

## Evolution of the DJ Mixer Crossfader

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- **Curves**
- **Pots - VCAs - Magnetics**
- **Performance**

### 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.

**Rick Jeffs**  
**Rane Corporation**

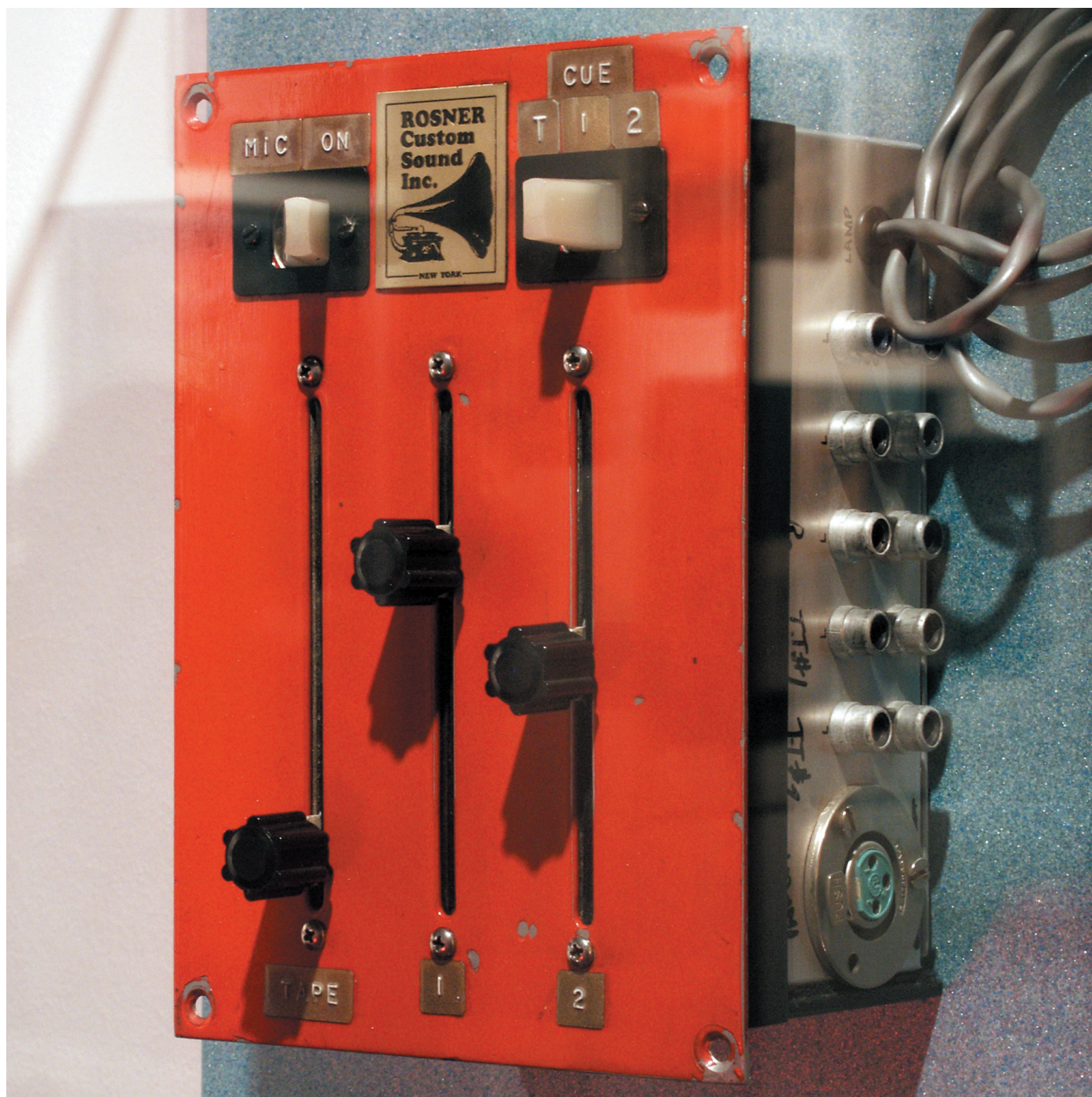
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Panning circuits were already used in recording studios to move a single source from *left-to-right* while maintaining constant acoustic energy. While the requirements for a single source panning circuit were well defined, those for maintaining constant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

The exact origin of the first use of a crossfader in the DJ world has proven difficult to track down. It seems certain to have come out of the broadcast industry,

where the term “fader” has been in use since at least the '50s (mentioned throughout the *Radiotron Designer's Handbook*, 4th ed., 1952) and the term “cross-fading” shows up in the *Tremaine's Audio Cyclopedia* in 1973. The earliest example documented so far was designed by Richard Wadman, one of the founders of the British company Citronic. It was called the model SMP101, made about 1977, and had a crossfader that doubled as a L/R balance control or a crossfade between two inputs.



"Rosie" is the first known DJ mixer, circa 1965. Courtesy EMP (Experience Music Project, Seattle).

