Welcome To:

Introduction To Music Technology (Audio Engineering class)

Instructor:

Anthony Walker

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http://anthonywalkermusic.com

http://anthonywalkermusic.com/Education

About the Instructor:

- 1967 Started playing guitar & piano
- 1972 Played clubs 6 nights/week during high school
- 1977 BS Degree Electrical Engineering (UMR)
- 1978 Hewlett-Packard NMOS Chip Design
- 1985 MS Degree Electrical Engineering (CSU)
- 1986 Developed MIDI Sequencer Software

Currently:

- Play with several bands including Tina Marx & Millionaires
- Music Directory/Arranger (Finale) Tina Marx &Millionaires
- Perspective Audio Video Services (Recording Studio in Fort Collins)
- Sound Reinforcement for Jefferson County Symphony

About the Students:

- Experience Performing/Instruments
- Experience Sound Reinforcement
- Experience Recording
- Math & Physics Background
- What do you want out of this class?

Original Syllabus

Introduction To Music Technology **(2 credits)**

A hands on study of a variety of music software programs which assist the student in functions such as music notation, ear training, composing and arranging, recording, sequencing and creating play along recordings. Students will show projects which were generated using the programs at the end of the semester.

Music Recording and Sound Technology **(1 credit)**

This course is a continuation of the Intro to Music Technology. Students will continue working with and expanding their knowledge of recording and sound technology through hands on projects while exploring the equipment, theory, and techniques of these subjects. This will include, but is not limited to, recording and providing sound for recitals, solo and ensemble performances, group and individual demo recordings, as well as gaining more experience by providing sound as requested outside of our facilities. [*Prerequisite: Introduction to Music Technology or Consent of Instructor*]

New Syllabus for Intro…

Introduction To Music Technology (Software) (1 credits)
Teacher: Ron Forte

A hands on study of a variety of music software programs which assist the student in functions such as music notation, composing and arranging. Students will show projects which were generated using the programs at the end of the semester.

Introduction To Music Technology (Audio Engineering) (1 credit)
Teacher: Anthony Walker

Introduction to the physics of sound and how this understanding can be applied to Sound Reinforcement and Recording. The course will consist of lecture and off-campus projects with Sound Reinforcement and/or Recording.

Approach…

Solve Music Problems

Engineering	Art

- **Do you want to learn <u>Engineering</u> or <u>Art</u> in this class?**
- **Which is most important?**

Details we may discuss…

- What is Sound in the Air or Electrically?
- Volume, Frequency, Pitch, Amplitude,
- Decibels, Phase, Harmonics
- Constructive and Destructive Interference
- Digital versus Analog
- How many bits do I need?
- Sampling Rate
- Feedback

Details we may discuss (cont…)

- Filters
- Preamps & Power Amps,
- Passive & Active Crossovers
- Balanced & Unbalanced Cabling
- Microphones
- MIDI
- Impedance
- DIs

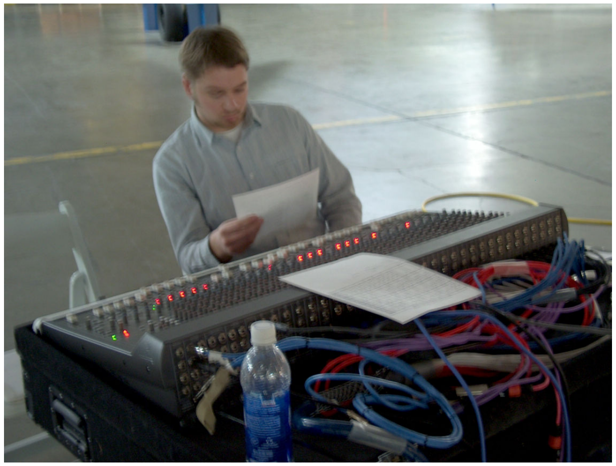
Details we may discuss (cont…)

- Bussing & Aux Sends
- <u>Effects</u>
  - Compressors
  - Multi-Band Compressors
  - Reverb Synthesis
  - Impulse Reverb
  - Digital Delay
  - Tape Saturation
  - Flangers, Phasers etc.

Details we may discuss (cont…)

- Mixing Tricks
- Mastering
- Room Tuning
- ProTools Details
- Mic Placement Live & Recording

Possible Projects/Field Trips



- Sound Reinforcement (TM&M) event in Denver on 1/28/2006 at Wings Over The Rockies Air Museum?
- Multi-Track Recording Project in Perspective Music Studio? Violins this weekend? One Sky mix?
- Demonstrations in studio of sound physics?

Text Book

Sound Reinforcement Handbook

Author: Gary Davis & Ralph Jones

Sponsored: Yamaha

ISBN: 0-88188-900-8

Publisher: Hal-Leonard Corporation

You can order at Barnes & Noble or New/Used On-Line.

Assignment #1A

Read section 1. Focus on signals, phase, speed of sound more so than on speaker design.

What is Sound?

- For example, guitar string vibrates back & forth.
- Pushes & pulls the air as it vibrates. What frequency?
- Creates high and low pressure. Where?
- The pressure variance becomes mobile (wave). Where does the wave go? What pattern?
- Wave collides with your ear drum.
- Ear drum moves back and forth which creates pressure differences in the Cochlea.
- Tuned hair/nerves generate nervous system signal.
- See http://www.bcm.edu/oto/research/cochlea/Volta/index.html

What is Pressure?

- What is <u>force</u>? Pounds!
- What is <u>area</u>? Square feet or square inch etc! (aka ft^2 or in^2)
- What is pressure? Pounds/ft^2
- 200 pound guy standing on a board that is 10in x 10in. How much pressure?
- 200 pounds/100 in^2 = 2 lbs/in2
- Air Pressure?
- 14 #/in^2

What Makes Ear Drum Vibrate?

Ear Drum

Air pressure In your head?

14 #/in^2

Air pressure outside your head?

+/-14 #/in^2

Which way does your ear drum move?

Assignment #1B

Write up an explanation in detail of how a microphone works. Describe it in a style similar to my explanation of how the ear works.

Review Lesson #1

Text Book?

Any questions from last week?

Write up an explanation in detail of how a microphone works. Describe it in a style similar to my explanation of how the ear works.

What did you come up with?

The main addition is that the sound hits the diaphragm of the microphone instead of your ear drum. The moving diaphragm is connected to magnetic or electrostatic electronics that converts the motion into voltage. Analog or Digital?

Class #2
Basic Sound Waves

What is a wave?

- Something that changes over time.
- Periodic (It repeats)
- Potentially in motion
- Does it have to be a sine wave?
- What does the sine mean in sine wave?

Units for Physical Measurements

Time: Seconds, Hours

NOTE: A msec is 1/1000 of one second

1,000 msec equals one second

Distance: Feet, Meters, Miles

Speed: Miles/Hour or Feet/Second

NOTE: Speed Of Sound = 1,130 feet/sec = 344 meters/sec

Approximately one foot per msec

Frequency: Cycles/second = Hertz (Hz)

NOTE: A cycle is not a real unit.

Unit Prefix Multipliers

http://whatis.techtarget.com/definition/0,,sid9_gci499008,00.html

Giga (G): Multiply by 1,000,000,000

Mega (M): Multiply by 1,000,000

Kilo (k): Multiply by 1,000

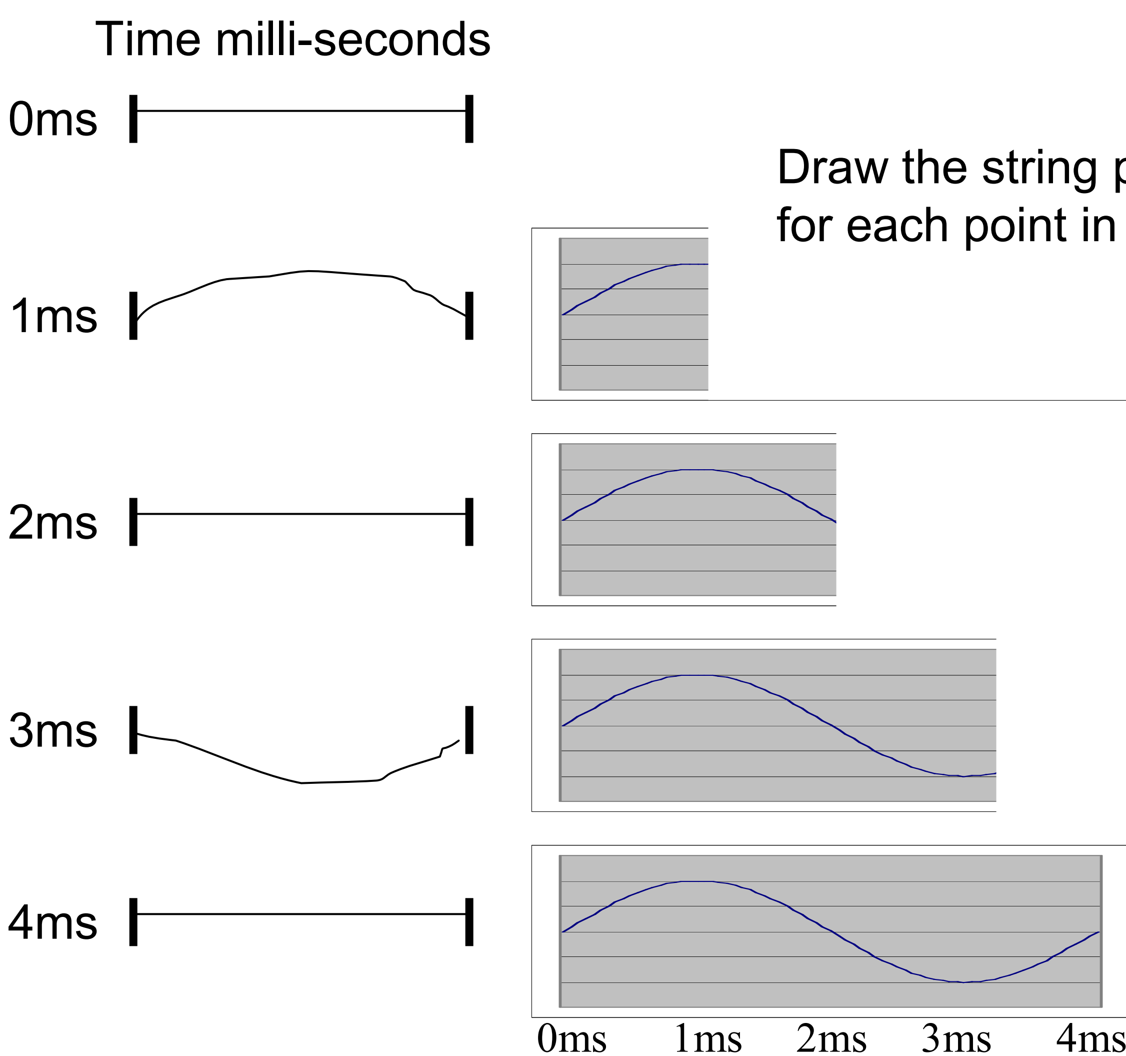
None: Multiply by 1

Milli (m): Divide by 1,000

Micro (μ): Divide by 1,000,000

Nano (n): Divide by 1,000,000,000

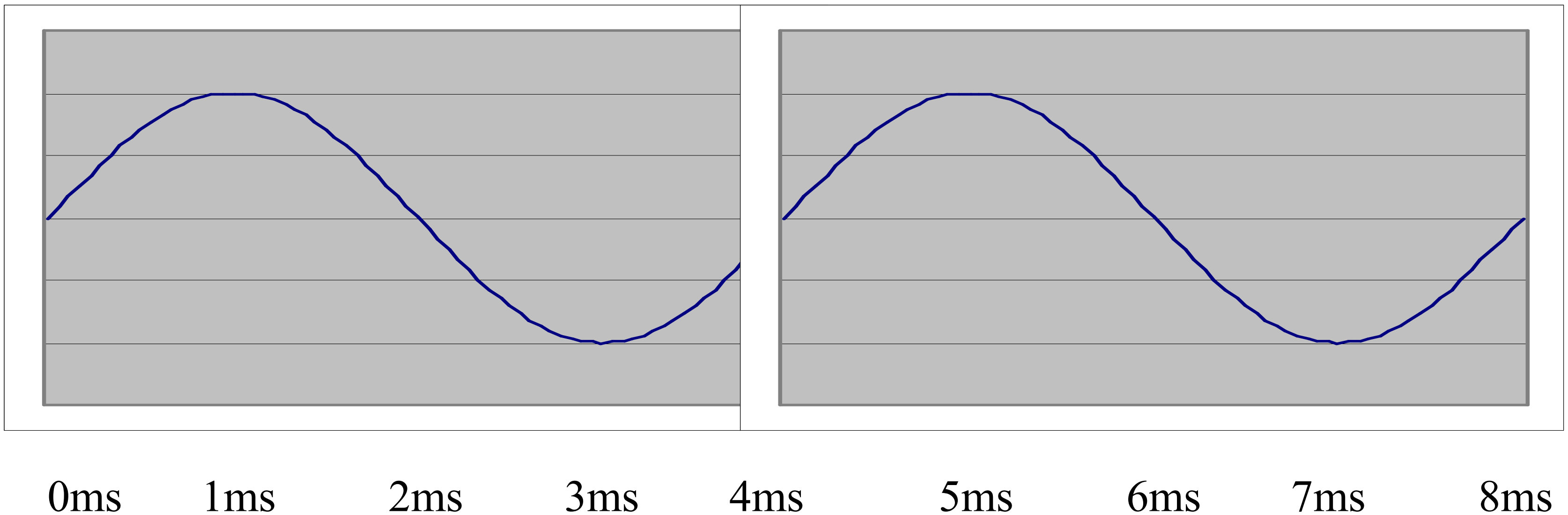
Guitar String Example



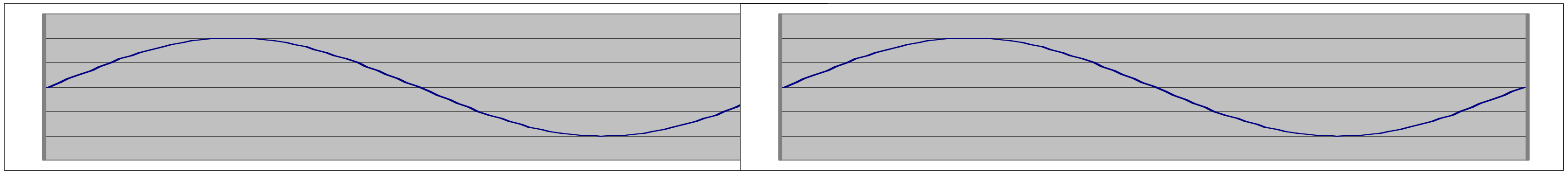
Draw the string position
for each point in time.

- Position change with time?
- Periodic?
- Exactly Periodic?
- Sine wave?

Guitar String Example
(2 cycles)



Guitar String Example



Period: How often does it repeat?

Period = One cycle every 4ms.

What is the **Frequency**?

$$\text{Freq} = \frac{1 \text{ cycle}}{4 \text{ ms}} \times \frac{1{,}000\text{ms}}{1 \text{ sec}}$$

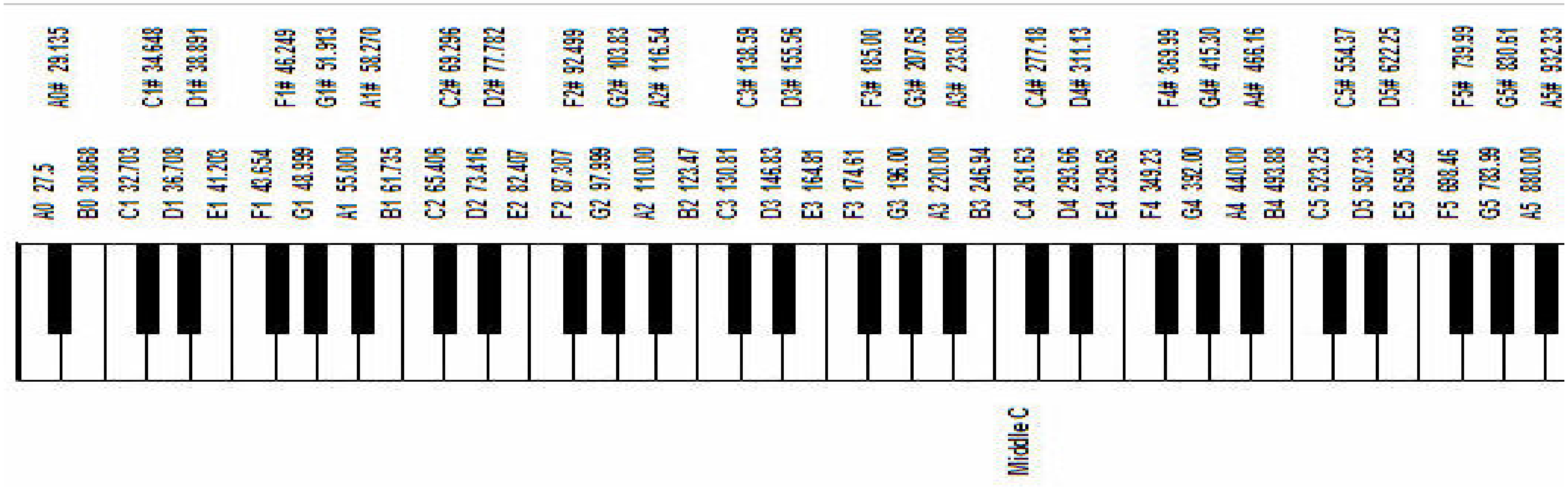
Freq= 250cycles/sec=250Hz

What **Note** is this?

Between **B** and **C**.

Piano Frequencies

http://www.vibrationdata.com/piano.htm



How low can you hear?

How High can you hear?

20Hz ← → 20kHz

Highest note on a piano is C8   4,186.0Hz

Assignment #2A

Create a table which contains the names of all of the guitar strings (open) and the following additional information:

- Frequency of each string
- Period of each string
- Wavelength of each string

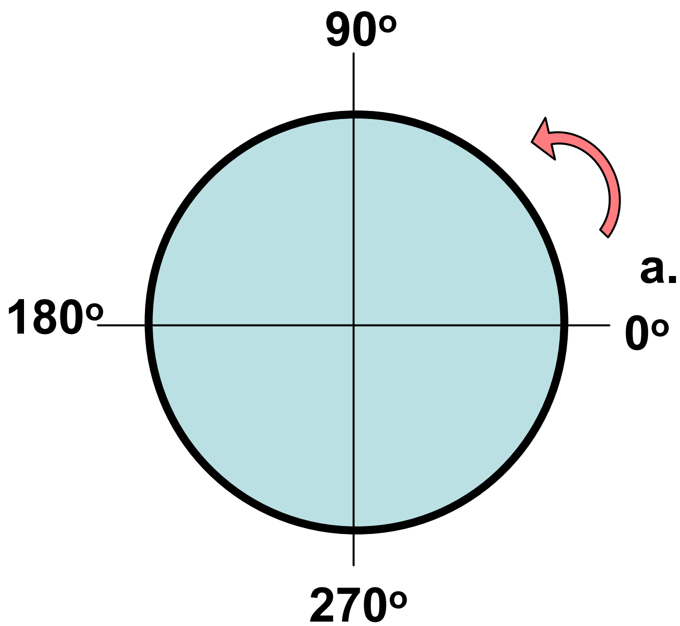
Class #3 Agenda: Adding Sound Waves

- Did you pick up the text book?
- Review Homework.
- One Sky Sound Reinforcement?
- Discuss circular model & angular degrees
- Finish the model of a wave
- Add waves together that are in phase
- Add waves together that are out of phase
- Add waves together that are delayed
- Balanced cabling

Circular Model

- Anything that's repetitive, can be modeled in science as a circle.
- Since sine waves (and sound waves in general) are periodic, circular math works well for modeling.
- Voltage = Amplitude X Sin(360 x time/period) where sin trigonometry function uses degrees.
- One cycle of the wave is 360 degrees.

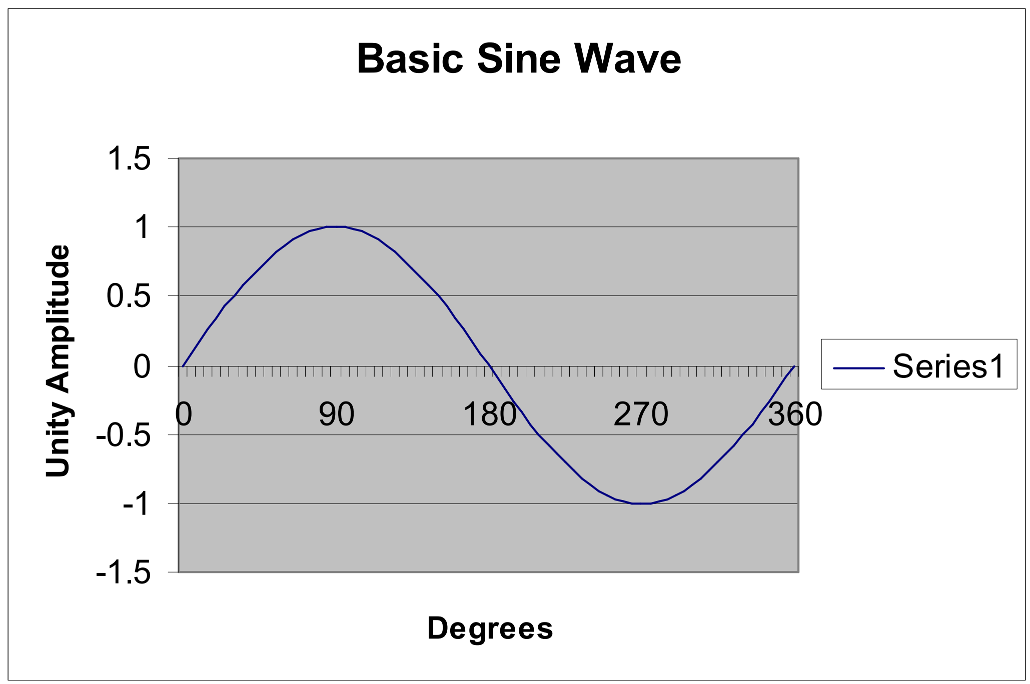
Circular Model (continued)



Voltage = Amplitude X Sin(360 x time/period)

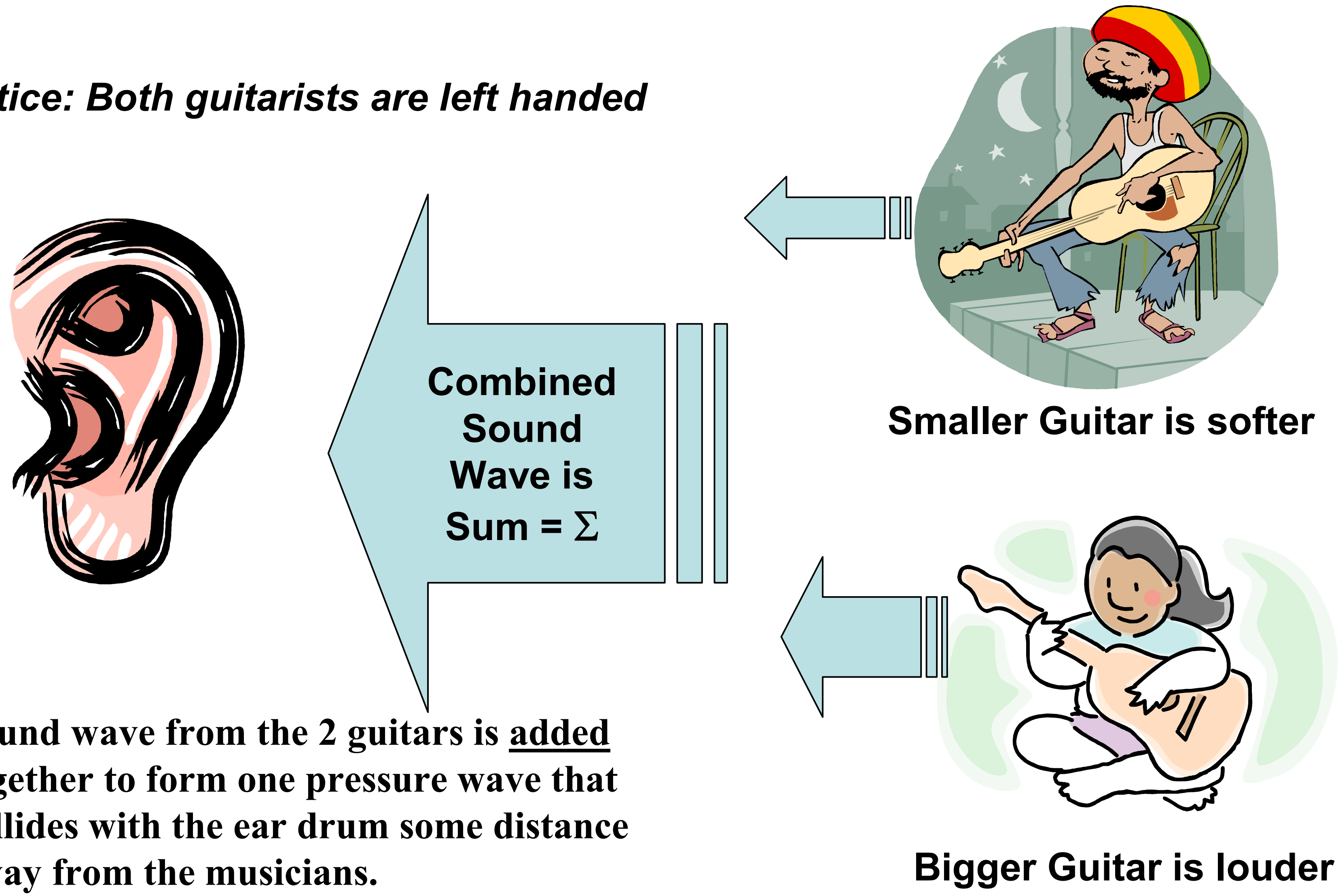
a.k.a. (360 degrees)

