (70 mm): 6 kanala, magnetni zapis

# Jednokanalni optički zapis na filmskoj traci





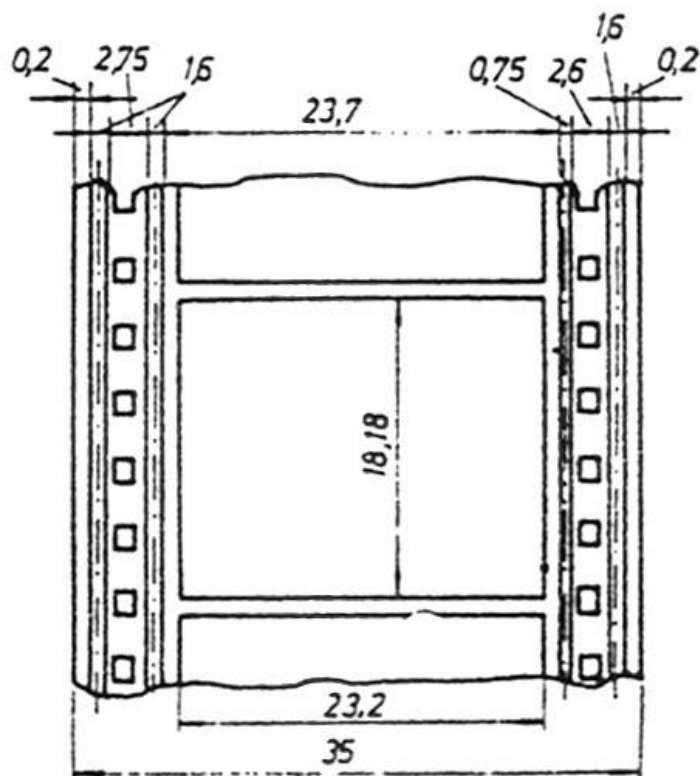
Perspekta – optički  
ton

Jednokanalni optički ton  
koji se dovodi na tri  
zvučnika intenzitetom  
koji definišu tri kontrolna  
signala (30 Hz, 35 Hz i  
40 Hz), zavisno od  
položaja izvora zvuka na  
slici

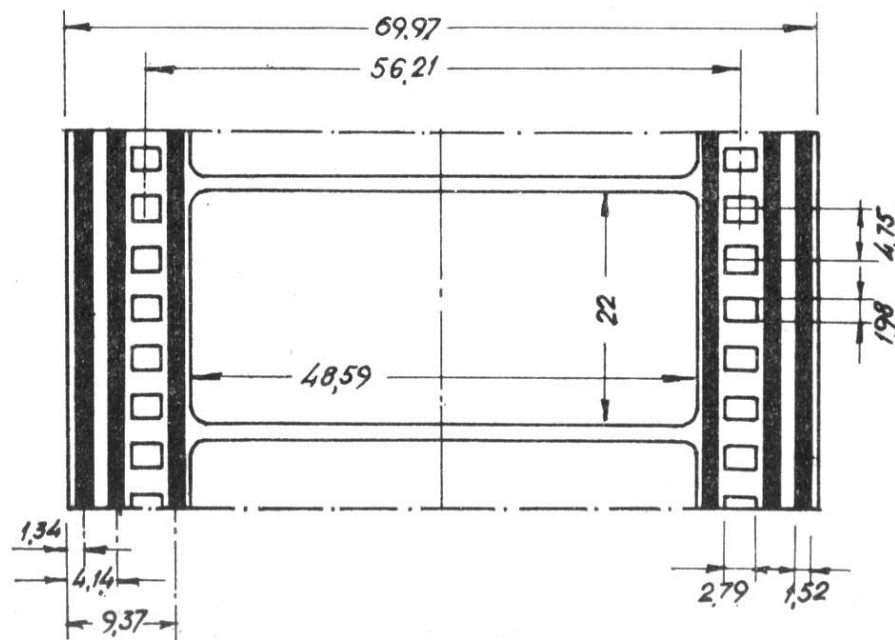
Kontrolni signali su  
usnimljeni preko  
osnovnog audio signala  
(60 Hz - 8 kHz)

# Višekanalni magnetni zapisi na filmskoj traci

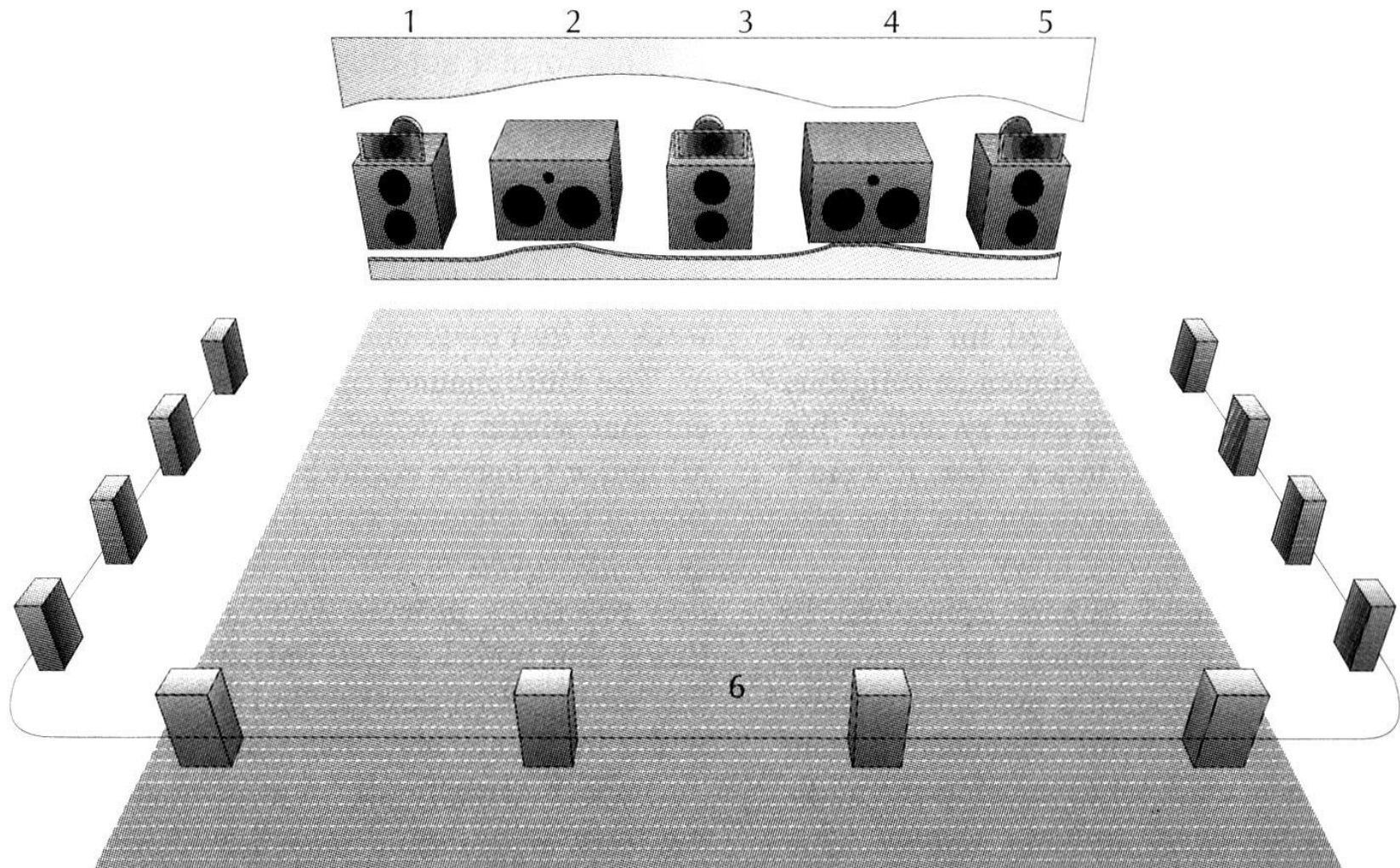
Sinema Scope – (35 mm): 4 kanala



Todd-AO – (70 mm): 6 kanala



# Reprodukcija 6 kanala u Todd-AO sistemu



## Gašenje magnetnog zapisa na filmu

I pored znatno poboljšanog kvaliteta tona na filmu korišćenjem traka sa magnetnim tragovima, primena ovog sistema u praksi, nakon početnog “buma” počinje da opada

Osnovni razlozi:

Veća cena trake sa magnetnim tragovima

Kraći vek trajanja trake sa magnetnim tragovima

Visoka cena održavanja i opreme za reprodukciju

# Analogni optički višekanalni formati na filmu

1977 – Dolby stereo (Dolby analog)

1986 – 1990 Dolby SR (Spectral Recording)

