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How can you tell if system gain is properly set?

Do you measure it or do it by ear?
Whose ear?

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Gain Structure Workshop: Defining & measuring proper gain structure

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Dan Andrewson, CQT

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ic26 What is gain structure?

“Gain structure is the strategic management of signal levels across every stage of the audio chain – from source to speakers – to maximize signal strength while minimizing noise and distortion”
– Radial Engineering Blog

The word 'infocomm' in a bold, sans-serif font, positioned in the bottom right corner of the slide.

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infocomm

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Stated another way...

We want to avoid that middle school talent show band vibe in our professional installations.

You know...like this one:

infocomm

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Goal of Proper Gain Structure

- Deliver audio at the required listen levels
- Optimized signal to noise ratio
- Minimal total harmonic distortion



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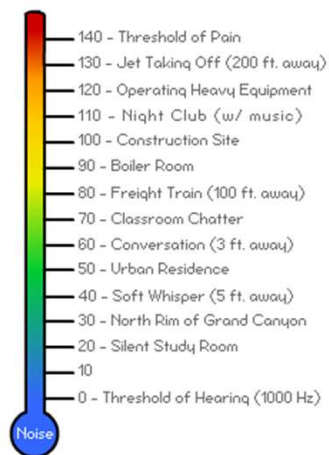
Listen Levels

What level should the system be by default?

What level should the system be able to handle?

What level do I design for?

Typical Sound Levels (dBA)



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Listen Levels

What level should the system be by default?

- Listen Level
 - 65 dB SPL, a-weighted (65 dBA)?

What level should the system be able to handle?

- Headroom
 - 15 dB (emphatic talker/explosion)?

What level do I design for?

- Listen Level + Headroom
 - 65 dBA + 15 dB = 80 dB SPL
 - Design for worst case

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How loud should the system be?

- “It depends” – Syn Aud Con
- Client preference
- Task
- Space
- No “right answer”, but should be defined, demonstrated, and approved

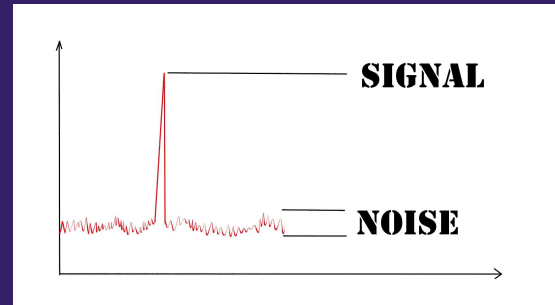


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Signal to Noise Ratio

- How much separation there is between “the signal” and “the noise”
- Measured in dB
- Use Listen Level for “the signal”
 - It’s “harder” than the Headroom Level



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How much SNR do we need?

Enough to not hear the hum/hiss

Electronic \gg Acoustic SNR

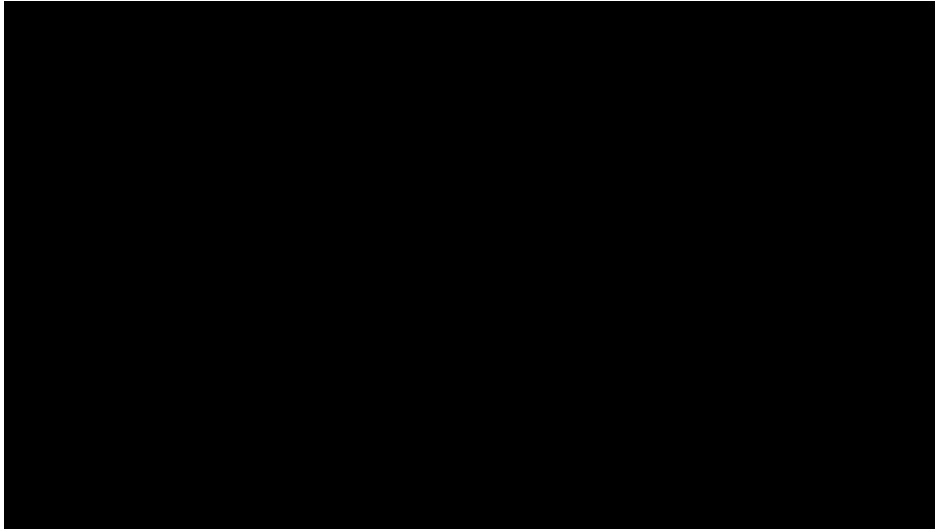
If it's 20 dB more than the acoustic SNR, you won't hear the noise



