Course 130: Equalization and Course 210: Advanced Equalization
Detailed Course Outline

The text in green is in Course 210 only.

Sound Fields

An aspect of equalization that is not very intuitive is that we don't want to take into count everything that we are hearing when we tune a sound system. Part of what you are hearing contains information and part of what you are hearing does not. So by making a distinction between the various sound fields, we can focus on the part that is carrying information. The sound fields break down into direct field, early reflected field, late reflected field and reverberant field. And of those sound fields, it is the direct and early reflected fields that carry information to the listener.

Three video clips covering these topics.

1. It's About Time
2. Room Acoustics
3. Room Impulse Response (RIR)
4. Post-Processing the RIR
5. Sound Absorption
6. Reflected Sound
7. Wave Behavior
8. The Direct Field
9. Early Reflections
10. Late Reflections
11. Reverberation
12. Conclusion

Universal Concepts

One of the things you find out quickly when you go to tune sound systems is that our ears are not good enough. We need instrumentation. As you learn how to tune sound systems some of the concepts apply to specific measurement platforms. Other concepts are universal in nature and apply to all of them. So that is what I will present in this lesson. These are bedrock principles, that if you master them, you can quickly acclimate to any specific measurement platform.

Three video clips covering these topics.

1. What's an Equalizer?
2. The "Curve"
3. The Real-Time Analyzer
4. The Dual-Channel FFT
5. A Hierarchy
6. The Time Domain
7. The Frequency Domain
8. Target Frequency Response
9. Equalizers
10. Equalization Objectives

One Lecture on Measurement Domains

1. Equalization Defined
2. Measurement Domains

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Real Time Analysis

Flashback fifty years to the first audio and acoustic analyzers. These are real-time spectrum analyzers typically at 1/3 octave resolution. The early days of equalization used this instrument to develop methods and procedures some of which still live on today. In this lesson, I want to talk about how to use this type of analyzer in conjunction with our ear-brain system and how it compares to more sophisticated techniques.

Three video clips covering these topics.

1. Introduction
2. Acoustic Zones
3. Critical Frequency
4. The Pressure Zone
5. The Modal Zone
6. The Diffusion Zone
7. The Absorption Zone
8. Spectrum Analzers
9. Source-to-Listener Distance
10. Diffuse Field Spectrum
11. The X-Curve
12. First Arrival Equalization
13. Spot Checks Using a RTA
14. Conclusion

Demo:
1. RTA Basics

Frequency Resolution

We can apply a time window to the impulse response and exclude part of the sound energy that we are taking into account when equalizing a system. But, with the application of a time-window comes the concept of frequency resolution. Your window has to be long enough to resolve the lowest frequency of interest. This is not a trivial topic. This is fundamental to what we do. If you don't properly resolve the response at the listener position, you won't know how to apply filters to correct the response.

One video clip covering these topics.
1. The Time Window (Again)
2. Frequency Resolution
3. Spectral Leakage
4. Guiding Principles
5. To Summarize

Two Lectures
Discrete Time and Frequency
1. A fourier Transform Example
2. Time/Frequency Interdependence

Resolution Tradeoffs
1. The Uncertainty Principle

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2. Waveforms and Spectra

Basic Measurements

This lesson is a string of short lectures that I have used through the years in teaching audio and acoustic instrumentation. These are not structured training videos like most most of the other lessons. I have not included the lesson text and there will not be a quiz. But, make sure you watch these and nailed them down before you proceed to the rest of the course.

Five Lectures covering these topics

Movement Types

1. Real-Time Spectrum Analysis
2. Transfer Function Measurements - Part 1 & 2

Measurement Roadmap

1. The Domain Chart
2. Time Windows

Making Measurements

1. Measurement Basics - Part 1, 2, & 3

Signal-to-Noise Ratio

1. Which Stimulus Type? - Part 1& 2
2. Measurement Averaging

Sweeps

Audio Filters Part 1

It is time to start talking about the tools of the trade - audio filters. This is a huge topic and I will be spending quite a bit of time on it. I will start basic with looking at filter types and magnitude response. Then I proceed on to some of the more esoteric concepts such as phrase response. Hang in there. Watch it more than once. The next lesson will be Audio Filters Part 2.

Four video clip covering these topics.

