Linear Technology Chronicle

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Product of the Month

High Speed Precision Rail-to-Rail Op Amps Operate on 2.7V, 5V or ±15V Supplies

No Compromise!

High speed op amp designs, especially for low supply voltages, have usually been a compromise between meeting three major requirements: high speed, precision and rail-to-rail voltage swings—until now.

Linear Technology introduces the solution: a complete new op amp family with high speed—to process video, precision—to buffer 12-bit ADCs, and rail-to-rail input *and* output performance—for low supply voltage, battery-powered signal processing applications.

The **LT®1630** and **LT1631** are dual and quad op amps with a 30MHz gain-bandwidth product and a 10V/µs slew rate. The **LT1632** and **LT1633** are dual and quad op amps with a 45MHz gain-bandwidth product and a 45V/µs slew rate.

Specification	LT1630	LT1631	LT1632	LT1633
Op Amps/Pkg	Dual	Quad	Dual	Quad
Gain-Bandwidth	30MHz	30MHz	45MHz	45MHz
Slew Rate	10V/µs	10V/µs	45V/µs	45V/µs
Max V_{OS}	525µV	525µV	1.35mV	1.35mV

Conventional op amps lose much of their input range and output swing when operated at low voltages. Users had to operate with ±12V or ±15V supplies to get a high bandwidth. The LT1630 family delivers high bandwidth and fast slew rate with much lower supply voltages of 5V and even 3V.

All four versions have excellent DC precision over the full range of operation. Input offset voltage (V_{OS}) is below 150µV typical (400µV for the LT1632/LT1633) and the products are virtually free of gain error. Patented trim techniques give the LT1630/LT1631 an exceptional common mode rejection ratio (CMRR) of 106dB (typical) over the full input range. Especially important for noninverting applications, the LT1632/LT1633 have excellent 90dB CMRR (typical).

All versions maintain their performance for supplies from 2.7V to 36V and are specified at 3V, 5V and ±15V. The inputs can be driven beyond the supply voltages without damage or phase reversal of the outputs. The output delivers load currents in excess of 50mA.

Maximum input offset voltage is 525µV for the LT1630/LT1631 and 1.35mV for the LT1632/LT1633. Input noise voltage is only 6nV/√Hz for the LT1630/LT1631 and 12nV/√Hz for the LT1632/ LT1633 (numbers are typical). The supply current is also very low, 3.5mA per amplifier for the LT1630/LT1631 and 4.3mA for the LT1632/LT1633.

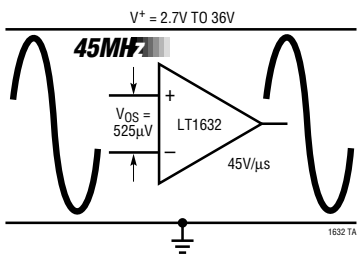
Great Systems Need Great Op Amps

The LT1630 family products can be used as plug-in replacements for many standard op amps to improve input and output range and performance. Use this new op amp family for:

- Rail-to-rail buffer amps for driving A/D converters
- Low voltage, high speed signal processing
- Battery-powered systems
- Active filters

High speed, precision, rail-to-rail inputs and outputs, with high CMRR and low noise—get it all from Linear Technology's new LT1630 family. Contact your local Linear Technology sales office for a data sheet and evaluation samples or visit our web site at **www. linear-tech.com** for more information.

High Speed, Rail-to-Rail and Low Supply Voltage with the LT1632



World's First SMBus DAC

Micropower, 10-Bit Current-Output DAC

The **LTC®1427-50** is a precise current-output digital-to-analog converter (DAC), designed to deliver 50µA at full scale. The serial interface to the DAC supports the 2-wire SMBus and I²C™ bus protocols.

This new Linear Technology DAC provides a digitally adjustable, precise current output. Other DACs are not well-controlled for absolute current output and are not suited for trim applications. Digital potentiometers do not offer either the resolution (10 bits) or the SMBus interface.

The LTC1427-50 is designed for use in the following applications:

- Software programmable power supplies
- Multilevel battery chargers (smart chargers)
- LCD contrast and backlight brightness controls

The 50µA full-scale current range is ideal for driving the feedback pin on adjustable voltage regulators. The user can have 10-bit digital control over the adjustment point and a 2-wire interface, compared to

Continued on page 4

Inside This Issue:

LTC1143L: New Low Supply Voltage Switcher

Extends Battery Operating Time

The **LTC1143L** is a high efficiency, dual output switching regulator controller that incorporates automatic Burst Mode™ operation to optimize efficiency in portable applications. Otherwise identical to the existing LTC1143, the LTC1143L provides fixed 5V and 3.3V outputs in a 16-lead SO package. The new product operates from a supply voltage of as low as 3.5V. An adjustable version, the LTC1143L-ADJ, is also available.

