Linear Technology Chronicle

August 1996 — **A Showcase of Linear Technology's Focus Products** — Vol. 5 No. 8

Products of the Month

Micropower Single Cell Boost Switcher in 8-Pin MSOP Shrinks Power Conversion Circuits

The **LT®1307** combines small packaging and high frequency operation to provide the world's smallest single cell boost DC/DC converter. Up to 75mA of output current at 3.3V can be generated from a depleted (1V) cell. Efficiencies as high as 80% are obtained with 1.5V to 3.3V conversion at 50mA. The LT1307 is offered in a new 8-lead MSOP package, less than two-thirds the size of an 8-lead SO package. This extremely small solution makes this switcher appropriate for many new miniature applications.

Fixed 600kHz frequency operation allows the use of very small and inexpensive ceramic output capacitors with values of 10µF usable for most applications. These surface mount capacitors can save 20¢ to 30¢ in solution cost over tantalum capacitors, formerly required for this function. Inductor size and cost is also reduced by using standard 10µH surface mountable devices. These small components and the 600kHz fixed switching frequency make the LT1307 ideal for compact communications systems, such as pagers and modems, where it is essential to keep switching noise out of the intermediate frequency (IF) bands.

The LT1307 also uses Burst Mode™ operation at low load currents to maintain high efficiency. Even in Burst Mode operation, there is no interference with 455kHz IF frequencies. The low switch saturation voltage (V_{SAT}) of the LT1307 minimizes switch losses and provides the high efficiency. An onboard comparator is included for low-battery detection.

The LT1307 is available in an 8-lead SO, 8-lead PDIP as well as the new 8-lead MSOP package. It is well suited for pager applications, which generally require operation specified at –20°C. The 0°C to 70°C temperature range devices are guaranteed to function at –20°C, while the industrial temperature specifications are guaranteed for –40°C to 85°C operation. For a data sheet and evaluation samples of the LT1307, contact your local Linear Technology sales office.

Burst Mode is a trademark of Linear Technology Corporation.

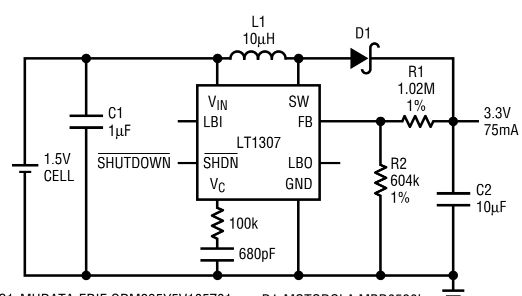

Figure 1. LT1307 Can Be Used as a Single 1.5V Cell to 3.3V Boost Converter

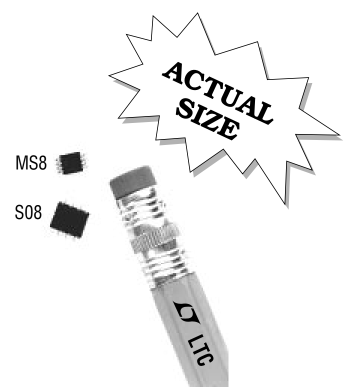

Figure 2. New MSOP Package Is Smaller Than SO-8

Industry's Smallest Dual 12-Bit DAC Fits in SO-8 Package

The **LTC®1446** is a dual 12-bit voltage output digital-to-analog converter that is complete with two rail-to-rail voltage output amplifiers, an internal reference and a 3-wire cascadable serial interface, all packed into an 8-pin SO or PDIP package. The 4.095V output voltage is guaranteed even when driving heavy loads with a reduced supply of 4.5V. The DAC outputs drive capacitive loads of up to 1000pF, over twice that of competitive solutions. It consumes just 5mW typical (7.5mW max) from a single 5V supply, making it the best solution for portable and battery-powered equipment, general trim pot applications and industrial control applications.

