

MAXIM Engineering Journal

Volume Forty

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News Briefs

■ MAXIM REPORTS RECORD REVENUES AND EARNINGS FOR THE FOURTH QUARTER AND FISCAL YEAR

Maxim Integrated Products, Inc., (MXIM) reported record net revenues of \$256.6 million for its fiscal fourth quarter ending June 24, 2000, a 60.9% increase over the \$159.5 million reported for the same quarter a year ago. Net income increased to a record \$82.9 million in the fourth quarter, compared to \$52.6 million last year, a 57.8% increase. Diluted earnings per share were \$0.26 for the fourth quarter, a 52.9% increase over the \$0.17 reported for the same period a year ago.

For the fiscal year, Maxim reported net revenues of \$864.9 million, a 42.5% increase over the \$607.0 million reported last year. Net income increased 43.1% to \$280.6 million in fiscal 2000, compared to \$196.1 million in fiscal 1999. Diluted earnings per share increased 37.5% to \$0.88 in fiscal 2000 from \$0.64 in fiscal 1999.

Fourth quarter bookings were approximately \$361 million, a 19% increase over the previous quarter's level of \$304 million and an 83% increase over the fourth quarter of last year. Turns orders received in the quarter were \$108 million, a 13% increase over the \$95 million received in the prior quarter (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). Bookings increased in all geographic locations. There was significant growth in demand for the Company's products targeting wireless and wired communications, portable equipment, networks, and broad-based industrial applications. Fourth quarter bookings by subcontract manufacturers exceeded third quarter levels.

Fourth quarter ending backlog shippable within the next 12 months was approximately \$420 million, including approximately \$314 million requested for shipment in the first quarter of fiscal 2001. The Company's third quarter ending backlog shippable within the next 12 months was approximately \$345 million, including approximately \$271 million that was requested for shipment in the fourth quarter. All of these backlog numbers have been adjusted to be net of cancellations and estimated future U.S. distribution ship and debit pricing adjustments.

Jack Gifford, Chairman, President, and Chief Executive Officer, commented on the results: "Fiscal 2000 was an excellent year for Maxim. Our bookings, revenues, earnings, and new product introductions grew to record levels. Cash and short-term investments increased over \$126 million during the year after we repurchased \$257 million of our common stock and invested \$45 million in properties and facilities and \$131 million in equipment."

Mr. Gifford continued: "Demand for our products has never been stronger and continues to exceed our expectations. End market bookings have continued to increase over the past nine months due in large part to a significant increase in new customer equipment applications utilizing Maxim products. The acceptance of our new products, the breadth of our proprietary product lines, and the increasing demand for our products from emerging markets also contributed to this growth. While bookings growth rates remain strong, turns orders as a percent of bookings have come down from 41% in the fourth quarter of fiscal 1999 to more historical levels of 30% in the fourth quarter of fiscal 2000. We expect turns orders to stay at this level as customers are placing more of their orders for delivery within the next three to six months. These orders remain within our 12-month booking schedule."

Mr. Gifford concluded: "We did an excellent job of meeting our product introduction goals this year. We introduced a record 383 products during our product introduction year ending July 22, 2000, compared to 284 products last year. The 35% increase year over year bodes well for Maxim's long-term growth expectations. These products are key to our achieving future revenue growth targets and position Maxim as one of the premier analog companies in the world."

ICs help implement a trim-free VCO¹ (Part 2)

A new family of integrated circuits can ease the task of developing compact, fixed-frequency, voltage-controlled oscillators (VCOs) for IF applications.

Designing a VCO for use with a fixed intermediate-frequency (IF) can be daunting. Fortunately, VCO ICs from Maxim (MAX2605–MAX2609) can simplify the task. Compared to conventional discrete-device VCOs, the Maxim parts cost less and require less PC board space.

In a traditional IF VCO design, the oscillator core and output buffer stage are formed by discrete transistors, resistors, capacitors, and inductors (**Figure 1**). The tank is built from a network consisting of the frequency-setting inductor, varactors, coupling capacitors, and feedback capacitors. The output stage uses reactive elements to match the output impedance to a particular load impedance.

