MAXIM

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MAXIM REPORTS RECORD REVENUES AND EARNINGS FOR ITS FOURTH QUARTER AND ITS FISCAL YEAR

Maxim Integrated Products, Inc. (MXIM) reported record net revenues of $155.2 million for the fourth quarter of fiscal 1998 ending June 27, 1998, compared to $117.0 million for the same quarter in fiscal 1997. Net income increased to a record $49.2 million in Q498, compared to $36.9 million for the fourth quarter of fiscal 1997. Income per share was $0.33 for Q498, compared to $0.25 for the same period a year ago.

For the fiscal year ending June 27, 1998, Maxim reported net revenues of $560.2 million, a 29% increase over the $433.7 million reported for fiscal 1997. Net income increased to a record $178.1 million in FY98, compared to $137.0 million in FY97. Income per share increased 26% to a record $1.18 in FY98 from $0.94 in the prior fiscal year.

During the quarter, the Company increased cash and short-term investments by $38.7 million after paying $41.6 million for its common stock and $20 million for capital equipment. For the year, the Company increased cash and short-term investments by $99.0 million after paying $123.1 million for 3.7 million shares of its common stock and $105 million for capital equipment. Return on average stockholders' equity was 32.5% for FY98, one of the highest in the industry today.

Fourth quarter ending backlog shippable within the next 12 months was $181 million. Seventy-five percent of the ending Q498 backlog consists of orders that were requested for shipment in Q199 or earlier.

During the fourth quarter, the Company experienced a 5% decline in end-market bookings from the Q398 levels as a result of softer demand in the U.S. distribution, Europe, and Pacific Rim sales channels (end market bookings are the actual customer bookings received by both Maxim and the Company's distributors during the quarter).

Net bookings on the Company in Q498 were also lower than in Q398. Maxim's backlog shippable in the next 12 months was adversely impacted by a $14.8 million reduction in net bookings on the Company in Q498 by U.S. distributors. This decrease is due largely to the elimination by the Company of a U.S. distributor during the quarter and the reallocation of that distributor's inventory to the Company's other distributors.

Turns orders received in Q498 were $35 million, a small increase over the Q398 levels. (Turns orders are customer orders that are for delivery within the same quarter and may result in revenue within the same quarter if the Company has available inventory that matches those orders.)

End market bookings for the last two quarters have been relatively flat. The Company's ability to grow revenues and earnings levels in Q199 will be dependent upon a resumption of bookings growth in Q199.

Gross margins for the fourth quarter increased slightly to 67.5%, compared to 67.4% in Q398. Research and development expense increased by $2.3 million in Q498 to 13.5% of net revenues. During Q498, the Company also recorded charges of $1.5 million related to reducing the carrying value of certain pieces of equipment. In addition, the Company increased its reserves for inventory by $5.4 million, further increasing cost of sales in Q498.

Jack Gifford, Chairman, President and Chief Executive Officer, commented on the year: "Fiscal 1998 was an excellent year for Maxim. We grew net revenues and income per share by more than 25%, we introduced 250 new products, and we successfully increased manufacturing productivity and capacity in both the wafer fabrication and end of line test areas with minimal increases in future depreciation expense. We repurchased $123 million of our stock and increased our cash by $99 million."

New ICs revolutionize the sensor interface

Maxim Integrated Products has introduced several ICs that are revolutionizing the interface to low-level bridge sensors in modern industrial systems. All of these ICs provide sophisticated sensor compensation and temperature correction. The high-end device (MAX1457) linearizes a sensor output by establishing 120 piecewise-linear segments, drawing on data stored in EEPROM. The resulting linearized output is accurate to within 0.1% of the sensor's repeatable error.

Though originally developed for use in piezoresistive pressure-sensor applications, these flexible signal-conditioning ICs are equally suited for use with accelerometers, strain gauges, and other low-level bridge-type sensors. They can be used in an industrial sensor, in a 4–20mA or 0 to 5V transmitter, or in a complete instrument. Self-calibration enables these ICs to derive high accuracy from less than ideal sensors—without the need for complex front-end analog circuitry or (in the case of the MAX1457) firmware-based linearizers or multi-order polynomials. Because the IC design is based on analog cells, the devices are easily customized for use with other sensor types (capacitive, inductive, etc.).

All of these ICs provide a signal path that includes flexible sensor-excitation circuitry, a programmable-gain amplifier (PGA), and an analog output. The basic device (MAX1450) includes only those functions. The midrange part (MAX1458) calibrates the gain, offset, and temperature drift of these parameters by adding four 12-bit digital-to-analog converters (DACs); one coarse 3-bit DAC; and a nonvolatile, internal EEPROM for storing the DACs' calibration data. The high-end device (MAX1457) contains six 16-bit DACs and one 12-bit analog-to-digital converter (ADC), and operates with a larger, external EEPROM.

Product descriptions

MAX14xx ICs offer different levels of integration and accuracy. The MAX1458, for example, is a high-integration, mixed-signal, compensating front-end device that includes EEPROM calibration memory, analog signal path, four 12-bit DACs for controlling offset and gain, and one coarse-offset 3-bit DAC **(Figure 1)**. Its analog output can be scaled from 0.5V to 4.5V for transducer applications or can feed directly to a system ADC for instrument applications.

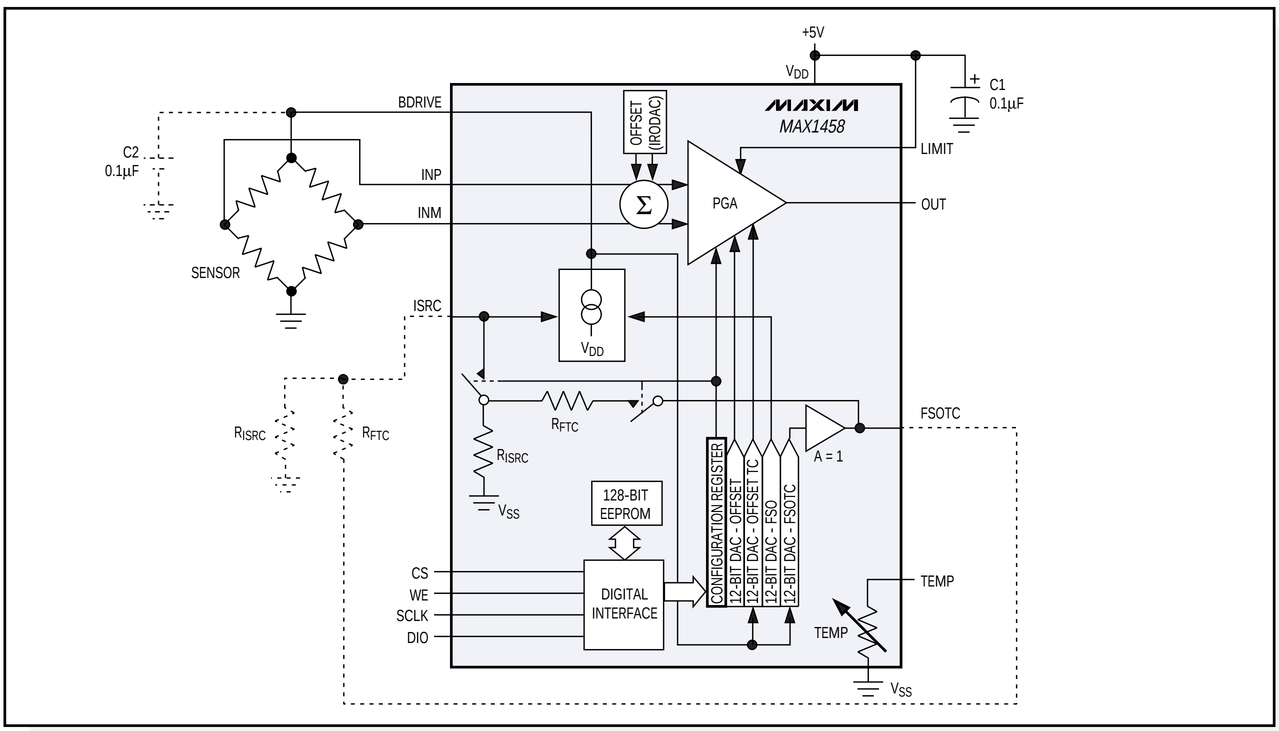


Figure 1. The MAX1458 sensor-interface IC in its ratiometric configuration.

Driven by the temperature and linearity errors of a piezoresistive transducer (PRT), the MAX1458 provides an accuracy of approximately 1%. Its high level of integration provides hands-off calibration without potentiometers. Because it makes corrections in the analog domain, the MAX1458 can also simplify the architecture of analog-output sensors and transmitters. Unlike systems that digitize the raw sensor output, make corrections in microprocessor firmware, and produce the analog output with a DAC, the MAX1458 achieves low cost, low noise, and simple operation with a signal path that is fully analog.

By adjusting the sensor's bridge-excitation current, two 12-bit DACs within the MAX1458 implement fine control of the sensor's gain and temperature coefficient (tempco) of gain. The internal, fully differential PGA/IA (instrumentation amplifier) front end has 90dB of common-mode rejection and digitally controllable gain in the +45V/V to +220V/V range. To achieve control of the sensor offset and the temperature compensation of offset, the signal following the PGA is summed with the outputs of two more 12-bit DACs. An on-board 128-bit EEPROM contains the input data for each DAC, plus a configuration register and 24 bits of "user area" for general use. The IC also includes a high-tempco resistor that is useful as a temperature sensor when compensating certain types of transducers.

The MAX1457 **(Figure 2)** is a high-accuracy, mixed-signal, *linearized* front-end device. Unlike the MAX1458, it includes a 12-bit ADC that digitizes the raw sensor temperature and develops addresses for an external linearization EEPROM. A 120-segment curve stored in this EEPROM applies the offset and gain corrections that linearize and temperature-correct the MAX1457 output.

Though it lacks an internal EEPROM, the MAX1457 directly addresses standard MICROWIRE™ EEPROMs such as the 93C66 from National Semiconductor Corp. Its analog signal path includes an uncommitted op amp, five 16-bit gain- and offset-controlling DACs, and a 12-bit ADC. In general, the MAX1457 sacrifices low cost and small size in favor of higher absolute accuracy

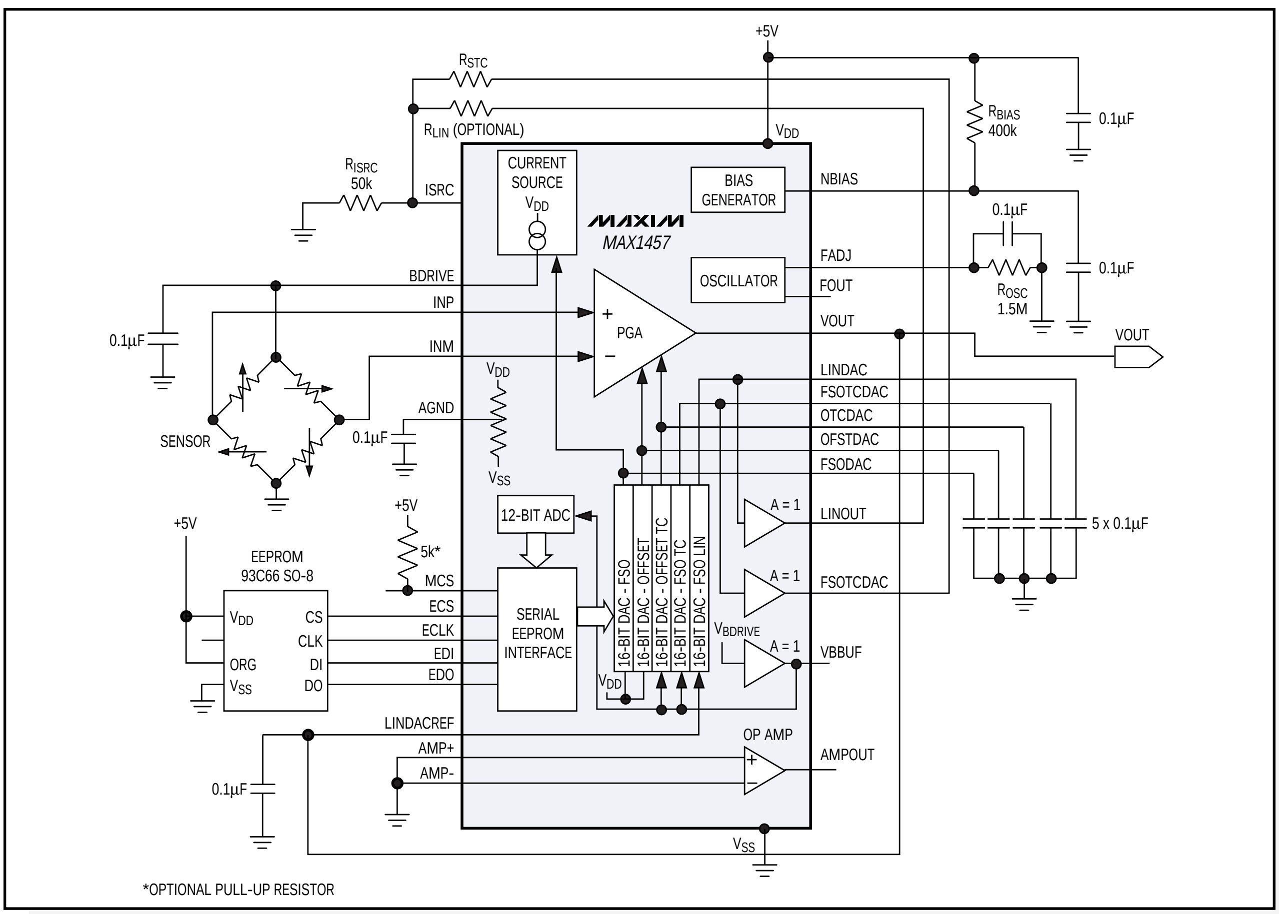


Figure 2. The MAX1457 sensor-linearizer IC in its ratiometric configuration.