The excellent typical differential nonlinearity (DNL) of 0.2LSB not only guarantees 12-bit monotonic performance

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but also provides exceptional performance in closed loop control systems. The LTC1446 3-wire serial interface allows several DACs to be daisy-chained to save board space and is compatible with SPI, QSPI and MICROWIRE™ protocols. Power-on reset ensures that the outputs are at zero-scale after a power-up sequence, easing initial software overhead.

The LTC1446 is screened to the commercial and industrial temperature ranges. Contact your local Linear Technology sales office for a data sheet and evaluation samples.

MICROWIRE is a trademark of National Semiconductor Corp.

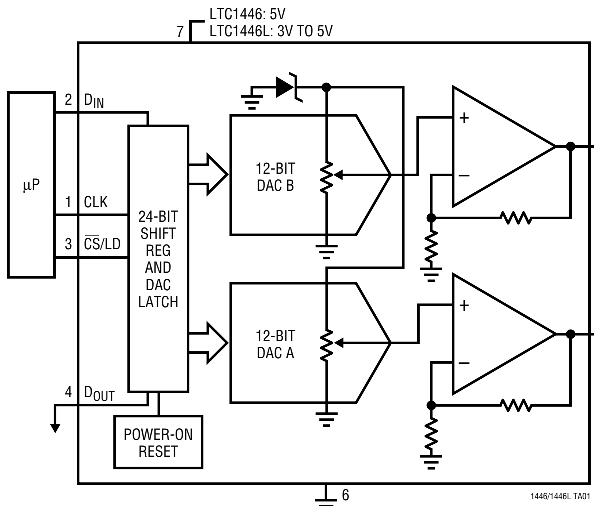

Figure 1. Functional Block Diagram: Dual 12-Bit Rail-to-Rail DAC

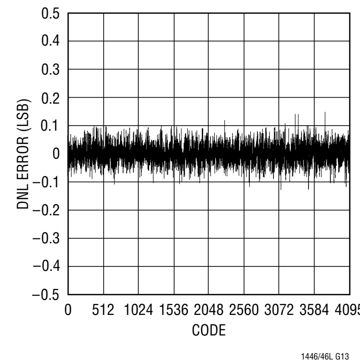

Figure 2. Differential Nonlinearity vs Input Code for the LTC1446 — DNL Is Less Than 0.2LSB

Low Power 8th Order Lowpass Filter in SO-8 Package

The **LTC1069-1** is the industry's first monolithic, 8th order, elliptic lowpass filter that fits in an SO-8 package. It requires no external components except for power supply bypass capacitors. With a single 3.3V supply, it draws just 2.0mA (typ) and has a dynamic range of over 80dB. The cutoff frequency of the LTC1069-1 is programmed by an external clock and is equal to the clock frequency divided by 100. It can be clocked-tuned to cutoff frequencies up to 12kHz with ±5V supplies, 8kHz with a single 5V supply and 5kHz with a single 3.3V supply. The stopband attenuation has a progressive elliptic response reaching 20dB attenuation at 1.2 $\times f_{CUTOFF}$, 52dB at 1.4 $\times f_{CUTOFF}$ and over 70dB at 2 $\times f_{CUTOFF}$. The gain at f_{CUTOFF} is –0.7dB and typical passband ripple is only ±0.15dB. These features make it a good choice for precision telecommunications and antialiasing applications where a compact solution is required. Figure 1 shows the frequency response of the LT1069-1 elliptic lowpass filter configured for 3.3V supply operation.

The low supply voltage operation of the LTC1069-1 does not penalize dynamic range—with an input range of $0.3V_{RMS}$ to $2.5V_{RMS}$ and a ±5V supply, the signal-to-(noise + THD) is >70dB. Figure 2 illustrates these characteristics for dual supply operation. For a ±5V supply typical quiescent current is 3.8mA and for a single 5V supply it is only 2.5mA over the full operating temperature range of 0°C to 70°C. The LTC1069-1 is immediately available in volume from stock in either an 8-lead PDIP or SO-8 surface mount package. Contact your local Linear Technology sales office for a data sheet and evaluation samples.

