A Basic Guide to Sound Systems

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Let us begin right off. **This document is not a technical manual**. The purpose is to bring to light the basics of setting up and operating a sound system for your performance group. The emphasis here is on Vocal Jazz performing ensembles, but the applications can be applied to any sound system set up for any kind of performance.

What is Sound?

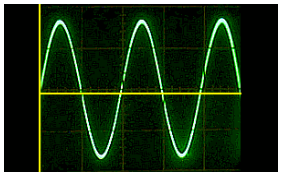
If a Tree Falls in the Forest, does it make a sound?
What about the bear hiding behind it?

Sound is the **vibration of air molecules**.
Sound moves at an average rate of 1130 feet per second.

Sound moves in waves similar to the way a pond will ripple when you drop a pebble into it. The concentric rings can be a visual display to what sound waves might look like.

Humans (and some musicians) perceive sound using their ears as a transducer to turn a sound wave into an electronic signal. By vibrating the tympanic membrane in the ear, a sound wave creates an electric current and routed to the brain, which says, "I hear something, I should listen louder".

Each pitch or tone that we hear can be identified by the rate at which it vibrates the air molecules around it, referred to as frequency. Measured in cycles of sound per second, or Hertz (Hz). When you reach 1,000 cycles of sound per second or more, we use Kilo Hertz or (KHz).



Typically, a piano is tuned to A-440. Which means, the A above Middle C on the piano is tuned to 440Hz. If you apply logic, moving up one octave, the next A becomes 880 Hz; moving down one octave, it would be 220Hz.

Listening vs. Hearing

Are you listening?? My mom never could tell.

Hearing is the physiological experience of our ears collecting auditory information. An example of hearing is when we sit in a classroom and there is ancillary noise going on. Things like the air handling system, or the fluorescent lights. We hear these things and our brain prioritizes them as background noise as we have no reason to truly listen to them.

Listening is the art of actively hearing what is going on in one's surroundings. We use our listening skills when we hear a recording of our favorite group or are trying to replicate the sound of Mr. Rogers piano. We listen to selectively and purposefully pick out nuances in music, like a voice just a bit too loud, or an instrument that we can't quite hear enough of.

Critical Listening is developed over time, with practice and repetition. Being able to reinforce, as accurately as possible, instruments and voices. To know inside your head what things are supposed to sound like, then to replicate that sound regardless of equipment brand, acoustic situation, or state of repair. We know that the performers are giving their all - so should the sound technician.

Sound Equipment includes but is not limited to:

Microphone

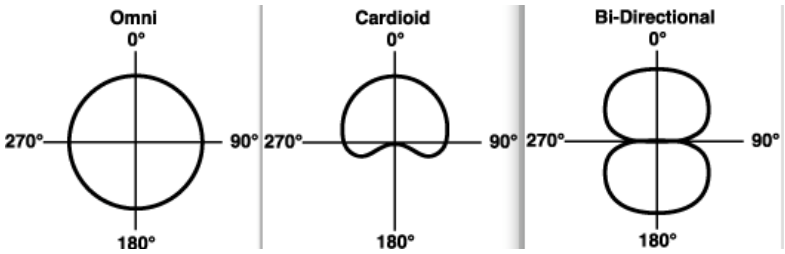
…Is a transducer that converts sound into an electronic signal. This is achieved by vibrating a Mylar diaphragm inside a magnetic field, creating an electrical signal. This signal is an amazingly small .008 volts.

There are 2 types of microphones:
Dynamic- requires no power supply to generate the signal.
Condenser- requires a DC power supply (battery or Phantom Power) to activate a charged electrical plate below the diaphragm. This increases microphone sensitivity as well as frequency response.

Pick up patterns:

1. Omni-directional
2. Cardioid
3. Bi-directional

Either type of microphone comes available in any of the pick up patterns.



Microphones: Choices and Placement

Handheld/Solo/Individual:
A handheld microphone should be held 2 fingers from the lips, with the microphone angled 60 degrees down like an extension of your chin. The sound is sung over the top of the microphone ball to minimize the popping "P" and bopping "B" through the system.

Group/Area Micing:
The 3-1 rule applies here. [For every 1-foot away from the sound source, you want to have 3 feet of space between microphones, to avoid phase cancellation] If you use 3 choir risers, place a microphone stand on each crack between them (total 2) with the boom extended to approximately 7 feet, with the microphone looking down slightly. (refer to stage setup on page 9)

Cabling 1

The cabling required to connect your system together is equally as important as the gear itself. Each connection uses cabling designed for a specific function, and we will define the differences and reasons.

