Linear Technology Chronicle

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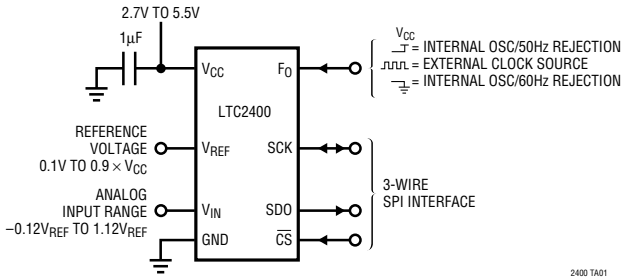
Product of the Month

LTC2400: A Stand-Alone 24-Bit ADC in SO-8 Package Delivers 10ppm Total Unadjusted Error While Drawing Only 200µA

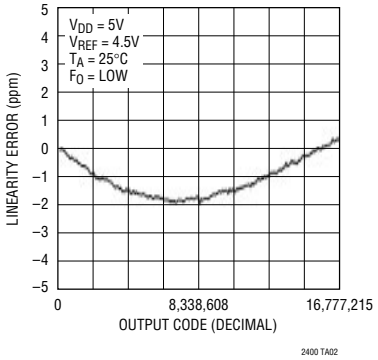
Linear Technology brings you the industry's smallest and easiest to use 24-bit ADC—the **LTC®2400**. Its internal low drift oscillator and sinc^4 digital filter give 120dB of 50Hz or 60Hz rejection without the need for a precision crystal or external clock. The LTC2400 is intended for DC measurements delivering 24-bit no missing codes and 10ppm Total Unadjusted Error (TUE) over both 2.7V to 5.5V supply and –40°C to 85°C temperature variations. Low noise of 0.3ppm (RMS) and 2ppm INL performance combine with 1ppm offset and 4ppm full-scale error to meet the most demanding DC measurement applications. Rejection of 50Hz or 60Hz is accomplished with a single pin. Packaged in an 8-pin SO, the LTC2400 supply current is a low 200µA while performing conversions and automatically reduces to 20µA for the data transfer cycle and while waiting for the next conversion command. The LTC2400 delivers unparalleled accuracy in a small, easy-to-use package.

It gets better. The LTC2400 uses a unique 4th order sinc filter that settles in a single conversion with a one-to-one correspondence between the analog input and the conversion result. This greatly simplifies multiplexed applications by providing accurate conversion results on the first conversion after channel selection. The LTC2400 performs autocalibration of offset and gain errors during each conversion transparently to the user. No need to flush digital filters and manage complicated status registers here. The converter operates on a "convert command" and outputs a 24-bit answer. The analog input range extends 12.5% below ground and above V_{REF} while still providing accurate results. This range allows measurement of signals below ground. The accuracy of the LTC2400 eliminates the need for a PGA to increase resolution in most applications. The reference input can be any value between 0.1V and V_{CC} allowing direct digitization of a wide variety of sensors. The on-chip oscillator can be defeated and an external clock source applied to set a user-defined rejection frequency and output rate. Communication with the LTC2400 is accomplished over an easy-to-use SPI compatible serial interface.

LTC2400 Complete Easy-to-Use 24-Bit Analog-to-Digital Converter in SO-8 Package



Total Unadjusted Error vs Output Code



Applications for the LTC2400 will benefit from the compact, easy-to-use design. Such uses include DC voltage and current measurement, gas analysis, weigh scales, temperature measurements, portable handheld instrumentation and DC multiplexed data acquisition. The small size, SO-8 package will allow next generation designs to be realized with unprecedented form factors and accuracy. A complete demonstration board and samples are available today.

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Inside This Issue:

LT1676/LT1776: Wide Input Range Step-Down Switching Regulators

For Automotive, "Fire Wire," 48V Telecom and Cell Phone Chargers

The **LT®1676** and **LT1776** are new switching regulators for high efficiency step-down regulation from up to 60V inputs. The circuits are pin-for-pin compatible and virtually identical. The difference is their internal oscillator frequencies—100kHz for the LT1676 and 200kHz for the LT1776. Both circuits operate at fixed frequency and can be synchronized to higher switching frequencies.

The internal switch is capable of up to 500mA output current. The input voltage range is 7.4V to 60V. Maintaining high efficiency in the upper portion of this range requires very fast output switch edge rates. The LT1676/LT1776 contain specialized circuitry to provide this performance. Other circuitry monitors output load level and reduces leading-edge switch rate when the output load is light. This function helps avoid pulse skipping at light loads and the consequent subharmonic behavior.

