

An Introduction to Live Sound Reinforcement

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1 Introduction

In an ideal world, sound reinforcement is unnecessary. For thousands of years theater has been performed live without electronic sound reinforcement, along with orchestral concerts and other forms of live performance. However, during the middle part of the 20th century musical theater changed forever, creating a new louder type of performance requiring sound reinforcement and electrified instruments. Unfortunately, as a side effect, this eliminated the need for actors to properly project.

Audio technology is sadly an art few people understand. Many small-time sound engineers for non-professional shows fail to utilize their ears and subsequently create a mix which is substandard, even given the limited equipment available to them. The single most important tool of the sound engineer is his or her **ears** – a fact which *cannot* be emphasized too heavily.

It is also important to keep in mind that the overall quality of the mix is limited by both the equipment used and the skill of the performers. A good engineer strives to make things sound as good as they can – and knows that perfection is often an unreachable goal.

2 Overall Aesthetic Considerations

Like writing a paper or computer program, a planning period is necessary when launching into a sound project. This planning period involves both artistic and technological considerations, as well as budgetary constraints and constraints of the venue. If equipment is being purchased or rented specifically for the show, it is also necessary to research what is available.

Artistic decisions involve the aesthetics of the work. This is one phase of the process where it is important that the sound engineer hold extensive discussions with the director and, if one exists, the music director. Some of these decisions might be tied to the particular piece of music being performed (such as Hair vs. Sound of Music) as well as the music director's opinions about style. Some directors may want everything to sound "just like the CD" but it is important to remember that it is nearly impossible to make a live performance sound like a CD recorded under near perfect conditions.

Technological considerations include exploring the limits of your space and equipment. If you are going to be choosing equipment or purchasing equipment for a show, you need to research this using literature available to you. Most microphone companies publish extensive specifications and literature regarding their products and comparing these can often give you a good impression. Combine this with reviews found online or in sound magazines and you should have no trouble choosing an excellent product.

Another physical concern is that of the venue. Smaller venues require less reinforcement, but are significantly more susceptible to feedback. Ironically, often harder to get an overwhelming loud sound in a small venue because smaller venues have feedback problems. Additionally, spaces designed expressly for performances always sound better than multi-use spaces ("Cafe-Gymna-Touriums"). Although choice of a venue is not typically up to the sound designer, it is important to know the limitations of your space and relay these to the directors.

3 Wired Microphones

For the purposes of this guide, wired microphones can be divided into **vocal microphones** and **instrument microphones**. Almost all microphones used for live sound use are **dynamic** microphones, which refers to the design of the microphone capsule. **Condenser** microphones are occasionally used on-stage, and **ribbon** microphones are extremely delicate and almost never used outside the recording studio. Details are unimportant, but keep in mind that dynamic microphones are the cheapest and most durable mic technology and are used for live sound by amateurs and pros alike.

Microphone specifications consist primarily of a frequency response chart and a pickup pattern. The frequency response chart indicates how the microphone responds to sounds of various pitches. Microphones designed for specific applications may have a shaped frequency response that accentuates an instrument's sound (If this is true, the manufacturer will mention it). The microphone pickup pattern indicates any directional pickup characteristics the microphone has. Most wired microphones used for live sound are directional.

Typically for theater sound, wired microphones used for vocal pickup are **fill microphones** such as hanging choral mics or floor microphones. These microphones are typically directional in order to exclude ambient noise and prevent feedback caused when amplified sound from the house reaches the floor mics. Unfortunately, these microphones rarely do much and often cause more problems than they are worth. To avoid muddy sound, try to position the microphones so that their pickup patterns will not overlap excessively.

Although not often seen in theater, hand held wired microphones such as the Shure SM58 can be used for vocal performances by a relatively motionless performer. For a situation where this is possible from an artistic standpoint, it is always preferable due to superior pickup.

If your directors are looking for a loud show or you are doing a rock opera, you might encounter electric instruments or a pit which requires some amplification. Most microphone

manufacturers have a wide range of live sound microphones designed for instrument pickup. By consulting a manufacturer or distributor, you can determine exactly which microphones are best suited to a particular instrument.