1. Introduction
2. Analog Filters
3. A Little Background
4. The Transfer Function
5. A High Pass Filter Example
6. The Band Pass Filter
7. Equalizers
8. The Shelf Filter
9. Notch Filters
10. In Review
11. Introduction
12. The Impulse Response
13. The Transfer Function
14. Phase and Phase Shift
15. Phase Signatures
16. Minimum Phase

17. Excess Phase
18. Linear Phase
19. Infinite Impulse Response (IIF) Filters
20. Finite Impulse Response (FIR) Filters
21. Conclusion

Four lectures covering these topics.
1. Audio Filters - Part 1, 2, and 3
2. Frequency Response Phase
3. Phase Shift Illustrated - Part 1 & 2
4. Minimum Phase Response
5. A Practical Example
6. The Band Pass Filter - Part 1 & 2

Audio Filters Part 2

I will admit that I am getting out in the weeds a little bit with this lesson. These are advance measurement and filter concepts. Some people find this interesting, some maybe not. There will not be quizzes in this lesson nor questions on the final exam. But if you ever wondered about these more advanced topics, this information will help.

Four lectures covering these topics.
1. Wavelets
2. IIR Filters
3. All Pass Filters - Part 1, 2, & 3
4. Conjugate Filtering
    A. PEQ Filters
    B. Applying the Filters: “Cut and Try”
    C. Applying the Filters: Curve Fit / Manual Transfer
    D. Applying the Filters: IIR Coefficients

Advanced Measurements

If we are in the audio business, we are in the synchronization business. There are two different ways things can get out of sync. This could be due to phase shift or it could be due to signal delay. These are often confused with each other because when we look at them on a time domain plot, we see the effects of these but we do not necessarily know which one we are looking at without a little further investigation. So while on the surface, they might appeared to be advanced topics, they are very fundamental to what we do.

Five lectures covering these topics.
1. Why Phase Matters
2. Phase Summary
3. Group Delay - Part 1, 2 & 3

Direct Field Correction

Sometime people ask, why does SynAudCon place so much emphasis on the direct field. There are some good reasons. First, it is the sound field that you can effect the most with an

equalizer. If you do not get the direct field right, the room can't correct what is lacking in the direct field. So you start there. It is the field with the highest order. It is where the field, the phase response and group delay have meaning. Analyzing the direct field is the best way to get a theoretical foundation for audio and acoustics. Yes, we spend a lot of time on the direct field but once you've mastered the principles to analyze it, they are directly applicable to other fields. We will do that as the course proceeds.

Three video clip covering these topics.
1. Equalization Layers
2. Frequency Response Correction
3. Placement Compensation
4. How Flat?
5. EQ Prep
6. Mic Placement Details
7. Applying Filters
8. The Process

Boundary Interactions

Direct field correction is always done in a free field. We do not want anything to influence the loudspeaker. We want to look at its response for the purpose of corrective equalization. But when you place that loudspeaker against a boundary or against two boundaries, you change the loudspeakers response. If your objective is to preserve the fidelity of the loudspeaker, an equalization layer to address boundary issues is called for. In the lesson, I will demonstrate it and show some equalization solutions for this problem.

Two video clips covering these topics.
1. Response Preservation
2. Equalizable
3. Loudspeaker and Boundaries
4. In-Boundary Placement
5. Near-Boundary Placement
6. Minimizing Boundary Interactions
7. Cavities
8. Arrays
9. Conclusion

Demo showing boundary effects on
1. Omni Source
2. Bookshelf
3. Horn
4. In-Boundary

Early Reflections

Early reflections is that sound energy within the room that is integrated with the direct field at the listener position. It changes the gain and tonality of what the listener hears. There are times when an equalization layer maybe be used to address the tonal changes caused by this field. In this lesson, I will go into that and provide some examples of what you might do to compensate for the differences. Now this is one of those equalization layers that may be referred to as room

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EQ. I want to remind you that we are not changing the room. We are changing what we put into the room and it is important to make that distinction.

Two video clips covering these topics.

1. Response Preservations
2. Early Reflection Demo
3. Art vs Science
4. Including the Room
5. Room Modes

Resonance Compensation

In addition to specular reflections, all rooms have resonances which are wavelengths that agree with room dimensions. Now at these frequencies you can get a lot of gain at specific positions in the room and it can ring out over time and dramatically change the sound. This layer of equalization addresses these room resonances. As one consultant put it, if you do not tickle it, it will not laugh. So we are choosing some frequencies to de-emphasize going into the room because we have determined what frequencies will resonant due to the room's internal volume.

Two video clips covering these topics.

1. Resonance Compensation
2. Revealing Resonances
3. Applying Filters
4. Speeding the Process
5. A Simpler Calculation
6. Room EQ?
7. Conclusion

One lecture covering these topics:

1. Stationary Sound Waves
2. Predicting Room Modes
3. An Example
4. Joint-Domain Plots

Case Study 1 - Short Line Array

Case Study 2 - Small House of Worship

Case Study 3 - Cafeteria