Linear Technology Chronicle

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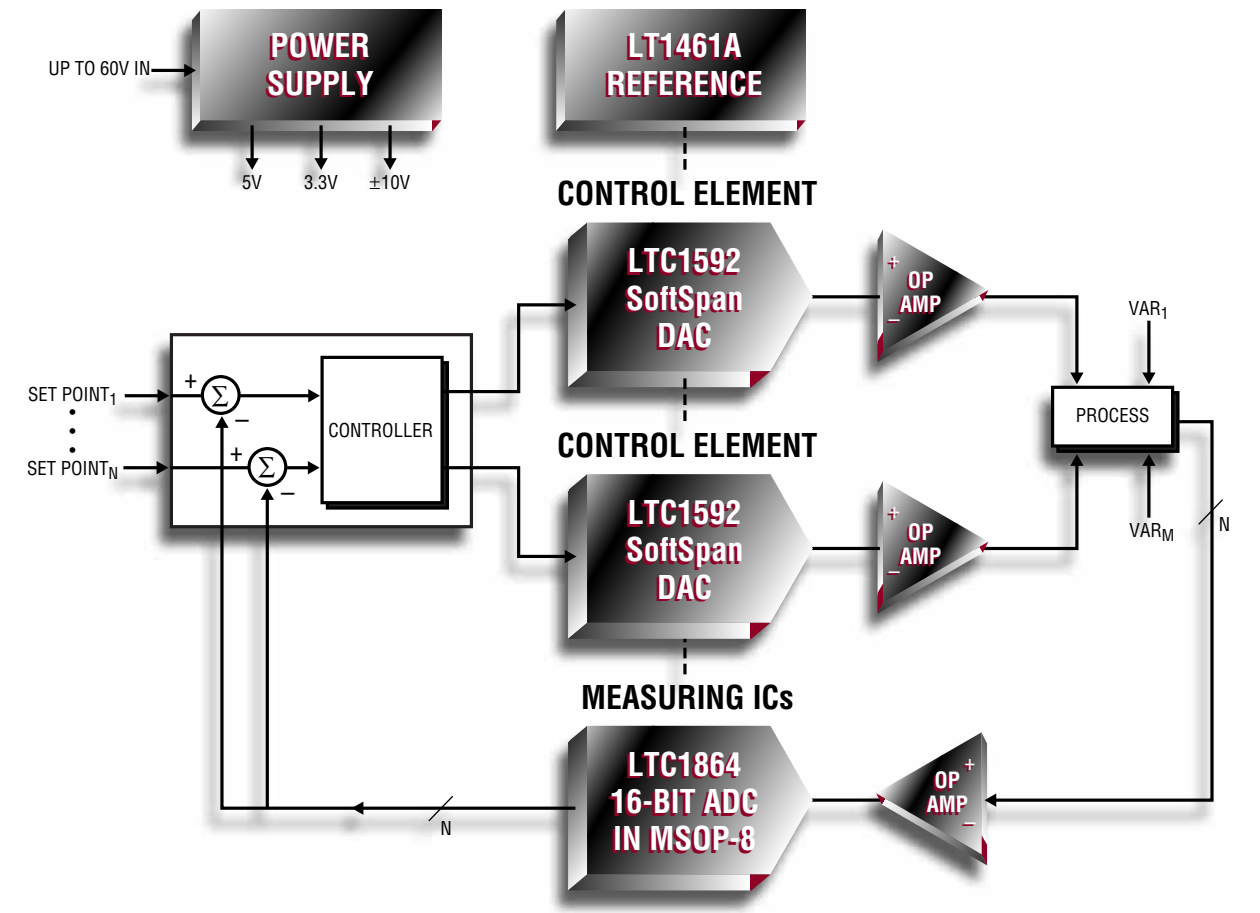
Industrial Process Control



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Process control encompasses a wide range of industrial applications, from factory floor automation, batch control for food and raw materials processing, chemical plants, semiconductor wafer fabrication, textile manufacturing, die cast operations, pharmaceuticals and oil refining to name a few. The basic components for intelligent control loops, transducers and other measuring elements, control elements (motors, valves, actuators, etc.) and digital intelligence (i.e., microprocessors) are used to accurately monitor and regulate "processes." From simplistic single-input systems to extremely large control loops with complex control algorithms, the key to proper control is obtaining accurate information in the form of user inputs, preset inputs, feedback information and variable inputs (such as changing load conditions) and taking appropriate action based on that information within a given timeframe.

