Balancing Audio Systems

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KRAMER

KRAMER

AV BEYOND THE BOX

Welcome!

Chuck Espinoza
Senior Staff Instructor

On Twitter

@madsoundguy

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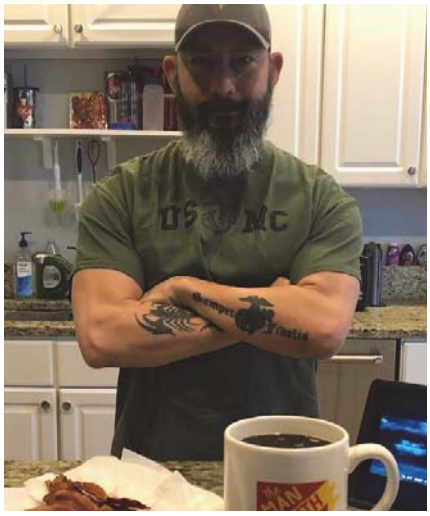

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Today's Agenda

- Goals
- System Levels Overview
- Methods for Setting Gain
- Equipment

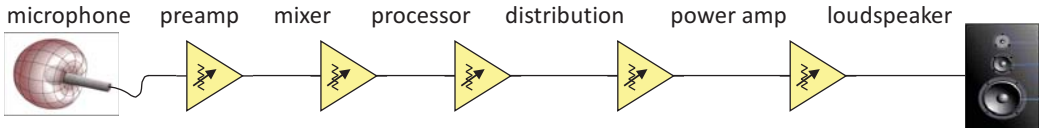
Goals

- Less
  - Hiss
  - Noise
  - Distortion
- Better S/N
- Meets Performance Criteria

Run Mixer near “0” under Normal Conditions

Signal Levels

- Expressed in dB’s or volts
- 0 dBu = 0.775 V
- +4 dBu = 1.23 V
- 0 dBV = 1 V
- -10 dBV = 0.316 V (316 mV)



Signal Levels

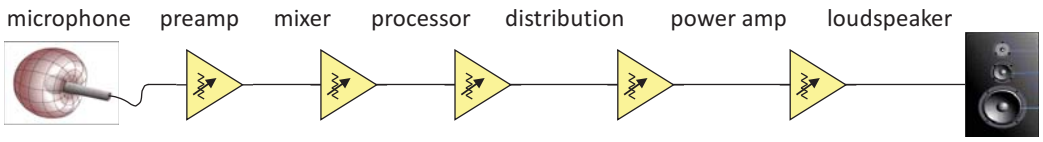
- Microphone Level

  -60 to -50 dBu (0.001 to 0.002 V)

- Line Level

  Pro 0 dBu to +4 dBu (0.775 to 1.23 V)

  Consumer -10 dBV (0.316 V or 316 mV)



Input Gain

- Most important setting foundation for your system
- Always set up but not necessarily well set up
- Microphones – gain needed – check specs
  - Handheld Vocals = 35 dB minimum
  - Handheld Presentation = 45 dB
  - Gooseneck desk = 45 dB
  - Boundary mic = 55 dB
  - Any farther away = 60 dB+

Microphone Specifications

Specifications

Type	Dynamic
Frequency Response	50 to 15,000 Hz
Polar Pattern	Cardioid
Sensitivity (at 1,000 Hz Open Circuit Voltage)	–54.5 dBV/Pa (1.85 mV) 1 Pa = 94 dB SPL
Impedance	Rated impedance is 150Ω (300Ω actual) for connection to microphone inputs rated low impedance
Polarity	Positive pressure on diaphragm produces positive voltage on pin 2 with respect to pin 3.
Case	Dark gray, enamel-painted, die cast metal; matte-finished, silver colored, spherical steel mesh grille
Connector	Three-pin professional audio connector (male XLR type)
Net Weight	298 grams (10.5 oz)
Dimensions	162 mm (6-3/8 in.) L x 51 mm (2 in.) W

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Mixer Specifications

FireWire Through (Record + Playback) Dynamic Range:
0 dBu mic input, to DAW, routed back to mixer direct to Control Room, all gain stages unity, 20 Hz to 20 kHz:

44.1 kHz sample rate:	-104 dB
96 kHz sample rate:	-106.5 dB

Frequency Response:

Mic input to any output (all gain stages at unity): +0/-0.5 dB, 20 Hz to 20 kHz

Stereo channel line input to any output (all gain stages unity): +0/-0.5 dB, 20 Hz to 20 kHz

FireWire in and out (mic input to FireWire send, returned to Control Room, all gain stages at unity):

44.1 kHz sample rate:	+/-0.5 dB, 20 Hz to 20 kHz -3 dB at 21 kHz
96 kHz sample rate:	+/-0.5 dB, 20 Hz to 20 kHz -3 dB at 45 kHz

Common Mode Rejection Ratio (CMRR):

Mic input to insert, max gain, 1 kHz, 150 ohm termination: -70 dB

Maximum Input Levels:

Mic input, gain at min (0 dB):	+22 dBu
Mic input, gain at max (60 dB):	–38 dBu
Line input, gain at -20 dB:	+22 dBu
Instrument input, gain at -20 dB:	+22 dBu
Tape input:	+12 dBu
Aux return:	+22 dBu

Maximum Output Levels:

All outputs:	+22 dBu

Equalization

Mono Channels

Low:	±15 dB at 80 Hz
Mid frequency:	100 Hz to 8 kHz

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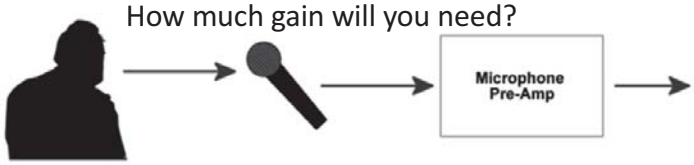
Microphone Pre-Amp Gain Required

- **Source:** Presenter located .25 meters (10 inches) away from the microphone produces 78 dB SPL.
- **Known:** You want to amplify the microphone level signal to line level (0 dBu) for routing and processing. Most microphone preamplifiers will provide around 60 dB of amplification.
- **Known:** You have -54.5 dBV (dynamic)

How much gain will you need?



Level at microphone		Microphone ref level		Microphone sensitivity		dBV to dBu		Output level req		Pre-amp gain required
①	-	②	+	③	+	④	-	⑤	=	⑥
dB_{spl}		dB_{spl}		dBV		dB		dBu		dB

Microphone Pre-Amp Gain

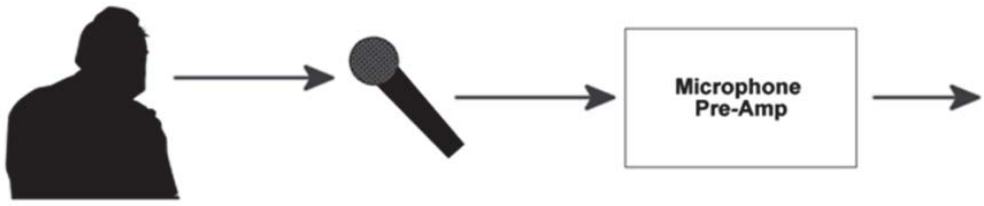
Level at microphone		Microphone ref level		Microphone sensitivity		dBV to dBu		Output level req		Pre-amp gain required
78 ①	-	94 ②	+	-54.5 ③	+	2.2 ④	-	0 ⑤	=	-68.3 ⑥
dB_{spl}		dB_{spl}		dBV		dB		dBu		dB

Microphone Specifications

Specifications

Type	Condenser
Frequency Response	20 to 20,000 Hz
Polar Pattern	Cardioid
Sensitivity (at 1,000 Hz)	Open Circuit Voltage: -45 dBV/Pascal (5.6 mV) (1 Pa = 94 dB SPL)
Impedance	Rated at 150 ohms (85 ohms actual) *Recommended minimum load impedance: 800 ohms*
Output Clipping Level	800 ohm Load: -4 dBV (0.63 V) 150 ohm Load: -15 dBV (0.18 V)
Maximum SPL (at 1,000 Hz)	800 ohm load: 136 dB (attenuator at 0) 146 dB (attenuator at -10) 150 ohm load: 128 dB (attenuator at 0) 138 dB (attenuator at -10)
Self-Noise	16 dB typical, A-weighted 19 dB typical, weighted per DIN 45 405
Hum Pickup	-3 dB equivalent SPL in a 1 mOe field (60 Hz)
Signal-to-Noise Ratio	78 dB (IEC 651)* at 94 dB SPL *S/N ratio is difference between 94 dB SPL and equivalent SPL of self– noise A-weighted*