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Signal to Noise Demo



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Acoustic SNR

- Avixa says at least 24 dB more than the ambient noise
- AQA V says at least 15 dB more than ambient noise
- The more the better!
- It can be challenging



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Electronic vs. Acoustic SNR

Acoustic (dB-SPL, pressure)

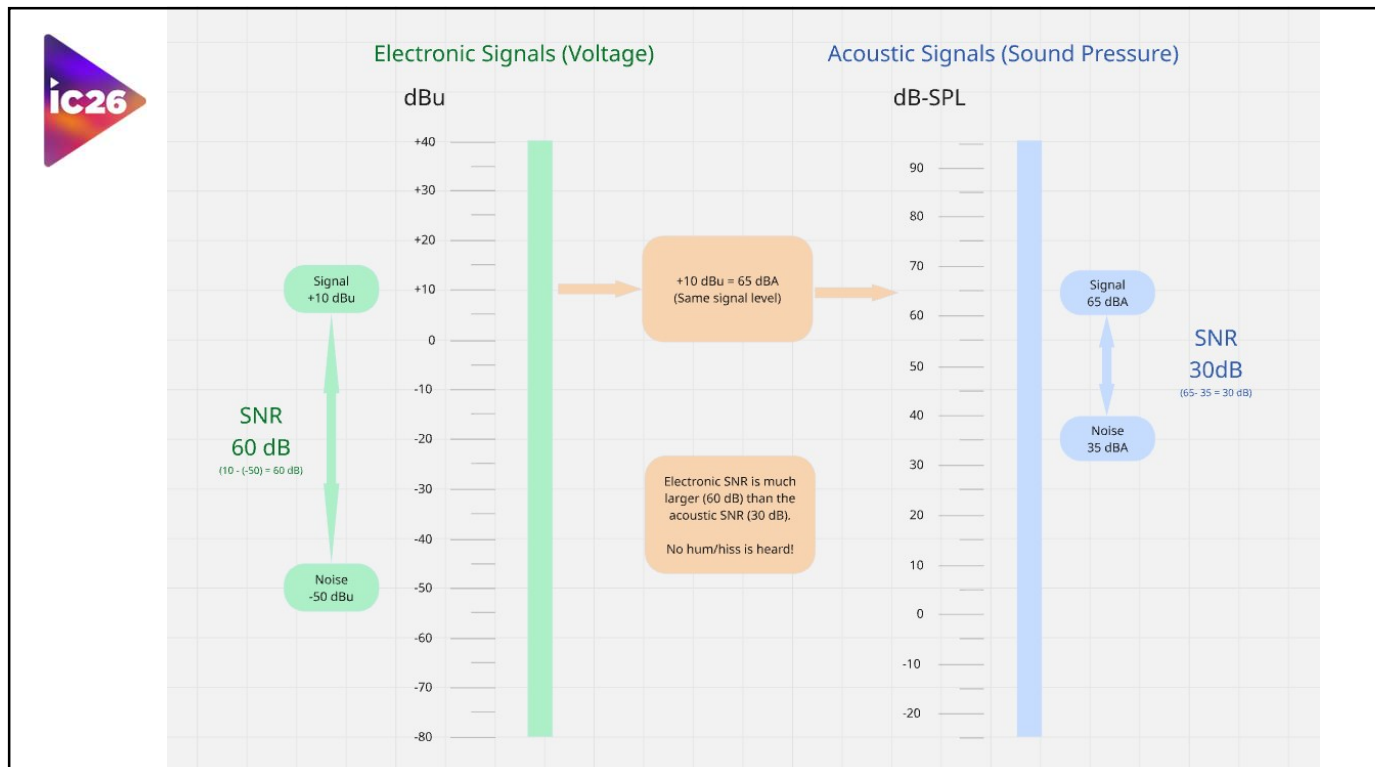
- Signal Level
 - Listen Level
 - 65 dBA
- Noise Level
 - Ambient Noise Level
 - 35 dBA
- SNR
 - $65 \text{ dBA} - 35 \text{ dBA} = \mathbf{30 \text{ dB SNR}}$