Microphone cable = 3 pin XLR connector usually 22 gauge wire, 2 conductors plus shield. This cable is designed for the type of current that a microphone provides in your sound system.

Snake = Multi Channel Extension cable for microphones - usually XLR inputs and outputs. Snakes will have a head or box, located on stage, for your microphone cables to plug into. The other end of the snake is called the fan, or collection of numbered, separate XLR cables to connect into your mixer.

Patch Cable = ¼" phone plug connector on each end, found either in Tip/Ring/Sleeve (TRS) balanced, or Tip/Sleeve (TS) unbalanced configuration.

¼"Phone Plugs

XLR Female/Male

Speakon

Board / Mixer / Console / Desk

A mixer is a routing device for each microphone or line level input device (i.e.: CD player, recording device, keyboard, electric bass, etc). The mixer allows each input to be manipulated in tone as well as determine how much or how little of each input will go to each allotted output, whether it is for the main speakers or monitors on stage, or even a recording. Mixers operate at line level, where the signal ranges from 1.0 to 1.25 volts.

Equalizer

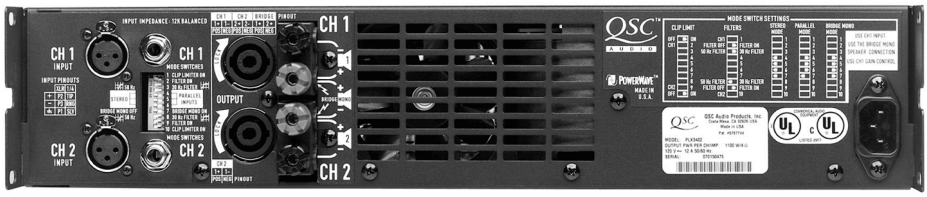
Just like your home stereo, an equalizer (or EQ) provides tone controls.
Bass- if you boost this, you get boom, boom, boom
Treble- if you boost this, you get ssht, ssht, ssht

There are 2 types of equalizers that we will discuss here: Graphic and Parametric. A graphic equalizer is just what the name implies; a visual representation of the frequencies that have been cut or boosted. A parametric equalizer usually has 5 bands for adjustment. Within that you can choose a specific frequency for each band, and how much of it to boost or cut. An EQ is also a lines level device, operating at 1.0 to 1.25 volts.

The primary purpose for an EQ is to eliminate feedback.

Power Amplifier

An amplifier is a device that makes an electronic copy of the signal being generated, only with higher voltage and current. This voltage and signal is sent to the speaker that it is attached to. The increased voltage and current drives the speaker. Speaker level voltage is roughly 3-150 volts.



Cabling II

Speaker Cable - Speaker cable carries a larger amount of voltage than your patch cables and should not be used interchangeably. Speaker cables come in much larger sizes, or gauges, due to the higher quantity of electrical signal being carried from the amplifier to the speaker. Monitors on your stage, and Main speakers use the same types of speaker cables, but depending on the amplifier power and speaker capability, the gauge of speaker cable may vary. Gauge of speaker cable ranges from: 10 gauge to 12, 14 and 16 gauge. The smaller the gauge number, the larger the cable diameter. Speaker cables can come with different types of ends: MDP dual Banana connector, 1/4" phone, or Speakon connectors.

Speakers

In its purest form, a speaker converts the electronic signal back to a sound wave. Speakers are split into 2 parts, a tweeter and a woofer. The tweeter is where the Mid/High frequencies are reproduced. The woofer is where the Mid/Low frequencies are reproduced. The Mid/Hi frequencies become more directional as the frequency rises. We see that horns are implemented on speakers to help direct this energy to the desired listening area. Be conscious of having the power amplifier and the speaker rating similar, to reduce your chances of under or over powering your speaker, causing damage to your cones or voice coils.

Full Range Main Speaker

Floor Monitor

How Do I Setup This Thing?

