Live Sound for Small to Medium Size Venues

Video 1 – Background and General Information

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Four Part Video Series

1. Background and general overview (this video).
2. Sound distribution – Speaker Systems.
3. Sound capture – Microphones and Direct Boxes.
4. Electronics – Mixing, Effects, Power Amplifiers.

Small to Medium Size Venue

- Small – up to 150 people.
- Medium – 150 to 500 people.
- The same basic principles apply to larger venues, but the equipment required is different, we will focus on equipment for medium and smaller venues.

Who this Video Series is Designed for

- Sound people, selecting, setting up and running the sound system.
- Artists who perform through a sound system.
- Venue owners/managers.

My Expertise

- Live sound since the mid eighties.
- At one point I was doing 2 to 4 gigs a weeks, 48 to 50 weeks a year.
- In the last few years, I have done sound for the two stages at the Falcon Ridge Folk Festival and been one of the sound people for the Me & Thee coffeehouse.
- I have studied live sound - read books and articles, watched videos, worked with other sound people.
- Technical background, degree in physics and worked in technical positions in the computer chip industry for 40 years.
- Worked with all genres for both indoor and outdoor venues and up to 2,500 people.

Objective of A Sound System

- Capture an artist's performance and distribute it out to the audience so a larger audience can enjoy the performance.
- A singer/songwriter can play acoustic guitar and sing for a dozen or two dozen people but beyond that they will be strain to provide enough volume.
- Even with small groups the artists must be good at matching volume, strumming guitar and singing, sing louder, finger picking guitar and singing, sing softer.

Four Elements of a Live Sound System

1. Capture – microphones and direct boxes.
2. Process – mix board, EQ, compression, reverb/effects.
3. Amplification – sound system power amplifier.
4. Distribution – speakers.

Two Types of Elements

1. Electrical – electrical signal in, electrical signal out, generally don't have a "sound" to them.
2. Electromechanical – electrical signal in, mechanical component creates sound or sound in, mechanical component generates electrical signal out, effect the sound.

What Determines How A Sound System Sounds

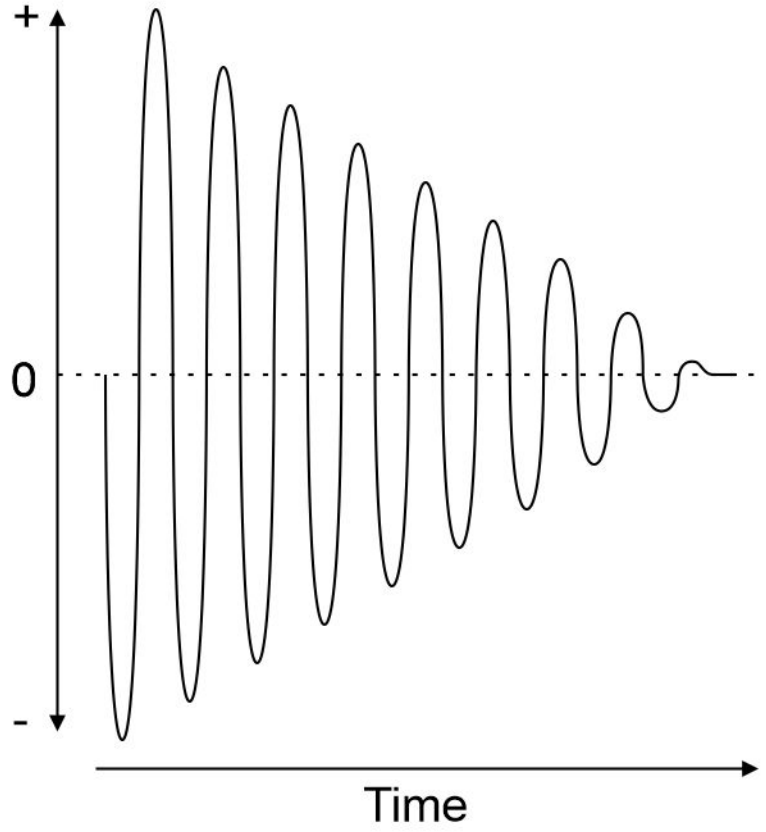
1. Speakers – electromechanical components that change the sound and everything goes through them.
    1. Room – speaker interactions – room dependent.
2. Microphones – electromechanical components but generally only pick up individual vocals or instruments.
3. Electronics.