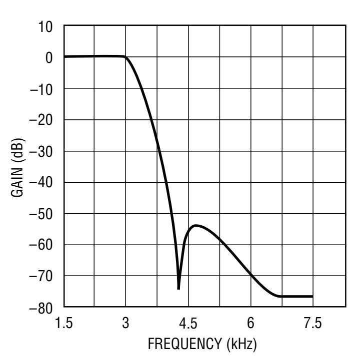

Figure 1. Frequency Response of the LTC1069-1 as a Single 3.3V Supply 3kHz Elliptic Lowpass Filter

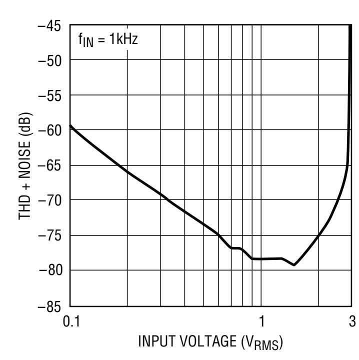

Figure 2. THD + Noise Characteristics of LTC1069-1 Under Dual Supply Operation

Application of the Month

Micropower Voltage-to-Frequency Converter

Figure 1 is a micropower voltage-to-frequency converter. A 0V to 5V input produces a 0kHz to 10kHz output, with a linearity of 0.02%. Gain drift is 60ppm/°C. Maximum current consumption is only 26µA, 100 times lower than currently available units.

To understand the circuit's operation, assume that C1's negative input is slightly below its positive input (C2's output is low). The input voltage causes a positive-going ramp at C1's input (trace A, Figure 2). C1's output is high, allowing current flow from Q1's emitter, through C1's output stage to the 100pF capacitor. The 2.2µF capacitor provides high frequency bypass, maintaining low impedance at Q1's emitter. Diode connected Q6 provides a path to ground. The voltage to which the 100pF unit charges is a function of Q1's emitter potential and Q6's drop. C1's CMOS output, purely ohmic, contributes no voltage error. When the ramp at C1's negative input goes high enough, C1's output goes low (trace B) and the inverter switches high (trace C). This action pulls current from C1's negative input capacitor via the Q5 route (trace D). This current removal resets C1's negative input ramp to a potential slightly below ground. The 50pF capacitor furnishes AC positive feedback (C1's positive input is trace E) ensuring that C1's output remains negative long enough for a complete discharge of the 100pF capacitor. The Schottky diode prevents C1's input from being driven outside its negative common mode limit. When the 50pF unit's feedback decays, C1 again switches high and the entire cycle repeats. The oscillation frequency depends directly on the input voltage derived current.

Q1's emitter voltage must be carefully controlled to get low drift. Q3 and Q4 temperature compensate Q5 and Q6 while Q2 compensates Q1's V_{BE}. The three LT1004s are the actual voltage reference and the LM334 current source provides 12µA bias to the stack. The current drive provides excellent supply immunity (better than 40ppm/V) and also aids circuit temperature coefficient. It does this by using the LM334's 0.3%/°C tempco to slightly temperature modulate the voltage drop in the Q2 to Q4 trio. This correction's sign and magnitude directly oppose the –120ppm/°C 100pF polystyrene capacitor's drift, aiding overall circuit stability. Q8's isolated 100pF drive to the CMOS inverter prevents output loading from influencing Q1's operating point. This makes circuit accuracy independent of loading.

The Q1 emitter follower delivers charge to the 100pF capacitor efficiently. Both base and collector current end up in the capacitor. The 100pF capacitor, as small as accuracy permits, draws only small transient currents during its charge and discharge cycles. The 50pF-100k positive feedback combination draws insignificantly small switching currents. Figure 3, a plot of supply current versus operating frequency, reflects the low power design. At zero frequency, comparator quiescent current and the 12µA reference stack bias account for all current drain. There are no other paths for loss. As frequency scales up, the 100pF capacitor's charge-discharge cycle introduces the 1.1µA/kHz increase shown. A smaller value capacitor would cut power, but effects of stray capacitance and charge imbalance would introduce accuracy errors.