Developing an order to your chaos will assist you in getting your sound system into the performance space, set up correctly, and ready for sound check and performance. Prepare in your mind the procedure for a load-in, setup of gear, and execution of the performance. The sound technician and the director will establish locations and preparations for equipment, cabling and electrical setup. The outline as listed below will help you to succeed in preparation for and execution of a performance.

a) Power – find clean, reliable electricity source on same circuit for all gear (stage amps, keyboards, etc. and mix position)
b) Location, location, location … establish setup on stage or performance area, with regard to position of rhythm section, singers, and speakers. Lay out a path for snake and cabling runs, and determine mix position in audience.
c) Load-in … get the gear off the truck, get it in place. (use your gig assignment)
d) Execute setup … pull power, run snake, build stage setup.
e) Add mix position in audience, connecting your mixer to snake, EQs, etc.
f) Check all your connectors, start from the microphones and work your way back. Then turn it on.
g) Around the world – check each microphone for functionality. Check monitor mixes one at a time, then check your house mix to make sure they work and that you have proper control over them.
h) Start your sound check. Balance and blend singers first. Add instruments one at a time, then run portions of tunes to balance stage monitors. (EQ)
i) Add main speakers to establish sound in space to deal with quality, quantities and balance of the mix. (EQ)
j) You should practice this event with the same importance as you would a new song.

X X X X X X X X X X X X

Drums on outside of Rhythm Section for maximum separation
Microphones in front of risers
use 3-1 rule for micing choir

An Equalization procedure

The Primary Purpose for an equalizer is to eliminate feedback.

I. Ring and Run.

After your system is completely patched together and powered on, you would turn all of the microphones on, with the monitor mix down. Bring the monitor mix up slowly until feedback begins. You will need to identify and eliminate the feedback for each frequency that is ringing. Is it a high tone or a mid tone or a low tone? By moving the matching EQ slider down, you can identify the tone of the feedback and eliminate it. With practice, this comes faster and easier to you. Make sure that you know where to stop. This usually happens when you have sufficient headroom, or gain before feedback. Remember that less is more – we're adjusting the sound energy to work within the room's acoustics.

II. Pink Noise with a real time analyzer.

As we talked about before, make sure all systems are go. Microphones on, and slowly bring up the pink noise in the desired mix. The analyzer will visually demonstrate the curve of the actual frequencies active in the room. You want to attenuate the level for each frequency that is drastically over the 0 (average) mark on the analyzer. You might try to cut 4 or 5 frequencies and then listen to the system and move in small steps from there. Keep in mind, that this tool is just that – a tool. No machine can make up for active listening in the venue, and the sound system must be musical while keeping a natural sound. The end result should be a relatively smooth line visually, not necessarily perfectly flat.

Note to self

The less changes that you make to the equalizer, the more natural the sound is going to be to your audience. After all, the job of the sound technician is not necessarily to amplify the sound, but more importantly to reinforce the performance happening on stage.

To identify the fundamental frequency and its harmonics, and you will have an educated guess as to where to go. Don't forget to stop when it is musical, not necessarily pretty. It has been my experience that if there is a smiley face or the bell curve as the front of house EQ, there is mostly rough guessing going on and less critical listening.

The Sound Wreck …I mean Check

This is the only time in the performance when the sound technician and the artist(s) can speak in complete sentences. The sound check is not a rehearsal. Our goal is to achieve balance and blend for each of the mixes, and establish the limits of the system in the room while maintaining a musical environment.