Example,
Time = 2ms
Period = 4ms
Angle=Phase=180 degrees



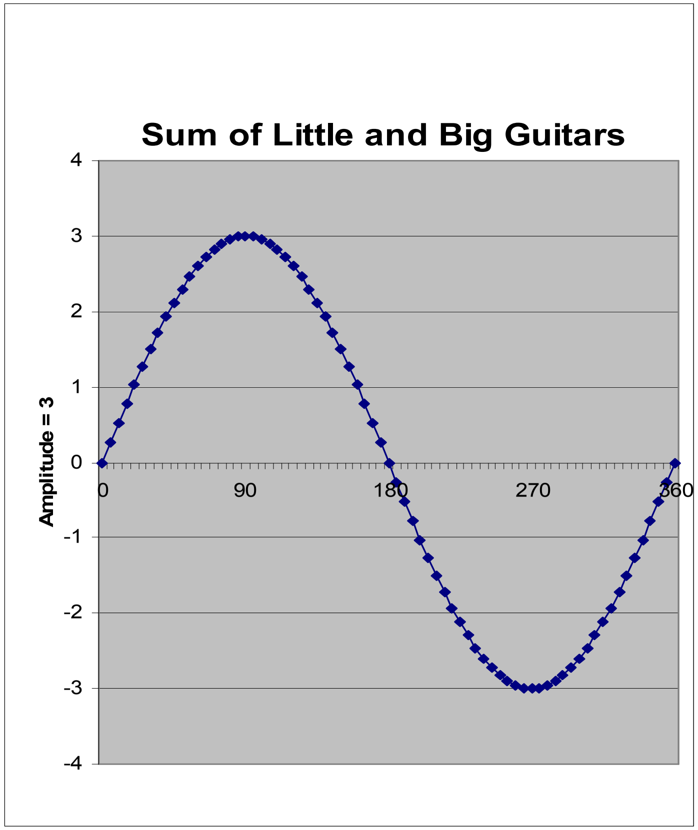
Sound From Two Guitars

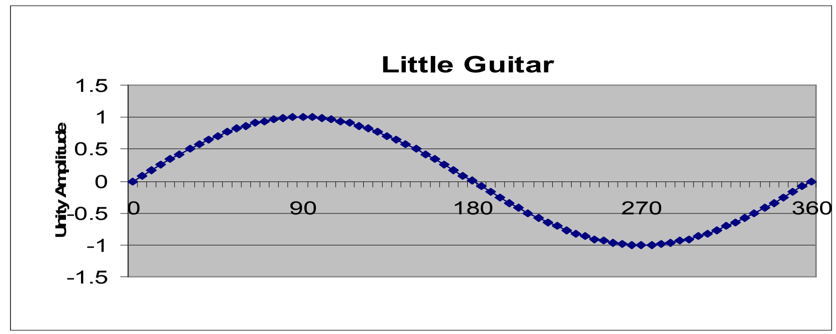
Notice: Both guitarists are left handed

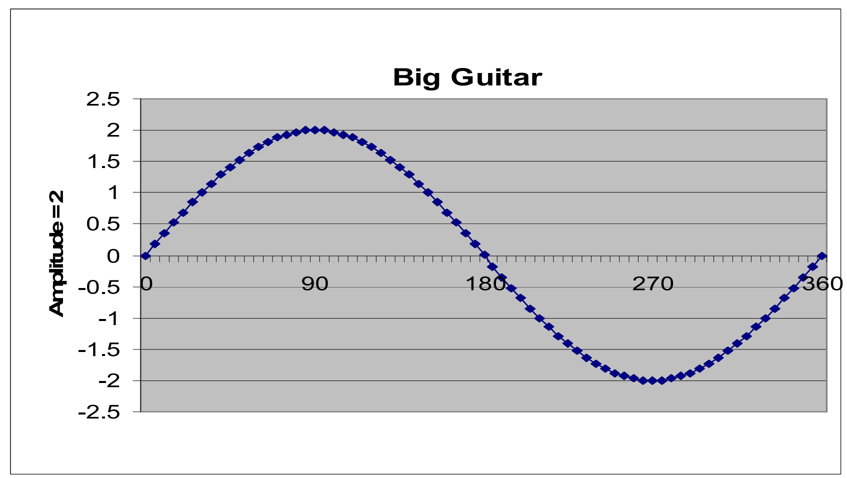


Sound wave from the 2 guitars is <u>added</u> together to form one pressure wave that collides with the ear drum some distance away from the musicians.

Summing 2 Guitar Sound Waves

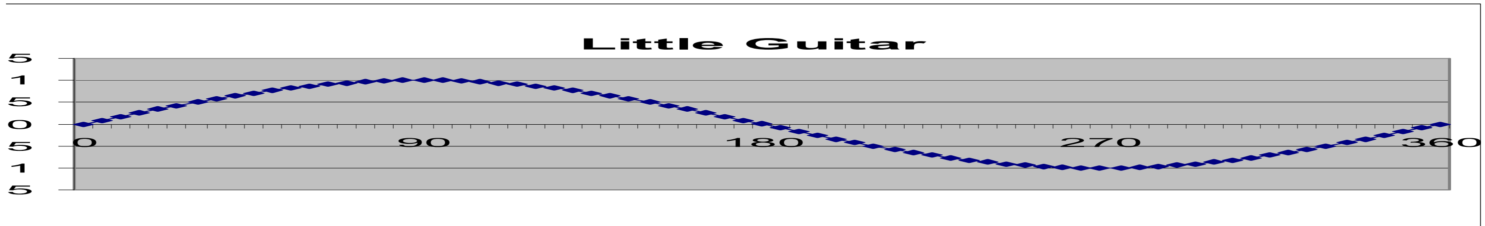


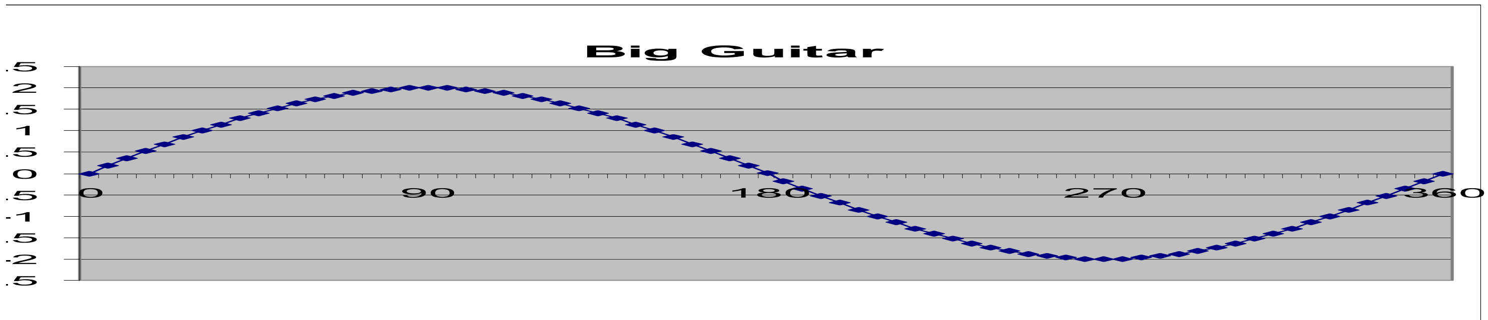


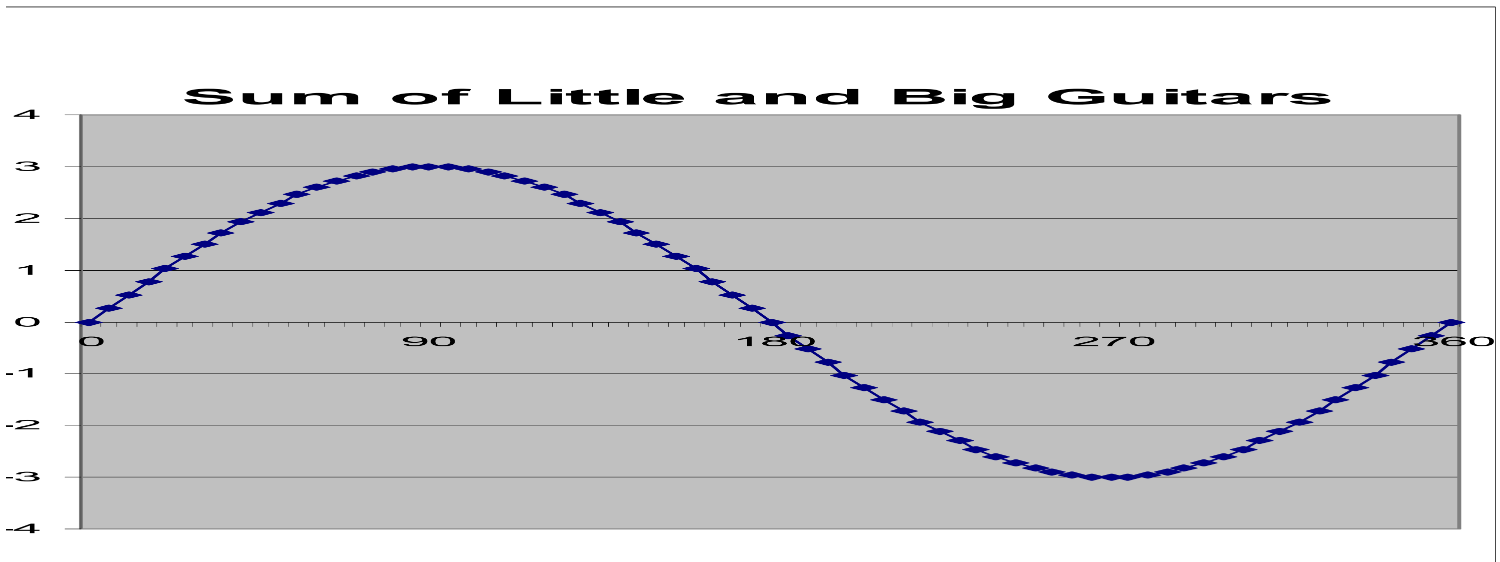


Summing Technique

Stack Vertically
Same X Axis

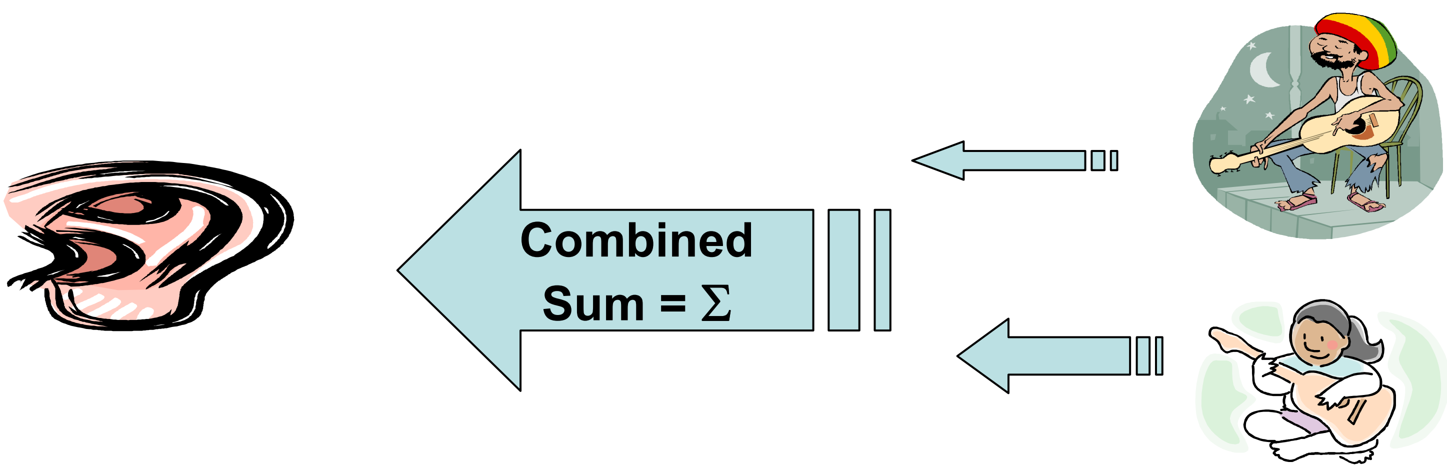






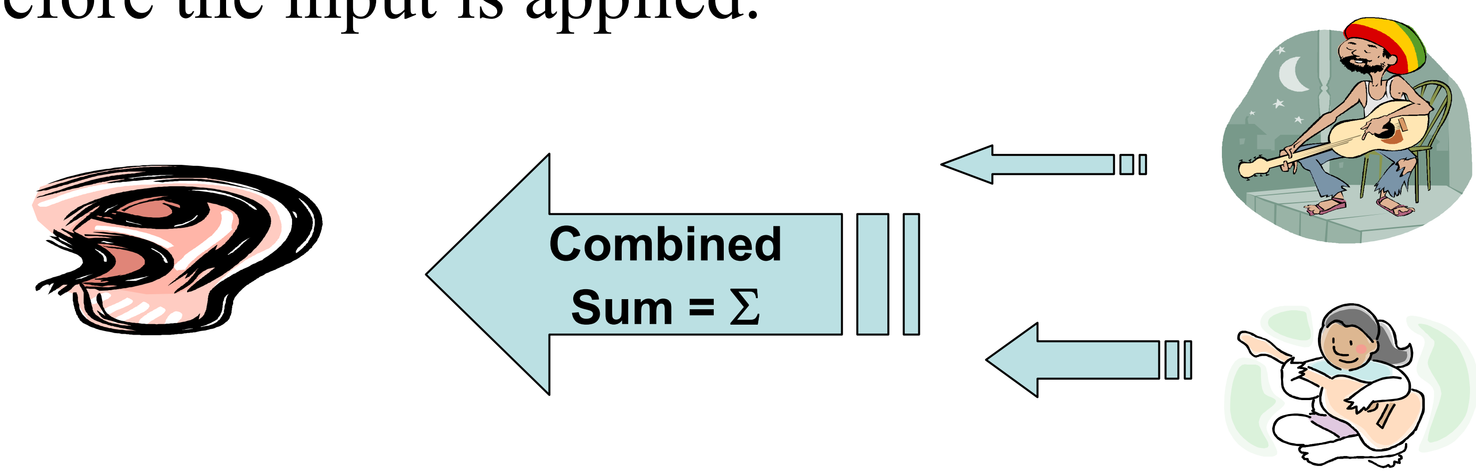
Air Pressure Summing

- Each guitar created a pressure wave that is traveling through the air.
- The two waves are added together in the air.
- That is the pressure from each wave is added at each point in space.



Math/Physics Terms For Summing

- **Superposition**: One wave is superimposed on the other.
- **Linear System**: *(Air is a linear system)*
  - <u>Superposition</u> is applicable
  - The <u>output</u> is the <u>sum</u> of the outputs of each input.
  - **Causality**: The output from one input cannot occur before the input is applied.



Examples of <u>Linear</u> Systems

- Air Pressure (at low volume)
- Ear Drum (at low volume)
- Electronic Mixer (summer circuit)
- Electric Guitar pickups
- Microphone diaphragm (at low volumes)
- Speakers (at low volume)
- EQ circuits – Two inputs summed together and then applied to an EQ will result in the same thing as each input applied to it's own EQ and the outputs summed.

Examples of Non-Linear Systems

- Distorted guitar amp.
- Fuzz box.
- Power Amp that is clipping. Why?
- Various Things at High Volume. Why?
- Digital Signal that exceeds max number the bits can describe. (Digital Clipping)
- Tape Saturation

Assignment #3

Read section 15 in text on cabling.

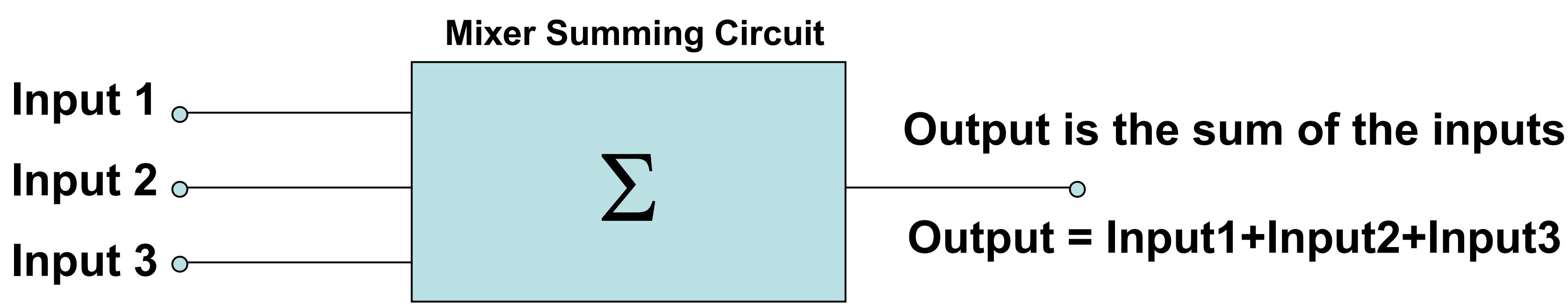
Focus on TRS and XLR 3 wire cabling.

Focus on Balanced and UnBalanced cabling.

Class #4 Agenda: Adding Sound Waves (continued)

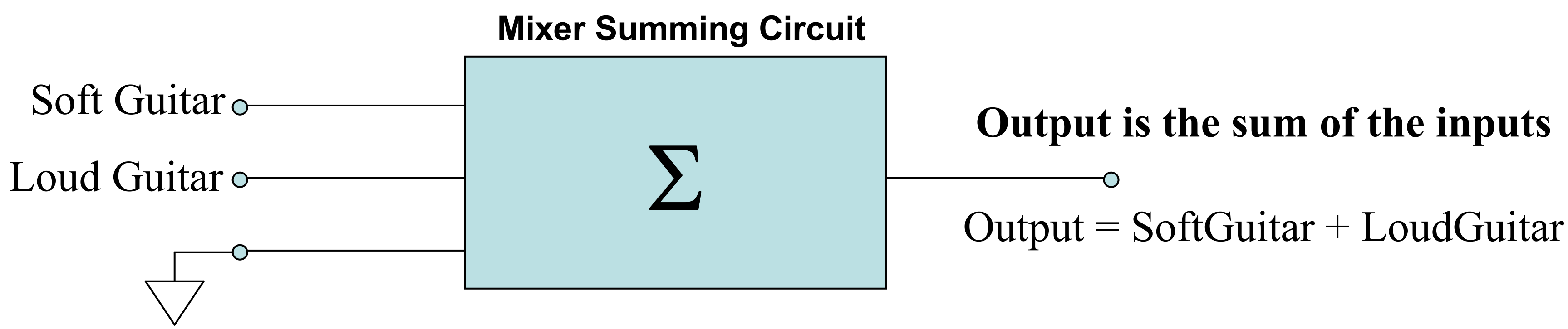
- Did you pick up the text book?
- Questions on the last class?
- Review Homework.
- One Sky Sound Reinforcement (probably going to happen)?
- Add waves together that are in phase
- Add waves together that are out of phase
- Add waves together that are delayed
- Balanced cabling

Electronic Summing



NOTE: Summing can be adding or subtracting.

Electronic Summing Two Guitars



NOTE: Unused input is tied to ground.
Ground is zero volts.

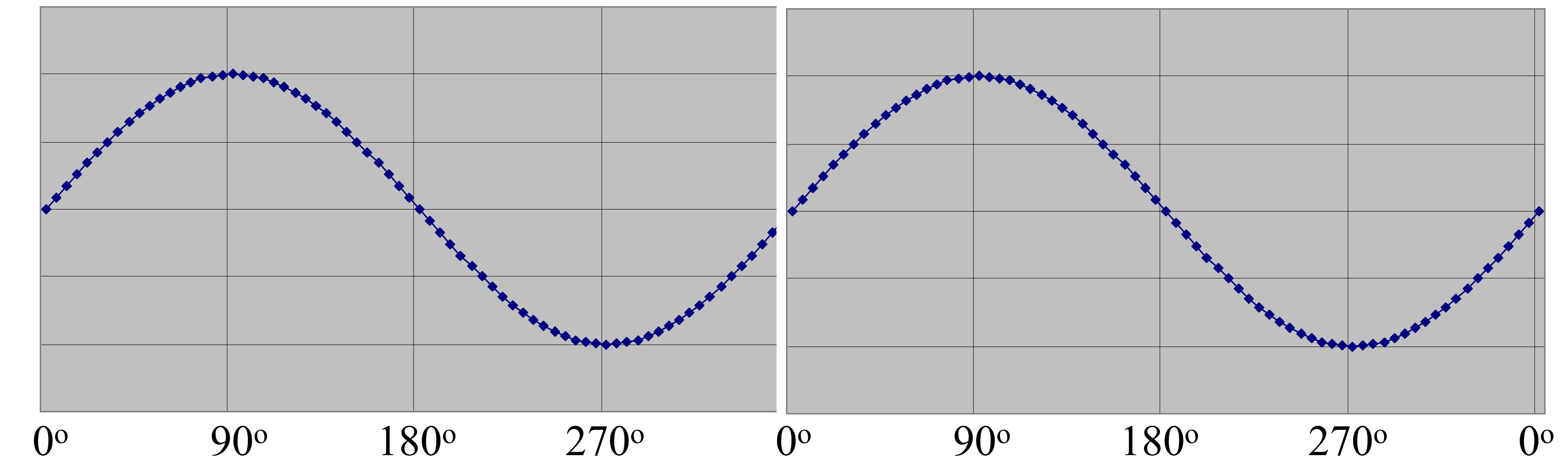
NOTE: Summing can be adding or subtracting.

Phase

- Phase is a term used to describe the angle of one wave relative to another wave.
- These two guitars are in phase because the sine wave goes through the same angle at the same time.
- Common to say the two waves are “In Phase”.
- If the wave forms were “Out Of Phase” then the waves would be the negative of each other.
- If the waves were “Out Of Phase” one wave would be offset from the other by 180 degrees.

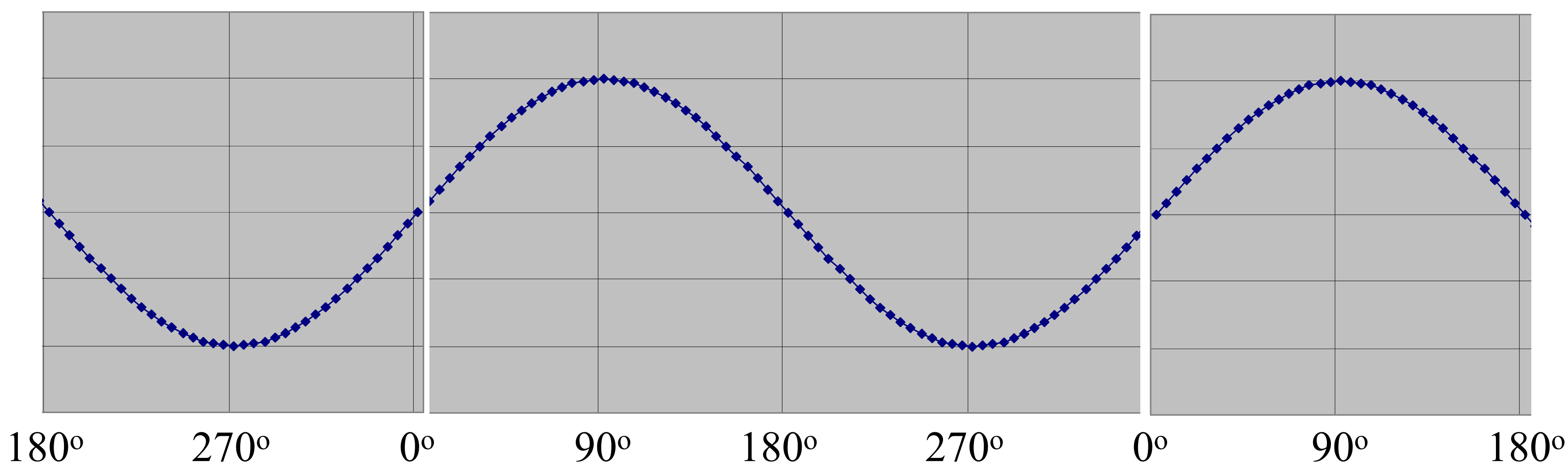
Out-Of-Phase Example

Wave #1

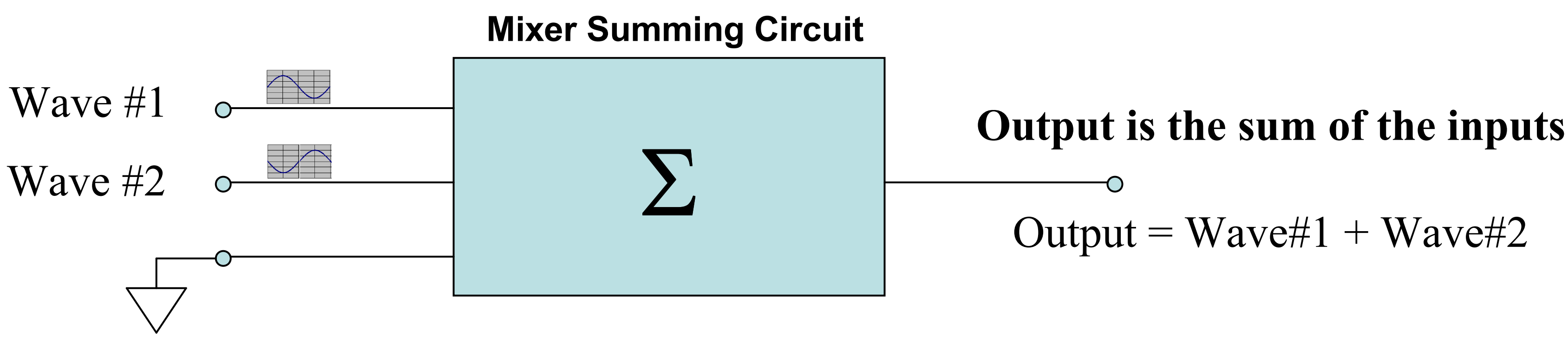


T=0 seconds

Wave #2

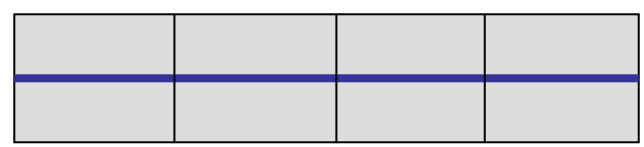


Electronic Summing Wave#1 & #2



NOTE: Unused input is tied to ground.
Ground is zero volts.

