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Product of the Month

Rugged, High Precision, Wide Operating Range—LT1782/LT1783 SOT-23 Op Amps

The **LT®1782** and **LT1783** are micropower, rail-to-rail, Over-The-Top™ single op amps in SOT-23 packages. The combination of 400µV offset voltage, 1500V/mV gain and 100dB CMRR (typical values) places them among the highest precision micropower op amps in SOT-23. The LT1782 and LT1783 feature a wide supply range of 2.7V to 18V. Competing products have operating voltages that are restricted to 6V or less, limiting their use in many applications.

The LT1782 and LT1783 are the first SOT-23 op amps to operate with either or both inputs above the positive rail (Over-The-Top). This LTC innovation is important in many high side current sensing applications (Figure 1) and in other cases where the input is at or up to 6V above the supply voltage.

Several features make the LT1782 and LT1783 the toughest SOT-23 op amps in the market. In addition to Over-The-Top operation, the inputs can be taken 9V below the negative supply without phase reversal or damage. This prevents false outputs from occurring when the inputs are below the negative rail. The LT1782 and LT1783 require no special protection when operating on batteries, since they are internally protected for 18V of reverse supply. Competing products require external protection circuitry or will be damaged if the supplies are accidentally reversed.

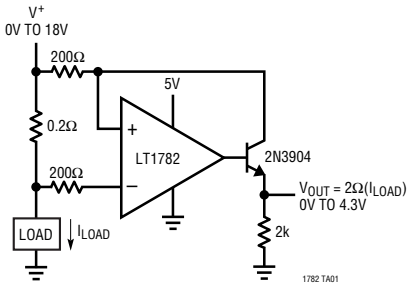

Figure 1. Positive Supply Rail Current Sense

Table 1. LT1782/LT1783 Performance, V_S = 3V/0V or 5V/0V, T_A = 25°C

Parameter*	LT1782	LT1783
Supply Voltage Range	2.7V to 18V	2.7V to 18V
Supply Current	55µA	300µA
Input Offset Voltage	800µV	800µV
Input Bias Current	15nA	80nA
Input Offset Current	2nA	8nA
Open-Loop Gain, R_L = 10k	200V/mV	200V/mV
PSRR	90dB	90dB
CMRR	90dB	90dB
Common Mode Range	0V to 18V	0V to 18V
Output Swing, Low	8mV	8mV
Output Swing, High	90mV	90mV
Slew Rate (typ)	0.07V/µs	0.42V/µs
Gain Bandwidth Product (typ)	200kHz	1.25MHz
C-Load™ Stability	500pF	500pF
Input Noise Voltage (typ)	50nV/√Hz	20nV/√Hz
Input Noise Current (typ)	0.06pA/√Hz	0.14pA/√Hz

*Guaranteed value unless noted as typ (typical). See data sheets.

Unlike other SOT-23 op amps that require high input overdrive to swing near the rails, a few millivolts of overdrive is enough to swing the outputs of the LT1782/LT1783 to their guaranteed value (Table 1). Both input and output operate rail-to-rail.

The LT1782 has a 200kHz bandwidth and draws less than 55µA supply current. The LT1783 is faster with a 1.25MHz bandwidth, yet its supply current is still less than 300µA. Each device can drive loads of up to 18mA. The excellent DC characteristics combined with the micropower rail-to-rail operation make these op amps an excellent choice in portable, battery-operated applications where performance is critical.

The LT1782 and LT1783 are available in 5-lead and 6-lead SOT-23 packages. The 6-lead version includes a shutdown function that limits the supply current to a maximum of 5µA.

16-Bit Rail-to-Rail Micropower DAC Runs On Single 3V Supply—LTC1655L

The **LTC®1655L** is a single, 16-bit, rail-to-rail, micropower DAC powered by a single 3V supply. A lower supply voltage and lower power version of the LTC1655, the LTC1655L typically draws only 600µA of supply current. With ±1LSB maximum DNL error, the LTC1655 offers 16-bit monotonicity over its full temperature range, critical for closed-loop feedback systems such as industrial control. The LTC1655L's low power and high performance make it

Continued on page 2

Inside This Issue:

Linear Phase, DC Accurate, 10th Order Lowpass Filters. Cutoff Frequency Set by a Single Resistor—LTC1569-6 and LTC1569-7 2
High Speed, Low Power, Dual Comparator Creates 1ns Pulse Stretcher—LT1720 3
Micropower SOT-23 Charge Pump Delivers 5V at 50mA from Single Li-Ion—LTC1754-5 3
Ultraprecise, Micropower, Low Dropout 2.5V Reference—LT1461-2.5 4
Important Update: Micropower Voltage References Available in SOT-23—LT1460 4
For Mobile VID Processors: Dual Output 2-Phase DC/DC Converter Combines Fast Transient Response and Small Solution Size—LTC1703 4

LTC1655L from page 1

ideal for applications such as automatic test equipment, instrumentation and digital calibration.

