WEEK 12

GAIN STRUCTURE

What is Gain Structure?

- Gain Structure is the relative balance of signal level between the inputs of a mixing console and its outputs and is the most important technique for a young sound engineer to grasp.
- Improper gain settings at the input of a console, misuse of the EQ section or even improper fader settings can severely limit what gain is available at the output of the console.
- Input and output must be constantly balanced to avoid clipping and over-saturation of the audio signal.

Clarification

- The process of achieving the correct gain structure is broken into two process’. One is system related and one is mixing console related.
- The system of crossovers, limiters amplifiers and speakers we call a sound system requires it’s own gain structure.
- The mixing console requires it’s own internal gain structure because of the wide variation of audio input signals that must be balanced in level.

What is Gain Structure?

- Before you start sound checking instruments there are actually several steps involved with setting up the audio system and tuning it's response to the room that we are not covering in the section. Nonetheless, these process' themselves are governed by good gain structure practices. When we talk about Gain Structure, it can actually be applied to at least two or three different parts of an audio system.

What is Gain Structure?

- The Speaker system;

- Crossovers, amplifiers, limiters and equalizers are all built-in components of modern day professional self powered speaker systems. Because of this built-in nature, they cannot be adjusted. The speaker is designed to have a full-range audio signal via a balanced XLR input. You cannot adjust the relative balance of HF and LF output. You cannot adjust the protection limiters. You cannot adjust anything except the quality of the signal you send to it! The manufacturer has designed the unit with a pre-set Gain Structure within the audio chain of the device. The device has an input sensitivity and will protect itself if one attempts to exceed the maximum gain the device is capable of producing.

What is Gain Structure?

- The Speaker system;

- Crossovers, amplifiers, limiters and equalizers are all separate components of semi professional and older analog PA systems and require that the engineer adjust the *Gain Structure of this set of components that comprise the "system".* Typically Pink Noise and other forms of noise and pure tones or sound waves are used to measure the response of the PA system within an acoustic environment. Not only is the gain structure adjusted within the speaker system to allow for maximum output before clipping, , it's output response is adjusted via EQ's to compensate for the acoustic limitations of the venue.

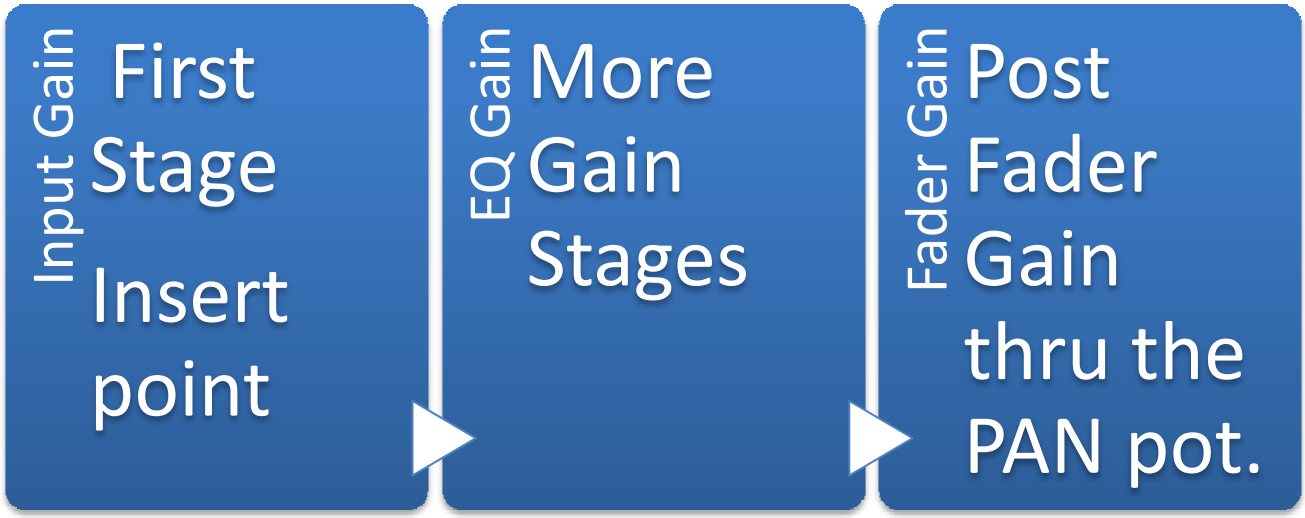
What is Gain Structure?