What does the output look like?



Inputs cancelled out

See Section 1 page 3 in text.

Can This Really Happen?

- In the air? YES
- In a mixer? YES
- Due to bad cabling? YES
- Can we use this idea to suppress noise? YES

Can This Really Happen?

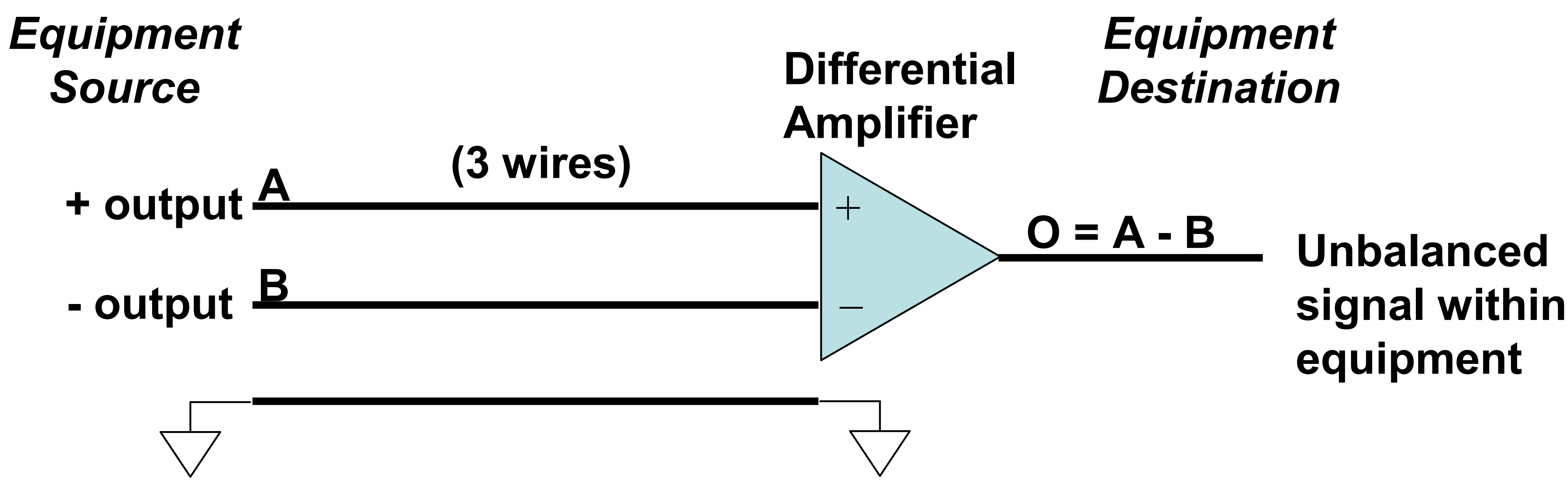
- In the air? (particularly for low frequencies, why?)
- In a mixer? (Yes, easy because no 3D space)
- Due to bad cabling? (Yes, particularly with balanced cabling)
- Can we use this idea to suppress noise? (Yes)

Balanced Cabling

Why is this so complicated?

Balanced Cabling

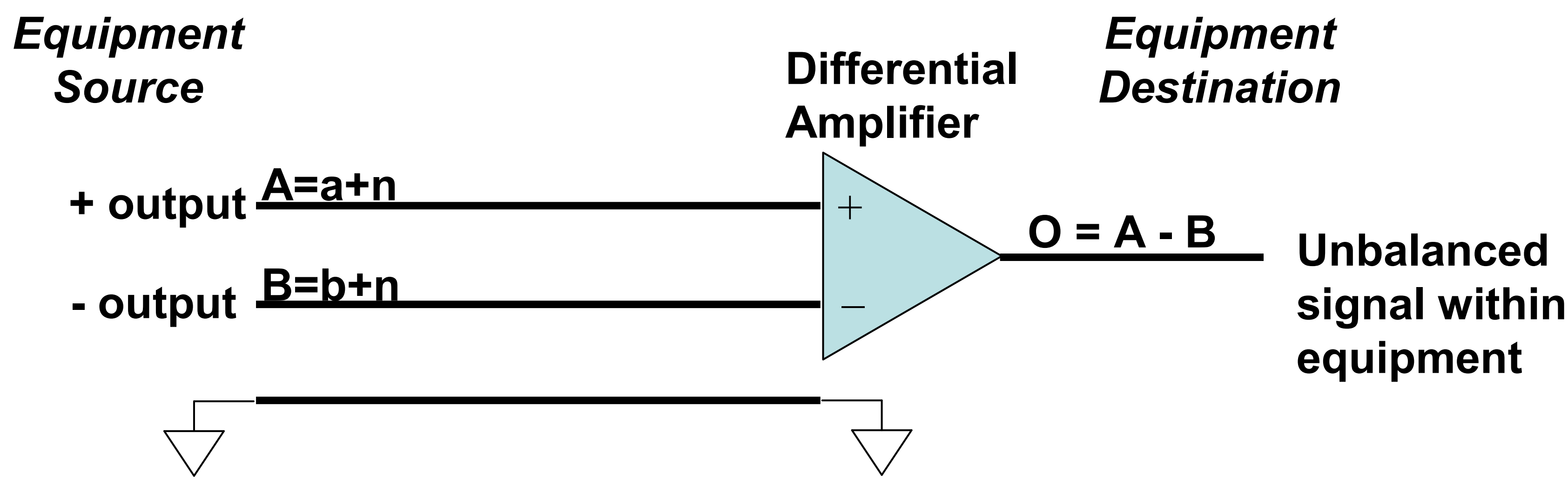
Complication helps with Noise Suppression!



How does this help with noise suppression?

Balanced Cabling

The noise (n) is common mode which means it couples into the + wire and the – wire equally. The longer the wire the more noise. Typically, the ground is a shield and +/- are twisted around each other.

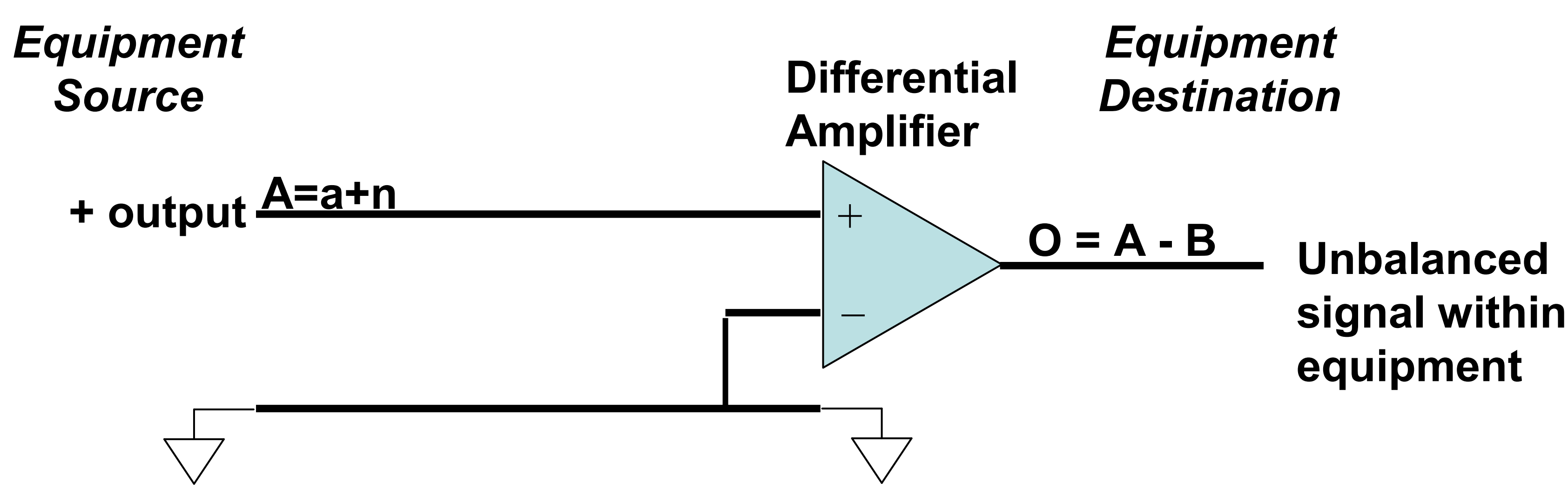


O = A – B = (a+n) – (b+n) = a + n – b – n = a – b = a – (-a) = 2a

All of the noise cancels out!

Un-Balanced Cabling

The noise (n) is common mode which means it couples into the + wire and the – wire equally. The longer the wire the more noise. Typically, the ground is a shield and +/- are twisted around each other.



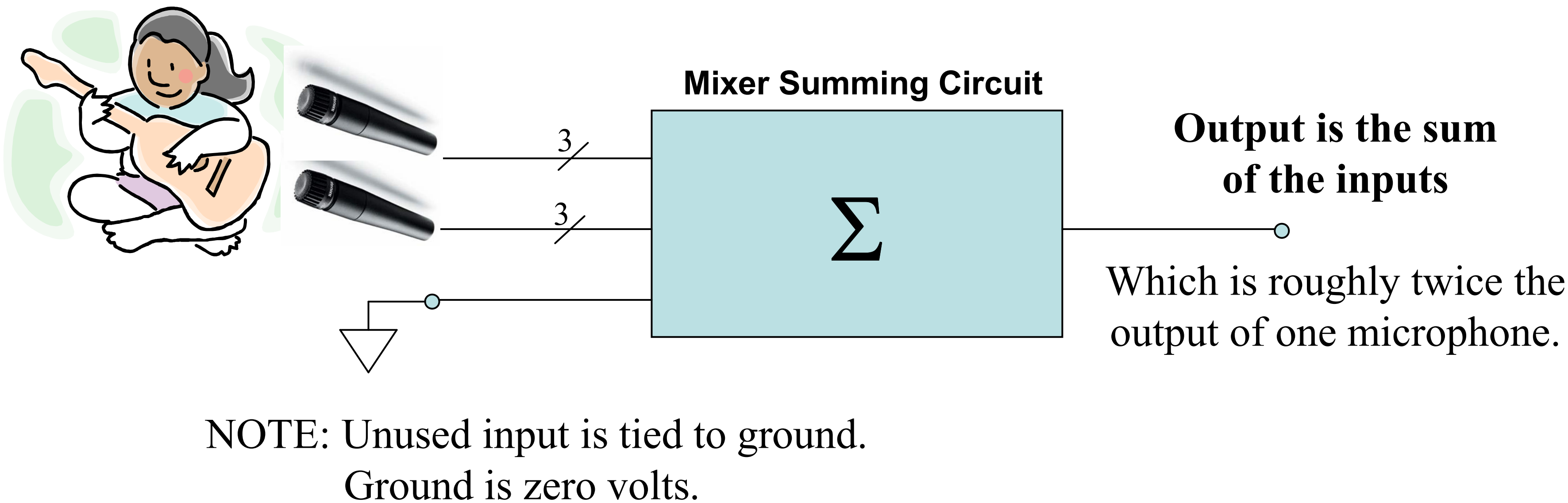
O = A – B = (a+n) – zero = a + n

None of the noise cancels out!   Signal to Noise Ration = SNR=a/n

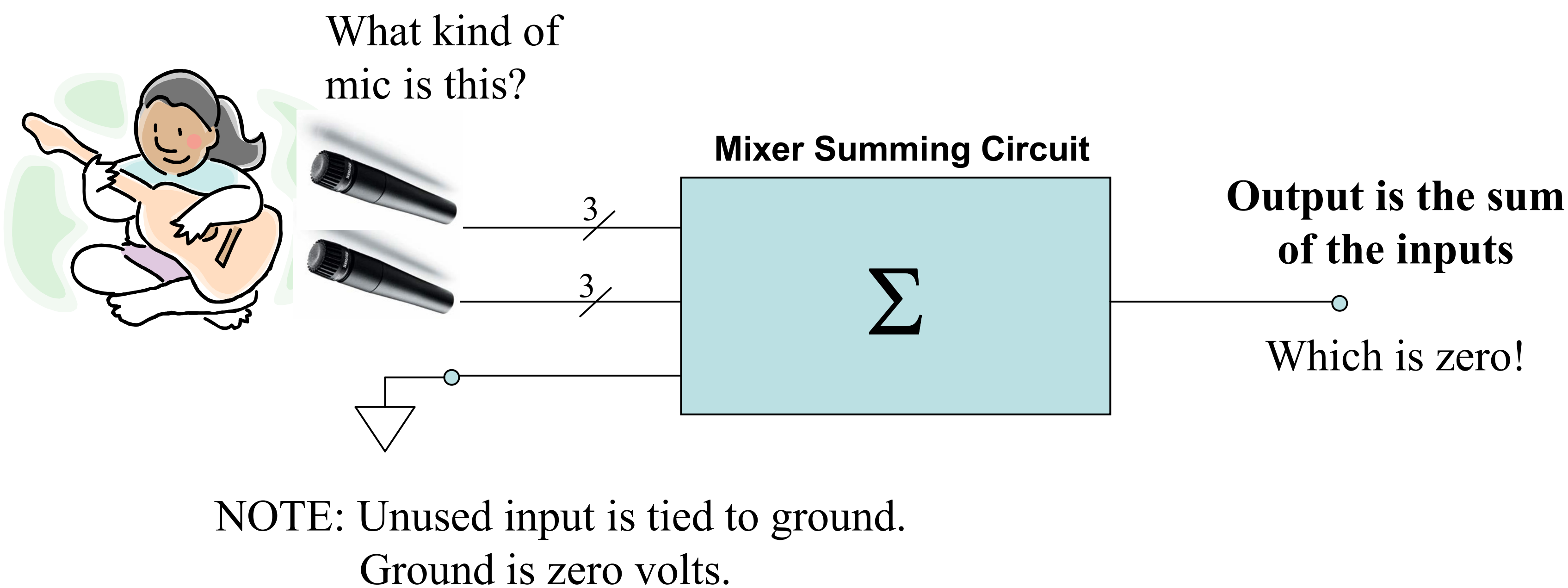
What equipment is typically balanced and what's unbalanced? What's noisier?

- Studio Mixer? (balanced)
- Professional PA? (balanced)
- Professional Microphone? (balanced)
- Guitar Amp? (unbalanced) [short cables]
- Synthesizer? (unbalanced/balanced)

Electronic Summing two microphones using balanced cables.

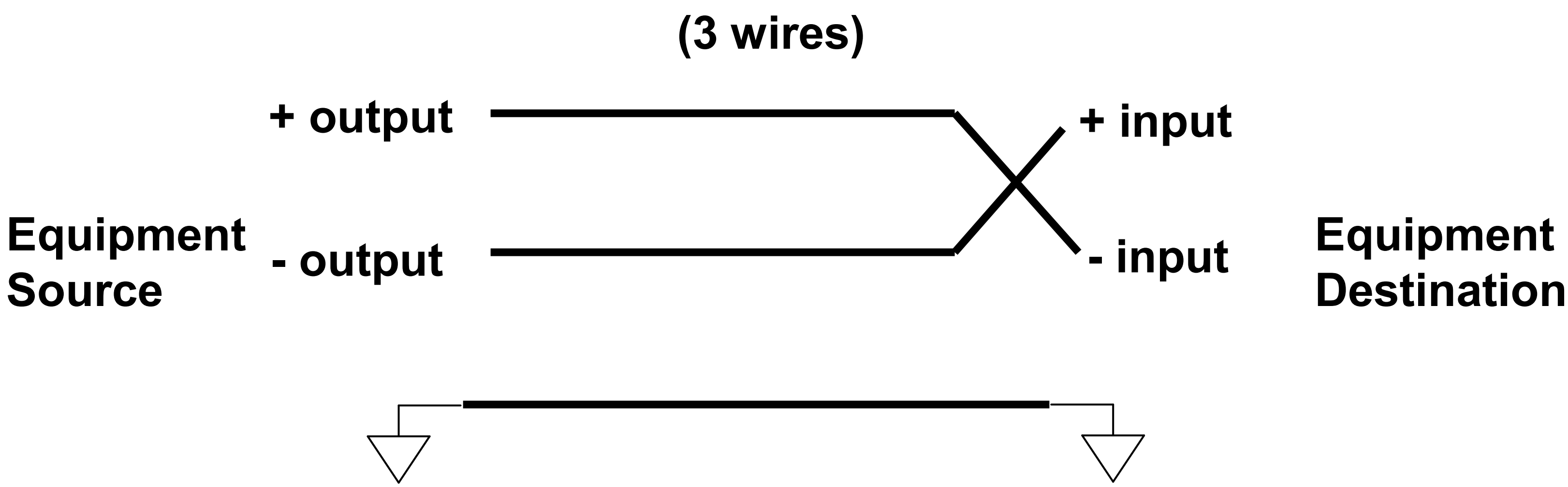


Electronic Summing two microphones using balanced cables out of phase.



If I accidentally exchange the + and – on one end of one cable then the signal will be 180° out of phase. This will cause the two microphones to cancel out. Particularly, in the bass frequencies. Why? How could I get a weird cable like this? Bad repair!

Balanced Cabling (Bad Wiring)



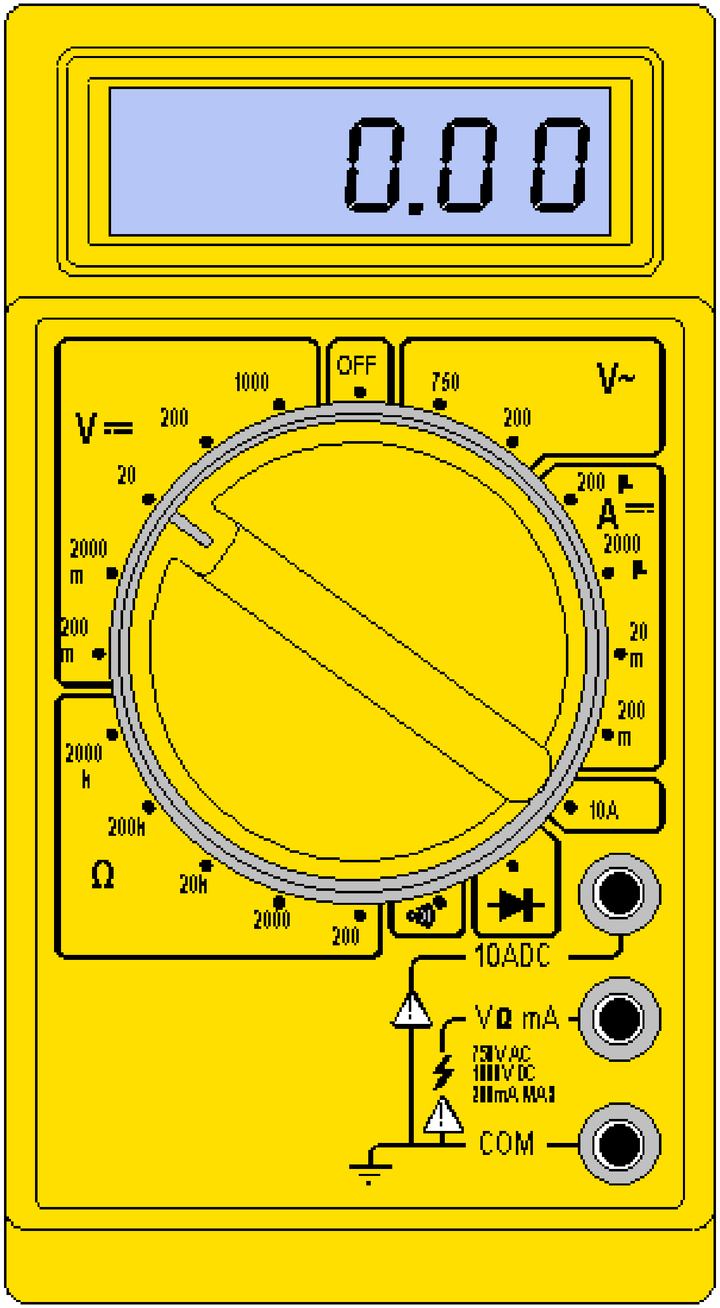
This sometimes happens during mic cable repair!

Multi-Meters Measure

- AC Voltage
- DC Voltage (battery)
- AC Current
- DC Current
- Resistance (ohms)
- See `http://www.doctronics.co.uk/meter.htm`

Which measurement is good for cabled repair?

Multi-Meter Example



- Set to ohms.
- Small R values.
- Touch leads together to confirm reading near zero.
- Touch two points on cable under test to determine if they ‘re connected.
- Purchase Whirlwind tester:

`http://www.whirlwindusa.com/test.html`

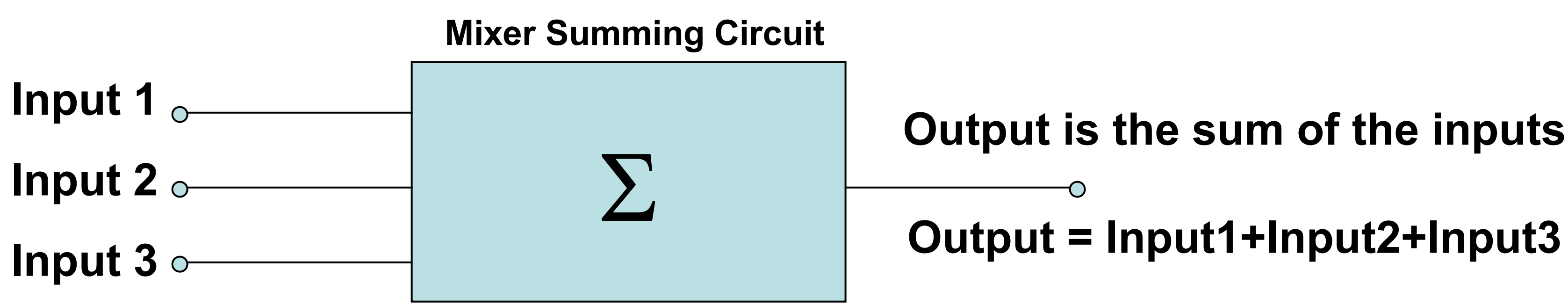
Homework

- Read the manual for Mackie 32x4 mixer.
  http://mackie.com/products/sr32-4vlzpro/index.html

Class #5 Agenda: Gain & Mackie 32x4 Mixer

- Questions on the last class?
- Review Homework (Did you download Mackie Manual?)
- One Sky Sound Reinforcement IS going to happen! (Are able to attend during what hours?)
- May have a metaphysical recording session following weekend. (Do you want to participate?)
- Gain
- Mackie 32x4 mixer operation

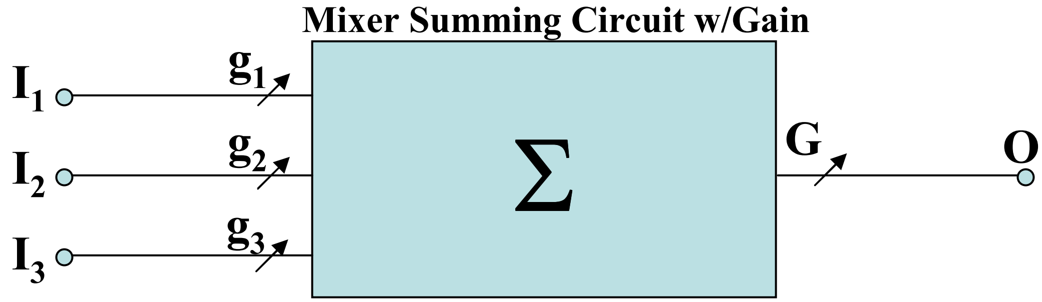
Electronic Summing
(review before discussing gain)



NOTE: Summing can be adding or subtracting.

NOTE: This is not sufficient to allow inputs to be made softer or louder or for the overall mix to be made softer or louder. What do we need?

Electronic Summing with Channel and Master Gain



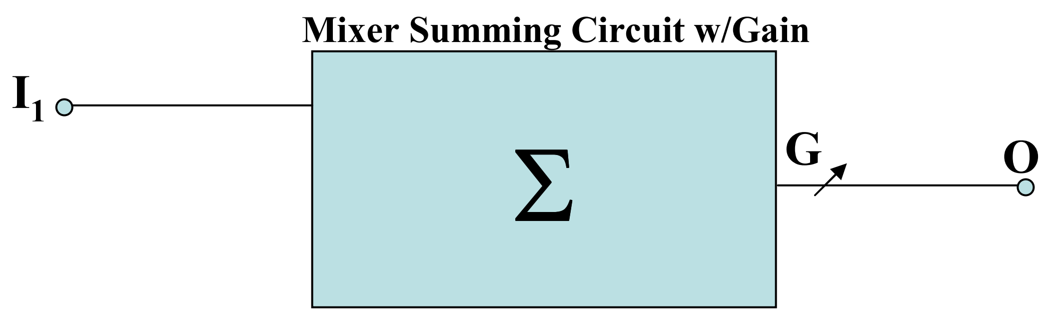
Output is the sum of each input times channel gain, multiplied by master gain.

EQUATION: $O = [(I_1 \times g_1) + (I_2 \times g_2) + (I_3 \times g_3)] \times G$

- What is gain?
- There's a gain control on each channel to make one input softer or louder!
- Channel gain could be master trim, fader or aux send!
- There's a master gain control to make the whole mix softer or louder!
- Master gain could be main out or Aux Send master!
- Etc.

What is Gain?

(Use only one input w/o channel gain for simplicity)



Output is the sum of each input times channel gain, multiplied by master gain.

EQUATION: $O = I_1 \times G$

Gain = Ratio of two signals (different versions of the same signal)

Example, the ratio of O to I_1 is G.

Ratio = $O / I_1 = G x I_1 / I_1 = G$ Duh!

- Range of gain can be somewhere between zero and a billion and beyond.
- That's huge.
- Must represent with a log scale – hence Decibels or DBs.
- What is the ratio of two signals? Something other than gain, perhaps SNR.