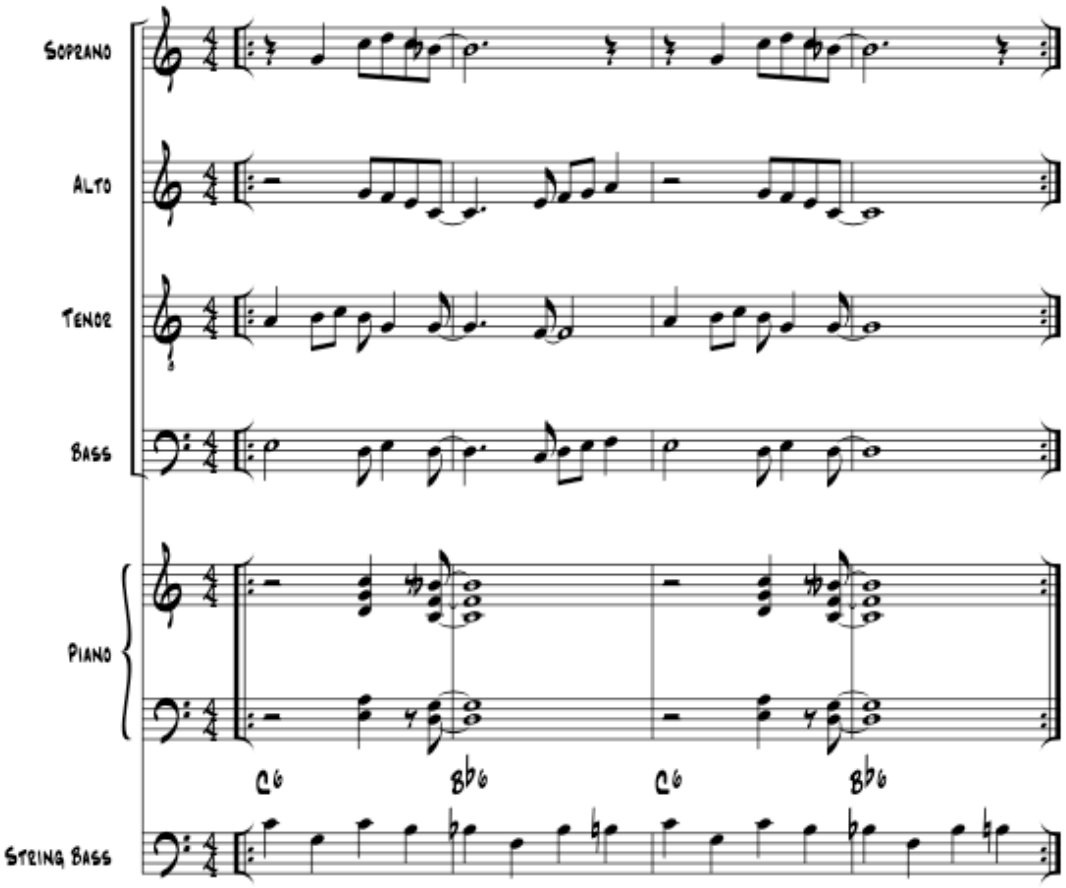
1. When all of the equipment is patched and powered, go around the world checking each mix for functionality and quality of sound. Then, you should invite the singers on stage and go down the line, checking each microphone to ensure that each microphone works. The point of this is purely functionality.
2. Sing by section, (SATB) a short riff (see next page) to begin balancing the voices in each monitor mix, one at a time. Each section should sing alone until there is a section blend and balance. Put together the 4 sections and blend musically.
3. Singers should perform part of an a-cappella tune as a group to make sure that all parts are represented and no one singer is pushing or holding back.
4. Add the rhythm section one instrument at a time to the monitor mix; piano, then bass, then drums.
5. At this point, you want to perform a medium tempo tune with all voices and instruments together. Check for balance between the voices and the instruments.
6. When you have achieved the blend and balance that you want on stage, add the main speakers to the sound check and make adjustments to the stage as needed.
7. At this point, listen to tunes with large dynamic contrasts as well as solos and features, to ensure proper balance and quality of sound through the different music being presented.

Remember:
It is not about listening for the individual voice, but the ensemble sound that is important. The sooner that all performers are comfortable in their performance space, the sooner the real music will come out.

See the Riff on the next page.
You may photo copy and have all of your singers and players learn it.

SOUND CHECK RIFF

KIRK MARCY



Use Syllables in cluding bu t not limited to:
Nu Nu Nu
Doo Doo Doo
2 2 2
Ba-yah-ba-dah
dool-ya doo dot

Have fun with this!!!

A Few Mixing Techniques

Our goal as a sound engineer is to accomplish a balance and blend of the ensemble, instruments and soloists to ensure a cohesive performance.

We want to achieve the maximum amount of headroom in the system while minimizing electronic noise. By driving the amplifiers ¾ to fully open, and keeping the mixer and EQs at their nominal levels, we can achieve full range clean sound with a minimum of noise. Overcoming signal to noise ratio issues will sometimes require adjustments to this formula – i.e.: notch down the amplifiers a bit and increase your EQ and/or mixer outputs to compensate. Again we are trying to maximize efficient clean sound by balancing the equipment levels appropriately.

Your mixer will likely have a minimal EQ on each channel strip. It is in your best interest to leave these EQs as flat as possible and adjust EQs based on the system, not the singer. The flip side to this is that channel EQs can be used to compensate for a mis-sounding microphone or instrument – not to adjust a vocal quality or quantity.

When mixing, pay attention. Can you see the director? If not… get your face out of the board and look up. The director holds the cards to what comes next.

