Audio Applications - System Optimization and Equalization Course Outline

Mixer Gain Structure

From Level 100 training, you are now familiar with the signal chain and the purpose of each component. The mixer is the "cockpit" of the sound system. All user interaction and control takes place here. Mixer is artistic control established within technical limits. To fully utilize the mixer, a proper gain structure must be established. As important as that is, it is rare to see a mixer that is setup properly and operating at its full potential.

In this lesson I present a logical, orderly and defensible way of setting up the mixer, one that is based on achieving two results:

1. The mixer's faders are in their proper range of operation.
2. The mixer's output is line level, and its meter(s) indicate this.

It is important to note that a mixer still "works" if neither of these conditions is met. It just isn't operating at its full potential. Since getting it there doesn't cost any extra, we might as well do so.

Four video clips covering these topics.

What is Gain Structure?
Dynamic Range
Peak Room
Level Controls 0:09
Maximum Output Level 0:45
The Piezo Trick   3:03
The Noise Floor
Dynamic Range Revisited
Channel Trim or Gain
Summing Room
Know Your Meter
PFL or Solo
The Sound Check

System Gain Structure

Now that the mixer's gain structure has been established, the system gain structure can be addressed. We are back to the signal chain again, assuring that each component is operating at its optimum level. A good sysem gain structure has two objectives:

1. No component is clipping the signal.
2. The residual noise is as low as possible.

Achieving this can be simple for some systems, but there are some conditions that can complicate it. I'll start simple and then handle the special cases.

Three video clips covering these topics.

Introduction
Signal Processing

Expected Levels
Finding Unity Gain
Quickie Gain Structure
Some Audio History
An Ideal Case
Peak Room Wars
An Analogy
Sizing a Pad
The Amplifier
Another Ideal Case

Sound Fields

Why does good audio gear sometimes sound bad? One big reason is the acoustic environment. I'll approach room acoustics in the same way that I approached the signal chain - divide and conquer. This lesson is the key to understand the effective use of equalization in the "system tuning" process. Nearly all serious audio practitioners eventually acquire instrumentation for measuring the performance of a sound system. That's a good thing, but to use the analyzer effectively, you must understand what you are measuring. For this reason the lesson on Sound Fields precedes the lessons on Equalization.

Three video clips covering these topics.

It's About Time
Room Acoustics
The Impulse Response
Post-Processing the RIR
Absorption
Scattering
Wave Behavior
The Direct Field
Early Reflections
Late Reflections
Reverberation
Conclusion

Equalization - Part 1

Ask 10 different audio people how to equalize a system and you may get 10 different answers! I showed that achieving system gain structure was just a matter of doing it in the right order. The same is true for equalization. By putting the most important steps first, you can know when you are finished and the system is at its maximum potential.
I'll close this introduction by saying that what is presented here is most of the equalization process, but possibly not all of it. There are always some final tweaks that may be subjective or may provide the "icing on the cake." That comes with experience. My objective it to get you to that point with some things that can be done to improve the performance of every sound system.

Three video clips covering these topics.

What's An Equalizer?
The Curve

Equalization Part 2

While it is possible to jump right in and adjust some filters in an attempt to get better sound, it is best to break the equalization process down into three layers. The most important of the three is equalization of the direct field from the loudspeaker. The other two equalization layers, Boundary EQ and Resonance EQ require that the loudspeaker be "in situ."

Virtually all loudspeakers need some corrective EQ to optimize their response. The EQ curve is sometimes provided by the manufacturer, either as a hardware processor or DSP present. When it isn't, then the direct field equalization must be performed by the audio practitioner. Since the direct field is independent of the room, I present some methods for isolating the loudspeaker's response from the influence of its environment. Once isolated, the required curve for a flat or target frequency response can be quickly determined.

The sound from a loudspeaker can be changed by the boundaries that surround it. Reflections from a wall or ceiling will produce frequency response bumps and dips. Some EQ filters may be needed to minimize the coloration. In this lesson I'll provide some tips on placing loudspeakers and adding the filters.

Two video clips covering these topics.