## 1977 – Dolby stereo (Dolby analog)

Standardna filmska traka – 35 mm – na istoj širini kao za raniji mono optički kanal usnimavaju se dva tonska optička zapisa

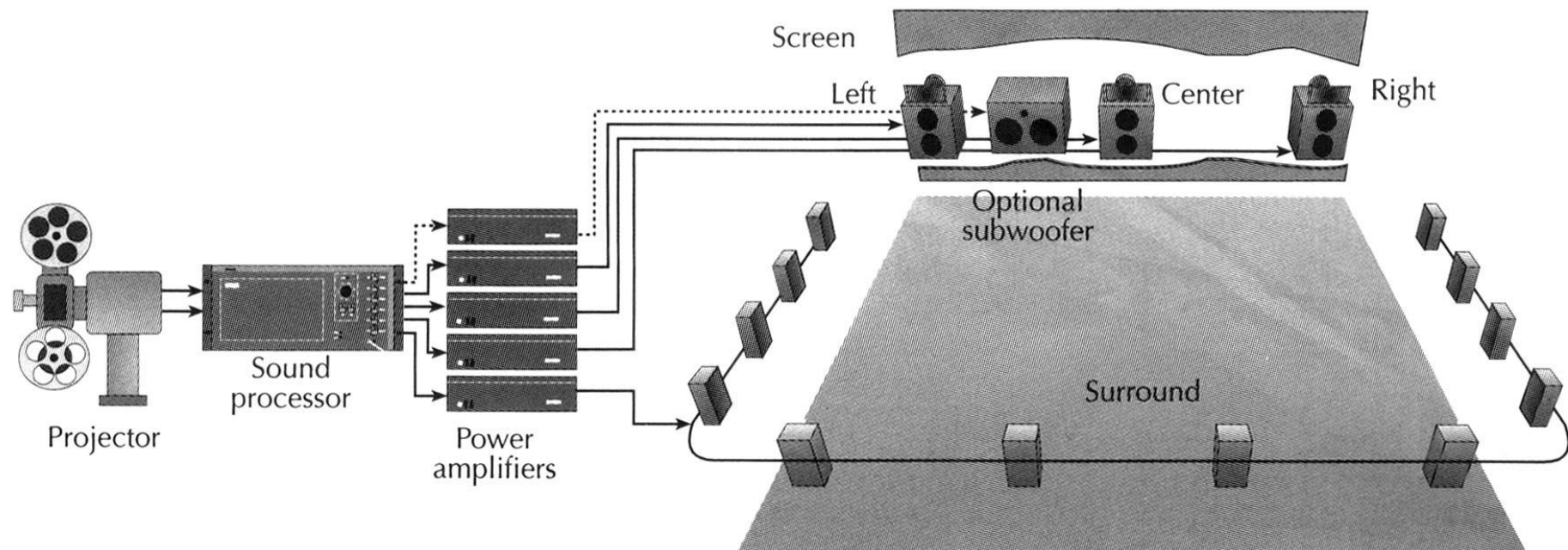
Dva optička zapisa nose podatke za 4 kanala (levi i desni kanal sa matrično kodiranim podacima za kanal C i surround (ambijent kanal i efekte)

Reprodukcija: dekodir 2:4

Proces kodiranja i dekodiranja: 4:2:4

# Dolby stereo

## Postupak dekodiranja i raspored zvučnika



## 1986 – 1990 Dolby SR (Spectral Recording)

Poboljšana verzija - eliminacije šuma (na bazi ranijih formata: Dolby A, B i C)

Primenjena u skoro svim modernim profesionalnim analognim snimcima (na traci)

Koristi se kao oprički analogni format na skoro svim 35 mm filmskim kopijama – Dolby SR analog



# Digitalni višekanalni formati na filmu



1990 – prvi 5.1 kanal – ni digitalni format: Cinema  
Digital Sound (CDS) – *Optical Radiation  
Corporation + Kodak*

Početak 90tih godina XX veka – pojavila su se tri konkurentna digitalna audio formata za 35 mm- ski film

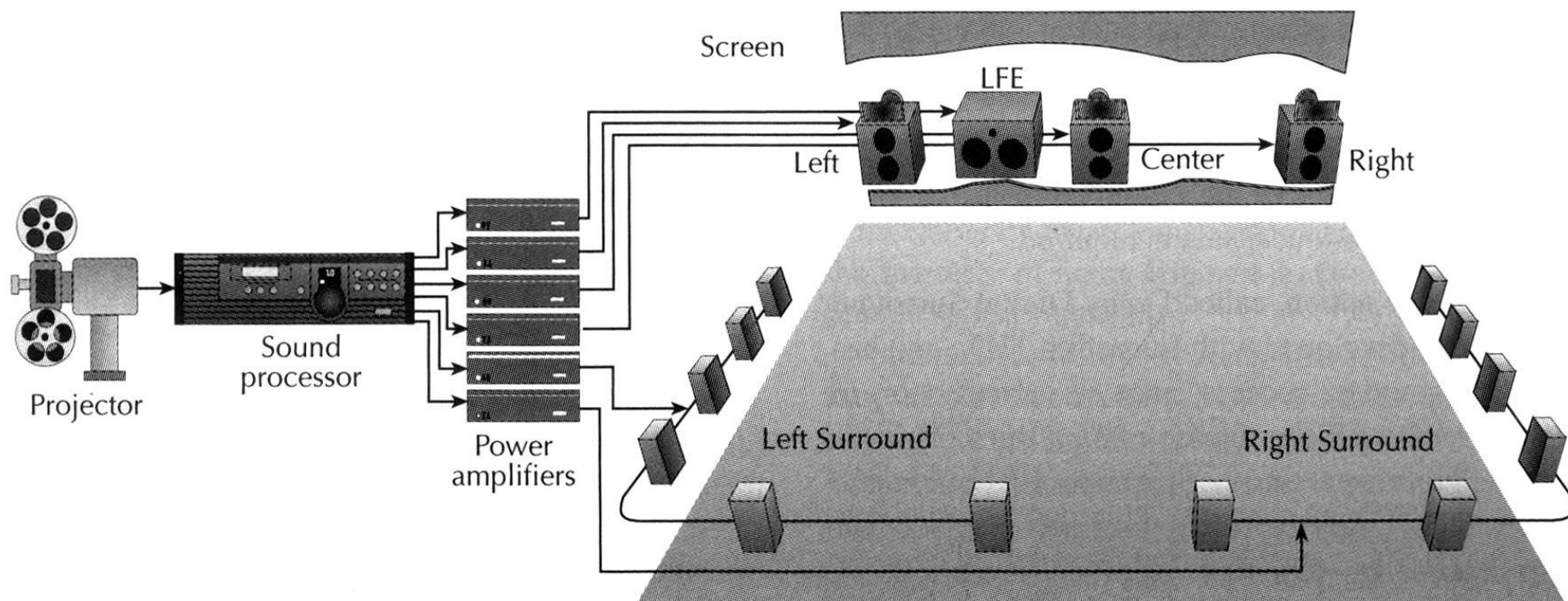
Dolby Digital

Digital Theatre Sound (DTS)

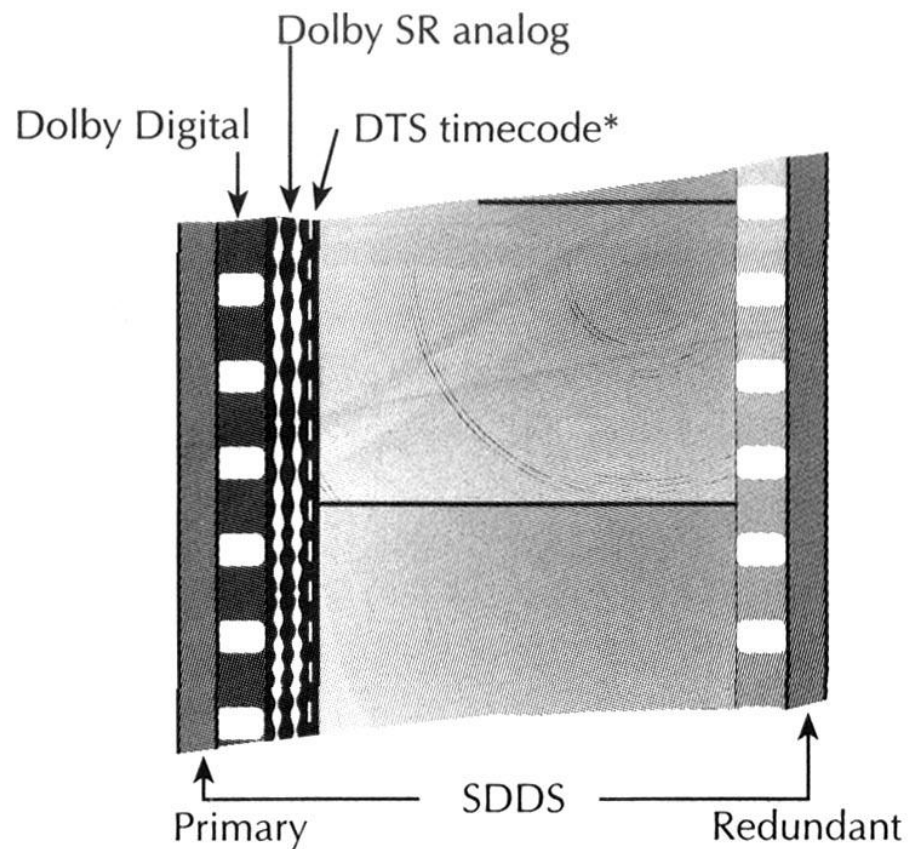
Sony Dynamics Digital Sound (SDDS)

