New England Institute of Art
AMT 150
Audio Technology II

Instructor: Owen Curtin
Winter 06

Course Description
This course is a continuation of study of the principles of audio signals and the equipment used to record, process, and distribute audio content. Sound in acoustical form is discussed to introduce students to issues related to studio acoustics. Students expand their understanding of signal flow of advanced audio systems by creating and reading complex block diagrams. The course is an in depth study of concepts and equipment used in all facets of audio production: signal processors, dynamic range, distortion, analogue recording, and SMPTE time code. Additional in depth discussion and demonstration of signal flow of advanced audio systems using block diagrams.

Prerequisite” AMT 101 Audio Technology 1

Objectives
• Create, read, and explain block diagrams of complex audio systems used in live sound and recording applications.
• Express the concepts that govern transformers and solve signal manipulation problems through the use of transformers.
• Know the typical types of audio connections and devices needed for proper signal flow between sources and destinations including connectors, jacks, and patch bays.
• Understand the causes and types of audio signal distortion and the methods for distortion measurement.
• Understand the principles of SMPTE time code and the variables that affect synchronization of audio systems. Solve theoretical problems using SMPTE time code.
• Understand the process of magnetic recording and the fundamental parameters that affect recording quality.
• Understand the processes involved in a typical multitrack recording project as well as the roles and responsibilities of the individuals involved.
• Understand the uses and operational parameters of frequency domain, amplitude domain, and time domain signal processors.

Texts:
Required: Understanding Audio, Daniel M. Thompson, Berklee Press
Resources for this course can be accessed at: http://homepage.mac.com/bcrabtree
Resources for this course can be accessed at: http://stu.aii.edu/~dl418/amt150links.html
Materials:
Scientific calculator (logs, antilogs, exponents, sin)
Graph paper, straight edge
BRING YOUR CALCULATOR TO ALL CLASSES

Grading:
25% Midterm exam
25% Final exam
35% Quizzes
15% Homework

Assignments:
There are no make-ups for assignments or quizzes. **Assignments will not be accepted late.** However, the lowest score (quiz or assignment) will be dropped and not included in your final average.

Attendance:
Attendance is required for this course. While the textbooks are a valuable resource with a good deal of required readings, many concepts are only presented in class and not available in the texts. Missing only one class may put you too far behind to catch up. **DO NOT MISS CLASS.** Under dire circumstances, if you miss a class, it is your responsibility to stay informed about homework, notes, or assignments. If you miss three classes, your maximum grade will be a D.
Week 1

Go Over Syllabus
Review rules for block diagramming
Microphones
Review studio 32 for Rec 1
Microphone Work Sheet
Block Diagram Work Sheet
Assignment 1

1. Label each component on the channel strip graphic with its name and corresponding block diagram symbol.

2. On a separate sheet, type a description of each component.


4. Study for Block Diagram Work Sheet for Quiz

5. Study for Microphone Work Sheet for Quiz

6. Email: owen_curtin@emerson.edu
   Subject: Tech 2 Winter 06
Week 2

Block Diagrams a Polar Patterns Quiz

Connectors Review: Do the reading we will have a quiz

VU vs. Peak

- VU (volume unit) vs. Peak or Peak Program Meter.
- VU corresponds to human perception
- Pinning will damage the meter.
- Peak Meters are fast and better for gauging clipping

Transformers

- Used in all sorts of audio devices
  - DI box
  - Microphone pre amps
  - Power amps.
- Two most important futures are:
  - Change voltage
  - Change impedance.

Voltage

Snow blowers example

- 440V comes from three phase power one the power line
- 400V Runs the fan and compressor motor.
- 120 or 110 (like home) runs the light
- 20V runs the switches.

Audio Example

- Line Level: approximately 1 volt
- Mic Level: Audio signals whose level is similar to those of microphones, that is, generally ranging from roughly 1 to 5 mV
- Microphone Pre Amps boost microphone level to line level.