Electronic (dBu, voltage)

- Signal Level
 - Listen Voltage at Amp
 - “10 dBu”?
- Noise Level
 - Electronic Noise Level
 - “-50 dBu”?
- SNR
 - $10 \text{ dBu} - (-50 \text{ dBu}) = \mathbf{60 \text{ dB SNR}}$

30 dB << 60 dB! Hooray!

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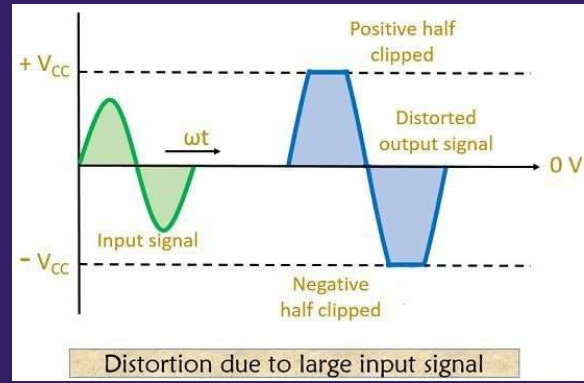


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No distortion in signal

- Signal should pass through system without distorting the waveform
- Maximum voltage can be reaching with a loud talker or loud audio in playback material
- Need to verify signal at maximum expected voltage
 - Aka: Headroom Level



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Distortion Demo

So fun!



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Measuring THD

Measured at Headroom Level

- Max level system is designed for

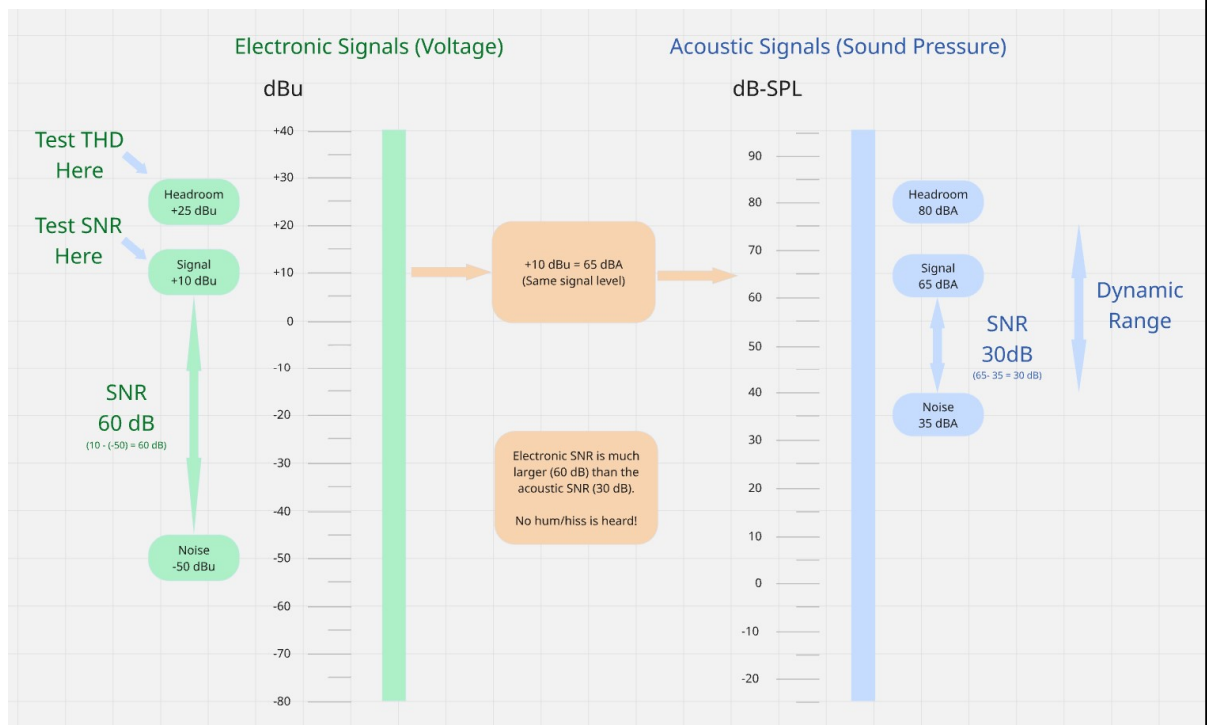
Must use an electronic sine wave (tone)

