Evolution of the DJ Mixer Crossfader

Origination: The DJ mixer crossfader was originally developed as a control for implementing smooth fades from one program source to another, but where did the idea come from? Fading between two independent sources was first accomplished by DJs using *two rotary knobs*. They would maintain constant acoustic energy (equal loudness) in the room while carefully fading from one program source to another. Some expertise was required to accomplish this effect accurately and consistently. It became obvious that if a way could be found to fade from one source to another with a single control, the task would be much easier and repeatable for the less experienced.

Panning circuits were already used in recording studios to move a single source from *left-to-right* while maintaining constant acoustic energy. While the requirements for a single source panning circuit were well defined, those for maintaining constant acoustic energy while fading from *one source to another* were *not*.

1st Generation: Knowledgeable engineers noted that if two source signals of equal RMS amplitude were statistically random and incoherent, a slight modification to the standard panning circuit would allow constant energy fading between sources. The new control was called a *crossfader* and has achieved wide use and acceptance. Figure 1 shows the classic constant-power response.

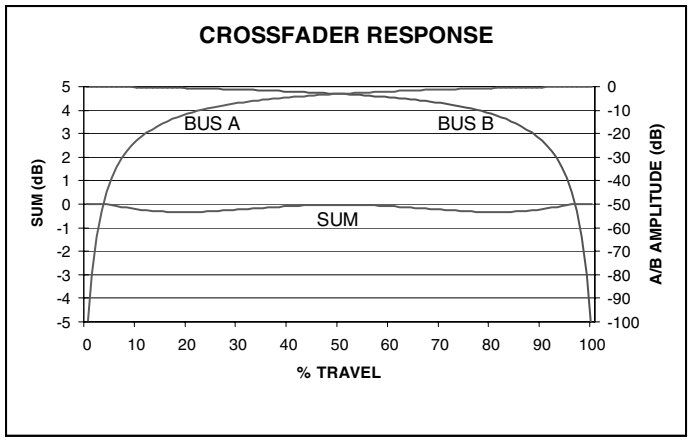

Figure 1: Constant-Power Response

The curve shown in Figure 1 only yields constant-power fading when *the original source signal assumptions are true.*

Limitations: It wasn't long before the basic crossfader topology showed some limitations. Disco dance music with a dominant beat challenged the original assumption of *random*. As beat matching source signals gained popularity, the assumption of *incoherence* became invalid. Those who had mastered the skill of two-knob-fading scoffed at the idea of a crossfader control, and were now saying "we told you so." It was apparent the traditional crossfader lacked flexibility.

In addition to the fundamental, smooth crossfade response shown in Figure 1, DJs wanted to perform more complex mixing functions. They wanted to *add* one dance song to another without losing energy in *either* until fully mixed. They wanted to *cut* in a beat and then *pump it up*. They wanted to *cut* one program in and out without affecting the other. Figures 2-4 show some of the tapers required for various effects.