Razlikuju se više po tome kako su rešeni njihovi digitalni audio kanali na traci nego po aktuelnim performansama

## 5.1 sistem – usvojen kao industrijski standard



# Univerzalna filmska traka 35 mm



\*DTS soundtrack is on a CD-ROM which syncs to the film via timecode

# DTS

**DTS** (*Digital Theater Sound*) – Steven Spielberg, Jurassic Park (1993.).

Compared with the Dolby Digital standard, DTS uses four times less compression and digitises sound at 20 bits instead of 16. Therefore, DTS's sound quality is theoretically higher, at the cost of a higher bit rate.

**DTS 6**, the most commonly used 5.1 standard, which can encode six-channel sound with less compression than the Dolby Digital standard. The first five channels are used for the satellite speakers, while the last is reserved for the subwoofer



**DTS ES** (*Digital Theater Sound Extended Surround*),  
6.1 standard which uses an additional rear channel  
(rear central).

The DTS ES standard has two variants:

**DTS ES Matrix**, which has a seventh channel  
interpolated with the primary channels. This is called  
"virtualisation".

**DTS ES Discrete** has an seventh independent  
channel.

# Dolby Digital EX

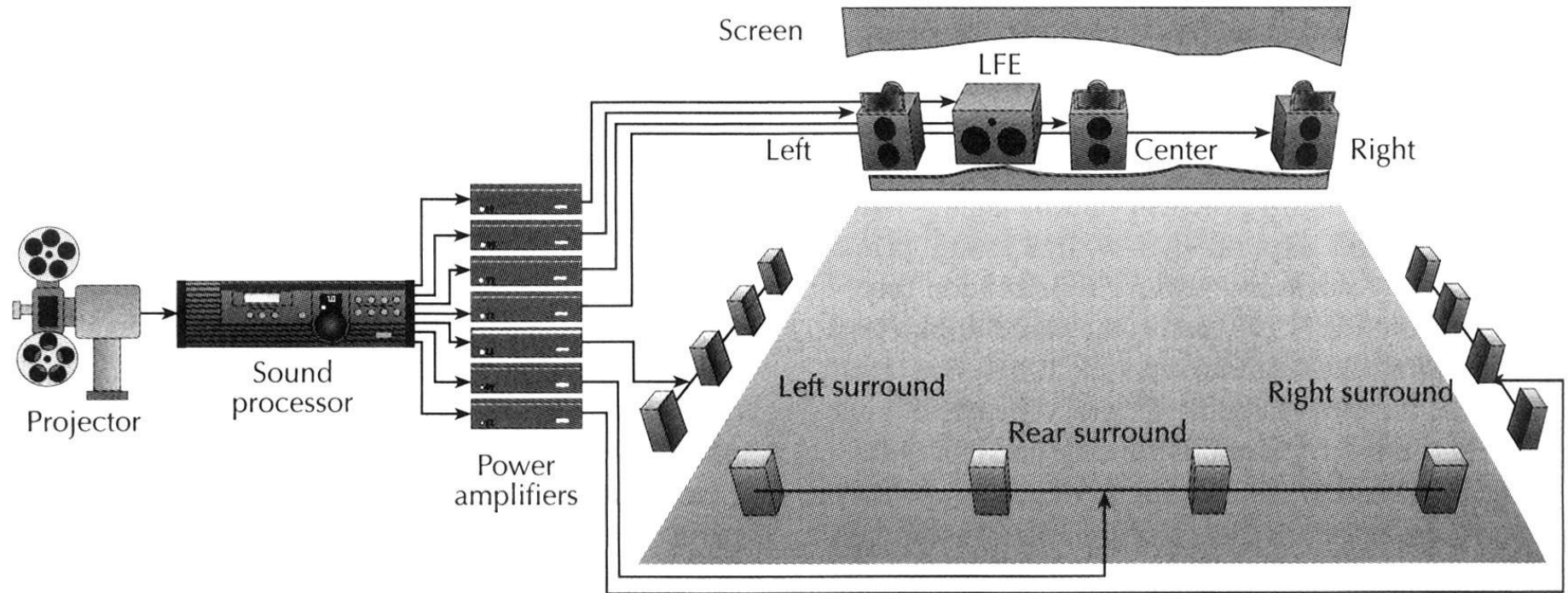


Dodatni zadnji kanal, sistem 6.1, ideja je da se popuni eventualni nedostatak u osećaju zvuka koji dolazi sa zadnjeg zida sale za projekciju

dodatni surround kanal, matrično kodiran u postojećim surround (levi i desni) kanalima standardnog digitalnog audio zapisa

(Obezbeđena je kompatibilnost sa standardnim 5.1 sistemom za reprodukciju. Korisnici koji žele dodatni surround kanal moraju imati dodatnu dekođer jedinicu i pojačavač snage. Mogu se prespajanjem iskoristiti već postojeći surround zvučnici).

# Dolby Surround Ex



## SDDS - 1993



Sony Digital Dynamic Sound  
5 screen channels (Left, Left center, Center, Right center,  
Right)  
+  
2 surround channels (Left surround, Right surround)  
+  
Subwoofer channel

Most installations use the 6-channel configuration. The 8-channel configuration is used only when the screen is large enough to handle the additional speakers between the screen.

## Varijacije sistema 5.1 za bioskope

SDDS – nudi dodatne kanale na poziciji iza platna u punom frekvencijskom opsegu: polu–levi i polu-desni (sistem 7.1)

Dolby Digital Surround EX – dodatni surround kanal, matrično kodiran u postojećim surround (levi i desni) kanalima standardnog digitalnog audio zapisa

(Obezbeđena je kompatibilnost sa standardnim 5.1 sistemom za reprodukciju. Korisnici koji žele dodatni surround kanal moraju imati dodatnu dekođer jedinicu i pojačavač snage. Mogu se prespajanjem iskoristiti već postojeći surround zvučnici).



# Digitalni višekanalni formati za kuću

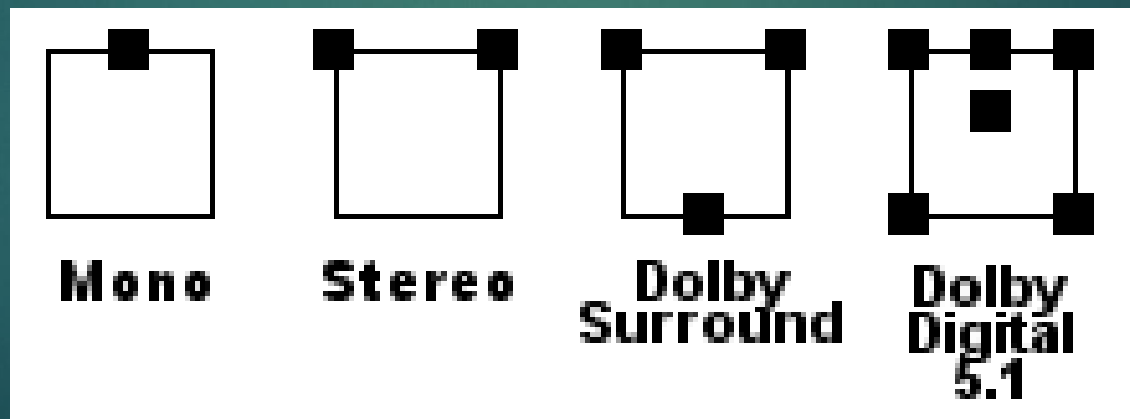
The term "**multichannel audio**" refers to the use of multiple audio tracks to reconstruct sound on a multi-speaker sound system.

Two digits separated by a decimal point (2.1, 5.1, 6.1, 7.1, etc.) are used to classify the various kinds of speaker set-ups, depending on how many audio tracks are used.