To ensure a successful design, the component values must not only establish a desired nominal oscillation frequency, they must also guarantee an adequate tuning range, proper biasing, oscillator startup under all conditions, and proper output-stage performance. Problems can

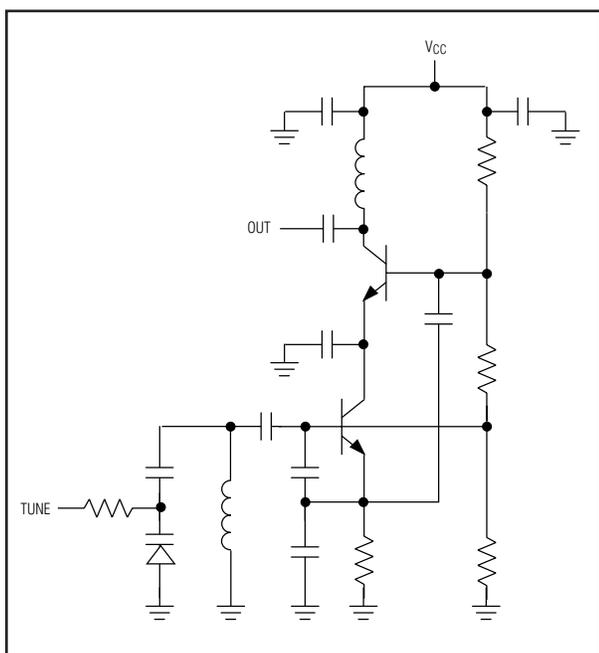


Figure 1. This schematic shows an IF VCO implemented with discrete circuit elements.

occur even with a good first-order design because of the trade-offs that exist among current consumption, startup margin, frequency tuning range, and phase noise.

A major disadvantage of discrete IF VCO designs is the amount of PCB area needed. Much effort must be expended in optimizing the layout to below 6mm x 10mm. Furthermore, the PCB layout has a critical effect on the VCO's performance and design accuracy. The layout contains parasitic capacitances and inductances that affect the oscillation frequency and must therefore be taken into account to implement the oscillator properly. Parasitic elements often cause an undesired shift in the nominal oscillation frequency, which causes greater design-centering errors and ultimately forces a need for greater tuning range to account for those errors.

The MAX2605–MAX2609 IF VCO family offers a better alternative. These five ICs are designed for low-power, fixed and single-frequency portable wireless applications with IF frequencies in the 45MHz to 650MHz range. Much of the required circuitry is included on chip; only the tank inductor (which establishes the oscillation frequency) is external.

Once you choose the correct external inductance value, the IC guarantees that some level within the tuning-voltage range (+0.4VDC to +2.4VDC) will tune in the corresponding frequency. The IC's tuning-voltage input can be driven directly from the loop-filter output following a phase-locked loop (PLL). MAX2605–MAX2609 ICs are designed for supply voltages in the +2.7VDC to +5.5VDC range, and the supply voltage connection does not require special regulation for proper operation. Each IC comes in a tiny, 6-pin plastic SOT23 package (**Figure 2**).

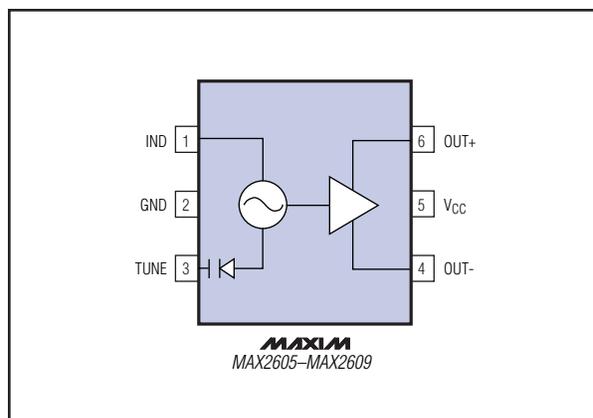


Figure 2. The MAX2605–MAX2609 IF VCO ICs come in a 6-pin surface-mount SOT23 package designed to occupy minimum PCB space.

