Linear Technology Chronicle

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Product of the Month

Ultralow Noise Switching Regulator Is Quieter Than Linear Regulators

The **LT®1533** is a DC/DC converter that produces less than 100µV peak-to-peak output noise—far less than linear regulators. The first in a new class of switching regulators, the LT1533 dramatically reduces both conducted and radiated noise by accurately controlling the voltage and current slew rates of the two internal power switches. Using this novel technique, high frequency harmonic noise can be reduced by as much as 40dB over typical switching regulators, with a relatively minor impact on power conversion efficiency. Figure 1 shows the comparison in output noise between a conventional switcher and the LT1533. Its ability to provide high efficiency voltage conversion with very low noise makes it ideal in such noise-sensitive applications as precision instrumentation and wireless communications.

The LT1533 is a complete current mode switching regulator that includes an oscillator, error amplifier, protection circuitry and two 1A power switches (Figure 2). By employing a push-pull switching topology to drive a center-tapped transformer, it significantly reduces the RMS ripple current observed at the converter's input and output. This topology and the ability to control switching harmonics can greatly reduce and even eliminate power supply shielding requirements in sensitive applications.

The LT1533 can be configured in low noise step-up/step-down, inverting and isolated DC/DC converters to regulate both positive and negative output voltages. Because the voltage and current slew rates are independently adjustable using external resistors, the designer is given the flexibility to select the optimum noise vs efficiency operating point for any application.

The LT1533 operates from an input supply voltage of 2.7V to 23V (input voltage is limited to 15V for push-pull configurations). It draws 9mA (typ) quiescent current and shuts down to only 12µA, making the part suitable for portable, battery-powered applications.

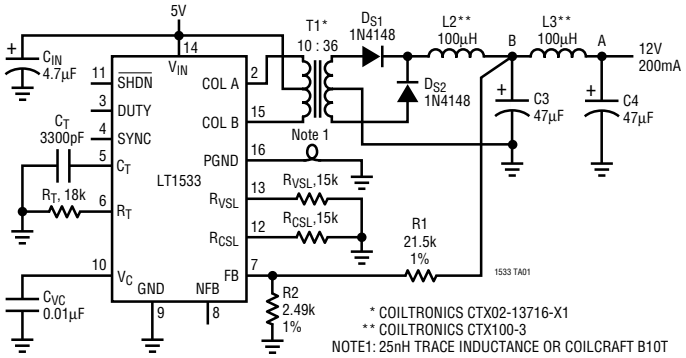


Figure 2. The LT1533 as a 5V to 12V Push-Pull Converter for Low EMI Applications

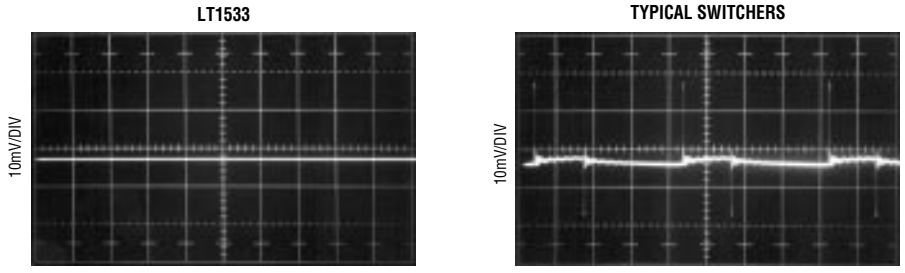


Figure 1. The LT1533 Produces Less Than 100µV Peak-to-Peak Output Noise over a 100MHz Bandwidth, Considerably Less Than Conventional Switchers

The switching frequency may be externally set with a single capacitor up to 250kHz and may be synchronized to an external clock source of up to 375kHz. Protection features include cycle-by-cycle current limiting, undervoltage lockout and thermal shutdown. For unregulated DC/DC conversion, the LT1533 may be configured to operate in a fixed 50% duty cycle mode.

The LT1533 is available from stock in a 16-lead narrow SO package, screened to the commercial and industrial temperature ranges. For a data sheet and evaluation samples, contact your local Linear Technology sales office or visit our web site at **www.linear-tech.com** for more information.

Inside This Issue:

Hot Swap Controller IC in SO-8 Permits Safe PC Board Insertion and Removal

The **LTC®1422** Hot Swap controller is designed to provide fail-safe insertion and removal of PC cards without interrupting system operation. The device controls a single supply voltage and limits potentially damaging inrush currents when a circuit board is plugged into a live backplane. It also eliminates glitches that disrupt the system bus when the board's connector makes or breaks contact, protecting against system failures. All that is required is an external N-channel MOSFET along with resistors and capacitors to set the timing and reset thresholds as shown in Figure 1. The LTC1422 is flexible enough to cover supply voltages ranging from 2.7V to 12V as well as –48V applications.