Equalization Part 3

The room is a filter that the sound from the loudspeaker must pass through en route to the listener. All rooms have resonances - frequencies with stronger amplification than the others around them. Reducing the direct field level at some of these resonant frequencies can dramatically improve the sound from the loudspeaker.

This final layer of the equalization process addresses the effect of room "modes". While rooms have many "modal" frequencies, not all of them may be excited at a particular listner position or loudspeaker placement. We will need to look at multiple listener positions to perform this step, and then process the data to determine a single compensation curve.

While this step is sometimes called "Room EQ," it is important to understand that we are not changing the room's acoustics. We are only de-emphasizing some frequencies in the loudspeaker's response that the room wants to hang onto longer than the others, thereby neutralizing the coloration of the sound.

Two video clips covering these topics.

Early Reflections
Early Reflection Demo
Art vs. Science
Including the Room
Resonance Compensation
Revealing Resonances
Applying Filters
Speeding the Process
Room Size
Room EQ?
Conclusion

Setting Amplifier Levels

The last step in establishing the system gain structure is the setting of the amplifier input sensitivity. This determines the voltage applied to the loudspeaker, and the resultant SPL at the listener. While it seems like a simple step, and it is, it is also controversial. Many practitioners assumed that maximum sensitivity is always desired, and start the gain structure process by "maxing out" the amplifiers.

In this lesson I will examine both sides of the argument, and present a logical process for this important gain structure finale. - Pat Brown

Three video clips covering these topics.

Smoke Alert!
A Common Misconception
Input Sensitivity
The Details
Setting the Amplifier Sensitivity
The 30/30 Guideline
Some Practical Considerations
Multi-way Loudspeakers
Fixed Gain Settings
Self-Powered Loudspeakers

Conclusion

Loudspeaker Power Ratings

The most abused rating in all of audio is the loudspeaker power rating. Few end users understand what it is or what it means, and yet it often profoundly influences the buying decision for many systems. This pressures the manufacturers to either play along or lose sales.

In this lesson I will demonstrate the power test procedure to show where the rating originates. This reveals how to use the rating to determine how to know when your loudspeaker is "maxed out" when establishing the system gain structure. - Pat Brown

Three video clips covering these topics.

Overview
Finding the MIV
Power Compression
Let’s Do It!
Don’t Exceed the MIV
Voltage Ratings
Conclusion

Amplifier Power Ratings - Part 1 - Loading Considerations

In the last lesson I showed how loudspeakers get their power ratings. The next logical step is to examine how this influences the selection of an appropriate power amplifier. I've divided it into several sub-topics.

1. An overview of how amplifiers interact with loads (loudspeakers).
2. A demonstration and some exercises on sizing amplifiers for various loudspeakers and applications. The lesson includes a Windows software calculator that you may download, install, and use in your design work.
3. A means of simplifying the amplifier selection process by eliminating everything that doesn't really matter.

The content of the loudspeaker and amplifier "power lessons" is the result of many years of investigation, experimentation and refinement. I am hopeful that they serve you in helping unravel this confusing area of sound reinforcement. - Pat Brown

Four video clips covering these topics.

Introduction
Ideal Voltage Source
Real-World Voltage Source
Amplifier Overload - 3:07
Sine Wave Ratings
Burst Ratings
Crest Factor
Noise Ratings
Dual Nature
Amplifier Sizing

Loading Considerations
The Common Amplifier Format

Wire Gauge Selection

Wire Gauge Selection
The last topic regarding amplifiers and loudspeakers is the interface between them. A variety of connector types are commonly used, and you will probably just go with whatever your products are equipped with. The wire gauge is the variable that we must consider. Undersize it and you will lose signal. Oversize it and you may waste money. In this lesson I will deal with how to select a wire gauge based on the characteristics of the amplifier and loudspeaker.

I will assume that you are using wire that is appropriate for audio applications. Namely, it has copper conductors, and consists of two stranded or solid conductors that are paired.

This lesson includes a Windows-based calculator to allow you to observe how the variables interact and to speed the wire selection process. - Pat Brown

One video clip covering these topics.

Overview
Wire Resistance
Wire Gauge Calculations
Examples
Conclusion