Along with true current mode operation, the LT1676/LT1776 include microampere shutdown and undervoltage lockout functions in 8-pin SO and PDIP packages. Burst Mode™ operation for higher efficiency at lower load currents may be implemented using an external comparator. Dual-output SEPIC and positive-to-negative conversion topologies are also directly supported. (See *Linear Technology* magazine, November 1998.)

The LT1776 is favored for its higher switching frequency that allows for a smaller inductor. However, the higher frequency means increased AC switching losses and thus higher thermal dissipation, so that the LT1676 may be preferred for many uses. The LT1676 can operate continuously at high loads at 60V while the LT1776 is limited to 40V in a continuous high output condition. Figure 1 shows a minimum component count circuit using the LT1676. The circuit produces 5V at up to 500mA output with input voltages in the range of 12V to 48V. No pulse skipping is observed even with no external load.

These circuits are perfect for automotive systems including the new 42V standard, for IEEE 1394 "Fire Wire" with its unregulated 8V to 40V power, for battery charging from a wide input range source, and for step-down from the 48V rail in telecom systems. LTC provides other 60V input voltage range switching regulators and controllers for output currents up to 50A.

Burst Mode is a trademark of Linear Technology Corporation.

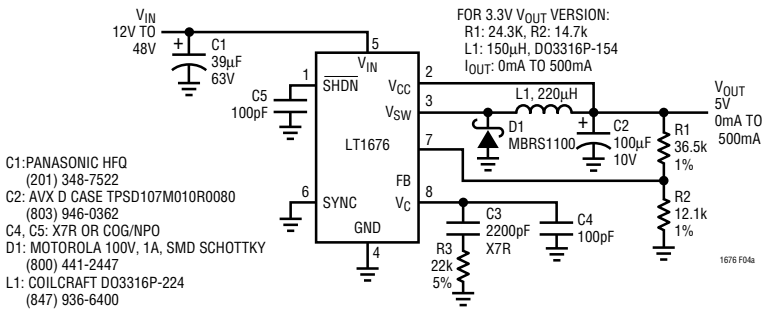


Figure 1. Minimum Component Count Application

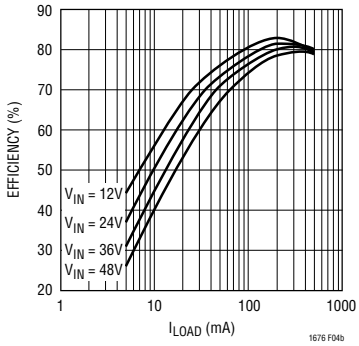


Figure 2. Efficiency of Figure 1's Circuit

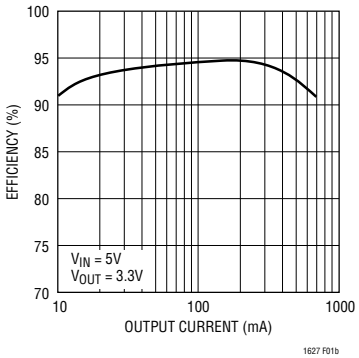
High Efficiency 500mA Step-Down Switcher Operates from 1- or 2-Cell Li-Ion Batteries

The **LTC1627** is a synchronous step-down switching regulator that is optimized for Li-Ion batteries in low voltage applications such as cellular phones and PDAs. This low dropout regulator combines constant frequency current mode control, Burst Mode operation and built-in power switches in an SO-8 package to offer the most compact and efficient power management solution for portable applications operating from 1- or 2-cell lithium-ion batteries.

A 2.5V output supply powered from a single Li-Ion battery (3.5V to 4V) can be constructed with the LTC1627 with few external components. Output voltage is user-programmable and can be set as low as 0.8V. Switching frequency of 350kHz allows the use of small surface mount inductors and capacitors. Efficiencies in excess of 90% over a wide range of output current and 100% duty cycle allow the user to extract the maximum power available from the battery. A precision 2.5V undervoltage lockout prevents battery damage due to over-discharge by shutting the LTC1627 down, drawing only 5µA of supply current. A secondary feedback pin allows regulation of the secondary winding output even when the main output is lightly loaded by forcing continuous operation.

The LTC1627 is an ideal choice for battery-powered applications including Li-Ion, NiCd and NiMH up to 8.5V where you need a step-down regulator with excellent efficiency in a very small footprint.

Efficiency vs Output Load Current



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LTC1650: 16-Bit Voltage Output DAC Now Available for ±5V Supply Systems

The **LTC1650** from Linear Technology delivers true 16-bit monotonic performance while dissipating only 75mW from ±5V supplies. The buffered voltage output swings rail-to-rail into 1000pF. The bipolar or unipolar output is selected by pin connections. The LTC1650 also features fast settling time of 4µs to 16 bits and a low 2nV-s midscale glitch for applications where dynamic performance is required.