Linear Technology excels in ICs specifically targeted for the process control market, including op amps, data converters, power supplies and interface ICs, with features specifically tailored to provide excellent performance in an industrial environment. To find out more, look inside for our latest product offerings.

Instrumentation Amplifiers

Bridge sensors, ADC front-ends, thermistor temperature measurements, I-to-V conversion and error amplifiers are just a few of the process control circuits using instrumentation amplifiers.

Requirements include:

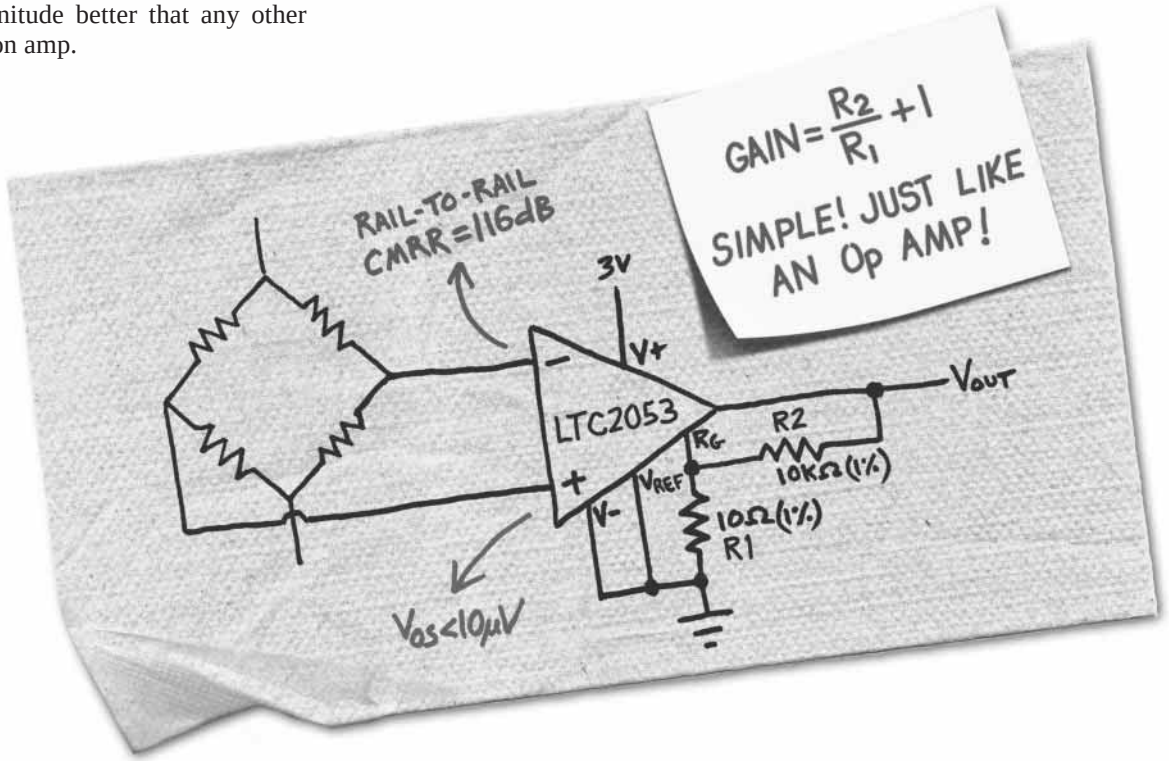
- **Low offset to reduce the effort and circuitry required for calibration**
- **Low drift to minimize errors due to temperature changes**
- **Low current and/or voltage noise which allows low level signals to be amplified**
- **High common mode rejection (CMR) which allows the presence of large DC inputs (typical in bridge applications) without degrading the amplifier's performance**
- **High CMR to attenuate line frequencies (50Hz/60Hz) in isolated thermocouple applications**

These parameters have been incorporated into a tiny package, yielding the highest precision MSOP-8 instrumentation amp available—the LTC®2053. The combination of 10µV offset voltage, 50nV/°C offset drift and the high CMRR of 105dB makes it an order of magnitude better that any other instrumentation amp.