Gain Subtlety

- You can implement <u>digital gain</u> with the equations described on the last slide. That's what a computer recording system does (e.g. ProTools).
- We're going to focus on <u>Analog</u> gain for now.
- Engineering (Designing) a high gain electronic circuit is very difficult.
- Because it's easy for the circuit to create white noise.
- Avalon preamp in the recording studio is much better than Mackie preamps.
- Quality can be partially described by SNR. (See Mackie Spec)
- Matters when recording or amplifying soft instruments like acoustic guitar.
- More difficult if the signal is small (e.g. microphone).
- Easier if the signal is large (e.g. line level).
- As a result the trim circuit is very simple.

Mackie Channel Strip

Trim

6 Aux Sends

(PreFader, PostFader & Switchable)

EQ

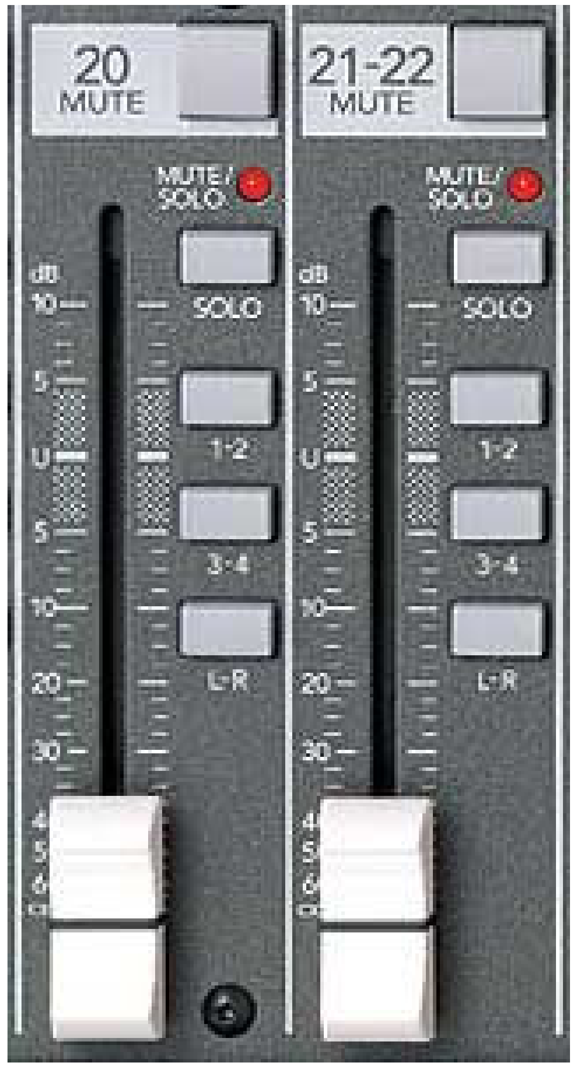
Pan

Mute

Bus & L/R Assign

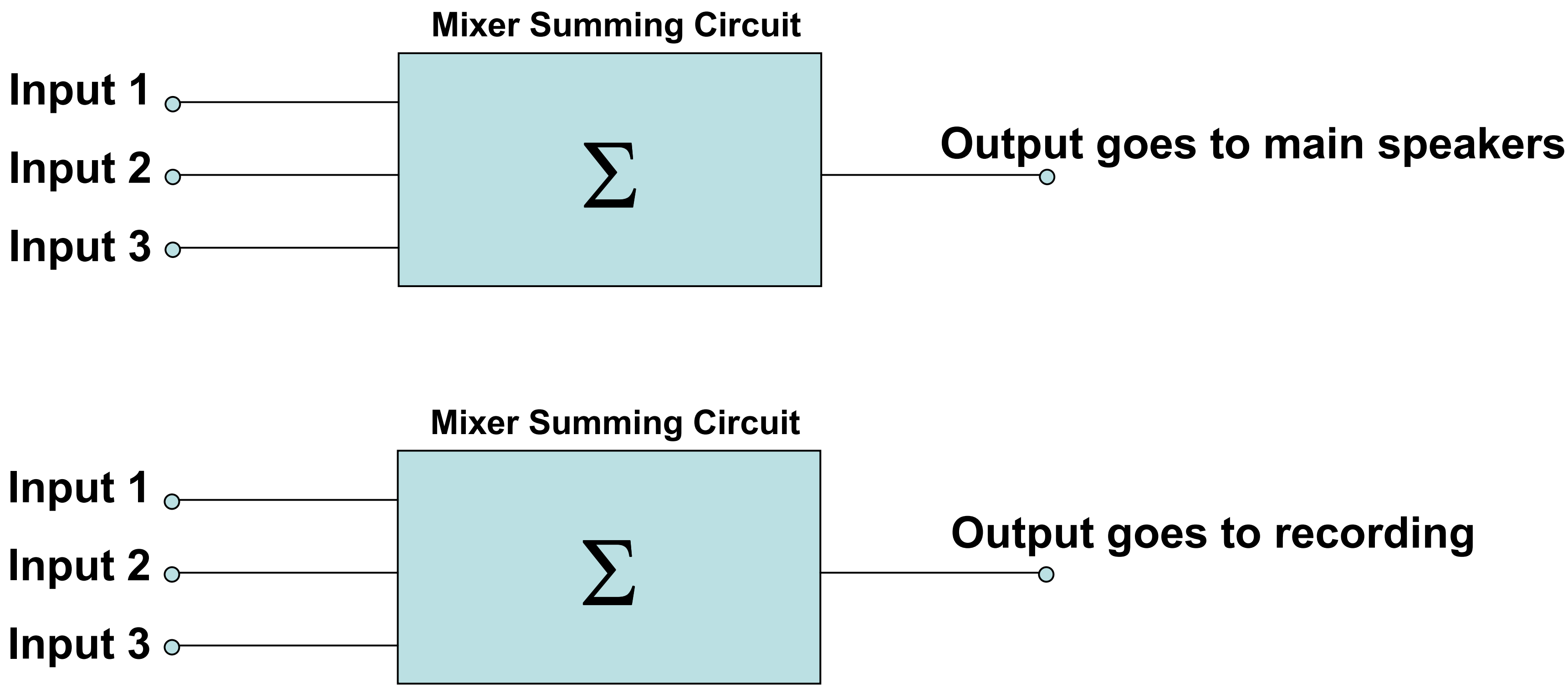
Channel Fader

- 0dbs → 60dbs of trim gain.
- U means unity gain.



- Mute makes gain zero.
- Solo button routes the channel output to the metering and headphone mix for adjusting trim etc.
- Channel fader adjusts the gain from minus infinity to +10dbs.

What If I Wanted Two Mixers?



Do I really need two mixers?
Is there a tricky way to do this with one mixer?
Might need more outputs for different monitor mixes!

Mackie Channel Strip

- The 6 Aux knobs are like 6 additional mixers.
- -infinity → +15dbs of gain.
- U means unity gain.
- PreFader means the input is connected just after the trim circuit.
- PostFader means that the input is connected just after the channel fader.
- Aux sends 3 and 4 are switchable between PreFader and PostFader.
- User for effects, monitors and recording.

Mackie Master Section

6 Aux Send Master Controls

& Metering

Bus & L/R Master Faders

Mackie Master Section

6 Aux Send Master Controls

&

Metering

Bus

&

L/R Master Faders

Logarithms Are Good 

- Used to make large scale measurements manageable.
- Used to make an exponential phenomena linear.
- Has a base like 10 or 2.
- Base 10 is used for decibels
- Base 2 is used for octaves & digital SNR etc.

Logarithm Values

Exponential Value Base 2	**$Log_2()$**	**Exponential Value Base 10**	**$Log_{10}()$**
$2^0=1$	0	$10^0=1$	0
$2^1=2$	1	$10^1=10$	1
$2^2=4$	2	$10^2=100$	2
$2^3=8$	3	$10^3=1000$	3
$2^4=16$	4	$10^4=10,000$	4
$2^5=32$	5	$10^5=100,000$	5
$2^6=64$	6	$10^6=1,000,000$	6
$2^7=128$	7	$10^7=10,000,000$	7

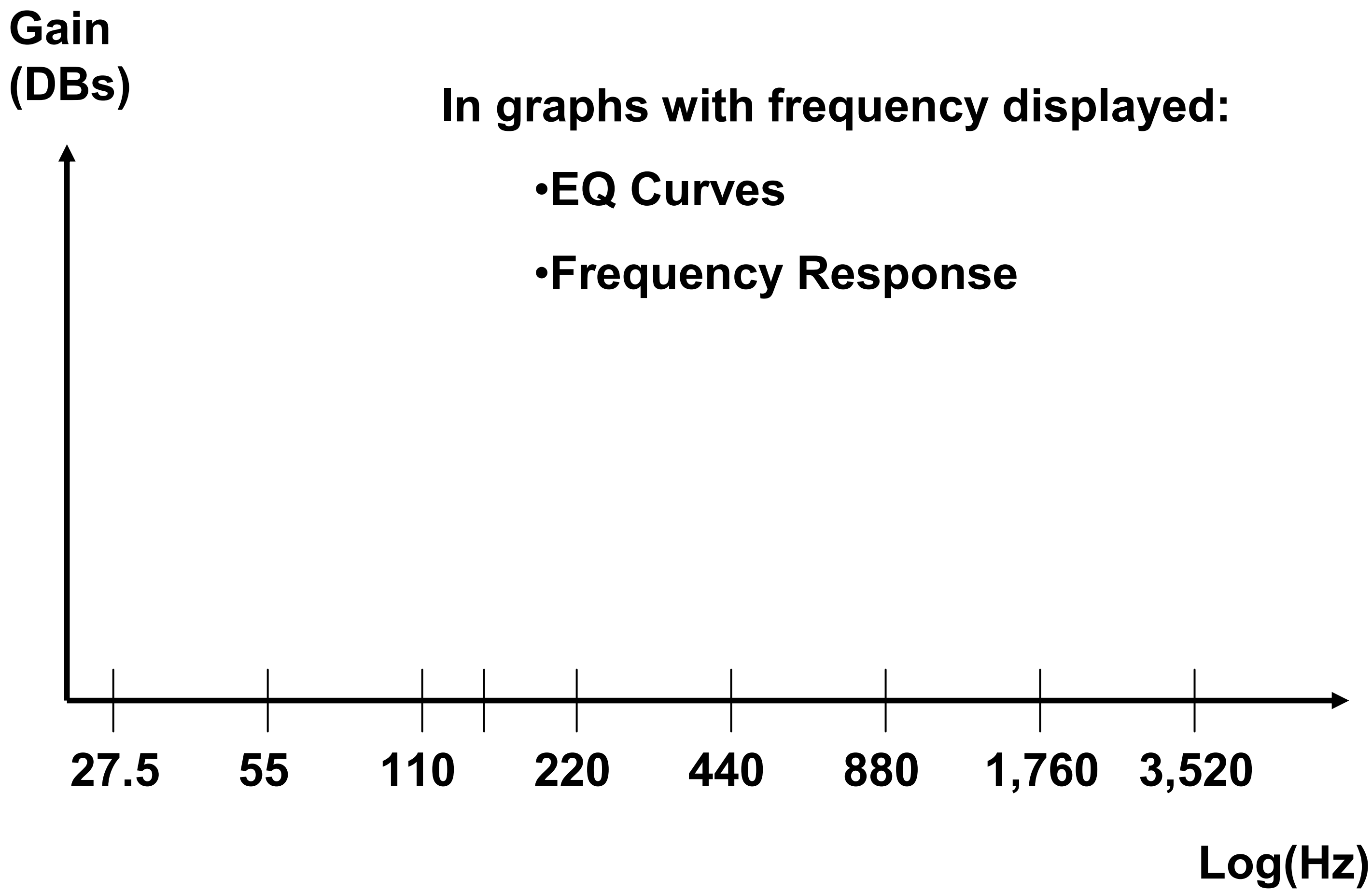
Octave Values

Frequencies Of Note A	**Exponent**	**$Log_2()$**	**Same As**
27.5 Hz	-4	$2^{-4}=1$	440/16
55	-3	$2^{-3}=2$	440/8
110	-2	$2^{-2}=4$	440/4
220	-1	$2^{-1}=.5$	440/2
440	0	$2^{0}=1$	1x440
880	1	$2^{1}=2$	2x440
1,760	2	$2^{2}=4$	4x440
3,520	3	$2^{3}=8$	8x440

How are log Frequencies Useful?

In graphs with frequency displayed:

- EQ Curves
- Frequency Response



Logarithms For Digital

- Every time I add a bit I get twice the resolution! That's exponential in base 2.
  - 1 bit → 2 values
  - 2 bits → 4 values
  - 3 bits → 8 values
  - 16 bits → 65,536 values
  - 24 bits → 16,777,216 values

Logarithms For Decibels Gain Equation

$$\text{DBs} = 20 \times \log_{10}(\text{Vout/Vin})$$

Vout/Vin	**$\log_{10}$(Vout/Vin)**	**DBs**
.01	-2	-40
.1	-1	-20
1	0	0
10	1	20
100	2	40

Class #6 Agenda
Post-mortem of One Sky One World Sound Reinforcement Event

(no slides)

Class #7 Agenda:

Equal Tempered Tuning

versus

Harmonic Tuning

(no slides/Just White Board)

Homework:
Fill out harmonic table for guitar 5th string!

- Any questions on the homework?
  Able to complete the table?
  What did you learn?
  Where is the most error?
  Let's confirm this on a guitar!
  What degrees of the scale did you see and what conclusion can you draw?

Class #8 Agenda:

Fourier Series
and
Square Wave Harmonics

Fourier Series

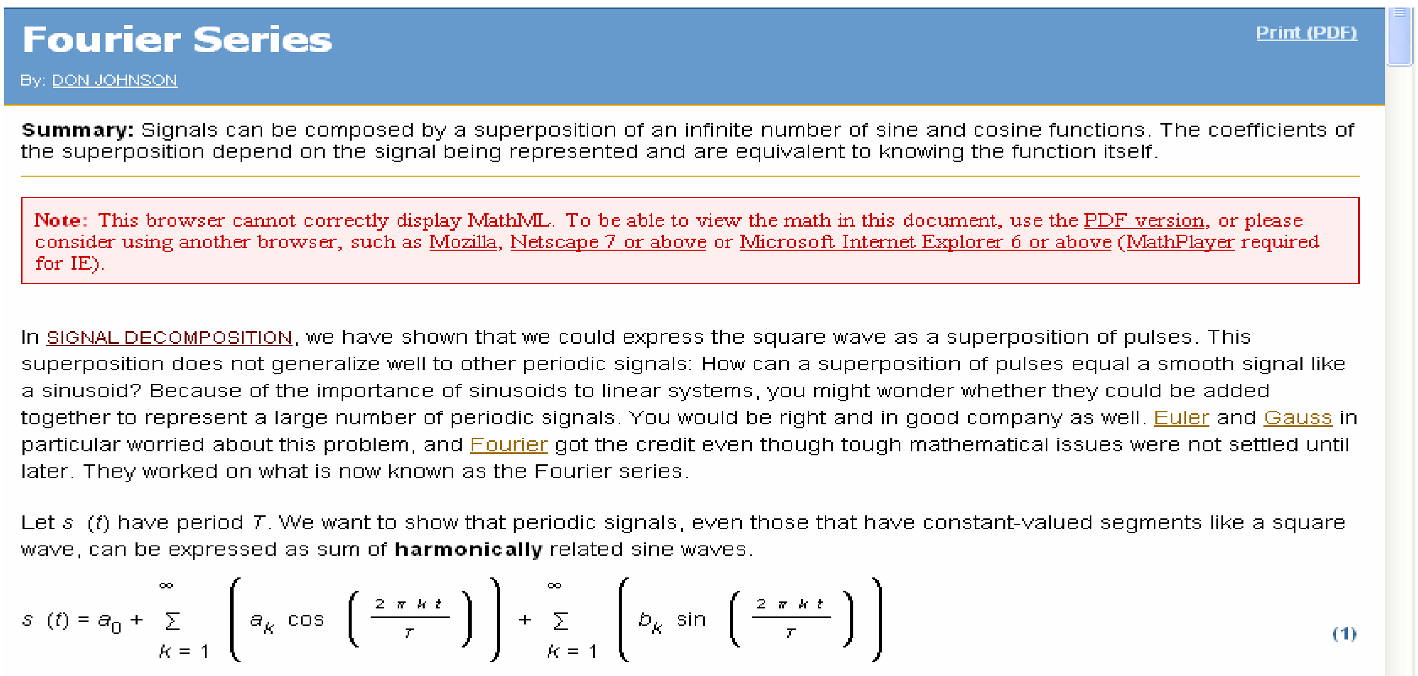
- As we've discussed in previous lectures, an arbitrary waveform can be modeled as an infinite mathematical series of an appropriate base equation like polynomials $A + Bx + Cx^2 + Dx^3$
  Fourier Series uses infinite series of sine waves of different frequencies.
  Each term of the series uses the next harmonic of the fundamental frequency. That is so much of the first harmonic, so much of the 2nd harmonic, so much of the 3rd etc.

Fourier Series

- We're discussing the analog version of the Fourier Series.
  There is also a discrete (a.k.a. digital) for of the Fourier Series.
  Digital or Analog Fourier Series can be used for all sorts of Electrical Engineering applications (e.g. cell phone antenna design).
  What's cool is that it maps exactly to how your perceive music. It is as if people hear the Fourier Series.

Fourier Series

- Very very complex math that is way beyond what can be taught in this class.
  For a detailed intro to the math go to the following URL
  http://cnx.rice.edu/content/m0039/latest/



Fourier Series

Print (PDF)

By: DON JOHNSON

Summary: Signals can be composed by a superposition of an infinite number of sine and cosine functions. The coefficients of the superposition depend on the signal being represented and are equivalent to knowing the function itself.

Note: This browser cannot correctly display MathML. To be able to view the math in this document, use the PDF version, or please consider using another browser, such as Mozilla, Netscape 7 or above or Microsoft Internet Explorer 6 or above (MathPlayer required for IE).

In SIGNAL DECOMPOSITION, we have shown that we could express the square wave as a superposition of pulses. This superposition does not generalize well to other periodic signals: How can a superposition of pulses equal a smooth signal like a sinusoid? Because of the importance of sinusoids to linear systems, you might wonder whether they could be added together to represent a large number of periodic signals. You would be right and in good company as well. Euler and Gauss in particular worried about this problem, and Fourier got the credit even though tough mathematical issues were not settled until later. They worked on what is now known as the Fourier series.

Let $s(t)$ have period T. We want to show that periodic signals, even those that have constant-valued segments like a square wave, can be expressed as sum of **harmonically** related sine waves.

$$s(t) = a_0 + \sum_{k=1}^{\infty} \left(a_k \cos\left(\frac{2\pi k t}{T}\right) \right) + \sum_{k=1}^{\infty} \left(b_k \sin\left(\frac{2\pi k t}{T}\right) \right) \quad (1)$$

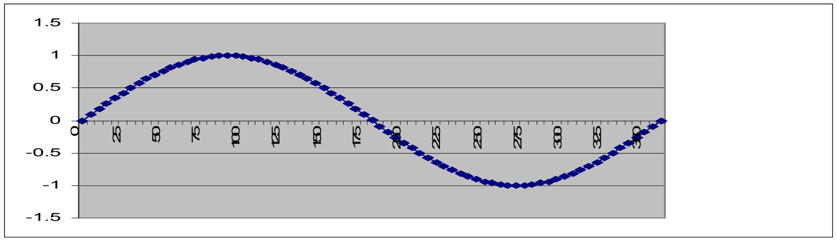
What does this mean? I’m confused!

- Apply a gain to the first harmonic then add that to…
- A gain applied to the second harmonic then add that to…
- A gain applied to the third harmonic then add that to…
- A gain applied to the fourth harmonic then add that to…

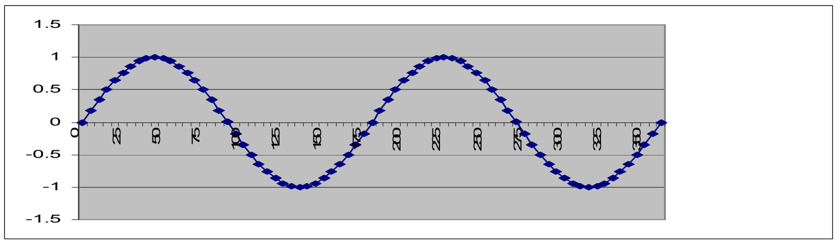
What Gain?

- That’s where the mathematical complexity comes in.
- It’s complicated to figure out the gains or amplitude for each harmonic.
- Fortunately, this has already been done for many standard waveforms (e.g. square wave).
- Fortunately, you’re not going to have to do it.
- Before we demonstrate and example, let’s look at what the harmonics look like.

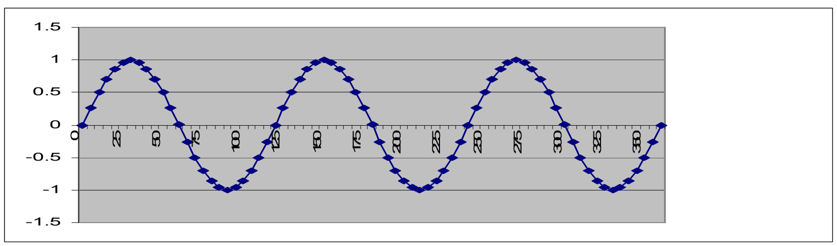
Harmonics



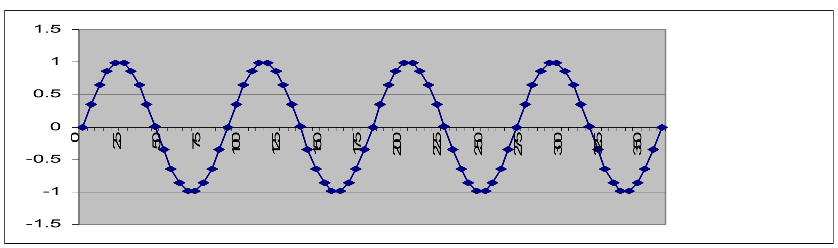
1st Harmonic (Fundamental)



2nd Harmonic (Octave higher)

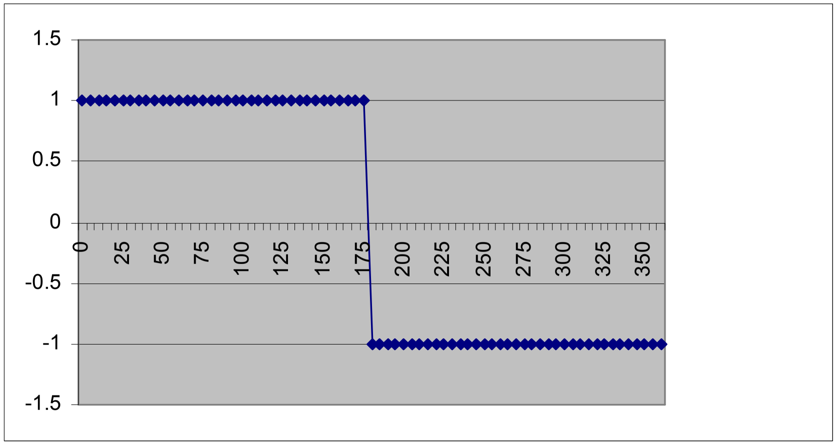


3rd Harmonic (Octave+5th higher)



4th Harmonic (2 Octaves higher)

etc…



Square Wave

- Because this waveform has "odd symmetry" there are no even harmonics.
- Only odd harmonics (i.e. 1, 3, 5, 7, etc.)
- Amplitude of each harmonic satisfies the following equation:

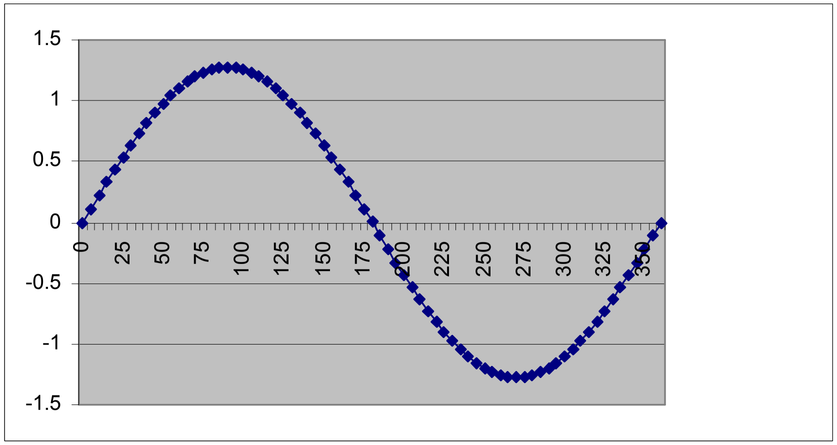
  $A_k = 4 / (k * \pi)$ where k is the harmonic number and π=3.141592654…

  Examples:

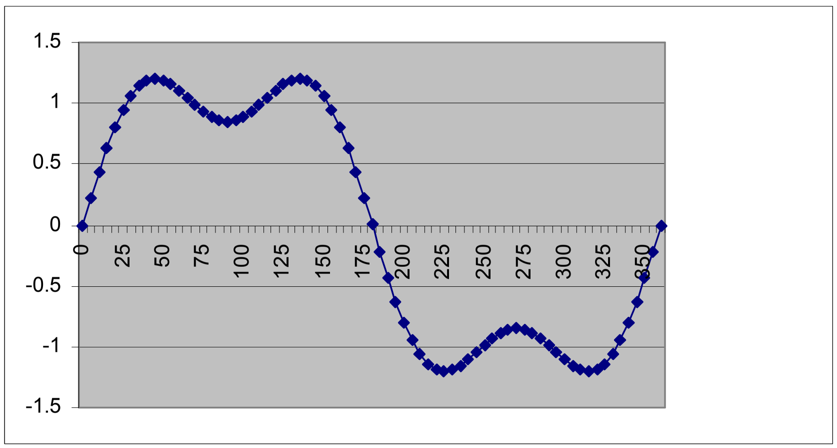
  First harmonic is $4/(1*\pi) = 1.27324$

  Third harmonic is $4/(3*\pi) = .42441$
- Notice: The 1st harmonic amplitude is bigger than the square wave.
- Notice: The higher the harmonic number the smaller the amplitude.