It would be wise for your ensemble to rehearse the setup procedure and gig assignments for setup and put-away of all equipment so everyone is as familiar with this as the music itself. A rehearsal spent productively practicing this routine will ensure efficiency through the year.

Troubleshooting

This is the thing that I do the most of in my life. If you have a clean environment to work in, you have a chance to find the problem quickly and fix it. Many times the simplest fix is the low tech fix. Is it turned on? Or is it plugged in?? Being able to go from point to point in the sound system, you can check each connection or input one at a time to learn what is not the problem. You might practice having sound system crash day by having someone who does not know how to do anything come in and help set up. You have the opportunity to learn what you do or do not know in a hurry.

- Use a logical format.
- Think low tech.
- Making a neat and tidy setup will help immensely.
- Know what goes on in the system.
- Make good judgements.
- An educated guess is somewhere to start.
- Don’t run, it will still be on fire when you get there. It only causes panic.
- Practice having a breakdown and find a way to make it work.
- We don’t always get our way.

- The more that each member of your group can communicate with you in the same technical language, the better you will be. "the thingy thing, that plugs into the boxy thing … is not working…there is no sound out of the monitors, I can't hear myself, just the tenors."
- A little education goes a long way.
- Practice setting up and taking down the equipment. It is a good investment.

Press any key to continue.

Audio Glossary

Amplitude
The height of a waveform above and below the zero line on an oscilloscope.

Auxiliary
(Fold backs, Cues) Generally used to provide auxiliary mixes separate from the main mix. These can be used for anything the sound tech wishes, such as stage monitors, effects, or recording.

Attention
The thing that you should pay. When you cannot afford anything else.

Balanced line
A line using two conductors to carry the signal, neither of which is connected to the ground, and both of which are out of phase with each other. Requires two conductors plus a shield wire. Good for long distance cable runs with a minimum of noise and static interference pickup.

Bi-directional pattern
Figure 8- a pattern, which has the maximum pickup on axis and 180 degrees off axis, and a minimum pickup at 90 and 270 degrees off axis

Cardioid pattern
A heart shaped pickup pattern. Sometimes called Unidirectional. Picks up most in the top of the mic, and less as you go around the microphone until there is none at the back of the mic. Excellent for stage applications with the pattern rejection (shadow) allowing Monitor levels to be appropriate before feedback.

Close proximity micing
Placing a mic close to the sound source in order to pick up mainly the direct sound. And avoid picking up the surrounding area. Can be handheld or stand mounted for vocals.

Compressor
A device, which decreases the dynamic range of a signal by limiting the output.

Condenser microphone
A microphone, which converts sound waves into an electronic signal. Requires a power supply, usually battery or phantom power provided at the mixer. Typically has a wider frequency response, and a slightly lower dynamic range before clipping.

Crossover network
An electronic network found in almost all speakers that separate high, mid, and low frequencies, and sends those frequencies to the appropriate speaker driver.

Current
The actual flow of electrons, usually measured in amps

Cycle
An alternation of a waveform which begins at a point, passes through the zero line, and ends at a point with the same value and moving in the same direction as the starting point.

Decay time
The time it takes for a signal to decrease to one millionth of its original value. (60 db down from its original level)

Diaphragm
The thin Mylar element in a dynamic or condenser microphone that is vibrated by sound a wave.

Direct box
A unity gain device that solves the problem of plugging a high impedance device into a low impedance input. Will allow for high impedance through connection to a stage amplifier and the sound system at the same time.

Direct sound
A sound that reaches a microphone or listener without bouncing off any obstacle.

Distant micing
Placing a mic far from a sound source so that a high proportion of reflected sound is picked up.

Dry signal
A signal without any reverb or any added effects.

Dynamic microphone
A microphone which the diaphragm moves a coil suspended in a magnetic field to generate an output voltage (.008v) Dynamic microphones are usually very durable, and require no power supply. Dynamic microphones will usually take a higher sound pressure level with less clipping.

Equalizer
A devise used to boost or cut the level of selected frequencies. The primary purpose of an equalizer is to eliminate feedback. 2 types include graphic and parametric.

Frequency
The number of cycles of sound waves per second. Measured in hertz.

Gig Assignment
The jobs, which each member of your ensemble will be responsible for during the set up and tear down of rehearsal or concerts.