A user-defined reset voltage is used to determine the output of the DAC during power-up or when a clear command is issued. The LTC1650 also contains a power supply sense circuit that activates the reset and notifies the system when any of the three supplies goes away. The reference input determines the full-scale output and has a range of –4.0V to 4.5V allowing 4-quadrant multiplication. The serial interface simplifies isolated applications and is cascadable allowing multiple DACs to be connected on the same data I/O line. It is contained in a narrow 16-pin package for minimal board space consumption.

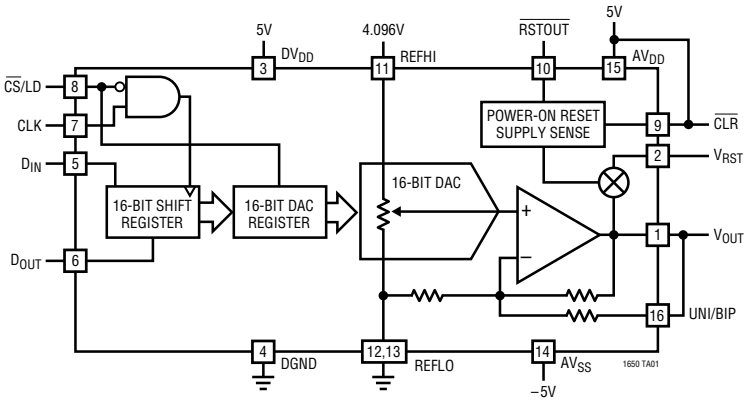


Figure 1. Voltage Output DAC Is 16-Bit Monotonic Over Temperature

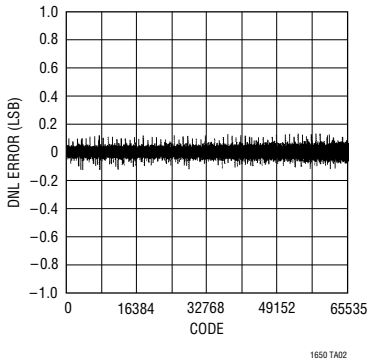


Figure 2. Differential Nonlinearity vs Input Code

LT1786F: SMBus Programmable Backlight Supply

The **LT1786F** is a fixed frequency, current mode switching regulator designed for SMBus control of CCFL (Cold Cathode Fluorescent Lighting) displays. A wide input range of 4.5V to 30V allows the circuit to operate well from 5V supplies, from high voltage wall adaptors and from widely varying battery inputs.

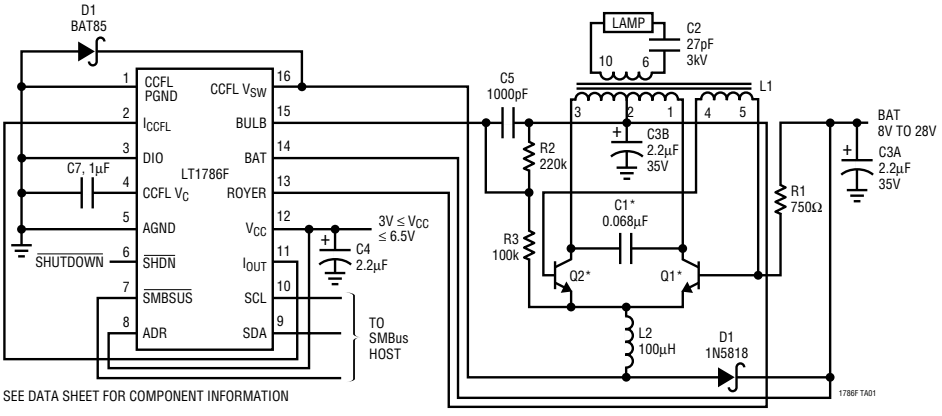
The 2-wire SMBus serial interface of the LT1786F provides simple "bits-to-lamp-current" output control. The circuit contains a high current switch, an oscillator, output drive logic, control circuitry and a micropower 6-bit DAC. The precision, 100µA output, full-scale DAC assumes midrange or zero scale on power-up depending upon the SMBus address selected.

The LT1786F acts as an SMBus slave device using one of two selectable addresses. The circuit operates with either grounded lamp or floating lamp configurations. No sense resistor is required for floating lamp operation and no external diodes are required for grounded lamp operation.

The LT1786F offers two shutdown modes. When shut down by an SMBus command, digital data for the DAC output current is retained internally and the supply current drops to 40µA for standby operation. A second shutdown function disables the CCFL control circuitry but keeps the DAC alert and draws 150µA supply current.

