Linear Technology Chronicle

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Product of the Month

LT1394: 7ns Comparator Requires Only 6mA Supply Current

A new ultrahigh speed comparator, the **LT®1394**, features TTL-compatible complementary outputs and 7ns response time. The LT1394 also provides single supply operation, ground-sensing capability, low power, high gain and low offset voltage. The LT1394 is much less prone to oscillation and other vagaries, even with slow transition input signals, than previous comparators.

The Underrated Linear Component

The versatility of the IC op amp has dominated the linear design world while comparators are perceived as crude devices with limited usefulness. The LT1394 helps to open new options to linear circuit designers. "High speed comparators can be used to implement linear circuit functions which are as sophisticated as any op amp-based circuit. Judiciously combining a fast comparator with op amps is a key to achieving high performance results," claimed staff scientist Jim Williams (see Application Note 72).

Proof in the Performance

Nanosecond domain linear circuits are widely associated with oscillations, mysterious shifts in circuit characteristics and unintended modes of operation. The LT1394 is stable in its linear region. Output stage switching does not appreciably change power supply current, further enhancing stability. Current consumption is far lower than previous devices. These features make the 200GHz gain bandwidth LT1394 considerably easier to use than other fast comparators.

The LT1394 operates on 6mA from a single 5V supply and delivers 7ns response with an input range that extends from ground to 3.5V (see Figure 1). It features low propagation delay, low quiescent current and the ability to accept low voltage input signals without amplification or level shifting. No minimum input slew rate requirement and low offset voltage (0.8mV) are additional features. Inputs can exceed the supplies without phase reversal of the outputs.

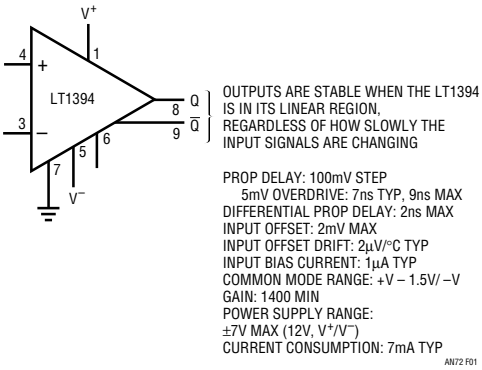

Figure 1. The LT1394 at a Glance

Civilized Speed at Work

"The LT1394 permits fast linear circuit functions that are difficult or impractical using other approaches," according to Williams. Applications include high performance NTSC crystal oscillators, single supply voltage-to-frequency converters and high speed, high accuracy level detectors. Other applications include logic switchable and voltage-controlled crystal oscillators, tunable clock skew generators, voltage-controlled delay functions and fast pulse stretchers.

Innovative circuit design, coupled with a new 6GHz complementary bipolar process, has enabled a new benchmark of high speed comparators. The LT1394 is easy to use, thanks to its stability, single supply capability and complementary outputs.

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LTC1258-2.5: Ultralow Power, Low Dropout Series Reference

The **LTC®1258-2.5** is a micropower bandgap reference that combines high accuracy and low drift with very low supply current and small package size. Low quiescent current, 4µA, plus low dropout voltage of only 200mV make it ideal for 3V and battery-powered equipment.

A Good Reference

The LTC1258 uses curvature compensation to obtain low temperature coefficient and trimmed thin-film resistors to achieve high output accuracy. The reference can supply up to 10mA and sink up to 2mA, making it ideal for precision regulator applications. Initial accuracy is ±0.15% maximum, good enough to eliminate system trimming in many applications.

The LTC1258-2.5 is stable without an output bypass capacitor, but is also stable with capacitance up to 1µF. This feature is important in critical applications where board space is a premium and fast settling is demanded (see Figure 1).