What is Sound

- Sound is a vibration that travels through the air, sound also travels through solids and liquids but for our purposes we are primarily concerned with sound in air.
- Sound has a frequency, how fast is it vibrating in cycles per second otherwise known as hertz. Lower frequency is low pitch, bass, high frequency is high pitch, the shimmer of cymbals.
- Sound has amplitude, how loud is the sound.
- Sound has phase, how the sound waves line up, phase differences can increase or decrease amplitude.

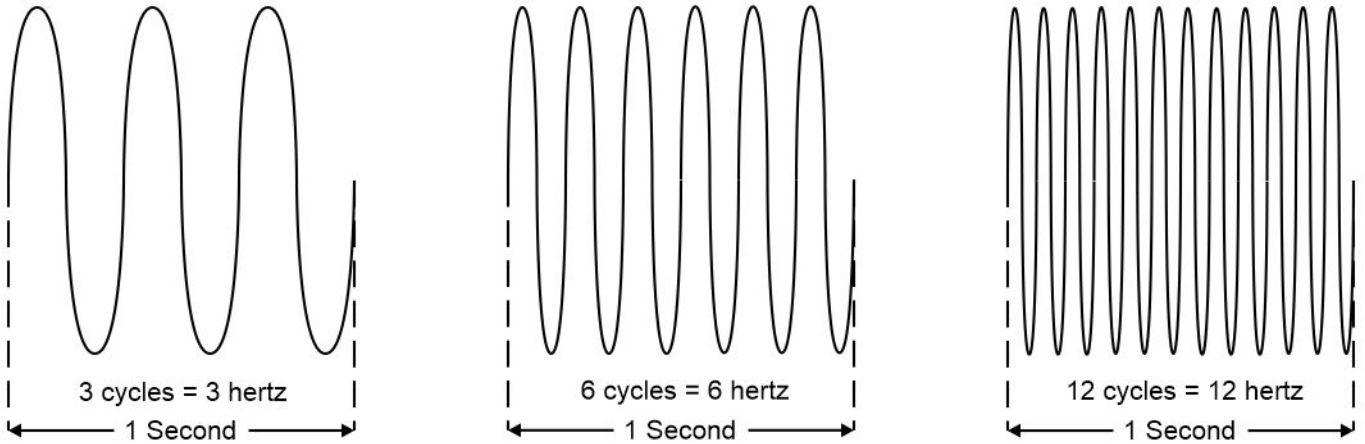
Frequency

- The head of a drum is stretched tight, strike the head and it will move down and then up through the neutral point where it started and move up.
- Each down, neutral point, up, back to the neutral point is a cycle.
- Over time the cycles die out.
- The graph on the right shows the position of the drumhead versus time.



Frequency 2

- Frequency is how many cycle per second a sound wave completes.
- Cycles per second are described as hertz.
- In the figure below, 3 cycles in 1 second is 3 hertz, 6 cycles per second is 6 hertz and 12 cycle per second is 12 hertz.



Range of Human Hearing

- The range of human hearing is generally agreed to be 20 hertz to 20,000 hertz (also know as 20 kilohertz, kilo = thousand).
- Practically speaking there is very little music below 40 hertz and most people don’t hear much above 16 kilohertz, focus on that range.

Sound Frequencies

Frequency (Hz)	Musical Content
20 to 40	Very little musical content, felt more than heard
40 to 80	41Hz is the lowest bass note, the thump of bass and kick drums lives here
80 to 160	Low end of instruments, vocals above 100Hz, crowded range
160 to 320	Low end of instruments, crowded range
320 to 640	Boxy or muddy sound if too much
640 to 1.28K	Honky, boxy, nasally vocals if too much
1.28 to 2.56K	Moves sound forward or back, vocal presence, too much at the high end is fatiguing.
2.56 to 5.12K	Edge/bright, not enough is dull
5.12 to 10.24K	Brilliance, presence, add to make vocals less dark and stand out
10.24 to 20.44K	Air, brilliance, boost unless de-essing, too much boost raises hiss and is fatiguing.