Microphone Pre-Amp Gain

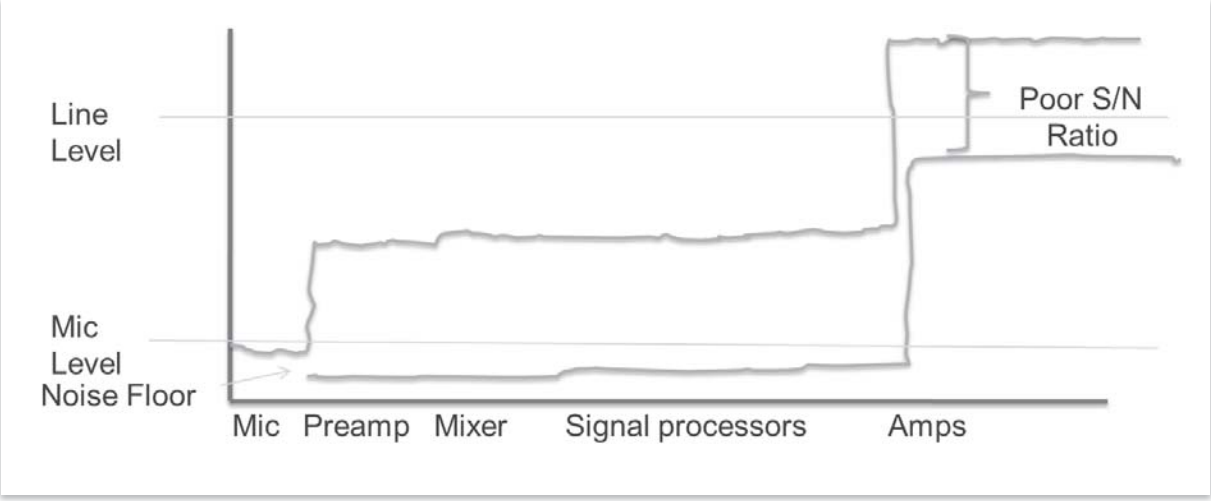


Level at microphone		Microphone ref level		Microphone sensitivity		dBV to dBu		Output level req		Pre-amp gain required
78 ①	-	94 ②	+	-45 ③	+	2.2 ④	-	0 ⑤	=	-58.8 ⑥
dB_{spl}		dB_{spl}		dBV		dB		dBu		dB

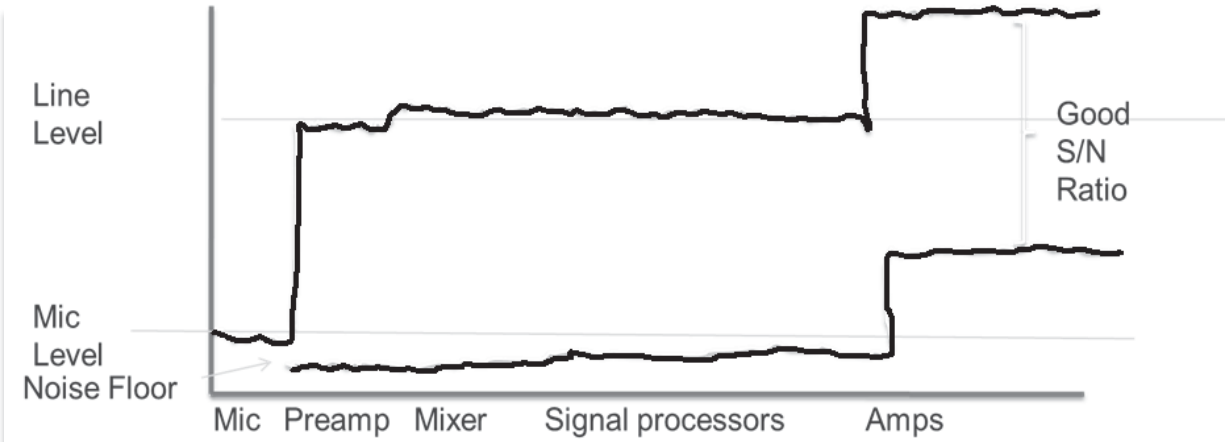
Input Gain

- Most important setting foundation for your system
- Multimedia:
  - Unbalanced? Consumer = +10 dB
  - Balanced? Professional = 0 to -8 dB