Ground
A point of zero voltage. The point of reference to which all voltage are measured

Ground Loop
Hum caused by current circulating through the ground side of a piece of equipment due to grounding it at two or more points of different voltage potential

Harmonics
Whole number multiples of frequencies. 4000Hz and 8000Hz are both harmonics of 2000Hz. They usually move in octaves or multiples of the fundamental frequency.

Headroom
The amount of room measured in decibels from the nominal level to unacceptable distortion.

Hertz
A measurement of cycles of sound waves per second.

High impedance microphone
A mic designed to be fed into an amplifier with input impedance greater than 20K ohms. Uses a ¼ inch tip sleeve connector and a cable run no more than 18 feet.

High pass filters
A filter designed to pass high frequencies and attenuate low frequencies.

Hyper cardioid
A directional pickup pattern where maximum discrimination occurs at more than 90 degrees and less than 180 degrees off axis. A very directional microphone.

Impedance
The opposition of a device to current flow. A combination of resistance, inductive reactance, and capacitive reactance. With regard to input and output impedances and connection of devices to one another. The general rule is: output impedance must be less than or equal to input impedance.

Limiter
A compressor where a ratio setting greater than 8:1

Low impedance microphone
A microphone designed to be fed into an amplifier with an input impedance of 150 to 250 ohms. Low impedance microphones are balanced. Allows long cable runs up to 5 miles.

Microphone
A transducer, which converts sound waves into an electronic signal.

Microphone pad
An attenuator placed between the output of a mic capsule and the input of a microphone pre amp designed to attenuate the signal by 10 to 60 Db.

Mixing console
A routing device which can combine several signals to one or more composite signals in any desired proportion.

Omni-Directional
A pickup pattern which is equally sensitive to sounds coming in from all directions.

Octave
A one to two frequency ratio. 2000 Hz is one octave higher than 1000 Hz, and 500 Hz is one octave lower than 1000 Hz.

Opportunity
A problem.

Pan pot
A knob on a mixing console, which distributes a signal between two or more channels such as left and right, or front and back. Short for Panoramic potentiometer.

Phantom power
A system used to supply voltage to condenser microphones. The DC current (12-48v) is sent through the same cable run that the signal flows through. Used with balanced low impedance microphones.

Pink noise
Random tone that is comprised of all audio frequencies between 20 Hz and 20 KHz being played at the same time and al frequencies are at the same level.

Polar Pattern
A visual display of the sensitivity of the microphone to sounds arriving from different directions.

Power amplifier
A unit that makes an electronic copy of the signal and boosts the voltage from 1.25 v to 3-150 v.

Reflected sound
Sound, which reaches a microphone or listener after one or more reflections off of the surrounding surfaces.

Release time
With regard to a compressor, the time it takes for the gain of the unit to return to 37% of its original value once the signal has been removed.

Reverberation
The persistence of a sound after the source stops emitting it. Caused by the many discrete echoes arriving at the ear so closely spaced in time that the ear cannot separate them.

Ribbon microphone
A microphone which used a thin metal foil ribbon which moves in a magnetic field, Usually very good sounding, but are expensive and very fragile.

Signal to noise ratio
The difference between in db between the noise floor of a device and a given level. (usually 0 db or nominal level)

Solo
To listen to one channel or mix at a time. Also can be called PFL (Pre Fader listen)

Sound pressure level
A measure of the acoustic energy created by a sound. Measured in Db.

Threshold of pain
The sound pressure level at which people feel actual pain. Approx 140 Db

Timbre [tam-burr]
The harmonic content of a tone, and the relative intensities of the different harmonics. Example: a piano has a different timbre than a flute.

Transducer
A device, which converts energy from one medium to another.

Unbalanced line
A line using two conductors to carry a signal. One of which is tied to the ground (Usually a shield) requires single conductor plus shield cable.

Unidirectional microphone
A microphone that picks up signals primarily from one direction and discriminates against or rejects sounds arriving from other directions

Unity gain
The same voltage going in to the channel is the same as the voltage coming out.

VU meter
A meter that gives the average level reading of a signal. Usually calibrated in Db. Has a fairly slow reaction time to fast transient signals. Does not measure peaks accurately.

Wave
Something that should not be done at a baseball game. The method of travel for sound. A vibration of air molecules. For example, in air at 70' F, the velocity of a sound pressure wave is 1130 feet per second.

Wet signal
A signal containing effects, such as reverb.

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