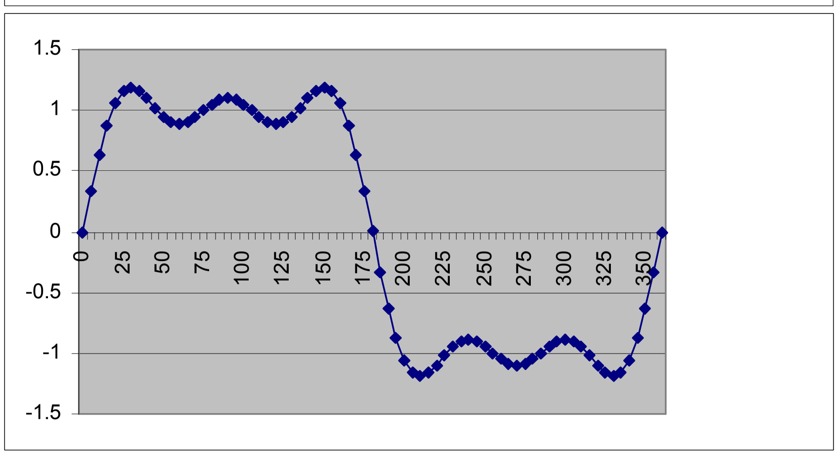
Square Wave



1st Harmonic

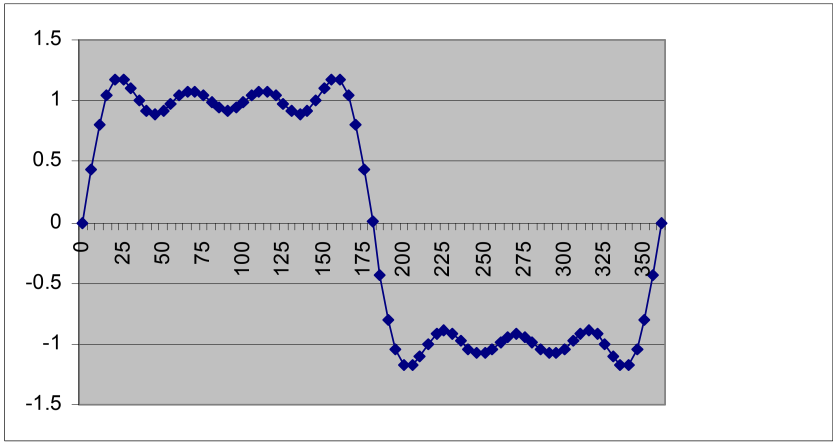


1st + 3rd Harmonic

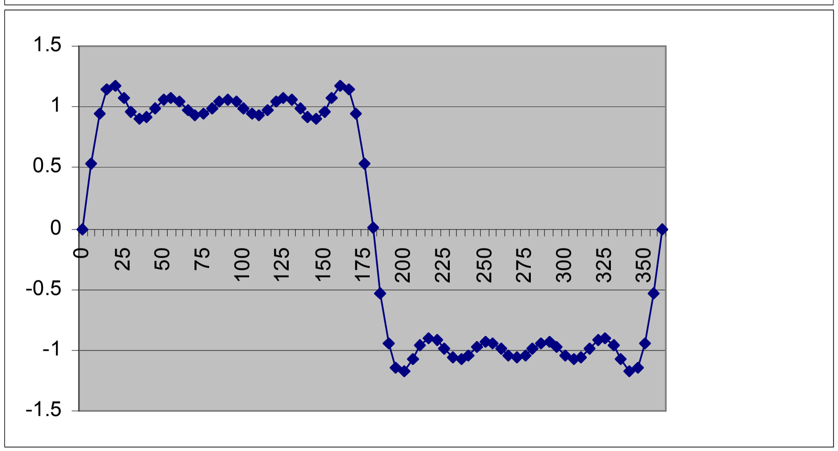


1st + 3rd + 5th Harmonic

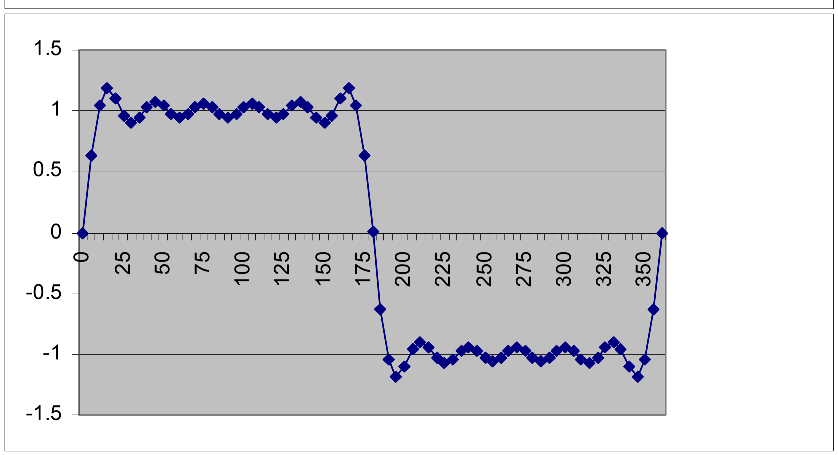
Square Wave



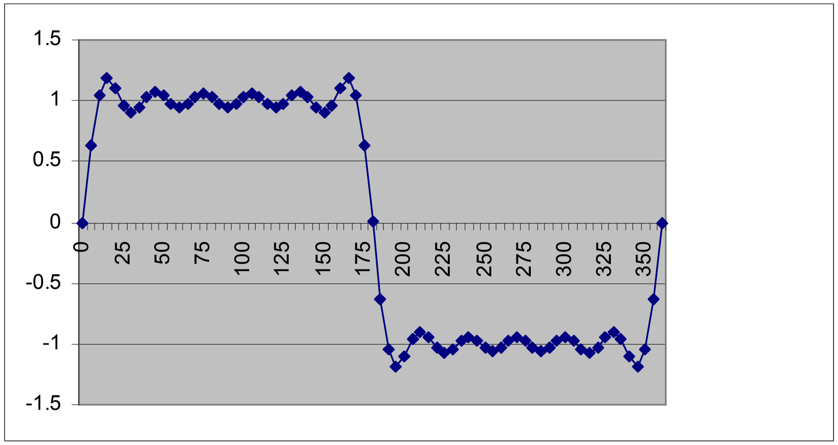
$1^{st} + 3^{rd} + 5^{th} + 7^{th}$ Harmonic



$1^{st} + 3^{rd} + 5^{th} + 7^{th} + 9^{th}$ Harmonic



$1^{st} + 3^{rd} + 5^{th} + 7^{th} + 9^{th} + 11^{th}$ Harmonic



Fourier Series Square Wave Conclusions

- This is amazing!

  Is a real square wave composed of harmonics? YES

  How many harmonics are needed?Infinite!

  Don't need the harmonics higher than you can hear.

  Reverse Logic: If you clip a waveform and make it square you accidentally create tons of harmonics.

  Waveforms with edges and fast slopes have lots of harmonics.

  Smooth slow changing waveforms have fewer harmonics.

  Extra credit: What does it mean for a waveform to have only even harmonics? For example, tube amp distortion folk-lore.

Class #9 Agenda:

<u>Review of Studio Field Trip</u>

<u>Filtering Waveform Harmonics</u>

What did we do?

- Using ProTools, inserted a signal generator in the insert of one of the tracks.
- The signal generator replaces the track audio with the generated signal.
- The signal frequency was 110Hz which matches the guitar A string.
- Ran the signal generator waveform through a bandpass filter with a high Q to remove all frequencies except the filter center frequency.
- It doesn't actually eliminate the other frequencies, it just attenuates them by about 15dbs. As a result, you still hear some of the original waveform.
- We do the following experiment for each waveform…

Experiment

- Dial in the filter center frequency (CF) to the fundamental of 110Hz.
- Every waveform sounds like the sine wave. Why?
- Move the CF to each harmonic beginning with 220Hz and observe if the harmonic is present and how loud.
- If the harmonic is present, we'll hear the volume increase and the sound will include a high pitch (the harmonic frequency) and the metering in ProTools will show the signal strength increase.

Results for Sine Wave

- No harmonics!
- Questions?

Results for Square Wave

- Only odd harmonics as predicted!
- Higher the harmonic, the softer it is.
- The volume of the harmonic was louder than the triangle wave. Why?
- Questions?

Results for Triangle Wave

- Only odd harmonics as predicted!
- Higher the harmonic, the softer it is.
- The volume of the harmonic was softer than the square wave. Why?
- Questions?

Results for SawTooth Wave

- Even and odd harmonics as predicted! Why?
- Higher the harmonic, the softer it is.
- Questions?

Distorted Sine Wave Results

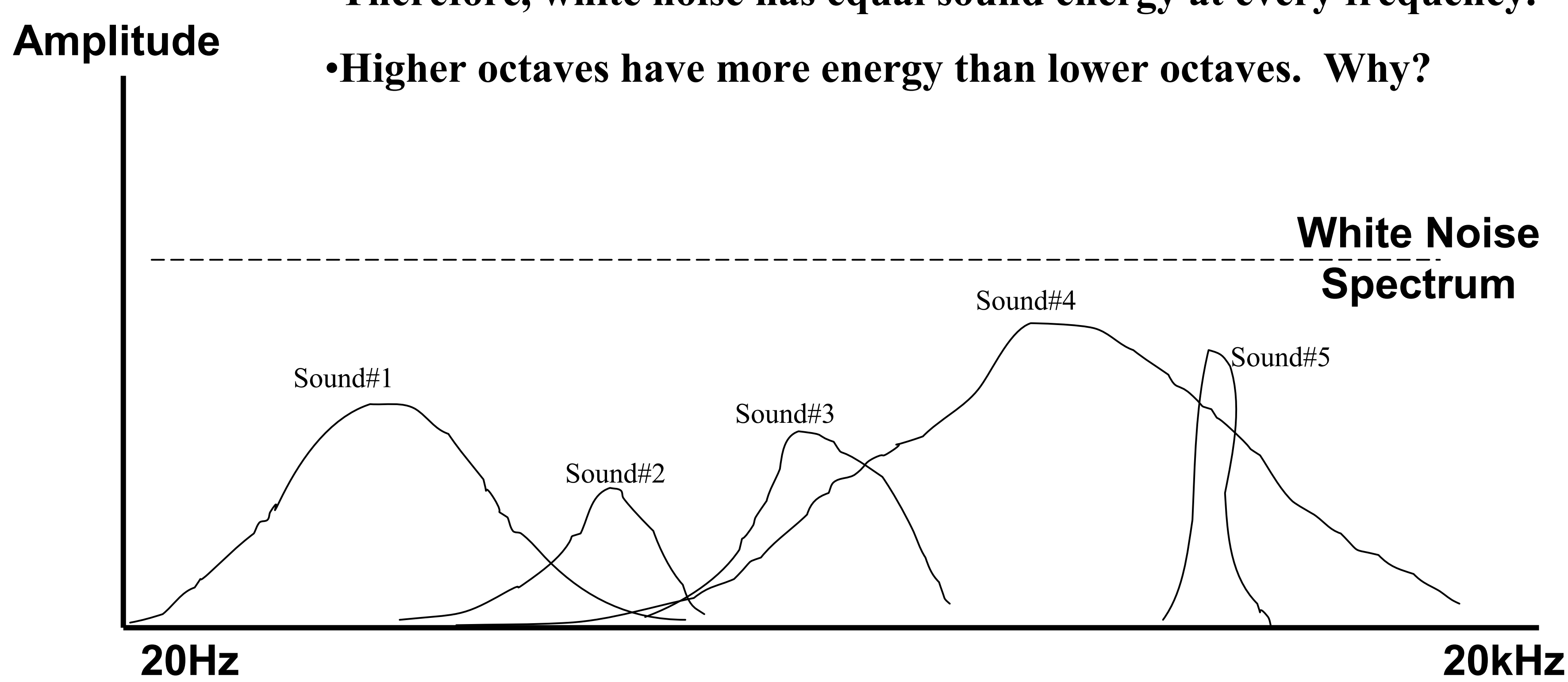
- Ran the sine wave through guitar amp ProTools plug-in via another insert.
- Turned on the guitar amp distortion.
- Only odd harmonics as predicted! Why?
- Sounded like the square wave but the harmonics were softer. Why?
- Questions?

Class #10 Agenda:

<u>Noise</u>

Adding Many Sounds Together Makes White Noise

- Is it more likely to make a sound around 100Hz or 100Hz?
- Since you can’t decide, the answer is that it’s <u>equally probable</u>.
- In fact it is the same probability for each frequency.
- Therefore, <u>all frequencies are equally likely</u>.
- Therefore, white noise has equal sound energy at every frequency.
- Higher octaves have more energy than lower octaves. Why?

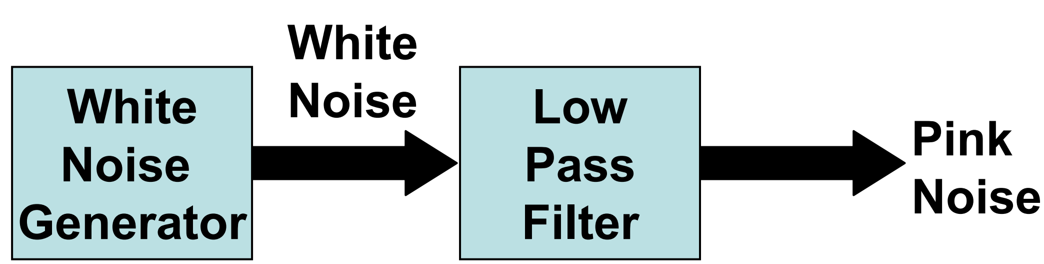


What’s Going on In A Star?

- Lots of collisions of high energy material banging into other high energy material.
- Very chaotic.
- Therefore, the probability of one electromagnetic frequency being generated is same as any other frequency.
- Therefore, the spectrum of light is very flat.
- That’s why it’s white.
- Stars are composed mostly of hydrogen but other materials are present too.
- The spectrum of hydrogen has discrete spectral lines like any material.
- However, the high energy hydrogen is moving at different speeds to and from the observer and the <u>Doppler Shift</u> smears the spectrum.

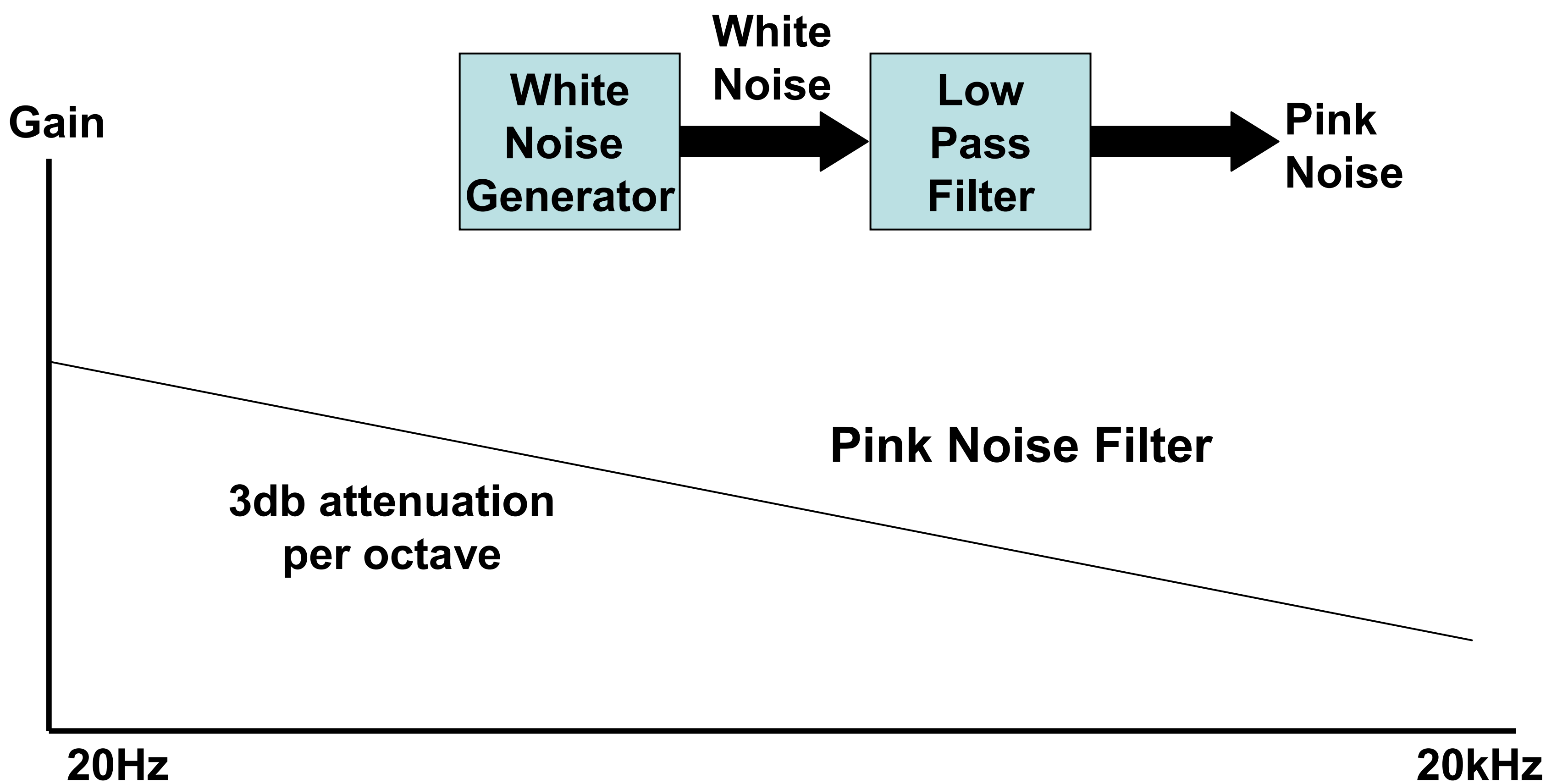
Pink Noise

- White noise has more energy in the higher octaves than the lower octaves because the higher octaves are wider.
- Each octave is twice the width of the previous octave and so contains twice the energy.
- 3db's of gain corresponds to twice the energy or power.
- Therefore, if I run white noise through a low pass filter that attenuates the high by 3dbs every octave I can create pink noise.
- Pink Noise is equal energy per octave.



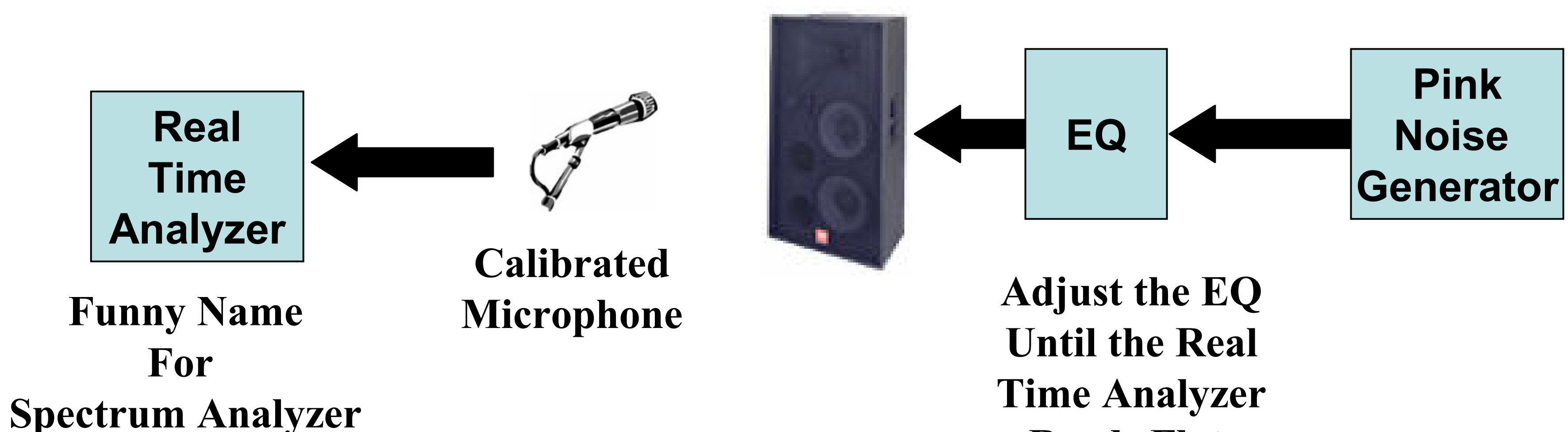
How Do We Synthesize Noise?

- Digitally white noise with a random noise generator.
- Analog white noise with high gain and no input. Where does the noise come from? Random motion of atoms in the material!



So What! What Can I Use This For?

- To calibrate a PA with!
- Send pink noise through the PA in a room.
- Measure that we have the same energy being output in each octave using a Real Time Analyzer.
- Need a calibration microphone.



Noise Summary

- A special signal that contains all frequencies of audible sound at the same volume or amplitude. That is every frequency is as loud as any other frequency.
- Same idea as white light which contains all visible frequencies of light.
- This implies that there will be more sound energy in the higher octaves because there are more frequencies in the higher octaves.
- Running white noise through a pink noise filter of 3dbs per octave creates equal energy per octave. Sounds muddier.
- Note the starting frequency of the pink noise filter is 0Hz.
- In the studio, the of noise through the bandpass filter created a sound that matched the filter CF at the harmonic frequencies and in-between. Why?
- Questions?

Class #11 Agenda:

<u>Resonance</u>

Resonance

- The sound something makes when you hit it with a hammer ;-) For example, a bell or guitar string.
- In engineering the hammer is called an impulse or delta function.
- This is the frequency that the object or material likes to vibrate at. Has something to do with the mass of the thing and the elasticity of the material.
- If after using the hammer, the object rings for a long time, it has a high Q.
- You can attempt to make an object vibrate at a different frequency by shaking it somehow. For example, a speaker has a resonant frequency but can generate many frequencies because it is shaken electrically.
- A speaker has a low Q.
- Questions?

Resonance & Sympathetic Vibrations

- It’s more effective to make an object vibrate at its resonant frequency or at a harmonic of its resonant frequency.
- A sound nearby an object will cause the object to vibrate like using a small hammer.
- If the nearby sound is the resonant frequency or a harmonic it the object will resonate sympathetically.
- For example, strike a C note in the piano and the G note will ring.
- The sympathetic strings on the sitar capitalize on this effect.
- A string has a high Q.
- Lots of manufacturers are beginning to make Impulse Response reverbs. They sound really good. Better than the Lexicon which is a synthetic reverb.
- Questions?

Studio Field Trip

- Instead of class next week…
- Do you want to come to a recording session at the studio?
- The session will be Saturday or Sunday. I'll send email.
- Stephen Johnson playing piano.
- If possible, I'll configure the Apogee D/A and A/D converters to use 96kHz sampling rate instead of 48kHz.
- Questions?

Stop for today!

Mackie Channel Strip

Trim

6 Aux Sends

(PreFader, PostFader & Switchable)

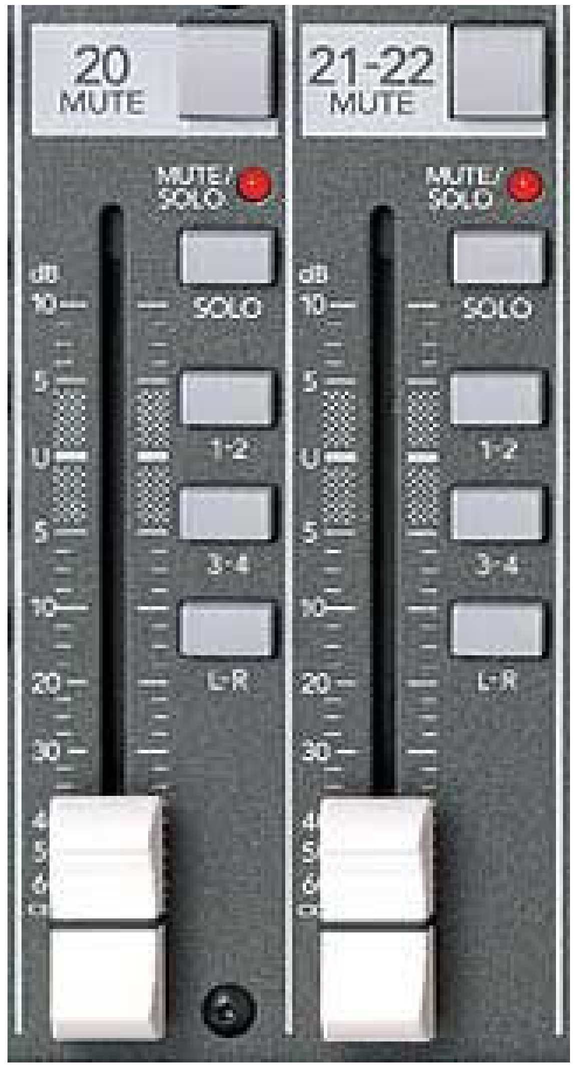
EQ

Pan

Mute

Bus & L/R Assign

Channel Fader



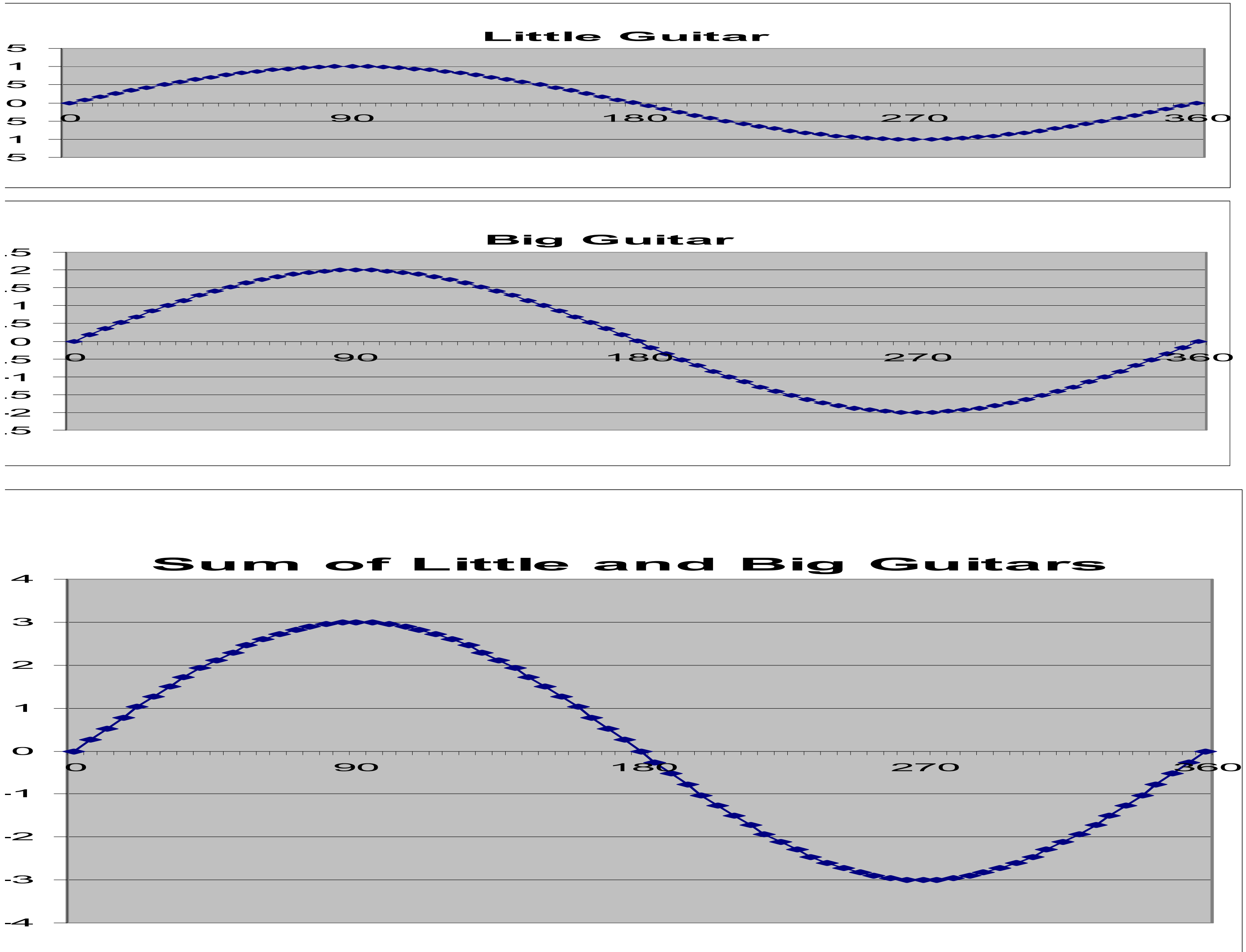
- 0dbs → 60dbs of trim gain.
- U means unity gain.