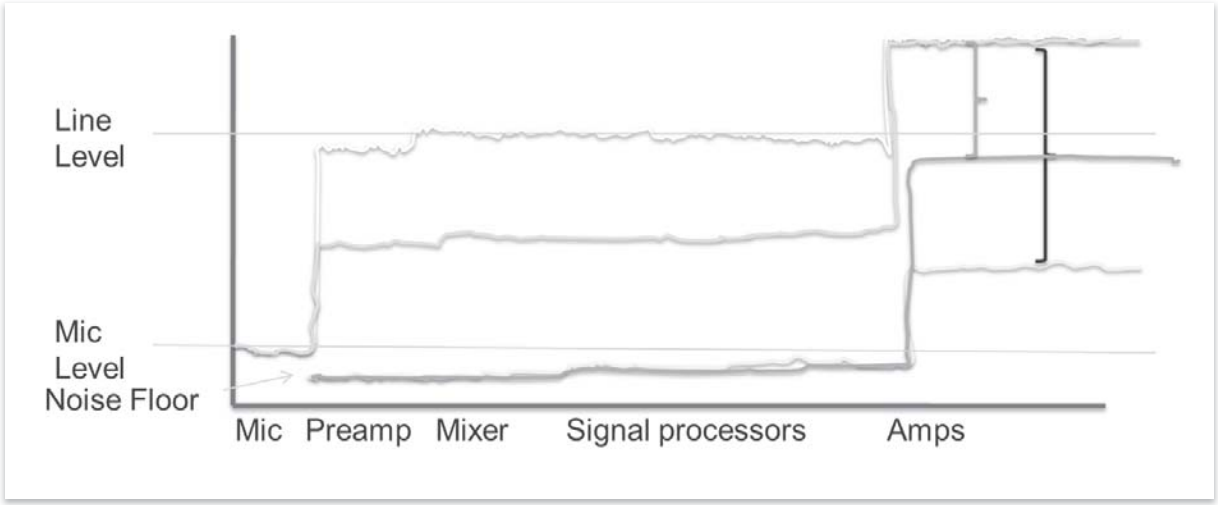
Poor Signal to Noise Ratio



Good Signal to Noise Ratio



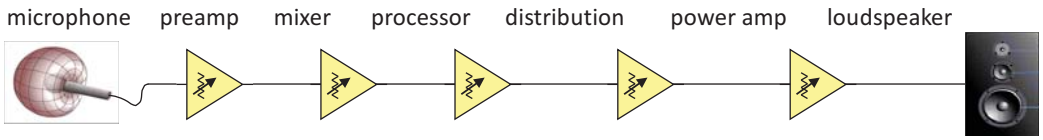
Signal to Noise Ratio: Comparison



Adjustments

- Microphone Preamplifiers
- Mix Buses
- Processing devices

  Compressors, Equalizers
- Power Amplifiers



Methods and Equipment

- Unity
- Optimization

- Generator

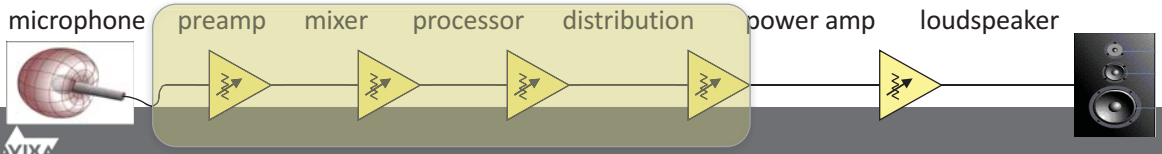
  1 kHz

  400 Hz

  Pink Noise
- Analyzer

  Analyzer, Volt Meter or maybe something else….
- SPL Meter

Unity – Defining Zero



Unity – Defining Zero and Setting Gain Structure

1. Set all mixer trims, faders, crosspoint gains, masters, etc. at their “0” (unity) settings
2. Configure a signal generator to output 1 kHz at 0 dBU (0.775 V) and connect to a line level input of the mixer
3. Adjust the input trim until the mixer’s output meter reads “0”
4. Measure the mixer’s output with an analyzer or voltmeter
5. Using that level, adjust all downstream devices in the signal path for that same level

LET'S DO THIS!!!!

