Volume, Part 1: Fiddling with Faders

By Alex Case

It is an axiom of the rock and roll recording craft that louder is better. The good old volume control is a powerful audio effect—and every studio has at least one. This and the next episode of Nuts & Bolts will explore the many applications of this humble effect—some obvious, and some not so obvious.

A sense of balance

Consider the first step in building a mix. Carefully, systematically, and iteratively you adjust and readjust the volume and pan position of each track until the combination starts to make musical sense. At that point the mix is balanced—the song can stand on its own, and every track contributes to the music without obliterating other parts.

In pop music, usually the vocal and the snare sit pretty loud in the mix, dead center, with the other pieces of the arrangement (tracks and effects) filling in around and underneath. If the guitar is louder than the vocals, you're probably going to have trouble selling records. If you can't hear the piano when the sax plays, the song loses musical impact. So you work hard to find a balance that's fun to listen to, supports the music, and reveals all the complexity and subtlety of the song.

This first step of a mix session is really a part of every session. For tracking and overdubbing, the players can't play, the engineer can't hear, and the producer can't produce until the signals from all the live microphones, recorded tracks, and effects are brought into some kind of balance. Relying almost entirely on volume controls, balancing a mix is one of the most important skills an engineer must master.

> In pop music, if the guitar is louder than the vocals, you're going to have trouble selling records. You work to find a balance that's fun to listen to, yet supports the music and reveals the song's subtleties.

On the level

If music is picked up with a microphone, you'll need a microphone preamplifier. Guess what? Mic preamps are nothing more than volume devices. And we've got to set the volume just right when we record to tape or hard disk (see sidebar).

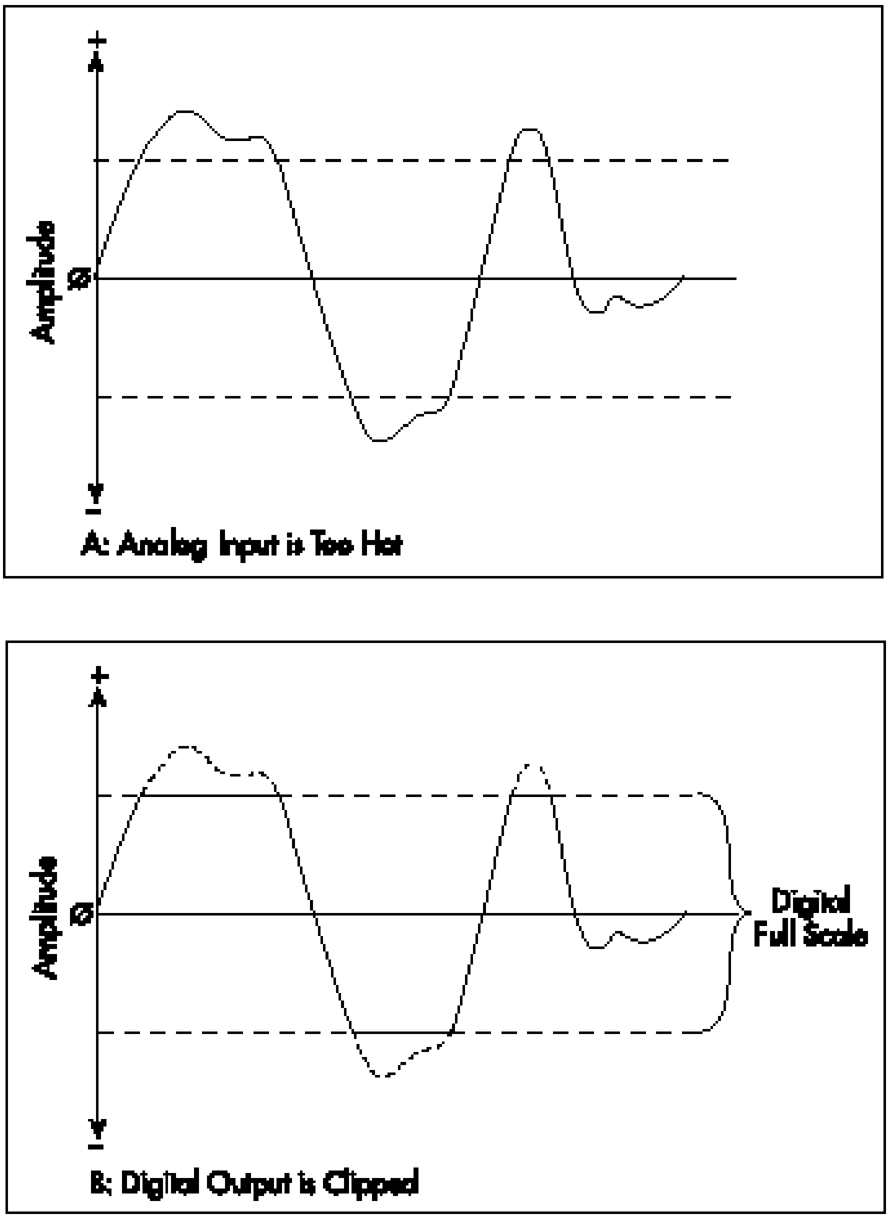
Because all equipment has some noise, we naturally try to record music at as high a level as possible so that the musical waveforms drown out the noise floor. So it seems true that louder is indeed better. The question is, how loud?