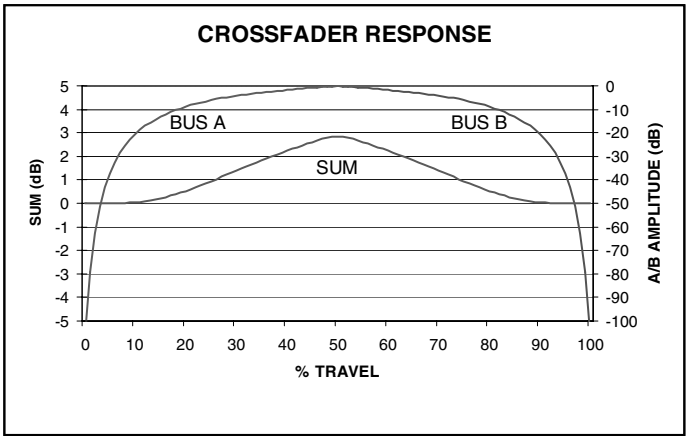

Figure 2: "No Dip" Taper for Adding Sources

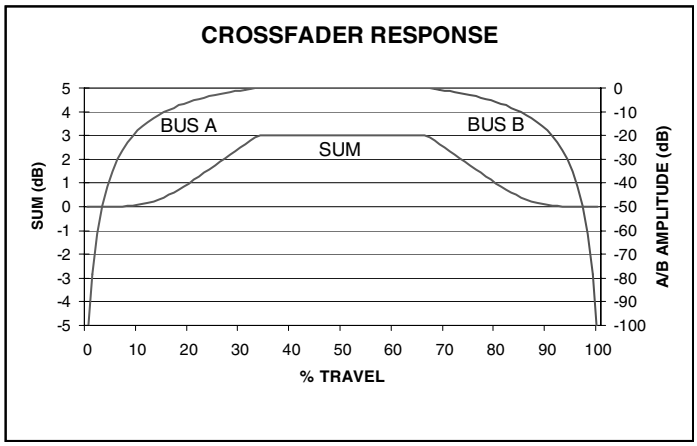

Figure 3: Medium Taper for Cut In and Pump-It-Up

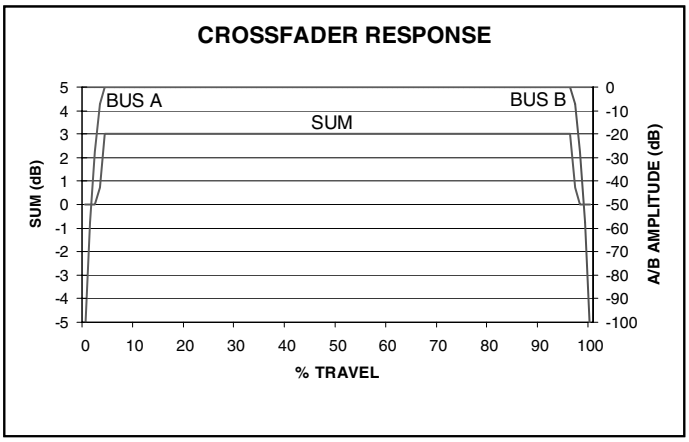

Figure 4: Sharp Taper for Cut and Scratch

2nd Generation: It was soon clear that one crossfader response curve was not suitable for all applications. No matter how skilled the DJ, it was not possible to achieve all of the desired effects. At first, the applications were distinct enough that manufacturers could design special mixers by selecting one of the tapers shown in Figures 1-4 for specific applications. However, as DJ performances became more sophisticated and competitive, a fixed taper became inadequate. DJs wanted to mix it up. By now they were familiar with the results possible with the various tapers and wanted them all. For performing DJs, the days of the application specific crossfader were over.

3rd Generation: The solution was to provide a second control that would allow the DJ to change the taper of the crossfader.

Limitations: At this point, most designers had lost track of the original constant-power crossfader taper. Implementations had become careless and undefined. Defined standards did not exist for the tapers shown in Figures 2-4. When crossfader taper control was added, it was not surprising that the range and shape of tapers was haphazard. Each implementation performed differently, causing confusion among performers.

The best passive controls could not meet the increasing demands on performance and usage. Passive controls are rated for a maximum number of operations, while maintaining given travel noise and force specifications. As the number of operations increases, travel noise goes up and travel force changes. Even high-quality controls with cycle life ratings as high as 100,000 to 300,000 require frequent service or replacement.

4th Generation: The high maintenance requirements of passive crossfader controls resulted in unacceptable service costs and down time. It was bothersome to disassemble a mixer just to clean and lubricate the controls. Replacement required costly factory service and could leave a DJ without income for weeks. The solution was to design mixers with field serviceable crossfaders. While doing nothing to resolve the reliability problems, the *removable crossfader* did help reduce service costs and down time.

5th Generation: To improve performance and extend service life, audio was removed from the crossfader control and processed in a voltage-controlled amplifier (VCA) or some other voltage/current controlled element. The crossfader control was only used to develop a DC control signal. However, this implementation was found only on expensive mixers. This practice greatly reduced travel noise and extended service life, but the performance of affordable VCAs was limited. In addition, crossfader tapers were still poorly defined as were the controls used to alter the tapers. Implementations were complex and consistency was poor.

