The Magic in 2-Channel Sound Reproduction
Why is it so rarely heard?

Siegfried Linkwitz
The Magic in 2-Channel Sound Reproduction

Why is it so rarely heard?

Hearing under anechoic conditions
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The room response
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Typical stereo reproduction
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Two loudspeaker design examples

My challenge to Loudspeaker Designers
Hearing under anechoic conditions

A - Headphone Stereo
Hearing under anechoic conditions

B - Loudspeaker Stereo
The Room Response

R1 - Reflections
The Room Response

R2 - Reflections

[Image of sound distribution diagram showing different reflection paths: Direct, Rear, Rear+Side, Rear+Floor, Side, Rear+Side+Floor, Side+Floor]
The Room Response

R3 - Reflections
The Room Response

R4 - Reflections
The Room Response

R5 - Resonance modes
The Room Response

R6 - Reverberated sound field

**a) Room dimensions**

- **L** = 22.6 ft \( \approx 6.88 \) m
- **W** = 16.0 ft \( \approx 4.88 \) m
- **H** = 9.0 ft \( \approx 2.75 \) m

**b) Acceptable room if:**

- \( 1.1 \cdot (W/H) < (L/H) < 4.5 \cdot (W/H) \cdot 4 \)
- 2.0 2.5 4.0

(R. Walker, BBC, 1996)

**c) Below frequency \( f_m = 150 \) Hz**

- Total number of modes \( N = 55 \)
- Avg. mode spacing \( df = 1.6 \) Hz at \( f_m \)

**d) Estimated avg wall absorption \( a = 25\% \)**

- Reverberation time \( T_{60} = 456 \) ms

**e) Estimated reverberation time \( T_{60} = 456 \) ms**

- Resonance bandwidth \( bw = 4.8 \) Hz
- Rise time \( T_{rise} = 146 \) ms
- Schroeder frequency \( f_s = 134 \) Hz
- Monopole reverb distance \( R_m = 0.80 \) m \( \approx 2.6 \) ft
- Dipole reverb distance \( R_d = 1.39 \) m \( \approx 4.6 \) ft
- Avg wall absorption \( a = 25\% \)

SL 5/27/15

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**Sensible Recording and Rendering of Acoustic Scenes**
Typical Stereo Reproduction

Generic box loudspeakers
Typical Stereo Reproduction

Design axis/window
Typical Stereo Reproduction

Auditory scene

Focused lateral imaging. Depth?
Height of scene = Height of speaker boxes
Auditory scene is hard-bounded by the speakers
Like listening to headphones at a distance
Scene collapses into nearest speaker
Aware of listening to 2 speakers in a room
Optimal Stereo Reproduction

Auditory scene

Focused lateral imaging. Depth
Height of scene much greater than Height of speaker boxes
Auditory scene is soft-bounded by the speakers
Like being at the performance venue
Scene is viewed from off-center seat without collapsing
Not aware of listening to speakers in a room
Optimal Stereo Reproduction

Loudspeaker & Setup Requirements

1 – Speaker’s $4\pi$ power response similar to on-axis response
2 – Speakers free of audible non-linear and linear distortion
3 – Speakers set up >1 m from large reflecting surfaces
4 – Space behind speakers is diffusive & absorptive behind listener
5 – Comfortable living space with RT60 around 450 ms
Two Loudspeaker Design Examples

D - Full-range dipole loudspeaker

H - Hybrid loudspeaker
Two Loudspeaker Design Examples

D1 – Open-baffles
Two Loudspeaker Design Examples

D2 – Woofer response at baffle opening

[Graph showing woofer response with labels: Proto #3 Woofer, opening, equalized, -12dB/oct, LR4]
Two Loudspeaker Design Examples

D3 – Lower midrange polar response
Two Loudspeaker Design Examples

D4 – Upper midrange polar response
Two Loudspeaker Design Examples

D5 – Tweeter polar response
Two Loudspeaker Design Examples

D6 – Equalization & Crossovers

[Graph showing frequency response and crossover points labeled LR4, LR2, LR4, W, LM, UM, T with a slope of -12 dB/oct]
Two Loudspeaker Design Examples

H1 – Hybrid loudspeaker
Two Loudspeaker Design Examples

H2 – On-axis response
Two Loudspeaker Design Examples

H3 – Polar response

![Graph showing frequency response with polar response](image)
Two Loudspeaker Design Examples

H4 – Polar response
Two Loudspeaker Design Examples

H5 – Equalization & Crossover
Optimal Stereo Reproduction

e.g. Dipole or Hybrid Loudspeaker

1 – Speaker’s $4\pi$ power response similar to on-axis response
2 – Speakers free of audible non-linear and linear distortion
3 – Speakers set up >1 m from large reflecting surfaces
4 – Space behind speakers is diffusive & absorptive behind listener
5 – Comfortable living space with RT60 around 450 ms
My Challenge to High-End Speaker Designers

• Recognize that the listening room is rarely the problem for sound reproduction, but how it is illuminated by the loudspeakers

• Therefore a flat on-axis frequency response is not sufficient

• Therefore reduce the variation in speaker directivity

• Reduce non-linear and linear distortions for higher SPL

• For meaningful, descriptive comparisons with other speakers designers & reviewers should own a pair of Lxmini as reference
Thank you for your attention

Please spread the message