MICROWIRE is a trademark of National Semiconductor Corp.

and better linearity. Though larger than the MAX1458, the MAX1457 employs analog-domain corrections that provide an architecture simpler than that of most analog output sensors. The analog output can be scaled to produce a 4–20mA signal, or it can feed directly to a system ADC. With PRT pressure sensors, the MAX1457 can achieve a typical corrected accuracy of 0.1%.

Figure 3 illustrates the MAX1457's ability to compensate for temperature and linearity errors. Graph **3a** shows the low-level output of an uncompensated piezoresistive sensor with its huge temperature errors of offset and gain **(3b)**. Graphs **3c** and **3d** show the signal after conditioning. The MAX1457 scales the sensor output in the 0.5V to 4.5V range **(3c)**, and limits gain and offset errors to 0.1% over a wide temperature range **(3d)**.

The MAX1450 is a stripped-down version of the MAX1457/MAX1458, containing only the analog front end of those devices without their DACs, ADCs, or EEPROMs. It offers a controllable sensor-excitation source and a PGA with very flexible calibration and offset features. As a flexible PGA and current source, it offers capabilities not found in standard IAs and PGAs: orthogonal and easily managed inputs for the correction of gain, offset, and other parameters. The coarse PGA gain is controlled digitally, and the offset and excitation current source (gain) are controlled by externally applied analog signals.

Background

Traditional transducers calibrate and compensate the sensor in the analog domain using "analog memory" components such as potentiometers, capacitors, and laser-trimmed thin-film resistors. Such transducers sometimes employ thermistors, diodes, or other analog techniques for temperature compensation. Though unwieldy, diode breakpoints are sometimes used to enhance linearity. All these approaches have major disadvantages:

- Compensation accuracy is restricted by nonlinear sensor errors
- Compensation devices are afflicted by temperature drift
- Laser trimmers and other automatic equipment are expensive
- Manual calibration ("pot tweaking") translates to higher cost.

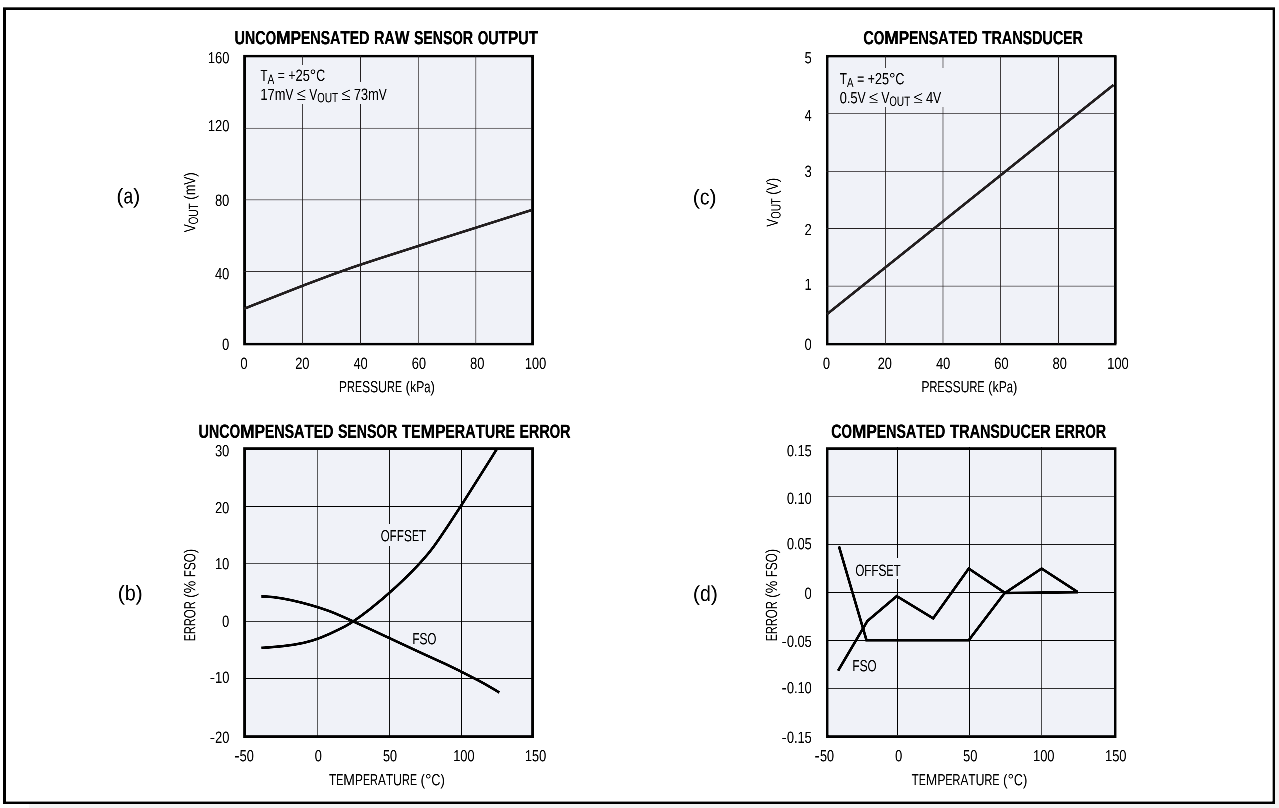


Figure 3. Raw output from a sensor (a) is amplified and conditioned by the MAX1457 (b), and the sensor's temperature errors (c) are compensated by the MAX1457 as well (d).

The emergence of low-cost, digital, programmable electronics has opened the possibility of trimming analog functions in the digital domain, with a capability for storing individual correction coefficients in nonvolatile digital memory (e.g., EEPROMs). For sensors, such electronic trimming has evolved in two directions:

Digital-Sensor Signal Processors (DSSP): DSSP techniques include conversion of sensor signals to the digital domain with an ADC, calibration and compensation in the digital domain using a microcontroller with EEPROM, and the use of a DAC (if required) to convert the compensated result back to an analog signal. The advantage of this approach occurs after digitization by the ADC, when further signal processing occurs in the processor's zero-drift digital domain. Disadvantages include software complexity, memory requirements, and a reduced dynamic range that calls for higher resolution in the ADC. Most of these problems will be solved by the DSSP architecture in the new MAX1460.

Analog-Sensor Signal Processors (ASSP): By adjusting the sensor excitation and digitally adjusting the amplifier offset and gain, ASSP techniques achieve sensor calibration and temperature compensation in the analog domain without quantizing the signal. Through the use of DACs, EEPROMs, and digitally adjustable analog electronics, this hybrid technique offers the best of the all-analog and all-digital approaches—signal processing in the analog domain with the "potless" ease of a digital system.

To linearize the sensor, ASSP systems adjust gain and offset using feedback from the raw sensor output to the DAC reference inputs. This powerful ASSP technique (used in MAX14xx devices) eliminates the unwieldy polynomial curve fitting required in DSSP approaches. The DAC, which multiplies a digital number by an analog voltage (the DAC's reference input), is the key element in an ASSP electronic trimming system.

High-resolution DACs are expensive, however, and a sensor requires several of them for proper ASSP compensation. This problem has been resolved by the development of a new sigma-delta technology for DACs and ADCs (MAX14xx series) that enables low-cost digital trimming. It yields 16-bit converters on very small areas of silicon, which in turn allows complex systems-on-a-chip that include multiple DACs and ADCs.

Test and calibration issues

An important consideration in the design of the sensor signal-conditioner architecture was the need to support advanced manufacturing technologies. To meet that requirement, the IC designers lowered manufacturing costs by integrating (along with signal-conditioning functions) the following three traditional sensor-manufacturing operations into one automated process:

Pretest: This operation tests sensor performance over the compensated temperature and pressure ranges. The ICs' MICROWIRE interface and three-state outputs enable control by a host test computer. These capabilities enable testing of multiple transducers in a parallel connection **(Figure 4),** and allow digital communication between the test system and any specific transducer (selected through a chip-select pin).

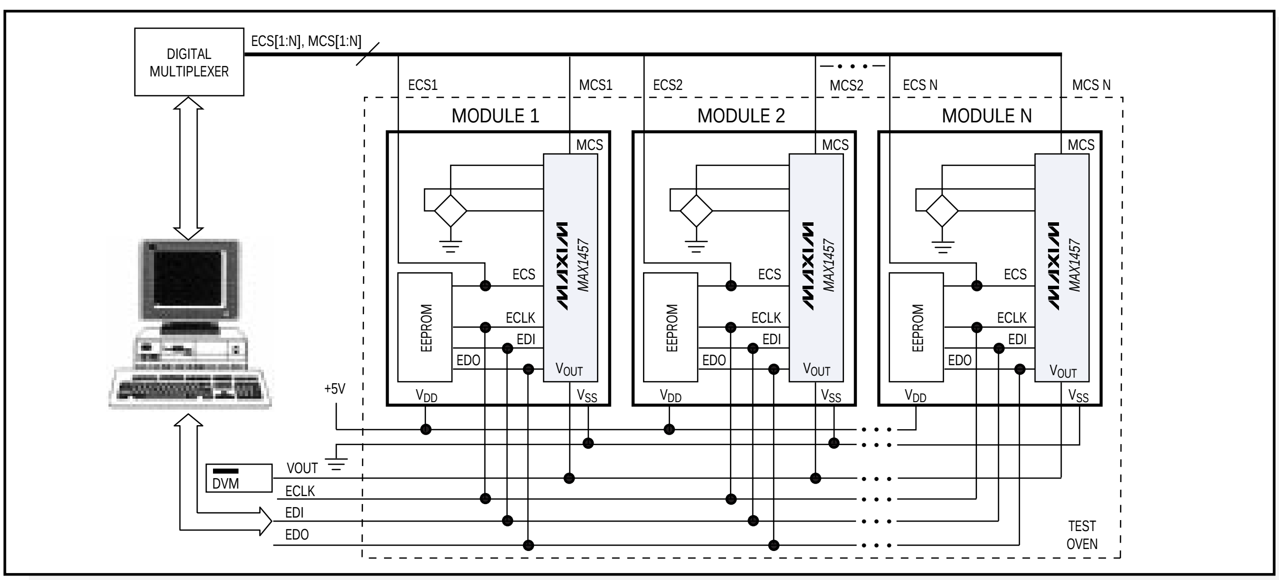


Figure 4. In this automated calibration system, the MICROWIRE interface simplifies the calibration of multiple sensors. The signal-conditioning ICs can be MAX1457s or MAX1458s.