Instruments and Vocal Ranges

- The chart on the right presents fundamental frequencies and harmonics for selected instruments and vocals.
- See also our Musical Frequency Chart with Equalization Notes available on our web site page listed at the bottom of this page.

Instrument/ Vocal	Fundamental frequency range (Hz)	Harmonics (Hz)
Bass Guitar	40 - 400	400 - 8,000
Drums - Cymbals	315 - 1,250	1,250 - 20,000
Drums - Kick	40 - 630	630 - 10,000
Drums - Snare	100 - 400	400 - 12,500
Drums - Toms	80 - 630	630 - 8,000
Guitar - Accoustic	80 - 1,600	1,600 - 6,300
Guitar - Electric	80 - 1,600	1,600 - 6,300
Human Voice - Female	80 - 1,000	1,000 - 10,000
Human Voice - Male	315 - 6,500	6,500 - 20,000

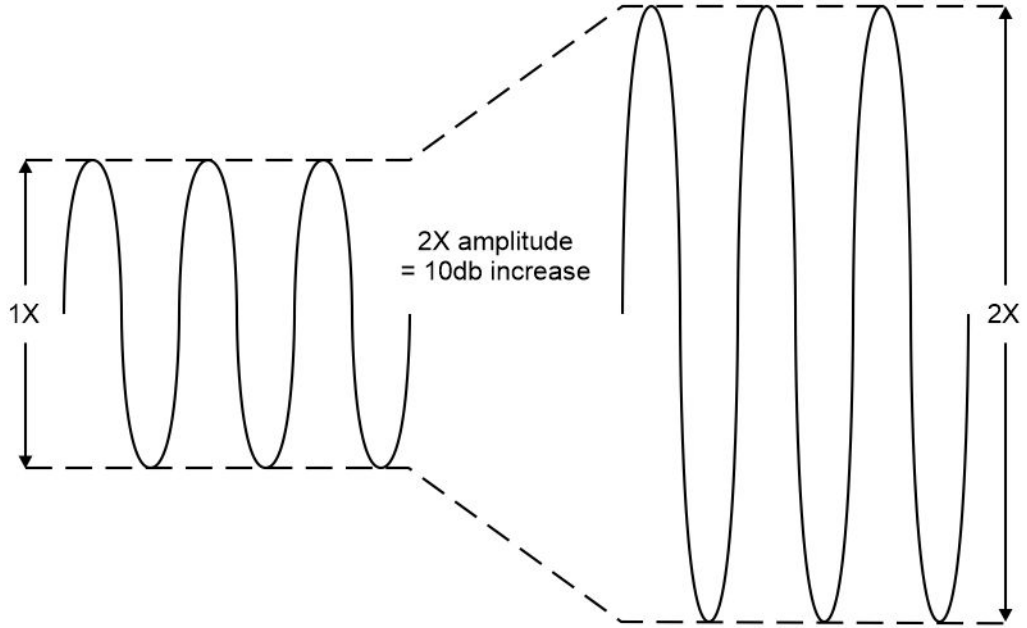
Sound Levels

- Sound levels are measured in decibels (dB).
- Decibels are a log scale ratio of a sound level to a reference level.
- Double the loudness is 10db
- Audio Tools by Studio Six Digital is an inexpensive app that can run on an iPhone or iPad and perform many useful audio measurements including sound level.

Sound level (dB)	Sound
190	Loudest possible sound
180	Rocket launch
170	
160	Shotgun blast
150	Fire crackers
140	Threshold of pain, front row Rock Concert
130	Jet engine
120	Siren, loud bar band
110	Power saw or mower
100	Helicopter
90	Hair dryer
80	Vacuum cleaner
70	Noisy restaurant
60	Conversation
50	Quiet office
40	Refrigerator
30	Library
20	Whisper
10	Breathing
0	Threshold of hearing

Sound Levels 2

- If you plot out a simple sound wave.
- An increase in amplitude is an increase in height.
- A 2x increase in height (amplitude) is 10db.