New Instrumentation Amplifiers

Parameter	LTC2053	LT®1789-1	LT1168A	LT1167A
Input Offset Voltage (Max)	10µV	100µV	40µV	40µV
Input Offset Drift (Max)	0.05µV/°C*	0.5µV/°C	0.3µV/°C	0.3µV/°C
Bias Current (Max)	10nA*	40nA	0.25nA	0.35nA
CMRR, G = 100 (Min)	105dB**	100dB	120dB	120dB
Noise (0.1Hz to 10Hz)	$2.5\mu V_{P-P}$	$1\mu V_{P-P}$	$0.28\mu V_{P-P}$	$0.28\mu V_{P-P}$
Gain Range	1 to 10k	1 to 1k	1 to 10k	1 to 10k
Gain Error (Max)	0.01%*	0.2%	0.02%	0.02%
Gain Nonlinearity (Max)	10ppm	75ppm	6ppm	6ppm
Bandwidth	400Hz	60kHz	400kHz	1000kHz
Slew Rate	0.2V/µs	0.02V/µs	0.5V/µs	1.2V/µs
Voltage Supply Range	2.7V to 11V*	2.2V to 36V	±2.3V to ±18V	±2.3V to ±18V
Supply Current (Max)	1.1mA*	0.095mA	0.53mA	1.3mA
Package	MSOP-8	SO-8	SO-8, PDIP-8	SO-8, PDIP-8

*Guaranteed over –40°C to 85°C. **Input referred for any gain and guaranteed over –40°C to 85°C.
Detailed information on other instrumentation amplifiers including the LTC1100, LT1101, LT1102 and LTC1043 is available on our website at **www.linear.com**.



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Transducer Amplifiers

Strain Gauges

The low impedance (350Ω typical) and low level differential output of the strain gauge demand:

- **High common mode rejection**
- **Low offset voltage drift over temperature and time**
- **Low voltage noise**
- **Excitation from either a precision current or voltage source**
- **Higher bandwidth when used for vibration measurements**

Low Impedance Strain Gauge Amplifiers

Part Number	Offset Voltage at 25°C (μV)	Offset Drift Max (μV/°C)	CMRR Min (dB)	Voltage Noise (nV/√Hz)	Gain Bandwidth Min (MHz)	Supply Voltage (V)
LT1001	25	0.6	114	9.6	0.8	8 to 44
LT1007	25	0.6	117	4.5	5	8 to 44
LT1677	60	1.5	105	5.2	4.5	2.7 to 40
LTC2050	3	0.03	115	$1.5\mu V_{P-P}$	3 (typ)	2.7 to ±5.5

Bridge Transducers

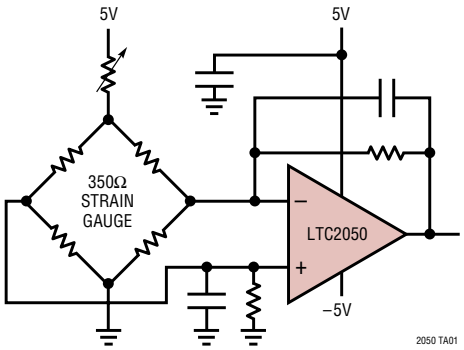
Bridge transducers with higher impedances (1kΩ and above) such as piezoresistive pressure sensors, piezoresistive accelerometers or high impedance capacitive sensors require amplifiers with:

- **A combination of low voltage noise and low current noise**
- **Low bias current**
- **True high impedance inputs, such as those provided by an instrumentation amplifier**

Amplifiers for Higher Impedance Strain Gauge Sensors

Part Number	Offset Voltage 25°C (μV)	I_{BIAS} at 25°C (pA)	Voltage Noise (nV/√Hz)	Gain Bandwidth Min (MHz)	Supply Voltage (V)
LT1792	600	800	4.2	4	9 to 40
LT1880	150	900	13	0.8	2.7 to 40
LTC1050	5	30	$1.6\mu V_{P-P}$	2.5 (typ)	5 to ±8
LTC2050	3	75	$1.5\mu V_{P-P}$	3 (typ)	2.7 to ±5.5

Differential Bridge Amplifier



Thermocouples

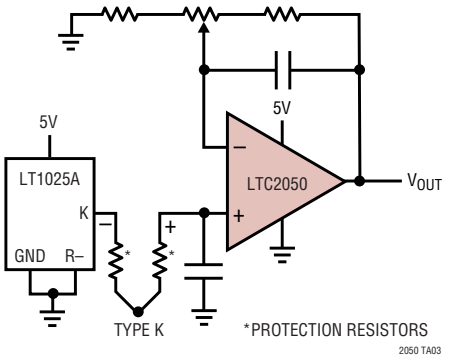
Thermocouples offer a small, inexpensive way to measure temperature over a very wide range. The low signal level (5μV/°C to 50μV/°C) and low impedance of the thermocouple demands:

- **Low offset voltage drift with temperature and time**
- **Low voltage noise**
- **High common mode rejection**
- **Cold junction compensation (such as that provided by the LT1025A)**

Thermocouple Amplifiers

Part Number	Offset (μV)	TC Offset (μV/°C)	V_{SUPPLY} (V)	Rail-to-Rail	Package	Notes
LT1001	25	0.6	±5/±15	—	N8/SO-8	Precision and low noise
LT1050	5	0.05	5/±8	—	N8/SO-8	
LTC2050	0.5	0.03	3/5/±5	Out	SOT-23	Lowest offset, zero drift
LTC2053	5	0.05	3/5/±5	In/Out	MSOP-8	Resistor-programmable gain

Single Supply Thermocouple Amplifier



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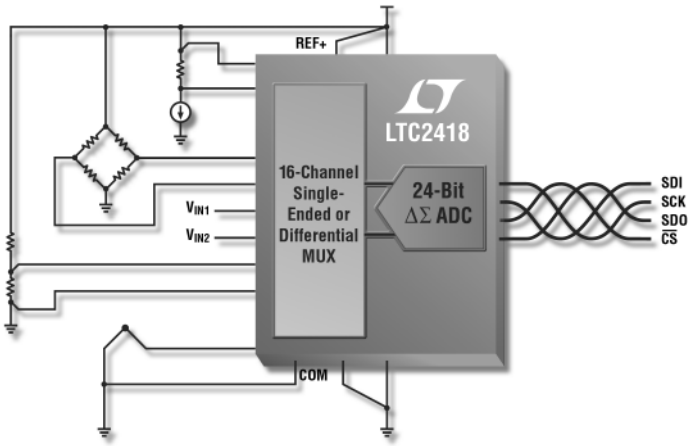
Process Control ADCs

Multiplexed Delta-Sigma ADCs

System Requirements: a high resolution ADC to digitize multiple low level DC input signals in harsh environments

Look for ADCs that offer:

- **High resolution up to 24 bits**
- **No latency—no waiting required when changing input channels or with large steps at the ADC input**
- **The ability to directly digitize low level signals to eliminate errors caused by front end circuitry**
- **Differential analog inputs and reference inputs to reject common mode signals**
- **Low power—can be powered from a 4 to 20mA loop**



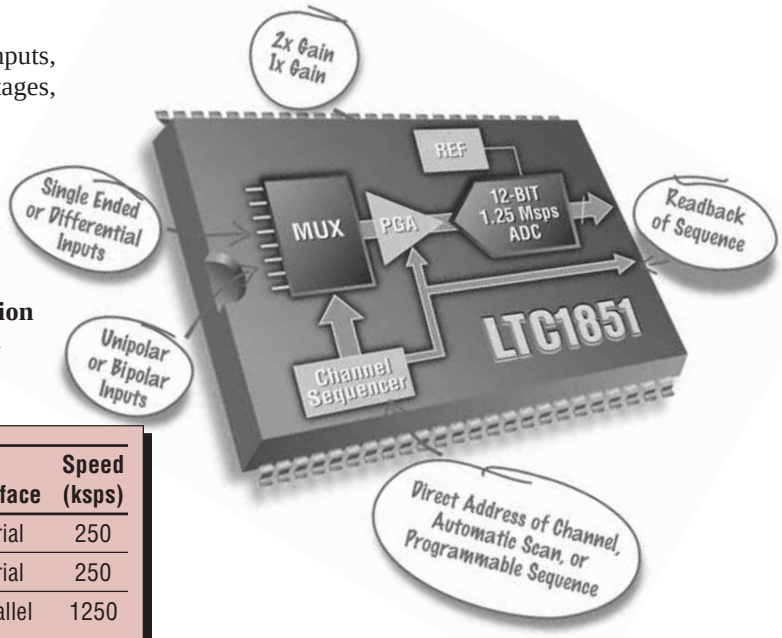
Part Number	Resolution (Bits)	Channels	Analog Input	Package
LTC2402	24	2	Single-ended	MSOP-10
LTC2404/LTC2408	24	4/8	Single-ended	SSOP-28
LTC2414/LTC2418	24	8/16 4/8	Single-ended Differential	SSOP-28
LTC2424/LTC2428	20	4/8	Single-ended	SSOP-28
LTC2422	20	2	Single-ended	MSOP-10

Multiplexed SAR ADCs

System Requirements: fast conversion times, DC or AC inputs, multiple channels, system monitoring of temperatures, voltages, currents, etc.

