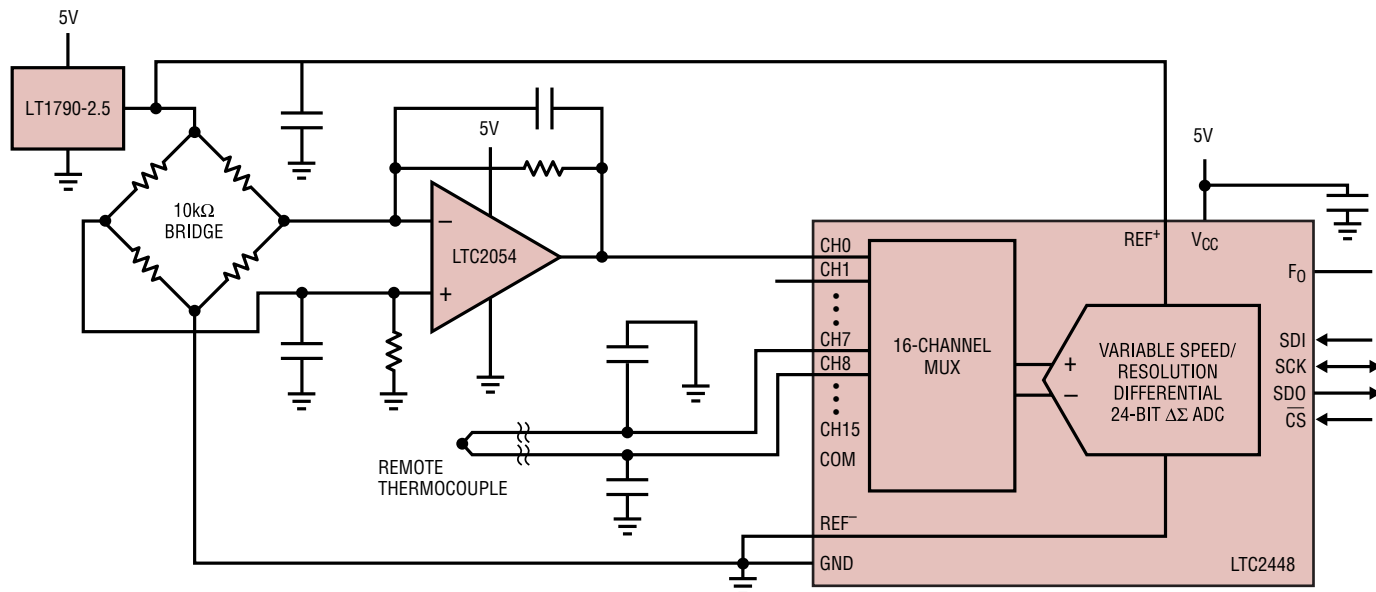


Linear Technology Chronicle

High Performance Analog Solutions from Linear Technology

Vol. 13 No. 5

Industrial Process Control



Inside This Issue:

- *Lowest Power Zero-Drift Amplifiers*
- *Digitally Programmable Zero-Drift Amplifiers*
- *Low Noise Precision Amplifiers*
- *Low Power Precision Amplifiers*
- *Programmable Gain Amplifiers*
- *8kHz, 24-Bit Delta-Sigma ADCs*
- *16-Bit Multichannel Delta-Sigma ADC*
- *SoftSpan Data Converters*
- *Multichannel 16- and 12-Bit SAR ADCs*
- *16-Bit DAC in QFN Package*



The long product life cycles of industrial equipment make quality and reliability key requirements of integrated circuits designed into industrial systems. The long cycle times also ensure availability of new innovative products when a board is redesigned. With each revision or board addition, smaller, lower power, higher accuracy ICs become available.

