

12-, 10-, and 8-Bit DACs with Integrated 10ppm/°C Reference in 2mm × 2.1mm SC70

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Introduction

Because the output voltage range of a DAC is directly proportional to its reference voltage, the accuracy of the reference directly impacts the accuracy of the output. Despite the critical nature of the reference voltage, it is often overlooked, and simply tied to a power supply rail. This makes the DAC output track the power supply—including its inaccuracies and noise, which may be unspecified and quite large.

In the LTC2630 family of small-footprint DACs, a high performance voltage reference is built in (Figure 1), eliminating the need for an external reference. The LTC2630 provides an unprecedented combination of accuracy, small size, integrated reference and ease of use, making it ideal for applications from general-purpose voltage adjustment in analog signal conditioning circuits to high accu-

racy industrial controls. An H-grade version that operates over a -40°C to +125°C temperature range is available for demanding industrial, military, or automotive applications.

Full Scale Defined by Integrated Reference or Supply

The LTC2630's integrated reference provides a full-scale voltage that is

low drift ($\pm 10\text{ppm}/^\circ\text{C}$) and insensitive to supply voltage variations. The LTC2630-L has a full-scale output of 2.5V and operates from a single 2.7V to 5.5V supply. The LTC2630-H has a full-scale output of 4.096V and operates from a 4.5V to 5.5V supply. When configured in supply-as-reference mode, the output of the LTC2630 can swing rail-to-rail referenced to the input supply.

The LTC2630 offers an unprecedented combination of accuracy, small size, integrated reference and ease of use, making it ideal for a wide range of applications.

Tiny SC70 Footprint and Ultralow Power

The LTC2630 fits the 12-, 10-, or 8-bit DAC and internal reference in an ultracompact 6-lead SC70 package (2mm × 2.1mm). Power consumption is low, too. When operating in internal reference mode, supply current is just 180 μA at 3V. Performance of the DAC, however, is anything but low.

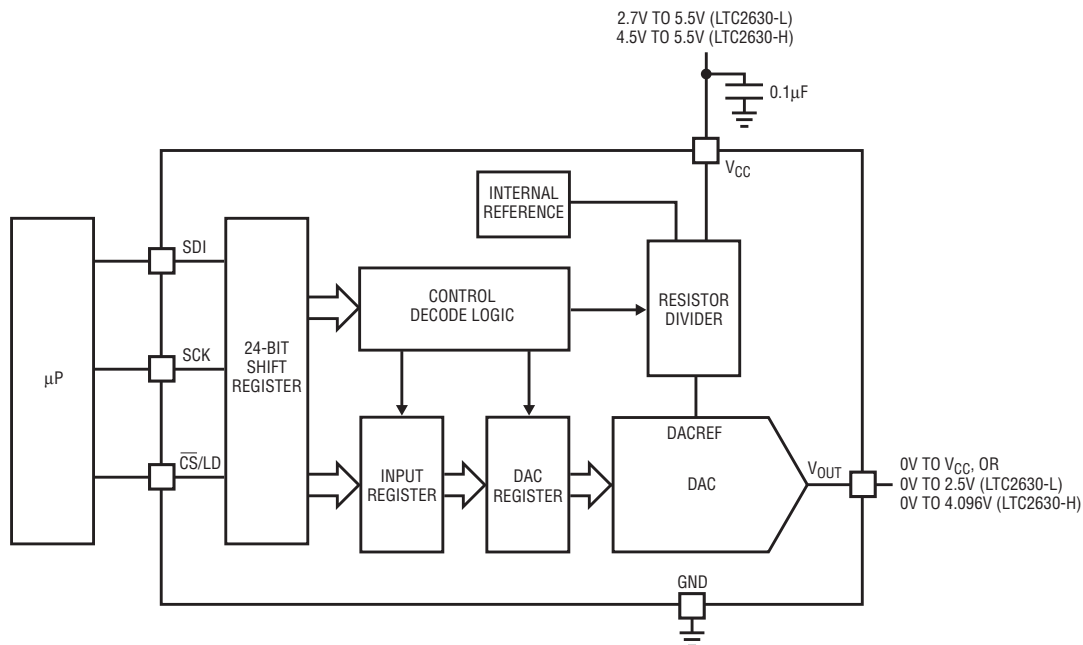


Figure 1. The LTC2630 integrates a high performance rail-to-rail amplifier, 10ppm/°C reference, and double-buffered input data path in an SC70 package.