Fast conversions times result in:

- **Improved control loop response time**
- **More time available for microcontroller/DSP data manipulation**
- **Potential reduction in microcontroller/DSP bus allocation**
- **More averaging to improve the measurement accuracy**
- **Reduction of the noise floor with oversampling**



Part Number	Resolution (Bits)	Input Range	Analog Inputs	Package	Interface	Speed (ksps)
LTC1865	16	V_{REF}	2	MSOP-10	Serial	250
LTC1861	12	V_{REF}	2	MSOP-10	Serial	250
LTC1851	12	V_{REF}, $V_{REF}/2$, $\pm V_{REF}$, $\pm V_{REF}/2$	8	TSSOP-48	Parallel	1250
LTC1853	12	V_{REF}, $V_{REF}/2$, $\pm V_{REF}$, $\pm V_{REF}/2$	8	TSSOP-48	Parallel	400
LTC1850	10	V_{REF}, $V_{REF}/2$, $\pm V_{REF}$, $\pm V_{REF}/2$	8	TSSOP-48	Parallel	1250
LTC1852	10	V_{REF}, $V_{REF}/2$, $\pm V_{REF}$, $\pm V_{REF}/2$	8	TSSOP-48	Parallel	400

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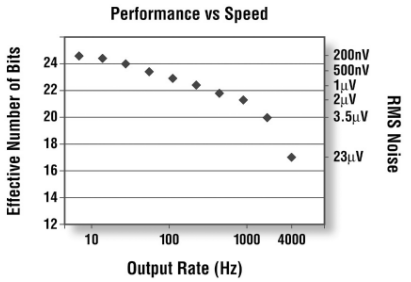
Process Control ADCs

Single-Channel Delta-Sigma ADCs

System Requirements: 20 bits to 24 bits resolution, faster conversion times, small package size

The LTC2440 sets a new performance level for delta-sigma converters with the lowest noise, fast conversion time and no waiting required between conversions.

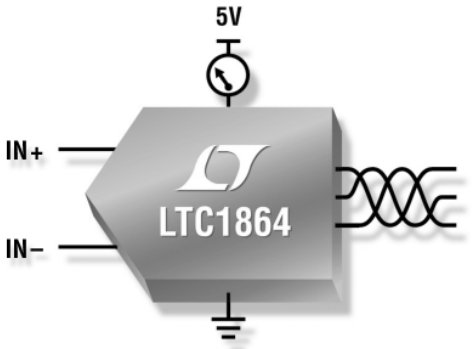
- **Conversion rates up to 4kHz**
- **Optimize for speed or noise performance (see graph)**
- **Lowest noise at 0.2μV_{RMS}—five times better than the nearest competition**
- **No latency—every conversion provides valid data, reducing software overhead**
- **Small size and low cost promotes a single ADC for each analog input**

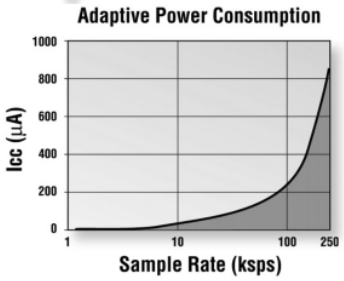


Part Number	Resolution (Bits)	Analog Input and Reference Input	Package	Notes
LTC2440	24	Differential	SSOP-16	4k conversions/sec, lowest noise
LTC2400	24	Single-ended	SO-8	First 24-bit SO-8 ADC
LTC2401	24	Single-ended	MSOP-10	Zero-scale/full-scale pins, smallest size
LTC2410	24	Differential	SSOP-16	Low noise and offset
LTC2411	24	Differential	MSOP-10	Smallest size
LTC2413	24	Differential	SSOP-16	Simultaneous 50Hz/60Hz rejection
LTC2420	20	Single-ended	SO-8	Pin compatible with LTC2400
LTC2421	20	Single-ended	MSOP-10	Pin compatible with LTC2401
LTC2430	20	Differential	SSOP-16	Pin compatible with LTC2410
LTC2431	20	Differential	MSOP-10	Pin compatible with LTC2411

Single-Channel SAR ADCs

System Requirements: resolutions up to 16 bits, higher conversion rates, input voltage ranges (up to ±10V), small package sizes