A built-in 1.25V bandgap reference sets the output voltage range from 0V to 2.5V. This reference pin can also be overdriven to higher voltages to achieve larger output swings (up to the positive supply rail). The LTC1655L also includes an internal rail-to-rail output buffer, eliminating the need for any external op amps.

The LTC1655L features a 3-wire serial interface compatible with SPI/QSPI and MICROWIRE™ protocols. The inputs are TTL/CMOS level compatible for ease of use and the CLK input has an internal Schmitt trigger, providing the noise immunity necessary for direct optocoupler connection to the inputs.

With its standard pinout, the LTC1655L provides a convenient pin compatible upgrade path for users of LTC's 12-bit voltage output DAC family. The LTC1655L is available in SO-8 and N8 packages in both commercial and industrial temperature ranges.

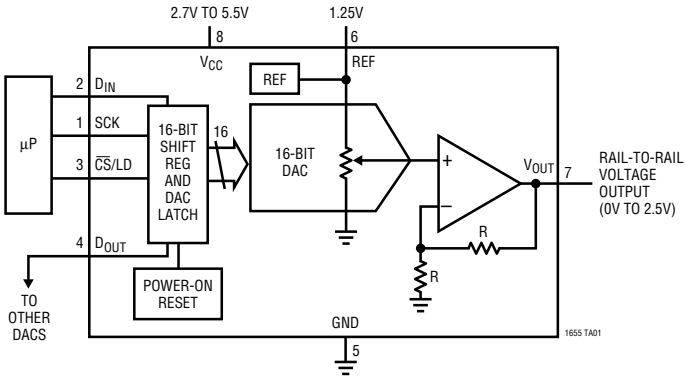

Figure 1. LTC1655L 16-Bit Rail-to-Rail V_{OUT} DAC

Linear Phase, DC Accurate, 10th Order Lowpass Filters. Cutoff Frequency Set by a Single Resistor—LTC1569-6 and LTC1569-7

The **LTC1569-6** and **LTC1569-7** are 10th order lowpass filters featuring linear phase, a root raised cosine amplitude response and DC accuracy. This unique family of switched capacitor filters is the first in the industry not to require an external clock to set the filter's cutoff frequency. The LTC1569-7 is designed for higher frequency applications with cutoff frequencies up to 300kHz on a single 5V supply. The LTC1569-6 is the lower power model with power consumption as low as 8mW on a single 3V supply. The LTC1569-6 should be used in applications with cutoff frequencies below 64kHz. Both versions can operate on power supplies from 3V to ±5V.

Most other sampled data filters use an external clock to set the cutoff frequency. Clock generation can therefore become quite difficult, requiring a crystal based master clock to be divided down to precisely the desired frequency. The LTC1569 family of filters avoids these complications. The cutoff frequency is set with a single external resistor. The filter cutoff frequency is accurate to ±3% for a given resistor value. Additionally, with a single pin the user can divide the cutoff frequency by 1, 4 or 16. This allows up to three cutoff frequency options to be obtained with each resistor value. Using various resistor values and divider settings, the cutoff frequency can be programmed over a range of six octaves. Alternatively, the cutoff frequency can be set with an external clock.

The LTC1569 family has excellent DC performance and dynamic range. An offset voltage of less than 5mV, DC linearity of 12 bits and common mode rejection ratio of 80dB make the LTC1569 well suited for DC accurate systems. Both filters offer differential or single ended inputs.

The high selectivity of the LTC1569-6 combined with its linear phase in the pass band makes it suitable for filtering both in data communications and data acquisition systems. Furthermore, its raised root cosine response offers the optimum pulse shaping for PAM data communications. The LTC1569-6 and LTC1569-7 are available in SO-8 packages.