The first digit shows the number of primary channels, each of which are reproduced on a single speaker, while the second refers to the presence of a *Low Frequency Effect* (*LFE* for short), which reproduced on a subwoofer.

Thus, 1.0 corresponds to mono sound (meaning one-channel) and 2.0 corresponds to stereo sound.

For any given number of audio channels, there is an optimal physical setup for the speakers that produces the best effect possible. For this reason, special icons are placed on surround sound equipment to symbolise the number of channels and the physical placement of the speakers. Small black squares (one for each channel) are placed in a square that represents a room to indicate how to set them up:



## Dolby surround -1982

Dva kanala + surround kanal (upper frequency limit of 7 kHz  
+ delay time of about 20 ms )

Dolby surround Pro Logic (Dolby Pro Logic – 1987)

Two side speakers in front

One central speaker (for reproducing the actors' voices )

Two rear surround speakers (in mono)

## Dolby Pro Logic II- 2000

5.1 sound environment, by applying computer processing to a  
stereo source (2.0) or Dolby Surround (3.0/4.0/4.1).

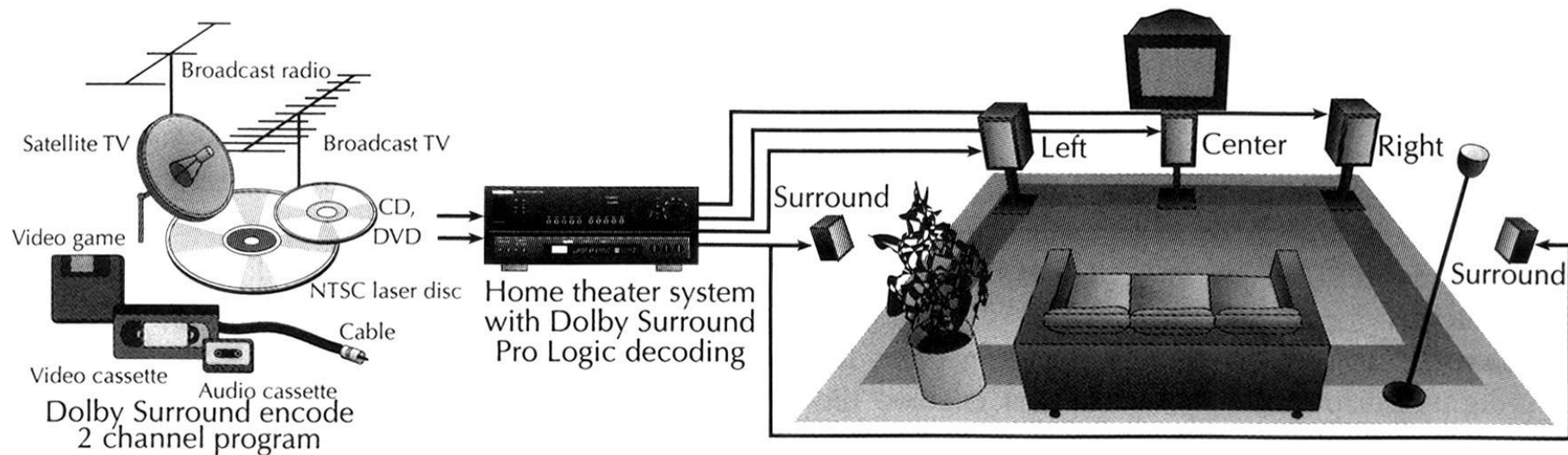
## Dolby Pro Logic IIx- 2003

can artificially reconstruct a 6.1 or 7.1 sound environment  
from a stereophonic source

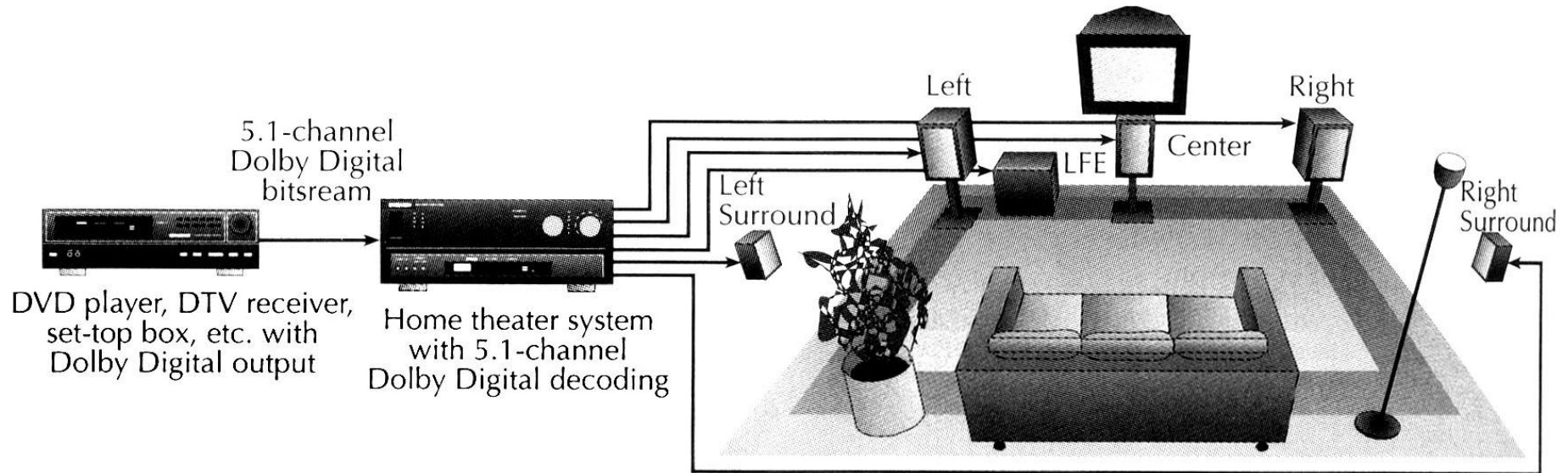
It offers several sound ambiance settings depending on how  
the speakers are being used:

*Movie for playing films,  
Music for playing audio CDs,  
Game for videogames.*

# Dolby Pro Logic kuční bioskop



# Dolby Digital kuční bioskop



| Decoder                                    | Encoder                          | Year                         | Description                                                                                                                  | Channels                             |  |
|--------------------------------------------|----------------------------------|------------------------------|------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|--|
|                                            | Dolby Stereo                     | 1975                         | Cinema use.                                                                                                                  | FL FR with C and RearMono matrixed   |  |
| Dolby Surround                             | Dolby Surround                   | 1982                         | First Home use. Analog.                                                                                                      | FL FR with C and RearMono matrixed   |  |
|                                            | Dolby SR                         | 1986                         | Cinema use.                                                                                                                  | FL FR with C and RearMono matrixed   |  |
| Dolby Pro Logic                            |                                  | 1987                         | Improved Dolby Surround. Upmix Stereo to Surround 4.0.                                                                       | FL FR with C and RearMono matrixed   |  |
| Dolby Pro Logic II                         |                                  | 2000                         | Improved Dolby Pro Logic. Upmix Mono(in Matrix mode) or Stereo to Surround 5.1 in either Matrix, Movie, Music, or Game mode. | FL FR C SL SR SUB                    |  |
| Dolby Pro Logic IIx                        |                                  |                              | Upmix Stereo or Surround 5.1 to 6.1 or 7.1 in either Movie, Music, or Game mode.                                             | FL FR C SL SR SUB and RearMono(x2)   |  |
| Dolby Digital                              | Adaptive Transform Coder 3 (AC3) | 1992 Film<br>1995 Laser Disc | Discrete channel encoder/decoder. Pro Logic Decoder can be used for downmixed stereo inputs.                                 | FL FR C SL SR SUB                    |  |
| Dolby Digital EX/Dolby Digital Surround EX |                                  | 1999                         | 6.1 or 7.1 (5.1 with Center Rear matrixed onto SL & SR)                                                                      | FL FR C SL SR SUB RearMono(x1 or 2x) |  |
|                                            | Dolby Digital Plus               |                              | High bitrate. Currently uses 7.1 channels with support for more.                                                             |                                      |  |
|                                            | Dolby TrueHD                     |                              | Lossless encoder for High Definition Video Sound. Eight full-range channels of 24-bit/96 kHz. Higher Bitrate than DD-Plus.   |                                      |  |
|                                            | Dolby Digital Live               |                              | On the Fly 5.1 encoder for Games.                                                                                            |                                      |  |



| <b>Dolby Surround</b> | <b>Left</b> | <b>Right</b> | <b>Center</b>        | <b>Surround</b>        |
|-----------------------|-------------|--------------|----------------------|------------------------|
| <b>Left Total</b>     | 1           | 0            | $\frac{\sqrt{2}}{2}$ | $j \frac{\sqrt{2}}{2}$ |
| <b>Right Total</b>    | 0           | 1            | $\frac{\sqrt{2}}{2}$ | $k \frac{\sqrt{2}}{2}$ |