## 1<sup>st</sup> Generation Curve Shape

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.

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.

## 2<sup>nd</sup> Generation Curve Slope

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.

## 3<sup>rd</sup> Generation Curve Slope

The solution was to provide a second control that would allow the DJ to change the crossfader taper.

**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.

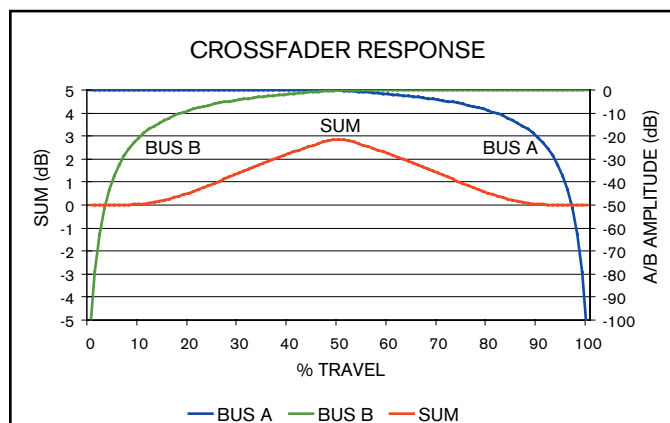


Figure 2. "No Dip" Taper for Adding Sources

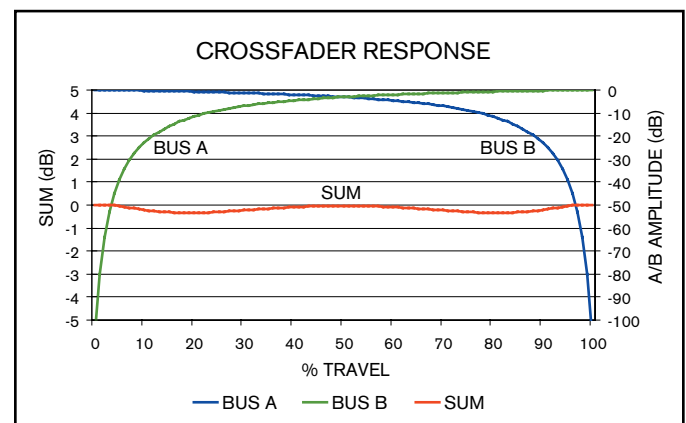


Figure 1. Constant-Power Response



#### 4<sup>th</sup> Generation Curve Slope

The high maintenance requirements of passive crossfaders 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 cross-fader* did help reduce service costs and down time.

#### 5<sup>th</sup> Generation Curve Slope

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 Crossfader*<sup>™</sup> 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 Crossfader* topology created an excellent foundation for more sophisticated designs.

#### The Musical Instrument Connection

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 & 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.

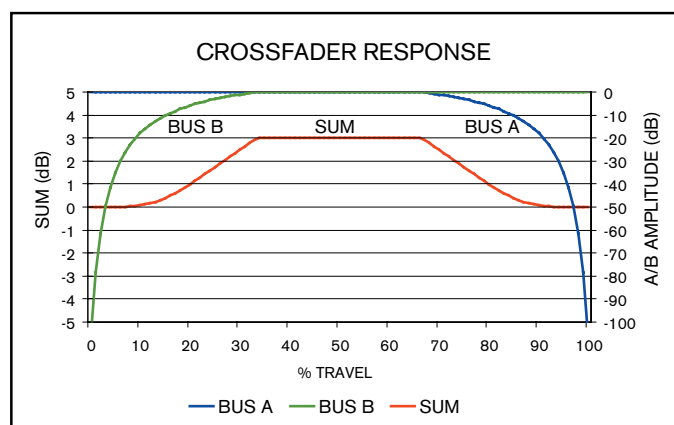


Figure 3. Medium Taper for Cut In and Pump-It-Up

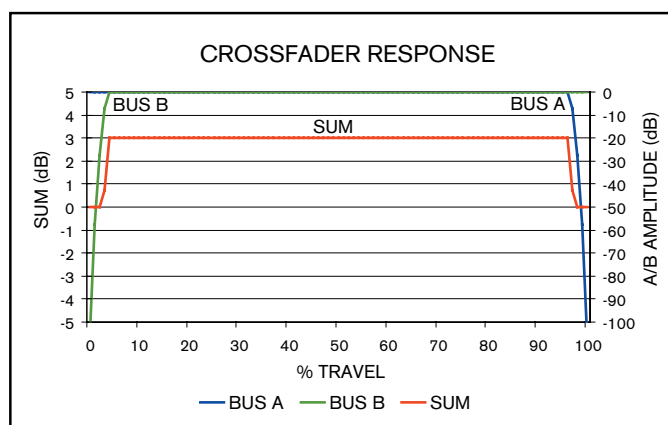


Figure 4. Sharp Taper for Cut and Scratch

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 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.