The LTC1143L is composed of two separate voltage regulator blocks, each driving a single external power MOSFET (P-channel) at switching frequencies up to 400kHz using a constant off-time current mode architecture.

The operating current level for both regulators is user-programmable with an external current sense resistor. The LTC1143L allows operation from 3.5V to 14V (16V maximum). 100% duty cycle allows low dropout voltage regulation limited only by the $R_{DS(ON)}$ of the external MOSFET and the resistances of the inductor and the current sense resistor.

Benefit to Battery-Powered Systems

The lower input voltage extends the operating time in battery-powered systems by allowing the switcher to stay in regulation longer as the battery voltage drops. Over 85% efficiency is possible with the LTC1143L, with high efficiency maintained over three decades of output current. The standby current at light loads is only 160µA/output. Shutdown of each output may be individually controlled. In shutdown, the device consumes only 10µA (typical), 20µA maximum.

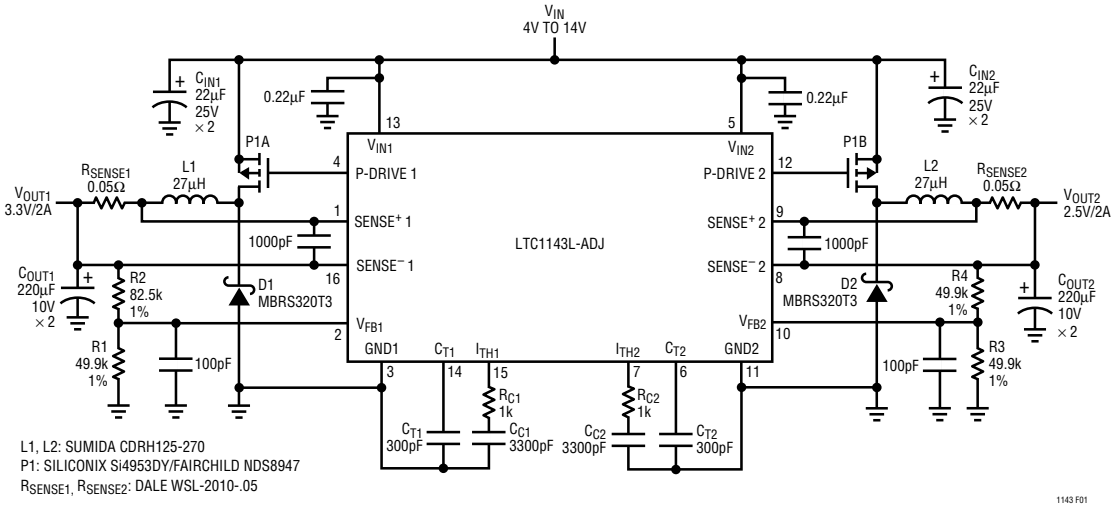
The LTC1143L is ideal for applications that require dual output voltages with very high conversion efficiencies over a wide current range in a small amount of board space. These applications include:

- Palmtop computers and personal digital assistants (PDAs)
- Portable instruments
- Other battery-operated electronics

Choose the Linear Technology LTC1143L—for the time of your battery life. For a data sheet and evaluation samples, contact your local Linear Technology sales office. For more information, visit our web site at **www. linear-tech.com**.

Burst Mode is a trademark of Linear Technology Corporation.

High Efficiency Dual 3.3V/2.5V Regulator



Dual Input 300mA Regulator in SO-8 Ensures Uninterrupted Output

The **LT1579** is a dual input, single output, 300mA low dropout regulator. It is designed to provide an uninterruptible output voltage from two independent input voltage sources on a priority basis. The LT1579 is now available in SO-8, SO-16 and GN-16 packages with an adjustable or fixed 3V, 3.3V or 5V output.

Key Features and Benefits

- **Remove, Recharge and Replace Batteries without Losing Regulation:** Fault tolerant regulator for critical systems
- **0.5V Dropout with No External Diodes Needed**: Minimizes battery drain, increases efficiency
- **50µA Quiescent Current, 7µA in Shutdown:** Extends battery life in standby modes
- **Dual Low-Battery Comparators, Status Flags and Logic Control Inputs:** Regulator can be operated using external logic or microcontroller
- **Fully Integrated Design**: Saves valuable PC board space

One of a Kind

The functional operation of the LDO provides 300mA output current, low quiescent current and 0.5V dropout with no diodes needed. Control circuitry is added to assure the backup input provides power when the primary input goes away, thus maintaining output voltage regulation regardless of the status of either input.

