Calibration and Gain Staging with Digital Transport

The world of audio cabling is changing, and digital audio distribution is at the forefront of this technological revolution, providing unprecedented flexibility and freedom from old problems such as ground loops. As with every significant innovation, there are some corresponding changes to the way we work that are necessary for getting the most out of the new technology. With the introduction of digital cabling and networked audio—major technological advances in connectivity—a few minor adjustments to our workflow are called for as well.

The most common source of trouble for console users making the switch to digital transport involves gain stage calibration, required to optimize the signal-to-noise ratio throughout the signal chain. The most common symptom of poor calibration is a marked increase in noise, sometimes so pronounced that the only explanation seems to be malfunctioning digital equipment.

The issue, though, is that effective use of digital transport requires a different approach to gain structuring, based on the differences in the signal path and circuitry compared to an analog system. Note that the principles discussed in this document apply to any digital transport system that uses A/D and D/A converters in the process of moving audio.

ANALOG V. DIGITAL TRANSPORT

With a passive (i.e., non-electrified) analog cable or snake, a signal enters the console with a very good signal-to-noise ratio. The signal level is adjusted using the console's gain trim knob and perhaps a pad when the source signal is line level. If a channel begins to clip at the preamp or the signal is too weak, the problem is corrected simply by adjusting the gain setting right at the console.

In many ways, analog cable has unbeatable audio performance. Noise levels on analog can be below –122dBu, and a signal can average a level of +4dBu, with peaks to +18dBu or higher. Achieving similar performance in the digital domain would require A/D and D/A converters with a signal-to-noise ratio of –140dB. However, the best converters available have signal-to-noise ratios in the –115 to –120dB range. Digital transport requires the use of active electronics, and these components, no matter how well crafted, introduce a certain amount of noise.

The key is to keep this unavoidable amount of noise inaudible, and properly calibrated gain staging ensures that the audio will remain clean. Without proper gain calibration, higher noise floors are simply inevitable.

Because the amount of noise is constant for a given converter—that is, the total amount of actual noise from a converter is not related to the audio signal's level—it is important to fill each channel, at each stage of the signal chain, with as much good audio signal as possible. As you calibrate, it's important to look at each stage independently so that the signal is optimized for each device.

FROM DIGITAL OUTPUT TO CONSOLE

To help isolate each device, it's often easier to work backwards through the signal chain using a test tone rather than real-world input signals. Working this way, the first step is to match the signal level of the digital output device (e.g., Aviom's AN-16/o or 64160) with the input on the console.

To get the best performance, you need to provide the console with the hottest signal possible. If the incoming signal is low, gain will need to be applied in the console to amplify the sig-

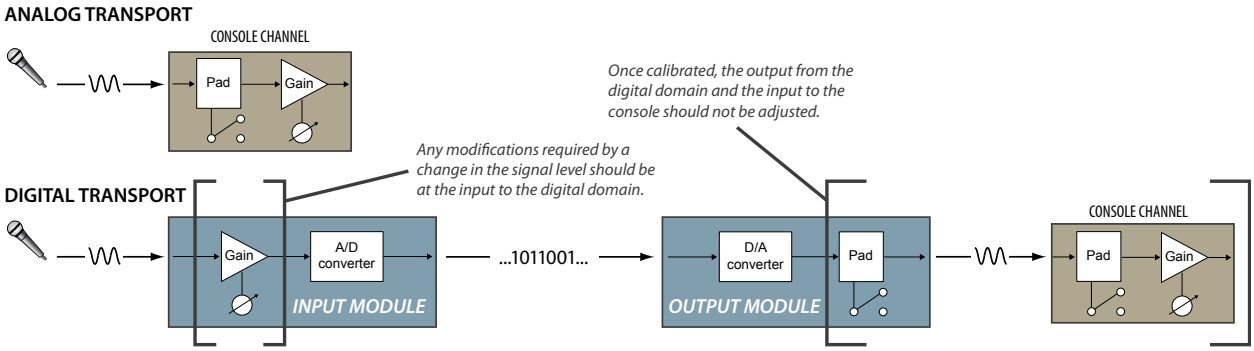

Figure 1. **With an analog system (TOP), the signal goes from the source into the console without passing through any active electronics. Digital transport (BOTTOM) introduces two additional points in the signal chain where level must be properly set in order to avoid unwanted noise.**

nal to an adequate level. But both the signal itself, *as well as any noise*, would be amplified with the added gain, resulting in a louder—but noisier—signal.