A "Series" Reference

Series references provide power dissipation advantages over shunt style references. To operate, shunt references require a resistor between the power supply and the output, chosen to supply the maximum current that is demanded by the circuit

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Inside This Issue:

LTC1649: High Efficiency Step-Down DC/DC Controller Operates from 3.3V Supply

The **LTC1649** is the first high power step-down DC/DC controller that operates from a 3.3V supply without requiring a secondary higher supply voltage. An onboard charge pump generates a 5V source to fully enhance the external MOSFET gates from an input as low as 2.7V. This enables the LTC1649 to operate at greater than 90% efficiency from a 3.3V supply at loads from 1A to 10A using standard logic level MOSFETs.

Who Needs 5V?

3.3V-only systems are becoming more common. Many systems use "bricks" to transform –48V to 3.3V bulk supplies and have no other source readily available. The LTC1649 eliminates the need to separately generate a boosted 5V supply to get good efficiency. The LTC1649's on-chip drivers drive all N-channel 5V MOSFETs with large gate capacitances. The LTC1649 operates from a 2.7V to 5V supply and provides an output from 1.27V to 2.5V. Proprietary control circuitry allows adjustable output current limiting without requiring a current sense resistor and provides ±1% output voltage regulation over line, load and temperature variations.

Constant Frequency, Synchronous Switching

The LTC1649 is a voltage feedback PWM switching regulator controller designed for use in high power, low input voltage step-down (buck) converters. It includes an onboard PWM generator, a precision reference trimmed to ±0.5%, two high power MOSFET gate drivers and all necessary control circuitry. It is capable of delivering output loads from 1A up to 20A with high efficiency. The constant frequency, 200kHz design minimizes external component count and size. The controller may be synchronized to an external clock source between 260kHz and 500kHz. Other features include a built-in soft start feature and thermal protection.

The LTC1649 uses a synchronous switching architecture, with MOSFET Q3 taking the place of the diode in a classic buck circuit (Figure 1). This improves efficiency by reducing the voltage drop across Q3 as compared to the V_F of the diode. In addition, Q3 can conduct current in either direction. The ability to sink current at the output allows the circuit to be used with reactive or other unconventional loads.

The LTC1649 features a shutdown mode that reduces supply current below 25µA when the $\overline{SHDN}$ pin is taken low. In shutdown, the external MOSFET drivers both go low, keeping the external MOSFETs off and isolating the output from the input supply. The CP_{OUT} voltage remains regulated at 5V in shutdown and can be used as a keep-alive supply.

Applications for LTC1649

Ideal applications for the LTC1649 are telecommunications supplies: base station switching, network or ethernet routers; low voltage CPU and DSP supplies in 3.3V-only systems; local regulation for distributed power supplies and high power 3.3V to 1.27V- 2.5V conversion.

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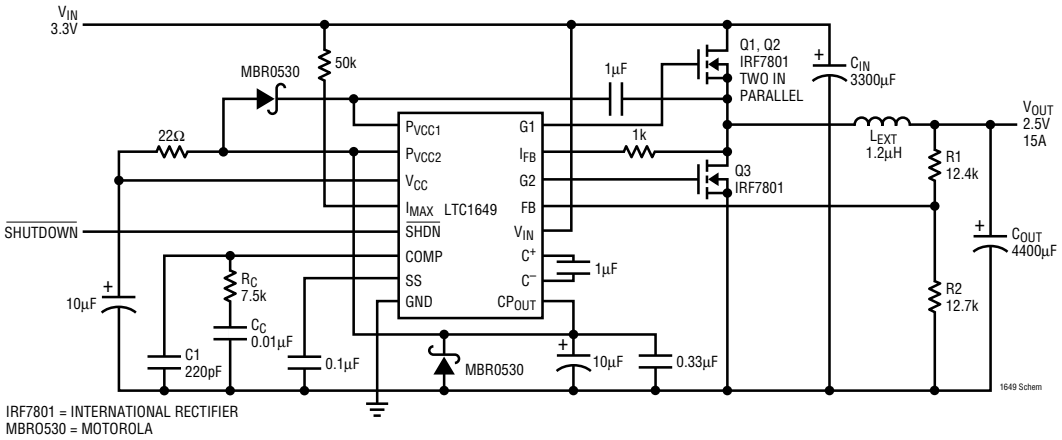