- There are three primary points that gain is added to the individual channel strip on a mixer. Remember that each channel will have a different source microphone or DI box and will require different adjustments. Careful visual checking of the metering WHILE you are listening closely is required. Make adjustments to one channel at a time.

What is Gain Structure?

- Achieving high amounts of gain without distortion or oversaturation throughout the signal path is the goal.
- In order to maintain a relative balance between very loud instruments and very quiet instruments, a console must have a gain structure allows for a very wide dynamic range.
- Different music styles and genres require completely different gain structure setups.

What is Gain Structure?



This block diagram illustrates a simple audio mixer input strip.

What is Gain Structure?

At the front end of each input strip is the mic-preamp. Gain is added to the -50 line level mic signal.

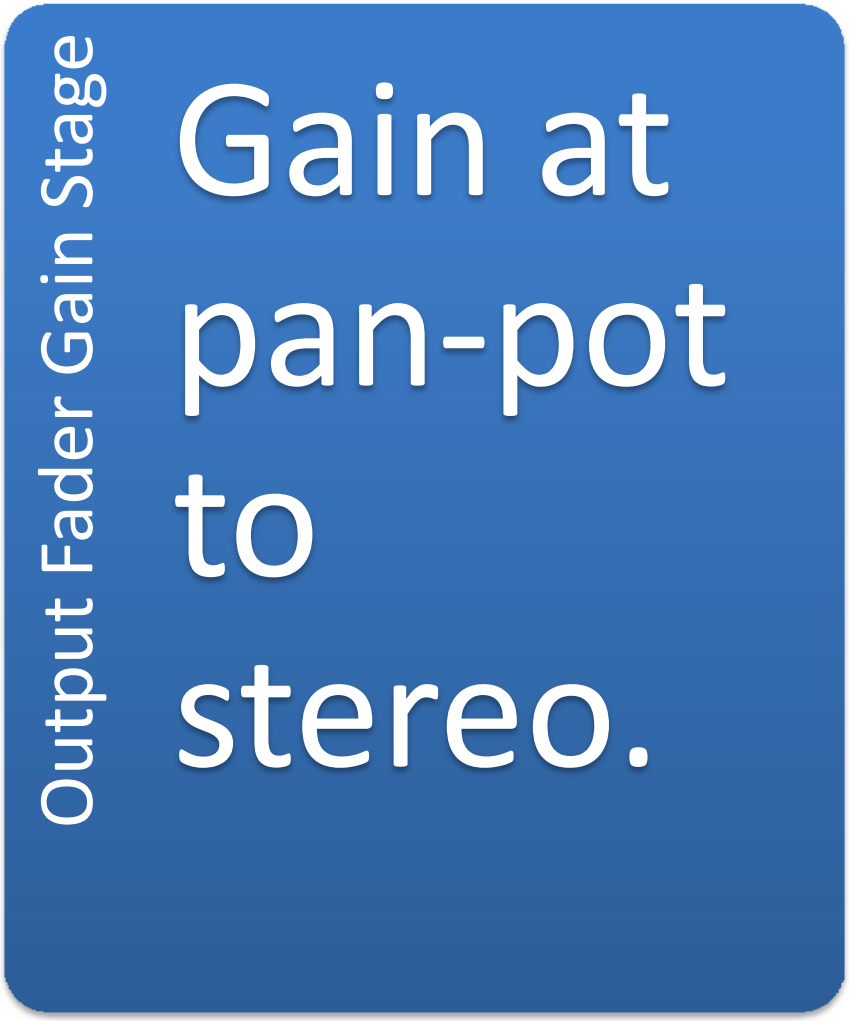
Use the Solo or CUE function to establish the proper input level before you ever push up the fader!

A noise gate or a compressor would be used at this point in the signal chain because it would be before the EQ section. Remember that minimal EQ adjustments can significantly degrade the effectiveness of a compressor or a noise gate for instance so it's best to insert devices like those in a PRE-EQ insert point.

What is Gain Structure?

