The LTC1597 16-bit current output DAC is capable of settling in the neighborhood of 1.7μs to 2μs using the 16-bit accurate LT1468 as an I-V converter. For applications needing higher throughput such as in-circuit testing, electrostatic sorting of organic materials, or electrostatic actuation of MEMS as examples, 1μs settling seems to be a common goal. This article shows a composite amplifier that can achieve settling in 1μs.

The topology shown in Figure 1 combines the low noise, low offset, low input current qualities of the LT1468, with the fast slewing output of the LT1227. The output of the first stage is still taken as the node that drives the compensation capacitor, but the second stage, the LT1227, configured with a closed loop gain of +7 produces the output, and is the source for global and DC feedback.

However, as there is no bandwidth limiting in the second stage other than the amplifier itself, the wide-band noise of the amplifier produces considerably more than 1 LSB of noise.

In addition, there is peaking in the first stage due to the effect of the large capacitance at the output of the DAC. The noise from the first amplifier is also amplified by the fixed gain of the second. This then requires bandwidth limiting to bring the noise level down to a level that could be considered acceptable using the common expectation that the signal remain within 1 LSB after settling. A 1st order 2MHz lowpass as shown will extend the settling time on the order of 5%. Note that settling time is DAC input code dependent.

A factor of two improvement in settling time would in itself be considered worthwhile, but perhaps more importantly for many applications of this part, it gets close to the target output considerably faster, and in a more consistent fashion across code changes, and amplitudes. In addition, as the composite does not spend as much time in a slew rate limited state, harmonic distortion is reduced.

The topology with the LT1468 by itself will be slew rate limited for any significant code changes. In the case of waveform generation, the slew rate limiting in itself is responsible for odd order harmonic distortion, and inter-modulation distortion. Any mismatch between positive and negative slewing, is responsible for 2nd harmonic distortion.

If the LTC1597 is used for waveform generation below a few kHz, these effects are not very significant, and 2nd harmonic distortion is on the order of –95dB, but above 5kHz to 10kHz, the slew limit related distortion becomes increasingly significant. At 20kHz, the slew rate of the LT1468 will limit a full-scale signal to a spurious-free-dynamic-range figure (SFDR) of about 70dB. At 20kHz, the composite produces on the order of –95dB SFDR. Similar improvement in multiplying applications can be achieved.

You will notice that the compensation capacitor is larger in the case of the composite, and yet the combination is faster. A larger cap is required because the signal swing at the output of the LT1468 is reduced by the same factor as the close loop gain in the output stage. The phase margin in the case of the composite is improved by virtue of the phase shift associated with the pole in the DAC feedback path being reduced to a greater extent due to the greater relative value of the compensation capacitor.

As there is more phase margin, as well as about 16dB more open loop gain, the variability of settling times versus code is reduced. Variability in settling time is due to variation in feedback factor, or noise gain, in the I-V stage, as well as variation in phase margin with changes in output capacitance and noise gain. Feedback factor is normally 2 in the case of an

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1. For more about the high speed settling performance of the LTC1597, used in conjunction with the LT1468, and how to measure it, see Linear Technology Application Note 74 by Jim Williams.
The LTC3727 has other features that make it efficient and easy to use. Its OPTI-LOOP® compensation feature allows the transient response to be optimized over a wide range of output capacitance and ESR values. It also provides different operating modes depending on the needs of the application. The Burst Mode feature boosts efficiency at light loads, whereas forced continuous or pulse skipping modes are designed to accommodate applications where low noise and small output voltage ripple is critical. Other features include a phase-lockable frequency of up to 550kHz, a power good output voltage monitor, a programmable output voltage up to 14V, a maximum input voltage of 36V and availability in a small 28-lead SSOP package.

**A High Output Voltage Automotive and Industrial Power Supply**

Figure 1 illustrates a common automotive and industrial application for the LTC3727. This power supply operates over an input voltage range of 15V to 24V and provides outputs of 12V at 4A and 5V at 4A. The PolyPhase architecture lowers input capacitance requirements, so that this circuit only needs 20µF of ceramic input capacitance for 68W of total output power. Only two 10µF, 25V low cost ceramic surface mount capacitors are used, and there is still minimal input voltage noise.

In this application, in order to reduce the MOSFET gate charge losses and optimize efficiency, the part operates at its lowest frequency of 250kHz, with the PLLFLTR pin grounded. Nevertheless, the LTC3727 could be synchronized to a higher frequency, up to 550kHz, to reduce the inductor size, but the efficiency suffers slightly.

Figure 2 shows that this simple circuit is over 90% efficient for both channels at output currents of 4A. The 12V channel uses a 100µF, 20V surface mount tantalum output capacitor to maintain an output ripple voltage of less than 100mV.

This versatile design is not limited to 4A. You can adjust the output current by modifying the components (i.e. sense resistor, MOSFETs) around the chip without changing the basic design.

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For situations where getting close fast is important, the output of this composite will get to within 12-bit accuracy within about 200ns versus approximately 1µs for the LT1468 alone.

There are some other subtle performance benefits of this composite. The LT1468 is not obliged to drive any significant output current in driving only the LT1227 input, and hence will not exhibit any thermal tails. The settling time of these circuits is variable due to variation in DAC feedback resistance, and output capacitance, as well as variation in LT1468 slew rate. If optimal results are required in either the original topology or the composite, trimming may be required.

The LT1468 alone is a simpler and lower power solution than the composite and depending on noise requirements, may not require an output filter. In the event that the load cannot be driven via the higher output impedance of the filter, the original topology may be a better choice. If the original is not fast enough, or if lower harmonic distortion is required, try the composite.

Figure 1 includes an alternate compensation scheme, which compensates for the output de-glitcher switch impedance built into the LTC1597.