Figure 1. 3.3V to 2.5V, 15A Converter

LTC1258-2.5 from page 1

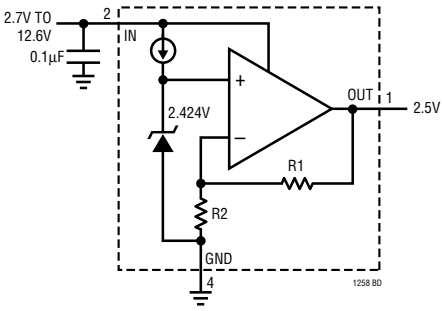

Figure 1. LTC1258-2.5 Micropower Reference: Low Dropout, No Output Capacitor

being regulated. The shunt reference must always sink this current, often resulting in high power dissipation and short battery life.

A MOSFET Pass Transistor Reference

The LTC1258 features an internal P-channel MOSFET pass transistor. This provides several advantages over similar designs that use a PNP bipolar pass transistor. The LTC1258-2.5 consumes only 4µA of quiescent current and provides a lower dropout voltage (200mV maximum) than PNP-based references. The LTC1258-2.5 will provide a 2.5V reference voltage from a supply as low as 2.7V, making it ideal for 3V systems.

Low power, portable and 3V systems such as are used in data acquisition or handheld instrumentation are great places to use the LTC1258-2.5's advantages: micropower, low dropout voltage, small board space and fast settling.

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Application of the Month

Micropower ADC and DAC in SO-8 Give PC 12-Bit Analog Interface

Need to add two channels of simple, inexpensive, low powered, compact analog input/output to a PC computer? Choose the **LTC1298 ADC** and **LTC1446 DAC**. The LTC1298 and the LTC1446 are the first SO-8 packaged 2-channel devices of their kind. The LTC1298 draws just 340µA. A built-in auto shutdown feature reduces power dissipation at reduced sampling rates (to 30µA at 1ksps). Operating on a 5V supply, the LTC1446 draws just 1mA (typ). Although the application shown is for PC data acquisition, these two converters provide the smallest, lowest power solutions for any other analog I/O application.

The circuit shown in Figure 1 connects to a PC's serial interface using four interface lines: DTR, RTS, CTS and TX. DTR is used to transmit the serial clock signal, RTS is used to transfer data to the DAC and ADC, CTS is used to receive conversion results from the LTC1298 and the signal on TX selects either the LTC1446 or the LTC1298 to receive input data. The LTC1298's and LTC1446's low power dissipation allows the circuit to be powered from the serial port. The TX and RTS lines charge capacitor C4 through diodes D3 and D4. An LT1021-5 regulates the voltage to 5V. Returning the TX and RTS lines to a logic high after sending data to the DAC or completion of an ADC conversion provides constant power to the LT1021-5.

Using a 486-33 PC, the throughput was 3.3ksps for the LTC1298 and 2.2ksps for the LTC1446. Your "mileage" may vary. C code software prompts the user to either read a conversion result from the ADC's CH0 or write a data word to both DAC channels. The code is available on disk from LTC.