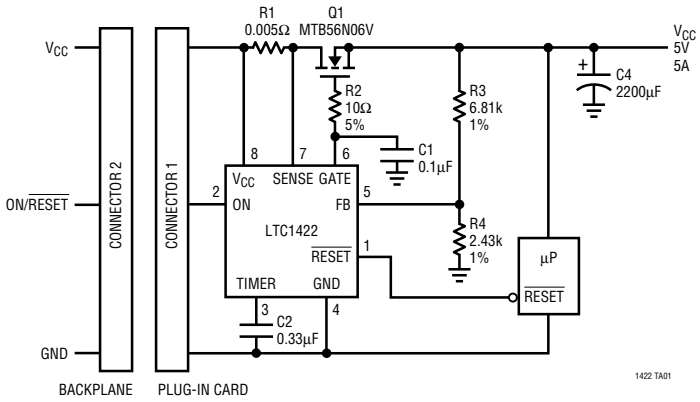


Figure 1. The LTC1422 Ramps Power Supply Voltages in a Controlled Fashion When a Board is Plugged or Unplugged into a Live Backplane

Hot swap means plugging a component into a socket that is already powered. The inrush current required to charge up all of the bypass capacitors can be several amps which can damage the connector and other in-line components as well as cause the system supply to glitch. The LTC1422 eliminates glitches on the system supply and allows the user to set the maximum current limit. Similarly, a user-programmable RESET threshold notifies the processor when supply voltage drops below the selected voltage.

The LTC1422 is available in the 8-pin PDIP and SO packages. Parts are screened to the commercial and industrial temperature ranges and are available from stock. For a data sheet and evaluation samples, contact your local Linear Technology sales office or visit our web site at **www.linear-tech.com** for more information.

Triple Reset Generator for PCI Applications Offers 0.75% Threshold Accuracy

The **LTC1536** is the industry's first micropower precision *triple* supply monitor for multiple voltage systems that meets the fast PCI timing specifications for reset. The LTC1536 offers the ability to monitor 5V, 3.3V and a third voltage input that is adjustable down to 1V, with a 0.75% threshold accuracy and glitch immunity. It draws only 100µA (typ) supply current and its RST output is guaranteed to be in the correct state for V_{CC5} or V_{CC3} down to 1V. These features make the LTC1536 ideal for precision system monitoring chores in PCI-based systems such as desktop and notebook computers, intelligent instruments and network servers as shown in Figure 1. The LTC1536 is available in the 8-lead MSOP—two-thirds the size of an SO-8.

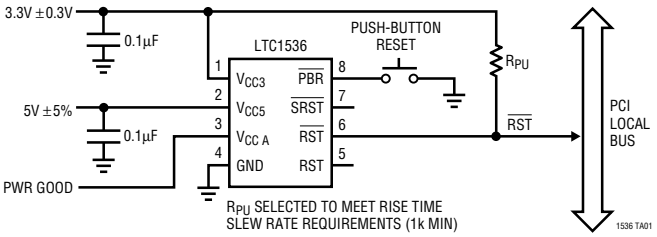


Figure 1. The LTC1536 Triple Reset Monitor is Designed for PCI Local Bus Applications with Multiple Supply Voltage That Require Accurate Supply Monitoring

PCI compliant means a RESET signal is generated in less than 500ns if either power rail falls ≥500mV below spec and ensures reset operation will occur in less than 100ns if the 5V supply falls below the 3.3V rail by ≥300mV (Figure 2). Add-in cards, in particular, require critical voltage monitoring because the supplies may be removed independently of any action occurring on the motherboard or backplane. It is vital that the processor be notified and the information stored before the power is completely lost.

For non-PCI applications, the LTC1326 micropower triple supply monitor is also available with a supply current of just 20µA for power-conscious system designs. (See May'97 *Chronicle* for more details). The LTC1536 and LTC1326 both offer $\overline{RST}$ (active HIGH reset output) and RST (active

Continued on page 3

Application of the Month

A 4-Cell to 5V Power Supply

A 4-cell pack is a convenient, popular battery size. Alkaline cells are sold in 4-packs at retail stores and four cells usually provide sufficient energy to keep battery replacement frequency reasonable. Generating 5V from four cells, however, is a bit tricky. A fresh 4-cell pack has a terminal voltage of 6.4V but at the end of its life, the pack's terminal voltage is around 3.2V; hence, the DC/DC converter must step the voltage either up or down, depending on the state of the batteries.