There are two different strategies for setting recording levels, depending on whether the storage format is digital or analog.

You've undoubtedly heard that for digital recording, the goal is to "print the signal as hot as possible without going over." Let's think a little bit about what that means.

Pressure in the air becomes voltage on a wire (thanks to the microphone), which then becomes numbers on tape or disk (thanks to the analog-to-digital converter). As the music gets louder in the air, the corresponding voltage gets higher on the mic cable. But at some point the numbers getting stored by the digital system can't get any bigger—it maxes out in much the same way that a child counting on his or her fingers runs out at ten.

FIGURE 1: DIGITAL OVERDRIVE



At that point the digital data no longer follows the musical waveform (see Figure 1). This is a kind of distortion known as hard clipping. The peaks are clipped off, gone forever.

Obviously, the way to prevent this kind of distortion is to make sure the analog levels going into the digital recorder never force the system past its maximum. The meters will help you here. Digital systems generally have meters that measure the amplitude of the signal in decibels below full scale,which is the "ten fingers" point at which the digital system has reached its maximum digital value.

If you are intrigued by the waveform shown in the lower part of Figure 1 and are wondering what it sounds like, you might want to overdrive the digital system on purpose. Be my guest, but be careful. First, monitor at a low level. This kind of distortion is full of high frequency energy that can melt tweeters.

Second, listen carefully. This type of distortion is extremely harsh; it's not a particularly musical effect, so it's best used sparingly if at all. But of course it's not strictly forbidden—music tends to rebel.

On analog magnetic recording systems, you typically record as hot as possible, and occasionally go over. Unlike digital audio, analog audio doesn't typically hit such a hard and fast limit; instead, it distorts gradually as you begin to exceed its comfort range. This gradual distortion at the peaks is called soft clipping, shown in Figure 2.

At lower amplitudes, the analog magnetic storage medium tracks very accurately with the waveform. As the audio signal starts to get too loud, the analog storage format can't keep up. It starts to record a signal that's not quite as loud. As it runs out of steam, it does so gracefully. Look carefully and you might notice that overdriven analog tape looks a lot like compression.

A quick glance at my effects rack reminds me: compression is an effect. I've bought rack spaces and pull down menus full of compression. Can you overdrive analog magnetic recorders for an effect? You betcha. So we find ourselves using volume as an effect simply by setting levels as we record music.

Analog machines, with faint tape hiss, prefer audio waveforms without quiet passages (low volume). While digital systems don't have tape hiss, they do introduce other sonic artifacts at low levels, as we'll discuss in a future Nuts and Bolts article.

Still, this low noise floor was a driving force in the transition from analog to digital audio. Classical and jazz engineers have to record acoustic music with a wide dynamic range—music that sometimes has long, open, quiet spaces. For this genre of recording, the nearly silent noise floor of digital storage was a dream come true.

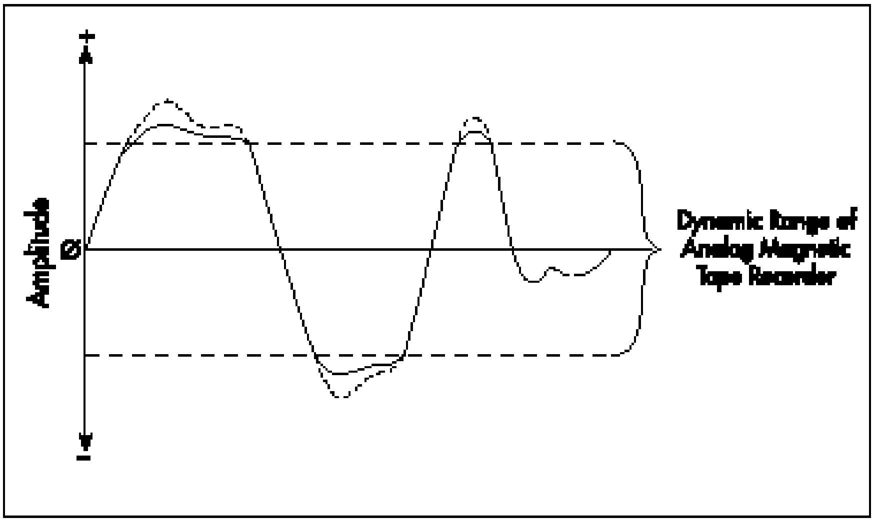
Rock and roll, on the other hand, tends to have a much more narrow dynamic range. The song kicks in and rarely lets up; hiss can't raise its ugly head over the screaming vocals and grinding guitars.