Factory automation, remote monitoring, redundant systems and self-learning processes are becoming more prevalent. Incorporating these technological advances requires the use of faster, smaller, more intelligent, low power front-end signal conditioning ICs and data converters. Many new products have been released since the first industrial process control LT Chronicle. These new ICs reinforce Linear Technology's commitment to the industrial market. They improve

measurement accuracy, reduce power and board space and add features that expand the capabilities of your system while reducing component count. Product families highlighted include PGAs, precision signal conditioning amplifiers, high-speed delta-sigma data converters, multichannel high-resolution ADCs, SoftSpan™ data converters and small footprint high resolution DACs. Here at Linear Technology, innovative new products are a way of life. Look inside for more details.

LT, LTC and LT are registered trademarks of Linear Technology Corporation. No Latency Delta-Sigma, SoftSpan and ThinSOT are trademarks of Linear Technology Corporation. All other trademarks are the property of their respective owners.

Zero-Drift Amplifiers

Lowest Power Zero-Drift Amplifiers

Lowering transducer power dissipation has multiple benefits. These include extending the life of battery-powered systems, reducing the amount of power that must be transmitted in remotely powered systems, simplifying the overall power supply design and minimizing thermal issues in systems where hundreds or thousands of environmental parameters are measured.

In many systems, precision cannot be sacrificed. The new LTC[®]2054/LTC2055 single and dual precision rail-to-rail zero-drift amplifiers are ideal for these low power front-end signal conditioning applications. With excellent DC performance and a miniscule 150 μ A supply current per amplifier over -40°C to 85°C , these devices are the lowest power, zero-drift amplifiers available. They operate from dual $\pm 5\text{V}$ supplies or a single 2.7V supply and are available in small ThinSOT[™] (single) and DFN-8 (dual) packages. Other features include:

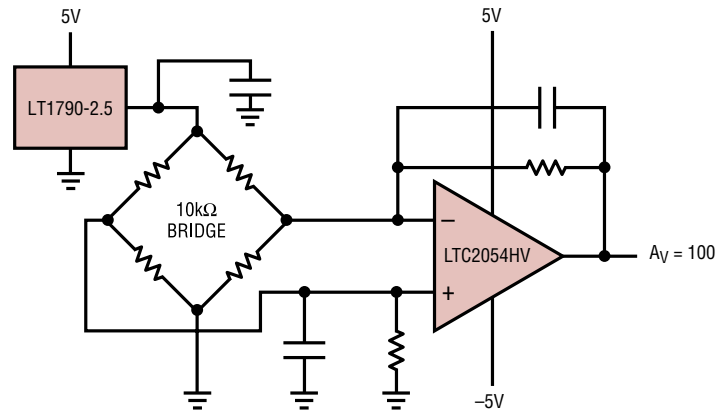
- 30nV/ $^{\circ}\text{C}$ offset drift (max)
- 3 μV offset voltage (max)
- 150pA bias current (max)

Digitally Programmable Zero-Drift Instrumentation Amplifier

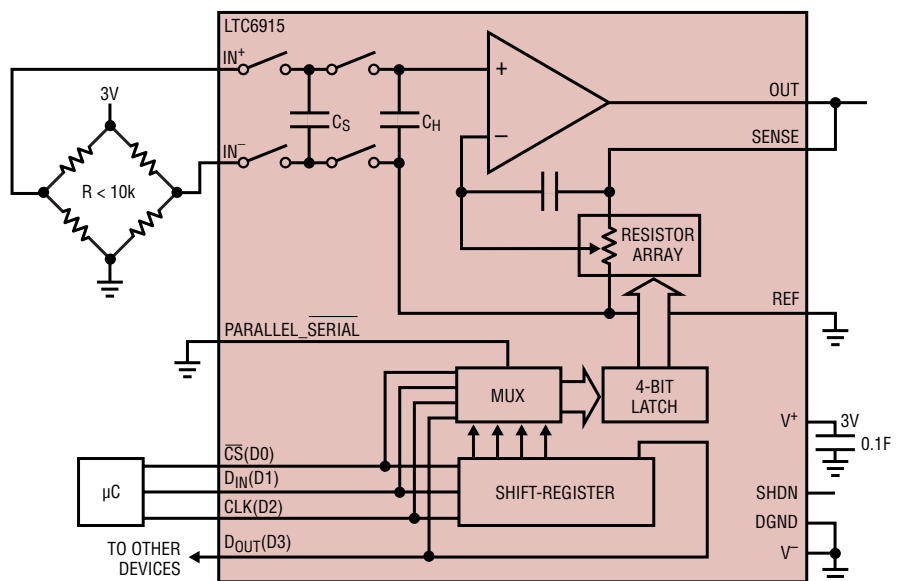
The LTC6915 combines an instrumentation amplifier with programmable gain circuitry resulting in a precision digitally programmable-gain instrumentation amplifier. The device allows both serial and parallel (4-bit wide) programming and has a binary gain range (0, 1, 2, 4 . . . to 4096). The digital control facilitates automatic gain control and auto-ranging applications. Features of the device include:

- 10 μV maximum offset voltage
- Excellent common mode rejection over the entire gain range (105dB min)
- 2.7V to $\pm 5\text{V}$ Supplies
- Rail-to-rail inputs and outputs

Simple Differential Bridge Amplifier



Differential Bridge Amplifier with Gain Programmed through the Serial Interface



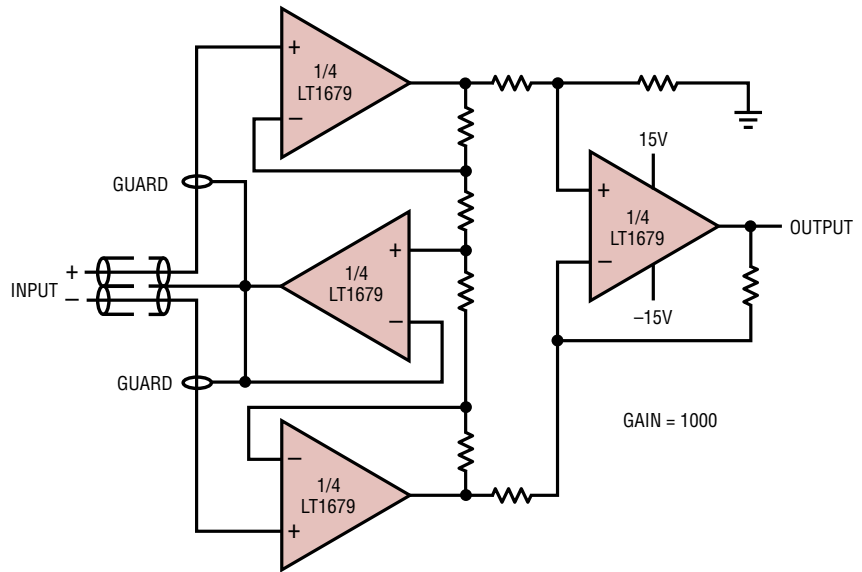
Precision Amplifiers

Low Noise Precision Amplifiers

When lowest voltage noise is a key system requirement, the LT[®]1678 (dual) and LT1679 (quad) amplifiers are excellent choices. With only 3.9nV/√Hz and a 20MHz gain bandwidth, their performance is well-suited for building discrete filters, integrators and amplifying both DC and AC signals. The devices operate from 2.5V to ±18V so they also can be used to generate ±10V signals preceding an ADC or following a current or voltage output DAC. Key features include:

- Rail-to-rail input and output
- 100μV input offset voltage
- Low 3.9nV/√Hz noise at 1kHz
- SO-8 package (dual) and SO-14 package (quad)

Instrumentation Amplifier with Shield Driver



Micropower Precision Amplifiers

With excellent DC specifications, a wide 2.7V to 40V operating range, rail-to-rail outputs and very low supply current, the LT6010/LT6011/LT6012 single, dual and quad amplifiers are well-suited for front-end sensor signal conditioning in power-sensitive applications. Supply current is a miserly 150μA per amplifier and the gain bandwidth is 330kHz, ideal for DC and low frequency

signals in portable applications. For higher frequency requirements, the decompensated LT6013 (single) and LT6014 (dual) extend the gain bandwidth out to 1.4MHz. Key Features:

- Excellent DC precision
 - V_{OS} : 35μV max
 - TC of V_{OS} : 0.8μV/°C max
 - I_{BIAS} : 110pA max

- Low supply current: ≤150μA
- Wide supply range: 2.7V to 40V
- Rail-to-rail output
- Ultra-compact 3mm x 3mm x 0.8mm DFN package available

LT6010 Family of Precision, Low Power Amplifiers

| Part Number | Amplifiers per pkg. | V_{OS} Max | I_{BIAS} (max) | V_S (min) | V_S (max) | I_S (max) | A_{VCL} (min) | GBW | Packages |
|-------------|---------------------|--------------|------------------|-------------|-------------|-------------|-----------------|--------|----------------|
| LT6010 | 1 | 35μV | 110pA | 2.7V | 40V | 150μA | 1 | 330kHz | SO-8, DFN |
| LT6011 | 2 | 60μV | 300pA | 2.7V | 40V | 150μA | 1 | 330kHz | SO-8, DFN |
| LT6012 | 4 | 60μV | 300pA | 2.7V | 40V | 150μA | 1 | 330kHz | SO-14, SSOP-16 |
| LT6013 | 1 | 35μV | 250pA | 2.7V | 40V | 165μA | 5 | 1.4MHz | SO-8, DFN |
| LT6014 | 2 | 60μV | 400pA | 2.7V | 40V | 165μA | 5 | 1.4MHz | SO-8, DFN |

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

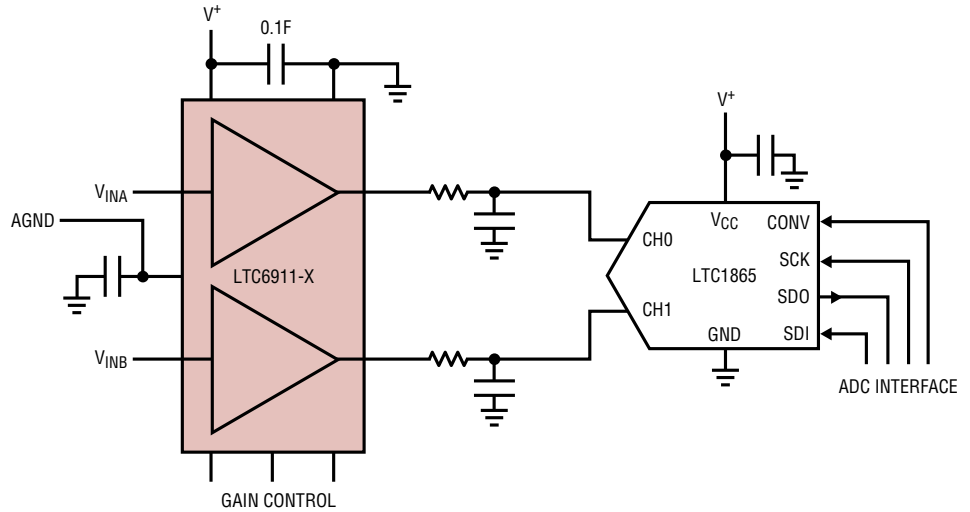
Programmable Gain Amplifiers

Linear Technology continues to expand its family of programmable gain amplifiers. These devices provide a quick and easy way to match a signal to the input range of an analog-to-digital converter, maximizing the converter's dynamic range and providing the best signal-to-noise performance. With -90dB total harmonic distortion at 10kHz and -80dB at 100kHz , the devices work well with 12-bit to 16-bit systems.