- Signal generator must match headroom level signal

Should be less than 0.5%



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“Sounds great”, but how?

^^ See what I did there?



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Assumptions for Today

- DSP Configuration was created per best practice
- Installation is complete
- The audio system is functioning and ready for “balancing”
- Acoustical dependencies have been delivered



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PRE: Acoustic Measurements

Able to predict/ justify performance

Key metrics:

- NC
- RT60
- Ambient Noise
- SNR @ mic
- STC



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Step 1: Confirm Physical Installation

Loudspeakers

- Location
- Taps
- Orientation

Microphones

- Location
- Orientation

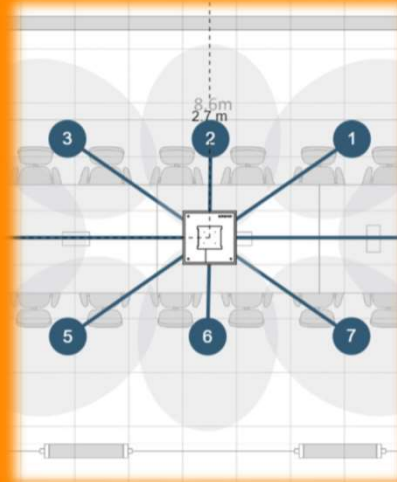


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Step 1+: Confirm Physical Installation

- Mic physical AND digital location are critical
- Be sure room graphic is scaled in software
- Be sure microphone placement in software matches physical placement in room
 - Talkers & Tables
 - Ceiling Height



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Step 2: Set Listen Levels

- Mixer output 0 dBu
 - “Unity gain”
- Pink Noise source
- Adjust amplifier until listen level is met (65 dBA)

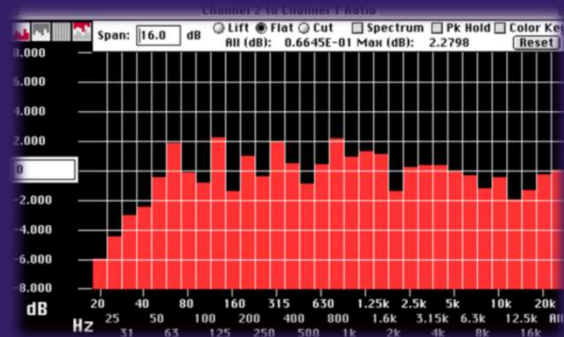


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Step 3: EQ Loudspeakers

- Pink noise source
- Adjust EQ to a relatively flat curve (or preferred)
- Parametric EQ may be easier



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Step 4: Set Mic Levels

Use standard talker

- 60 dB-SPL @ 1m

Wired

- 0 dBu at mixer input

Wireless/Processor

- “Nominal” at receiver
- 0 dBu at mixer input

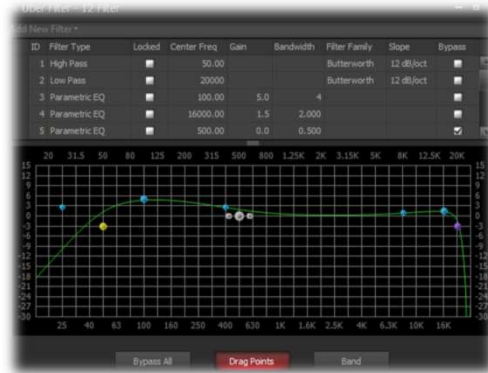


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Step 5: EQ Microphones

- Roll off highs/low
- Ring out room to maximize stability
 - When applicable
- No more than 6 dB
 - Attenuate only
- Know when enough is enough



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Step 6: Set Program Levels

- Nominal program source (-10 dBu)
- Pink noise is easiest
- Adjust input to achieve listen levels (60 dBA?)