A flyback topology with a costly, custom designed transformer could be employed, but Figure 1's circuit gets around these problems by using a flying capacitor scheme along with a second inductor. The circuit also isolates the input from the output, allowing the output to go to 0V during shutdown. The circuit can be divided conceptually into boost and buck sections. L1 and the LT1300 switch comprise the boost or step-up section, and L2, D1 and C3 comprise the buck or step-down section. C2 is charged to V_{IN} and acts as a level shift between the two sections. The switch node toggles between ground and $V_{IN} + V_{OUT}$, and the L2-C2 diode node toggles between $-V_{IN}$ and $V_{OUT} + V_D$. Figure 2 shows efficiency versus load current for the circuit. All four energy storage elements must handle power, which accounts for the lower efficiency of this circuit compared to a simpler boost circuit.

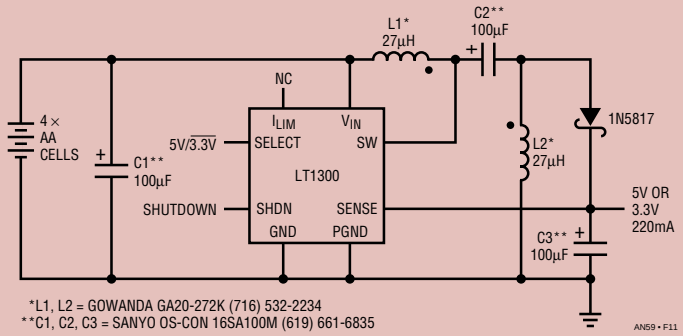


Figure 1. 4-Cell to 3.3V or 5V Converter Output Goes to Zero When in Shutdown. Inductors May Have, but Do Not Require Coupling; a Transformer or Two Separate Units Can Be Used

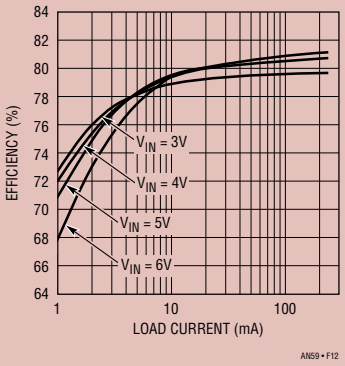


Figure 2. Efficiency of Up/Down Converter in Figure 1

Efficiency is directly related to the ESR and DCR of the capacitors and inductors used. Better capacitors cost more money. Better inductors do not necessarily cost more, but they do take up more space. Worst-case RMS current through C2 occurs at minimum input voltage and measures 0.4A at full load with a 3V input. C2's specified maximum RMS current must be greater than this worst-case current. The Sanyo capacitors shown in the schematic specify a maximum ESR of 0.045Ω with a maximum ripple current rating of 2.1A. The Gowanda inductors specify a maximum DCR of 0.058Ω.

LTC1536 from page 2

LOW reset output) to accommodate processors with either requirement. Both have a "soft" reset which signals the processor when short duration glitches occur on the supplies. Processors can use the soft reset to detect the presence of transients while using the "hard" reset to detect supply failures. Both have a push-button input to manually reset the system.

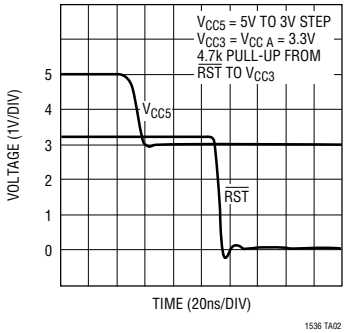


Figure 2. In the PCI Timing Specification, Rev. 2.1, a RESET Signal Occurs When the 5V Supply Falls Below the 3.3V Supply by 300mV or More

The LTC1536 and LTC1326 are available from stock in 8-lead MSOP and SO packages. Contact your local Linear Technology sales office for a data sheet and evaluation samples. Visit our web site at **www.linear-tech.com** for more information.

Push-Button DACs in SO-8 Packages Tweak Adjustable Regulators

The **LTC1329** and **LTC1428** are new precision current output DACs, designed to sink or source up to 50µA of output current at full scale with a guaranteed accuracy as low as ±1%. These DACs are designed for trim applications on power supplies—the current range is ideal for driving the feedback pin on adjustable regulators instead of using a digital potentiometer. Each has a serial interface that can be used with a simple push-button to trim the adjustment point. For applications with PWM feedback control, the LTC1426 dual 6-bit voltage out DAC provides a PWM signal that swings from 0V to V_{REF} and allows the duty cycle output to be varied by a simple push-button interface. All these DACs (see Table *Push-Button DACs*) have a shutdown mode that drops the supply current to 0.2µA without jeopardizing their contents. With push-button control, there is no need for a microcontroller to create a serial data stream and shift it into the device. They are ideal for adjusting the voltage output of power supplies, in backlight brightness control and for LCD contrast control.

