

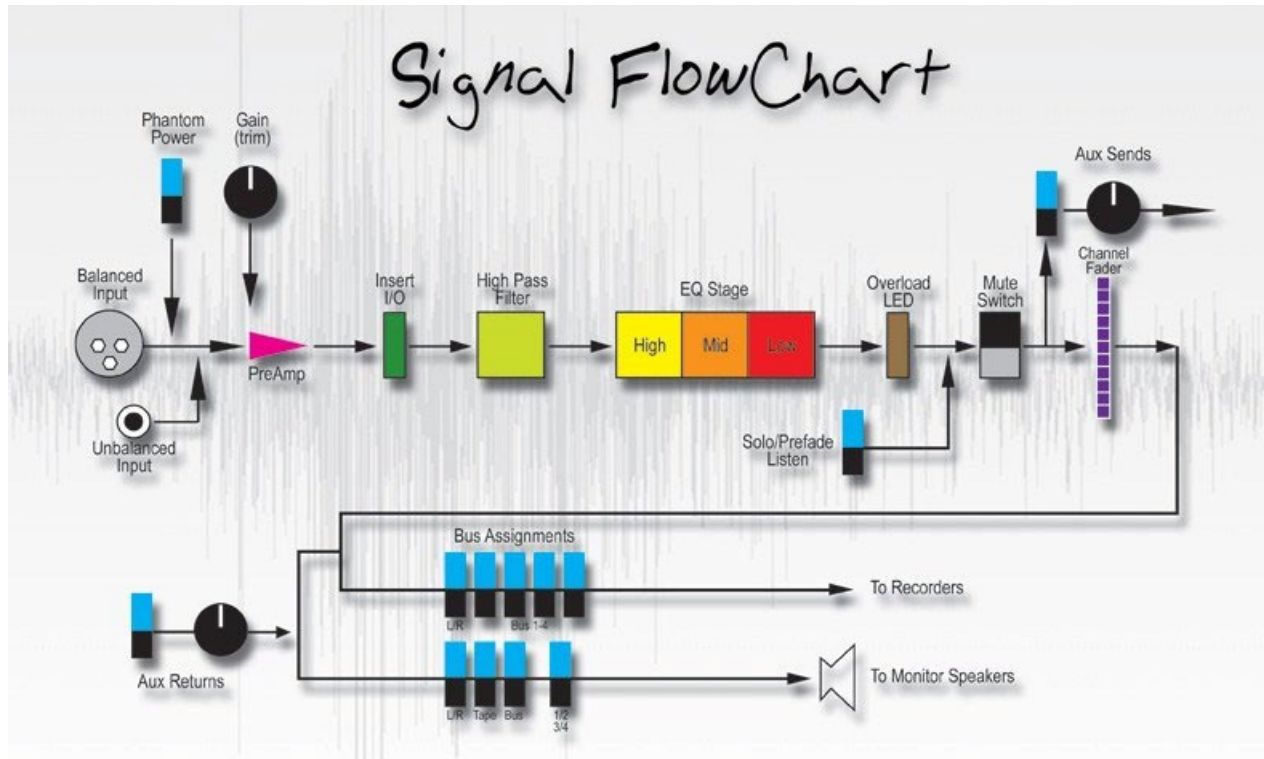


UNDERSTANDING BASIC AUDIO

by Brett Armstrong

Signal Flow

The most important skill that a live sound engineer must have is a solid understanding of signal flow. Without it, there's no music, no singing, no nothing.



You must know where the signal is coming from, where it needs to go and how to get it there at all times. To do that, you need to understand how all the pieces of the sound system work together.

Mixing Console

The mixer is command central –where all inputs (mics, instruments, etc.) are controlled, processed and routed to the appropriate outputs. Every console is different, but they all serve the same function.

The console has various input channels, subgroups, stereo “main” outputs and multiple “AUX” outputs for stage monitors, in-ear monitors (IEMs) and outboard effects.

Generally, most consoles are outfitted with semi-parametric 3-band EQ on every channel. Some consoles will have onboard processors for effects, while others won't. Most will accommodate outboard processors for dynamics, such as gates and compressors.

After signal processing, all channels are eventually routed to the main stereo outputs and sent to the sound system (amps, speakers) for the audience to hear. Still, first, you need to connect the console to the speakers.