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Step 7: Conference Audio

- Tx = Rx = 0 dBu in mixer
- Rx distributed at listen levels
- Test for echo
- Test for double talk (full duplex operation)
- Use NLP and NR sparingly



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Step 7+: AEC Reference

- AEC Ref = 0 dBu
- Must include all audio sources that need to be cancelled
 - Rx
 - Program
 - Other Rein. Mics
- Verify ERL/ERLE (and RMLR)



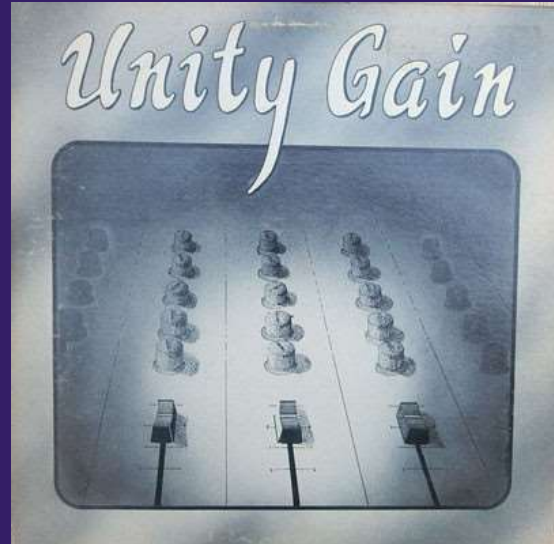
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This is the big secret!

All levels set to "0 dBu"

- Mics
- Conference Rx
- Conference Tx
- AEC Reference

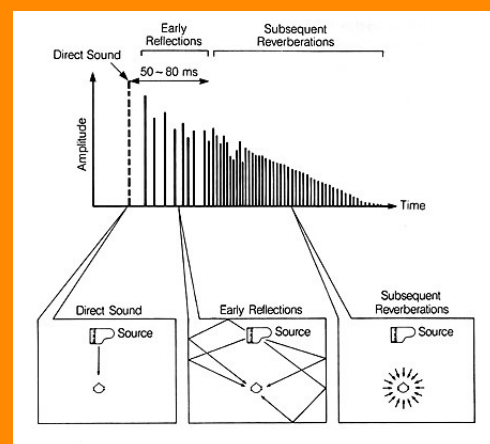


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Why 0 dB?

- Comes down to signal to noise ratio
- Uber complex waveform in a multi-path environment
- DSP needs a robust signal without distortion to work with
- 0 dB is the answer
 - And it's easy to remember!



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Step 8: Conf Program Audio

- Remember the program audio in conferencing
- Tx should be heard at program listen levels
- Rx should be heard at program listen levels



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Step 9: Confirm All Presets

- DSP “gotcha”!
- Remember to re-test each preset
- Remember to save settings to each preset
 - Save it twice!
 - ...or three times



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Step 10: Demonstrate

- Confirm operation
- Verify expectations were met



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Still some art to it...

- SOP can get us 95% there in minutes
- Does not account for:
 - Difficult rooms
 - Challenging preferences
 - Unique solutions



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Functionality is not enough!

Once we have the room “tuned”, we also need to verify the gain structure electronically:

- Verify listen levels
- Measure Acoustic SNR at Listen Level
- Measure Electronic SNR at Listen Level
- Measure THD at Headroom Level



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Verify Listen Levels

Use SLM to measure listen levels

Confirm they meet requirements



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Verify Acoustic SNR

Use SLM to measure ambient noise levels

Calculate SNR

Must be > 15 dB
(or 24 dB)