The LTC6911 is a dual PGA with 3-bit digital control allowing quasi-exponential or binary gain steps. Available in a small MSOP-10 package, it provides a cost-effective convenient way to provide gain without having to use a matched precision resistor network and discrete switches. Features include:

- **2.7V to 10.5V operation**
- **11MHz gain bandwidth product**
- **Rail-to-rail inputs and outputs**
- **0.1dB channel-to-channel gain matching**

Expanding a Dual Channel ADC's Dynamic Range



LTC's Growing Family of Programmable Gain Amplifiers

| Part Number | Amplifiers/Package | Gain Settings | Package | Gain Select Method | Notes |
|-------------|--------------------|-----------------------------|-----------------|--------------------|---|
| LTC6910-1 | 1 | 0, 1, 2, 5, 10, 20, 50, 100 | ThinSOT | 3-Bit Port | Single inverting amp |
| LTC6910-2 | 1 | 0, 1, 2, 4, 8, 16, 32, 64 | ThinSOT | 3-Bit Port | |
| LTC6910-3 | 1 | 0, 1, 2, 3, 4, 5, 6, 7 | ThinSOT | 3-Bit Port | |
| LTC6911-1 | 2 | 0, 1, 2, 5, 10, 20, 50, 100 | MSOP-10 | 3-Bit Port | Dual, matched inverting amp |
| LTC6911-2 | 2 | 0, 1, 2, 4, 8, 16, 32, 64 | MSOP-10 | 3-Bit Port | |
| LTC6912-1 | 2 | 0, 1, 2, 5, 10, 20, 50, 100 | DFN-12, SSOP-16 | SPI | Independent control of amplifier gain settings. Hardware shutdown pin |
| LTC6912-2 | 2 | 0, 1, 2, 4, 8, 16, 32, 64 | DFN-12, SSOP-16 | SPI | |



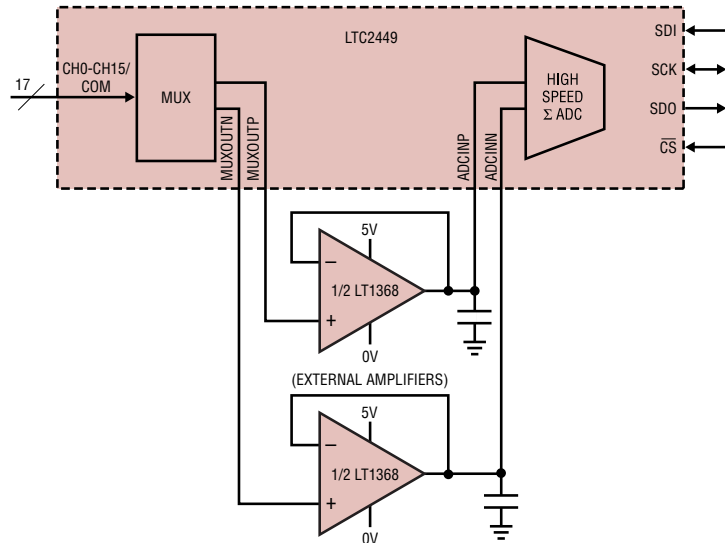
Multichannel 8kHz 24-Bit Delta-Sigma Data Converters

With 24-bit resolution, the LTC2444/LTC2445/LTC2448/LTC2449 family of converters target high-resolution temperature, pressure and bridge sensing. With an 8kHz maximum output data rate (4kHz with zero latency), they trade off resolution and low noise performance for increased speed. Ease of use is a differentiating feature compared with other devices in the market. Cycle-by-cycle offset calibration is transparent to the user so that data measurements do not need to be halted to calibrate the device. This technique practically eliminates offset drift errors.

