

# DESIGN NOTES

## 12-bit DAC in TSOT-23 Includes Bidirectional REF Pin for Connection to Op Amp or External High Precision Reference

Design Note 448

Kevin Wrenner, Troy Seman and Mark Thoren

### Introduction

The LTC®2630's combination of a 12-bit DAC and low-drift integrated reference in a tiny SC-70 package has proven popular for a wide variety of applications. Two new DACs, the LTC2631 and LTC2640, take this winning formula and further expand its reach by adding a bidirectional REF pin and an optional I<sup>2</sup>C interface in a tiny TSOT-23.

Like their predecessor, these parts feature 1-bit INL and DNL, offer excellent load regulation driving up to 10mA loads, and can operate rail-to-rail. See Table 1 for a list of options.

### Applications Using REF Pin

The bidirectional REF pin can be used as an output, where the accurate 10ppm/°C reference is available to the rest of the application circuit, or it can be used as an input for an external reference.

To configure REF as an output, simply tie the REF\_SEL pin high. As an output, the REF pin simplifies pairing the DAC with an op amp. For instance, to achieve an output range centered at 0V, drive the plus input of the op amp, with REF connected to the minus input. Avoid loading the REF pin with DC current; instead, buffer its 500Ω output with an LTC2054 or similar precision op amp.

The LT1991 precision op amp is a superb choice for amplifying or attenuating the DAC output to achieve a desired output range because it requires no precision external resistors. Its integrated, precision resistors are matched to 0.04%, allowing gain to be set by simple pin strapping (see the data sheet for a large variety of gain options). Figure 1 shows the configuration for a difference gain of 4, resulting in a ±5V output with 12-bit programmability under I<sup>2</sup>C control. Integral nonlinearity, seen in Figure 2, is better than 1LSB.

Figure 3 shows a negative output system using a similar setup, this time with the LT1991 configured as an inverting amplifier with a gain of -0.25. The 0.1μF capacitor at REF reduces the already low DAC noise by up to 20%.

For applications requiring more accuracy at full scale, the LTC2631 and LTC2640 can be referenced to an external source. Figure 4 shows how, using an LT1790 low-dropout reference that's accurate to 0.05%. Tying REF\_SEL low configures the REF pin as a reference input. If reset-to-zero is needed, an LTC2640-LZ12 can be substituted. (For that option, pin 8 is rededicated as a CLR pin, and, upon powering up, External Reference mode must be selected by software command before the code is changed from zero.)

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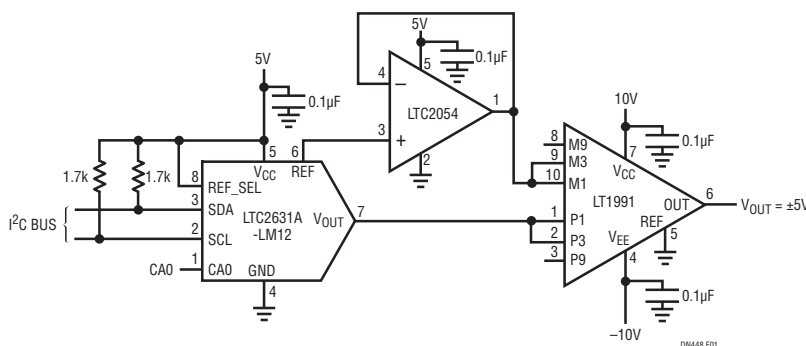


Figure 1. Programmable ±5V Output

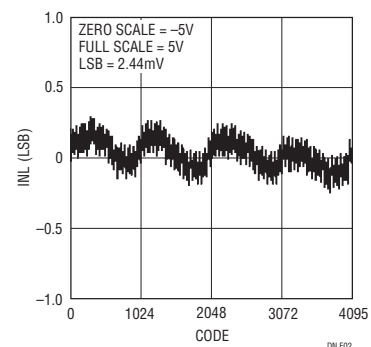


Figure 2. Integral Nonlinearity of Programmable ±5V Output

The REF pin enables the LTC2631 and LTC2640 to share their full-scale range with another device, as shown in Figure 5. A 16-bit LTC2453 ADC and LTC2631 DAC are referenced to the same 5V full scale. This circuit allows a variety of possible transfer functions to be applied to an input under computer control. It is easy to implement functions such as squaring and square root, or time-dependent functions such as integration or proportional-integral-derivative (PID) control in this manner, resulting

in a circuit that is much simpler and more stable than a purely analog circuit.