Homework

- Read the manual for Mackie 32x4 mixer.
  http://mackie.com/products/sr32-4vlzpro/index.html

Summing Technique

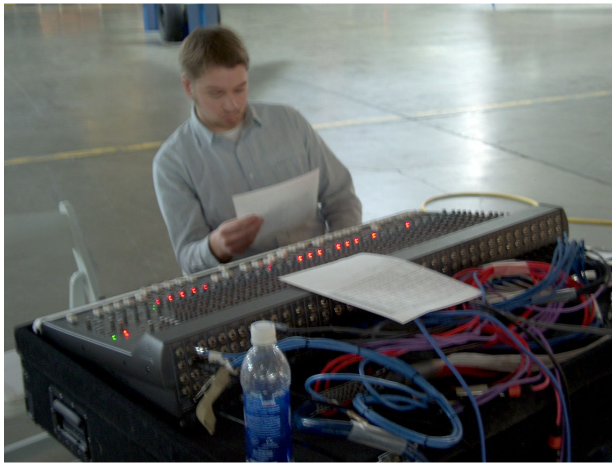
Stack Vertically
Same X Axis



What is Sound?

- For example, guitar string vibrates back & forth.
- Pushes & pulls the air as it vibrates. What frequency?
- Creates high and low pressure. Where?
- The pressure variance becomes mobile (wave). Where does the wave go? What pattern?
- Wave collides with microphone. The pressure variance moves the mic diaphragm.
- Moving diaphragm creates an electrical voltage. Analog or digital?
- Po

Sound Reinforcement Trips



- Sound Reinforcement (TM&M) event in Denver on 1/28/2006 at Wings Over The Rockies Air Museum.
- One Sky One World Event.
- Fire On The Front Range Thurs/Fri/Sat?

Class #2 – Tina Marx & Millionaires Sound Reinforcement Gig? Saturday 1/28/2006

- **DIRECTIONS:** http://tinamarx.com/private/Directions/Denver_Municipal_Directions.htm
- **ARRIVE AT:** No later than 4pm (May change a little)
- **PLAY/RECORD:** 8pm
- **CELL PHONE:** Bring it if you have one. Anthony's is: (970)690-7210
- **DRESS:** Band will be in tuxes. Dress grubby to setup, nice to perform.

!!! Please show up if you commit to come !!!

Class #2
Sound Reinforcement

- PA = Public Address System
- Sound Reinforcement –NOT – Sound Replacement
- Use Stage Acoustic Energy when possible w/o Amplification

Instruments & Vocals

Microphones & DIs

Mix Inputs Into 1 Stereo Output

Amplify

Three Kinds Of Inputs

Sound Reinforcement

Acoustic, Electronic & Loud

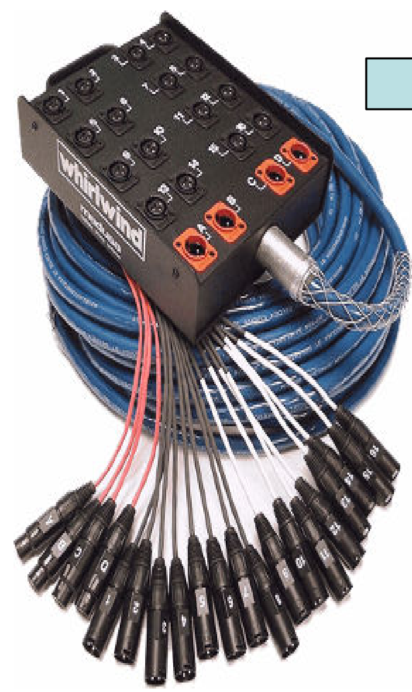
- Acoustic inputs (vocals, sax, bongos) we’ll capture with a microphone of the appropriate type.
- Electronic inputs (keys, bass) we’ll capture with DI’s which convert unbalanced stage signal to balanced.
- Loud inputs (Electric Guitar, Drums) we may not capture at all.
- For On-Location DAT Recording, we’ll use recording microphones instead of mixing that too.

Got To Get The Sound From the Stage to the Mixer & Then Back To The Stage

Sound Reinforcement

Mic and/or DIs

32 in/ 8 out SNAKE



Mackie 32x4 Mixer

- **Mix stereo output**
- **Mix wired monitors**
- **Mix wireless monitors**
- **Mix recording**

http://www.mackie.com/products/sr32-4vlzpro/index.html

Main Speakers

Monitor Speakers

Mackie Channel Strip

Trim

6 Aux Sends

(PreFader, PostFader & Switchable)

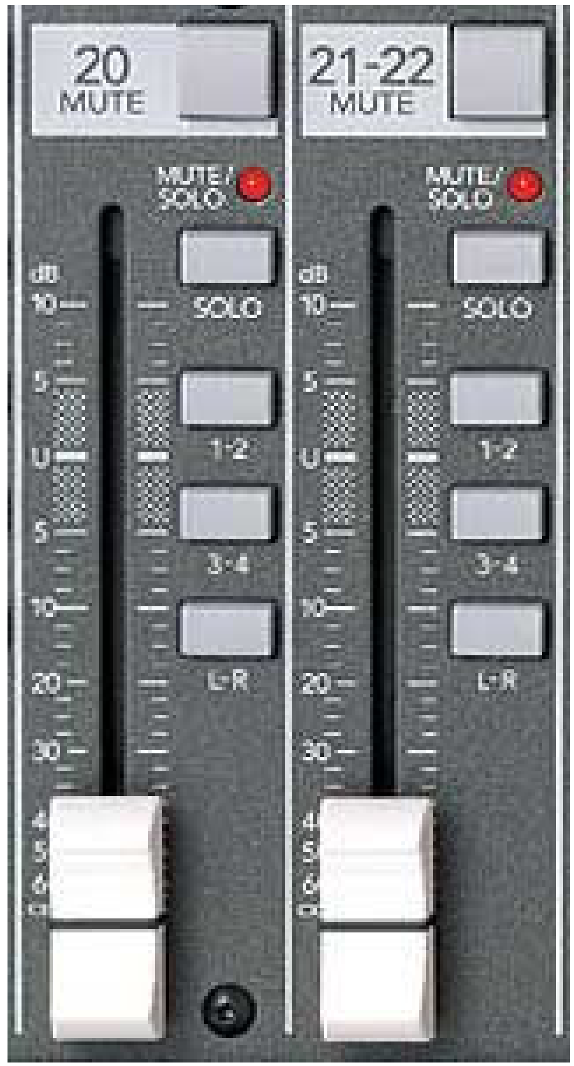
EQ

Pan

Mute

Bus & L/R Assign

Channel Fader



- 0dbs → 60dbs of trim gain.
- U means unity gain.

How To Setup The Mixer

- Set the trim until signal almost clips
- Leave the EQ flat
- Turn off all aux sends
- Set the master fader at 80%
- Let the band play w/o amplification (except vocal)
- Add in instrument if needed
- Won't use reverb
- Baby-sit monitor mix
- Use 2 aux sends on unused channel for DAT recording
- Adjust as little as possible. Too much adjustment will result in feedback.

DBX Drive Rack 260 Solves Problems

http://www.driverack.com/260.htm

- Feedback Elimination
- 2.7 seconds of delay to time align PA and band. This also helps with feedback.
- Global EQ
- Electronic Crossover
- Compression
- Pink Noise / Real Time Analyzer
- RS-232 Remote Control
- Can use my old Sabine to Notch Filter Stage Monitors

Sound Reinforcement Jefferson Symphony Orchestra

http://www.jeffersonsymphonyorchestra.org

Can you provide Sound Reinforcement for the Jefferson County Symphony Orchestra for their summer concerts?

- I was asked this at a 3 piece jazz gig where the keybd was the conductor David Ackerman.
- I naively said yes!
- Then started analyzing what this meant.
- I knew that I had plenty of mics and power. Just had to understand the orchestra.

Symphony Rehearsal

Symphony Rehearsal

Symphony Rehearsal

Symphony Rehearsal

Symphony Rehearsal

Percussion Section has bass instruments like timpani and high frequency instruments like xylophone. And the instruments are spread out over a large area. How do you mic this?

Symphony Rehearsal

Symphony Rehearsal

Brass are always too Loud.

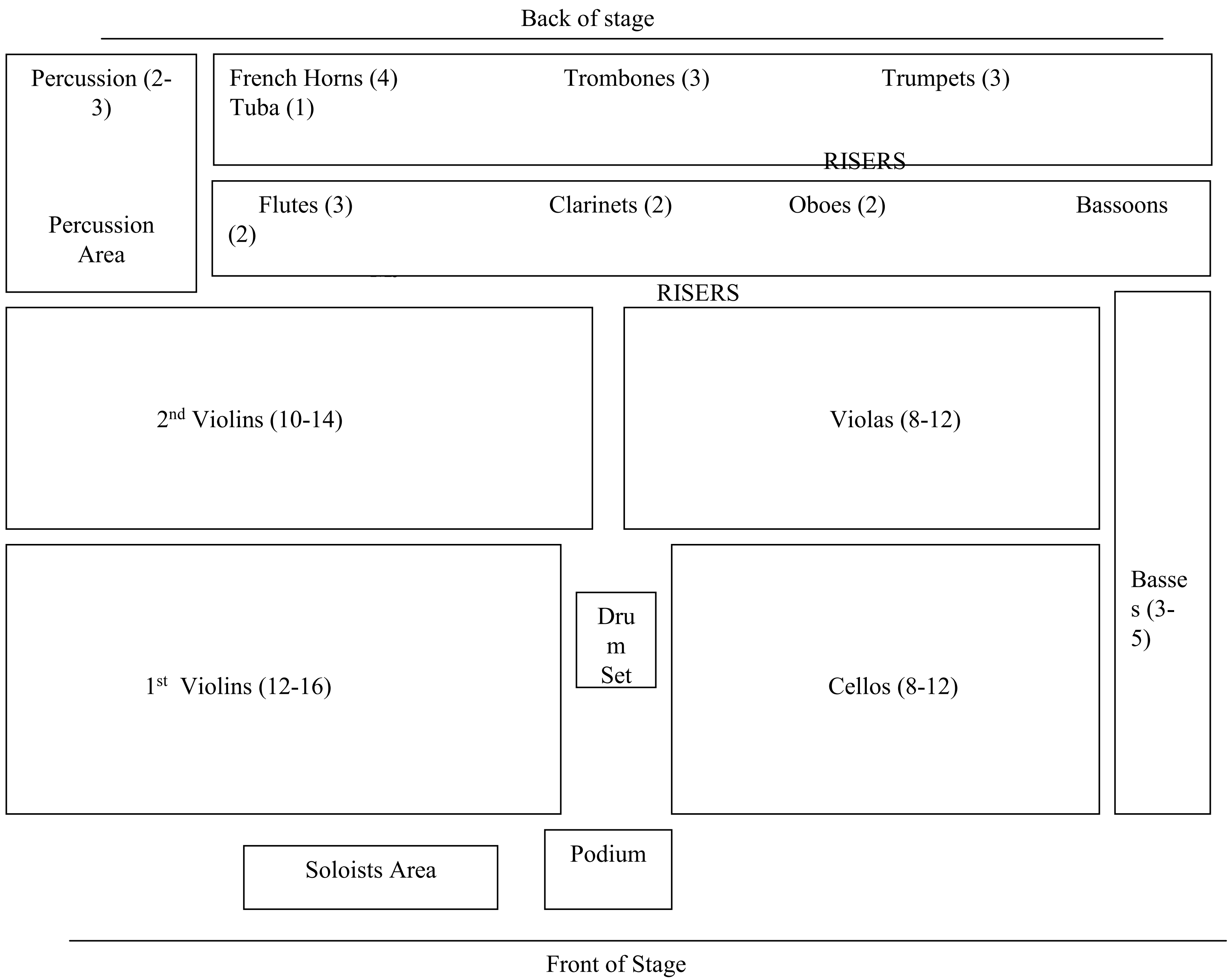
Symphony Rehearsal

The conductor is a jazz musician & decided to include a trap set (drums). Rock drums are loud. How do you mic this? Also not shown is electronic piano. How should this be mic'd?

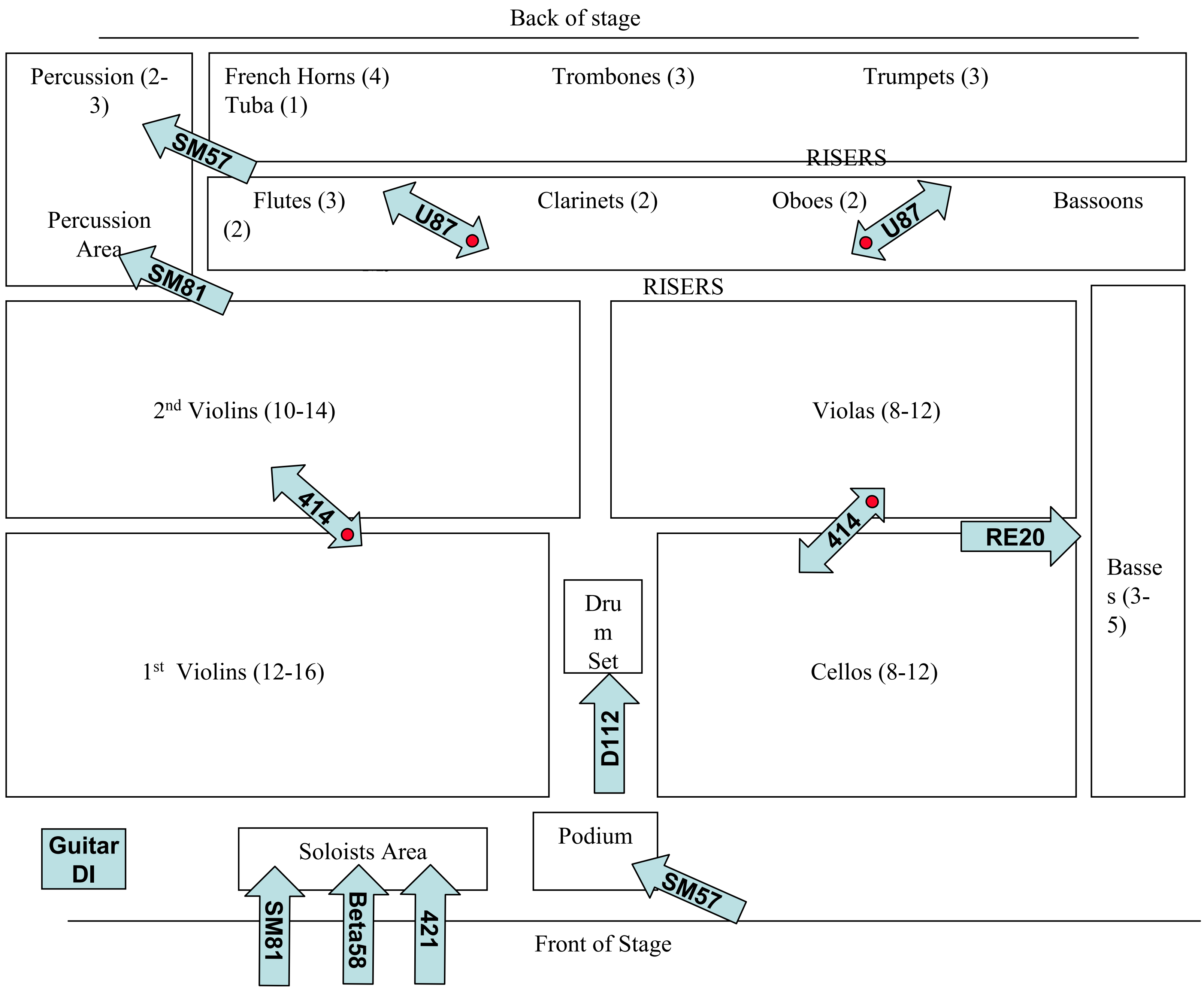
Symphony Summary

1. **Originally thought you could use 2 mics (one stereo mic) but that only works in a concert hall. Won't work outside.**
2. **Must mic Violins over a wide area using Figure-8 Pattern. NULL at PA.**
3. **Similarly for Violas and Cellos.**
4. **Can use Electrovoice RE-20 Dynamic mic on Double Bass since need boom.**
5. **Mic only kick drum on trap set using AKG D112 mic.**
6. **Use 2 Neumann U87 Figure-8 on Woodwinds – large area & need fidelity. NULL at PA or brass depending on layout.**
7. **Use SM57 on percussion for bass etc. and SM81 on Xylophone etc.**
8. **Don't mic brass.**
9. **Use DI (Direct Injection) on Keys, Acoustic Guitar and Accordion.**
10. **Any mic for conductor. Roll all the bass off to understand speech.**
11. **User wireless Beta SM-58 for Solo mics to make it easy to move around.**
12. **Anything for vocalists. Minimize monitors.**
13. **Phase up the matching Figure-8 patterns.**
14. **Reverb on Soloist**

Symphony Layout



Symphony Microphones



Medusa Snake/Channel Assignments Jefferson Symphony Orchestra

1 **SM57** **Percussion**	**2** **SM81** **Percussion** **Xylophone**	**3** **AKG414** **Violins** **Figure8**	**4** **AKG414** **Viola** **Cello** **Figure8**	**5** **U87** **Wood** **Winds** **Figure8**	**6** **U87** **Wood** **Winds** **Figure8**	**7** **Kick** **Drum** **AKG** **D112**	**8** **Double** **Bass** **RE20**	**A** 1	**B** 2
9 **Solo** **Wireless** **Beta58**	**10** **Solo** **421**	***11*** **Solo** **SM81**	***12*** **Guitar DI**	**13** **Piano L** **DI**	***14*** **Piano R** **DI**	***15***	***16***	**C** 3	**D** 4
17	**18**	**19**	**20**	**21**	***22***	**23**	**24**	**E** 5	**F** 6
25	***26*** **Conductor** **SM57**	***27*** *Reserved* *for Reverb* *(left)*	***28*** *Reserved* *for Reverb* *(right)*	***29*** *Reserved* ***for*** *Echo* *(left)*	***30*** *Reserved* *For* *Echo* *(right)*	**31** Reserved for CD (left)	**32** Reserved for CD (right)	**G** 7	**H** 8

Snake Return A: Main Mix L (stage right)
Snake Return B: Main Mix R (stage left)
Snake Return C: Vocal Monitor
Snake Return D:
Snake Return E:
Snake Return F:
Snake Return G:
Snake Return H:

Aux 1: Monitor
Aux 2:
Aux 3: L DAT Recorder
Aux 4: R DAT Recorder
Aux 5: Echo Send
Aux 6: Reverb Send

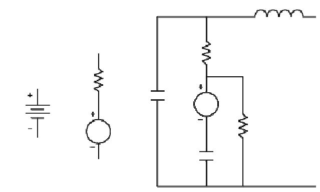
Mixer = Mackie 32x4
Crossover = Drive Rack
JBL Speakers = 4,800 Watts on top
3,000 Watts on bottom

Symphony Mastering

At Anthony’s Studio Next Week

Electronics 101

(Simple Electrical Components)



Voltage (volts) // Across Variable

Current (amps) // Through or Flow Variable

Resistor (DC ohms Ω)

Impedance (AC ohms Ω) (not impotence)

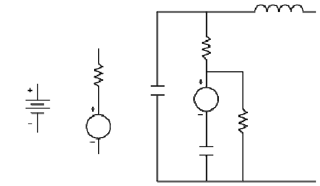
Batteries (DC volts)

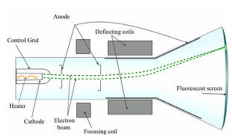
Capacitor (a.k.a. Condenser) µFarads

Inductor (a.k.a. coil) µHenry

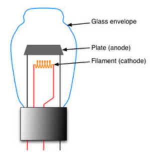
Electronics 101

(Complex Electrical Components)





CRT (Cathode Ray Tube) 30K volts DC



Vacuum Tube

Diode (R=0 or R=infinity)

Bipolar transistor

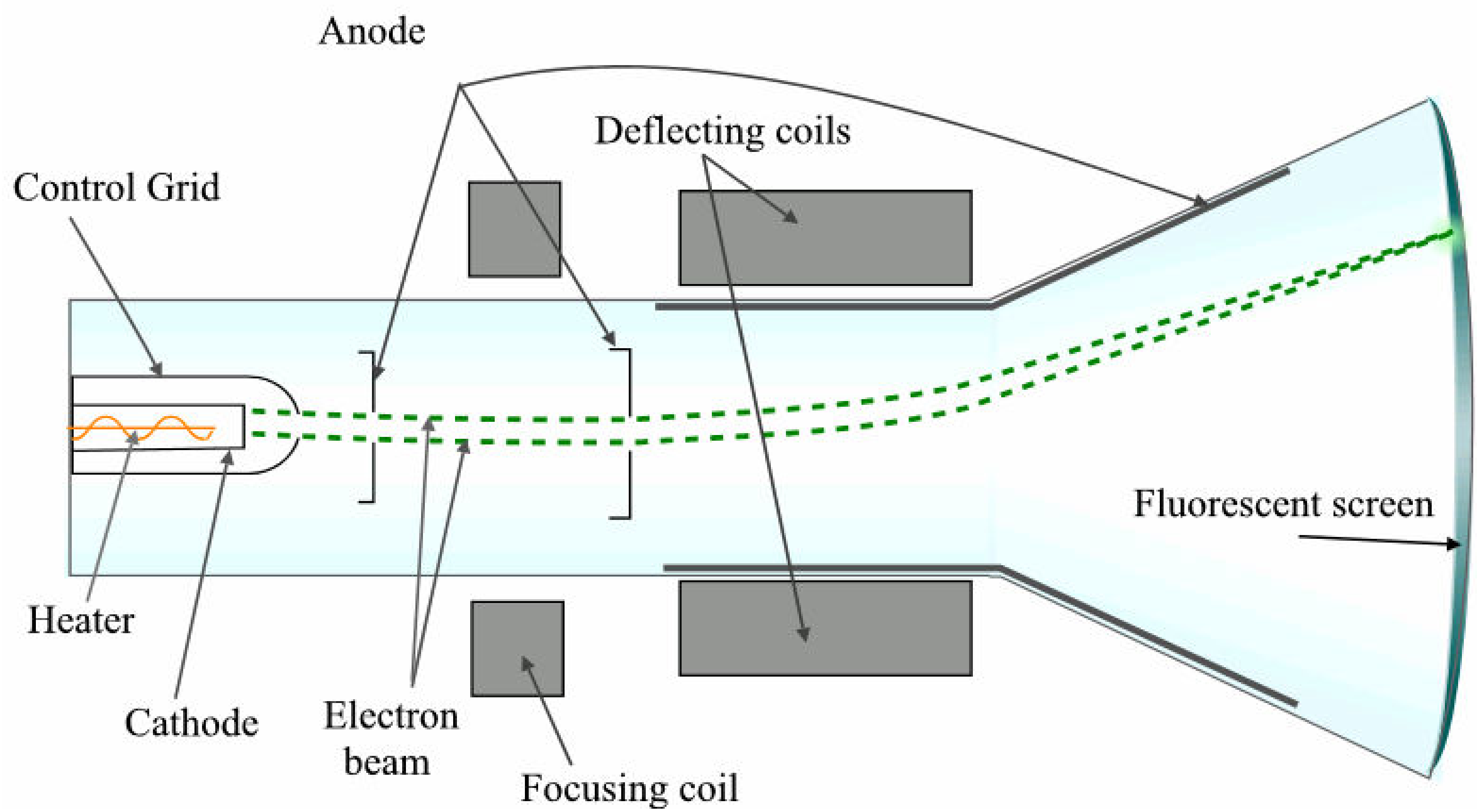
FET (Field Effect Transistor)

MOSFET (Metal Oxide Semiconductor FET)

CMOS (Complementary MOSFET)