The LTC1428-50 8-bit current *sink* output DAC delivers 50µA ±3% full scale and can be biased from 2V to 10V. Supply current is 130µA over a supply range of $3V \le V_{CC} \le 6.5V$. Figure 1 shows it used as a digitally controlled LCD bias generator. The LTC1329-50 8-bit current *source* output DAC has an output range of 0µA to 50µA ±3% (biased from –15V to 2V or –15V to 2.5V in 3.3V and 5V supply systems, respectively) and draws a supply current of 95µA. The LTC1329A-50 is a precise (±1% accuracy) current output DAC, designed to source 50µA at full scale. For low supply operation, the LTC1329-10, which sources 10µA at full scale, draws only 75µA supply current. This part is particularly appropriate for LCD display voltage bias applications.

The current output DACs (LTC1329-10, LTC1329-50, LTC1329A-50 and LTC1428-50) can communicate with external circuitry by using one of three interface modes: standard 3-wire serial mode or one of two pulse modes. Pulse Mode 1: wire interface uses the CLK signal to increment the DAC in 4LSB steps to adjust the output in a simple manner. Pulse Mode 2: wire interface can increment or decrement the DAC in 4LSB steps using the CLK and D_{IN} pin (to set UP or DOWN). The LTC1426 voltage out dual DAC can be controlled using one of two interface modes: push-button and pulse (see Figure 2). A pulse mode interface allows the user to increase or decrease the output by simply sending a single pulse to the device. It automatically configures itself into the appropriate mode at start-up by monitoring the state of the CLK pins.

The LTC1329 and LTC1428 are offered in an 8-lead SO package and the LTC1426 is available in 8-lead MSOP and SO packages. Parts are screened to the commercial and industrial temperature ranges and are available from stock. For data sheets and evaluation samples of this series of push-button DACs, contact your local Linear Technology sales office or visit our web site at **www.linear-tech.com** for more information.

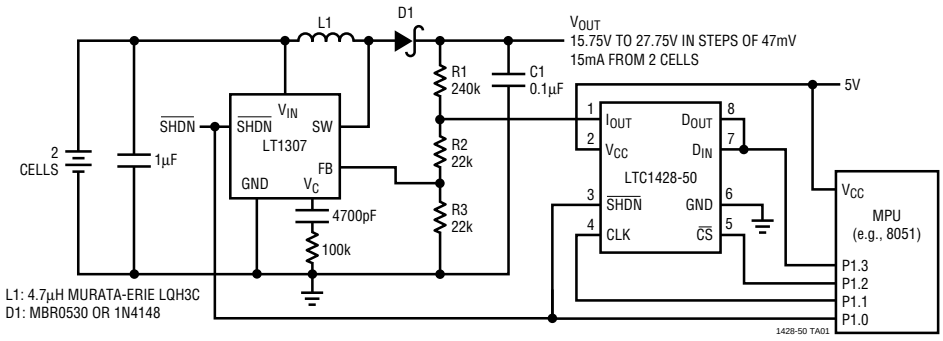
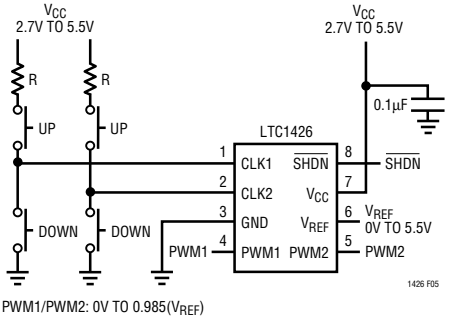


Figure 1. LTC1428-50 8-Bit Current Output DAC Sinks up to 50µA with ±3% Accuracy. It is Shown Here as a Digitally Controlled LCD Bias Generator



PWM1/PWM2: 0V TO 0.985(V_{REF})

LIMITING RESISTOR R PREVENTS SHORTING OF V_{CC} AND GND WHEN BOTH BUTTONS ARE SIMULTANEOUSLY PUSHED. THIS RESISTOR CAN BE PLACED EITHER IN THE V_{CC} OR GND LEG AND THIS DETERMINES THE FUNCTION WHEN BOTH BUTTONS ARE PUSHED. VALUE OF R < 50k

Figure 2. Push-Button Mode Interface of the LTC1426 6-Bit DAC

Push-Button DACs

Part Number	Resolution	Type DAC	Output	Compliance Voltage (V)	Supply Voltage (V)
LTC1329-10	8-Bit	Current Source	10µA ±3%	–15V to 2.5V	$2.7V \le V_{CC} \le 6.5V$
LTC1329-50	8-Bit	Current Source	50µA ±3%	–15V to 2.5V	$2.7V \le V_{CC} \le 6.5V$
LTC1329A-50	8-Bit	Current Source	50µA ±1%	–15V to 2.5V	$2.7V \le V_{CC} \le 6.5V$
LTC1428-50	8-Bit	Current Sink	150µA ±3%	2V to 10V	$3V \le V_{CC} \le 6.5V$
LTC1426	Dual 6-Bit	PWM Voltage Out	0V to V_{REF}	–	$2.7V \le V_{CC} \le 6.5V$

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