Calibration and Compensation: This operation can be performed immediately after pretest, without removing the transducers from their test sockets. The test computer simply calculates the calibration and compensation coefficients (4kbits) and downloads them through the MICROWIRE interface to the transducer's EEPROM.

Final Test: This operation verifies transducer performance, again without removing the device from its test socket.

MAX1457/MAX1458 compensation scheme

Two compensation methods are implemented by the MAX1457. The first is analog, in which two DACs compensate the 1st-order temperature errors: an offset-TC DAC adjusts the output offset, and an FSO-TC DAC adjusts the bridge-excitation voltage by adjusting its excitation current **(Figure 5)**. The less expensive MAX1458 makes these corrections and no others.

The second method of compensation is digital. An ADC driven by the bridge-excitation voltage (a temperature signal) generates the EEPROM address. The EEPROM output is a multiple-segment approximation (up to 120 segments) that corrects residual higher-order errors. MAX1457-based compensation employs 16-bit DACs to provide all of the functions listed in **Table 1**. The MAX1458 employs four 12-bit DACs and a 3-bit offset DAC to provide only those functions marked with asterisks.

Initial offset is corrected by feeding to the PGA's summing junction a voltage obtained by multiplying (within the offset DAC) a fraction of the supply voltage by a 16-bit word. The full-span output (FSO, or gain) is calibrated in two adjustments: coarse gain is set by feeding a 3-bit digital word to the PGA, and fine gain is set by adjusting the bridge current using another 16-bit word.

Table 1. Digital Compensation DAC Functions

FUNCTION	DAC TYPE
Initial offset calibration*	Offset
Initial FSO calibration*	FSO
Correction of TC slope for analog offset	Offset TC
Correction of TC slope for nonlinear offset	Offset TC
Correction of TC slope for analog FSO*	FSO TC
Correction of TC nonlinearity for nonlinear FSO*	FSO TC
Correction of pressure nonlinearity	FSO linearity

Two DACs connected to the bridge voltage (the offset-TC DAC and FSO TC DAC) compensate linear components of the zero and FSO TC. Bridge voltage is proportional to temperature, and a properly valued digital word (the multiplier coefficient) causes the DAC output to compensate the temperature slope by following the quasilinear change in bridge voltage.

MAX1457 multislope compensation scheme

Digital multislope temperature compensation allows compensation of arbitrary error curves, whose shape is determined only by the shape of the temperature signal and the adjustment range available in the electronics. This compensation is implemented with 120 number pairs (corrections for offset TC and FSO TC) stored in EEPROM look-up tables. The EEPROM address is the output word of a 12-bit ADC driven by the bridge voltage, which (with constant current excitation of the bridge) is temperature dependent. See **Figure 5.**

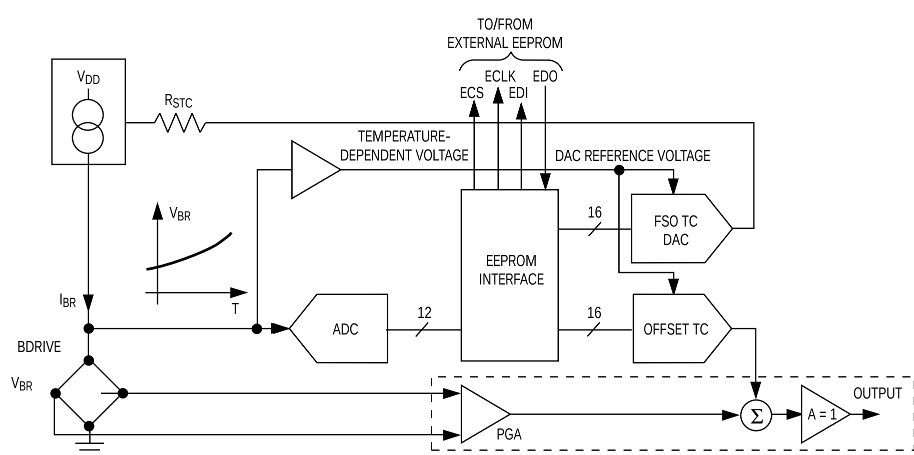


Figure 5. Simplified circuitry within the MAX1457 illustrates the correction of temperature errors. Analog voltage across the sensor bridge generates the DAC reference voltages, which in turn produce the 1st-order analog corrections. The bridge voltage is also digitized to provide fine correction through the EEPROM look-up table.

Pressure nonlinearity is corrected by feedback from the output voltage to the bridge current source. To gain control of this feedback, the output voltage is routed to the reference input of a DAC, whose output connects to the current source and is then subject to the DAC's digital input, driven by a coefficient stored in the EEPROM **(Figure 6)**. Thus, coefficients delivered to the DAC can introduce a nonlinearity in the bridge current that compensates (often by an order of magnitude) for nonlinearity in the sensor output. See the product data sheets for further details on operation.

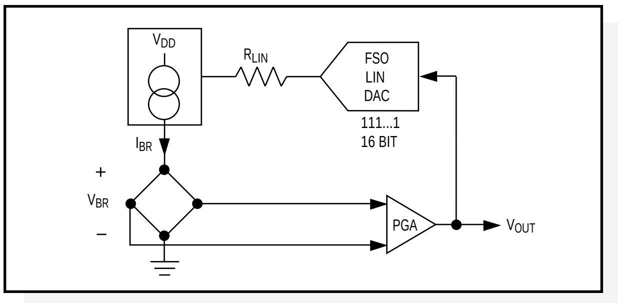


Figure 6. This simplified circuit, also internal to the MAX1457, demonstrates the concept of pressure-nonlinearity correction.

Application example

Although the MAX1457 was designed as an ASIC, primarily for voltage-output configurations, it also includes support for the popular fixed-output, 4–20mA, 2-wire transducers. An on-chip, uncommitted op amp lets you create the 2-wire current loop. As shown in **Figure 7**, this amplifier and an external resistor form a programmable current source. Loop current is set by resistor R_A and controlled by feedback via R_C. A voltage regulator (REF02) accepts the 4–20mA current-loop voltage (typically 20V to 40V), and provides a stable 5V reference for the MAX1457. Thus, the REF02 increases the circuit's operating voltage while providing independence from changes in the supply voltage.

A diode in series with the positive power-supply terminal protects against reverse-polarity connections in the field, and another specialized diode (TransZorb™) connected across the power terminals protects against voltage spikes. The optional resistor RD reduces power dissipation in the output transistor.

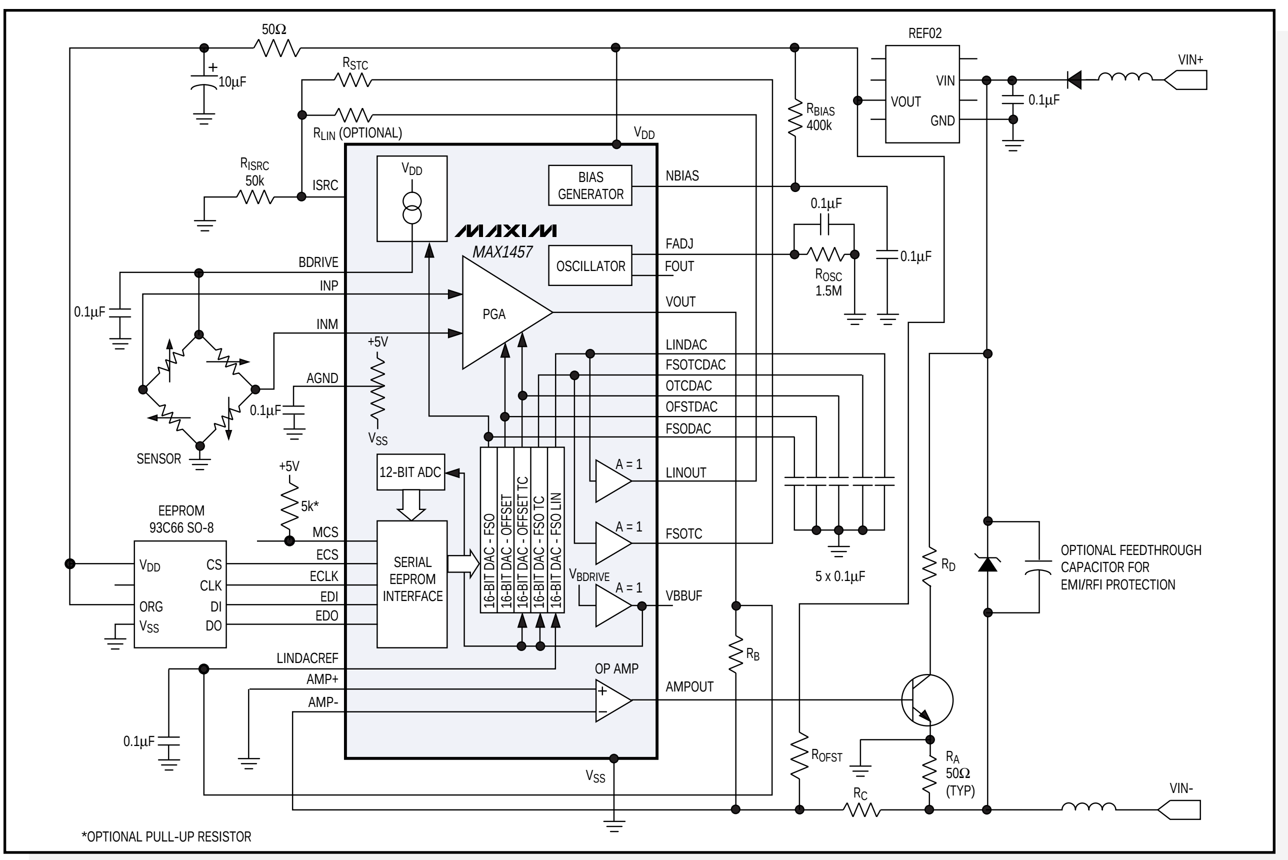


Figure 7. Four milliamps power the transducer in this 4–20mA, 2-wire circuit based on the MAX1457. Pressure is proportional to a 0–16mA current transmitted over the same pair of wires.

TransZorb is a trademark of General Semiconductor Industries, Inc.

DESIGN SHOWCASE

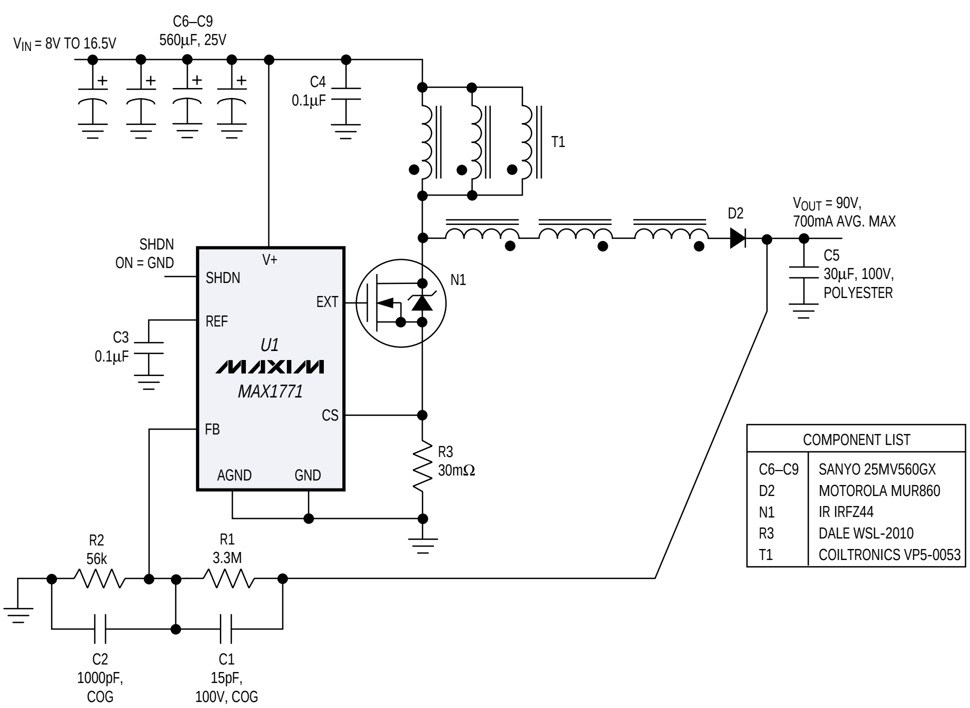
Off-the-shelf transformer limits capacitor inrush current

Energy stored in a high-voltage capacitor activates many applications, including radiological sensors, pulsed lasers, particle-beam generators, and automotive direct fuel-injection systems. In the last case, the fuel injector discharges the capacitor as it sprays fuel directly into the car's combustion chamber. The speed and control required for this application can be achieved using a standard, inexpensive transformer.