¹A similar article appeared in the August 2000 issue of *Microwaves & RF* magazine.

The MAX2605 tunes from 45MHz to 70MHz, with -117dBc/Hz phase noise at 100kHz from the carrier. For the other devices, these parameters are: 70MHz to 150MHz tuning with -112dBc/Hz phase noise at 100kHz from the carrier (MAX2606), 150MHz to 300MHz with -107dBc/Hz (MAX2607), 300MHz to 500MHz with -100dBc/Hz (MAX2608), and 500MHz to 650MHz with -93dBc/Hz (MAX2609).

The frequency tuning range, biasing, startup, and other oscillator characteristics are all managed within the IC, eliminating the design headaches typically associated with VCO design. An on-chip varactor and capacitors simplify IF VCO design by eliminating the need for external tuning elements. A graph of inductance versus oscillation frequency (see the MAX2605–MAX2609 data sheet) further simplifies the task of choosing an external inductor.

The MAX2605 family provides several important new benefits for RF designers. The ICs are designed to create VCOs that are trimless and do not need external adjustments. To accommodate the anticipated range of system IFs found in dual-conversion systems, they are designed to cover a wide range of application frequencies. In addition, they have a flexible output interface to help reduce the cost of IF VCOs and shrink the size of the final design.

Because the MAX2605–MAX2609 represent a new concept in VCOs, they required a fundamentally new circuit approach to achieve the product objectives. Maxim devised an oscillator scheme based on the reliable and flexible Colpitts oscillator structure. This topology was

adapted so that all the oscillator circuit elements (except the inductor) could be integrated within the IC. Integrating nearly the entire oscillator on chip provides all the desired operating objectives of a good VCO: proper oscillator startup, wide frequency range, required tuning characteristics for trimless operation, controlled current consumption, and biasing that was independent of temperature and the power-supply voltages.

An off-chip inductor allows the VCO to be applied over a very wide range of operating frequencies. On-chip capacitance remains the same, but changing external inductance values modifies the resonant frequency of the oscillator tank circuit. If the inductor has a minimum quality factor (Q), the phase-noise and startup behavior can be guaranteed (**Figure 3**).

To implement this new approach, the IC technology needed a full complement of active and passive elements to support construction of the oscillator circuit shown. Specifically, the process technology had to provide high-frequency transistors, high-Q capacitors, high-Q varactor diodes with high capacitance ratios, and PNP or PMOS devices.

The MAX2605–MAX2609 are fabricated on a silicon BiCMOS process developed specifically for RFICs that include monolithic oscillator structures. This process features PNP, NMOS, and PMOS devices, NPN transistors with transition frequencies (f_T) of 25GHz, low-series-resistance varactor diodes with better than 2:1 capacitance ratio (for tuning voltages from 0.4V to 2.4V), very high-Q metal-insulator-metal (MIM) RF capacitors, precision thin-film resistors, and three layers of metal.