•Depending on the type of EQ your console has, this section can easily have 2 to 5 gain stages.
•Think of a 1/3 octave EQ as 31 volume faders across the human frequency spectrum. Parametric EQ's have less "interplay" and therefore require more precise judgment when deployed.
•Parametric EQ's afford superior control. They are required for proper feedback suppression.
•Increasing the gain of any portion of the frequency spectrum should be done with caution.
•The channel strip EQ should not be the main tool for controlling dynamic range and response in the PA system.
•A properly deployed PA system will not require much additive EQ on channel strips.

What is Gain Structure?



The fader is no different than a knob. Think of it as a linear potentiometer.
The fader is your main "creative" tactile interface with signal flow in the console. A clear understanding of your metering scheme is paramount to interpreting that flow!
There is a lot of gain in the fader above the unity gain line (UGL). If you are having to push a fader far above the UGL, that is a clear indication that your gain structure is out of balance!

What is Gain Structure?

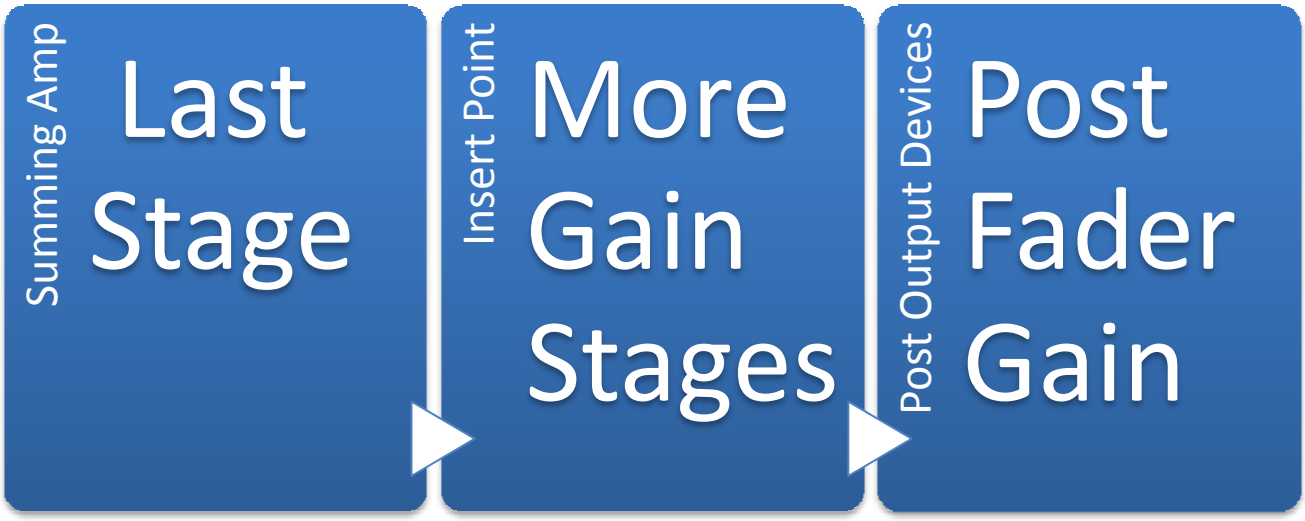
By applying excess gain after the channel strip UGL, you begin to send an excessive amount of signal to the input of the summing amplifier. Bad idea.

Instead you need to rebalance your gain structure by what is at first glance, a non-intuitive move.

You must pull all of the input faders back equally, quickly (like wait till between songs unless it's an emergency) and push up the output MASTER fader to get the gain back in balance.

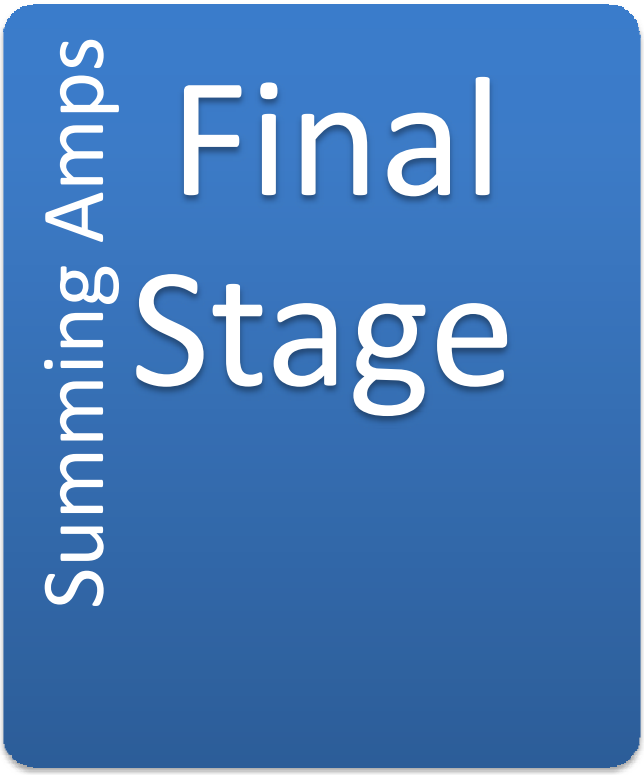
Where that balance is, largely depends on the program input. Acoustic instruments require a very different approach to gain structure compared to a heavy metal band!