Part Number	Resolution (Bits)	Input Range (V)	Channels	Supply Current (mA)	Supply Voltage (V)	Package	Interface	Speed (ksps)
LTC1864	16	V_{REF}	1 Diff	1.3*	5	MSOP-8	Serial	250
LTC1609	16	±10, 10, ±5, 5, 4	1	20	5	SSOP-28	Serial	200
LTC1605	16	±10	1	16	5	SSOP-28	Parallel	100
LTC1860	12	V_{REF}	1 Diff	1.3*	5	MSOP-8	Serial	250

*Adaptive Power™ consumption—the supply current drops to microamps at lower sampling rates (see graph).

Part Number	Initial Accuracy (%)	Drift (ppm/°C)	Output Voltage (V)
LT1461A	0.04	3	2.5
LT1460	0.075	10	2.5
LT1236A-5	0.05	5	5
LT1019A	0.05	5	2.5/5
LT1790	0.05	10	2.5

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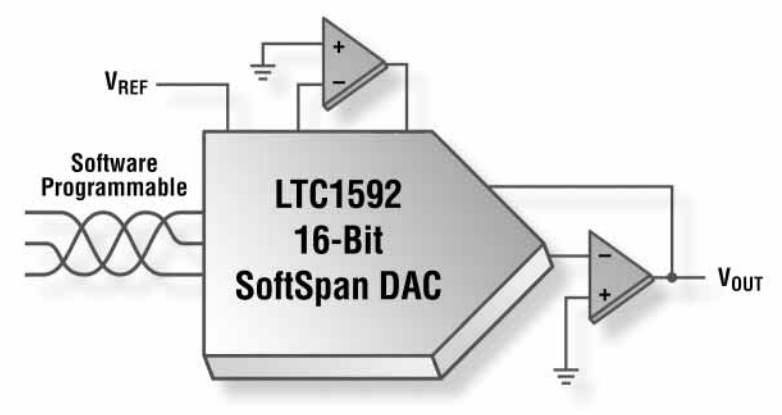
High Resolution DACs

Precision DACs

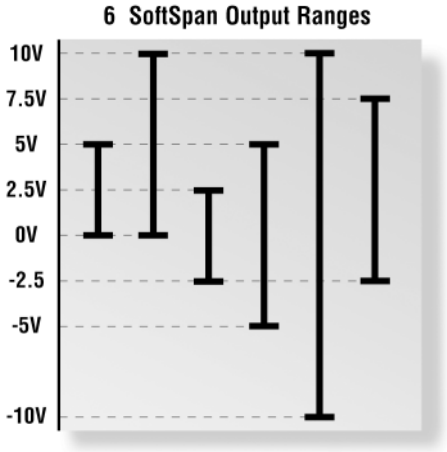
For precise control and accurate analog output signals, high resolution, high accuracy DACs are required. Flexibility in the DAC's output span optimizes signal compatibility with other devices.

With SoftSpan™ control, the DAC output range is user-programmed to one of six possible ranges by simply writing the appropriate command to the DAC. The serial interface also allows for simultaneous updating of DACs in a multi-DAC environment.



Key features:

- **Six user-programmable unipolar or bipolar output ranges**
- **Very low glitch impulse energy (< 2nV • s)**
- **4-quadrant multiplication allows DAC to be used as a digital attenuator**



Part Number	Resolution (Bits)	DNL (LSB)	INL (LSB)	Output Type	Output Voltage Range (V)	Interface	Package	Notes
LTC1592	16	±1	±1	Current	5, 10, ±10, ±5, ±2.5, 7.5/–2.5	Serial	SSOP-16	SoftSpan
LTC1821	16	±1	±1	Voltage	±10, 10, –10	Parallel	SSOP-36	2µs settling
LTC1597	16	±1	±1	Current	N/A	Parallel	SSOP-28	4-Quadrant resistors
LTC1591	14	±1	±1	Current	N/A	Parallel	SSOP-28	4-Quadrant resistors

Monotonic Servo-Loop Control and Offset/Gain Adjustment DACs

When high resolution is required but absolute accuracy is not needed, look for DACs with relaxed integral nonlinearity error. LTC's devices provide the control you need in the smallest footprint.