The LT1786F has a switching frequency of 200kHz for small component sizes. The circuit is available in a 16-pin narrow SO package.

90% Efficient Floating CCFL with 2-Wire SMBus Control of Lamp Current



CCFL BACKLIGHT APPLICATION CIRCUITS CONTAINED IN THE LT1786F DATA SHEET ARE COVERED BY U.S. PATENT NUMBER 5408162 AND OTHER PATENTS PENDING

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LTC1694: SMBus Accelerator Improves Data Integrity

Compensates for Bus Loading

The **LTC1694** is a dual SMBus active pull-up designed to enhance data transmission speed and reliability under all specified SMBus loading conditions. With the LTC1694, the user can connect more devices or use longer, more capacitive interconnects without compromising slew rates or penalizing bus performance.

Resistive pull-ups are used in many communications protocols that employ open-collector or open-drain devices. Their simplicity is offset by the relatively slow rise times they afford when bus capacitance is high. Rise times can be improved by using lower pull-up resistor values, but the additional current through the low value resistors increases the low state bus voltage, decreasing noise margins. Slow rise times can seriously affect data reliability, lowering practical bus speed and violating SMBus standards.

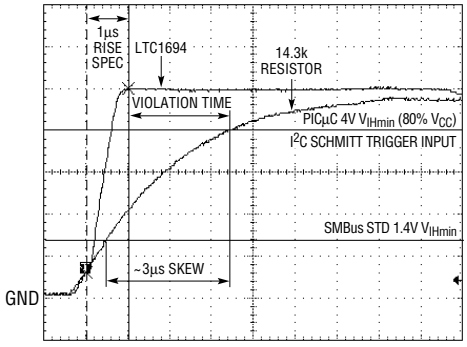

Figure 1. SMBus Open-Drain Signal Rise Times

The LTC1694 overcomes these limitations by using bilevel, hysteretic current sources as pull-ups. During positive bus transition, the current sources provide 2.2mA to quickly slew the SMBus line despite any parasitic bus capacitance (Figure 1). During negative transitions or steady DC levels, the current sources switch to 275µA, within the SMBus limit of 350µA, to improve negative slew rate and improve low state noise margins. An autodetect standby mode reduces supply current if the bus is idle.

The LTC1694 is available in the 5-lead SOT-23 plastic surface mount package, requiring virtually the same board area as two surface mount resistors.

LTC1597: Ultra-Accurate 16-Bit DAC with On-Chip 4-Quadrant Resistors

The **LTC1597** is a parallel input 16-bit multiplying current output DAC that operates from a single 5V supply. INL and DNL are accurate to 1LSB over the industrial temperature range in both 2- and 4-quadrant multiplying modes. True 16-bit, 4-quadrant multiplication is achieved with on-chip precision resistors.

The sensitivity of INL and DNL to op amp offset has been greatly reduced compared to previous generations of multiplying DACs. For the LTC1597, a 500µV op amp offset will cause about 0.55LSB INL degradation and 0.15LSB DNL degradation with a 10V full-scale range. The DAC unipolar output range is 0V to –10V and the DAC bipolar output range is ±10V for a fixed 10V reference input.

The device includes an internal deglitcher circuit that reduces the glitch impulse to less than 2nV-s typically. The LTC1597 has an asynchronous clear input that resets the output to zero scale. A second version, the LTC1597-1, resets to midscale. The circuit has power-on reset and is double-buffered with two 16-bit registers, a feature that permits the update of several DACs simultaneously.

The parallel input of the LTC1597 is advantageous for fast settling applications. Used with the LT1468 high speed op amp, the circuit's settling time to 0.0015% with a 10V step is 2µs. See *Application Note 74*.

The LTC1597 is designed for applications such as process control and industrial automation, direct digital waveform generation, software-controlled gain adjustment and automatic test equipment. The LTC1597 operates with very low supply power dissipation, typically 10µW. The circuit is available in a 28-pin SSOP package and is specified over the commercial and industrial temperature ranges.

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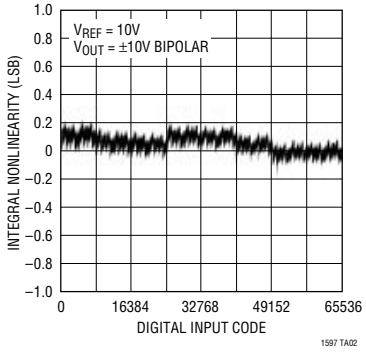
LTC1597/LTC1597-1
Integral Nonlinearity



16-Bit, 4-Quadrant Multiplying DAC