Rane developed an *Active Crossfaderä* design, featuring high quality VCAs, low cost, and simplicity. The classic response of the design is shown in Figure 1. In addition to providing an accurate constant-power response, the circuit produced the optimum integration time for removing travel noise without noticeably affecting the reaction time of the control. The *Active Crossfaderä* topology created an excellent foundation for more sophisticated designs.

Musical Instrument Generation: A new art form emerged from hip-hop. Turntablist (scratch DJs) take small bits and pieces of music from different locations on vinyl records and create new compositions. A mixer and a couple of turntables become their instrument. This emerging art form again put demands on crossfaders that current state-of-the-art designs could not meet.

The following is a list of the new requirements:

· Music instrument quality and performance.
· Accuracy, reliability and repeatability for all functions.
· More than a 10-times increase in crossfader usage over previous applications.
· Crossfader with a taper range adjustable from constant-power to less than a .1 inch (2.5mm) pitch between full off and maximum level.
· Mechanically durable crossfader control with a knob that provided a fine music instrument feel.
· Crossfader taper control with smooth and predictable settings.
· Reverse operation of the crossfader.

In addition to the new crossfader demands, *all of the same demands were now placed on the input (or program) faders.*

None of the existing designs met all of the new demands. In addition, many manufacturers were timid about providing *any* product for fear of service liability problems. Available products were either very expensive with limited performance and feature-sets, or cheap throw-away toys with virtually no warranty.

Rane accepted the challenge and designed a performance mixer meeting all of the new demands, with music instrument quality and reliability. Because the combination of features was complex, and performance requirements very high, it was apparent that the new design would need new technology.

The challenge was to find an active or VCA topology that would provide the required performance without excessive cost or complexity. A single, low-cost, high performance, quad gain core that provided crossfader *and* input fader gain control for a stereo, two bus system was one answer. The actual audio signal path is very simple, yet the topology allows complex control.

This patent pending design isolates all audio from the control elements, greatly extending the life and performance of the controls.

The taper of the crossfader is adjustable from the gentle, constant-power curve shown in Figure 1, to the steep taper shown in Figure 4. Careful control of attack and decay rates yields low noise and smooth performance. In addition to predictable taper control, the design provides crossfader reversal.

Because the input faders use the same VCA design as the crossfader, these controls also have excellent control isolation, performance and reliability. As with the crossfader, implementation of accurate taper control (shown in Figure 5) and reversal functions, is possible without affecting audio quality.

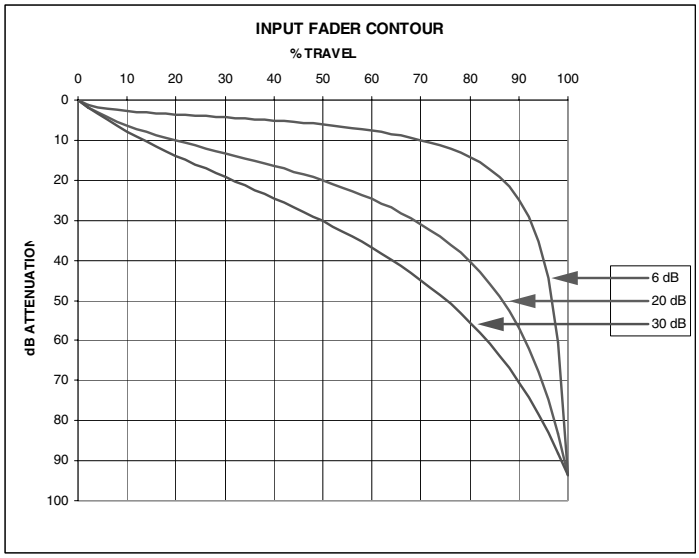

Figure 5 Input Fader Taper Control.

In the end, the crossfader has provided functionality far beyond what was originally envisioned. Advanced topologies allow mixing styles not possible with two knobs (can you imagine scratching on a UREI; however, we must concede that some traditional mixing tasks are best accomplished with the two knob method.)

While disco dance, hip-hop and scratch are well established genre, new mixing styles continue to develop. What's next? As mixing styles continue to evolve, so will the performance mixer. There may soon be as many styles of performance mixers as there are guitars. One thing is for sure; the evolution isn't over! Performers continue to demand new levels of performance and reliability, and designers continue to respond.

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