What is Gain Structure?



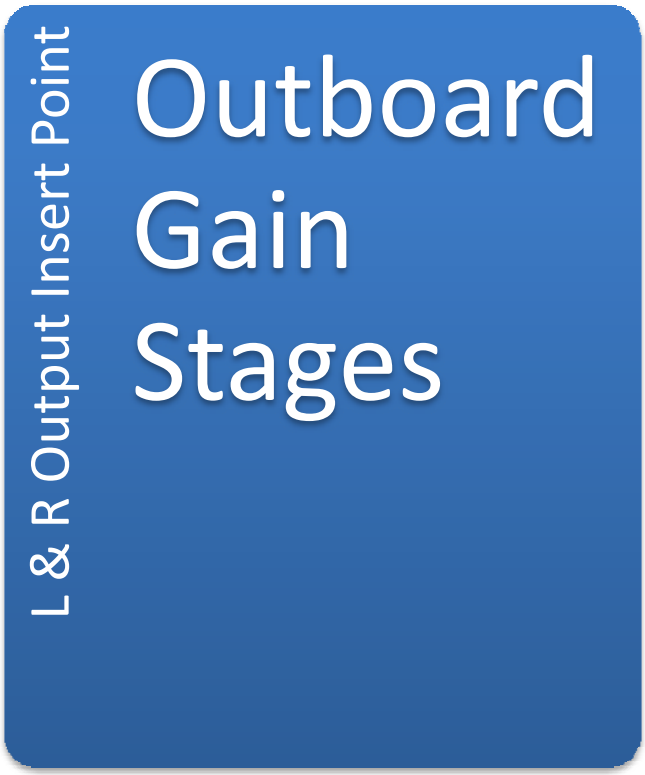
This Line Diagram illustrates the output stages of a mixer, the 1/3 EQ for mains and the speaker management system of crossover.

What is Gain Structure?



Think of this as where the actual “mix” part of mixer is really happening.
The individual mic signals have had a fairly discreet path until they all meet here at the input of the summing amplifier and get combined into two signals, a blend of Left and Right depending on the individual pan pot settings.
Alan Blumlein figured it all out.

What is Gain Structure?



The House EQ should always be ***inserted before the master output fader.***

A Noise Gate or compressor always gets inserted before the channel strip EQ.

What is Gain Structure?

Post fader devices are all the electronics connected to the output of the mixing console. A common question is which came first, the compressor or the EQ?

The EQ always comes first in the line and preferably is *inserted* before the master fader with the compressor connected directly after the fader.

In modern live sound environments, all these jobs are commonly handled in a unified speaker management system.

Input gain: A Closer Look

- Microphones produce very low level signals.
- A mic pre-amplifier is required to raise the signal to a useable level in a mixing console.
- Mic preamps are as diverse sounding as any other electronic device.
- They play an important role in the quality of the microphones' overall "sound".

Input gain: A Closer Look

- Analog consoles use various forms of circuit design to amplify the signal from the mic.
- Transformers and differential amplifiers are the two main types. Read this article on microphone preamps.
- Various schemes are used to limit or counteract the adverse or conditions under which these connections are made.

Input gain: A Closer Look

- Digital consoles use a combination of a differential amplifier and an Analog to Digital converter called a Head Amp.
- Once an analog signal has been converted into the digital realm, RF is not a factor. The electronics circuits that handle digital signals are still prone to RF pollution but the digitized waveforms are not!
- In the digital realm, clipping and oversaturation are factors and are still relevant to correct gain structure.