Unity – Setting Gain Structure

- Provides adequate S/N for basic audio systems
- Easy and Fast

- Headroom varies from device to device
- Downstream devices may clip before the mixer clips

Optimization – Setting Gain Structure

1. Set all mixer trims, faders, crosspoint gains, masters, etc. at their “0” (unity) settings
2. Configure a signal generator to output 400 kHz at 0 dBU (0.775 V) and connect to a line level input of the mixer
3. Connect an oscilloscope or piezo tweeter at the output of the mixer
4. Adjust the input trim until clipping is indicated and then reduce the level to just under the clip point
    1. Document the voltage
5. Connect the o’scope or piezo to the next device in the signal path and do the same
    1. Document the output voltage at each device

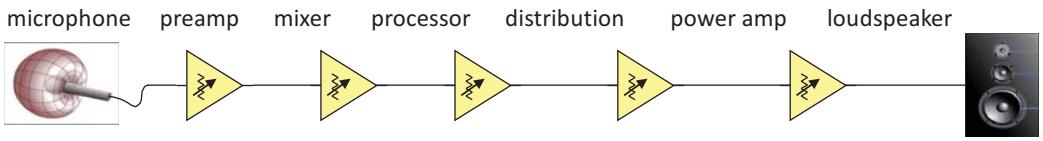
LET’S DO THIS TOO!!!!

Optimization – Setting Gain

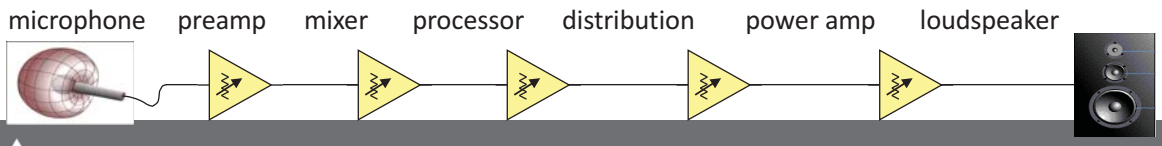
- Maximum S/N
- Each device has the same amount of Headroom
- Mixer indicates system's condition
- Bit more time and skill
- Some devices overloaded (requires inline attenuators)

Setting Individual Channel Levels

- Now it's time to set each input channel level
  - –Microphones
  - –Line level devices, pro and consumer



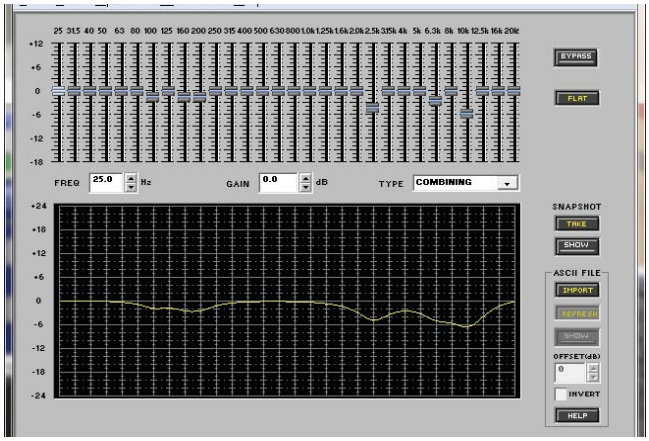
Setting Individual Channel Levels



LET'S DO THIS WITH A MIC!!!!