Part Number	Resolution (Bits)	DACs (#)	DNL (LSB)	INL (LSB)	Output Type	Output Voltage Range (V)	Interface	Package
LTC1655	16	1	±1	±20	Voltage	V_{REF}	Serial	SO-8
LTC1658	14	1	±1	±8	Voltage	V_{REF}	Serial	MSOP-8
LTC1659	12	1	±0.5	±5.5	Voltage	V_{REF}	Serial	MSOP-8
LTC1451	12	1	±0.5	±4	Voltage	V_{REF}	Serial	SO-8
LTC1458	12	4	±0.5	±4.5	Voltage	V_{REF}, $2V_{REF}$	Serial	SSOP-28
LTC1663	10	1	±0.75	±2.5	Voltage	V_{CC}	2-Wire	SOT-23
LTC1661	10	2	±0.75	±2	Voltage	V_{REF}	Serial	MSOP-8
LTC1660	10	8	±0.75	±2.5	Voltage	V_{REF}	Serial	SSOP-16

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Power for Industrial Process Controls

High voltages and harsh environments mean that your power supplies need to be rugged. High temperatures and input transients can kill your system supply. LTC's line of monolithic switching regulators and switching regulator controllers are designed to handle these tough conditions.

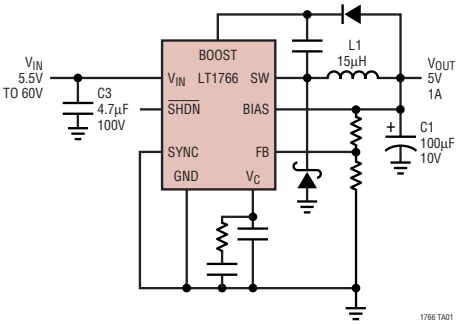
Monolithic Switching Regulators

- **Up to 60V input range**
- **High switching frequency for small solution size**
- **Thermally enhanced surface mount packages**
- **Full industrial temperature range (–40°C to 85°C)**
- **V_{OUT} down to 1.2V**
- **Peak switch currents up to 5A**

Part Number	V_{IN} Max (V)	V_{OUT} Min (V)	Output Current (A)	Switching Frequency	Supply Current (mA)	Package
LT3430	60	1.2	2.75	200kHz	2.5	TSSOP-16/E*
LT1956	60	1.2	1.20	500kHz	2.5	TSSOP-16/E*
LT1766	60	1.2	1.20	200kHz	2.5	TSSOP-16/E*
LT1676	60	1.2	0.44	100kHz	3.2	SO-8
LT1776	40	1.2	0.56	200kHz	3.2	PDIP-8/SO-8
LT1374/ LT1374HV	25/32	2.4	3.60	500kHz	2.5	SO-8/DD-7/T5/ TSSOP-16/E*
LT1765	25	1.2	2.40	1.25MHz	1	SO-8/TSSOP-16/E*
LT1767	25	1.2	1.20	1.25MHz	1	SO-8

*Thermally enhanced package

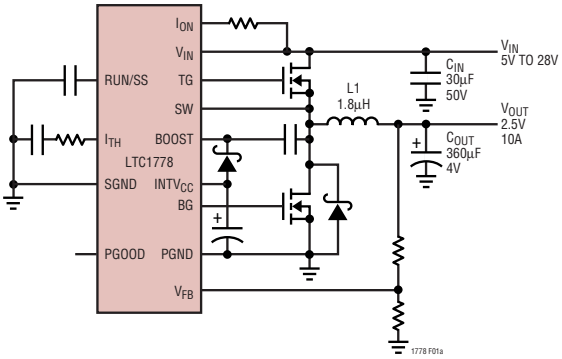
60V Input Step-Down Switching Regulator



Switching Regulator Controllers

- **Up to 36V input range**
- **Synchronous control for highest efficiency to lower heat in enclosed field mounted or rack mounted systems**
- **PolyPhase® operation minimizes input and output ripple**
- **High current applications > 20A**
- **Multiple outputs**
- **Full industrial temperature operation**