Graphic Equalizers

Console Main Outputs ➡ Graphic EQs



Graphic equalizers (GEQs) are used to correct the frequency response of a speaker.

Connect the main outputs of your console to the EQ and use it to “tune the room” or correct problem frequencies caused by standing waves in the room (reflections).

When using stage monitors, connect each AUX output to an EQ channel before sending the signal to the stage. Use it to “ring out” the monitors or eliminate frequencies likely to cause feedback.

Crossovers (Passive Speakers)

Console Main Outputs ➡ Graphic EQs ➡ Crossover

Crossovers are devices that split your audio signal in two – low frequencies go to the subs and everything else goes to the main speakers.

Plug the main outputs of your console into the GEQ, then plug the outputs of the GEQ into the inputs of the crossover. Set the frequency where you’d like to split the signals, then connect the “low” outputs to the power amps for the subs and the “high” outputs to the power amps for the main speakers.

Some crossovers include 3-way splitting for low, mid and high speakers, but these are typically found on more advanced systems.

Active speakers have built-in crossovers, so there’s no need for an outboard unit.

Power Amps (Passive Speakers)

Console Main Outputs ➡ Graphic EQs ➡ Crossover ➡ Power Amps

Power amps have one job: they supply power to passive speakers. There's nothing fancy about them. The only control is volume output. Many engineers choose to run their power amps at full blast, although if not correctly Gain Staged, it could lead to a low signal-to-noise ratio.

Power amps are vital to your sound system. If you use the wrong power amp, the speakers could blow, the amp could catch fire or both.

To properly pair speakers and power amps, you need to know the following:

- Power Amp Impedance
- Power Amp Power
- Speaker Impedance
- Speaker Power

Ohms measure resistance (impedance) and tell us how resistant the power amps and speakers are to electricity. Always make sure that the speakers and power amps have the same ohm rating (8 ohm, 4 ohm, 2 ohm) running parallel or in series.



Power is measured in watts and sometimes referred to as program, continuous or root-mean-square (RMS) power rating. It's the continuous music power that the amplifier can deliver. You must use an amp that is 50% more powerful than your speakers.

For instance, if you're using two 8-ohm, 1000-watt speakers, you'll need two 8-ohm, 1500-watt power amps, or a single 8-ohm, 2-channel 3000-watt power amp.

After connecting your crossover outputs to the power amps, finish the chain by connecting the power amps to the speakers.

Active speakers have built-in power amps, so there's no need for outboard amp units.

Main Speakers

Console Main Outputs ➡ Graphic EQs ➡ Crossover ➡ Power Amps ➡ Main Speakers

The speakers are the very end of your signal chain – the last stop before all this electricity

turns back into music.

Speakers come in two basic types: active and passive.

Active speakers are powered. There's a power amp built into the unit; all you need to do is plug the power cable into the wall to turn them on. These are available from small to large speakers.



To connect active speakers to your console, run an XLR or tip-ring-sleeve (TRS) signal cable from the main outputs of the GEQ to the inputs on the speakers.

Passive speakers are unpowered. They require a connection to an external power amp to turn on. These are very common in permanent installations.

To connect passive speakers to your console, run an XLR signal cable from the main outputs of the GEQ to the inputs on your crossovers and then to the power amps. Now connect the power amps' outputs to the speakers' inputs using 1/4-inch tip-sleeve (TS) or Speakon cables.

Subwoofers

Console Main Outputs → Graphic EQs → Crossover → Power Amps → Subwoofers

Many systems include multiple subwoofers for extra low-end reinforcement.



If only two active subwoofers are used, simply route the console's main outputs to the subwoofers' inputs. Then, use the "thru" outputs to connect the subwoofers to the active "tops" using XLRs.

Active subwoofers include built-in "crossovers," which are devices that split your signal in two – low frequencies go to the subwoofers and everything else goes to the main speakers.

If passive speakers are used, you need an outboard crossover, which works the same way as the ones on active subs.

Occasionally, more than two subwoofers are required, so you'll need to use a speaker management system. These usually include lots of digital signal processors (DSP) like EQ, compression, limiting and stereo imaging. Most importantly, they allow you to split a stereo signal into eight or more outputs, which gives you the freedom to include multiple subs.

Monitors

Console Main Outputs ➡ Graphic EQs ➡ Power Amps ➡ Monitors

Now that you have the sound system up and running, it's time to connect the stage monitors so the band can hear itself.