With low-level input signals (i.e. 10mV full scale), the device can provide over 16 bits (65536 counts) of resolution without requiring amplification or gain calibration circuitry. The eight differential inputs can be configured as single-ended, differential or any combination of differential and single-ended. The LTC2445/LTC2449 have a unique feature that allows signal conditioning to be placed between the multiplexer and the ADC. This configuration allows the offset and offset drift of the signal conditioning amplifier as well as the ADC to be eliminated. Features include:

- **Single 5V Supply**
- **Up to 8kHz output data rate**
- **Very low 200nV RMS noise at 6.9Hz data rate**
- **38-pin, 5mm x 7mm QFN package**
- **Simultaneous 50Hz/60Hz rejection at 14Hz output rate**

LTC2445/LTC2449 Calibrate Out Signal Conditioning Offset and Drift Errors



High-Speed Delta-Sigma Converter Family

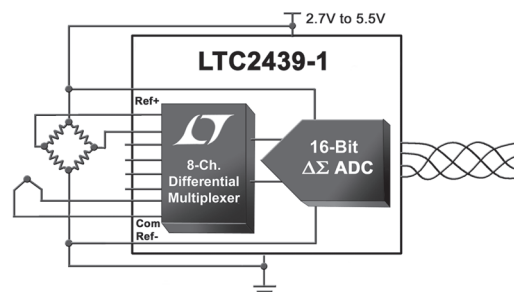
| | LTC2440 | LTC2444 | LTC2445 | LTC2448 | LTC2449 |
|---|---------|------------------|------------------|------------------|------------------|
| Channels Differential/ Single-Ended | 1/1 | 4/8 | 4/8 | 8/16 | 8/16 |
| MUXOUT/ADCIN Pins for Signal Conditioning Calibration | NO | NO | YES | NO | YES |
| Package | SSOP-16 | 5mm x 7mm QFN | 5mm x 7mm QFN | 5mm x 7mm QFN | 5mm x 7mm QFN |

Multichannel Low-Power 16-Bit No Latency Delta-Sigma™ ADC

For low power 16-bit performance, the new LTC2439-1 provides 8 differential (or 16 single-ended) channels in a 28-pin SSOP package. It operates from a single 2.7V to 5.5V single supply and dissipates only 600µW of power ($V_{DD}=3V$). The LTC2418 provides a 24-bit upgrade path for this device. Features include:

- **Sample rates to 100Hz**
- **Simultaneous 50Hz/60Hz rejection**
- **4µA auto-sleep mode**

16-Bit, 8-Channel, $\Delta\Sigma$ ADC



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

SoftSpan ADCs

With multisensor monitoring, configuration flexibility is important as new sensors and sensor modules with different full scale ranges are added to existing systems. The ability to allow a range of inputs to be accurately converted with minimal signal conditioning circuitry saves components, time and cost. The LTC1859 is an 8-channel, 100ksps 16-bit ADC with software programmable input ranges (5V, 10V, $\pm 5V$ and $\pm 10V$) that simplifies data conversion in multisensor systems. Using software, each channel can be configured with the correct input voltage range. The channels can be

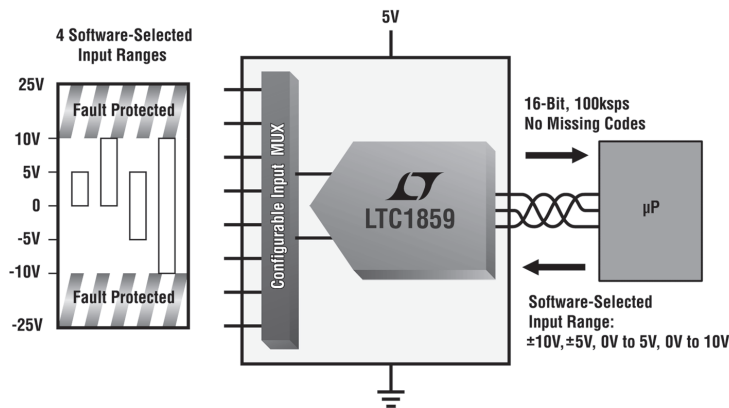
configured for single-ended or differential and the 100ksps allows many channels to be converted quickly at 16-bit resolution, allowing plenty of time for data processing in control loop operations.