Continued on page 4

Application of the Month

Tiny 1MHz Lowpass Filter Uses No Inductors

The **LTC1560-1** is a fully integrated continuous-time filter in an SO-8 package. It provides a 5-pole elliptic response with a pin-selectable cutoff frequency (f_C) of 1MHz or 500kHz. Several features distinguish the LTC1560-1 from other commercially available high frequency, continuous-time monolithic filters:

- 5-pole 0.5MHz/1MHz elliptic in an SO-8 package
- 70dB signal-to-noise ratio (SNR) measured at 0.07% THD
- 75dB signal-to-noise ratio (SNR) measured at 0.5% THD
- 60dB or more stopband attenuation
- No external components required other than supply and ground decoupling capacitors

The LTC1560-1 delivers accurate fixed cutoff frequencies of 500kHz and 1MHz without the need for internal or external clocks. Other cutoff frequencies can be obtained upon demand; please consult LTC marketing. The extremely small size of the part makes it suitable for compact designs that were never before possible using discrete RC active or RLC passive filter designs.

Frequency and Time-Domain Response

Figure 1 shows a simple circuit for evaluating the performance of the filter. The LTC1560-1 offers a pin-selectable cutoff frequency of either 500kHz or 1MHz. The filter gain response is shown in Figure 2. In the 1MHz mode, the passband gain is flat up to $(0.55)(f_C)$ with a typical ripple of ± 0.2dB, increasing to ± 0.3dB for input frequencies up to $(0.9)(f_C)$. The stopband attenuation is 63dB starting from $(2.43)(f_C)$ and remains at least 60dB for input frequencies up to 10MHz.

The elliptic transfer function of the LTC1560-1 was chosen as a compromise between selectivity and transient response. Figure 3a shows the 2-level eye diagram of the filter. The size of the "eye" opening shows that the filter is suitable for data communications applications. Additional phase equalization can be performed with the help of an external dual op amp and a few passive components. A 2nd order allpass equalizer is cascaded with the IC. The allpass function is achieved through traditional techniques, namely, passing a signal through a low Q inverting bandpass filter and then performing summation with the appropriate gain factors. (See Design Note 169.) Figure 3b shows the eye diagram of the equalized filter.

Conclusion

The LTC1560-1 is a 5th order, user friendly, elliptic lowpass filter suitable for any compact design. It is a monolithic replacement for larger, more expensive and less accurate solutions in communications and data acquisition.