The capacitor must be recharged quickly during each engine cycle, but in a controlled way that minimizes noise and voltage transients in the electrical system. Control of the charging waveform also allows a finer tuning of cost/performance trade-offs when selecting circuit components.

An inexpensive, off-the-shelf, 6-winding transformer **(Figure 1)** can be used to limit the capacitor's inrush current without the expense of added feedback and control circuitry, and without the efficiency loss associated with a traditional inrush-current limiter. T1 is configured as an autotransformer in which three windings in parallel form the primary between V_{IN} and the MOSFET drain, and three windings in series form a secondary between V_{IN} and D2. The turns ratio is 1:4.

When feedback to the step-up DC-DC controller (IC1) detects a drop in the capacitor voltage, the controller turns on the MOSFET and allows current in the primary to ramp up and generate magnetic flux in the transformer's core. When this current reaches a 3.3A threshold set by the current-sense resistor (R3), IC1 interrupts the current by turning the MOSFET off.



COMPONENT LIST	
C6–C9	SANYO 25MV560GX
D2	MOTOROLA MUR860
N1	IR IRFZ44
R3	DALE WSL-2010
T1	COILTRONICS VP5-0053

Figure 1. The autotransformer in this boost converter reduces inrush to the discharge capacitor, allows use of a smaller capacitor, and reduces the MOSFET's required voltage rating.

In accordance with Lenz's Law, the transformer opposes the instantaneous change in magnetic flux by generating a voltage surge that forces current through the output diode. The resulting current in the transformer secondary is $I_{SEC} = I_{PRI}/N = 3.3A/4 = 0.83A$. Thus, the transformer causes a 75% reduction in the peak instantaneous current flowing from the output diode to the discharge capacitor. It also reduces the maximum MOSFET-drain voltage by 75%.

The 75% reduction in the instantaneous secondary-winding current limits the inrush of charging current by forcing a proportional reduction in the maximum average output current. The result is a well-controlled charging ramp **(Figure 2)**. By relaxing ESR requirements for the capacitor, it also allows use of a 30µF polyester-film capacitor to save size and cost. The lower maximum voltage at the MOSFET drain allows use of an inexpensive 60V MOSFET with lower $R_{DS(ON)}$, which improves efficiency.

A similar idea appeared in the 6/22/98 issue of Electronic Design.

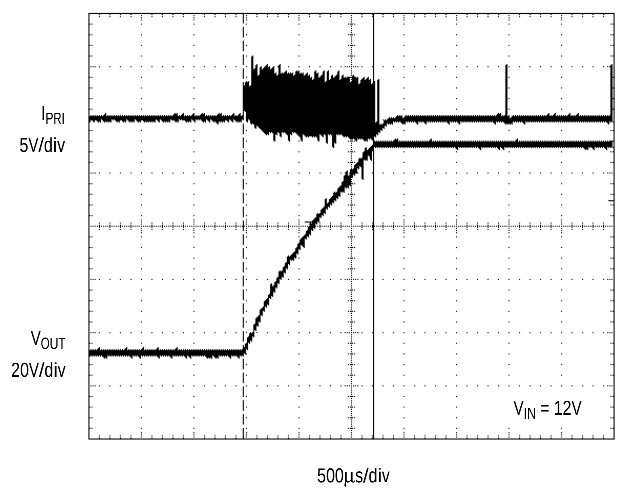


Figure 2. By limiting the peak instantaneous output current to 25% of the instantaneous primary current, the autotransformer in Figure 1 limits the capacitor's inrush current to a well-controlled ramp during charging.

DESIGN SHOWCASE

Crystal oscillator has dual or differential outputs

A quality frequency source (i.e., oscillator) is often required for applications such as the local oscillator (LO) in a wireless handset, the frequency reference in a phase-locked LO, or the master clock source in a microprocessor or data-acquisition system.

For a system designer, the important signal-source parameters are frequency accuracy and frequency stability. Accuracy pertains to the initial value of frequency, and stability pertains to the frequency's phase noise (short-term) and drift (long-term) as affected by temperature and aging. For a crystal-oscillator designer, the key parameters are those of the resonator itself: resonant frequency, reactance, and Q-factor. With the possible exception of phase noise, these parameters are almost entirely a function of the crystal.

Low phase noise depends on the resonator and the active element. The resonator should have high Q (most crystals have an extremely high Q in the 10,000 to 50,000 range). The active element should have low flicker noise and low noise figure, and its loading on the resonator should be minimal. Such attributes describe the active device in a MAX2620 IC: it exhibits the low flicker noise inherent in a high-frequency bipolar process, a low noise figure, and a low parasitic r_b, whose minimal load on the active device maintains the high loaded Q desired in an oscillator circuit. **Figure 1** shows a simple crystal oscillator.

Other MAX2620 features desirable in an active-oscillator element include buffer amplifiers that minimize load-pulling on the oscillator frequency,

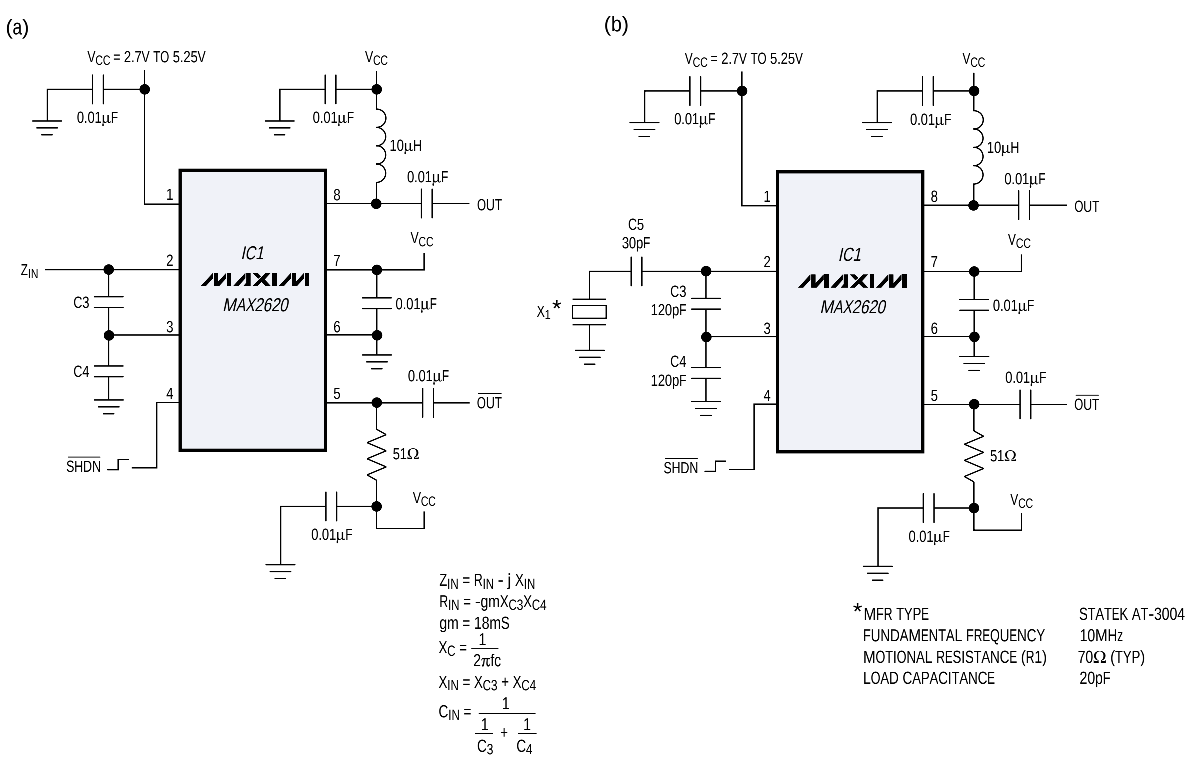


Figure 1. This simple crystal oscillator is based on a single oscillator IC. The crystal resonator, X_1, is shown in (b).

operation over supply voltages in the +2.7V to +5.25V range, supply-insensitive internal biasing, shutdown capability, and two open-collector outputs that can be configured as two single-ended outputs or a single differential output.

The primary criteria for selecting a crystal resonator are nominal frequency, initial frequency accuracy, and frequency stability vs. temperature and aging. In practice, a designer should take note of the crystal resonator's center frequency, Q, motional resistance, and load capacitance. These parameters enable the designer to calculate values for the oscillator circuit's external capacitors.

In **Figure 1b,** the crystal resonator (X_1) is a surface-mount, fundamental-mode device from Statek. The motional-resistance value is needed to calculate values for C3 and C4 in **Figure 1a,** but the worst-case (high) value is preferred to the typical value. In this case, the device manufacturer specifies a maximum motional resistance of 150Ω. For oscillation to start, this value should be less than the magnitude of input negative resistance ($R_{IN} = -g_m X_{C3} X_{C4}$) for the active device; refer to **Figure 1a.** As a matter of good practice, it should be less than half. Therefore,

$$g_m X_{C3} X_{C4} \geq 2R1_{MAX}$$

where

g_m is the active-device transconductance. In this case, it equals 18mS (18 milli-Siemens).

X_{C3} is the reactance of capacitor C3 (1/2πfC3).

X_{C4} is the reactance of capacitor C4 (1/2πfC4).

$R1_{MAX}$ (150Ω) is the crystal resonator's maximum motional resistance.

Rearranging and choosing $X_{C3} = X_{C4}$,

$$X_{C4} \geq \sqrt{2R1_{MAX}/g_m} = 129.1$$

At 10MHz, the value for C3 and C4 (assumed equal) is:

$$C3 = C4 = 1/2\pi f X_{C4} = 123.3\text{pF}$$

Choosing an industry-standard capacitor value of 120pF, the load capacitance across the crystal resonator is the series connection of C3 and C4: 1/(1/C3 + 1/C4) = 60pF. To ensure oscillation at the desired frequency, however, the crystal resonator must be loaded by its specified load capacitance (20pF). This can be achieved by decreasing the value of C3 and C4 to 40pF each, but the result is a very large excess gain (R_{IN} + $R1_{MAX}$) that may be detrimental to the oscillator's noise performance. The preferred method for setting a 20pF net load capacitance is to introduce a 30pF series capacitor (C5 in the completed circuit of **Figure 1b**).

The open-collector pins $\overline{\text{OUT}}$ and OUT (pins 5 and 8) provide either a differential output or two single-ended outputs. Each pin can sink about 2.5mA of quiescent current, and each requires a pull-up to V_{CC}. Either an RF choke or a resistor can serve as the pull-up, but for differential outputs be sure to use the same type on each line. Note that resistive pull-ups greater than 100Ω cause an excessive voltage drop. For 50Ω loads, the single-ended output level is about -6dBm (320mVp-p) with an RF-choke pull-up, and about -13dBm (140mVp-p) with a 50Ω resistive pull-up.

A similar idea appeared in the 4/98 issue of Microwaves and RF.

DESIGN SHOWCASE

Pulsed sensor extends battery life

Activating the sensor circuit in **Figure 1** for 1 second every 30 minutes reduces the circuit's 20mA supply current to an average of 70µA. For a battery consisting of three AA Duracells, this pulsed operation extends the battery life to several years.

The sensor shown is an optocoupler with an infrared-emitting diode. Designed to monitor the level of salt crystals in a water softener, it relies on a reflection from the crystals to generate a "no-alarm" level of emitter current in the phototransistor (Q3). As the salt level drops past the sensor's position, this current level makes a step change downward.