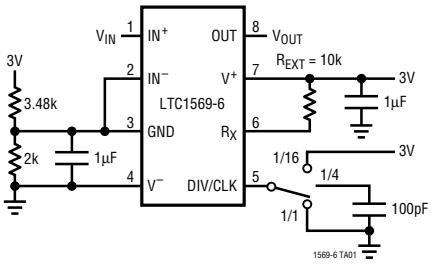

Figure 1. LTC1569-6 Lowpass Filter

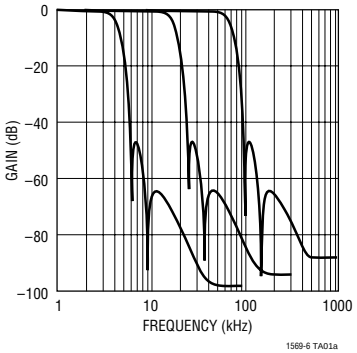

Figure 2. LTC1569-6 Frequency Response

Application of the Month

High Speed, Low Power, Dual Comparator Creates 1ns Pulse Stretcher—LT1720

For detecting short pulses from a single sensor, a pulse stretcher is often required. The circuit of Figure 1 acts as a one-shot, stretching the width of an incoming pulse to a consistent 100ns. Unlike a logic one-shot, this circuit triggers on only 100pV-s of stimulus. The UltraFast™ LT1720 dual comparator draws a low 4mA per comparator.

Comparator C1 functions as a threshold detector, whereas comparator C2 is configured as a one shot. The first comparator is prebiased with a threshold of 80mV to overcome comparator and system offsets and to establish a low output in the absence of an input signal. An input pulse causes the output of C1 to go high, which, in turn, latches C2's output high. The output of C2 is fed back to the input of C1, causing regeneration and latching both outputs high. Timing capacitor C now begins charging through R and after 100ns, C2 resets low. The output of C1 also goes low, latching both outputs low. A new pulse at the input of C1 can now restart the process. Timing capacitor C can be increased without limit for longer output pulses.

This circuit has an ultimate sensitivity of better than 14mV with 4ns to 10ns input pulses. It can even detect an avalanche generated test pulse of just 1ns duration with sensitivity better than 100mV. (See *Linear Technology* magazine, November 1998 and Application Note 47.) New single and quad versions of the LT1720 are also available (LT1719 and LT1721).

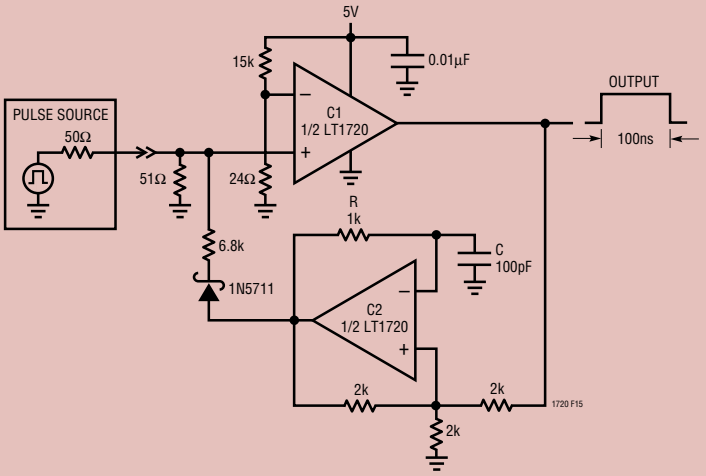

Figure 1. Low Power 1ns Pulse Stretcher

Micropower SOT-23 Charge Pump Delivers 5V at 50mA from Single Li-Ion—LTC1754-5

The **LTC1754-5** is a micropower 5V charge pump in a 6-lead SOT-23 package that delivers up to 50mA of output current from a single Li-Ion cell. Its tiny size and extremely low operating and shutdown currents (13µA and less than 1µA typically) extend battery operating time and make it an excellent choice for a wide variety of space-restricted applications, such as cellular phones, bar code and smart card readers, handheld computers and portable instruments. The LTC1754-5 is also useful for battery back-up supplies and local 3V-to-5V conversion.

The LTC1754-5 operates over an input voltage range of 2.7V to 5.5V at an operating frequency of 700kHz. It produces a regulated output voltage of 5V with a ±4% tolerance. Efficiency is greater than 82% from 1mA to 50mA (Figure 1). This inductorless DC/DC converter requires only three small capacitors to form a complete boost converter circuit that fits into a PC board space of just 0.05 square inches (Figure 2). The high frequency also means lower ripple that is easier to filter for RFI suppression.

The device offers short-circuit and thermal protection—important fault tolerant features—and the load is disconnected from the input in shutdown which eliminates any battery drain. The LTC1754-5 is available in the tiny 6-lead SOT-23 package. It's an excellent choice whenever an ultrasmall 5V supply is required using a single Li-Ion cell.