Circuit start-up or overdrive can cause the circuit's AC-coupled feedback to latch. If this occurs, C1's output goes low; C2, detecting this via the 2.7M-0.1µF lag, goes high. This lifts C1's positive input and grounds the negative input with Q7, initiating normal circuit action.

To calibrate this circuit, apply 50mV and select the indicated resistor at C1's positive input for a 100Hz output. Complete the calibration by applying 5V and trimming the input potentiometer for a 10kHz output.

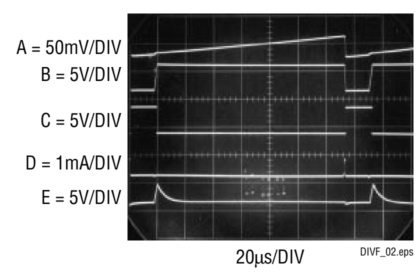

Figure 2. Waveforms for the Micropower V/F Converter

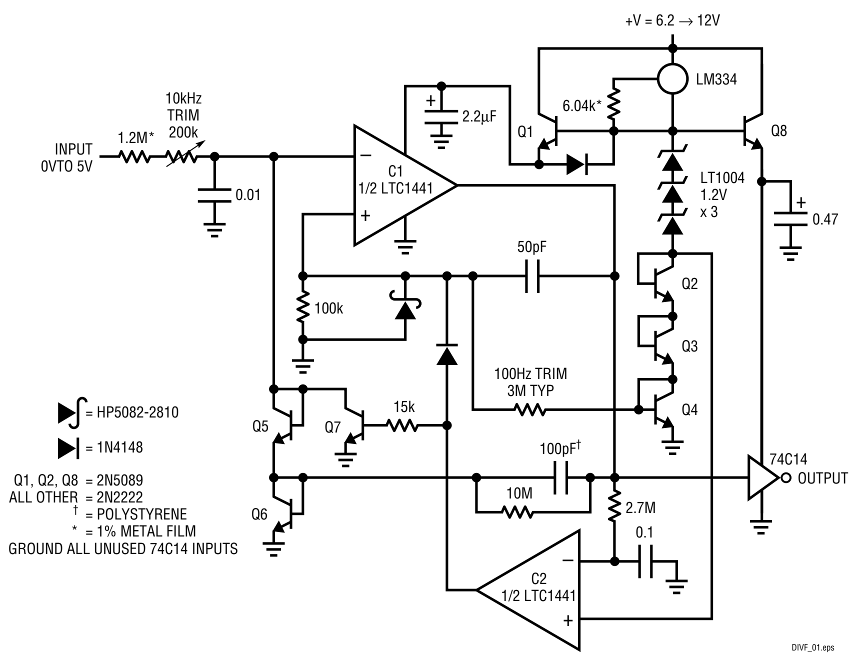

Figure 1. 0.02% V/F Converter Requires Only 26µA Supply Current

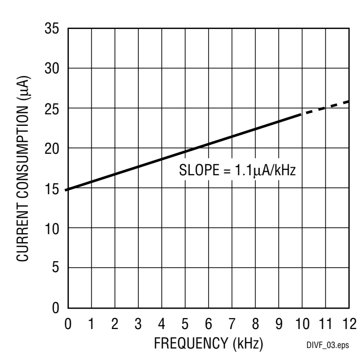

Figure 3. Current Consumption vs Frequency for the V/F Converter

Power Factor and PWM Controllers for 150W to 3000W Applications

The **LT1508/LT1509** controllers provide a complete synchronized power factor corrected solution for universal off-line switching power supplies. They implement a power factor corrector (PFC) and an off-line DC/DC controller (PWM) in a single 20-lead package. This results in synchronized performance of the PFC and PWM sections to ensure low harmonic content. The LT1509 includes a current mode PWM controller and the LT1508 includes a voltage mode PWM controller.