The LTC1859 also has $\pm 25V$ fault protection. A MUX_{OUT}/ADC_{IN} pin pair allows signal conditioning to be placed between the multiplexer output and the ADC (instead of replicating the same signal conditioning on each channel) for additional savings.

Features include:

- **16-bit 100ksps successive approximation register ADC**
- **SoftSpan operation – four software programmable ranges**
- **Single 5V operation**
- **3-wire serial interface**

LTC1859 Features Software-Selectable Inputs and $\pm 25V$ Fault Protection

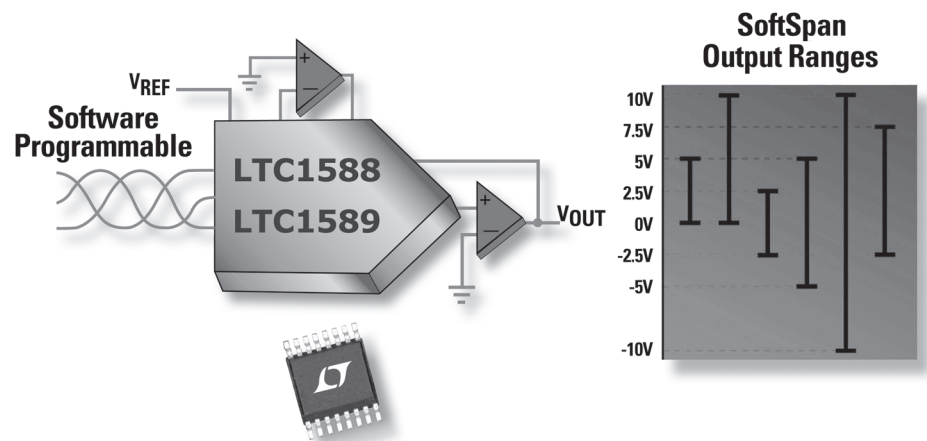


SoftSpan DACs

The LTC1589/LTC1588 are current-output 14-bit/12-bit DACs with six software programmable output ranges. The devices feature $\pm 1LSB$ DNL and $\pm 1LSB$ INL error, low total unadjusted error and on-chip precision resistors for 4-quadrant multiplication. They eliminate the need for precision matched low temperature-coefficient external resistors and gain-ranging circuitry by incorporating these features on-chip. Features include:

- **6 output ranges include 5V, $\pm 5V$, 10V and $\pm 10V$**
- **Single 5V power supply**
- **Internal matched resistors for 4-quadrant multiplication**
- **Resets to 0V at power-up**

12-Bit and 14-Bit SoftSpan DACs



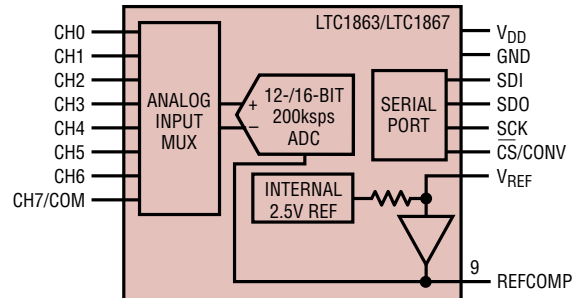
True Differential Input Multichannel 16-Bit 200ksps ADCs

The LTC1867 is a 16-bit successive approximation ADC with several unique features. True differential input sampling means that you don't have to hold the negative analog input at 0V or a "common" voltage because the device samples both the positive and negative inputs. The device also accepts unipolar (4V) and offset bipolar ($\pm 2V$) signals which simplifies interfacing to transducers.