Patch bays, normal, hardwired, 1/2 normal
Assignment 2

Print, Read and Highlight
Pages 71 and 77 on Meters

http://stu.aii.edu/~dl418/Audio%20Connectors.pdf (study questions for quiz)

• Name types of two pin and three pin connectors?
• A two-pin connector can be three-pin connector do what?
• What is the main advantage of a balanced connection?
• What does it mean if two patch points are “normalled”?
• Explain the difference between full normal and half normal patch points.

Patch Bay Design

Create a patch bay design for a small studio. The studio will include the devices listed below. Try to incorporate all inputs and outputs on the devices, and designate connections being non-normalled, or normalled with a color code. Organize your patch bay as user-friendly as possible. Try to put the outputs on the top and inputs on the bottom of the patch bay. You only need to draw the patch bay. Do not include any audio devices in this diagram.

2 Patch Bays - each 48 points wide, 2 points tall = 96 points on each bay.

16 Channel Mixing Console
• Mic Inputs on each channel
• Line inputs on each channel
• Insert Send and Insert Return on every channel
• L/R mix bus insert
• Group 1-8 Outs
• Aux Outs 1-6
• Stereo Aux Returns 1&2
• (2) L/R Mix Outputs
• Two-track in A L&R
• Two-track in B L&R

2 Stereo Time-Based Effects Processors
2 Stereo Compressors
1 Stereo Parametric EQ
1 Mono Outboard Mic Preamp
Microphone Input Box - 16 Inputs (from performance space)
8 Track Recording Device
CD recorder / player
DAT machine
Headphone Amplifier
Week 3

Transformer and DI Box and Connectors Quiz

Live to 2, Live Sound Reinforcement, Multitrack, Mixing

Block Diagrams of Mixing and Live sound setups

DTRS Machines: Input/Insert/Auto Input

Live to 2 Track

![Live to 2 Track Diagram]

Multitrack

![Multitrack Diagram]
Assignment 3

Print Read and Highlight
http://www.trinitysoundcompany.com/eq.html
http://www.rane.com/note122.html

Studio Design Project
Define, shop for and diagram of you own personal studio or dream studio for less then $5000.

1. Define the intention of the studio’s use.
2. Make a list of all the gear you would buy with $5K.
   a. Brand
   b. Model
   c. Brief Description
   d. Prices
      i. Define New or Used
      ii. (find at ebay or sweetwater.com)
   e. Ins
      i. How many
      ii. Balanced or unbalanced
      iii. Connector type
   f. Outs
      i. How many
      ii. Balanced or unbalanced
      iii. Jack type
   g. Digital
      i. What Format
      ii. Jack type
   h. Midi Yes or NO

3. Draw a diagram illustrating signal flow.
   a. Define Balanced vs. Unbalanced
   b. Midi
   c. Digital

4. Design and Draw a patch bay to work in your studio.
Week 4

Check Highlighting from readings.
Review Transformers and Connectors Quiz
Present Studio Designs

Types of effects
- EQ/Spectral
- Dynamic
- Time Based

Which are inserted? Why?
Which are sent to an Auxiliary.

**EQ: Spectral**

EQ types
- Pass Filters: Freq
- Shelf: Gain, Freq
- Notch: Gain, Freq, Q

Graphic: Used to “Ring Out” a room in live sound,
Parametric and Quasi – Parametric are found on most consoles

Bandwidth: high frequency - low frequency
Center Hz: The Hz in a notch filter with the greatest change in dB.
Q = Center Hz / Bandwidth
Higher numbers make narrower Q
Slope: The dB change per octave. (impacts phase shift!)
Stop Point: The frequency at which a shelving-filter levels out.

What kinds of EQ are on the Studio 32?

Fill out worksheets
Draw the connections used to make this a function sound reinforcement setup.
1. What type of EQ increases or decreases amplitude above a set frequency but levels out at a stop frequency.