Stage monitors are connected essentially in the same way as the mains, but they use the AUX outputs instead of the main outputs.

Each stage monitor requires its own GEQs and AUX send. Start at the console and connect the AUX outputs to the GEQs using XLR or TRS cables. Then, connect the GEQs to the power amps using XLRs or TRS cables. Finally, connect the power amps to the monitors using TS or Speakon cables.

For IEMs, utilize an IEM system where you connect the AUX output to the input on the IEM mixer. Each musician can then adjust their mix using the compatible controller.

Active stage monitors have built-in power amps, so there's no need for outboard amp units.

Turning the System On

Now that everything is connected, you just need to turn on everything. Always start at the beginning of the signal chain – the console. Then, simply follow the chain down the line and turn on each item one by one.

Boot up the GEQs next, followed by the crossover and any additional processing. The last things to turn on are the speakers/power amps; if you turn them on earlier, you'll get a nasty pop in the system.

Channel Strips

Mixing consoles can be intimidating. Some have several channels or more, dozens of knobs, buttons and touch screens, and more LED lights than an average Christmas tree. The main takeaway is that if you can understand how one channel strip works, you can understand how roughly 80% of the console works.

Aside from the center, or “master,” section, the rest of the console operates the same as channel one. If you’re accustomed to mixing in a digital audio workstation (DAW), you’ll be pleased to see that the channel strips are laid out almost the same way on the console, and while every console is a little different, they all work in essentially the same way.

Preamp / Gain

It all starts with the input preamp. Whether you’re plugging mics directly into the back of the board or using a “stage snake” to feed the signals from the stage, the first step is amplifying the mic using the gain knob on the console.

So... while we’re on the subject, what exactly is gain? First of all, let’s talk about what gain isn’t.

Gain is not volume. To increase the signal volume, you reach for the channel fader, not the gain knob.

Gain, on the other hand, controls mic or channel sensitivity. It increases the intensity of what the microphone can “hear” and is used to dial in the appropriate intensity of each mic or instrument.

Too much gain and the signal can clip and distort. Too little gain and the signal feels weak and noisy.

To set the gain for a channel, have a musician start playing their instrument, and with the channel fader down, slowly turn up the gain knob until you hit the console’s “sweet spot.”

Every console is different, but this is usually where the signal turns from green to yellow or orange. Just make sure you keep it out of the red!

After setting the gain levels, slowly bring up the channel fader until the instrument is at the appropriate volume in the main speakers for the room.

Inserts

From here, the signal typically travels through the “insert” section, where you can connect outboard processors (like gates and compressors) before running through the EQ section. Most consoles have a pre/post button that allows you to move the insert point before or after the EQ.

On most large-format consoles, channels have a 1/4-inch “insert send” output to send the signal to the processor and a 1/4-inch “insert return” input to return the processed signal.



Some compact consoles use a single 1/4-inch Y-cable insert point, which has three ends: one that plugs into the insert point on the back of the console, one that plugs into the input of the processor (send) and one that plugs into the output of the processor (return).

EQ

Up next is the EQ section. Most consoles are outfitted with some semi-parametric EQ, which sounds intimidating but really isn't.

You'll typically have fixed low and high bands with adjustable gain and frequencies. Occasionally, there will be a button to switch between a shelf and a bell shape.

Next, you'll have bell-shaped low-mid and high-mid bands with fully adjustable gain, frequency and Q (bandwidth) parameters.

Finally, there's usually a fixed high-pass filter switch set to a specific slope and frequency (usually around 80 Hz) – this is used mainly for vocal mics.

AUX Sends

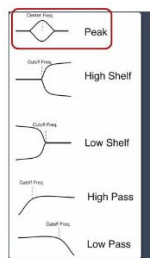
Next, your signal runs through the AUX send section. Most consoles have four or more AUX sends, which can duplicate signals and route them to one of two places: monitors or FX processors (like reverb or delay).

To send a signal to an AUX send, simply find the AUX send section of the desired channel and turn up the send to the corresponding AUX channel.

Ensure the AUX Outputs on the back of the board are connected to the correct monitors and/or FX processors.

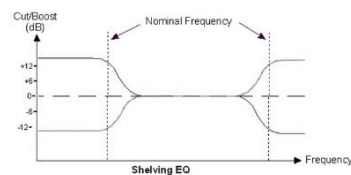
Bell EQ

- Bell equalization boosts or attenuates a range of frequencies centered around a certain point.
- The specified point is affected the most, frequencies further from the point are affected less.