Moreover, as we know from listening to radio, listening to great mixes, and experimenting in our own studios, rock and roll also loves a bit of compression. As a result, even in this very digital age, many pop records are still recorded onto analog tape.

Adding further irony, these days digital audio devices are consistently less expensive to own and operate than professional analog audio tape machines. Today, we essentially must pay extra for the tape compression effect.

NUTS and BOLTS

FIGURE 2: SOFT CLIPPING



Given a choice, the sound quality differences between analog and digital recorders as they react to where the volume knob is set are a key factor in selecting which format to use on a recording project. And here's another clear case of using the volume knob as an effect.

Flavor

In the recording studio, we generally run into two types of analog volume control: the variable resistor and the voltage controlled amplifier.

Because all equipment has noise, we try to record music at a high level so that the music drowns out the noise floor. So it seems true that louder is indeed better....

Electrical resistance is a property of all materials describing how much they restrict the flow of electricity. Materials with very high resistance are classified as insulators; they pretty much don't conduct electricity at all. We appreciate this property when we handle things like power cords.

At the other extreme, devices with very low resistance fall into the category of conductors. Copper wire is a convenient example. The copper within that power cable conducts electricity from the wall outlet to the piece of audio equipment, getting the LEDs to flicker, motivating the meters to twitch, enabling us to make and record music.

The volume knob on a home stereo, electric guitar, or analog synthesizer is (with a few model-specific exceptions) a variable resistor. Set to a high resistance, electricity has trouble flowing and the volume is attenuated. To turn up the volume, lower the resistance and let the audio waveform through. Also called potentiometers, we typically think of them as simple volume controls.

In the recording studio, we have to look more closely at our volume controls because there is a second type: voltage controlled amplifiers. Hep cats resort to three letter acronyms—VCA. The idea behind them is simple and clever.

If the fader on an analog console is a potentiometer, it makes sense to picture the fader as a variable resistor. But in the case of a VCA, the fader that sits on the console is separated from the audio by one layer. Instead of having that slider on the console physically adjust the resistance in a potentiometer, it adjusts a control voltage. This control voltage in turn adjusts the amount of gain on an amplifier.

...The question is, how loud?

Most compressors use VCAs, which are capable of reacting to voltage changes very quickly. And for consoles, the only other way to have something other than the engineer adjust the level would be to stick a motor on the fader. This is a pricey, complicated option, but motorized faders are certainly available—and at an ever-decreasing price.

Automation

Mix automation can do many things these days. If you have a hip digital audio workstation or digital console, you can automate it so that it wakes you to music first thing in the morning (noon), starts the coffee maker, and draws a warm bath.

While this is all quite useful, automation is almost always just used for two very simple processes: fader rides and mutes. The point of pushing faders and pressing mute buttons? Controlling volume.

Not too long ago even the fanciest consoles offered the ability to automate only the faders and the cut (mute) buttons. Studios spent a few hundred thousand dollars on a top of the line, state-of-the-art console and still couldn't automate pan pots, aux sends, equalizers, compressors, or reverbs.

NUTS and BOLTS

But as we know from all the music released from the beginning of time up to about 1995, extraordinarily elaborate and complicated mixes were built with this relatively limited amount of automation capability. Clever volume effects—mostly using VCA-based automation—are the key.

For example, using the humble mute switch, the mix engineer controls the multitrack arrangement. Cut the bass in the extra bar before the chorus, pull the flute out of the horn part until the last chorus, etc. This sort of mix move happens throughout pop music. But check out an extreme example by listening to U2's Achtung Baby. The album begins with some heavy cut activity as the drums and bass enter at the top of the first tune of the album, "Zoo Station."

Automating fader rides in support of the arrangement is a natural application of automation. Maybe it makes sense to push the guitar up in the choruses, pull the Chamberlin down during the guitar solo, and such.

Ideally, the band (maybe with the advice of a producer) gets these dynamics right in their performance. But in the studio, the full arrangement of the song may not come together for several months as overdubs are gradually added to the tune. Fader rides may be just the ticket to help this assembly of tracks fall into a single piece of music.

> Look carefully and you might notice that overdriven analog tape looks like compression.

Volume changes are automated just to keep the song in balance as multitrack components of the song come and go. But it's usually a good idea to keep these moves quite subtle; they're aimed at the musical interpretation of the mix, trying to make the song feel right. With few exceptions, it should pretty much never sound like a fader was moved. Listeners want to hear the music, not the console.