2. What type of EQ can increase or decrease the level of a band of frequencies around a center frequency.

3. What type of filter attenuates below a set frequency?

4. What is the formula for Q?

5. What is the bandwidth of a parametric EQ with a center frequency of 1000 Hz and a Q of 10?

6. True or false, a larger number defines a wider Q.

Hint:

<table>
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<th>Gain</th>
<th>Q</th>
</tr>
</thead>
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<td></td>
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</tr>
<tr>
<td>Shelf</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Parametric</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Assignment 4 (cont.)

Equalization Curve Graphing

On graph paper, plot each of the following frequency changes separately.

Graph on a frequency domain plot (frequency by octave on the x-axis and positive and negative amplitudes on the y-axis).

1. Bell Curve, Center Frequency 1 kHz, 6 dB boost, 2-octave bandwidth.
2. Low Shelving Filter, Cutoff Frequency at 250 Hz, 3 dB cut.
3. Low Pass Filter, Cutoff Frequency at 10 KHz, slope 6 dB/octave
4. Bell Curve, Center Frequency 250 Hz, 9 dB cut, 1-octave bandwidth.
5. High Shelving Filter, Cutoff Frequency at 6 kHz, 6 dB cut.
6. High Pass Filter, Cutoff Frequency at 125 Hz, slope 9 dB/octave

Draw:

High Pass filter: Cut Off Frequency: 160Hz, Slope: 10dB per octave
Notch Filter. Center Frequency: 640Hz Gain: -35dB Q: Narrow
High Shelf Filter Cut off Frequency: 5K Hz Gain: -20dB Stop Point: 1 Octave
Week 5

EQ Quiz and Check Highlighting

Review dynamic range
  Noise Floor
  Peak Level
  Reference Level Tape vs. Digital
  Headroom is the difference between peak and Reference Level.
  Dynamic Range is measured by the signal to noise ratio.
  Signal to Noise Ratio

Consumer Cassette:  50 dB
Pro Tape machine.  65 dB
16 bit Audio  94 dB

Dynamic Effects:
  Compressors, Expanders, Gates, Limiters
  Companders, DeEsser, Ducker
  Noise reduction

Envelope: “contour: of the amplitude of a sound
  ADSR: Attack, decay, sustain, and release

Threshold: The level in dB that must be exceeded to change the output of the processor.

Attack: The difference in time from when the input signal exceeds the threshold and when the processor acts on the input signal.

Release: The difference in time from when the input signal falls below the threshold and when the processor stops acting on the input signal.

Ratio: The proportionate difference between the inputs on output stages of a dynamic processor.

The “key” signal triggers the processor but is not always the same as the input signal.

Makeup Gain is the amount the output signal is amplified
Dynamic Range Work Sheet:

An audio device has headroom of 18dB and a dynamic range of 48dB what is the formula to calculate the signal to noise ratio?

An audio device has signal to noise ratio of 50dB and a dynamic range of 60dB what is the formula to calculate the headroom?

A professional audio devise has a dynamic range of 65 dB. The headroom is 10dB. What is the ceiling level?

Given the same device as in question 3, what is the noise floor level?

A consumer audio device has a signal to noise ratio of 55 dB and headroom of 5dB. What is the dynamic range?

Given the same consumer device, what is the level of the noise floor?

Given the same consumer device, what is the ceiling level?

The parameter that adjusts how long it takes for a gate to begin opening is:

A compressor is used to reduce the___________ ___________ of an audio signal.

On a compressor, the control that determines how quickly gain reduction begins once the signal exceeds the threshold is called ______________

An expander is a device that ___________ the dynamic range of an audio signal.

The “contour’ of the amplitude of a sound is called the ______________.
Assignment 5

Read, Print and Highlight:  
http://pages.emerson.edu/faculty/O/Owen_Curtin/Composer.pdf  
Read it all.