Thus, whenever possible, use a line-level output from the digital system and a line-level input (or mic-level input with a pad) on the console. Use mic-level outputs from the digital system only when there is no line-level input (and no pad) available on the console. Because a mic-level signal is lower than line level, while the amount of noise from the components is fixed, there will be relatively more noise in both the pre- and post-gain signals in the console if a mic-level signal is output from the digital system.

It's also important to remember that unlike with analog cables, improper gain structure on the console can result in a noisy signal *even if there is no digital input module or audio source connected to the system*. The digital output module has active electronics which are outputting data to the console, but with no audio present, all that gets amplified is the noise inherent to the components. And because the noise from each channel accumulates across the console to the main output, a system connected in this manner could sound quite poor with the main faders up even a bit, especially if the channel gain settings are high.

FROM SIGNAL SOURCE TO DIGITAL INPUT

The other stage requiring calibration is the gain at each input channel on the digital system, according to the level of each input signal (vocal mic, kick drum, etc.) and the dynamics of the performance. This must be done at the digital input module and not at the console because the levels of the incoming source signals must be set for the needs of the analog-to-digital converters and not the console.

If the input level is set too high at the input module, the signal will clip at the A/D converter. Conversely, if the signal level is set too low, the digitized signal will have an inferior signal-to-noise ratio because the amount of noise is fixed for a given converter. With a strong incoming signal, the resulting digital data stream is optimized for the signal-to-noise ratio of the converters. This will then present a low-noise signal to the digital output module, which will output a clean, strong analog signal to the console.

If the intensity of the signal entering the digital input module changes, it is essential that the gain adjustment be made at the digital input module, NOT at the console. Because the gain and pad on the console are used only to match levels with the output of the digital system's D/A circuitry (and not a particular signal such as a vocal mic or guitar), adjusting these console settings because the intensity of the original signal changed is not addressing the source of the problem.

CALIBRATION STEPS

Start by setting the master output level of the console to minimum to protect your hearing and your speakers.

1. *Set a signal generator to output a 1kHz sine wave.*
2. *Connect the signal generator to one channel of the Input Module (e.g., AN-16/i or 6416i).*
3. *If using a signal generator with a fixed output level setting, choose its +4dBu setting.*
4. *Set the gain on the Input Module as high as possible without clipping.*
5. *Connect the Output Module (e.g., AN-16/o or 6416o) to the Input Module with a Cat-5e cable.*
6. *Connect a balanced audio cable from the Output Module channel with the sine wave signal on it to an input channel on the mixing console. Use a line-level input if available. If none is available, connect to a mic-level input and turn on the pad.*
7. *Set the output level on the corresponding channel of the Output Module to the line level, unless you are using a mic-level input on the console without a pad. (Note: If you are using a TRS or EB version of the AN-16/o, use the -10dBv setting in most cases.)*
8. *Set the console's input gain trim to minimum on the selected channel, and set the channel's fader to 0dB.*
9. *Monitor the input channel's level meter as you start to increase the gain. Be sure to use the channel's Gain knob (not the channel fader). Because the main faders are down, you will not hear the test signal.*
10. *Increase the channel gain until the channel's meter either reads 0dB or just before the clip light comes on.*
11. *Repeat this for each channel, being sure to select the correct output level on the Output Module before adjusting the channel gain on the console.*
12. *Disconnect the test-tone generator and connect the real inputs (mics, instruments, etc.). For each channel, adjust the Input Module's gain to get as high as possible without clipping. No changes should be made at the console or digital Output Module.*

MIXING IN A CALIBRATED SYSTEM

Once each stage in the signal chain is calibrated, there should be no need to adjust the settings of the console input gain or pads or the output levels of the digital output module. All gain adjustments *must* be made at the digital input stage. Of course, channel faders on the console should be used freely for mixing!

Digital transport is unquestionably more flexible and more scalable than analog snakes. Yet getting outstanding performance from a digital system requires a bit more setup than simply plugging in the wires. But the steps are simple, and with the gain stages optimized, you're guaranteed all the benefits of digital—including excellent audio quality.

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