Shelving EQ

- In shelving equalization, all frequencies above or below a certain point are boosted or attenuated the same amount. This creates a "shelf" in the frequency spectrum.



Remember, when using outboard FX processors, you can send a signal from the AUX sends, but if you want to hear the effect, you need to return it as well. Most consoles have dedicated Stereo AUX returns specifically for FX, although any channel input will do.

There's also an "AUX Master" section on the console, which has a master volume control for each AUX send just in case you have the balance right but need a little more or less volume overall. Make sure it's turned up (typically to unity), or you won't be sending any signal!

Pan Knob, Fader and Routing Buttons

Next are the Pan Pot, the Volume Fader and the routing assignment buttons.

Aside from panning stereo signals left and right, there's not a lot of use for panning in live sound. Sure, some engineers choose to tilt their toms a little this way or move a keyboard over there to get it out of the way in a busy mix, but overall, most signals are panned in the center.

Panning makes sense when everyone is wearing headphones, but when everyone in the room has a different place in the stereo spectrum, it starts to cause more problems than it's worth.

The next piece of the channel strip is the fader. Get to know how the fader feels under your fingers. Become one with the fader.

From there, you need to tell the signal where to go. Most consoles usually have a few buttons (M, 1+2, 3+4, etc.) next to each fader, allowing you to send the signal to the mains and/or one or more subgroups.

Often, engineers use channel strips to process individual signals and use subgroups to balance the mix. Think about it. What would you do, pull up eight mics simultaneously during the drum solo?

By routing similar signals to subgroups (like drums, bass, guitars, vocals, etc.), you can balance levels by controlling multiple mics at once, leaving your other hand free to mix effects, run lights or fight off the droves of groupies that are constantly fighting to hang out with the sound engineer.

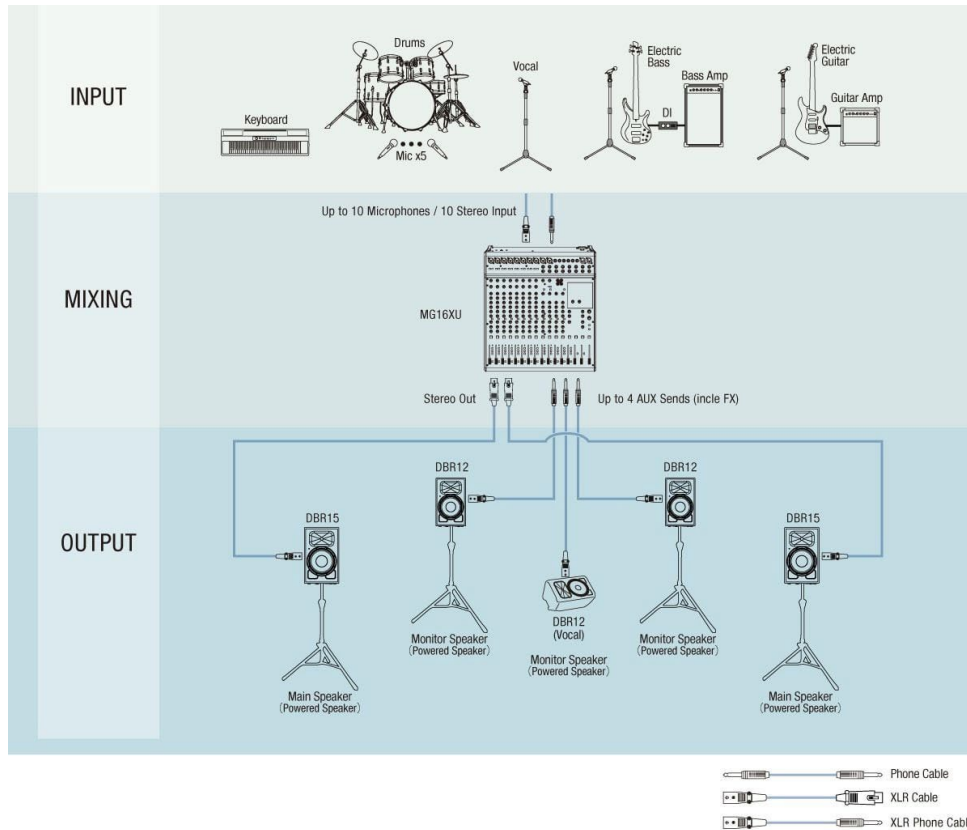
Board Mix

While every engineer does things a little differently, here's an example of what a typical board mix might look like, including common microphone options, inserts and AUX sends.

