“Principles of Audio” Detailed Course Outline

The Time Domain

The first three lessons of Course 100 form a foundational unit for the rest of this course, as well as all other SynAudCon courses. I cannot overstate the importance of understanding the concepts of time, frequency, and wavelength with regard to characterizing audio and acoustic signals and systems. These topics can appear mundane and obvious on the surface, but the implications go deep. Later, when you are dealing with advanced topics such as audio and acoustic measurements, modeling, and digital signal processing you will constantly utilize these fundamental concepts.

I'll start with what it means to consider a variable as a "function of time."

Pat Brown

Three video clips covering these topics.

1. Audio vs. Acoustic Waves
2. Piston Source
3. Wave Analysis
4. Functions
5. Voltage
6. Analog vs. Digital
7. A Time Record
8. The Sine Wave
9. Putting It All Together
10. Loudspeakers as Pistons
11. Sines, Cycles, and Circles
12. Time and Frequency
13. Harmonics
14. Superposition
15. Phase Relationships
16. The Square Wave
17. Audio and Acoustic Superposition

The Frequency Domain

Frequency has been described as "a measure of often-ness." While that may not be a word, it aptly describes the concept. Audio signals have a *spectrum*, and audio components have a *bandwidth*. We must understand both to effectively deploy, tune, and troubleshoot sound reinforcement systems.

It is also important to understand the inter-dependency of time and frequency, since they are defined in terms of each other. Each provides an alternative perspective of the system response, allowing the practitioner to use the one most meaningful for the task at hand .

Once I have presented this look at the frequency domain, we'll move on into the spatial domain of *wavelength*.

Pat Brown

Three video clips covering these topics.

1. What is Frequency
2. The Audible Spectrum
3. Pitch
4. Proportional Change
5. Linear vs. Logarithmic
6. Dividing the Spectrum
7. Loudspeaker Bandwidth
8. Introduction to the Decibel
9. Spectrum vs. Frequency Response
10. Octaves and Octave Fractions
11. Frequency Resolutions
12. Spectrum Analysis

Wavelength

We are in the wave business. Both audio and acoustic waves have a physical size that determines how they interact with each other, as well as how audio signals behave on cables and how acoustic signals behave in rooms. Now that we have covered the time and frequency domains, we are ready add another important layer - wavelength.

The time domain answers the question "When?" The frequency domain answers the question "How often?" Wavelength answers the question "How big?" With knowledge of all three we can fully characterize both audio and acoustic signals.

Pat Brown

Two video clips covering these topics.

1. Wave Dimension
2. Audio vs. Acoustic
3.Audio Wavelength Issues
4. Acoustic Wavelength Issues
5. Wavelength Examples
6. Conclusion

CAFViewer Calculator Demo - Time, Frequency, Wavelength Relationships.

“Principles of Audio” Detailed Course Outline

The Decibel

If one intends to live and work in a country, they had better speak the language. Nowhere is this more true than in audio.

"The decibel is the language of audio." - Don Davis

Trying to do audio without being fluent in the dB is like trying to live in the United States without speaking English. Yes, it's possible, but it is not optimal. The decibel is not well-grasped among audio practitioners, but you can be the exception. This lesson presents the dB from the ground up so that you not only understand "how" but "why." It will help you integrate it's use into your audio conversations and make you stand out among your peers.

Watch the videos several times. There's a lot of information here. Be sure to spend some time with the CAFViewer™ dB calculator presented at the end of the lesson. It was designed to do the math so that you can concentrate on the concept.

Pat Brown

Six video clips covering these topics.

1. Introduction
2. Sound Pressure
3. Proportional Pressure Changes
4. Sound Power from Electrical Power
5. Logarithms and the Bel Scale
6. “Power-like” Quantities
7. A Different Perspective
8. The dB Chart
9. An Example
10. Rinse and Repeat
11. The Power Equation
12. Signal Voltage
13. Relative Levels
14. Absolute Levels
15. dBV
16. dBu
17. Using the Decibel

“Principles of Audio” Detailed Course Outline

Sound Pressure Level

Now armed with the decibel, we are ready to venture into acoustic levels. These are easily addressed by building upon the foundation established in the previous lesson. Acoustic levels are the sound-related equivalents of electrical levels.

"You already know this stuff, you may just not know that you know it." - Bruce Howze

Pat Brown

Three video clips covering these topics.

1. Sound Pressure from Sound Power
2. Sound Pressure Level
3. Loudness Time-Dependence
4. Loudness Frequency / Level-Dependence
5. Weighting Scales
6. Peak SPL
7. More About Loudness
8. SPL Measurements
9. Equivalent Level - LEQ
10. Calibration
11. In Conclusion

Audio Meters

Audio meters have been around since the beginnings of our industry nearly 100 years ago. They are based on decibels and were invented to solve problems. Several types have endured to become today's go to tools for observing audio levels. This lesson is especially relevant to the current role of audio as a means of conveying information through broadcast, narrowcast, and podcast. Those producing online videos will tell you that the audio is the hardest part to get right.

