strymon

dBucket™ Technology

Analog vs. Digital

Analog delay chips move a signal along a chain of analog storage elements (capacitors) in a fashion that is similar to the way water gets transferred in an old-time firefighting bucket brigade. Hence the name of these Bucket Brigade Delay (BBD) devices. The total time of the delay is determined by the number of storage capacitors (buckets) and the time it takes (controlled by a clock chip) to move from one bucket to the next.

Digital ICs use a fundamentally different approach to delay a signal. The signal is converted to digital and stored in a memory bank where it is read out at a later point in time and converted back to analog. The total delay time is determined by the size of the memory bank.

Limitations

In the BBD chip, there is signal 'loss' at each bucket transfer, similar to water being spilled when pouring from bucket to bucket. The loss degrades the fidelity of the delayed signal by introducing noise and distortion. To achieve long delay times, more buckets are required, which results in yet more loss.

Alternatively, a slower clock signal from the clock chip can be used to increase the delay time. But extra filtering is required to prevent excessive artifacts that arise due to the slow clock, and this also reduces the fidelity of the delayed signal. Therefore there are practical limitations on the maximum delay times achievable with an analog BBD delay, as delay time is increased at the expense of fidelity.

In contrast, digital delays experience no loss of fidelity after the conversion process, and can have arbitrarily long delay times without adverse consequences. While extended delay times are a good thing, the high fidelity of the digital delays can sound 'cold' and 'sterile’ compared to the ‘warm’ and ‘organic’ sounds of the analog delay.

Digital Evolves

To address the sterile hi-fi qualities, digital delays have made use of filtering and distortion (in either analog or digital) to simulate the sonic degradations that occur in the analog BBD chips. See below for a simplified diagram. These delays can sound excellent, and may have many features by exploiting the programmability and virtually unlimited storage space available in the digital system. However, delays of this type cannot fully capture the subtle nuances of an analog BBD delay.

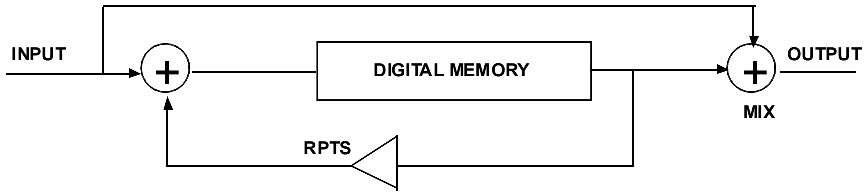

FIG. 1: BASIC DIGITAL DELAY

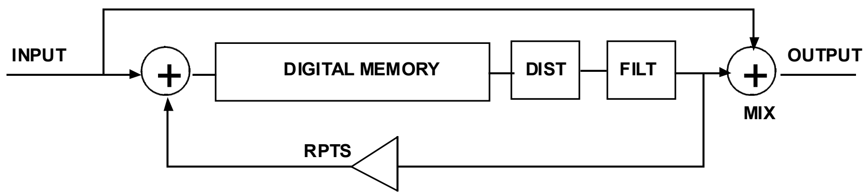

FIG. 2: 'ANALOG-VOICED' DIGITAL DELAY

What's Missing?

To understand the shortcomings of the 'analog-voiced' digital delay in achieving true analog BBD-like sounds, a thorough analysis of the BBD Integrated Circuit (IC) is required on a micro-level. As stated before, the loss in a BBD delay occurs at each bucket stage along the delay line. The loss is a function of the device-properties of the transistors and capacitors that make up each bucket, and it is dependent on the signal traveling through the bucket. Loud signals experience a different loss than quiet signals, and high-frequency signals experience a different loss than low-frequency signals. These non-linear losses cannot be accurately reproduced by lumping the effects into an all-at-once process.

Additionally, an integral part of the operation of the BBD is its interaction with the clock chip. The clock chip will contribute its own sonic artifacts that can become extreme at longer delay times. This aspect is absent in the analog-voiced digital delays.

Enter Strymon dBucket^{TM} Technology

So what is the solution? The BBD must be recreated in its entirety, with all transistors and capacitors being described mathematically, and the signal moving along the bucket with consideration of the clock chip's contribution to the process. This is computationally complex, and requires a powerful Digital Signal Processing (DSP) chip to be dedicated to this task. But the result is one that accurately captures the subtleties and nuances of an analog BBD delay, including the loss characteristics, self-oscillation qualities, pitch effects, and delay-time artifacts.

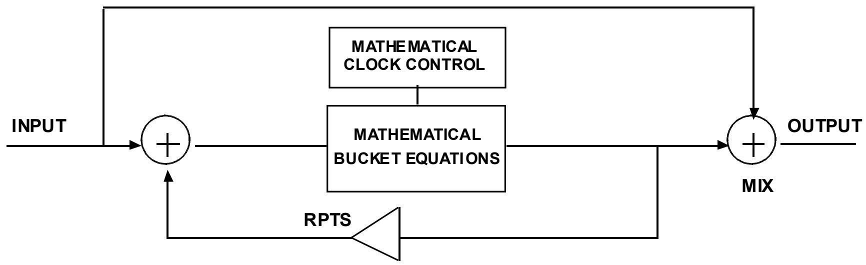

FIG 3: Basic dBucket Block Diagram

dBucket Applications

With the dBucket faithfully recreating the characteristics of the BBD, the other aspects of designing a delay-based circuit can be considered in the same way as when designing in analog. These considerations include companding, filtering, limiting, input conditioning etc. The dBucket lends itself naturally to all traditional BBD applications, including delay, flanger, chorus and vibrato.

What are the Advantages of dBucket Technology?

Since the dBucket is described in mathematical terms, its properties can be manipulated to provide varying degrees of loss, essentially running the delay with different BBD chips. The various components of bucket loss can be isolated to provide independent control of distortion mechanisms without increasing noise, or to create a 'cleaner' bucket than possible with integrated circuit technology. As a result, the limitations on delay time imposed by the bucket loss and clock chips can be managed to provide BBD delay sounds with extended delay times that would be unachievable with traditional analog BBD chips. Additionally, since it is implemented is a digital system, all the digital feature benefits of parameter control, presets, MIDI etc can be taken advantage of.

Summary

A powerful SHARC processor is dedicated to recreating the entire signal path of an analog BBD chip, on a transistor level of detail. Each bucket is described mathematically and controlled with consideration of the clock chip. This results in an experience that captures the subtleties and nuances of an analog BBD delay, including the loss characteristics, self-oscillation qualities, pitch effects, and delay-time artifacts. This is Strymon dBucket™ Technology.