Input gain: A Closer Look

- Our modern world is full of Radio Frequency Pollution that will interfere with delicate circuitry like audio mixers and components.
- Long “snakes”, or more correctly, multicore wire, connect stage inputs to remotely located mixing consoles and are subject to a wide range of interference phenomena of which radio frequency (RF) noise is just one.

Input gain: A Closer Look

- Years of empirical design advances have reduced the impact of RF on modern systems but there are many circumstances where faulty wiring and incorrect use of cables and connectors can compromise those advances.

Input gain: A Closer Look

- If you have a problem with noise at a console input, change the mic cable, the stage patch and the snake channel, in that order, to try and correct the problem.
- Cabling will always be the first suspect when you troubleshoot a noisy mic input or open circuit.

Input gain: A Closer Look

- Channel strips have several tools for routing and control of the mic signal once it’s connected to the console.
- Each tool for shaping sound on the input strip can introduce clipping in the signal. Careful metering is required of all of them and of source the Mic Preamplifier is the first place you begin.

Input gain: A Closer Look

- Clipping is typically monitored at three points in the path after the signal enters the connector on the mixing console;
- Directly at the mic pre-amp
- After the EQ section
- After the channel fader

These are the signal “shaping” tools the engineer uses to adjust tonality and level of individual mics or sources.

Input gain: A Closer Look

- All three points add gain and are capable of clipping and distortion.

- The object is to make adjustments that minimize distortion and over-saturation and avoid clipping. EQ clipping and Fader clipping can be very subtle.

Channel Strip Gain: A Closer Look

- Adding gain via the EQ will clip a signal that is already hot coming from it's upstream source, in this case the mic pre. Keep mic pre levels reasonable, -6 to -3 max to allow for extra loud moments that will clip otherwise!
- A hot mic pre-amps sound different on every console. You must experiment with your mixer to determine it's best performance through careful visual metering while you listen closely.

Channel Strip Gain:A Closer Look

- Pushing a fader too far past it's unity gain position will introduce clipping as well. The fader is a gain stage and can add a considerable amount of gain above the UGL. Depending on the "taper" of the fader, gain can be gently sloped and smoothly distribute power above the unity line, or it can steeply ramp up exponentially. These "tapers" are classified as "A" or "B" type etc and you can find out what type is in your mixing console by examining the fader specs from the manufacturer.

Channel Strip Gain: A Closer Look

- Gain comes in limited quantities in any circuit.
- Clipping and distortion arise from ignoring these limitations.
- Careful visual metering while you listen carefully is the only way to avoid clipping.
- Subtle forms of clipping and distortion are hard to detect by ear alone at times and only the combination of using your ear and careful metering can detect these.

The Mix Bus & Summing Amps

- Mix busses are also called Sub Mixes.
- Routing similar instruments to sub mixes gives you a visual indication of relative power use.
- After following the signal path through the input strip, the mic signal will have to be routed to the output.
- Using sub mixes can be very important to monitoring the gain structure of your console.

The Mix Bus & Summing Amps

- Summing amplifiers combine all the signals into the stereo (or mono) output.
- Summing amps have a limited amount of gain as well. And more importantly are just as sensitive to overloading at their input as they are of overloading at their output. Careful metering of both pre-fader input levels and post-fader output levels is necessary at all times!
- Read about Op Amps.

The Mix Bus & Summing Amps

- Correct gain structure will yield relatively uniform response on a meter when comparing pre and post fader levels.
- Route channel level signals to sub-mix busses to better observe relative levels between different groups of instruments.
- Route sub-mix signals to the stereo buss (summing amp) and use sub-mix faders to adjust relative gain structure of your entire mix before the output section.

Conclusions

- The process of achieving the correct gain structure is broken into two process’. One is system related and one is mixing console related.
- The system of crossovers, limiters amplifiers and speakers we call a sound system requires it’s own Gain Structure. One can think of the mixer and the speaker system operating in unison with another. Each with their own separate gain structure and interactions.

Conclusions

- PA system gain structure is dictated by the type of system you have and the controls that you have within the various different devices. Modern professional powered-speaker systems have a pre-designated gain structure designed by the manufacturer. While somewhat restricting in some ways, these modern systems are nonetheless, very powerful and allow the engineer to focus more closely on other more important tasks.