The LT1508/LT1509 provide the power factor correction mandated by present and future international regulations to alleviate the peak current load strains on wiring in buildings and homes. Operation up to 300kHz can be achieved with 99% power factor over a 20:1 load current range. The voltage mode PWM section (or current mode in the case of LT1509) contains all the primary side functions to convert the PFC preregulated high voltage output to an isolated low voltage output. The PWM duty cycle is internally limited to 47% (50% max) to prevent transformer saturation.

PWM soft start begins when the PFC output reaches the preset voltage. Start-up current is 250µA (typ) and once operating the supply current is 13mA (typ). Gate drivers deliver 1.5A with rise and fall times of 25ns. A dedicated overvoltage protection pin is provided and is activated when the threshold is 1.05 times the reference voltage.

The LT1508/LT1509 provide complete control solutions for output power from 150W to 3000W over a wide line and load range. These applications include universal input off-line power supplies, telecom supplies (48V outputs), network and data communications equipment, instrumentation, industrial control, motor control equipment and distributed power buses of 24V or 48V.

LT1508/LT1509 are offered in 20-lead PDIP and SO packages. Contact your local Linear Technology sales office for a data sheet and evaluation samples. For additional application information see the Off-Line Conversion section in the LTC *1996 Power Solutions* brochure, a free publication available from LTC.

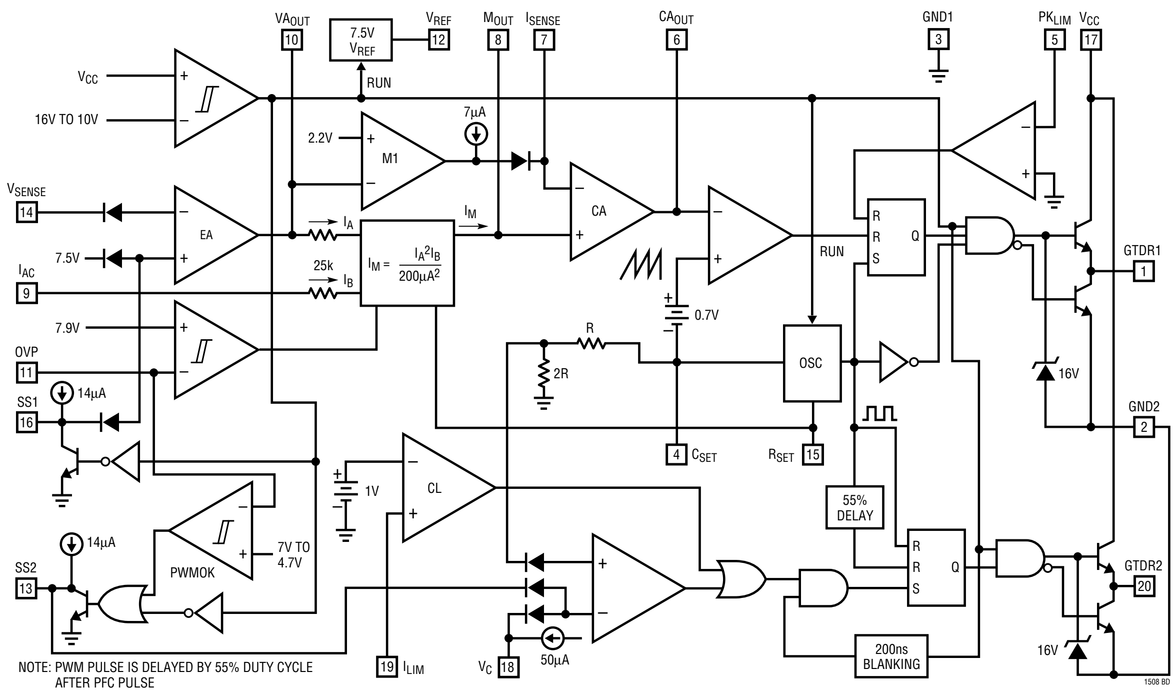

Figure 1. LT1508 Power Factor and PWM Controller (Voltage Mode)