When the drop across R7 equals the reference voltage in the comparator/reference device (IC2), comparator B's output goes high and releases the manual reset on the voltage monitor (IC3). After a minimum reset-delay interval of 140ms, Q4 turns on and sounds the buzzer. Comparator A monitors the battery voltage via R1 and R2; at levels above 3V, it activates the IR-emitting diode (D3) by turning on the constant-current sink consisting of Q2 and associated components. Thus, the buzzer sounds for 1 second every 30 minutes if the battery voltage is below 3V, or if the salt level is low.

Power for the sensor is available only when Q1 turns on. Q1 is controlled by IC1—a microprocessor supervisor configured as a time-base generator. (IC1 consumes less power and has a smaller footprint than the alternative 5556 timer or a 555 timer with multistage counters. It also eliminates the large capacitors otherwise required.) Connected directly across the battery, it draws 60µA at 4.5V and 40µA at 3.0V.

IC1's external connections cause its internal watchdog timer to cycle repeatedly. With C2 = 1.5µF as shown, the internal timeout is 3.6 seconds, and connecting WDS high multiplies this value by 500, extending it to the desired 30 minutes. Each timeout produces a reset pulse that applies power to the remaining circuitry by turning on Q1 for an interval of 1 second (approximately). From the MAX6304 data sheet:

t_{RESET} = (2.67) (C1) (in µF) = 1.25 seconds

$t_{WATCHDOG}$ = (2.67) (C2) (in µF) (500) = 30 minutes.

A similar idea appeared in the 1/1/98 issue of EDN.

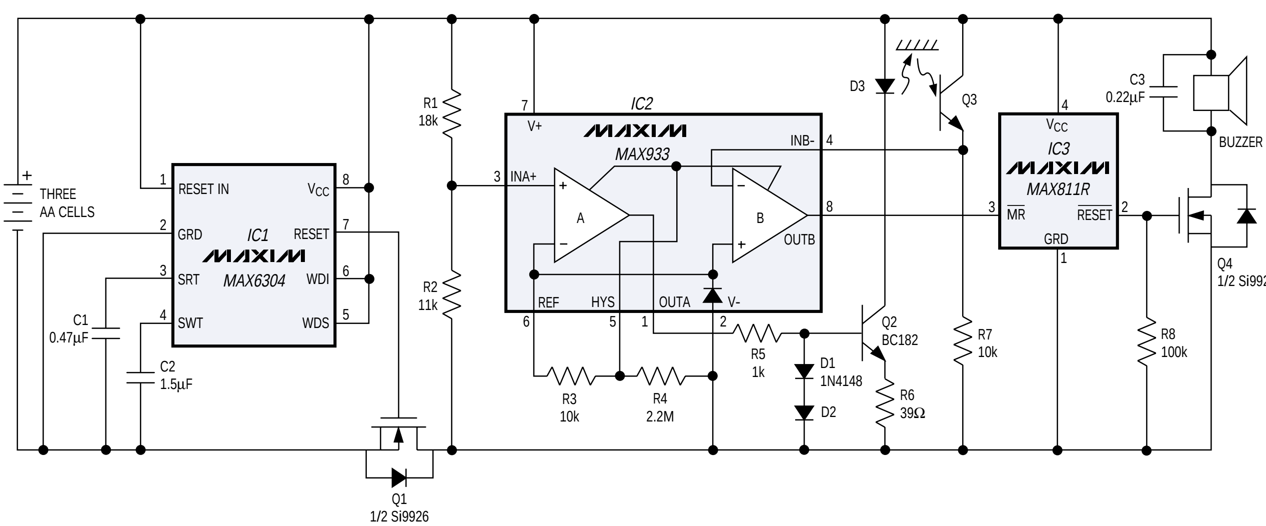


Figure 1. Powered by three AA cells, this optoelectronic sensor has a battery life of several years.

DESIGN SHOWCASE

Adjustable LNB power supply is DiSEqC compatible

The circuit of **Figure 1** provides a digitally switchable 13V or 17V for the low-noise block (LNB) typically found in satellite receivers at the antenna feedhorn. This variation of supply voltage "tells" the remotely located LNB electronics whether it should set the antenna polarization clockwise or counterclockwise, which thereby eliminates the need for an interface and cable connection to the antenna.

The circuit shown also supports an emerging and more sophisticated communications bus called the DiSEqC standard (for Digital Satellite Equipment Control). Developed by the European Telecommunications Satellite Organization, the open DiSEqC standard promises to become a de facto world standard for communications between satellite receivers and satellite peripheral equipment. More details and circuits are available at the DiSEqC web site: http://www.eutelsat.org.

DiSEqC provides a 22kHz pulse-position-modulated signal of about 0.6V amplitude, superimposed on the LNB's DC power rail. Its coding scheme allows the remote electronics to perform more complex functions—like varying the downconversion frequency or physically rotating the antenna assembly.

IC1 is a PFM boost-converter controller that controls an external FET to provide the step-up conversion from 5V to either 13V or 17V. The digital-input

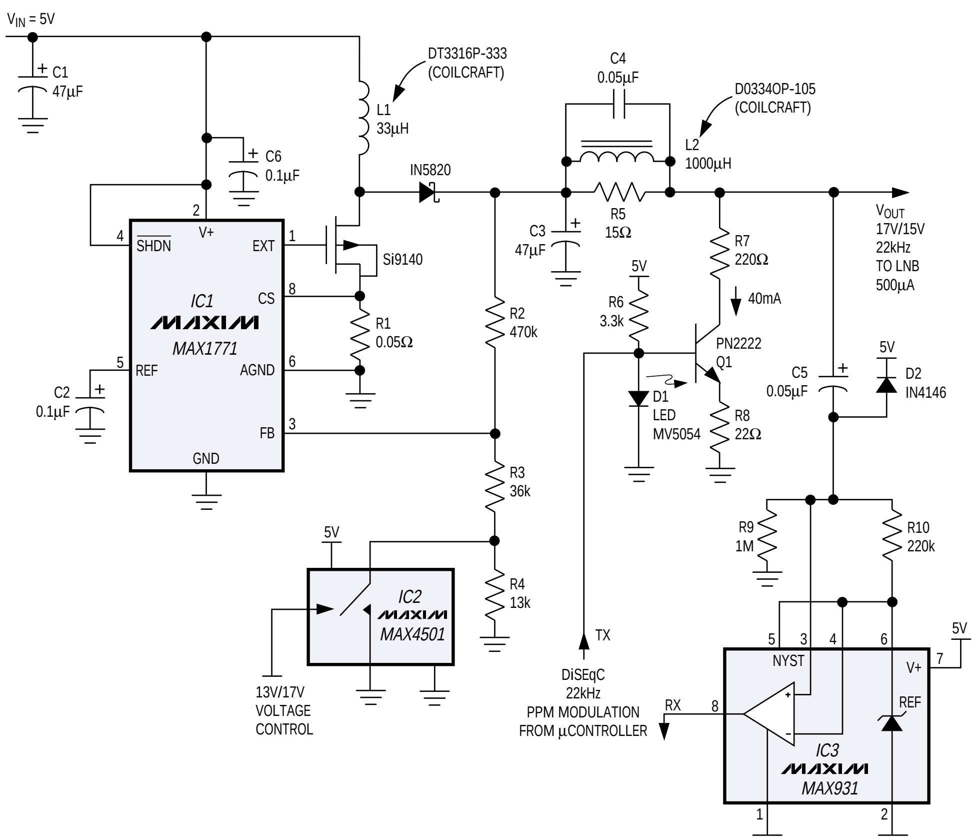


Figure 1. Designed for the low-noise block in a satellite receiver, this DiSEqC-compatible power supply communicates data by toggling its supply voltage between 13V and 17V.

Voltage Control sets the position of an analog switch that determines the amount of feedback to IC1, and hence the output voltage level. Thus, an input logic low selects 13V and a logic high selects 17V. IC2, a single switch in a tiny SOT23-5 package, is ideal for this simple switching task.

Components on the right side of the schematic provide compatibility with the DiSEqC standard. The comparator in IC3 forms a receiver that detects data transmitted from a slave LNB assembly (the DiSEqC standard specifies bidirectional data flow). This output connects to the IRQ or port pin of a microcontroller (not shown) for decoding.

The DiSEqC transmitter consists of transistor Q1 and an LED (D1), which acts as a transmit indicator and also as a constant-voltage source that forces a relatively constant current of about 40mA through Q1. During encoded bursts of 22kHz from the microcontroller, the low portions turn off the LED by sinking its drive current, which forces Q1 off as well. The 40mA switched current flows through R5, providing 600mV output swings as required by the specification.

C4, L2, and R5 form a resonant circuit whose impedance at 22kHz is 15Ω, as required by the specification. The inductor's DC resistance must be 0.5Ω or lower to accommodate the 0.5A maximum load currents. The circuit also operates on 12V, and does so with greater efficiency. When operating at 12V, consult the MAX1771 data sheet for suitable values of L1 and R1.

A similar idea appeared in the 4/20/98 issue of Electronic Design.

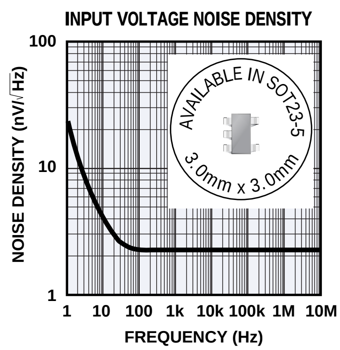
NEW PRODUCTS

Ultra-high-speed open-loop buffers in SOT23 offer low power, low noise

The MAX4200–MAX4205 open-loop buffers feature a proprietary architecture that enables ultra-high-speed performance. The MAX4201/MAX4202 offer -3dB bandwidths of 780MHz and 0.1dB gain flatness to 280MHz, and all offer 4200V/µs slew rates. Operating from ±5V supplies and drawing quiescent currents of only 2.2mA per buffer, they offer excellent driving capability for capacitive loads. MAX4200/MAX4203 outputs can drive a minimum of ±90mA.

These single (MAX4200–MAX4202) and dual (MAX4203–MAX4205) buffers differ in their internal back-termination resistor values: 50Ω for 50Ω transmission lines (MAX4201/MAX4204), and 75Ω for 75Ω transmission lines (MAX4202/MAX4205). The MAX4200 and MAX4203 have no internal termination resistors.

High speed and low noise (2.1nV/√Hz voltage-noise density and 0.8pA/√Hz current-noise density) suit these buffers for use in data communications applications and for driving the inputs of high-speed analog-to-digital converters. Single buffers come in 5-pin SOT23 and 8-pin SO packages; duals come in 8-pin µMAX and SO packages. Prices start at $1.70 (1000 up, FOB USA).



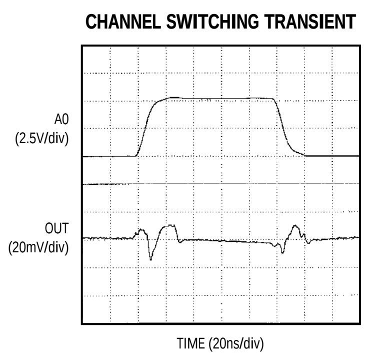
High-speed, single-supply video mux-amps have ultra-low switching transient

The MAX4310/MAX4313 high-speed multiplexer-amplifiers (mux-amps) combine low-glitch switching and single-supply operation (down to +4V) with excellent video specifications. The MAX4310 integrates a 2-channel mux with an adjustable-gain amplifier optimized for unity-gain stability, and the MAX4313 combines a 2-channel mux with a +2V/V fixed-gain amplifier. Fast channel switching (40ns) and ultra-low switching transients (10mVp-p) make these devices ideal for video-switching applications. Also, low differential gain/phase errors (0.07%/0.02°) make them an excellent choice for broadcast-video applications.

Operating from a single supply in the +4V to +10.5V range, the MAX4310 and MAX4313 exhibit Rail-to-Rail® outputs and an input common-mode range that extends to the negative rail. Supply currents are only 6.1mA. The MAX4310 has a -3dB bandwidth of 280MHz and a slew rate of 460V/µs. The MAX4313's 150MHz bandwidth (-3dB), 540V/µs slew rate, and +2V/V fixed gain are well suited for driving back-terminated cables. Both parts feature a low-power shutdown mode that places the outputs in a high-impedance state and lowers the supply current to just 560µA.