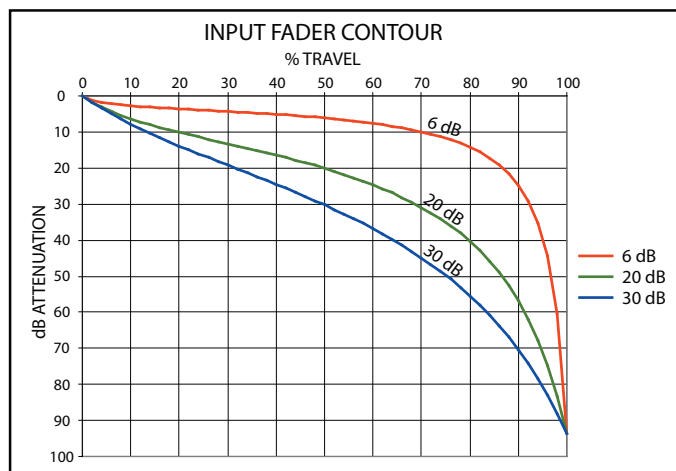


Figure 5. Input Fader Taper Control.

## Magnetics

The new patented Rane magnetic fader is the fastest, most accurate, and longest lasting on the planet. The design uses non-contact technology previously reserved for the most demanding aerospace and industrial applications. *No travel noise — no bleed — ever.*

Unlike *optical* non-contact faders, Rane's *magnetic* fader is impervious to smoke, moisture, temperature, ambient light and aging. (*You know, only the stuff you run into at every club.*) The electrical performance of the new fader is — *literally* — unaffected by use. The mechanical life exceeds *10 million* operations.

Rane's magnetic fader accurately translates hand motion into precise audio level control. This system provides more flexible curve selection and fader assignment options than ever before. And they are the first to offer true morphing between curves.

It is common for a crossfader to undergo millions of operations over the life of a mixer. High-quality potentiometers used with VCAs yield 100,000 to 500,000 operations. More exotic, doped-plastic-element potentiometers yield 2 million operations. *In all cases, contact-based controls generate travel noise and exhibit electrical performance decline with use.* Non-contact fader technology is the only way to fully address the needs of the professional performance DJ.

Non-contact controls sense position without the use of electrical contacts. This eliminates both travel noise and electrical performance decline as parts wear. Possible methods include optical (*light and a shutter*), sonic (*sound and a receiver*), inductive (*coupling between coils of wire*), capacitive (*coupling between conductive plates*) and magnetic (*sensing the strength of a magnetic field*). Each of these methods varies in complexity, accuracy and immunity to environmental changes.

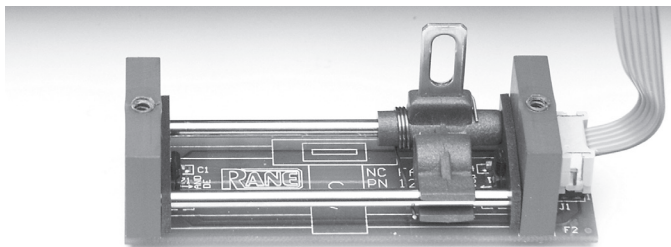
Rane favors magnetic position sensing due to its unique combination of *simplicity*, *accuracy* and *environmental immunity*. How does it work? It's as simple as 1-2-3:

- 1) Finite Element Analysis (FEA) is used to map the flux density field of a small, rare-earth magnet. [*FEA is a computer-based modeling technique.*]
- 2) A stationary Hall effect sensor is used to measure the flux density of the moving magnet. [*Hall effect, named after its discoverer E.H. Hall, describes a voltage that is generated by the effect of an external magnetic field acting perpendicularly to the direction of the current.*]
- 3) The location of the magnet (*your hand*) is determined by comparing the measured flux density value to a stored master flux density map.

[*For more details on Hall effect sensors, Lorentz forces and other exciting things see the Pro Audio Reference. Meanwhile, if you can't wait, Rick Jeffs explains: "When a perpendicular magnetic field is present, a Lorentz force is exerted on the current flowing in a thin sheet of semiconductor material (Hall element). This force disturbs the current distribution, resulting in a potential difference (voltage) across the output. The stronger the magnetic field, the greater the voltage difference."*]

Rane uses only the finest materials: nickel-plated neodymium-iron-boron magnets, space age plastic with embedded Teflon®, surface-passivated and polished stainless steel bearing rods and stainless steel handle. The result is a control offering unprecedented feel, control and years of accurate, carefree operation.

*The Rane magnetic fader is the fastest, most accurate, and longest lasting on the planet. See it on the TTM 56 and TTM 57SL.*



## Summary

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, hip-hop and scratch are well established genre, new mixing styles are evolving at a rapid pace: Trance - techno - electro - jungle - breaks - gabber - scratch - house - drum 'n' bass - acid - etc.

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. The invention of non-contact fader controls has answered the need for reliable controls. The use of microprocessor based methods of translating hand motion into virtually any desired response answers the need for versatility. 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.