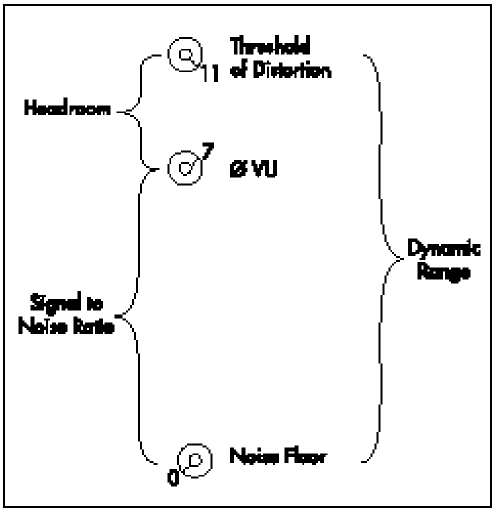
Another automated volume effect is the Automated Send. Some very sophisticated mix elements can be created this way sends. Automation is employed to add rich and spacious reverb to the vocal in the bridge only, introduce rhythmic delay to the background vocals on key words, increase the chorus effect on the orchestral strings in the verses, add distortion to the guitar in the final chorus, etc.

The automated send—just another volume effect—offers a way to layer in areas of more or less effects, using nothing more than straight forward faders and cuts automation.

We'll keep digging deeper into volume next month, moving beyond faders and exploring the finer points of compression, expansion, gating, and tremolo, and how volume affects the eq curve. Stay tuned.

Getting paid to play the volume control is why Alex Case became a recording engineer. He used to do it for free. Speak up to case@recordingmag.com.

FIGURE 3: AUDIO DYNAMICS



Dynamic Range

Musical dynamics are so important to composition and performance that they are notated on every score and governed closely by every band leader, orchestra conductor, and music director. Making clever use of loud parts and soft parts is a fundamental part of composition and arranging.

In the studio we must concern ourselves with a different sort of dynamics: Audio Dynamics. Follow along in Figure 3 as we keep careful control over the range of amplitudes that we encounter when recording audio signals.

Exploring the upper limit of dynamic range comes naturally to most of us. We turn it up—whatever 'it' is—until it hurts our ears, our equipment, or the music. Cranking it 'till it distorts. It seems to be the sole determinant for the position of the volume knob on most guitar amps (including mine), car radios (at least for the car in the lane next to me), portable stereos (the jogger who just passed me), home stereos (my neighbor in my freshman year college dorm)… Here we have encountered a basic property of all audio equipment: turn it up too loud, and distortion results.

At the other extreme (turning it down too much) lives a different audio challenge: we start to hear the inherent noise of the audio equipment we are using. All audio equipment has a noise floor—equalizers, compressors, microphones, and even patch cables. Yup. Even a cable made of pure gold manufactured in zero gravity during the winter solstice of a non-leap year will still have a noise floor, however faint.

A constant part of the recording craft is using our equipment in the safe zone between these two extremes. This is the *dynamic range*, and it's quantified in decibels (dB). The target nominal level is typically labeled 0 VU (that's a zero, not an O). At 0 VU the music gets through well above the self-noise of the equipment, but safely under the point where it starts to distort.

If we recorded pure sine waves for a living, we'd turn the signal up right to the point of distortion, back off a smidge in level, and hit Record. However, the amplitude of a real life musical waveform races wildly up and down due to both the character of the particular musical instrument and the way it is being played.

Electric guitars amps cranked to the limit—at that much savored edge of becoming fire hazards—have very little dynamic range. If you haven't already witnessed this yourself, record a guitar the way Spinal Tap's Nigel Tufnel does—with the amp set to eleven. You'll observe the meters on your console and multitrack zip up at the downbeat. And they barely move until the end of the song.

Percussion, on the other hand, can be a complicated pattern of hard hits and delicate taps. Such an instrument is a challenge to record well. The musical dynamic range of the instrument must somehow be made to fit within the audio dynamic range of your studio's equipment.

Accommodating the unpredictability of all musical events, we record at a level well below the point where distortion begins. The amplitude 'distance' (expressed in decibels) between the target operating level—0 VU—and the onset of distortion is called *headroom*. This gives us a safety cushion to absorb the musical dynamics without exceeding the audio dynamic range of the gear.

The relative level of the noise floor compared to 0 VU, again expressed in decibels, is the *signal-to-noise ratio*. The trick, of course, is to send your audio signal through at a level well above the noise floor so that listeners won't even hear that hiss, hum, grit and gunk that might be lurking down in the depths of each piece of equipment.

Making effective use of dynamic range influences not just how we record to tape, but how we use a compressor, a de-esser, a reverb, or any other piece of gear.