The MAX4310/MAX4313 are available in 8-pin SO or µMAX packages, with prices starting at $2.20 (1000 up, FOB USA).

Rail-to-Rail is a registered trademark of Nippon Motorola, Ltd.



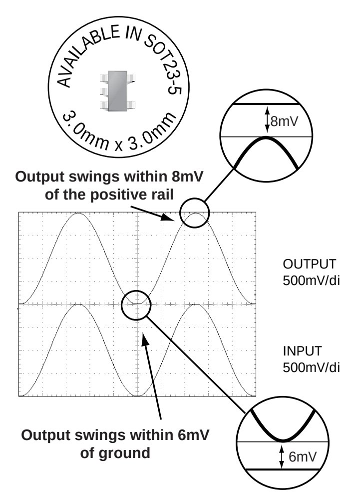
SOT23, ultra-low-voltage, Beyond-the-Rails op amps draw only 10µA

The MAX4240–MAX4244 single/dual/quad, low-power, low-voltage op amps feature Beyond-the-Rails™ inputs and rail-to-rail outputs, which allow the full range of supply voltage to be used for signal range. The op amps provide 90kHz gain-bandwidth products while drawing only 10µA per amplifier. In portable and battery-powered systems, two AA alkaline cells enable operation up to 200,000 hours.

MAX4240–MAX4244 op amps operate from a single supply of +1.8V to +5.5V or a dual supply of ±0.9V to ±2.75V. The MAX4241 and MAX4243 have a shutdown mode that places the outputs in a high-impedance state and reduces the supply current to only 1µA. The input common-mode range extends 200mV beyond each rail, and with 100kΩ loads the outputs typically swing to within 8mV of each rail. The op amps feature 200µV input-offset voltages and outputs that are unity-gain stable for capacitive loads to 200pF.

The single MAX4240 comes in a tiny SOT23-5 package. The single MAX4241 and dual MAX4242 come in 8-pin µMAX or SO packages, and the dual MAX4243 is packaged in a 10-pin µMAX or 14-pin SO. The quad MAX4244 comes in a 14-pin SO. Prices start at $0.83 (1000 up, FOB USA).

Beyond-the-Rails is a trademark of Maxim Integrated Products.



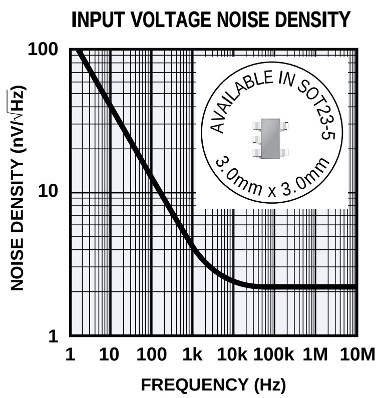
NEW PRODUCTS

Low-noise, low-distortion op amps deliver 880MHz in SOT23-5

The MAX4104/MAX4105 and MAX4304/MAX4305 ultra-high-speed op amps have a low input-noise density of 2.1nV/√Hz. The unity-gain-stable MAX4104 draws only 20mA while delivering 880MHz bandwidths, 400V/µs slew rates, and 0.1dB gain flatness to 100MHz. The MAX4304, compensated for a minimum gain of +2V/V, delivers 430MHz and 1000V/µs. The MAX4105, compensated for a minimum gain of +5V/V, delivers 430MHz and 1400V/µs. The MAX4305, compensated for a minimum gain of +10V/V, delivers 350MHz and 1400V/µs.

Low noise and low spurious-free dynamic range (-88dBc) make these op amps ideal for low-noise/low-distortion applications in video and telecommunications. They feature wide output-voltage swings (±3.7V) and high output-current capability (±70mA).

MAX4104/MAX4105 and MAX4304/MAX4305 op amps are available in 5-pin SOT23 and 8-pin SO packages, with prices starting at $1.70 (1000 up, FOB USA).



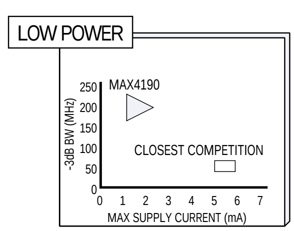
250MHz, low-power current-feedback amplifiers offer high-speed enable/disable mode

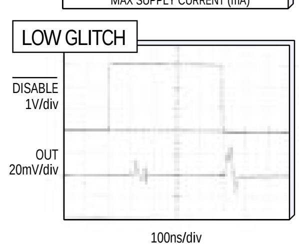
The MAX4188–MAX4190 series of current-feedback amplifiers combines 0.1dB gain flatness (up to 80MHz) with differential gain/phase errors of 0.03%/0.05°, making them ideal for video applications. The MAX4188 and MAX4190 are optimized for closed-loop gains of 6dB (+2V/V) or greater, and provide -3dB bandwidths of 250MHz. The MAX4189 is optimized for closed-loop gains of 0dB (+1V/V) or greater, and provides a -3dB bandwidth of 250MHz.

MAX4188–MAX4190 amplifiers operate from a single +5V supply or from dual supplies in the ±2.25V to ±5.5V range. Well suited for use in battery-powered applications, they draw only 1.5mA per amplifier and are capable of delivering output currents of ±55mA. A high-speed enable/disable capability isolates the inputs, places the outputs in a high-impedance state, and cuts the supply current to 450µA per amplifier. Each amplifier can be disabled independently.

Low switching transients (45mVp-p) and fast enable/disable times (120ns/35ns) make the MAX4188/MAX4189 devices suitable for use in portable video-multiplexer applications. Other capabilities make them useful in general-purpose high-speed systems: settling times of 22ns to 0.1%, slew rates of 350V/µs, and low distortion (-70dB SFDR for f_C = 5MHz and V_O = 2Vp-p).

The MAX4188/MAX4189 triple amplifiers are available in 14-pin SO and space-saving 16-pin QSOP packages. The single MAX4190 is available in tiny 8-pin µMAX and SO packages. Prices start at $3.25 (1000 up, FOB USA).





Low-cost, low-power SOT23 op amps have rail-to-rail I/O

The MAX432_ family of low-cost, low-power op amps has a 5MHz gain-bandwidth product, excellent DC accuracy (250µV offset voltage), and rail-to-rail operation at the inputs and outputs. These features make the devices ideal for cost-sensitive portable equipment, and allow designers to avoid unsatisfactory trade-offs between price and performance. Included are the single MAX4322 (in a 5-pin SOT23 package), the single MAX4323 (with shutdown), the dual MAX4326/MAX4327 (both with shutdown), and the quad MAX4329.

MAX432_ devices operate on a single supply of +2.4V to +6.5V or dual supplies in the ±1.2V to ±3.25V range. They require only 650µA of supply current per amplifier, and overdriving their inputs does not cause a phase reversal at the outputs. All are unity-gain stable (for capacitive loads to 500pF) and are capable of driving 250Ω loads. Shutdown mode (MAX4323/MAX4327) lowers the supply current to 25µA and places the outputs in a high-impedance state.

The rail-to-rail input common-mode range and output swing suit these amplifiers for low-voltage, single-supply operation. In addition, their low offset voltage and high speed make them ideal for use in the signal-conditioning stages of precision, low-voltage data-acquisition systems.

Package options include the tiny 5-pin SOT23 or 8-pin µMAX and SO (MAX4322), 8-pin µMAX and SO (MAX4323 and MAX4326), 10-pin µMAX and 14-pin SO (MAX4327), and 14-pin SO (MAX4329). Prices for the MAX4329 start at $0.24 per amplifier (100,000 up, FOB USA).

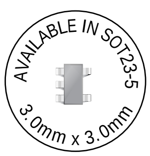
NEW PRODUCTS

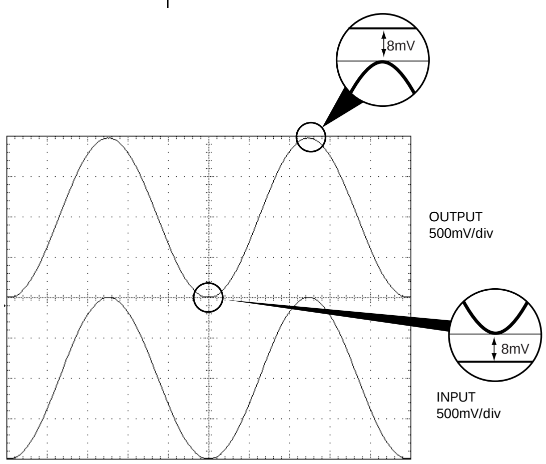
SOT23, ultra-low-power, rail-to-rail I/O op amps deliver low cost and high performance

The MAX4040–MAX4044 series of low-cost, ultra-low-power op amps have rail-to-rail inputs and outputs (to within 10mV of either rail with a 100kΩ load), which allows the full range of supply voltage to be used for signal range. Their 90kHz gain-bandwidth product and 10µA per amplifier supply current make them ideal for cost-sensitive portable equipment.

The MAX4040 family of op amps operates from a single supply of +2.4V to +5.5V or dual supplies of ±1.2V to ±2.75V. The MAX4041 and MAX4043 have a shutdown mode that places the outputs in a high-impedance state and reduces the supply current below 1µA. All devices feature input-offset voltages of 250µV and outputs that are unity-gain stable for capacitive loads to 200pF. They are ideal for low-voltage, low-power, precision applications in portable and battery-powered systems.

Package options include the tiny 5-pin SOT23, 8-pin µMAX, or 8-pin SO for the single MAX4040, the 8-pin µMAX or SO for the single MAX4041 and dual MAX4042, the 10-pin µMAX or 14-pin SO for the dual MAX4043, and the 14-pin SO for the quad MAX4044. Prices for the MAX4044 start at $0.24 per amplifier (100,000 up, FOB USA).





Versatile quad analog switch configures as 4xSPST, 2xSPDT, or DPDT

The MAX4613 quad-SPST analog switch has two normally on switches and two normally off switches. User-configurable as four SPST switches, two SPDT switches, or a single DPDT switch, it is pin-compatible with the industry-standard DG213.

The MAX4613's low on-resistances (85Ω max) are matched to within 4Ω max and flat to within 9Ω max over the signal range. They conduct equally well in either direction. The device guarantees low charge injection (10pC max) and low off-leakage current over temperature (less than 5nA at +85°C). Per MIL-STD-883, Method 3015.7, this device withstands 2kV min ESD.

The MAX4613 handles rail-to-rail signals, switches t_{ON}/t_{OFF} in less than 250ns/70ns, and consumes only 35µW max while operating on a single supply of +10V to +30V (or a dual supply of ±4.5V to ±20V). Digital inputs are TTL/CMOS compatible. The MAX4613 is available in 16-pin QSOP, DIP, and TSSOP packages. Prices start at $1.05 (1000 up, FOB USA).

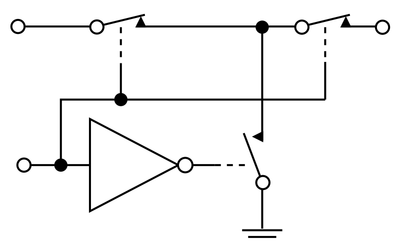
Low-voltage, 300MHz video/RF switch provides high-frequency off-isolation

The MAX4529 is a low-voltage analog switch intended for use in switching DC-to-300MHz RF and video signals in 50Ω and 75Ω systems. The switch is constructed in a "T" configuration that ensures excellent high-frequency off-isolation (-80dB at 10MHz).

Operating on dual supplies in the ±2.7V to ±6V range or on a single supply in the +2.7V to +12V range, the MAX4529 consumes less than 1µW and handles rail-to-rail analog signals in either direction. With ±5V supplies, the on-resistance (70Ω max) is flat to within 10Ω max over the specified signal range. Off-leakage current is less than 1nA at +25°C (20nA at +85°C).

When operating on 5V or ±5V, the MAX4529 digital inputs exhibit 0.8V/2.4V thresholds that ensure compatibility with TTL and CMOS logic. The device includes protection per MIL-STD-883, Method 3015.7, for ESD >2kV. Prices start at $0.88 (1000 up, FOB USA).

MAX4529
"T" SWITCH CONFIGURATION



NEW PRODUCTS

250MHz differential line driver slews 1400V/µs

The MAX4142 differential line driver features high speed, a closed-loop gain of +2V/V, and fully symmetrical differential inputs and outputs. It is well suited for driving back-terminated cables and transmission lines.