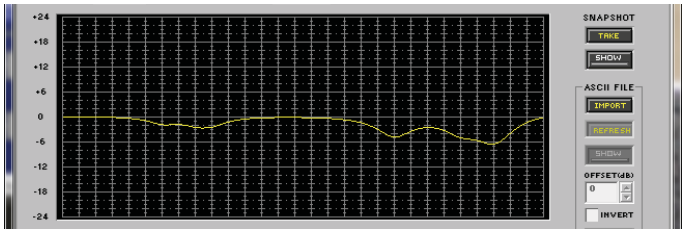
Setting Gain – After Equalization

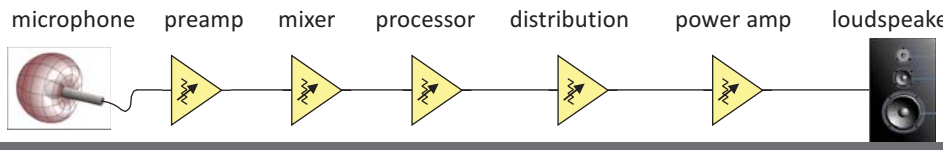
- After equalization…



Setting Gain – After Equalization

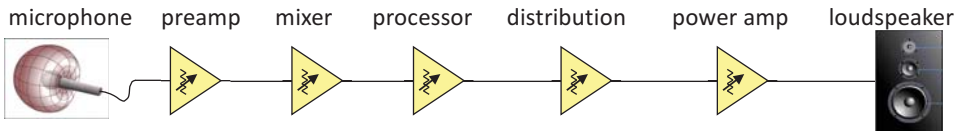
- Equalization removes energy from the spectrum
- Configure a generator for pink noise at 0 dBu and connect it to a line level input of the mixer





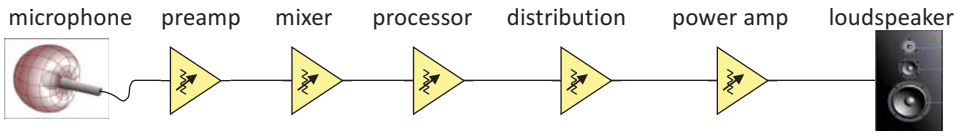
Setting Gain – After Equalization

- Unity
  1. Adjust the input to read “0” at the output of the mixer
  2. Using the reference level discovered before, connect an analyzer at the output of the equalizer
  3. Increase the gain at the EQ until it reaches the reference level



Setting Gain – After Equalization

- Optimization
  1. Adjust the input to read “0” at the output of the mixer
  2. Using the reference level discovered before, connect an analyzer at the output of the equalizer
  3. Using the output voltage at the output of the EQ documented earlier, increase the gain at the EQ until it reaches the reference level



Last Adjustment

- What hasn't been mentioned?

It's not a…..

Amp Setting

- Properly setting the Amp for loudspeakers/ listening area

Finding the EPR

- EPR is the Electrical Power Required at the Loudspeaker.

To do this we will need some information –

- Target Listening SPL
- Headroom Required
- Loudspeaker Sensitivity (spec)
- Distance to the Listener

Find the Target SPL (Lp)

- Given an SPL meter determine the target desired SPL for your audio system
  - –Measure the ambient noise of the space
    - SPL meter set to “A” weighted, Slow
    - Target SPL should be 25-30 dB SPL above Ambient

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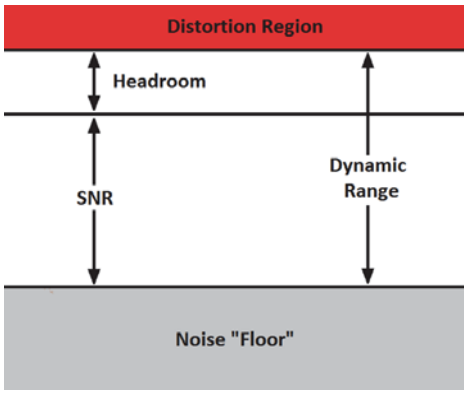
Allow for Headroom (H)

- **Headroom** refers to the amount by which the signal-handling capabilities of an audio system exceed a designated level
  - –10 dB SPL for Speech
  - –20 dB SPL for Program



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Find the Loudspeaker Sensitivity (Ls)

- **Loudspeaker Sensitivity:** a measure of Sound Pressure Level (SPL) at a specified distance for a specified input signal.