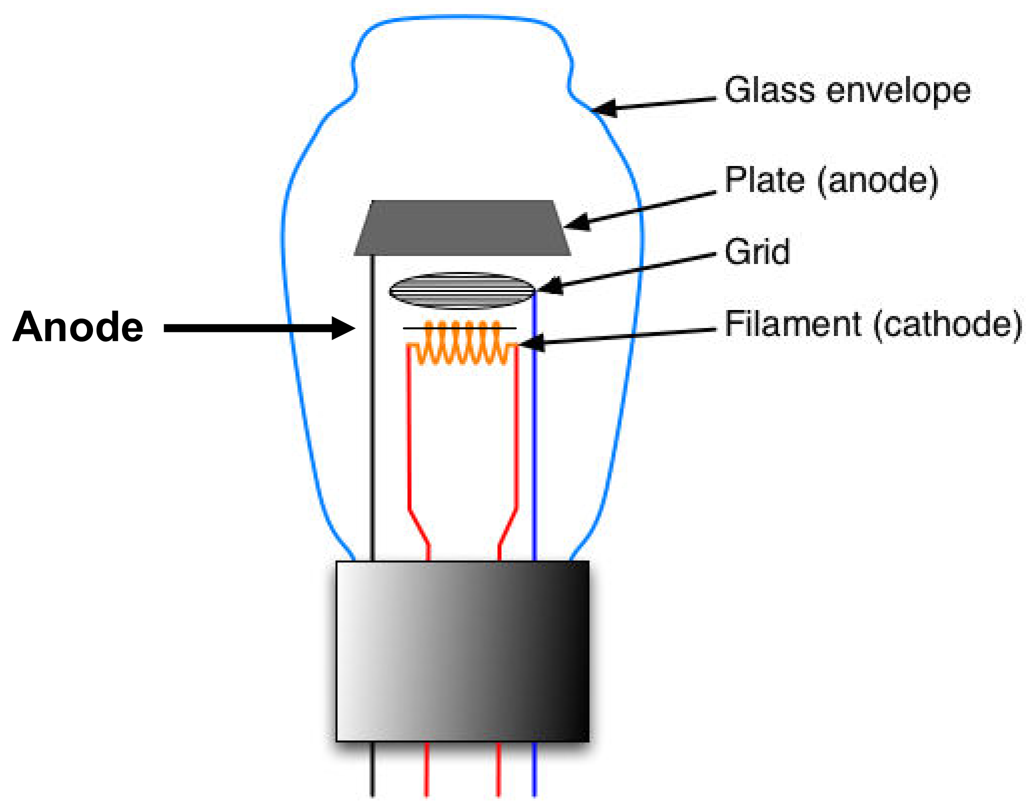
Electronics 101

(Cathode Ray Tube)



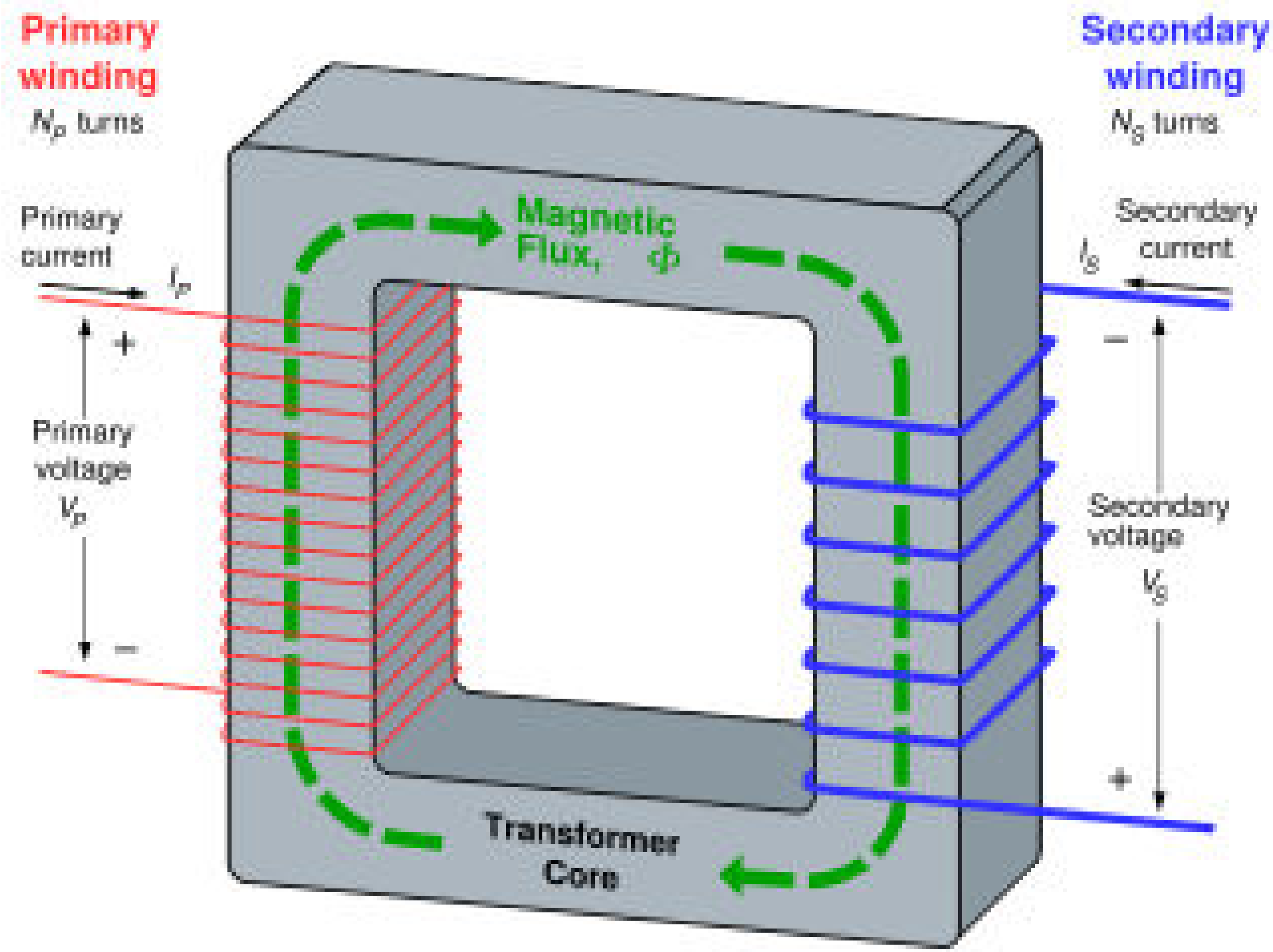
Electronics 101

(Triode Vacuum Tube)

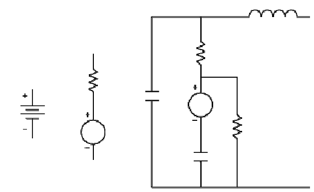


Electronics 101

(Transformer)



Electronics 101



(Electrical Systems)

- Voltage Divider
- Pots (volume control)
- Voltage Divider with capacitors or inductors
- Power supply & full wave rectifier
- Speakers in series or parallel
- Voltage Controlled Amplifier ???
- Compressor ???

Binary Number System

http://en.wikipedia.org/wiki/Binary_numeral_system

- Computers use only binary
- MIDI Communication is in binary
- MIDI Technical Specification is in binary
- Digital Audio is stored in binary (e.g. CD’s are 16 bit)
- <u>Boolean</u> Values are <u>True</u> or <u>False</u> (Logic)
- You can think of <u>True</u> as corresponding to the <u>number 1</u>
- You can think of <u>False</u> as corresponding to the <u>number 0</u>
- A Bit is a Binary Digit and can be 0 or 1
- A Byte is 8 Bits (e.g. 11001010)
- 16 Bits is two bytes (e.g. 1100101011001010)
- High End Audio uses 24 bit to store each sample

Decimal Number System

http://en.wikipedia.org/wiki/Decimal

- People use the decimal system
  - Base 10
  - Because we have 10 fingers

100,000's column
10,000's column
Thousands column
Hundreds column
Tens column
Ones column

124,602

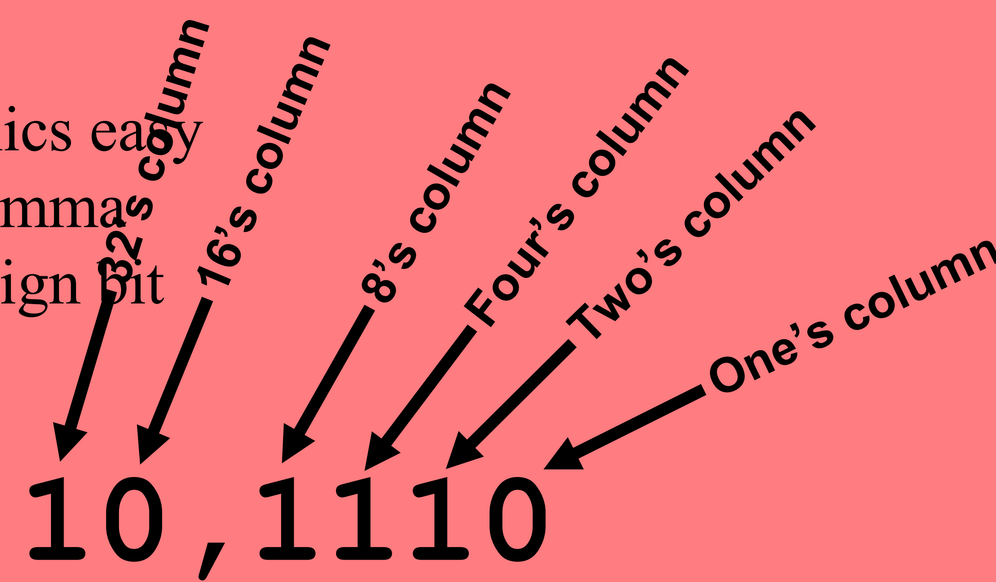
Value=2x1 + 0x10 + 6x100 + 4x1000 + 2x10,000 + 1x100,000

Value=$2x10^0 + 0x10^1 + 6x10^2 + 4x10^3 + 2x10^4 + 1x10^5$

Binary Number System

http://en.wikipedia.org/wiki/Decimal

- Computers use binary system
  - Base 2
  - Makes digital electronics easy
  - Notice I moved the comma
  - Sometimes left bit is sign bit
  - Two's Complement
  - Possibilities = 2^{bits}
  - Max Number = $2^{bits}-1$
  - Smallest Number = 0



Value=0x1 + 1x2 + 1x4 + 1x8 + 0x16 + 1x32

Value=$0x2^0 + 1x2^1 + 1x2^2 + 1x2^3 + 0x2^4 + 1x2^5$

Hexadecimal Number System

http://en.wikipedia.org/wiki/Hexadecimal

- Easy way to group bits
- So humans can deal with it
- Base 16
- Not as complicated as it looks
- MIDI Specification uses hex

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	1	2	3	4	5	6	7	8	9	a	b	c	d	e	f

4,096's column → f, 256's column → f, 16's column → e, One's column → 7

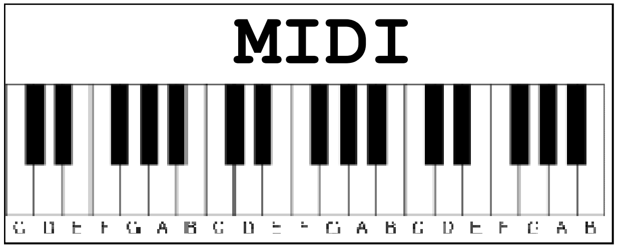
ffe7

Same As

1111 1111 1110 0111

Value=7x1 + 14x16 + 15x256 + 15x4,096

Value=$7 \times 16^0 + 14 \times 16^1 + 15 \times 16^2 + 15 \times 16^3$



Musical Instrument Digital Interface

http://en.wikipedia.org/wiki/Midi

What is MIDI good for?

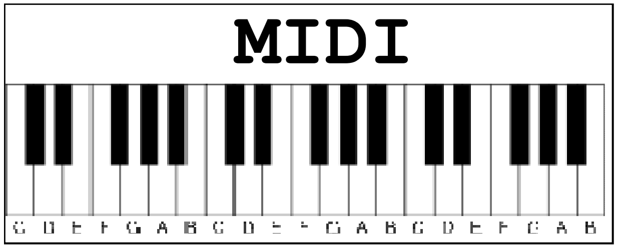
- Separating keyboard from sound electronics
- Allowing one keybd to drive multiple sound modules
- Recording key-strokes instead of sound. Edit Performance using a sequencer editor. Playback with a different sound than recorded.
- Allow keybd to be split
- Allow automation of keybd configuration during a song
- Saving of proprietary synth config via SysExclusive
- Synchronization of Analog & Digital Audio Recorders with each other, Sequencers and Video!
- General MIDI allows web pages to publish sequences that might sound something like intended when downloaded.

MIDI

Musical Instrument Digital Interface

http://en.wikipedia.org/wiki/Midi

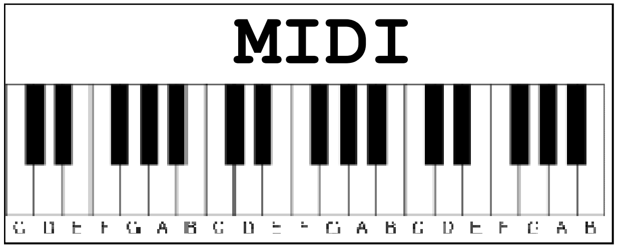
Who Needs It? Rick Wakeman?



Synthesizer Architecture

http://en.wikipedia.org/wiki/Synthesizer

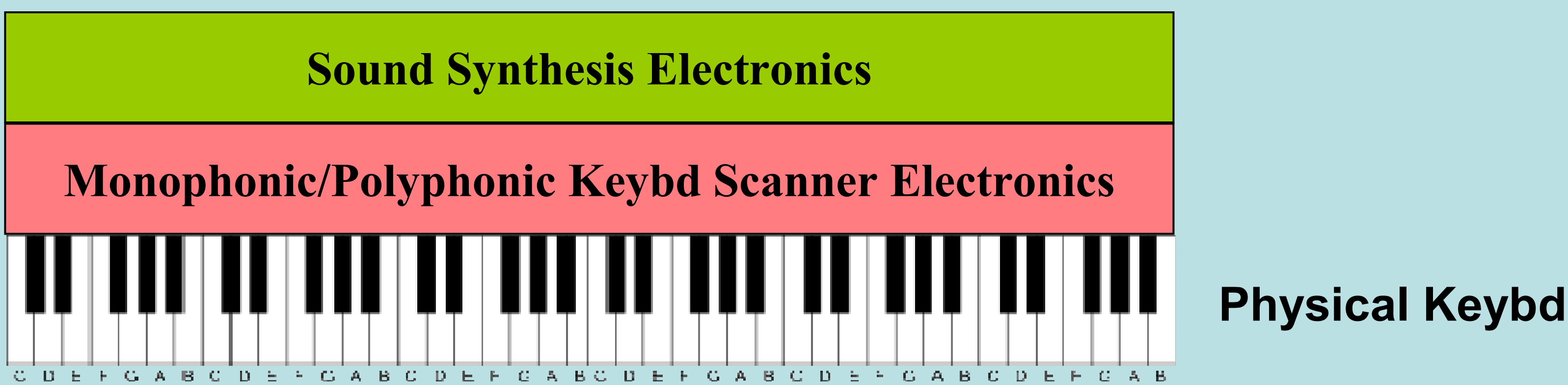
What's inside any synthesizer?

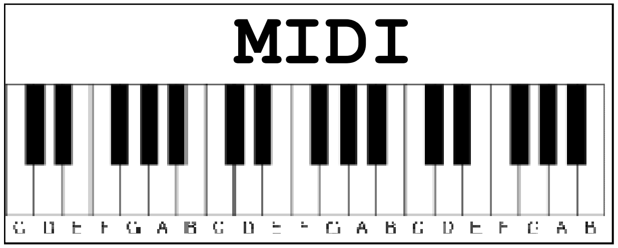


Synthesizer Architecture

http://en.wikipedia.org/wiki/Synthesizer

- What part was most expensive in 1960?
- What part is most expensive now?
- How can we reduce the cost of multiple sounds?
- How can we reduce the weight to transport?





Synthesizer Architecture

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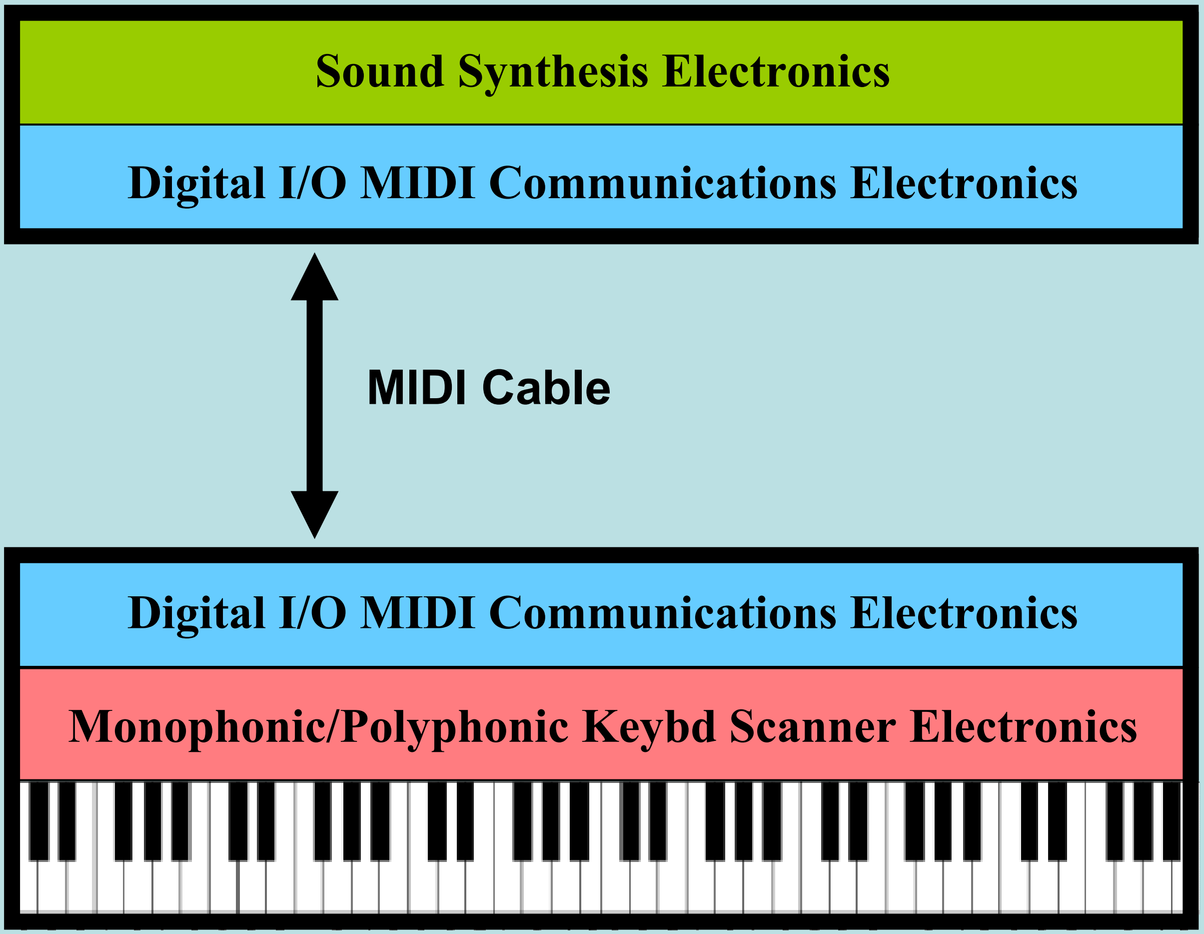
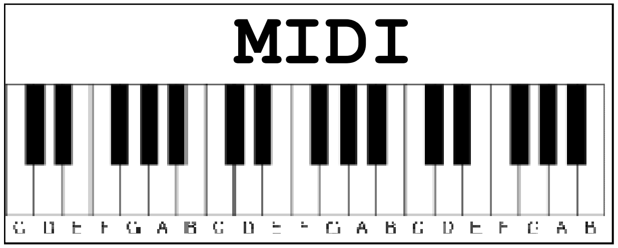


MIDI

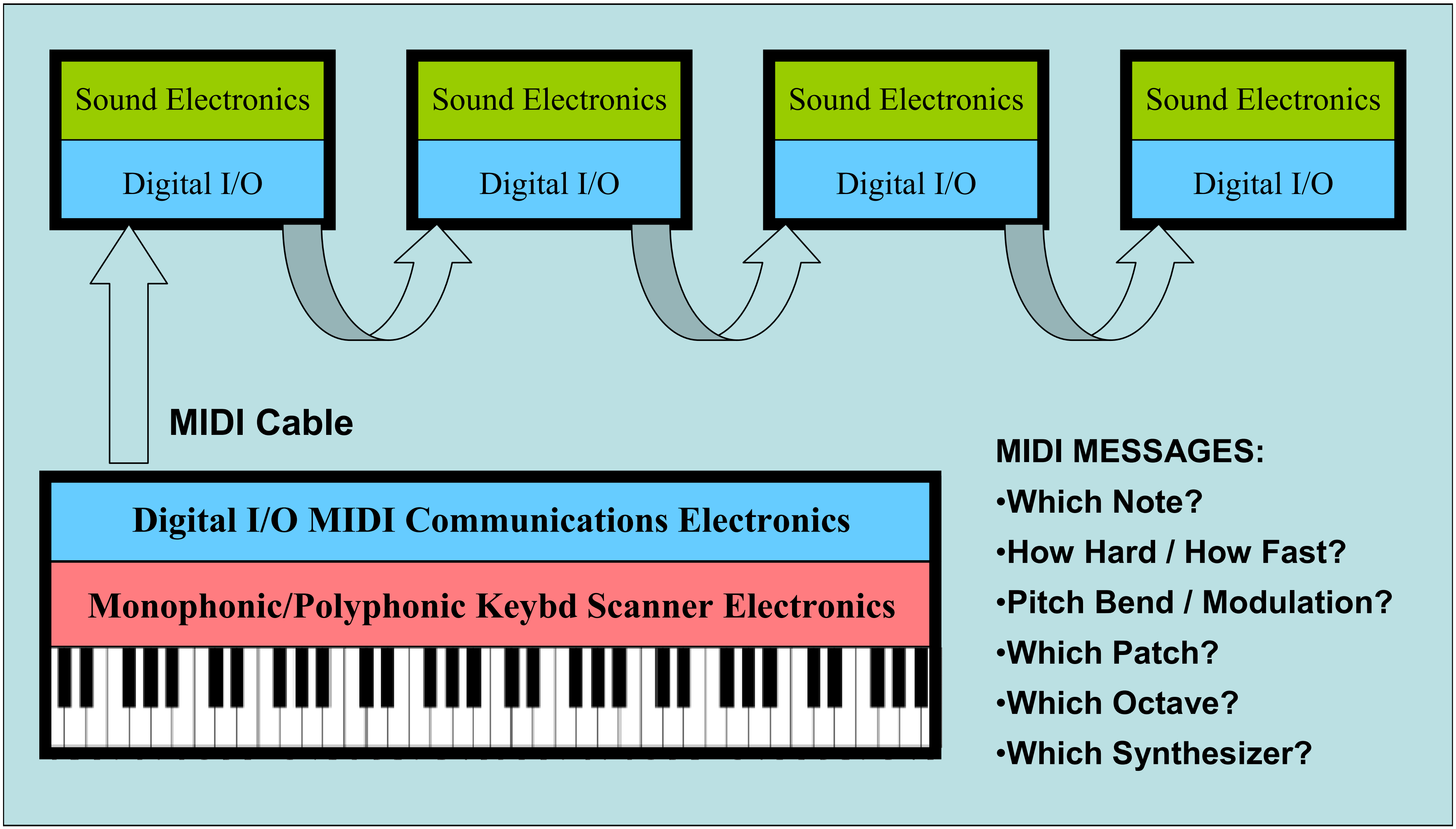
MIDI Cable

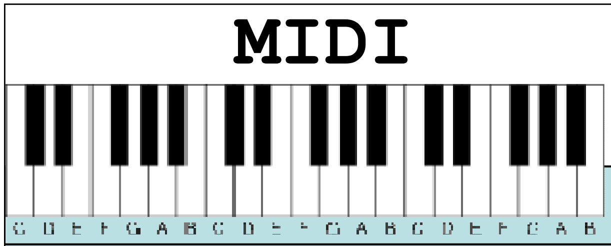
In/Out/Thru



Synthesizer Architecture

http://en.wikipedia.org/wiki/Synthesizer

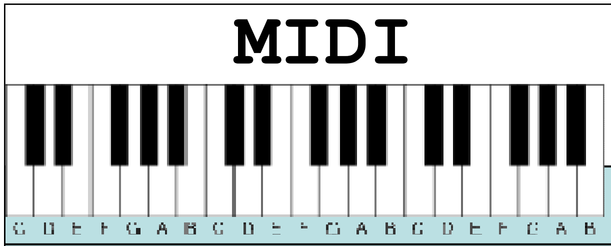




Protocol

http://www.midi.org/about-midi/abtmidi.shtml

- MIDI Data is transmitted serially one byte at a time
- Bytes are either <u>Status Bytes</u> or <u>Data Bytes</u>
- <u>Status Bytes</u> always start with a one
- <u>Data Bytes</u> always start with a zero
- Most MIDI messages are 3 bytes: 1 Status & 2 Data
- If two consecutive messages have the same status byte, then you don't need to transmit the status byte again. Therefore, two messages can be sent in 5 bytes.
- Four bits are used to address the particular synth for standard messages
- nnnn (for bits) 0→15 corresponds to MIDI channel 1→16
- System Exclusive has it's own rules for proprietary messages.