*$j = +90^\circ$  phase-shift,  $k = -90^\circ$  phase-shift*



| <b>Dolby Pro Logic</b> | <b>Left</b> | <b>Right</b> | <b>Center</b>        | <b>Rear Left</b>      | <b>Rear Right</b>     |
|------------------------|-------------|--------------|----------------------|-----------------------|-----------------------|
| <b>Left Total</b>      | 1           | 0            | $\frac{\sqrt{2}}{2}$ | $j\frac{\sqrt{2}}{2}$ | $j\frac{\sqrt{2}}{2}$ |
| <b>Right Total</b>     | 0           | 1            | $\frac{\sqrt{2}}{2}$ | $k\frac{\sqrt{2}}{2}$ | $k\frac{\sqrt{2}}{2}$ |

*$j = +90^\circ$  phase-shift,  $k = -90^\circ$  phase-shift*

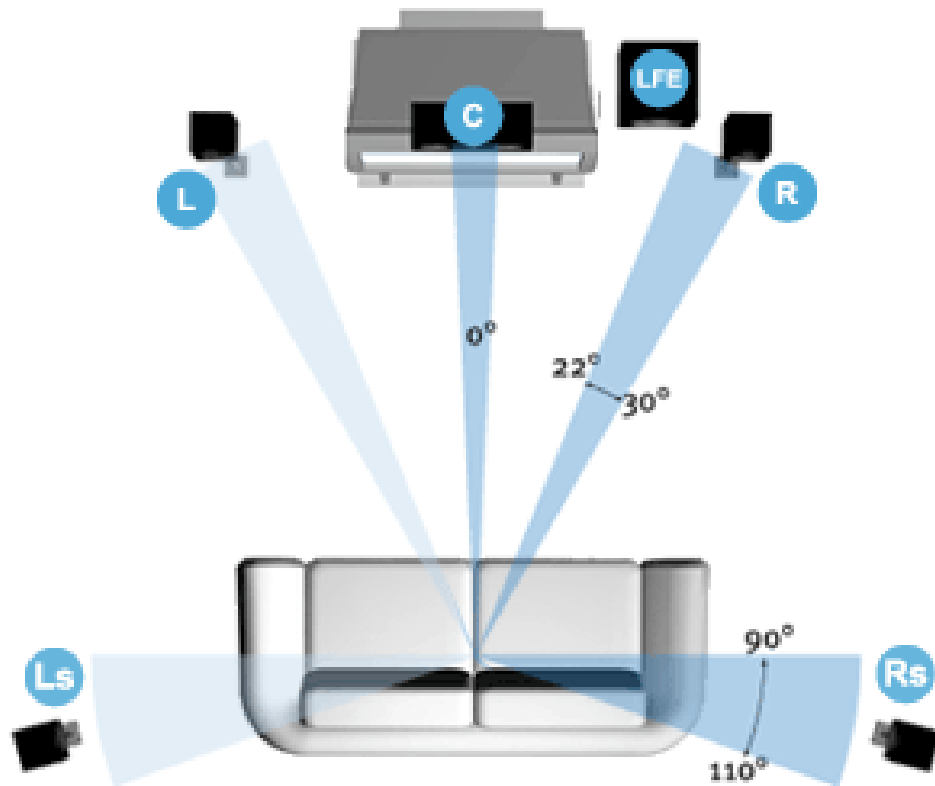


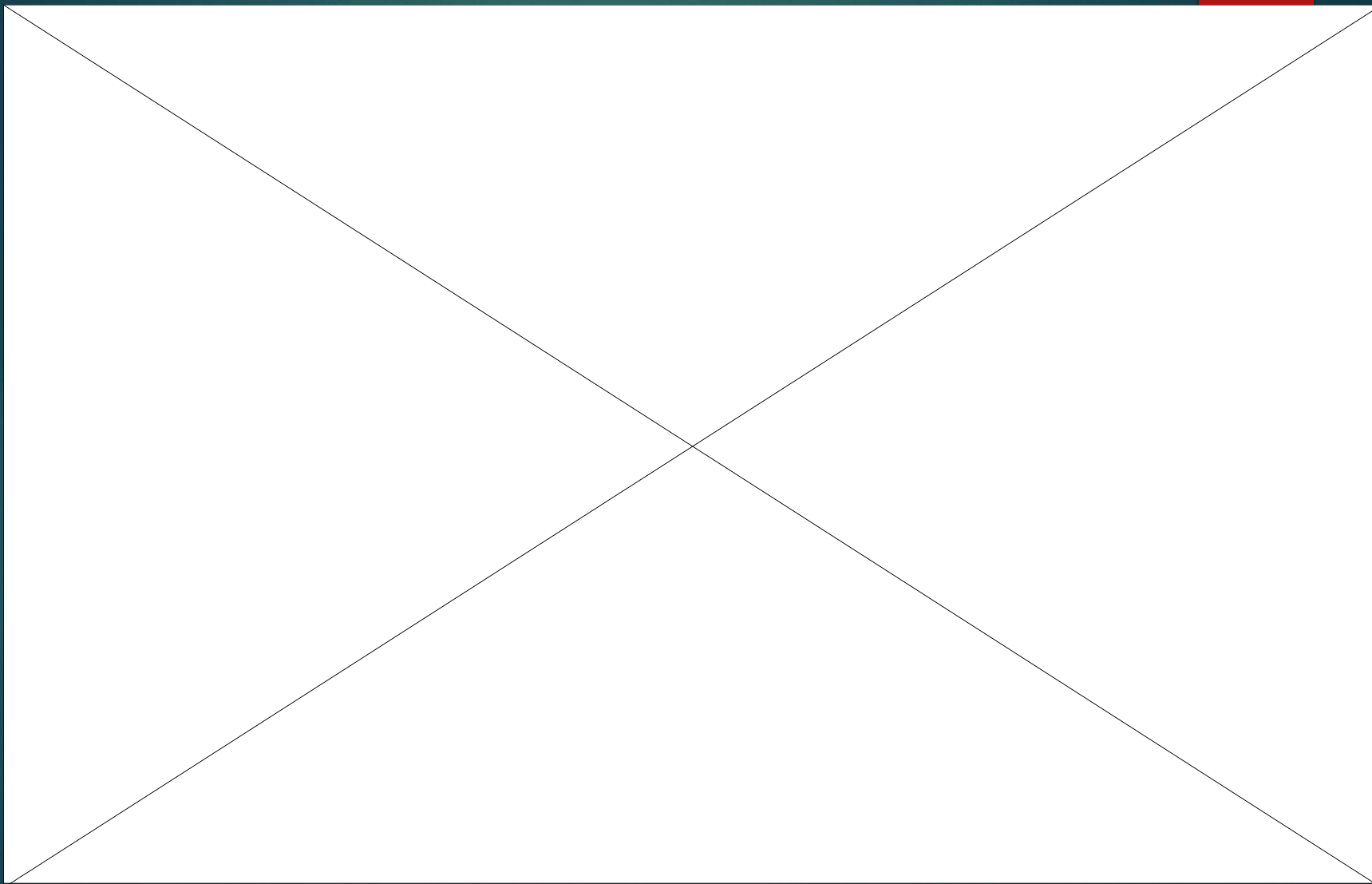
| <b>Dolby Pro Logic II</b> | <b>Left</b> | <b>Right</b> | <b>Center</b>        | <b>Rear Left</b>       | <b>Rear Right</b>      |
|---------------------------|-------------|--------------|----------------------|------------------------|------------------------|
| <b>Left Total</b>         | 1           | 0            | $\frac{\sqrt{2}}{2}$ | $j \frac{\sqrt{2}}{3}$ | $j \frac{\sqrt{1}}{3}$ |
| <b>Right Total</b>        | 0           | 1            | $\frac{\sqrt{2}}{2}$ | $k \frac{\sqrt{1}}{3}$ | $k \frac{\sqrt{2}}{3}$ |