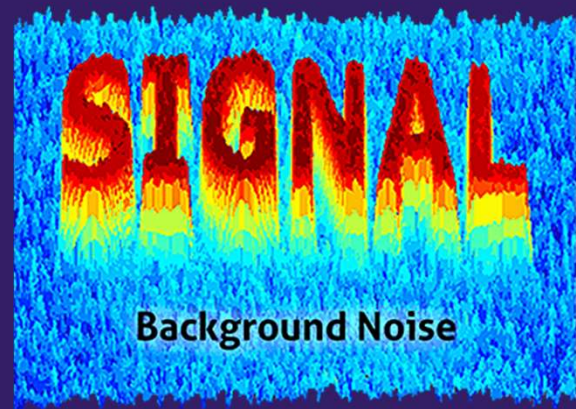


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Verify Electronic SNR

- Use pink noise source
- Set up a standard talker
- Verify listen levels
- Measure signal voltage at amplifier output (dBu)
- Remove signal source
- Measure noise voltage at amplifier
- Calculate SNR
- Verify E-SNR \gg A-SNR



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Verify THD

- Replace standard talker with signal generator
- Set generator to a tone at Headroom Level
- Match signal dBu level at amp and add headroom dB
- Measure THD of tone at Headroom Level
- Verify THD < 0.5%



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So, now let's play!

...and now the real fun starts!



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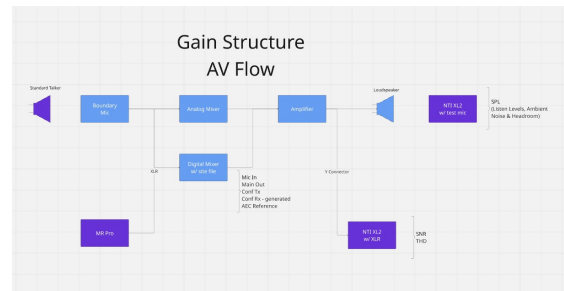
Demos

Simple gain structure
with analog mixer

Simple gain structure
with DSP

Installed sound vs. event
sound amplifier setting

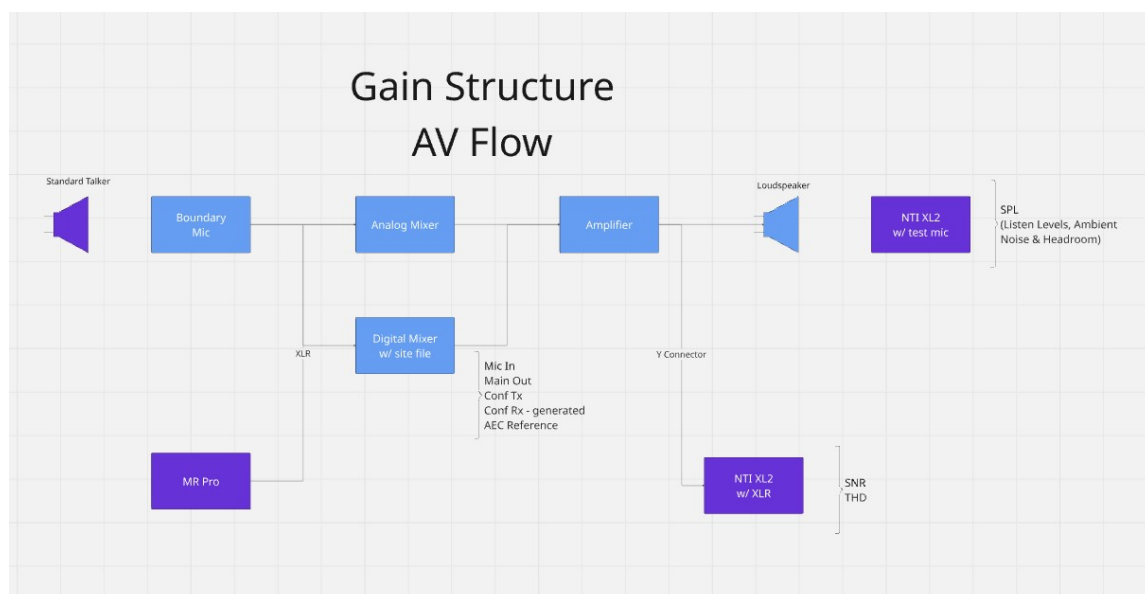
- AKA: Let the amp sleep
vs. Set the amplifier at
11!



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Demos



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Questions? Discussion?

Reach out at:

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We Value Your Feedback!

Please take a moment to complete the
session evaluation in the App

Thank you!

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