Various instruments demand different miking techniques. Electric guitars should have a single dynamic microphone such as the Shure SM57 placed directly in front of the cabinet. Electric bass amps typically have a clean direct out on the rear of the amp which can be cabled directly into your mixing console. Violins, horns, acoustic guitars, pianos, and other acoustic instruments can all use various purpose built microphones or you can use a versatile microphone such as the SM57 on a tight budget. If you are in a large venue, it may be necessary to mic drums. Every engineer has their own technique for placing drum microphones, and the best places to look for more information are audio magazines and the Internet. From there you can work to develop your own technique, depending on how many microphones you have at your disposal. For placement of microphones on other instruments, it is recommended that you consult the microphone manufacturer's manual or website. Because of a phenomenon known as the **proximity effect**, microphones placed closer to the sound tend to have a reinforced bass response. This can be corrected at the mixing desk if a close placement is necessary to avoid feedback.

Although not technically microphones, **direct boxes** facilitate transmission of electronic keyboards and acoustic-electric guitars with pickups. The unbalanced signal output from these instruments is not suitable for transmission all the way to the mixing desk. The direct box converts the instrument signal into a balanced signal suitable for transmission over the extended distance from the band to the console.

4 Wireless Lavalier Microphones

Unfortunately, when dealing with a loud pit orchestra/band or actors who fail to project wireless "body mics" become necessary. These devices are no panacea, but every current Broadway show uses them on every singing or speaking actor. By placing an omnidirectional microphone very close to the singer, we can obtain excellent sound quality and reject most ambient noise.

Wireless systems range from approximately \$250 to well over \$3000. Sadly for those with small budgets, you do get what you pay for. However, quality middle-of-the-road systems can be found for under \$1000. Most microphones included with a package system are decent, but for true quality alternative microphone elements are available. In order to get maximum concealment and sound quality, this is a necessity.

Broadway shows are currently moving towards a system that uses head mounted boom mikes such as the Shure Beta 53. These microphone units place the microphone at the end of a flesh colored boom right next to the performer's mouth, allowing for best quality while rejecting any feedback potential. Unfortunately, the Beta 53 retails for over \$500, well out the budget of most regional theaters.

Sub-miniature Lavalier mics such as the Shure WL50 are slightly cheaper, yet offer an excellent element which can be concealed in the hair. This is also the best option if the "Britney Spears" boom-mic look is inappropriate for your show. The small microphone can be pinned in hair using bobby pins or hair elastics, in addition to elaborate schemes created by the costume crew for wigs and hats. Although these microphones typically offer a lapel clip used for film and TV use, they are almost never used in this manner for theater due to quick costume changes and visibility.

Before we continue: Most people do not realize exactly how delicate microphones are. Even durable dynamic microphones are damaged by such innocent acts as tapping or blowing into the mic to see if it is “live”. The preferred method of testing an expensive microphone is to snap your fingers near it. When you are dealing with expensive and delicate pieces of equipment, it always pays to be gentle.

5 Speaker Placement and Feeding

Speakers can be divided into three categories: **front-of-house**, **fill**, and **monitors**. Front of house speakers are the primary speakers in a venue, referring to their position just in front of the proscenium. Fill speakers are time delayed speakers mounted further back in the house, designed to fill out the house and keep the sound level consistent throughout. Monitor speakers are speakers pointed onto the stage or into the pit which help the performers hear themselves and other performers. Additional speakers in the green room or theater lobby might also be called monitors, and are typically used to let the cast and/or latecomers know what is going on.

Most of the time, speaker design is integrated into the house. However, sometimes it is necessary to understand how things are set up and why. Additionally, traveling shows may require you to configure your own speakers. If your venue is large enough to need fill speakers, it will be necessary to use a time delay on the fill speakers.

In order to understand the fill delay, consider the classic physics example of lightning and thunder. The lightning flashes occur before the thunderclap because sound travels slower than light. In audio cabling, electrical signals travel at the speed of light (for our purposes). We can assume that the signal travels nearly instantly in the wire and 1130 feet per second as sound. Therefore, delay per foot is $.98ms$. This may not seem like much, but it can create a muddy sound and cause noticeable effects even in a small house. Fortunately, most digital loudspeaker management processors such as the dbx DriveRack support input of the delay in feet.

When setting up monitors the effects of delay aren’t really noticeable. The biggest problem with on-stage monitors is the potential for feedback. When you are using omnidirectional wireless Lavalier mics, there is very little **gain before feedback**. However, well positioned directional mics can and will reject a considerable amount of sound from the rear and can safely be positioned in front of monitors. Certain digital anti-feedback equipment or old fashioned graphic EQs can also be used to eliminate specific frequencies which cause feedback in the monitor circuit, allowing the performers to hear more of themselves and each other. With any of these techniques, it is always important to test your monitoring system fully before you go live.