Name these filters and patterns:
Perform the following calculations:

1. An audio signal is 12 dB above the threshold level. The compression ratio is set to 4:1.
   a. What is the output over the threshold level?
   b. What is the gain reduction of the signal?

2. An audio signal is 24 dB above the threshold level. The compression ratio is 8:1.
   a. What is the output over the threshold level?
   b. What is the gain reduction of the signal?

3. A digital compressor has its threshold level at -20 dBfs. The audio signal has an input of -4dBfs. The ratio is 4:1.
   a. What is the output level of the compressed signal?
   b. What is the gain reduction of the signal?

4. An analog compressor has its threshold at -12 dBu. The input level is +4dBu. The ratio setting is 8:1. The makeup gain is +12 dB.
   a. What is the output level of the compressor?
   b. What is the gain reduction of the signal?
Week 6

Check reading and review worksheet.
Collect Assignment 5 questions on dynamic processors.

**Review**
Transformers and the associated math
EQ and associated vocabulary
Dynamic Processors and associated vocabulary
Connectors and Patch bays

**Work Sheet:**

A guitar is connected to a mic pre using a direct box. The direct box is a 20:1 transformer.

- The guitar has an output impedance of 20kΩ.
- The voltage output of the guitar is 500 millivolts.
- The mic pre has an input impedance of 2.5kΩ

1. What is the voltage level entering the mic pre?
2. What impedance does the guitar present to the mic pre after running through the DI box?
3. What input impedance does the guitar “think” it is plugged into?
4. The amount of phase shift (also called phase change) that a filter imposes on a signal is dependent on:
5. Which filters is not commonly found on a console?
6. Which has the widest dynamic range, CD or Tape Cassette?
Week 7

Midterm Exam

Assignment 6

Print, Read and Highlight
http://www.shure.com/support/technotes/app-critical.html
http://www.acoustics.salford.ac.uk/acoustics_world/duck/duck.htm
http://www.harmony-central.com/Effects/Articles/Reverb/
http://www.harmony-central.com/Effects/Articles/Delay/

Try the experiment from the reading
Measure the Dc in to locations.

Understanding Audio: Chapter 16
Week 8

Review Midterm
Check Highlighting
Collect Measurement from experiment in Dc

**Time based effects:** Reverb and Delay

Rhythmic and repeating delays
- 1 Sec = 1000 ms
- 1 Minute = 60 X1000 = 60,000
  - BPM = Beats Per Minute = Tempo
  - ms per beat = 60,000 /bpm = X
  - ms per 1/8 mote = X/2

Feedback

Types of Reverb:
- Chambers
- Springs and plates
- Digital.

Decay Time or Reverberation Time, or RT60: The time it takes for reflected sound within a space to decrease by 60 dB after the sound was made.

Pre delay: The amount of time between the original dry sound, and the audible onset of early reflections. Adjusting the pre-delay makes a difference in the "clarity" of a mix.

Damping: Reducing sympathetic vibrations or the acoustic reflectivity of a room.

Bass multiplier: Adjusts the decay time of the bass frequencies in the reverberations. The bass level has a strong effect on the overall 'mood' or sound of the virtual room. A bright room has less bass response, while warm rooms have a more bass response.

Print, Read and Highlight

http://www.harmony-central.com/Effects/Articles/Chorus/
http://www.harmony-central.com/Effects/Articles/Flanging/

Bring in CDs with examples of time based effects.

Answer and explain:
What reverb parameter would adjust the listener’s perception of the size of the room?

What reverb parameter would effect the listener’s perception of the wall surfaces?

If the tempo is 100 BPM, what delay time makes a quarter note delay? ________ms
Week 9

Check Highlighting
Review Reverb and Delay
Reverb Quiz.

**Time based effects:** Chorus and Flanger

Listen to examples on CD

Demo effect in Pro Tools.

