CURRENT INJECTION

THE SHORTEST SIGNAL PATH EVER

Fig. 1 Traditional Circuit

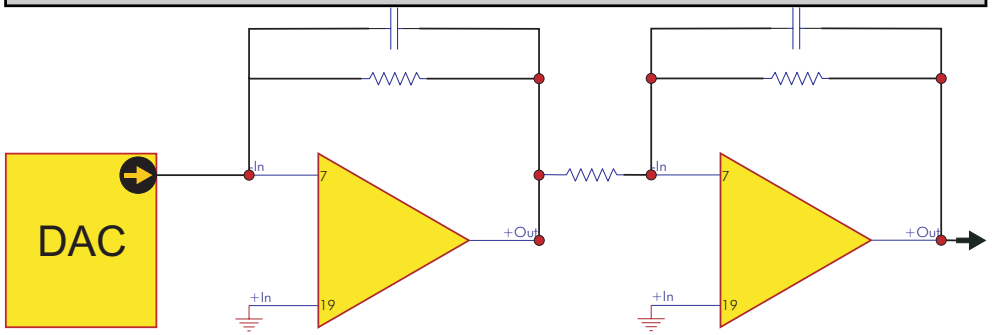
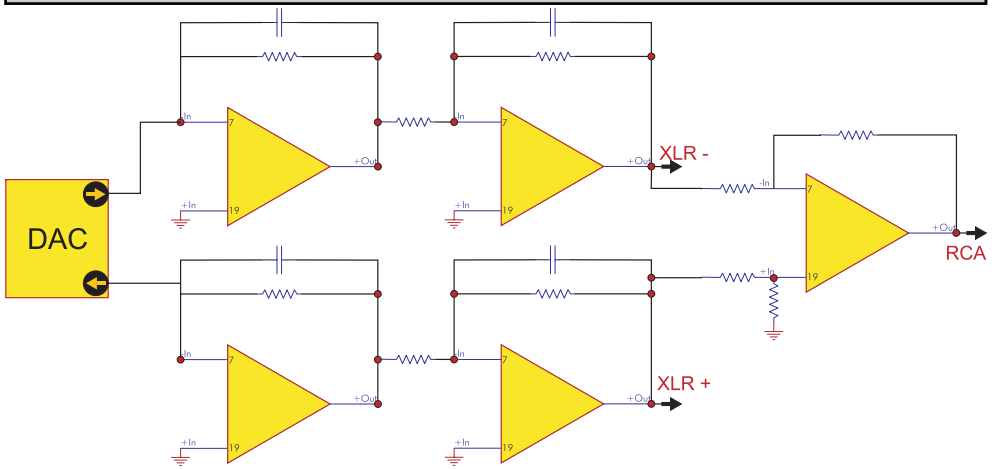


Fig. 1b Balanced Traditional Circuit



Current Injection describes a method of shortening the signal path and improves the sound quality and measurement specs significantly. The effective simplicity of *Current Injection* requires a non-feedback-loop amplifier. While *Current Injection* replaces the voltage amplifier *LEF* guarantees best performance of the current amplifier with low THD. Both technologies complement each other and overcome the limitations of traditional circuitry to a better standard of music reproduction.

This essay intends to give an understanding of the basic idea of *Current Injection.*

As an example a digital / analogue converter output stage is used.