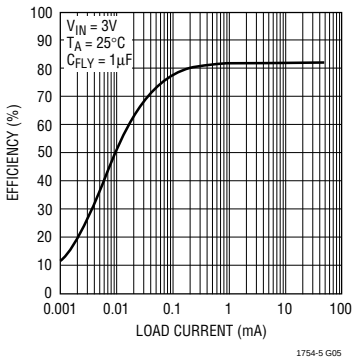

Figure 1. Efficiency vs Load Current for the LTC1754-5

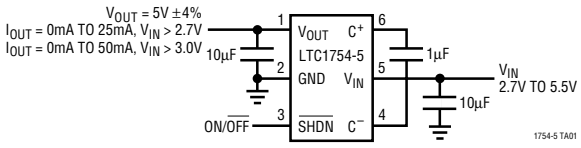

Figure 2. Regulated 5V Output from a 2.7V to 5.5V Input

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Ultraprecise, Micropower, Low Dropout 2.5V Reference—LT1461-2.5

The **LT1461-2.5** is the first low dropout reference to combine the high precision of power hungry references with the low power consumption of micropower references. The LT1461 draws only 35µA of supply current, making it ideal for low power and portable applications. However, its high 50mA output drive makes it suitable for higher power requirements such as precision regulators.

In low power applications, a dropout voltage of less than 300mV ensures maximum battery life while maintaining full reference performance. Line regulation is nearly immeasurable, while the precise load and thermal regulation will not add significantly to system error budgets. A shutdown pin further reduces power when output is not required.

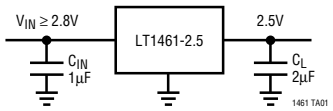

Figure 1. LT1461-2.5 Voltage Reference

The LT1461-2.5 is available in four performance grades and three temperature ranges, as shown in Table 1.

Table 1. LT1461-2.5 Performance Grades

Performance Grade	Temperature Coefficient	Tolerance	Temperature Range
A	3ppm/°C	0.04%	C (0°C to 70°C) and I (–40°C to 85°C)
B	7ppm/°C	0.06%	C (0°C to 70°C) and I (–40°C to 85°C)
C	12ppm/°C	0.08%	C (0°C to 70°C) and I (–40°C to 85°C)
D	20ppm/°C	0.15%	H (–40°C to 125°C)

Important Update: Micropower Voltage References Available in SOT-23—LT1460

The **LT1460** family of micropower series voltage references is now available in the tiny SOT-23 package, offering high accuracy in a small footprint. Further reducing board area, the LT1460 does not require an output compensation capacitor and the output voltage is stable for a wide range of output capacitance values. Fixed output voltages of 2.5V, 3V, 3.3V, 5V, and 10V are available in the SOT-23 package.

The LT1460 is available in three performance grades. The high performance "A" grade parts have an initial accuracy of 0.2% and a temperature coefficient of 20ppm/C. All grades are micropower references with supply currents as low as 180µA.

For Mobile VID Processors: Dual Output 2-Phase DC/DC Converter Combines Fast Transient Response and Small Solution Size—LTC1703

The **LTC1703** is a 2-phase DC/DC synchronous dual controller for 5V or 3.3V supplies that allows the smallest solution size. Mobile PCs using the most recent Intel Pentium® III processors require very high performance DC/DC conversion coupled with a DAC-controlled voltage to the core supply. The LTC1703 is designed specifically for this application and includes a 5-bit DAC controlling one of the outputs. The LTC1703 creates two high current outputs at voltages as low as 0.8V.

The LTC1703 enables the use of smaller, less expensive external components than competing solutions. Its 25MHz GBW error amplifier provides faster transient response than conventional solutions, thus reducing output capacitance requirements. The 2-phase architecture runs each output stage 180° out-of-phase to lower the input ripple current; this minimizes input capacitance, lessens EMI radiation and simplifies filtering. The LTC1703's 550kHz constant frequency operation and compact 28-lead SSOP package also shrink solution size.

The high power, all N-channel synchronous design (Figure 1) allows the LTC1703 to drive large MOSFETs with high gate capacitance: each output channel can support up to 25A of output current with excellent total output accuracy of 1%. It also features Burst Mode™ operation at light loads for better than 85% efficiency over a wide range of output currents. Onboard power good and overvoltage (OV) fault flags indicate when the output is in regulation or an overvoltage fault has occurred. Either output can be shutdown without affecting the operation of the other side. The LTC1703's quiescent current drops below 100µA when both outputs are shut down.

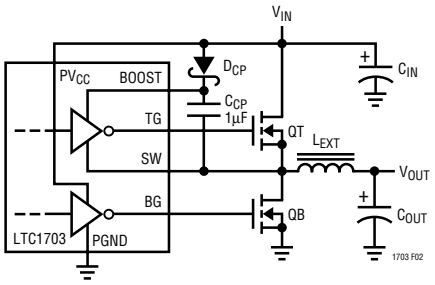

Figure 1. LTC1703 Switching Architecture

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