Laser-trimmed thin-film resistors and common-mode cancellation circuitry enable the MAX4142 to deliver an outstanding common-mode rejection of 70dB at 10MHz. Its internal current-feedback techniques achieve a bandwidth of 250MHz (A_V = +2V/V) and a slew rate of 1400V/µs. Low gain/phase error (0.01%/0.01°) and low noise make the MAX4142 an excellent choice for video and RF signal-processing applications.

The device operates from ±5V supplies and draws only 12mA of quiescent current. Its shutdown capability is 800µA, and its output stage drives a 100Ω load to ±6V differentially or to ±3V in single-ended applications.

The MAX4142 is available in a 14-pin SO package with prices starting at $2.50 (1000 up, FOB USA).

Compact, dual-output DC-DC converter powers digital camera CCD

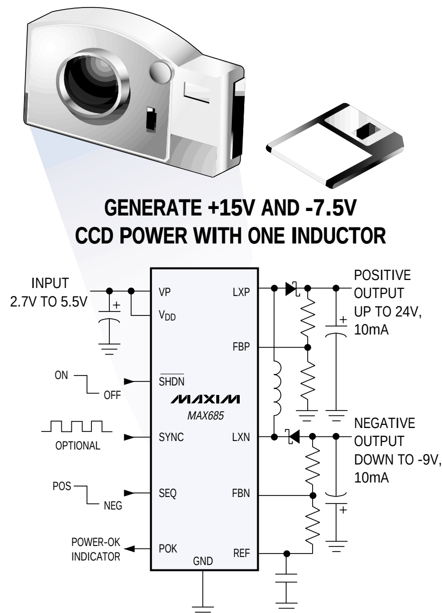
The MAX685 DC-DC converter powers the charge-coupled device (CCD) and LCD in a digital camera. Replacing bulky and expensive transformers with a single inductor, the compact MAX685 generates dual, low-noise, +15V and -7.5V supply voltages from an input voltage in the 2.7V to 5.5V range.

The combination of internal power switches and control via fixed-frequency, 400kHz pulse-width modulation enables the MAX685 to occupy only 0.15in^2 (97mm^2). The output voltages are independently regulated and are adjustable in the -9V to +24V range with simple resistor-dividers. Output-ripple voltages are only 30mVp-p. With an additional diode and capacitor, the output range becomes -16V to +45V with a 10mA output-current capability at each output.

The MAX685's power-sequence-select input allows the user to set whether the positive or negative output comes up first. A power-OK output signals when both outputs have reached regulation.

Unlike other step-up DC-DC converters, in which a diode connects the input and output at all times, the MAX685's logic-controlled shutdown input turns off both outputs completely.

A preassembled evaluation kit (MAX685EVKIT) with recommended external components is available to reduce design time. The MAX685 comes packaged in a 16-pin QSOP (same area as an 8-pin SO), with prices starting at $3.44 (1000 up, FOB USA).



New step-down DC-DC controllers offer size reduction, 96% efficiency

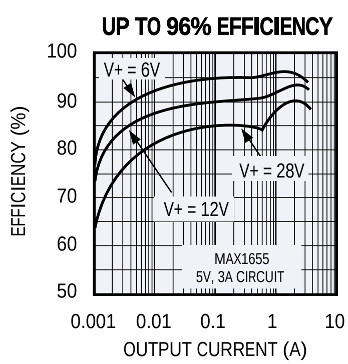
The MAX1652–MAX1655 step-down DC-DC controllers are the next generation of the popular MAX797 family. They offer lower quiescent power consumption (1mW vs. 5mW), lower dropout voltage (200mV vs. 600mV), lower adjustable output voltage (1.0V vs. 2.5V min), and smaller size (16-pin QSOPs, which occupy only half the area of a 16-pin narrow-SO package).

These devices achieve efficiencies as high as 96% by using synchronous rectification and a 300kHz, low-noise, PWM/Idle Mode™ control scheme. They deliver output currents as high as 10A by controlling inexpensive, external, dual n-channel MOSFETs.

The MAX1652–MAX1655 controllers operate from input voltages in the 4.5V to 30V range, and provide a pin-selectable output of 3.3V or 5.0V (or an adjustable output, as low as 1V for the MAX1655). The MAX1652 has an additional feedback pin that allows regulation of a secondary positive output voltage such as 12V. On the MAX1654, this pin allows regulation of a secondary negative voltage such as -5V.

A preassembled evaluation kit (MAX1653EVKIT) with recommended external components is available to reduce design time. All MAX1652EEE–MAX1655EEE devices come in small, 16-pin QSOP packages occupying the same area as an 8-pin SO. MAX1653ESE/MAX1655ESE devices are also available in 16-pin narrow-SO packages, and are pin-compatible plug-in replacements for the original MAX797ESE. Prices start from $3.50 (1000 up, FOB USA).

Idle Mode is a trademark of Maxim Integrated Products.



NEW PRODUCTS

Ultra-small negative bias for GaAsFET PAs is half the size of an 8-pin SO

The MAX881R charge-pump converter has an internal, low-noise linear regulator that creates the negative bias voltage required for GaAsFET power amplifiers (PAs) in cell phones and wireless handsets. The fixed-frequency 100kHz charge pump and the linear regulator's filtering action combine to limit output ripple and noise to less than 1mVp-p at a fixed frequency.

The MAX881R package (a 10-pin µMAX) is less than 1.11mm high and occupies only half the area of an 8-pin SO. Its charge pump operates with tiny ceramic capacitors: three of 0.22µF and one of 4.7µF. A power-OK (POK) output signals when the bias voltage is within 5% of its nominal regulated level. POK indicates when the output is sufficient to drive the drain switch of a GaAsFET PA, and thereby prevents damage to a PA that is switched on before the proper bias is available.

The MAX881R's input voltage range (2.5V to 5.5V) allows operation either from a +3V or +5V supply or directly from a lithium-ion battery. Quiescent supply current is a low 500µA, and the logic-controlled shutdown cuts that current to only 0.05µA. The MAX881R output voltage is preset at -2V. An external resistor-divider can be adjusted in the -0.5V to $-V_{IN}$ range. The guaranteed output-current capability is 4mA.

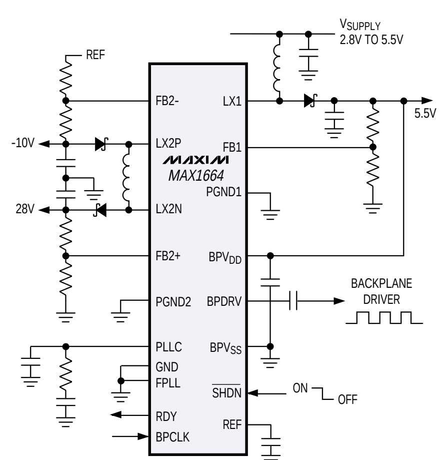
A fully assembled evaluation kit (MAX881REVKIT) with recommended external components is available to reduce design time. The MAX881R comes in a 10-pin µMAX package, with prices starting at $1.85 (1000 up, FOB USA).

Power supply/backplane driver powers active-matrix LCD

The MAX1664 integrates the power-supply and backplane-drive circuitry for active-matrix, thin-film-transistor liquid-crystal (LCD) displays. It includes a single-output pulse-width-modulation boost converter with 0.25Ω switch; a dual-output, single-inductor converter with complementary 0.9Ω switches; an LCD-backplane driver with complementary 0.35Ω switches; and a simple phase-locked loop that minimizes interference by synchronizing the three outputs.

The phase-locked operation and high switching frequency (1MHz nominal) maintain low output noise while enabling the use of tiny, minimum-height external components. The input range (2.8V to 5.5V) allows use with any logic supply. Output voltages are adjustable to 5.5V (DC-DC1) and to 28V (DC-DC2). You can adjust the negative supply to -20V by adding external components. Also included is a logic-level shutdown (to 1µA) and a ready output that signals when all three outputs are in regulation.

Users can set the boost-converter operating frequency at 16, 24, or 32 times the LCD-backplane clock. These ratios allow use of a high converter frequency with backplane frequencies in the 20kHz to 72kHz range. The MAX1664 is available in a 20-pin TSSOP package only 1.1mm high. Prices start at $3.83 (1000 up, FOB USA).



Remote/local temperature sensor uses SMBus serial interface

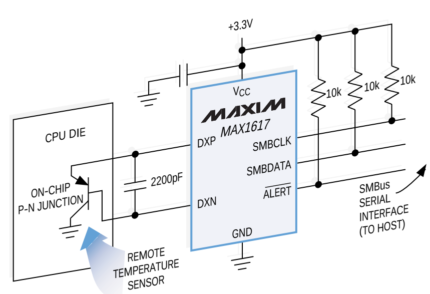
The MAX1617† is a precise digital thermometer that reports the temperature of both a remote sensor and its own package. The remote sensor—a Pentium II die or an easily mounted, diode-connected npn transistor such as the low-cost 2N3904—can replace a conventional thermistor or thermocouple. Such transistors, from multiple manufacturers, can provide ±3% accuracy without calibration. The remote channel can also measure the temperature of any IC (such as a microprocessor) that includes an accessible diode-connected transistor.

To read temperature data and program the remote thresholds, the MAX1617 accepts standard write-byte, read-byte, and receive-byte commands through a 2-wire serial interface called the System Management Bus (SMBus)™. The data format is 7 bits plus sign, two's complement, in which each LSB represents 1°C. Conversion rate (and therefore current drain) is programmed by the user, who also programs the under- and over-temperature alarms and sets the device for single-shot or continuous measurements.

The MAX1617 operates on a supply voltage of +3V to +5.5V and draws only 3µA (typical) in the standby mode. It comes in a 16-pin QSOP package specified for the military temperature range (-55°C to +125°C). Contact factory for prices.

† Patents pending.

SMBus is a trademark of Intel Corp.



NEW PRODUCTS

High-efficiency DC-DC converter for pagers starts from 0.87V

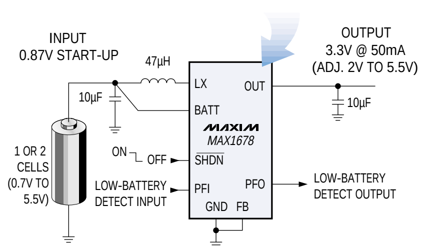
The MAX1678 is a high-efficiency, step-up DC-DC converter for pagers and other applications powered by 1 to 3-cell batteries. It delivers output currents to 50mA while operating from a single alkaline, NiCd, or NiMH cell. Quiescent supply current is only 37µA (2µA in shutdown), and the device is guaranteed to start from voltages as low as 0.87V.

An internal synchronous rectifier saves space and cost by eliminating the need for an external Schottky diode. It also boosts efficiency to 90%, especially for low output voltages. When operating from two cells, the MAX1678 can deliver 90mA. You can select the 3.3V preset output voltage, or adjust the output between 2V and 5.5V using two external resistors.

The MAX1678 has a built-in damping switch that eliminates electromagnetic interference by suppressing inductor ringing. Other features include a power-fail comparator and reverse-battery protection. The entire circuit (MAX1678, two small 10µF capacitors, and an ultra-small, surface-mount 47µH inductor) fits in only $0.07in^2$ ($49mm^2$).

A preassembled evaluation kit (MAX1678EVKIT) with recommended external components is available to reduce design time. The MAX1678 is specified for the extended temperature range (-40°C to +85°C). It comes in a 1.11mm high, 8-pin µMAX package, which occupies just half the board area of a standard 8-pin SO package. Prices for the MAX1678 start at $1.65 (1000 up, FOB USA).

NO DIODE NEEDED!

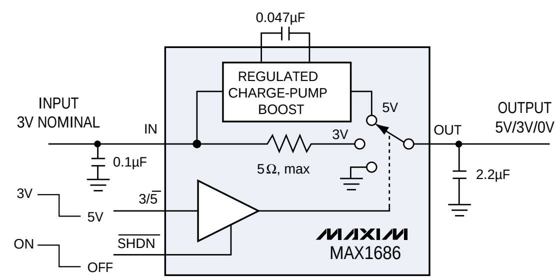


Ultra-small, +3V to +5V supply powers SIM cards

The MAX1686 is a power supply for subscriber identification module (SIM) cards, which provide 3V or 5V outputs in 3V-only cell phones. The MAX1686 either powers the SIM card directly by closing a switch from input (a 3V phone voltage) to output, or it enables an internal regulated charge pump that boosts the input voltage to 5V.