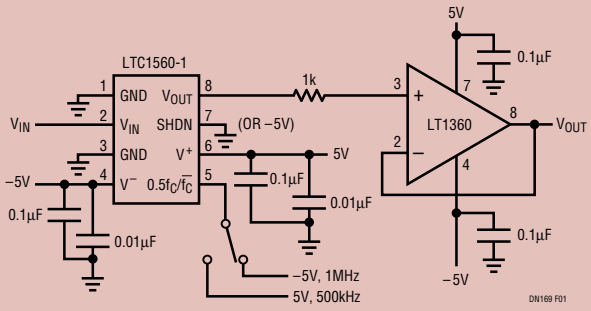


Figure 1. A Typical Circuit for Evaluating the Full Performance of the LT1560-1

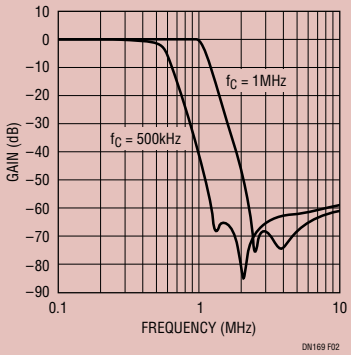


Figure 2. Gain vs Frequency of the 1MHz and 500kHz Lowpass Filters

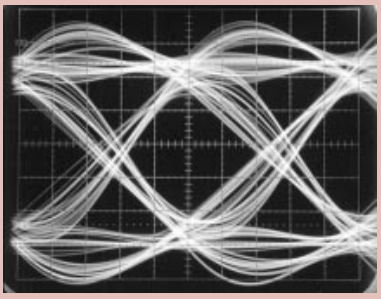


Figure 3a. 2-Level Eye Diagram of the LTC1560-1 Before Equalization

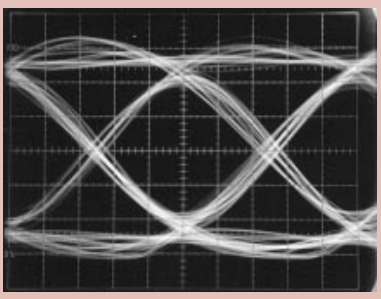


Figure 3b. 2-Level Eye Diagram of the Equalized Filter

LTC1427-50 from page 1

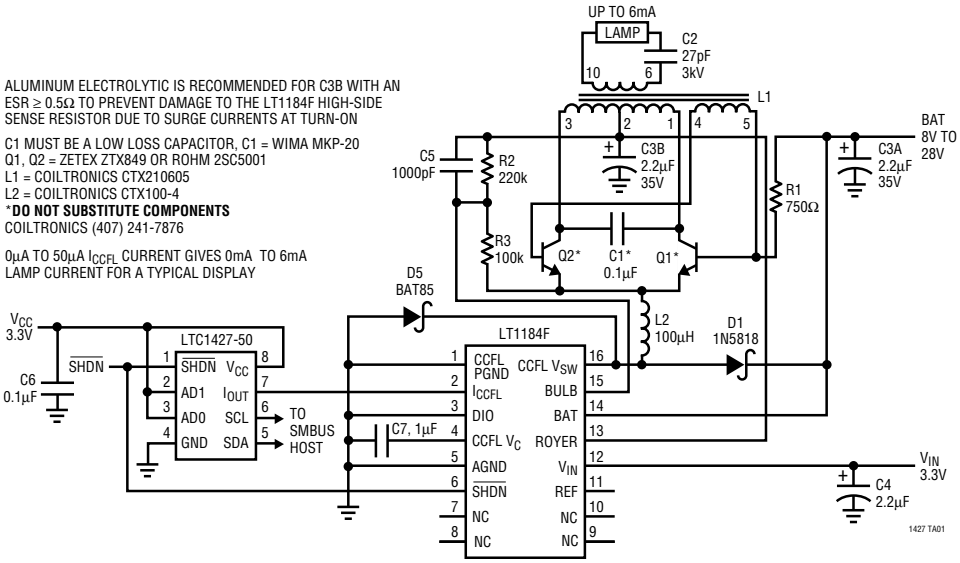
8-bit and a 3-wire or pulse mode interface of other approaches.

The SMBus standard interface allows multiple peripheral devices to be controlled by a microprocessor using a simple 2-wire interface. The SMBus serial interface is also I^2C compliant.

The LTC1427-50 consumes very low power. Supply current is only 115µA from supplies of 2.7V to 5.5V and drops to 10µA in its shutdown mode. The DAC output is guaranteed monotonic and DNL is less than 0.9LSB (maximum) under all operating conditions. Full-scale accuracy is ±2.5% over the commercial temperature range. The product is available in an 8-pin SO package.

The DAC powers up at its midrange output. This feature benefits the feedback adjustment because the system will start at its nominal value and can be adjusted up or down to the desired level. The DAC output value is retained in shutdown and can also be read back in a 3-wire mode. This simplifies the process of returning the system to a previously adjusted point. The product has four selectable SMBus addresses.

SMBus-Controlled Floating CCFL Power Supply



Related Products

Linear Technology provides a family of SMBus interface devices including:

- LTC1623 SMBus Dual High-Side Switch Controller
- LTC1380 8-Channel Single-Ended MUX with SMBus
- LTC1393 4-Channel Differential MUX with SMBus

Get on the SMBus with Linear Technology's LTC1427-50, the world's first 10-bit current output DAC with the SMBus (and I^2C) interface. Contact your local Linear Technology sale office for a data sheet and evaluation samples or visit our web site at **www. linear-tech.com** for more information.

LTC1579 from page 2

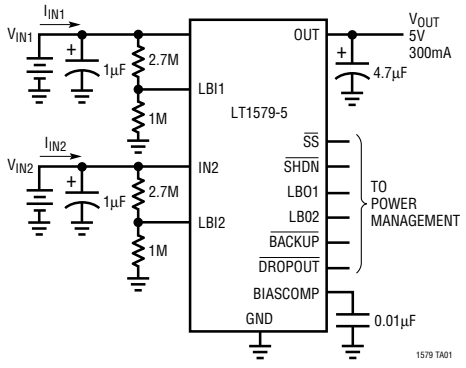
The LT1579 is targeted at battery-backup applications that are powered on a priority basis *and* must maintain output voltage regulation regardless of the status of either input supply.

Ideal applications for the LT1579 include the following examples:

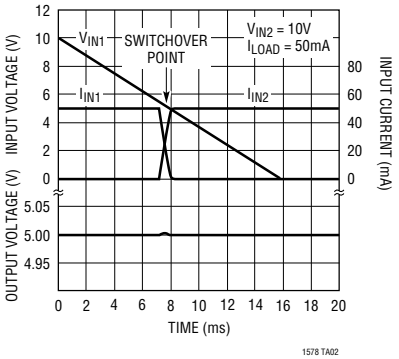
- Portable data acquisition—bar code readers, inventory scanners, data terminals
- Dual battery and fault-tolerant systems
- Medical instrumentation for non life support systems
- Multiple input devices (wall adapter/battery inputs)

For a data sheet and evaluation samples, contact your local Linear Technology sales office. For more information, visit our web site at **www. linear-tech.com**.

5V Dual Battery Supply



Automatic Input Switching



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