Sound Level Safety

- Safe hearing levels depend on duration as well as level.
- 85db is safe for 8 hours, for every additional 3dB the safe duration time is cut in half.
- Many concerts exceed 100dB and a single concert can damage your hearing.

Sound level (dB)	Safe duration (hrs)
97dB	0.5
94dB	1
91dB	2
88dB	4
85dB	8

- I wear ear plugs to concerts to protect my hearing:
  - Foam ear plugs have poor fidelity and make sound – sound muffled cutting off the highs.
  - Etymotic Research make better ear plugs but they still sound somewhat muffled.
  - The best option is custom fit ear plugs that sound like you turned down the volume maintaining the overall balance and fidelity.

Sound Levels Versus Distance

- Sound levels fall off approximately 6dB every time you double the distance.
- In the chart below the top row is sound levels 1 meter from a speaker, you want to keep sound levels below 90dB where people are sitting for ear safety, and above approximately 63dB for them to hear the music well.
- These limits mean a speaker only covers a range of distances with acceptable sound levels.
- If for example, your speakers are putting out 100dB at 1 meter, you need to keep listeners between 4 meters and 64 meters from the speaker.

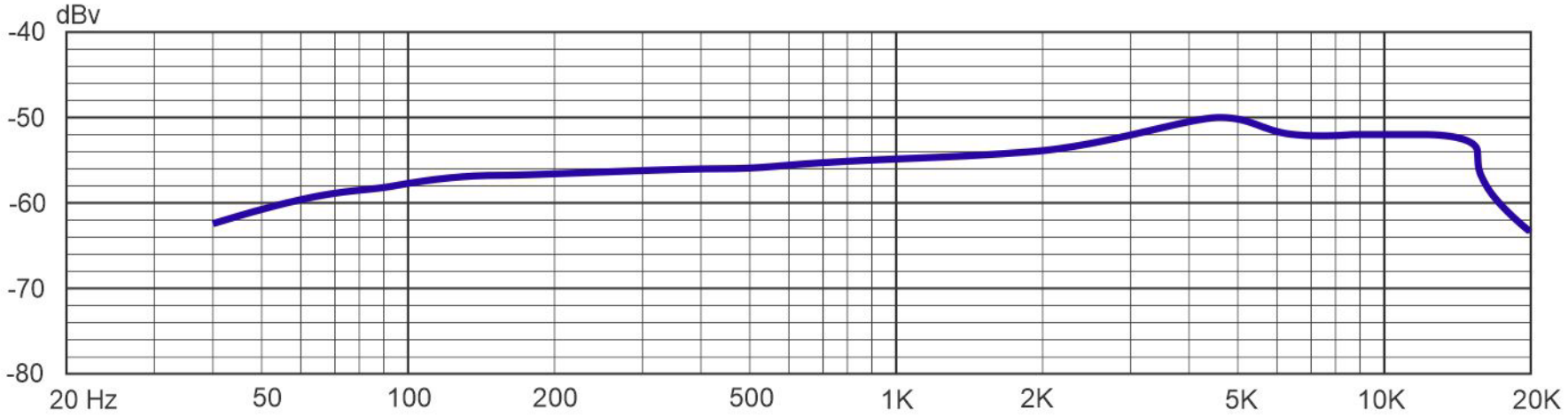
Distance (m)	Distance (ft)	Sound Pressure Level (dB)					
1	3.28	80	90	100	110	120	130
2	6.56	74	84	94	104	114	124
4	13.1	68	78	88	98	108	118
8	26.2	62	72	82	92	102	112
16	52.5	56	66	76	86	96	106
32	105	50	60	70	80	90	100
64	210	44	54	64	74	84	94
128	420	38	48	58	68	78	88
256	840	32	42	52	62	72	82
512	1,679	26	36	46	56	66	76
1,024	3,359	20	30	40	50	60	70