Outstanding DAC Performance

Linearity: at 12-Bit Accuracy, DNL and INL are Guaranteed ± 1 LSB

The LTC2630 family uses Linear Technology's proprietary, inherently monotonic voltage interpolation architecture, the benefits of which can be seen in Figure 2. For the LTC2630A-12, the DNL is ± 0.2 LSB, the INL is ± 0.5 LSB, and both are guaranteed to be less than ± 1 LSB over the full operating temperature range of the part. For the LTC2630-12, DNL and INL are guaranteed to ± 1 LSB and ± 2 LSB over temperature, respectively. At 10 bits (LTC2630-10), DNL and INL are guaranteed less than ± 0.5 LSB and ± 1 LSB over temperature, respectively. At 8 bits (LTC2630-8), both are guaranteed less than ± 0.5 LSB over temperature.

Predictable and Usable Output Range

Over its rated temperature range, the LTC2630 has a maximum offset of ± 5 mV. The low offset enables a starting code voltage closer to 0V than competing devices. When full scale is set by the internal reference, the full-scale error voltage is just $\pm 0.8\%$ of the full-scale range (FSR), and linearity is guaranteed to the upper code limit. The invariance of these parameters over temperature is shown in Figure 3. Together, low offset and low full-scale error define a predictable output range and maximize the number of usable codes.

Excellent Load Regulation Means Hidden Error is Reduced

The LTC2630's output buffer is guaranteed to be capable of sourcing and sinking 5mA at 2.7V and 10mA at 4.5V. Its high gain amplifier holds the output resistance at only 0.1 Ω (0.156 Ω max) despite having a single GND pin. Figure 4 shows how this minimizes output voltage error due to DC loading—only 0.1 LSB per mA of load current (0.16 LSB/mA max) for the LTC2630-12H and 0.13 LSB per mA (0.256 LSB/mA max) for the LTC2630-12L. In comparison, the lowest DC

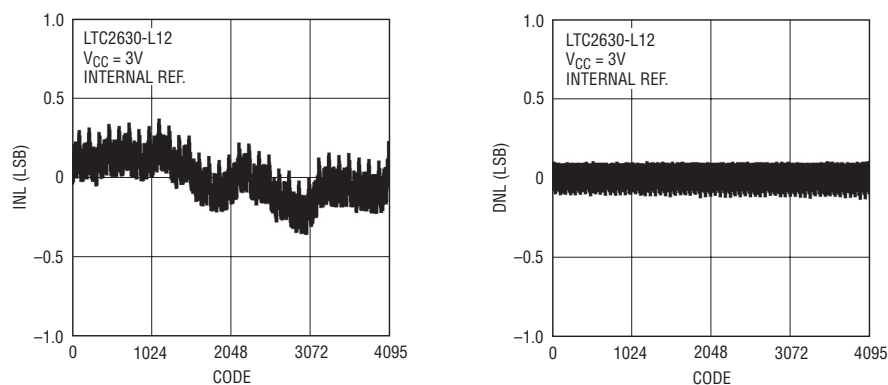


Figure 2. Integral and differential nonlinearity in internal reference mode. The LTC2630's excellent DNL guarantees its monotonicity.