Print Read and Highlight

Understanding Audio: Analog Magnetic Recording (Chapter 13 pages 267-285)

Using the reading, type answers to these questions:

1. What is the order of heads on a tape recorder?
2. When over dubbing, what head plays the pre-recorded music?
3. Another name for the record head is the ________ Head.
4. Explain Bias:
5. Explain Sync Replay
Analog Magnetic Recording

Another name for the record head is the ________ head.

What are common widths for analog tape?

A C30 Cassette tape has ______ minutes of playback per side.

True or false, higher bias levels enable the audio signal to be recorded more deeply into the oxide layer of analog tape than would be the case with lower bias levels?

MOL stands for?

A tone/test tape is a reference standard recording containing pre-recorded tones at a guaranteed ______________ level.

Why should we play tapes to the end and then store them “tails out”.

IPS stands for? _________ _________ _________

HF stands for? ________________________________

Explain Repro and why you would use it.

In a professional studio, who provides the supply reel?

True or False, a tape machine running at 15 IPS records sound with less fidelity than when running at 30 IPS.

http://www.alesis.com/support/cc/sync.html
Working with Tape

Analog vs. Digital

Analog is continuously variable.

Tape is Analog. The polarity and strength of voltage is “analogous to” the shape of the waveform it represents.

Tape Speed

Measured in IPS (Inches Per Second)

Heads and Overdubs

While Overdubbing, a non-musical delay will be rendered if the pre-recorded material is played back on the play head and the new material is recorded with the record head. The delay is caused by the time it takes for the tape to travel the distance between the two heads.

The record head is also called the sync head because it can be used as a playback head for any of the tracks that are not recording.

New Tapes and Tails Out

New tape comes on a reel. The real and tape are flipped over and rewound onto the studio’s supply reel. Then the empty reel is flipped again and the tape is feed back on.

- Tapes are played to the end and stored.
- Red leader marks the end of the tape.
- Print-through will sound like a post echo.
- Tape will be tightly wound.
Tape Alignment

Playback Alignment.
By playing back a tape with a known level the output can be calibrated by adjusting the Play Head Pre Amp.

1. Monitor the Play Head. (REPRO)
2. Play the Alignment Tape from the 1kHz tone.
3. Adjust the “Repro Level” to the desired level.
4. Repeat 1-3 using the sync head.

Record Alignment:
Send a tone to the tape and adjust its level so that the play head meters (repro) read the same as they did during playback alignment. In this way we can say we are recording onto the tape the exact level as the know level on the alignment tape.

1. Monitor the play head. (REPRO) Start recording. (Use the set area on the alignment tape)
2. Adjust the “Record Level” to the same level you used during play back alignment.

Alignment Tones
• At the start of your tape, record 60 seconds of each tone: 1kHz, 10kHz and 100Hz.
• Record the tones at the level you determined during playback alignment.
• These tones will be used to calibrate the machine for the remained of the project.
• Mark the tape box as shown.

Tones @ 1kHz, 320nWb⁻¹ = 0dB

1kHz is the Frequency of the tone.
320 nWb⁻¹ Is a measurement of voltage or magnet flux recorded on to the tape. This number will be found on the alignment tape.
0dB is an example of the playback level you chose to set during Playback and Record Alignment.

Tape Bias
Adding an inaudibly high frequency tone increases the tapes magnetism and the evens out its frequency response. (Complete this step after Playback alignment)
1. Record a 10kHz tone on all tracks. (Use the set area on the alignment tape)
2. Monitor the play head. (REPRO)
3. Turn the bias pot all the way down. Then slowly turn it up.
4. The VU meter will rise to then begin to fall. (Over biasing)
5. Stop turning when the VU meter has fallen to the predetermined level.