Frequency Response Curve

- There is a special kind of noise – pink noise that is equal energy in each octave.
- If you feed pink noise into a speaker, you can measure the speakers sound output amplitude versus frequency.
- You can also do this for a microphone or electronic component.
- The plot on the next slide is an example of a frequency plot, ideally you want it to be over the range of frequencies you are using it for. For speakers 40Hz to 20,000Hz (discussed more in the second video in this series), for microphones it depends on what you are trying to capture (discussed more in the third video in this series)

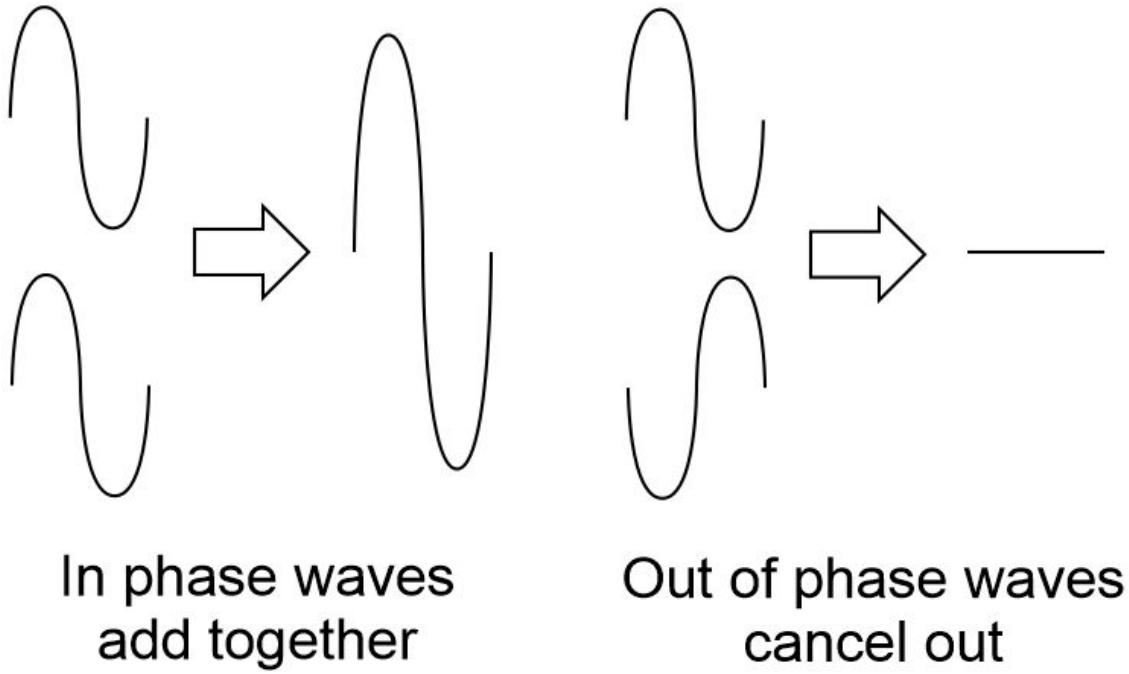
Example of a Frequency Plot

- Frequency plot for a well-regarded vocal microphone.
- The microphone picks up down to 40hz, rises smoothly to a peak between 4KHz and 5KHz where vocal brightness and presence is and then continues out to around 16KHz before rolling off.
- Frequency plots are important tools for picking speakers and microphones and identifying where a speaker or microphone may be prone to feedback.



Phase

- Phase is a measure of how two or more sound waves relate to each other.
- Waves that are in phase increase and decrease at the same time.
- Waves that are out of phase increase and decrease at different time.
- In phase waves add together, out (constructive interference) of phase waves can cancel each other out (destructive interference) if exactly 180^{o} out of phase and the same frequency.



For complex musical signals interference can increase or decrease the amplitude of individual frequencies resulting in complex interference.

Conclusion

- In this video we went over the basic background information needed to put the next three videos in context.
- In part 2 of this series we will discuss sound distribution – speaker systems and how to use them for front of house and monitoring.

Resources

- Our production page has a resource section with the presentations used to make these videos and other live sound reference material available to download.
- https://scottenjones.com/production/