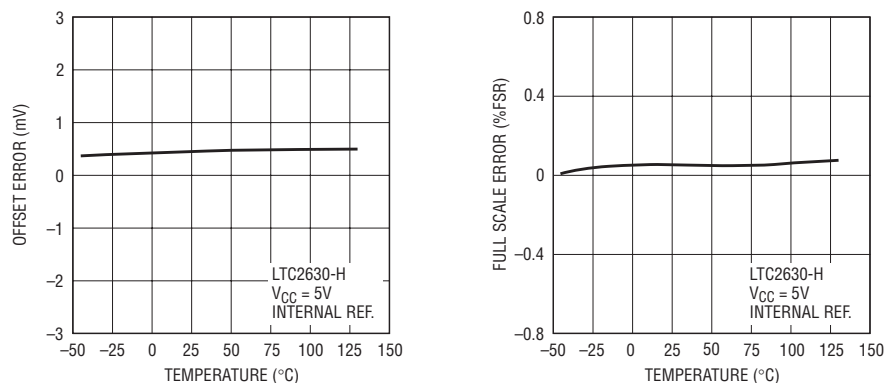


Figure 3. Low-drift offset error voltage and full-scale error voltage.

output impedance of any competitor is 0.5 Ω , easily introducing five times greater load-induced error.

Easy Operation

The LTC2630 family operates off a single supply and can drive loads up to 500pF without any stability concerns.

Its simple SPI/MICROWIRE-compatible 3-wire interface can be operated at clock rates of up to 50MHz. Setup and hold times of only 4ns allow problem-free operation in optoisolated and other applications having slow edge rates. The internal data registers are double-buffered, allowing simultaneous updating of multiple devices in a system. All three parts in the LTC2630 family use the same 24-bit load sequence (32-bit is also supported). There are six command codes for selecting internal or supply reference modes, powering down, writing to the input register, updating the DAC register and performing a combined write and update.

Other Features

At power up, the internal reference is selected by default, and the code is reset to either midscale (LTC2630-M) or zero (LTC2630-Z). Internal circuitry holds the output glitch to less than 5mV if the supply is ramped no faster than 1V/ms.

The LTC2630 can be placed in a power-saving mode in which current

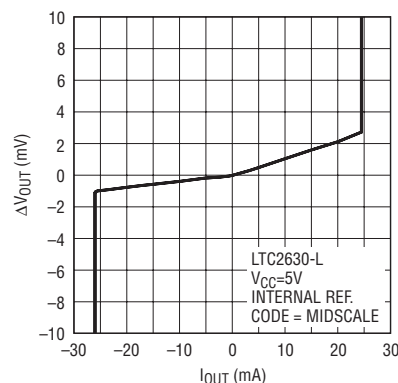


Figure 4. Load regulation. The high drive output buffer is guaranteed to source and sink 5mA at 3V, and 10mA at 5V, well inside the bounds of current limiting. Output resistance of only 0.1 Ω keeps the error contributed by DC loading to a minimum.