In 3V mode, the MAX1686 shorts input to output with an internal switch of less than 5Ω. In 5V mode, the regulating charge pump delivers as much as 12mA from 4.75V (4.55V min). Supply currents are 3µA (3V mode) and 45µA (5V mode). Whether in 3V or 5V mode, shutdown pulls the output to ground and lowers the supply current to 0.1µA.

The charge pump operates at frequencies to 1MHz, and requires only three small external ceramic capacitors (0.047µF, 0.1µF, and 2.2µF). The MAX1686 features soft-start capability and short-circuit protection, and comes in a 1.11mm-high, 8-pin µMAX package that occupies only half the board area of a standard 8-pin SO. Prices start at $1.45 (1000 up, FOB USA).

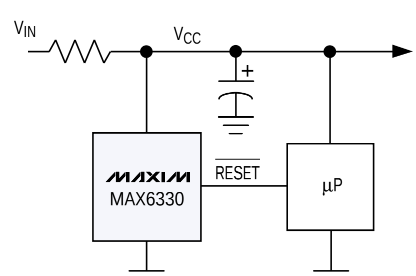


Precision ICs combine shunt regulator with reset function

The MAX6330/MAX6331 ICs combine a precision shunt regulator with power-on reset in a single SOT23-3 package. They offer a low-cost method for operating small µP-based systems from high-voltage sources while protecting the µP from power-up, power-down, and brownout conditions.

Each is available in 5V, 3.3V, and 3.0V versions in which the push/pull outputs are either active-low reset (MAX6330) or active-high reset (MAX6331). Reset-threshold tolerance at +25°C is ±1.5%. MAX6330/MAX6331 devices operate over a wide shunt-current range (100µA to 50mA) and provide very good transient immunity. Compared with multiple-IC alternatives, their 3-pin SOT23 package offers advantages in board space and reliability. Prices start at $1.19 (2500 up, FOB USA).

SINGLE-CHIP SOLUTION



NEW PRODUCTS

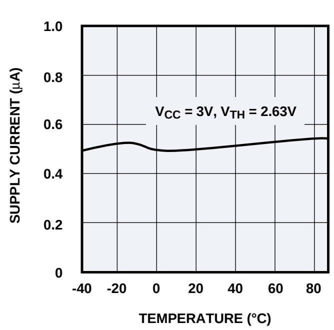
SOT reset ICs draw only 500nA while monitoring 2.5V

The MAX6326/MAX6327/MAX6328 and MAX6346/MAX6347/MAX6348 ultra-low-power reset circuits are designed to monitor 2.5V, 3V, 3.3V, and 5V power supplies in digital systems. Ultra-low supply currents (500nA typical at +3.3V) make them ideal for use in portable equipment. By eliminating external components and adjustments, they provide excellent reliability and low cost.

Each device asserts a reset signal of 100ms min whenever V_{CC} declines below a preset threshold, and maintains the reset for at least 100ms after V_{CC} returns above that threshold. The ICs differ only in their output structures: active-low push/pull (MAX6326/MAX6346), active-high push/pull (MAX6327/MAX6347), and active-low open-drain (MAX6328/MAX6348). All outputs are guaranteed valid for V_{CC} levels down to 1V. The internal comparator is designed to ignore fast transients on V_{CC}.

Standard, factory-trimmed reset thresholds of 2.20V, 2.33V, 2.63V, 2.93V, 3.08V, 4.38V, and 4.63V result in 21 standard versions of these devices. Please consult the factory for nonstandard threshold values, which are available in approximate 100mV increments from 2.20V to 4.63V. The MAX6326/MAX6327/MAX6328 and MAX6346/MAX6347/MAX6348 are available in 3-pin SOT23 packages specified for the extended temperature range (-40°C to +85°C), and priced at $0.99 (2500 up, FOB USA).

SUPPLY CURRENT vs. TEMPERATURE



µP supervisors offer 3,224 combinations of reset output, watchdog, and manual reset

The MAX6316–MAX6322 microprocessor (µP) supervisory circuits monitor the power-supply voltages and µP activity in digital systems. They offer a software watchdog, manual reset, and several combinations of push/pull, open-drain, and bidirectional (i.e., Motorola 68HC11-compatible) reset outputs. For a listing of functions associated with each of the ten devices, see Maxim's *Product Selector Guide.*

The available product variations include 26 factory-trimmed reset voltages (in increments of 100mV, from 2.5V to 5V), one of four minimum reset-timeout periods (1ms, 20ms, 140ms, or 1.12sec), and one of four minimum watchdog-timeout periods (6.3ms, 102ms, 1.6sec, or 25.6sec). These products draw supply currents as low as 5µA, and each is designed to ignore fast negative transients on V_{CC}. The reset outputs are guaranteed valid for V_{CC} down to 1V.

MAX6316–MAX6322 devices are available in 5-pin SOT23 packages specified for the commercial temperature range (0°C to +70°C), with prices starting at $1.14 (2500 up, FOB USA). The minimum order for nonstandard versions is 10,000 pieces. Contact the factory for availability.

Transceivers deliver high-speed, low-power RS-232 communications

The 3V MAX3224–MAX3227 data transceivers provide high-speed, low-power RS-232 communications for portable and battery-powered products. Their 1µA supply currents maximize battery life. The MAX3224/MAX3225 each contain two transmitters and two receivers, and the MAX3226/MAX3227 are 1-transmitter/1-receiver devices in small 16-pin SSOPs, suitable for size-constrained applications that do not require extra handshaking or control lines.

The MAX3224/MAX3226 ICs guarantee data rates to 250kbps, and the MAX3225/MAX3227 ICs (which include Maxim's MegaBaud™ feature) guarantee 1Mbps for ISDN modems and other high-speed applications.

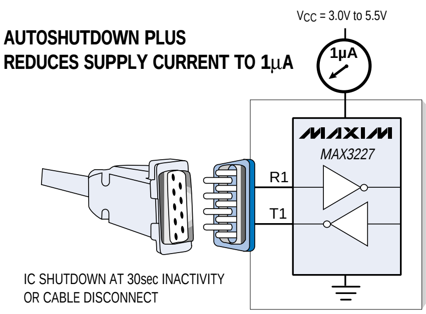
A proprietary voltage doubler and low-dropout output stage enables MAX3224–MAX3227 devices to deliver true RS-232 performance for V_{CC} in the 3V to 5.5V range. Unlike power-hungry voltage triplers, these devices require only four external capacitors regardless of the supply voltage. Maxim's revolutionary AutoShutdown Plus™ architecture enables systems to save power automatically without changes to software.

All MAX3224–MAX3227 devices enter a low-power shutdown mode when valid RS-232 activity is absent for more than 30 seconds (e.g., when the RS-232 cable is disconnected or when the device is not actively communicating with a connected peripheral). They resume normal operation upon sensing a valid transition at any transmitter or receiver input, and the receivers are always active—even in shutdown.

Available packages include 20-pin DIPs and SSOPs. Prices (1000 up, FOB USA) start at $1.85 for the MAX3224/MAX3225 and $1.25 for the MAX3226/MAX3227.

MegaBaud and AutoShutdown Plus are trademarks of Maxim Integrated Products.

AUTOSHUTDOWN PLUS REDUCES SUPPLY CURRENT TO 1µA



NEW PRODUCTS

Signal-conditioning ICs achieve 1% accuracy for piezoresistive sensors

The MAX1450/MAX1458 signal-conditioning ICs are designed for use with piezoresistive pressure sensors. By correcting for offset, full scale, offset tempco, and full-scale tempco, they achieve an accuracy of 1% (subject to the sensor's inherent linearity error). This accuracy simplifies calibration and compensation of the sensor.

The MAX1458 includes an EEPROM, four 12-bit adjustment digital-to-analog converters (DACs), a current source, and a 3-bit programmable-gain amplifier (PGA). The internal current source drives the external sensor bridge and is programmable from 0.1mA to 2mA. The EEPROM stores the calibration and compensation coefficients, which are downloaded to the DACs after the sensor has been characterized. The resulting corrections greatly simplify the operations of sensor pretest and production manufacturing.

The MAX1450 is a low-cost signal conditioner that includes a programmable current source and a 3-bit PGA. It relies on external laser-trimmed resistors (or potentiometers, or DACs) for sensor compensation and calibration.

Both devices operate from a single +5V supply, provide ratiometric operation, and are suitable for use with accelerometers, strain gauges, and other resistive sensors. They accept low-level, differential, full-span input signals from ±10mV to ±30mV, and yield a compensated pressure-transducer output in the 0.5V to 4.5V range.

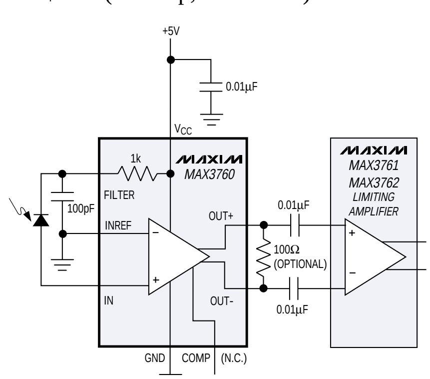
The MAX1458 is available in a 16-pin SSOP package with prices starting at $3.48 (1000 up, FOB USA). The MAX1450 is available in a 20-pin SSOP with prices starting at $1.98 (1000 up, FOB USA).

622Mbps, low-noise, transimpedance preamplifier serves optical receivers in LAN/WAN systems

The MAX3760 is a transimpedance preamplifier for 622Mbps ATM applications. It converts small photodiode currents to measurable differential voltages, and includes a DC-cancellation circuit that reduces pulse-width distortion by providing true differential output swings over a wide range of current levels. It operates from a single +5V supply and typically consumes 100mW.

The MAX3760 has a 6.5kΩ transimpedance gain and 560MHz bandwidth, and handles input overloads to 1mA. With an operating temperature range of -40°C to +85°C, its low input-referred noise (73nA) allows a typical input sensitivity of -31.5dBm for 1300nm receivers. Typical optical-input overloads of -3dBm give an overall dynamic range of 28.5dB.

The MAX3760 is internally compensated and requires few external components. In die form its space-saving filter connection provides positive bias for the photodiode through a 1kΩ resistor to V_{CC}. These features allow the MAX3760 and photodiode to be easily assembled in a TO-style header. The MAX3760 is designed for use with the MAX3761 or MAX3762 limiting amplifier. When combined with a photodiode, the resulting chipset forms a complete, 5V, 622Mbps receiver. The MAX3760 is available as die or in an 8-pin SO package. Prices start at $8.30 (1000 up, FOB USA).



5th-order elliptic filters save space and power

The MAX7411/MAX7415 5th-order, switched-capacitor, lowpass elliptic filters reside in 8-pin DIP and µMAX packages. The proprietary µMAX package is 80% smaller than an 8-pin DIP, making that version the smallest 5th-order switched-capacitor filter available in the industry.

The MAX7411/MAX7415 filters draw only 1.2mA of supply current from a single supply voltage of +5V (MAX7411) or +3V (MAX7415). In shutdown mode, the quiescent supply current drops to only 0.2µA. Small size, low cost, and low power make these filters ideal for anti-aliasing and post-DAC filtering in cost-sensitive portable equipment.

The MAX7411/MAX7415 provide sharp rolloffs with a transition ratio of 1.25. They also maintain -81dB of THD+N and 37dB of stopband rejection. Corner frequencies are clock-tunable from 1Hz to 15kHz, with a clock-to-corner ratio of 100. Two clocking options are available: self-clocking via an external capacitor, or external clocking for tighter control of the cutoff frequency. The offset-adjust pin can either nullify the output offset (typically 4mV) or introduce a deliberate shift of DC output level.

Package options include the 8-pin µMAX and plastic DIP. Prices start at $0.99 (100,000 up, FOB USA).

WORLD'S SMALLEST
5TH-ORDER LOWPASS FILTER