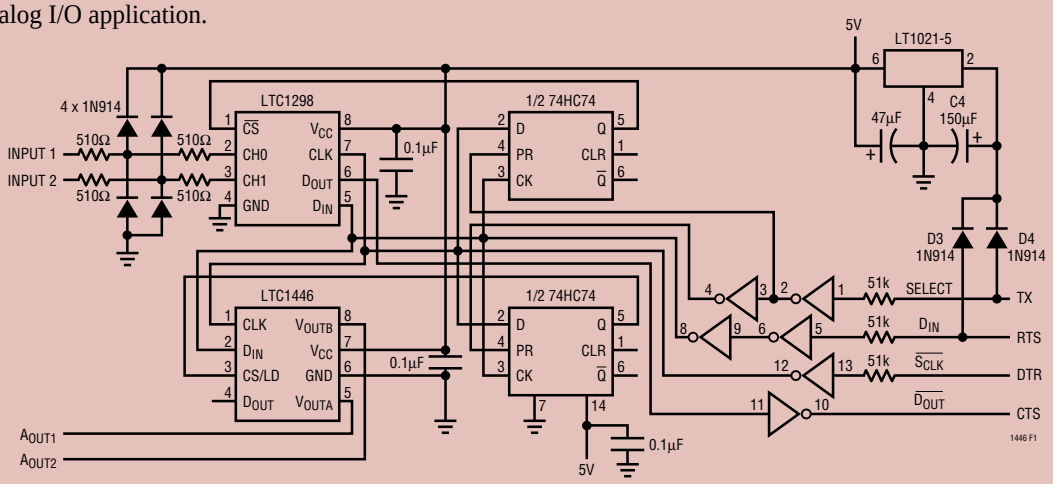

Figure 1. Communicating over the Serial Port, the LTC1298 and LTC1446 in SO-8 Create a Simple, Low Power, 2-Channel Analog Interface for PCs

LT1638/LT1639: 200µA, 1.2MHz Rail-to-Rail Op Amps with Over-The-Top Inputs

The **LT1638** is Linear Technology's latest general purpose, low power, dual rail-to-rail operational amplifier and the **LT1639** is the quad version. The circuit topology is based on the popular LT1490/LT1491 op amps but hopped up for five times higher speed.

Tough, Versatile Op Amps

Users have appreciated the LT1490 for its "toughness" and other unique features but some applications require higher gain bandwidth or slew rate. The LT1638/LT1639 op amps meet that need while still qualifying as micropower circuits. The parts are guaranteed to withstand reverse supply voltages to 18V (typically 40V). Their input stages incorporate protection to prevent the output from phase reversing when the input is forced to 22V below the negative supply. Input protection resistors limit the current from becoming excessive when the input is forced to this extreme.

The LT1638/LT1639 operate on single and split supplies with a total voltage of 2.5V to 44V with specifications tested and guaranteed at 3V, 5V and ±15V. The output can swing within 30mV of the positive rail and 5mV of the negative rail with no load. The gain-bandwidth product is 1.2MHz and the amplifier is stable with capacitive loads up to 200pF under all loading conditions (see Table 1).

Table 1. LT1638/LT1639 Typical Performance, 25°C

Parameter	Typical Value
Input Offset Voltage	200µV
Input Bias Current	15ns
Input Offset Current	1nA
CMRR	98dB
Open-Loop Gain	1500V/mV
PSRR	100dB
Supply Current per Amp	190µA