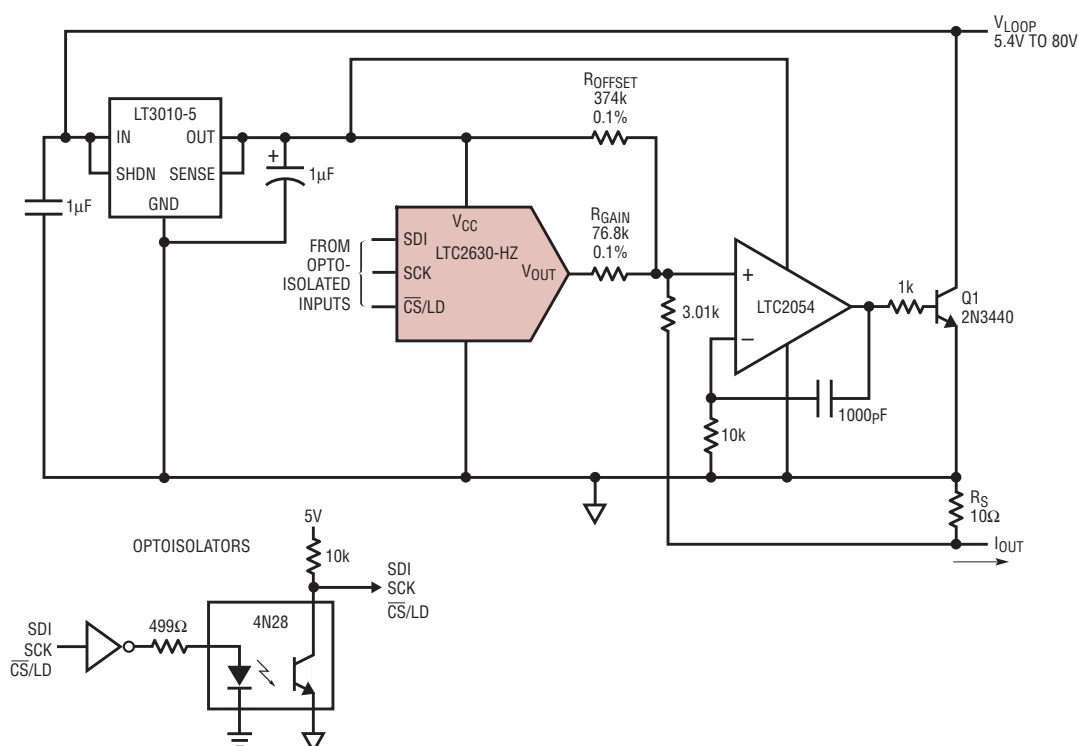


Figure 5. Optoisolated 4mA to 20mA process controller. This circuit digitizes an output current for use in an isolated control loop.

draw at 5V is reduced to below 1.8μA (5μA for H-grade operating at 125°C). Upon exiting power down mode, the output settles at midscale to 12-bit accuracy in 18μs.

Optoisolated 4mA to 20mA Process Controller

LTC2630 is well-suited to industrial applications, including control loops. Figure 5 shows an optically-isolated,

digitally-controlled 4mA to 20mA transmitter using the LTC2630HZ. The transmitter circuitry, including optoisolation, is powered by the loop voltage, which has a wide 5.4V to 80V range. The 5V output of the LT3010-5 sets the 4mA offset current and the DAC digitally controls the 0mA to 16mA signal current. The supply current for the regulator, DAC and op amp is well below the 4mA budget

at zero scale. R_S senses the total loop current, which includes the quiescent supply current and additional current through Q1. Note that at the maximum loop voltage of 80V, Q1 dissipates 1.6W when I_{OUT} is 20mA, so it must have an appropriate heat sink.

The values of R_{OFFSET} and R_{GAIN} are as close to ideal as possible using 0.1% resistors to meet the 4mA–20mA design objective. Alternatively, R_{OFFSET} can be a 365k, 1% resistor in series with a 20k trim pot and R_{GAIN} can be a 75.0k, 1% resistor in series with a 5k trim pot. If the application calls for a high speed serial bus, use 6N139 rather than 4N28 optocouplers.

Conclusion


The LTC2630 is a family of single voltage output DACs in 6-lead SC70 packages with integrated references. Each DAC can provide its own accurate full-scale voltage and can operate rail-to-rail referenced to the input supply. Twelve options are available in various combinations of accuracy (12-, 10-, and 8-bit), full-scale voltage (2.5V or 4.096V), and power on reset value (zero or midscale); see Table 1. 

Table 1. Available part options. The LTC2630 is offered in twelve combinations of full-scale voltage, power-on reset, and accuracy.

	Full-Scale Reference	Power-On Reset Code	Accuracy (Bits)	V_{CC} (V)
LTC2630-LM	2.5V	Midscale	12 10 8	2.7–5.5
LTC2630-LZ	2.5V	Zero	12 10 8	2.7–5.5
LTC2630-HM	4.096V	Midscale	12 10 8	4.5–5.5
LTC2630-HZ	4.096V	Zero	12 10 8	4.5–5.5