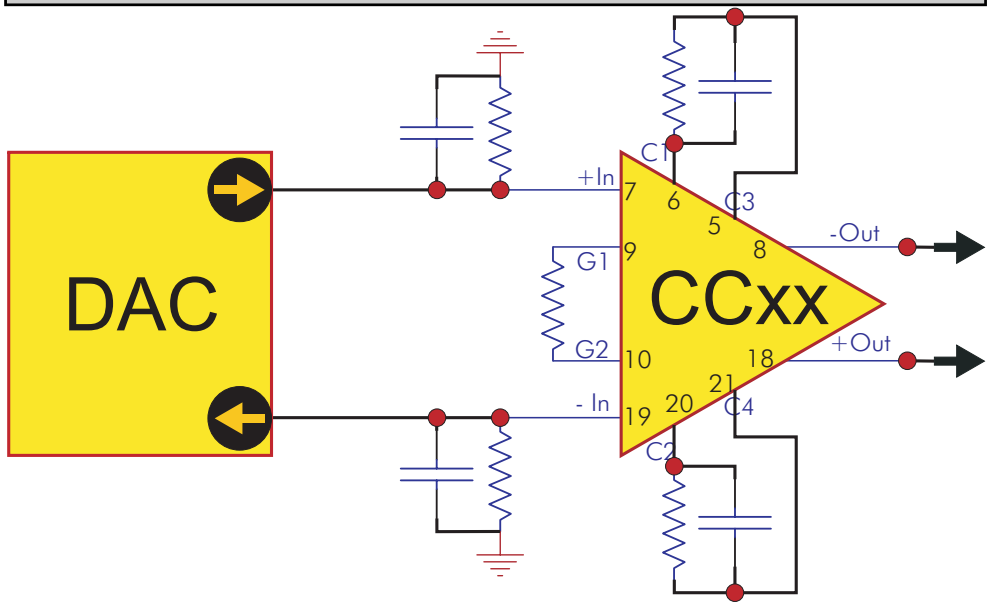
Fig1. shows a simplified traditional connection of a current output digital / analogue converter to an analogue amplifier stage. The current to voltage conversion as well as the first filter pole is done through a feedback loop which is a questionable solution concerning dynamic performance.

Basically it should be understood that any normal amplifier concept replaces the original signal by a “copy”. No copy is as good as the original and the more the original music signal is “copied”, the more the result differs from the original.

The input signal “moves” the voltage amplifier stages in the OP-amplifier (at least 2 voltage amplifier stages within one OP-amplifier). Each stage delivers a “copy” of the original signal and finally the current buffer stage generates a further “copy”. Because all these copies are certainly far from being perfect a negative feedback loop is used for reducing the signal degradation—this method is not free of side effects.

Due to the filtering requirements of a digital audio device at least 2 OP-amplifier are required, which adds a further “copy session”. In total the traditional solution requires at least 6 copies. A proper handling of balanced signals as shown in Fig. 1b further increases the quantity of amplifier stages within the signal path. In case differential DAC signal proceeding is required for XLR output as well, the quantity of amplifier stages would even exceed Fig. 1b.

Fig. 2 Improved Circuit Using CCxx LEF Modules



When using a genuine CCxx LEF amplifier module (e.g. CC75 or CC80) a sound quality improvement and design simplification are easy to achieve. Due to the LEF current amplifier and a very low THD voltage amplifier stage a negative feedback loop is not necessary anymore.

Fig. 2 shows such design.