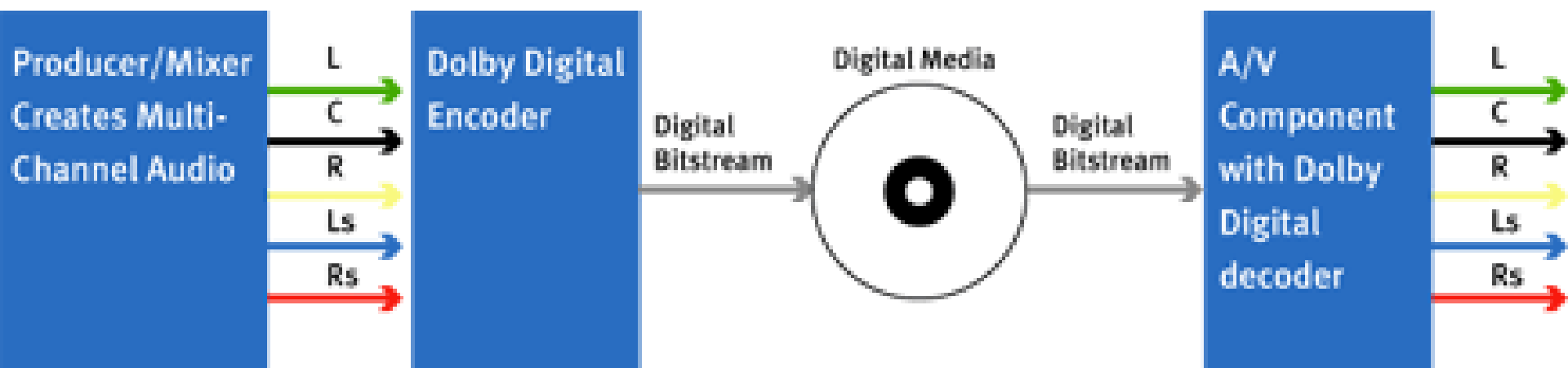
*$j = +90^\circ$  phase-shift,  $k = -90^\circ$  phase-shift*

Stereo  
Movie, Music  
or Game  
Audio

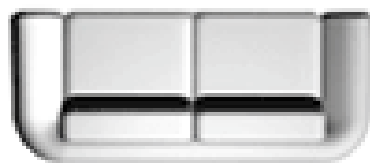
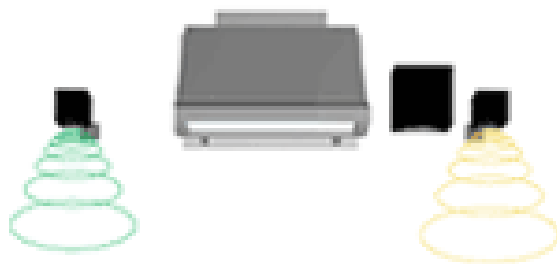
## Dolby Pro Logic II Speaker Configuration



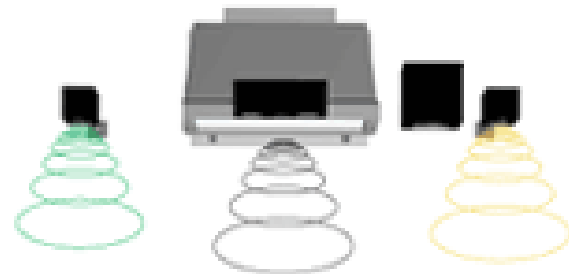




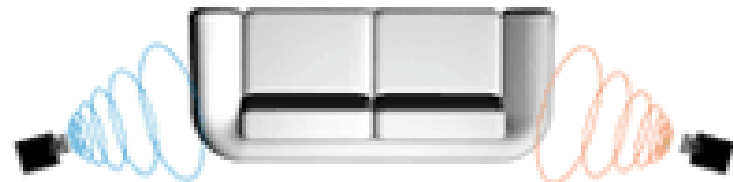
## Dolby Digital Stereo



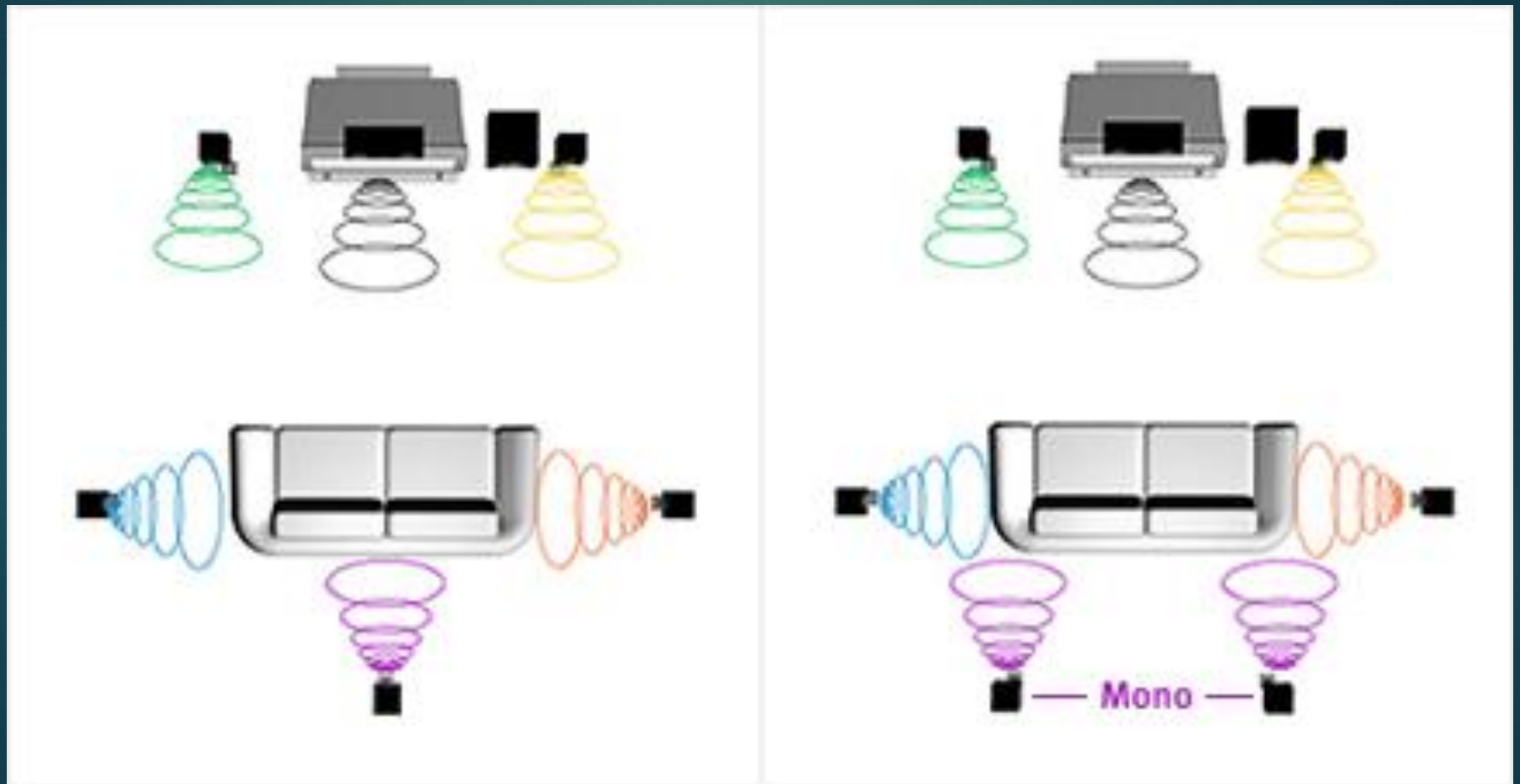
## Dolby Digital 5.1



Each surround signal is unique



# Dolby digital EX 6.1 i 7.1



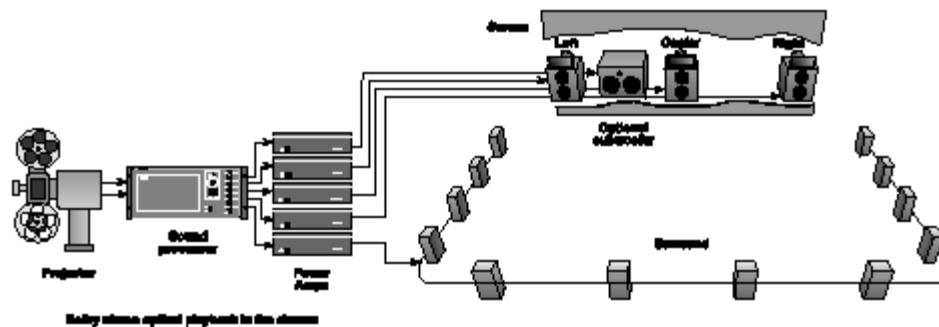


Figure 2-2 Dolby® Stereo (Motion Picture Matrix Four-Channel [4:2:4]) Setup for Theatres