While not strictly a loudspeaker, many high budget shows and concerts are currently using **in-ear monitoring** units which consist of a transmitter, wireless belt-pack receiver, and miniature ear bud. These units entirely eliminate the problems of conventional speaker monitors, reduce on-stage volume, and allow the performer to choose their own custom mix. In a Broadway scale production or concert tour there is typically a monitor engineer in addition to the main front of house engineer. The monitor engineer sits backstage and is entirely dedicated to mixing the monitors. With the advent of in-ear monitoring technologies, the monitor engineer can give each artist their own combination, and exclude almost all other sounds – also helping to reduce artists’ hearing damage.

6 Mixing it all Together

In the introduction, ears were mentioned as the most important aspect of sound mixing. The trick to mixing is always listening, and listening before acting. It helps if you play a musical instrument, and it also helps if you regularly listen to music of the type you're mixing. As you get a feel for the technique, continue to listen and improve.

Besides your biological tools, there are some equipment tools which are helpful for mixing. It is important that you work with a good console. Most experienced engineers have religious affiliations with various console makers, so we can conclude that console choice is largely a matter of preference. However, it is important to choose a mixing desk with sufficient inputs for your application. Additionally, although lots of knobs and lights may seem confusing at first, you will likely yearn for more control and monitoring later on. Purchasing a console is not a lightweight decision! An additional piece of useful equipment is a good pair of headphones. When adjusting settings on an individual channel, one can use the **solo** feature to send only that channel to our headphones.

Whether you have your own console or one associated with your venue, you're now sitting in front of it looking down in awe. In a high budget Broadway production of Jesus Christ Superstar I attended, the Front of House engineer was managing a fifty six channel console. A large format mixing console can be intimidating. However, once you get your bearings everything will be easy to understand.

Whether the console is large or small, a channel input strip for each channel will start at the top with a gain trim knob. There will typically be a number of **aux send** knobs used to create a monitor mix, as well as an EQ section. The channel fader will be instantly recognizable, and near it will be a switch used to solo that channel to the meters and the phones jack.

In order to adjust a channel correctly, have the performer play or sing normally while you solo the channel and adjust the **gain** or trim knob until audio levels fill the range of the meters. After adjusting all channels like this, you will have a common reference point: When all the channel faders are set to "U" or **unity** they will be mixed equally. When a performer comes on stage, you'll know exactly where to bring their fader up to. From here you can begin adjusting the EQ (using your ears) and find spots where things sound best. Remember that mics close to their source will have an enhanced bass response, and consider correcting for this by **rolling off** some of the bass frequencies. You can do this by rotating the low frequency EQ knob to the left. Additionally, many consoles have a "low pad" or "low cut" switch which will cut out extreme low frequencies associated with rumble.

Now that you have your bearings, you can begin experimenting with various levels and EQ during your rehearsals and sound checks. Keep in mind that as you add mics into your mix you increase the number of potential feedback sources, lowering your gain before feedback. In certain shows, it may be practical to turn off all but one performer's mic during a solo. However, this requires ultimate alertness and intimacy with the show's music cues.

If it isn't already clear by now, the key to mixing live sound is experimenting. An experienced technician will have many techniques in his repertoire, but those were developed through experience, not magic. As you mix during a rehearsal, consider getting up and walking to various sections of the house to determine how the mix sounds. Ask others what they think, and work with the performers and crew to meet their needs.

Once the rehearsal period is over and the show opens, feel free to make small changes, but keep things relatively constant. If you decide to change levels or EQ during a performance,

do it gradually and smoothly. As your ears improve you will be able to distinguish between extremely small degrees of EQ, enabling you to tweak the mix without sounding unprofessional to the audience. Additionally, before each performance, make sure all batteries are fresh and do a complete sound check. It is best to eliminate all possible problems before they manifest themselves.

There is no black art to making things sound good. With decent equipment and an acoustically good house, you can do it with relatively little prior experience. The key is to familiarize yourself with equipment at your disposal and work frequently to develop your listening skills. When you attend performances as a spectator, chat with the house engineer and ask him about his techniques and preferences. As you gain experience, things will begin to sound even better and eventually you will find yourself an expert.