Listeners can immediately tell if the level isn't right. Meters are needed to get it right and keep it right.

Pat Brown

Four video clips covering these topics.

1. Why Do We Need Audio Meters
2. Signal Attributes
3. Clipping Distortion
4. Monitoring Audio Waveforms

5. The True Peak Meter
6. The Peak Program Meter
7. 0 dBFS
8. The Volume Indicator (VU Meter)
9. K-System Metering
10. Loudness Unit Metering
11. Which Meter Do I Have
12. Conclusion

Demo: Test Audio Meters

Basic Electricity

Modern life would be impossible without electricity. Take it away and we become paralyzed as a society. Even so, few people understand even the most basic operation of an electrical circuit. Fortunately, the concepts are fairly simple and we use them in other aspects of everyday life. This lesson will familiarize you with the basics of electrical circuits, making it easy to understand how audio interfaces work.

I've provided a Voltage Divider calculator in the CAFViewer™ app that I will demonstrate after the teaching videos. It's designed to allow you to play with the variables and become accustomed to their typical values in various types of audio circuits, as well as how they interact.

Pat Brown

Five video clips covering these topics.

1. Introduction
2. Nature Loves Equilibrium
3. Pressure and Flow
4. Opposition to Flow
5. Impedance Examples
6. DC Electrical Circuits
7. AC Electrical Circuits
8. Electrical Definitions
9. The Voltage Divider
10. Interface Classifications
11. Low vs. High Impedance
12. Some Practical Examples
13. Universal Principles

Demo: Basic Utility Power Circuit

CAFViewer Calculator - Audio Circuits

“Principles of Audio” Detailed Course Outline

Audio Interfaces

This is the lesson we have been building up to.

Now that you know how a voltage divider works, you can easily understand how any audio interface works. From it we get the meanings of common audio terms such as "high impedance," "low impedance", "balanced," "unbalanced," and others.

I will also address some of the fundamentals of power and audio system grounding and shielding. You will understand why sound systems are sometimes plagued by "hum and buzz" and what to do about it.

Finally, a hat's off to some industry pioneers that established much of the theory and practice presented here, namely Henry Ott, Neil Muncy, Ralph Townsend, Bill Whitlock and many others.

Pat Brown

Five video clips covering these topics.

1. Introduction
2. Active vs. Passive Components
3. Signal Ground
4. Unbalanced Outputs
5. Balanced Outputs
6. Unbalanced Inputs
7. Balanced Inputs
8. Balanced-to-Unbalanced
9. Polarity
10. The Cable Shield
11. The Pin 1 Problem
12. Parallel-Connected Loads
13. Series-Connected Loads
14. Series-Parallel Loads
15. Conclusion

Demo: Loop EMI Susceptablity

Demo: The Pin 1 Test

Mixer Study:

Digital Audio Overview

SynAudCon spent years developing a course on digital audio - an in-person seminar for which I served as co-instructor. In this lesson I have taken the most important tenets of that course and distilled them into a concise overview of digital audio in general. I can easily remember the time

when I found this topic to be baffling without even knowing where to start with regard to understanding it.

If you are that person, then this lesson is for you.

Remember that there is a separate PDF download for this lesson in the Resources and Downloads section at the beginning of this course.

Pat Brown

Four video clips covering these topics.

A. Creating Digital Data
Introduction
Sampling Theorem
Quantization
The ADC

B. Moving Digital Data
The Bit Stream
Data Formats
Timing
The Digital Audio Interface
Latency
Digital Audio Format Details

C. Processing Digital Data
Overview
The FIR Filter
The IIR Filter
Additional Processes

D. Moving More Data Farther
Introduction
AES50
Audio-over-Ethernet (AoE)
The OSI Model
Which Is Best?

Demo: Wave Olympics

CAFViewer Calculator - Discrete Time / Frequency

“Principles of Audio” Detailed Course Outline

Loudspeaker Fundamentals

I am admittedly a "loudspeaker guy." Outside of developing our training programs, many of my hours are spent in the lab testing both loudspeakers and amplifiers for manufacturers all over the world. I'm going to pass along some concepts that I have figured out over the years.

After nearly 100 years of sound system evolution, we're still pushing air with pistons. This lesson presents the most important attributes of loudspeakers in a universal and brand-agnostic manner. You need to understand a subset of loudspeaker specifications to compare, select, and deploy loudspeakers for systems of all types.

There are several demo videos at the end of the lesson that present some low-cost, simple, and practical methods for testing some important loudspeaker parameters. Perhaps their greatest value is in helping you understand how these devices work.

Pat Brown

Four video clips covering these topics.

1. Loudspeaker Types
2. Important Attributes
3. Efficiency
4. Sensitivity
5. Impedance
6. Power Ratings
7. Polarity
8. Spherical Spreading
9. Near, Far and Free Field
10. Directivity
11. The Balloon Plot
12. Summary