For demonstration purposes, let's assume you're working with a 4-piece band: drums, bass, one guitar, keyboards and three vocals.

There are three stage monitors: stage left, center stage and stage right. They're connected to AUX 1 thru 3, respectively.

You also have two FX processors: one for reverb and one for delay. The reverb unit is connected to AUX four.



This template won't work for every band but use it as a starting point or a reference guide when setting up, and you should be prepared for most services.

Set your stage inputs to the console as you see them on stage, starting from your left to your right.

Glossary of Terms

Active Speakers:

Powered speakers, also known as self-powered or active speakers, are loudspeakers with built-in amplifiers. They can be connected directly to a mixing console or other low-level audio signal sources without needing an external amplifier.

AUX:

An AUX send is an output used on most live sound and recording mixers. It allows you to create an "auxiliary" mix in which you have individual-level control over each input channel on your mixer to your AUX send output. This will enable you to add those effects to an output or channel on your mixer.

DAW:

A digital audio workstation is an electronic device or application software for recording, editing and producing audio files.

DI:

Direct boxes are often referred to as DI, or direct injection, boxes. Their primary purpose is to convert unbalanced and/or high-impedance instrument signals into a format suitable for direct connection to a mixing console's mic input – without using a microphone.

GEQ:

A graphic equalizer is used to alter the frequency response of an audio system using linear filters. Since equalizers "adjust the amplitude of audio signals at particular frequencies," they are, "in other words, frequency-specific volume knobs."

IEM:

An in-ear monitor is used in place of monitor speakers that are usually placed on the stage in front of the band.

Insert:

In audio processing and sound reinforcement, an insert is an access point built into the mixing console, allowing the audio engineer to add external line-level devices into the signal flow between the microphone preamplifier and the mix bus.

Passive Speakers:

A passive speaker has no built-in amplifier; it must be connected to an amplifier through an ordinary speaker wire.

Pre/Post:

Pre and Post Sends are AUX sends. They control the sound sent to objects like nursery speakers, stage monitors or anything other than the main house speakers. A pre-AUX send delivers the signal out of the mixer BEFORE it passes through the channel fader, pre-fader.

Preamp:

A preamp is a "preamplifier." As the name suggests, it prepares the signal from a pickup or microphone for further amplification.

Semi-Parametric EQ:

Sometimes called pseudo or quasi-parametric EQ, a semi-parametric EQ is a parametric equalizer with one or more missing features. This term is sometimes used to describe a single band of equalization, which generally means a parametric EQ that does not have a Q control (the Q is fixed).

Signal-to-Noise Ratio:

The signal-to-noise ratio (abbreviated SNR or S/N) is a measure used in science and engineering that compares the level of the desired signal to the level of background noise. SNR is defined as the ratio of signal power to noise power, often expressed in decibels.

Speakon:

Speakon is a trademarked name for an electrical cable/connector. Initially manufactured by Neutrik, it is mainly used in professional audio systems for connecting loudspeakers to amplifiers. Other manufacturers make compatible products, often under the name "speaker twist connector."

Subgroups:

Subgroups are a way to "pre-mix" several channels on a sound console before sending them to the master output mix.

TRS:

Tip-Ring-Sleeve refers to the parts of the jack plug that the different conductors are connected to. A TRS cable has three conductors vs. the two on a standard guitar cable. A guitar cable is a TS or Tip Sleeve cable.

Unity:

Unity gain is a term used when establishing the balance between pieces of audio equipment. The idea is that input should equal output level-wise. Audio that goes into a device at one level and comes out of that device at the same level is said to be at unity gain.

Gain Stage:

Gain staging is the process of managing the relative levels in each step of an audio signal flow to prevent the introduction of noise and distortion.

Pink Noise:

Pink noise definition is - a mixture of sound waves with an intensity that diminishes proportionally with frequency to yield approximately equal energy per octave.

Q-Value:

Stands for "Quality Factor," defining the bandwidth of frequencies that will be affected by an equalizer.

XLR:

XLR refers to a three-pin locking connector that is used in audio applications.