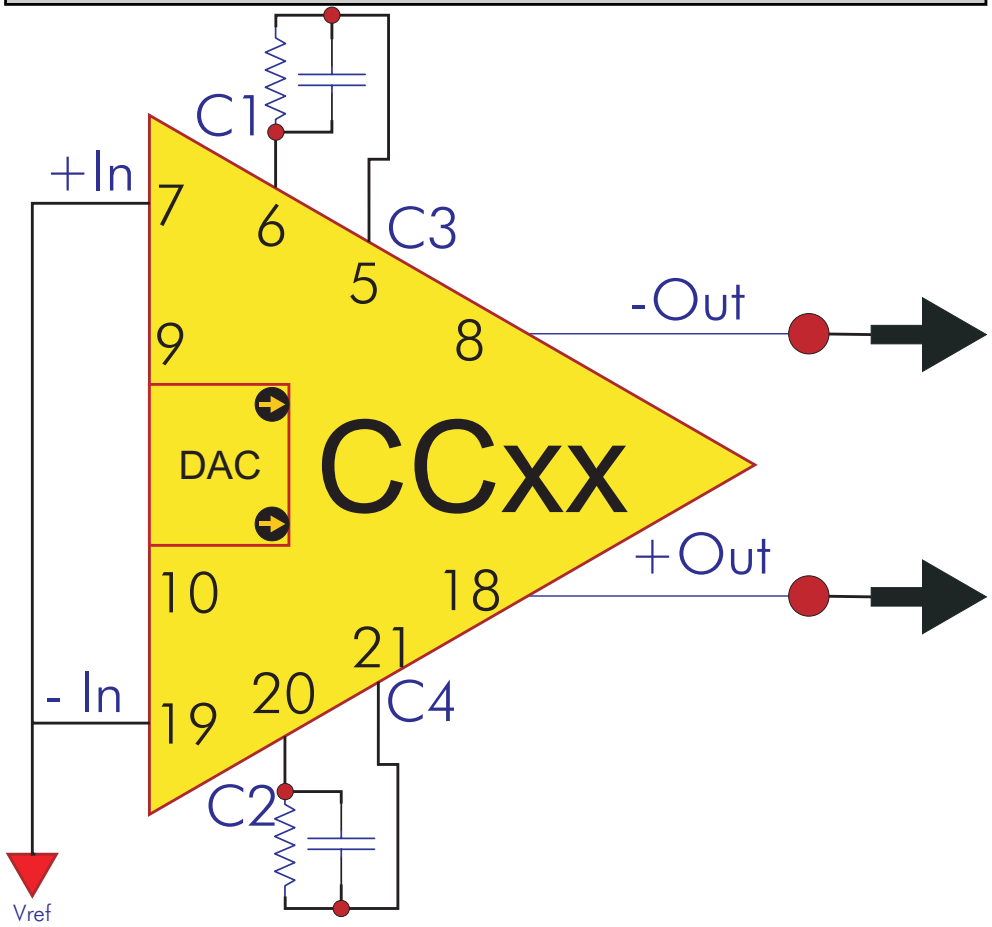
The current to voltage conversion is done passively without any dynamic sound quality degradation. 6 signal “copies” of the traditional design are replaced by just 2 signal “copies” - just one voltage amplifier stage and one LEF current driver.

In addition the basic circuitry of the CCxx modules suites balanced designs much better than any OP-amplifier. Most high quality applications require balanced circuitry. A true balanced circuitry solution with operational amplifiers further increases the number of amplifier stages.

Even though this circuit already improves the sound quality remarkably compared to traditional solutions, it is not perfect indeed. The passive current to voltage conversion causes a voltage swing at the DAC output. Thus some DAC increase the amount of harmonic distortions. The noise figures of a single ended class A amplifier without any negative feedback loop are limited to about 100 dB, which is quite good already.

The voltage amplifier inside the CCxx module produces a higher distortion level than a traditional amplifier with negative feedback loop correction. The total distortion level is about 10 times higher than high quality OP-amplifier solutions. Regarding no use of any feedback loop this is an excellent result anyway.

Fig. 3 Current Injection



For achieving an even better solution than Fig. 2, preserving the original music signal and achieving measurement specs beyond any discussion, the traditional idea of thinking in separate functional units (DAC, voltage amplifier, current booster…) has to be replaced by integrative thinking. The result is *Current Injection* combined with *LEF*.

Fig 3 shows a simplified *Current Injection* solution.

The DAC (digital analogue converter) is drawn inside of the CCxx module, which symbolizes the merging of these functional stages. The DAC is an internal part of the amplifier design and there is no more amplifier input. A voltage amplifier does not exist anymore. The output voltage is generated by the original DAC current and thus no “copy”. Current injection avoids the input noise and almost all distortions caused by a voltage amplifier.

“Un-measurable” specs like dynamic performance are also unmatched when using *Current injection*.

At last there is just the LEF current booster left providing the only “copy” of the original music signal. This LEF circuit provides an outstanding performance.

There is also no voltage swing at the DAC output and thus the DAC provides it’s optimum performance.

Without any negative feedback, without a lot of amplifier stages, with single ended class A performance and with optimum balanced signal handling current injection achieves noise and distortion specs on the level of top operational amplifier solutions. However *Current Injection / LEF* surpasses the traditional circuitry in any musical aspect. Unlike the traditional design, the non-feedback Current Injection / LEF design has no difference of static (e.g. sine-wave measurement) and dynamic performance (music).