### Conclusion

The LTC2631 and LTC2640 add I<sup>2</sup>C capability and a bidirectional REF pin to LTC's family of 12-, 10-, and 8-bit DACs with an integrated reference. For applications requiring a modified output range, the LT1991 op amp with internal precision resistors is an ideal counterpart.

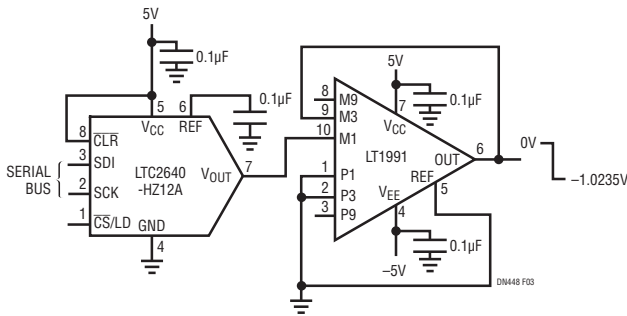


Figure 3. Negative Output, 0V to -1.024V

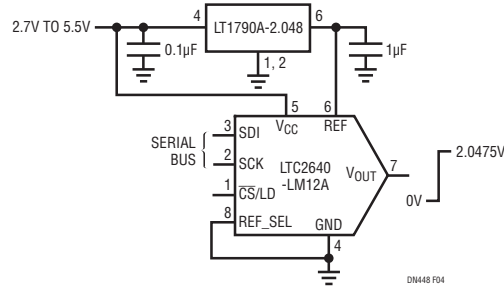


Figure 4. 0V to 2.048V Output Derived from External Reference

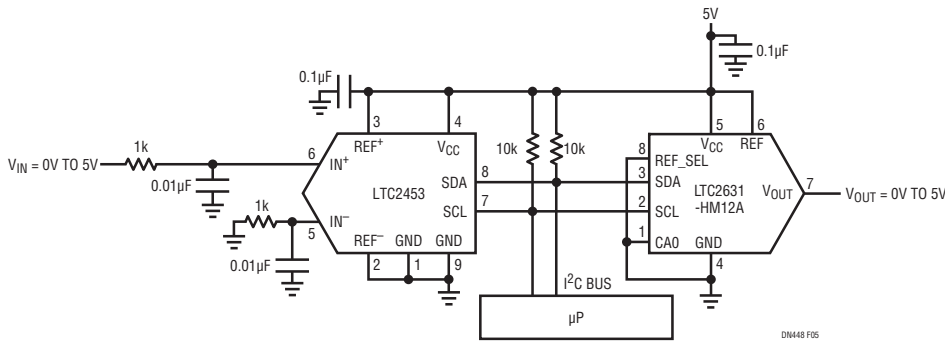


Figure 5. Electronic Transfer Function Generator

Table 1. Family Characteristics. Each part has a bidirectional REF pin and is available in 12-, 10-, and 8-bit accuracy.

PART NUMBER	TYPE	FULL-SCALE	POWER-ON RESET CODE	PIN 8 FUNCTION
LTC2631-LM	I <sup>2</sup> C	2.5V	Midscale	Select default REF
LTC2631-LZ	I <sup>2</sup> C	2.5V	Zero	6 add'l addresses
LTC2631-HM	I <sup>2</sup> C	4.096V	Midscale	Select default REF
LTC2631-HZ	I <sup>2</sup> C	4.096V	Zero	6 add'l addresses
LTC2640-LM	SPI	2.5V	Midscale	Select default REF
LTC2640-LZ	SPI	2.5V	Zero	DAC Clear
LTC2640-HM	SPI	4.096V	Midscale	Select default REF
LTC2640-HZ	SPI	4.096V	Zero	DAC Clear

Data Sheet Download

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