Loudspeaker Specifications (example)

Frequency Response (-3 dB) (1)	79 Hz - 21 kHz
Frequency Range (-10 dB) (1)	60 Hz - 24 kHz
System Sensitivity (1 W @ 1 m) (2)	91 dB (1 W = 2.45 V for 6 Ohms)
Nominal Coverage Angle	90 degrees conical
Coverage Angle (1 kHz to 6 kHz)	93 degrees conical
Directivity Factor (Q)	7.7 averaged 1 kHz to 6 kHz
Directivity Index (DI)	8 averaged 1 kHz to 6 kHz
Rated Maximum SPL (2)	Average: 109 dB Peak: 115 dB
Power Handling (3)	Average: 60 W Programme: 120 W Peak: 240 W
Recommended Amplifier Power	120 W @ 6 Ohms
Nominal Impedance	6 Ohms
Transformer Taps (via front rotary switch)	70 V: 60 W / 30 W / 15 W / 7.5 W / OFF & low impedance operation 100 V: 60 W / 30 W / 15 W / OFF & low impedance operation
Crossover	2.5 kHz

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Finding the EPR

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To do this we will need some information –

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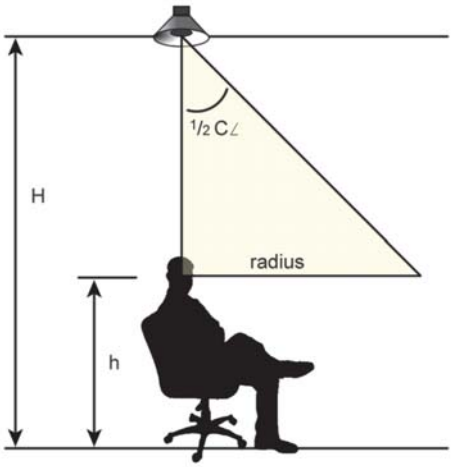
- ✓Headroom Required
- ✓Loudspeaker Sensitivity (spec)
- Distance to the Listener

Calculate Distance to Listener

H – h

H = ceiling height
h = height of listeners



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Calculate Wattage at the Loudspeaker

$$EPR = 10^{\wedge}\left(\frac{\left[L_p + H - L_s + 20\,Log\,(D_2/D_r)\right]}{10}\right) * W_{ref}$$

–EPR = Amount of electrical power required at the loudspeaker
–LP = Sound pressure level required at distance D2
–H = Headroom required
–LS = Loudspeaker sensitivity at 3.28 feet (1 m)
–D2 = Distance from the loudspeaker to the farthest listener
–Dr = Distance reference value
–Wref = Wattage reference value, assume 1 unless otherwise noted

Calculate Wattage at the Loudspeaker

$$EPR = 10^{\wedge}\left(\frac{\left[L_p + H - L_s + 20\,Log\,(D_2/D_r)\right]}{10}\right) * W_{ref}$$

–EPR = Amount of electrical power required at the loudspeaker
–LP = 75 dB SPL
–H = 20 dB (program material)
–LS = 91
–D2 = (Ceiling height) 10 ft (3048mm) – (ear height *seated*) 4 ft (1219mm)
–Dr = (reference value from Loudspeaker spec) 1m or 3.28 ft
–Wref = (reference value from Loudspeaker spec) 1watt

Calculate Wattage at the Loudspeaker

$$EPR = 10^{\wedge}\left(\frac{\left[L_p + H - L_s + 20\,Log\,(D_2/D_r)\right]}{10}\right) * W_{ref}$$

$$EPR = 10^{\wedge}\left(\frac{[75\text{ dB} + 20\text{ dB} - 91\text{ dB} + 20\log(6/3.28)]}{10}\right) * 1$$

$$10^{\wedge}\left(\frac{[4\text{ dB} + 20\log(6/3.28)]}{10}\right) * 1$$

Calculate Wattage at the Loudspeaker

$$EPR = 10^{\wedge}\left(\frac{[L_p + H - L_s + 20\,Log\,(D_2/D_r)]}{10}\right) * W_{ref}$$

$$EPR = 10^{\wedge}\left(\frac{[4\text{ dB} + 20\log(6/3.28)]}{10}\right) * 1$$

$$10^{\wedge}\left(\frac{[4\text{ dB} + 5.24]}{10}\right) * 1$$

Calculate Wattage at the Loudspeaker

$$EPR = 10^{\wedge}\left(\frac{[L_p + H - L_s + 20\,Log\,(D_2/D_r)]}{10}\right) * W_{ref}$$

$$EPR = 10^{\wedge}\left(\frac{[4\text{ dB} + 5.24]}{10}\right) * 1$$

$$10^{\wedge}\left(.924\right) * 1$$

8.39 watts

Amp Setting

- Matching Amp to speaker load

Come on out

Don't be shy. Let us help you solve your challenges. Bring on the questions!

Thank You

www.AVIXA.org