10A Output Step-Down DC/DC Controller



Part Number	V_{IN} Max (V)	V_{OUT} Min (V)	Output Current (A)	Switching Frequency	Supply Current (mA)	Comments
LTC1735	36	0.8	20	200kHz to 600kHz	TSSOP-16/SSOP-16	Single phase controller
LTC1775	36	1.19	20	150kHz	SSOP-16	No R_{SENSE}™ controller
LTC1778	36	0.8	20	Adjustable	SSOP-16	No R_{SENSE}, maintains high efficiency with large V_{IN}/V_{OUT} differentials
LTC3778	36	0.6	20	Adjustable	SSOP-20	Optional R_{SENSE}, maintains high efficiency with large V_{IN}/V_{OUT} differentials
LTC1628	36	0.8	20	150kHz to 300kHz	SSOP-28/QFN-32	2-phase, dual output
LTC3727	36	0.8	25	150kHz to 300kHz	SSOP-28	2-phase dual, high V_{OUT}
LTC3728	36	0.8	25	250kHz to 550kHz	QFN-28/SSOP-28	2-phase dual, high switching frequency
LTC1629	36	0.8	240	150kHz to 300kHz	SSOP-28	Up to 12 phases for high output current
LTC3729	36	0.8	240	250kHz to 550kHz	SSOP-28	Up to 12 phases for high output current

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Robust Serial Communications

Isolated RS422/RS485

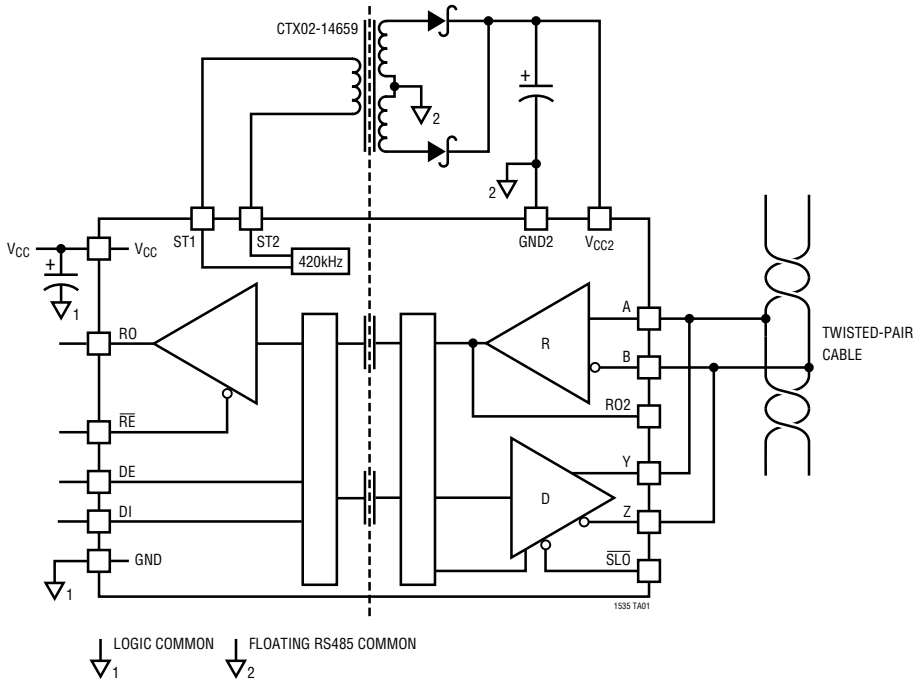
Robust, reliable communication is essential in industrial process control, especially when presented with harsh environments that include large inductive spikes, large common mode voltages and multiple ground loops. The LTC1535 full-duplex isolated differential line transceiver breaks ground loops, reduces component count, and simplifies the design and implementation of the RS422/RS485 protocol.

- **UL Recognized**
- **2500V_{RMS} capacitive isolation between transceivers and logic interface eliminates ground loops**
- **Slew rate controlled operation**
- **Half- or full-duplex communication**
- **Fail-safe receiver input detects open or short circuits**

±60V Fault Protected RS485

- **Protects against overvoltage line faults to ±60V with the receiver active, shut down or off**
- **ESD protected to ±15kV (air discharge)**
- **Thermal shutdown protection**
- **Industry standard 8-pin and 14-pin packages**

LTC1535 Complete Isolated RS422/RS485 Transceiver Uses an Off-the-Shelf Transformer and Two Diodes



LTC's Family of RS422/RS485 Transceivers

Part Number	Package	±60V Fault Protection	Guaranteed Min Data Rate Bits/Sec	Fail-Safe Receiver Inputs	Notes
LTC1535	SO-28	—	250k	X	Half- or full-duplexed, 2500V isolation
LT1785	PDIP-8/SO-8	X	250k	—	Half-duplex
LT1785A	PDIP-8/SO-8	X	250k	X	Half-duplex
LT1791	PDIP-14/SO-14	X	250k	—	Full-duplex
LT1791A	PDIP-14/SO-14	X	250k	X	Full-duplex

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