Multiple channels allow several sensor input signals to be digitized and the 200ksps sample rate provides the conversion results quickly. The input channels can be configured as differential, single-ended or any combination to simplify interfacing to sensor signal conditioning. The device is available in a small 16-pin SSOP package providing 8 channels in a package size of many single-channel devices. Other features include:

- **Single 5V operation**
- **Guaranteed 2 LSB INL error**
- **No missing codes**
- **Unipolar and bipolar input range**
- **Internal 2.5V reference**
- **12-bit pin- and software-compatible downgrade (LTC1863)**

LTC1863/LTC1867 16-Bit 200ksps ADC Block Diagram



Single Supply 16-Bit Successive Approximation Register ADCs

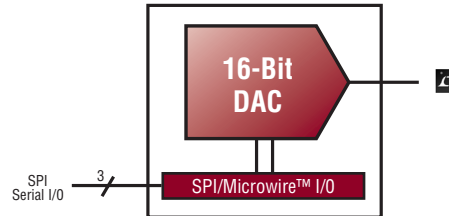
| Part Number | Speed (ksps) | Channels | Input Range (V) | Supply (V) | Interface |
|-------------|--------------|----------|---|------------|-----------|
| LTC1864 | 250 | 1 | 5 | 5 | Serial |
| LTC1865 | 250 | 2 | 5 | 5 | Serial |
| LTC1606 | 200 | 1 | ± 10 | 5 | Parallel |
| LTC1867 | 200 | 8 | ± 2 , or 4 | 5 | Serial |
| LTC1609 | 200 | 1 | ± 10 , 10, ± 5 , 5, 4, ± 3.3 | 5 | Serial |
| LTC1864L | 150 | 1 | 3 | 3 | Serial |
| LTC1865L | 150 | 2 | 3 | 3 | Serial |
| LTC1605 | 100 | 1 | ± 10 | 5 | Parallel |
| LTC1605-1 | 100 | 1 | 4 | 5 | Parallel |
| LTC1605-2 | 100 | 1 | ± 4 | 5 | Parallel |

Smallest 16-Bit DAC for Control Loop Applications

Available in a small 3mm x 3mm DFN package, the LTC2601 16-bit DAC provides monotonic steps for control loop applications. The device runs from a 2.5V to 5.5V single supply, requires only 330µA of supply current and settles in 10µs. A 50MHz 3-wire serial interface allows fast updates. The device complements Linear Technology's existing family of duals, quads and octals. Also available are 14-bit and 12-bit versions.

- **2.5V to 5.5V single supply operation**
- **Guaranteed monotonic over temperature**
- **Single, dual, quad and octal versions available**
- **Relaxed INL for closed loop control**
- **Rail-to-rail voltage output DACS**

16-Bit LTC2601 Fits in 3mm x 3mm DFN



16-Bit Single Supply Monolithic DACs*

| Part Number | DACs per Package | Supply Current per DAC | Package | Notes |
|-------------|------------------|------------------------|---------|---------------------------------------|
| LTC2601 | 1 | 300µA | DFN-10 | Smallest package 3mm x 3mm |
| LTC2602 | 2 | 300µA | MSOP-8 | Dual DAC in small 3mm x 5mm footprint |
| LTC2604 | 4 | 250µA | SSOP-16 | Separate REF input for each DAC |
| LTC2600 | 8 | 250µA | SSOP-16 | Ultralow 10µV crosstalk |

*Pin-compatible 14-bit, 12-bit and 10-bit versions also available.

U.S. Sales Offices

NORTHWEST REGION
(408) 428-2050 (San Jose)
(503) 520-9930 (Portland)

SOUTHWEST REGION
(949) 453-4650 (Orange Co.)
(818) 703-0835 (Los Angeles)

CENTRAL REGION
(847) 925-0860 (Chicago)
(440) 239-0817 (Cleveland)

NORTHEAST REGION
(978) 656-4750 (Boston)
(215) 638-9667 (Philadelphia)

SOUTHEAST REGION
(972) 733-3071 (Dallas)
(919) 677-0066 (Raleigh)

North American Distributors

ARROW (800) 777-2776
DIGI-KEY (800) 344-4539
LINEAR EXPRESS (866) 546-3271
NU HORIZONS (888) 747-6846

© 2004 Linear Technology Corporation/0904DP/Printed in USA

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