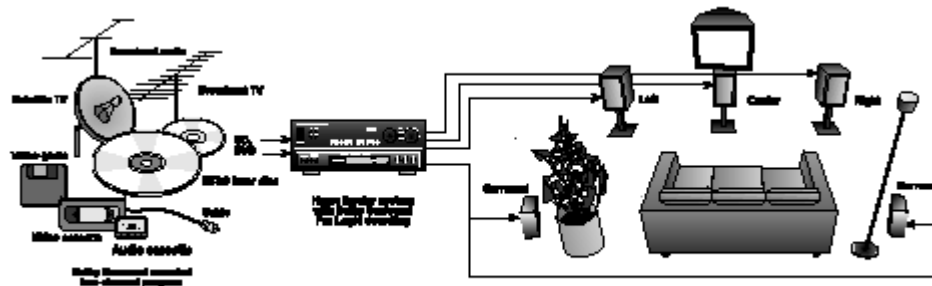
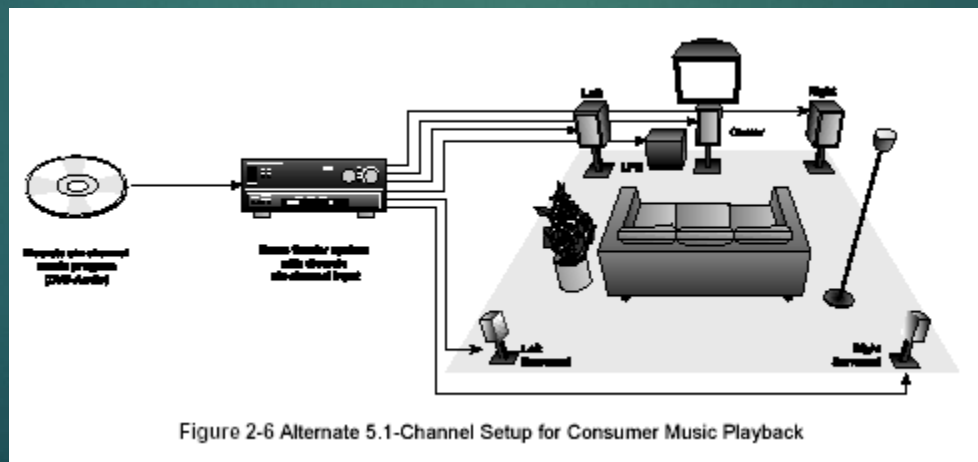
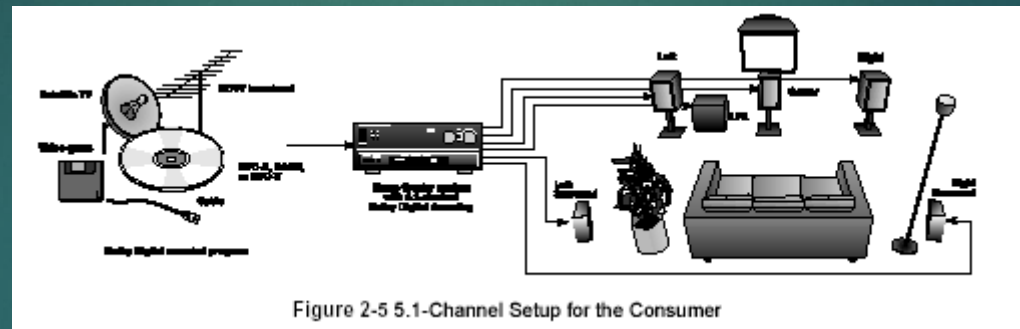
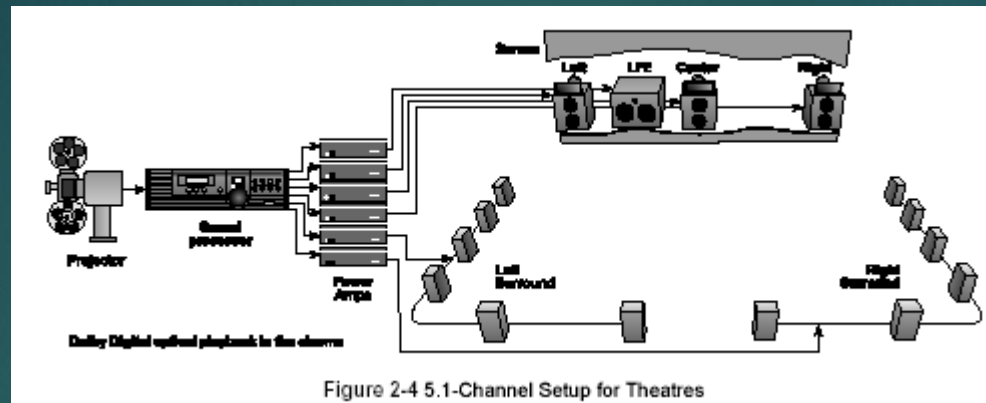


Figure 2-3 Dolby Surround (Matrix Four-Channel [Pro Logic®]) Setup for the Consumer



## Room dimensions

A minimum height of 3 meters (9 feet) is desirable.

Table 3-1 Room Dimensions

| Parameter        | Units/Conditions                                                                                                                       | Value                                                                                                                              |
|------------------|----------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------|
| Room Floor Area  |                                                                                                                                        | $>30 \text{ m}^2$ (320 $\text{ft}^2$ )                                                                                             |
| Room Volume      |                                                                                                                                        | $<300 \text{ m}^3$ (10,500 $\text{ft}^3$ )                                                                                         |
| Room Proportions | L = Length (larger dimension, irrespective of orientation)<br>W = Width (shorter dimension, irrespective of orientation)<br>H = Height | $1.1W/H \leq L/H \leq 4.5W/H - 4$<br>with $L/H < 3$ and $W/H < 3$<br>No ratios of L, W, and H within $\pm 5\%$ of an integer value |

## Acoustics

### Early Reflections

Any early reflections (within 15 ms) should be at least 10 dB below the level of the direct sound for all frequencies in the range 1 kHz to 8 kHz [6].

### Reverberation Field

Reverberation time is frequency-dependent. The nominal value,  $T_m$ , is the average of the measured reverberation times in the 1/3-octave bands from 200 Hz to 4 kHz and should lie in the range:  $0.2 < T_m < 0.4$  s.  $T_m$  should increase with the size of the room; the formula in Table 3-2 is a guide. The reverberation time  $T$ , measured in 1/3-octave bands over the frequency range from 63 Hz to 8 kHz, should conform to the tolerance mask shown

Table 3-2 Reverberation Values

| Parameter       |                    | Units/Conditions                                                                                                                                                  | Value                             |
|-----------------|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|
| Reflected Sound | Early Reflections  | 0–15 ms (in region 1–8 kHz)                                                                                                                                       | < –10 dB relative to direct sound |
|                 | Reverberation Time | $T_m$ [s] = nominal value in region of 200 Hz to 4 kHz<br>V = listening room volume<br>$V_0$ = reference room volume (100 m <sup>3</sup> [1075 ft <sup>3</sup> ]) | $\approx 0.25(V/V_0)^{1/3}$       |

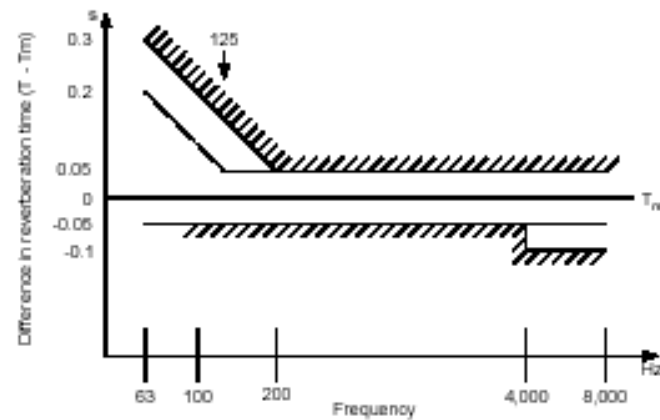


Figure 3-1 Tolerance Limits for Room Reverberation Time  
(dotted lines = tighter tolerances proposed by the AES, see [1])

## **Background Noise**

The listening area should ideally achieve an NC rating of 10 or below with the equipment off, measured at the reference position. A studio with equipment such as video projectors, video monitors, and other ancillary equipment powered on should achieve a rating of iÜ NC 15. Any background noise should not be perceptibly impulsive, cyclical, or tonal in nature.