Note: the ideal bias level varies with the type of tape and the tape speed.
Week 11

Review Tape Machines
Quiz on Tape machines
Check highlighting

**House Sync**: provides a speed reference for all decks. Called “black burst” or “house black”

**Word Clock** defines the start of digital words and can sync to house sync.

**Time Code** defines the *address* at any point on the tape.

**SMPTE**: Society of Motion Pictures and Television Engineers. Defined two code formats

**LTC**: Longitudinal Time Code is transmitted with sound. LTC can be read in play but not in pause.

**VITC**: Vertically Integrated Time Code. The code is transmitted visually so it may be read in play or pause.

**Master**: This is either a sync controller or a *Master Deck*. It is common to pick your slowest and least controllable deck to be the master.

**Slave**: This is the deck that chases the time code on the Master. Machines with high levels of control or random access (hard drives) chase more quickly.

**Synchronizer**: This device monitors address information from all decks and controls the speed of the slave decks.

NOTES: Time code must be found on both the Master and the Slave decks.
Week 12

Multi Track session procedures

TRACK SHEET

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<th>Kick out</th>
<th>SN Top</th>
<th>SN shell</th>
<th>H. Tom</th>
<th>M. Tom</th>
<th>L. Tom</th>
<th>OH Mono</th>
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<table>
<thead>
<tr>
<th>Guitar Cab (incl)</th>
<th>Guitar Cab (room)</th>
<th>Bass (L)</th>
<th>Key</th>
<th>Sax</th>
<th>Trumpet</th>
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<tr>
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<th>Lead Vox</th>
<th>Coiled Vox</th>
<th>BG Vox 1</th>
<th>BG Vox 2</th>
<th>BG Vox 3</th>
<th>Time Code</th>
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Input Sheet

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<th>Chan</th>
<th>Buss</th>
<th>Track</th>
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<td>19</td>
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<td>22</td>
<td>S 5</td>
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</table>

| Bass (L)           | 1/23        |            | 23   | 23   | D: 6 |       |          |
| Bass (R)           | 1/24        |            | 24   | 24   | D: 7 |       |          |
| Key                | 1/25        |            | 25   | 25   | B 8 |       |          |

Artist: David Moore
Producer: Bill Porter
Engineer: John Davis
Date: 10/10/01
Studio A-B-C
Assistant: M.-J.
Week 13

In Live vs. Split Consoles
Tape Return
Monitor Section
Listening to your record deck
The implications for overdubbing

Take Home Quiz: Rough Draft due next week. Final Draft due on the last day of class

Complete the diagram of an inline console described on the next page.
Submit a copy of your final project: your submission will not be returned.
Scale you copy down to 8.5 by 11.
Below are images that will help you on your way.
For this project, you will create an inline console block diagram. Use graph paper and a straight edge. Presentation will be a large percentage of your grade.

Console Description:

Audio Channels

24 mono audio channels
Each channel will have a channel path and monitor path.
Line Input and Mic Input
Monitor Path Line Input (Tape In)
4-band fully parametric eq (switchable between channel and monitor path)
Bounce button (monitor path takes assignment matrix)
Direct Output (Channel Path) (Direct Output of Channel 1 feeds Tape Send 1. etc.)
Insert Send / Return (insert switches with EQ between channel and monitor path)
Phase Reverse Switch
6 Aux Sends
   Aux 1&2 Stereo Aux (1 Level Control, Pan Pot)
      Pre / Post Fader
      Channel / Monitor Path
   Aux 3 and 4 Mono Aux Sends
      Pre / Post Fader Monitor Path
   Aux 5 and 6 Mono Aux Sends
      Post Fader Monitor Path

Busses

L/R Mix Bus
Sub-Groups 1-8 (Bus 1 feeds Tape Send 1 etc.)
Aux Busses 1-6

Master Section
Link to L/R from Group pairs (for Sub-grouping)
Control Room Monitor Section:
   Monitor Sources:
      2 track A In
      2 track B In
      L/R Mix
   Speaker:
      Nearfield
      Mains Select
Week 14

Review For Final
Collect Rough Draft of Block Diagram (%20 of grade for this quiz)

Week 14

Block Diagrams are due today.
Final Exam:

Congratulations, you have completed Audio Tech II.