Protocol

http://www.midi.org/about-midi/abtmidi.shtml

Channel Voice Messages

```
1000 nnnn  Note Off
0kkk kkkk  Which key 0→127
0vvv vvvv  Velocity (How Fast)

1001 nnnn  Note On
0kkk kkkk  Which key 0→127
0vvv vvvv  Velocity (How Fast)

1010 nnnn  Polyphonic Key Pressure (After Touch)
0kkk kkkk  Which key 0→127
0ppp pppp  Pressure (How Hard)

1011 nnnn  Controller Change (e.g. Modulation Wheel)
0ccc cccc  Which controller 0→121 (122-127 reserved)
0vvv vvvv  Value of Controller

1100 nnnn  Program Change (i.e. Patch Change)
0ppp pppp  Which patch 0→127  (2 byte message)
```

Channel Voice Messages (cont)

```
1101 nnnn  Channel Pressure (Global After Touch)
0ppp pppp  Pressure (How Hard)

1110 nnnn  Pitch Wheel
0LLL LLLL  LSB (Least Significant 7 Bits)
0MMM MMMM  MSB (Most Significant 7 Bits)
```

VALUE IS 14 BITS: MMMMMMMLLLLLLL 0→16K?

NOPE: +/- 8K

NOTE: There was one 4 bit binary status byte value we didn't use. 1111nnnn or Fn. This is used for System Exclusive.

Channel Mode Messages

```
1011 nnnn  Channel Mode if ccccccc > 121
0ccc cccc  Controller 121→127
0vvv vvvv  Special Value

122:  Local Control     v=0 Off    v=127 On

123:  All Notes Off     v=0

124:  Omni Mode Off     v=0

125:  Omni Mode On      v=0

126:  Mono Mode On      v=0 Max    v=#Mono MIDI Channels

127:  Poly Mode On (Mono Mode Off) v=0
```

System Exclusive

```
1111 0000  Start System Exclusive
…
…
…
1111 0111  End System Exclusive
```

Used to transmit proprietary information like configuration
Of a patch on a particular synthesizer.

System Common Messages

```
1111 0001  Undefined

1111 0010  Song Position Pointer
0LLL LLLL  14 bit song position
0MMM MMMM

1111 0011  Song Select
0sss ssss  Song #

1111 0100  Undefined
1111 0101  Undefined
1111 0110  Tune Request
1111 0111  EOX (End of System Exclusive)
```

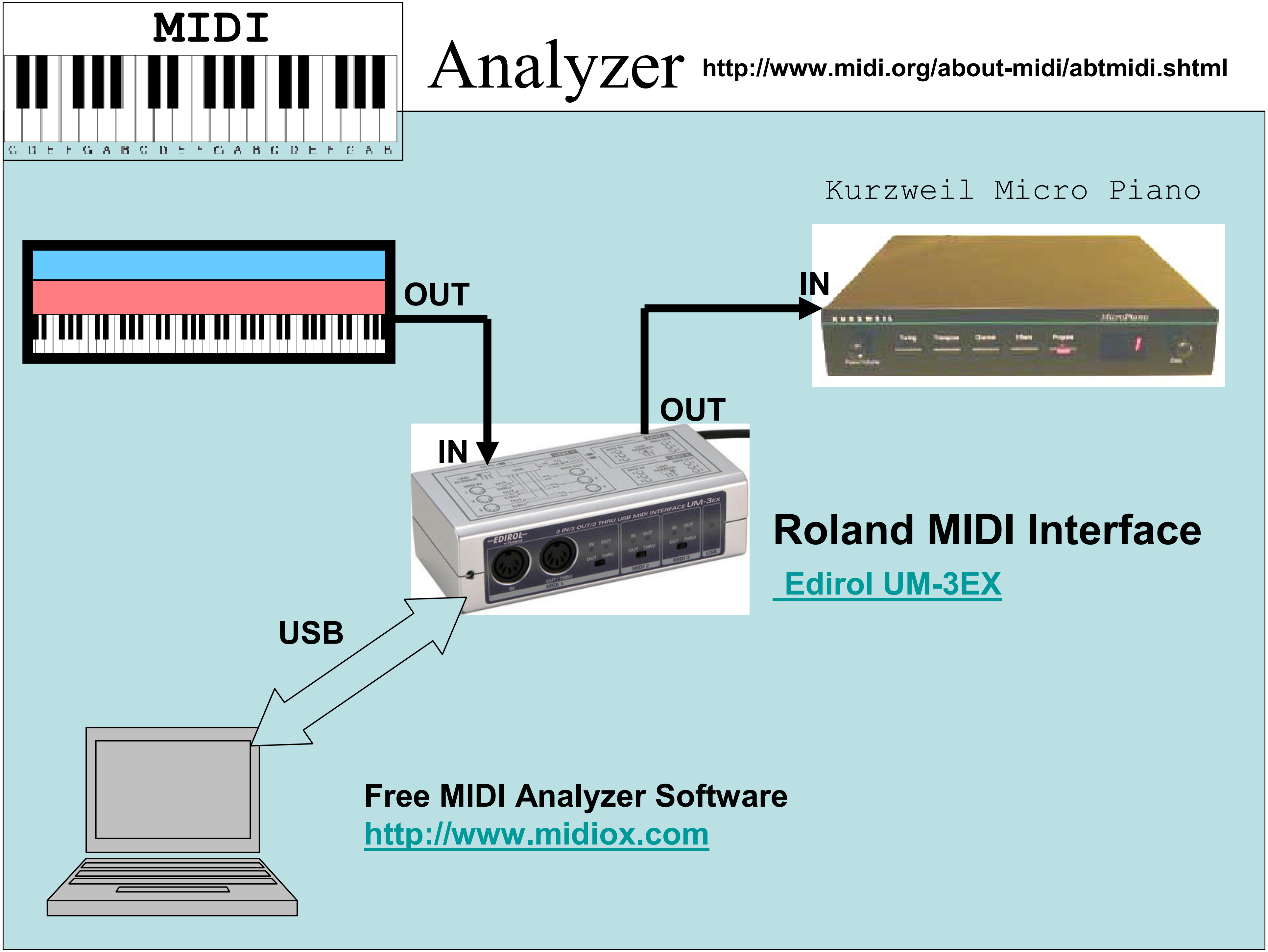
Protocol

http://www.midi.org/about-midi/abtmidi.shtml

System Real Time Messages

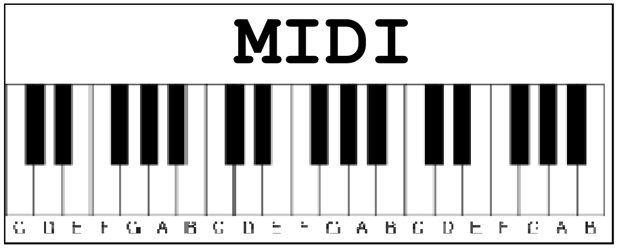
```
1111 1000  Timing Clock (a.k.a. MIDI Clock)

1111 1001  Undefined
1111 1010  Start
1111 1011  Continue
1111 1100  Stop
1111 1101  Undefined
1111 1110  Active Sensing (Detect if MIDI cable is unplugged)
1111 1111  System Reset
```


MIDI
Analyzer
http://www.midi.org/about-midi/abtmidi.shtml
Kurzweil Micro Piano
OUT
IN
OUT
IN
USB
Roland MIDI Interface
Edirol UM-3EX
Free MIDI Analyzer Software
http://www.midiox.com

Synchronization Evolution

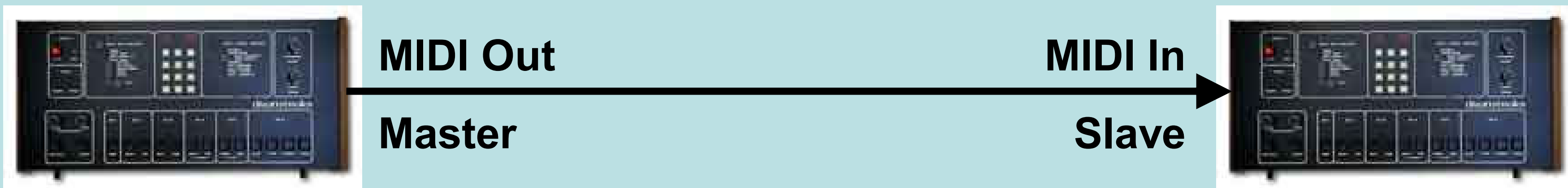
1. MIDI device to MIDI device (e.g. Drum Machine /Sequencer)
2. …..using MIDI Clock (beats not seconds)
3. What if one device is not on a time grid?
4. What if one device is not music? Film?
5. Film Industry uses SMPTE (seconds & frames)
6. MIDI Time Code (seconds)
7. Transport modeled using MIDI Machine Code



MIDI Clock Synchronization

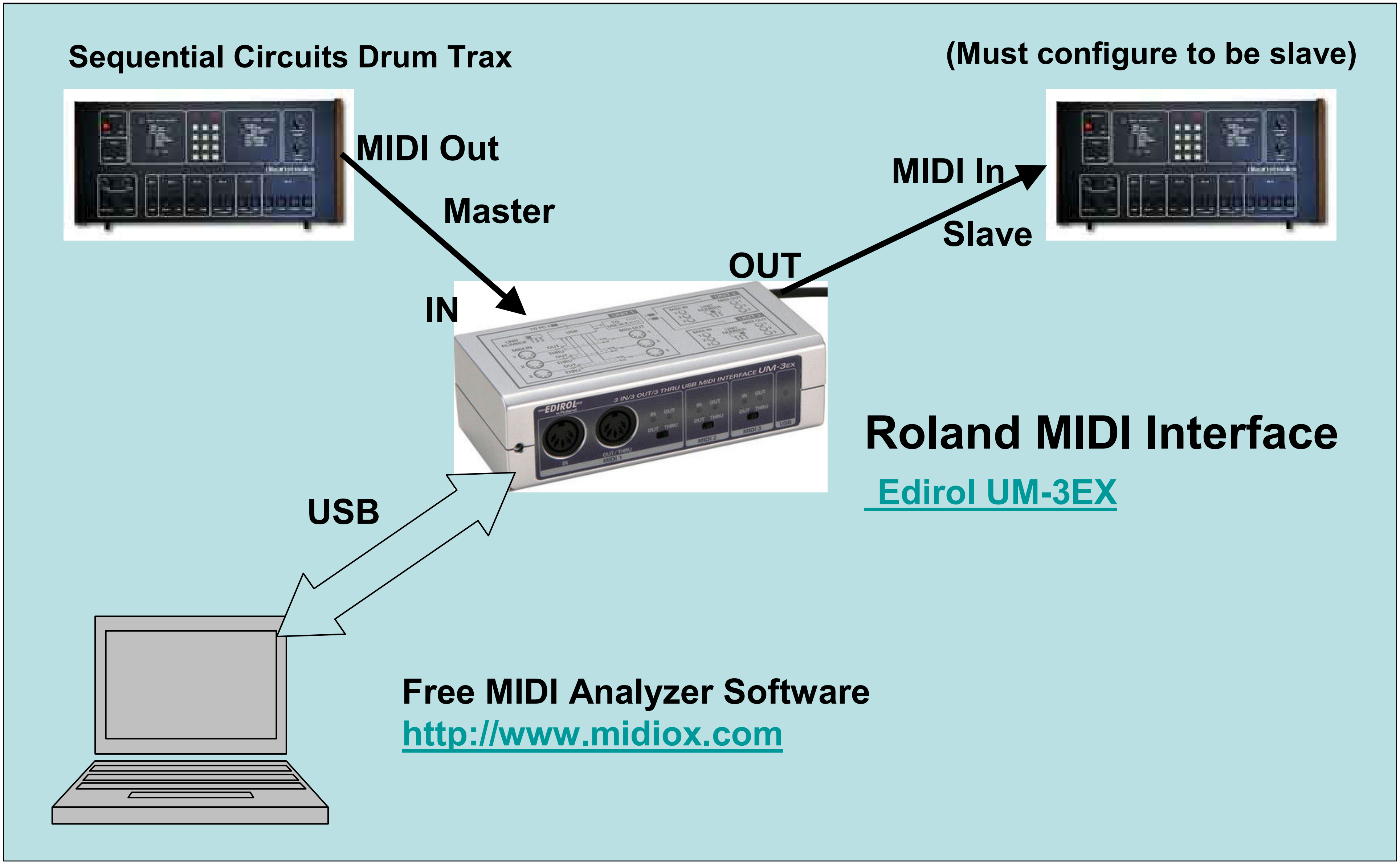
Sequential Circuits Drum Trax

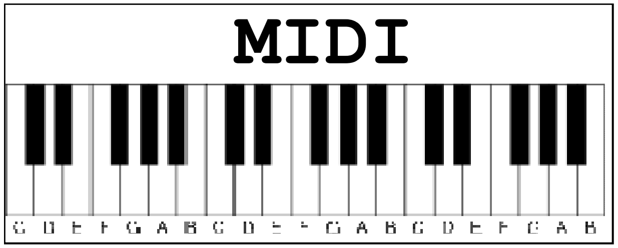
(Must configure to be slave)



1. MIDI Clock is 96^{th} notes.
2. May also see MIDI Song Select or MIDI Position.
3. Not Real Time (seconds)
4. Does not make sense when sync'ing to non-music (e.g. film)
5. Master must be a music thing or you'll have complex configuration.
6. Works with ProTools etc.
7. Works with ADATs etc. (ADAT master or slave)
8. Does MIDI Clock have a MIDI Channel?

MIDI Clock Experiment



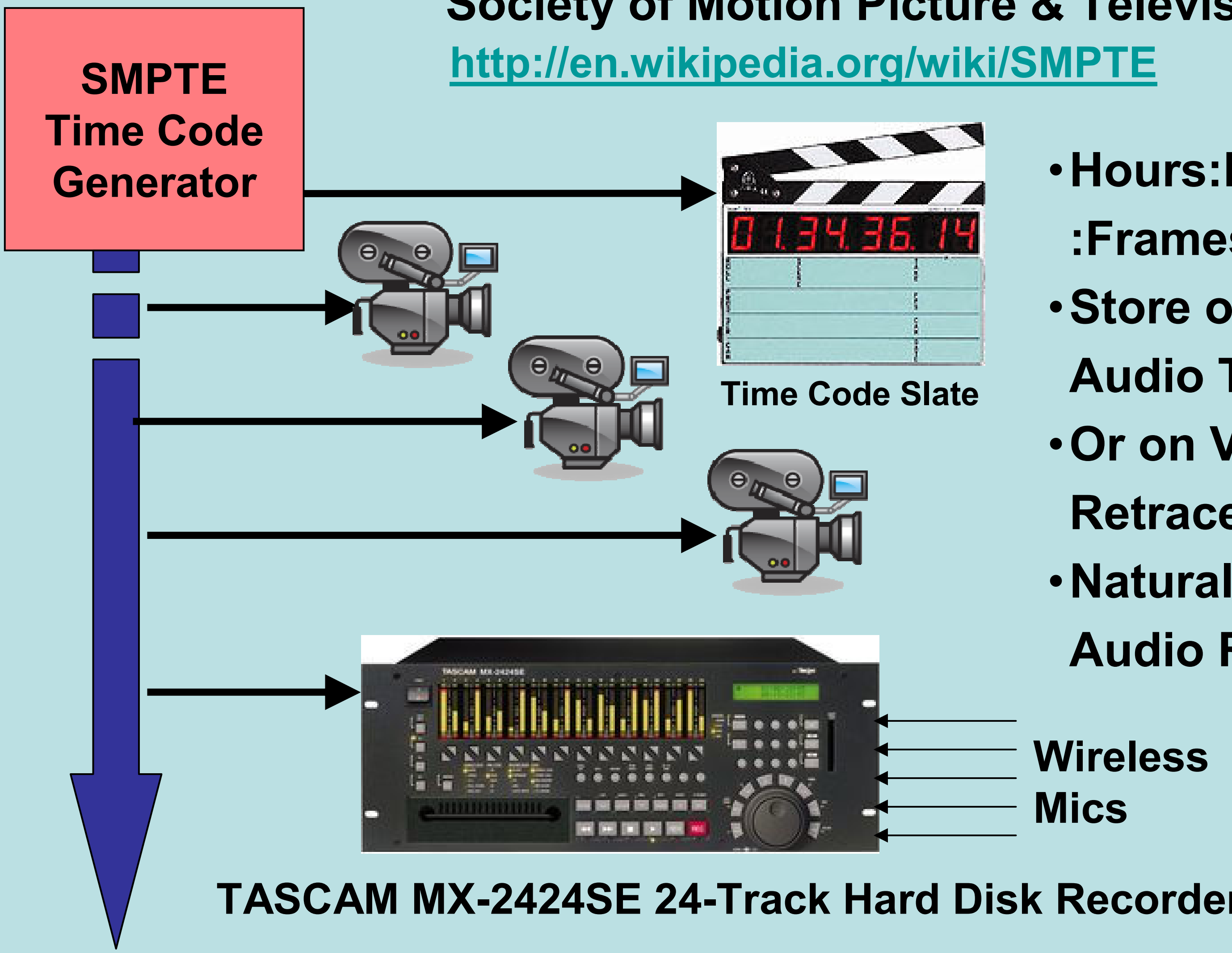


Film

(Real Time/Seconds & Frames)

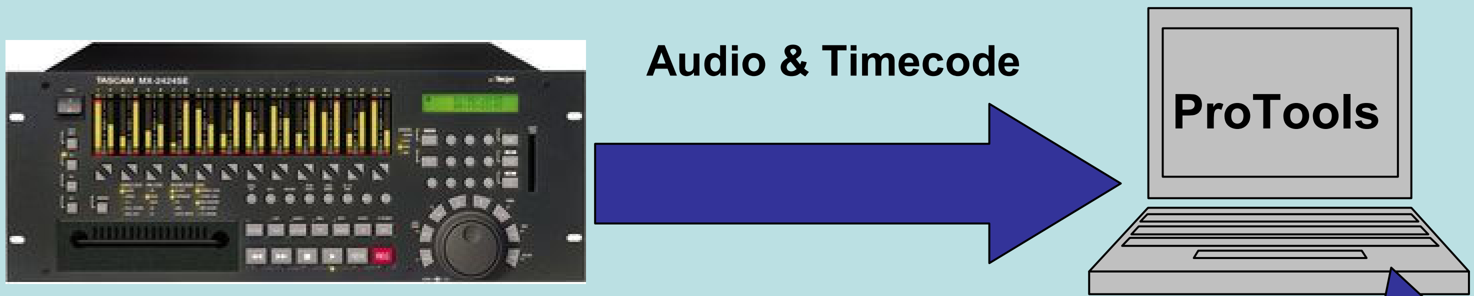
Society of Motion Picture & Television Engineers

http://en.wikipedia.org/wiki/SMPTE



- Hours:Minutes:Seconds :Frames
- Store on Video Camera Audio Track
- Or on Video Vertical Retrace
- Naturally part of Digital Audio Recorder

Film Editing
(Real Time/Seconds & Frames)

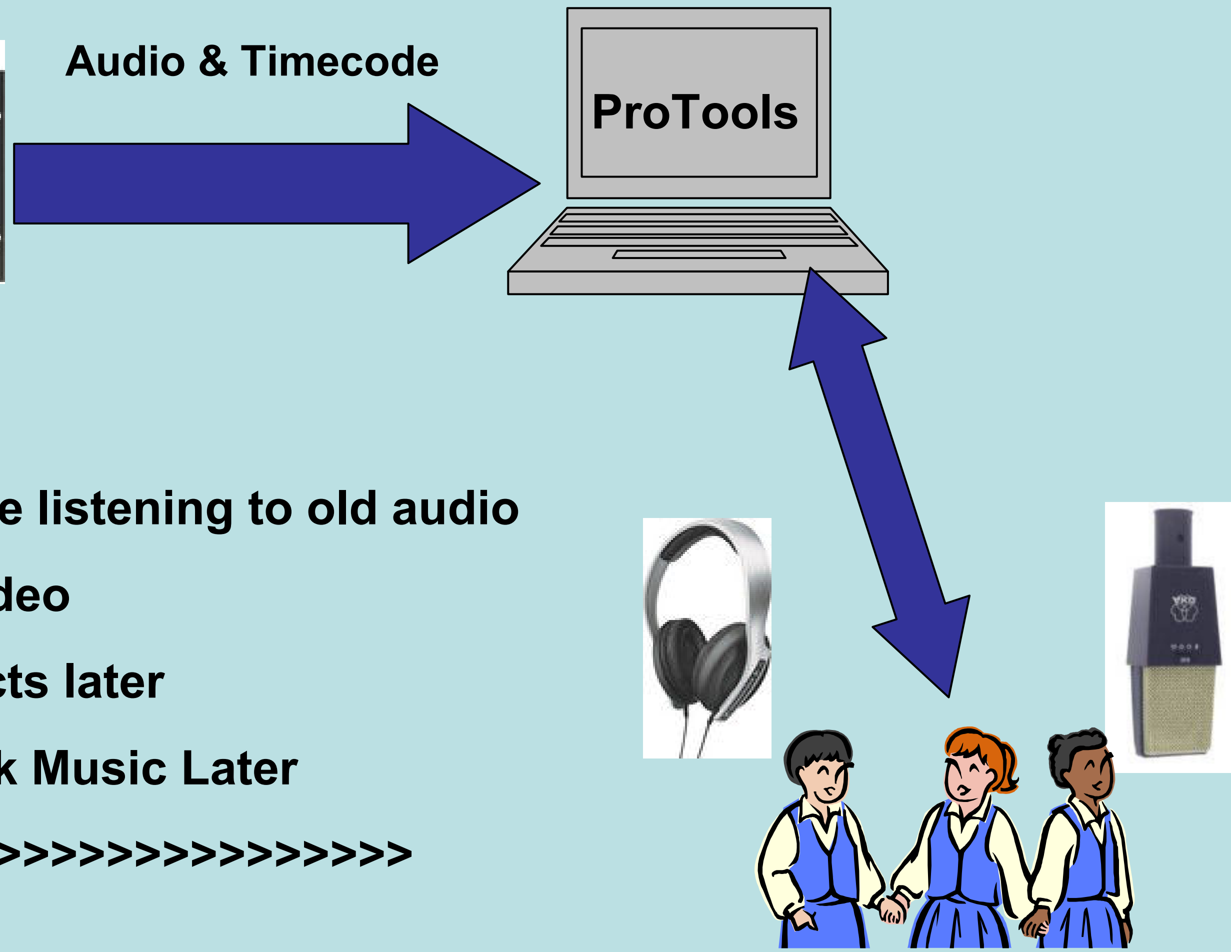


- Overdub new audio while listening to old audio
- Remains in sync with video
- Combine w/ Sound Effects later
- Combine w/ Sound Track Music Later

MIDI

MIDI Time Code

(Real Time/Seconds & Frames)



- •Overdub new audio while listening to old audio
- •Remains in sync with video
- •Combine w/ Sound Effects later
- •Combine w/ Sound Track Music Later
- •MORE TO COME>>>>>>>>>>>>>>>>>>>>>>>>

Mastering

- What is it?
- My mix is good already, isn’t it?
- Science or Black Art (versus mixing)?
- Do I have to mix differently if I’m going to master the CD?
- What mix format should I bring to the mastering session?
- Does Anthony really know anything about mastering?
- Who is the best mastering house in the area?

Who does it?

- Airshow Mastering does the mastering for the Dave Mathews Band and is located in Boulder near Wind Over The Earth

  http://www.airshowmastering.com/frame.html

- Anthony mixed a cut for Francesco Bonifazi (Jazz Whistler) which was mastered with the other CD cuts by David Glasser at Airshow. No changes.

Mastering

Typical Recording Process

SONG 1
1. Record Groove
2. Record Overdubs
3. Mix/Effects
4. Master

SONG 2
1. Record Groove
2. Record Overdubs
3. Mix/Effects
4. Master

SONG 3
1. Record Groove
2. Record Overdubs
3. Mix/Effects
4. Master

SONG 4
1. Record Groove
2. Record Overdubs
3. Mix/Effects
4. Master

1. **Master Collection so songs sound like they're from the same session.**
    - **Normalize**
    - **Fix mix mistakes**
    - **Final compression and/or multi-band compression**
    - **Add Ambience**
2. **Adjust Relative Volume of Collection.**
3. **Define the order of songs.**
4. **Adjust spacing or cross fade between songs.**

Mixing Tips

1. Get a good arrangement (you can't fix everything with mixing and mastering)
2. Don't be afraid to hire someone with skills you don't have (e.g. horns).
3. Don't be afraid to eliminate some audio or tracks etc.
4. Consider double tracking vocals and horns.
5. Don't overuse EQ.
6. Use EQ cut versus boost when possible.
7. Roll off the bass on everything but kick and bass.
8. Don't overuse reverb.

Mixing Tips (continued)

9. Use effects to put different instruments in different spaces or to distinguish instruments:
    - Claves with tons of reverb
    - Flanging on non-groove guitar
10. Use pan to put different instruments in different spaces.
11. AM Radio is mono. Phase issues?
12. Compress solos and vocals
13. Use a master compressor (in master section of mixer) to make things louder and to optimize the vocals versus the groove.
14. Save the Multi-Band Compressor for Mastering step.

What’s wrong with my mix?

1. Now that I’ve done the mix, I don’t like the EQ. I’m afraid to mix again.
2. The EQ on song 3 is lots different and sounds like it doesn’t fit.
3. Song 4 is too soft.
4. My mixes are not as loud as a commercial CD.
5. My mix doesn’t seem to have enough blend.
6. I need more ambience. Too sterile.

Mastering

Anthony's Mastering Steps

1. Normalize each song.
2. Apply Multi-Band Compression evenly.
3. EQ Steady State for average song or per song.
4. Tune Multi-Band Compressor for Transient
5. Add Ambient Reverb if needed.
6. Order songs and place rough Track Markers
7. Tune gap and cross-fade between songs
8. Adjust the Relative Volume of songs by turning some songs down or compressing some songs.
9. See Samplitude Master: http://www.samplitude.com/eng/sam/uebersicht.html

Mastering

Room Tuning – Why?

1. Portable Mixes & Mastering
2. Overall Better Sound
3. Prevent Speaker Blowout
4. How to use SubWoofers

Room Tuning

Presentation:

http://anthonywalkermusic.com/Education/MixMagazine/RoomTuningBobHodas/mix_webinar_short_final.pdf

http://anthonywalkermusic.com/Education/MixMagazine/RoomTuningBobHodas/MixMagRoomTuning.mp3

See Also:

- http://www.bobhodas.com/ and http://www.mixonline.com
- Smaart or Spectra Foo (Much Less Expensive than SIM)
- Prefer Smaart
- Earthworks M30 calibrated microphone