An Over-The-Top Application

A battery current monitor powered by a 5V supply (Figure 1) demonstrates the

Continued on page 4

Publications Printed in June and July 1998

Catalog:	Spring/Summer New Products Catalog
Data Sheets:	
LT1167	Low power, precision instrumentation amplifier that requires only one external resistor to set gains of 1 to 10,000
LTC1326-2.5	Triple supply monitor for systems with multiple supply voltages. Micropower operation, small size, high accuracy, glitch immunity
LT1374	500kHz monolithic buck mode switching regulator. 4.5A current mode for fast transient response and good loop stability
LTC1416	2.2µs, 400ksps, 14-bit sampling A/D converter that draws only 75mW from ±5V supplies. High dynamic range and precision reference
LTC1418	Low power, 200ksps, 14-bit A/D converter. Data output is selectable for 14-bit parallel or serial format
LTC1435A	Synchronous step-down switching regulator controller that drives external N-channel power MOSFETs. 99% duty cycle
LT1506	500kHz monolithic buck mode switching regulator. 4.5A switch, current mode for fast transient response and good loop stability
LTC1517-3.3	Micropower charge pump DC/DC. Extremely low operating current (typically 6µA with no load) and low external parts count
LTC1541	Micropower amplifier, comparator and bandgap reference in an 8-pin package
LTC1542	Micropower amplifier and comparator in an 8-pin package. Single 2.5V to 12.6V or dual supply. The input current is 10pA typical
LT1575/77	UltraFast™ transient response, low dropout regulator controllers, drive N-channel MOSFETs without tantalum or electrolytic capacitors
LTC1595/96	Serial input, 16-bit multiplying current output DACs. Pin and hardware compatible with the 12-bit LTC8043 and LTC8143/LTC7543
LTC1604	333ksps, 16-bit sampling A/D converter, 220mW from ±5V supplies, high dynamic range sample-and-hold, high speed parallel output
LT1610	Fixed frequency 1.7MHz, single cell micropower DC/DC converter, internal 300mA switch
LT1614	Inverting fixed frequency 600kHz switching regulator, internal 500mA switch, 1V to 5V input
LTC1623	SMBus switch controller is a slave device that controls two high side N-channel MOSFETs on either the SMBus or the I^2C™ bus
LT1634	Micropower precision shunt voltage reference, 10µA operating current, 0.05% initial accuracy, 10ppm/°C maximum drift
LT1640	Hot Swap™ controller for insertion and removal from a live backplane. Inrush current is limited to a programmable value
LTC1650	Deglitched rail-to-rail voltage output 16-bit (DAC). 16-bit monotonicity over temperature, 3-wire cascadable serial interface
LTC1660	Octal 10-bit DAC, 16-pin narrow SSOP package. 56µA total supply current per DAC. DC output currents in excess of 5mA
LT1671	60ns, low power, single supply, ground-sensing comparator
LTC1706-19	Four VID inputs, output voltage between 1.3V and 2V is programmed in 50mV increments for the Intel Mobile Pentium®II

LTC1638/LTC1639 from page 3

LT1638/LT1639's ability to operate with their inputs above the positive rail. In this application, a conventional amplifier would be limited to a battery voltage between 5V and ground, but the LT1638 can handle battery voltages as high as 44V. The LT1638 shuts down with V_{CC} removed and the input leakage is less than 0.1nA. No damage to the LT1638 will result from inserting the battery backwards. The current level and polarity may be detected and buffered with one quad amplifier (see *Linear Technology* magazine, May 1998).

Over-The-Top Value

With its 1.2MHz speed, Over-The-Top capability, reverse-battery protection and rail-to-rail input and output features, the LT1638 and LT1639 are ideal candidates for multiple general-purpose op amp applications.

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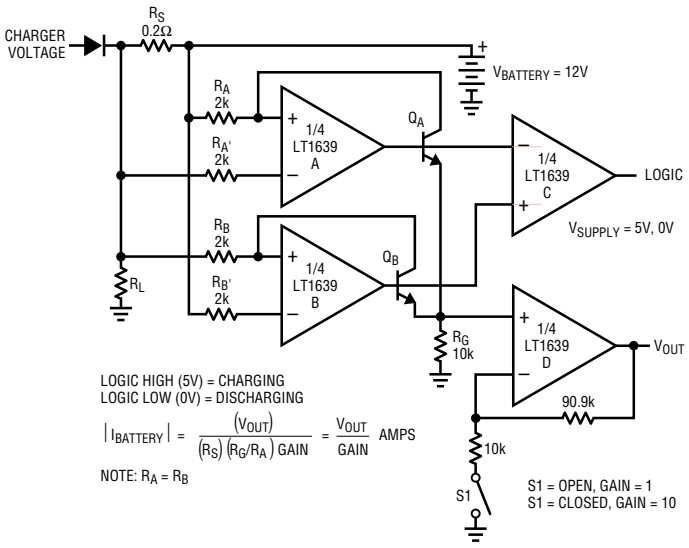

Figure 1. LT1639 Battery Current Monitor—An Over-The-Top Application

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