One-third octave band background noise level limits noise rating curves, based on the former ISO NR curves, ISO Recommendation R1995 (1972)

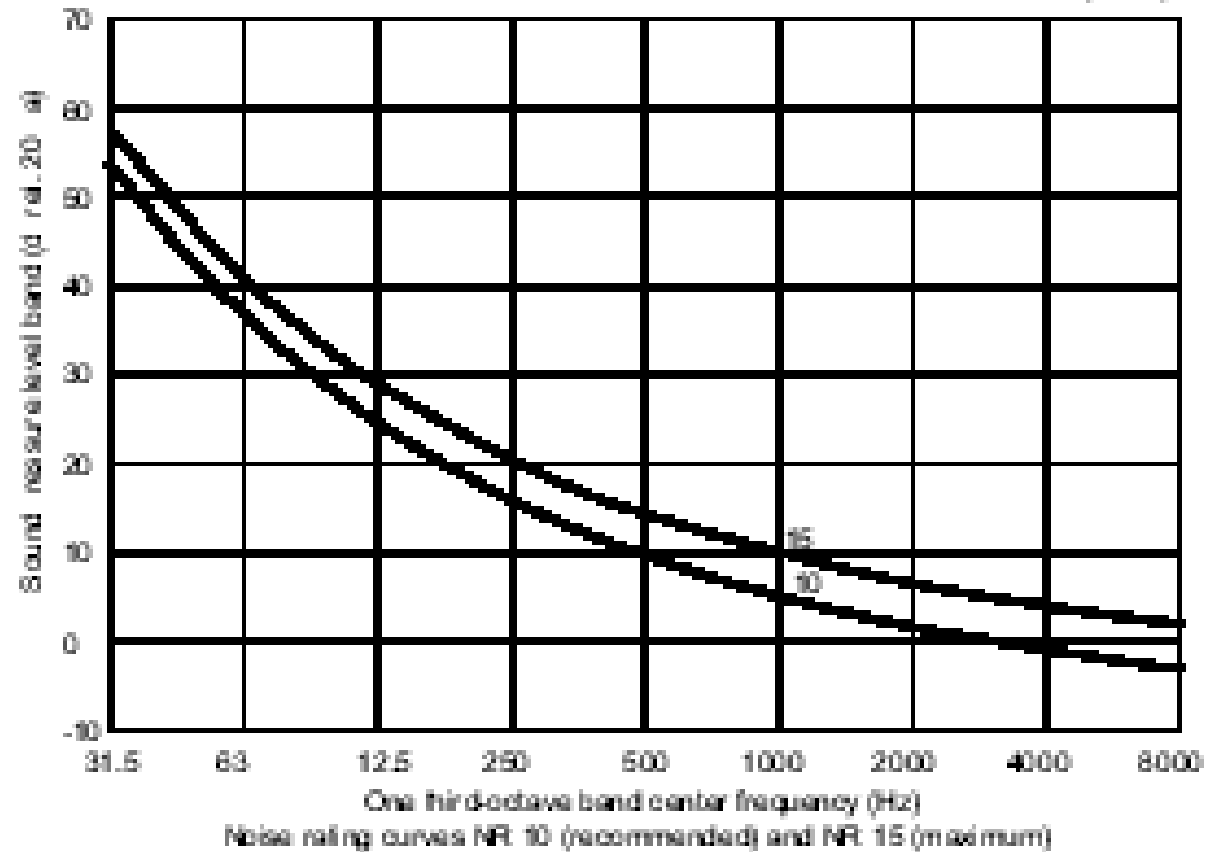
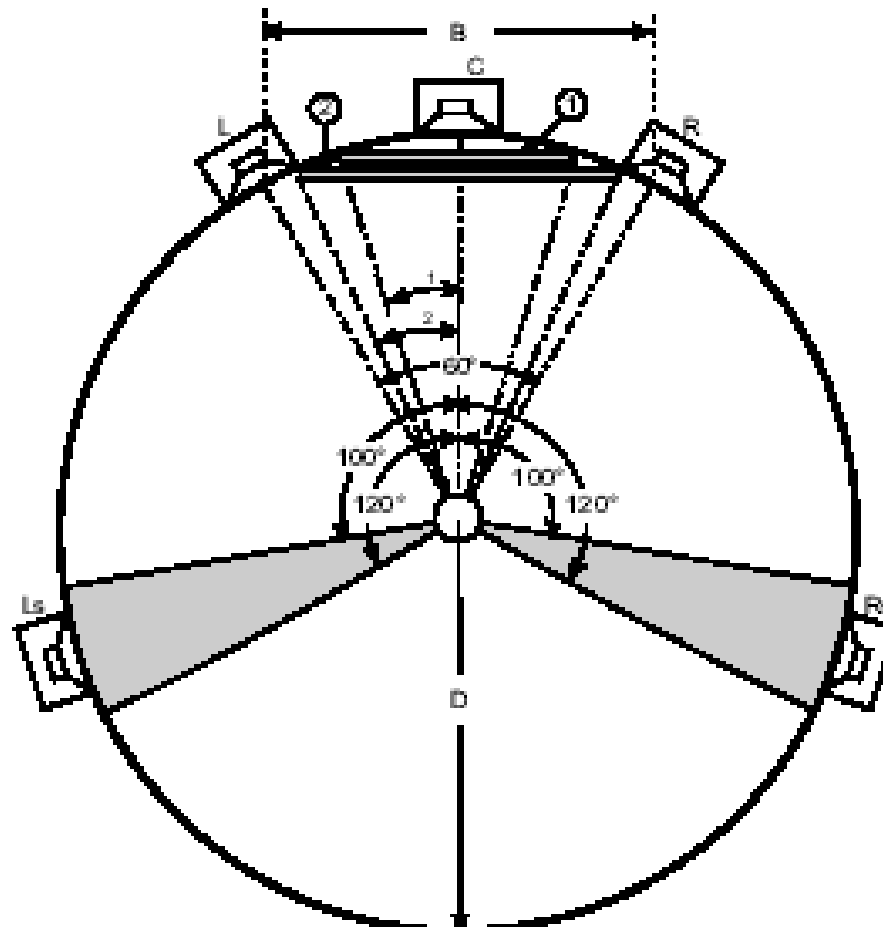


Figure 3-2 Noise Rating Curves



H: height of screen

B: loudspeaker base width

D: listening distance

Screen 1 HDTV: reference distance =  $3H$  ( $2 \times 1 = 33^\circ$ )

Screen 2 =  $3H$  ( $2 \times 2 = 48^\circ$ )

| Loudspeaker | Horizontal Angle from Center (degrees) | Height (meters/feet) | Inclination (degrees) |
|-------------|----------------------------------------|----------------------|-----------------------|
| C           | 0                                      | 1.2/4                | 0                     |
| L, R        | 30                                     | 1.2/4                | 0                     |
| Ls, Rs      | 100–120                                | $\geq 1.2/4$         | 0–15 down             |

Figure 3-3 Reference Loudspeaker Placement

## **Console Placement**

In most cases, the console should be placed equidistant from the listening studio sidewalls. Lateral placement is discussed in Section 3.3.

## **Reference Positions**

The reference position of the mixer's head is typically:

- At the center of the console
- Equidistant from the sidewalls
- Directly above the rear edge (arm rest) of the mixing console
- 1.2 meters (48 inches) off the floor

This imaginary point is the reference point for all speaker distances and aiming angles.

Table 3-3 Reference Loudspeaker Specifications

| Parameter                                                                                           | Units/Conditions                       | Value                                                                   |
|-----------------------------------------------------------------------------------------------------|----------------------------------------|-------------------------------------------------------------------------|
| Amplitude/frequency response                                                                        | 20 Hz to 20 kHz* on axis ( $0^\circ$ ) | 4 dB                                                                    |
|                                                                                                     | $\pm 10^\circ$                         | Deviation to $0^\circ$ , 3 dB                                           |
|                                                                                                     | Horizontal $\pm 30^\circ$              | Deviation to $0^\circ$ , 4 dB                                           |
| Difference between speakers                                                                         | In the range >250 Hz to 2 kHz          | .5 dB                                                                   |
| 4 Directivity Index                                                                                 | 250 Hz to 16 kHz                       | 8 dB $\pm$ 2 dB                                                         |
| Nonlinear distortion attenuation (SPL = 96 dB)                                                      | <100 Hz                                | -30 dB (=3%)                                                            |
|                                                                                                     | >100 Hz                                | -40 dB (=1%)                                                            |
| 5 Transient fidelity<br>Decay time $t_s$ , for reduction to a level of $1/e$                        | $t_s$ [s]                              | $< 5/f$ [Hz]<br>(preferably $2.5/f$ )                                   |
| 6 Time delay                                                                                        | $\delta t$                             | $\leq 10 \mu s$                                                         |
| 7 System dynamic range<br>Maximum operating level (per IEC 60268, § 17.2, referred to 1 m distance) | $L_{eff max}$                          | >112 dB<br>(at IEC 60268 program simulation noise or special condition) |
| Noise level                                                                                         | $L_{noise}$                            | $\leq 10$ dBA                                                           |

\* 20 kHz is a minimum value. Some delivery formats contain content up to 96 kHz. Choice of speakers may depend on the production format in use.

Source: Modified from AESTD1001.1.01-10