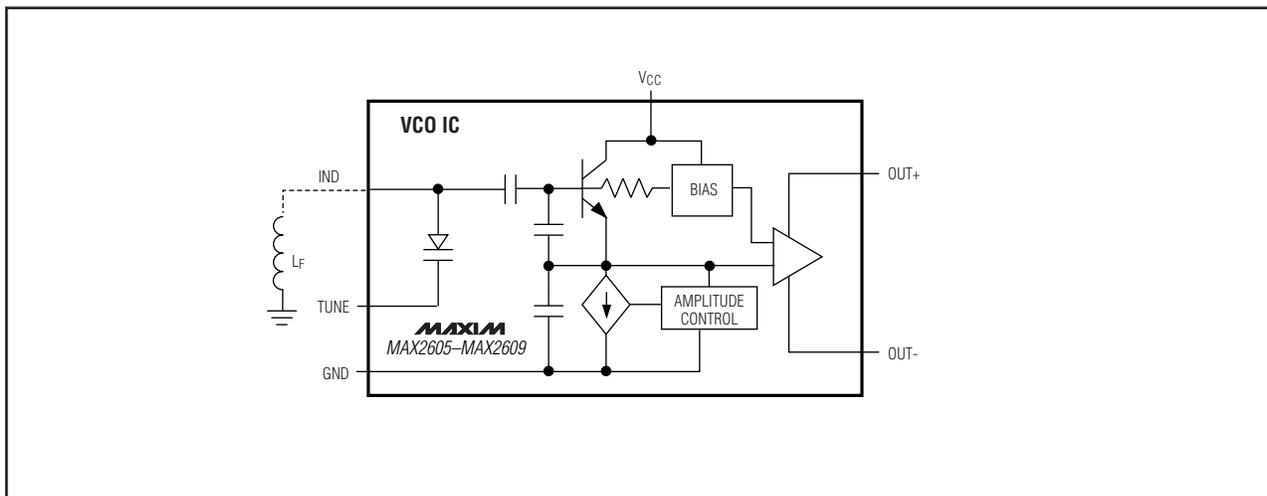


Figure 3. This simplified circuit diagram of the MAX2605–MAX2609 VCO ICs shows that only an external inductor is necessary to complete the resonant circuit, which sets the oscillation frequency.

This full complement of devices allowed implementation of the complete IC. The VCO design required careful and extensive computer simulations, including multiple design iterations between various aspects of performance to ensure that all specifications and requirements could be guaranteed over all operating conditions.

Finally, to guarantee that the oscillator possessed a sufficient frequency-tuning range to account for the shift in operating frequency caused by component tolerances, Maxim elected to perform production testing on the devices and guarantee a set of frequency limits. These limits provide MAX2605–MAX2609 users with a guaranteed set of high- and low-frequency tuning limits (f_{MAX} and f_{MIN}), in which passing ICs have a frequency of oscillation (f_{OSC}) $\leq f_{MIN}$ at a tuning voltage (V_{TUNE}) of 0.4V, and $f_{OSC} \geq f_{MAX}$ at $V_{TUNE} = 2.4V$. Assuming an external inductor with $\pm 2\%$ tolerance, including temperature drift, and a small design centering error ($<0.5\%$), this testing guarantees that the VCO always tunes to the operating frequency selected by the inductor, without adjustment of the external inductance value. The result is a trimless VCO design.

MAX2605–MAX2609 applications are highly simplified and easy to understand. Two simple steps are involved:

- 1) Select and implement an external inductance to set the desired oscillation frequency.
- 2) Resistively or reactively match the output stage to the load (**Figure 4**).

The nominal operating frequency (f_{NOM}) desired for the VCO is determined solely by the effective external inductance value at IND (pin 1), as determined by a curve (**Figure 5**).

The inductance value (L_F) required for a desired operating frequency will not necessarily coincide with any of the standard values for surface-mount-technology (SMT) inductors, which typically increase in steps that differ by a factor of approximately 1.2. To achieve the desired value in such cases, the inductance must be constructed from two inductors, L_{F1} and L_{F2} . L_{F1} should be chosen as the nearest standard value below the desired value. Then, choose L_{F2} as the nearest standard value just less than $L_F - L_{F1}$. L_{F1} should adhere to the minimum Q requirements, but L_{F2} can be implemented as a lower cost thin-film SMT type. Because its value is less than 20% of the total, its lower Q has only a small effect on the overall Q.

It is also permissible to adjust the total inductance value by implementing small amounts of inductance with PCB traces. For MAX2608/MAX2609 circuits, the inductance value for L_{F2} is sometimes more precisely implemented as a PCB trace shorted to ground than as an SMT inductor. Once the required inductance value is established at pin IND, the VCO is guaranteed to tune to this oscillation frequency over all component variations, operating temperatures, and supply voltages.

MAX2605–MAX2609 VCOs include a differential output amplifier after the oscillator core. The amplifier stage provides valuable isolation and offers a flexible interface to IF functions such as a mixer and/or a PLL prescaler.

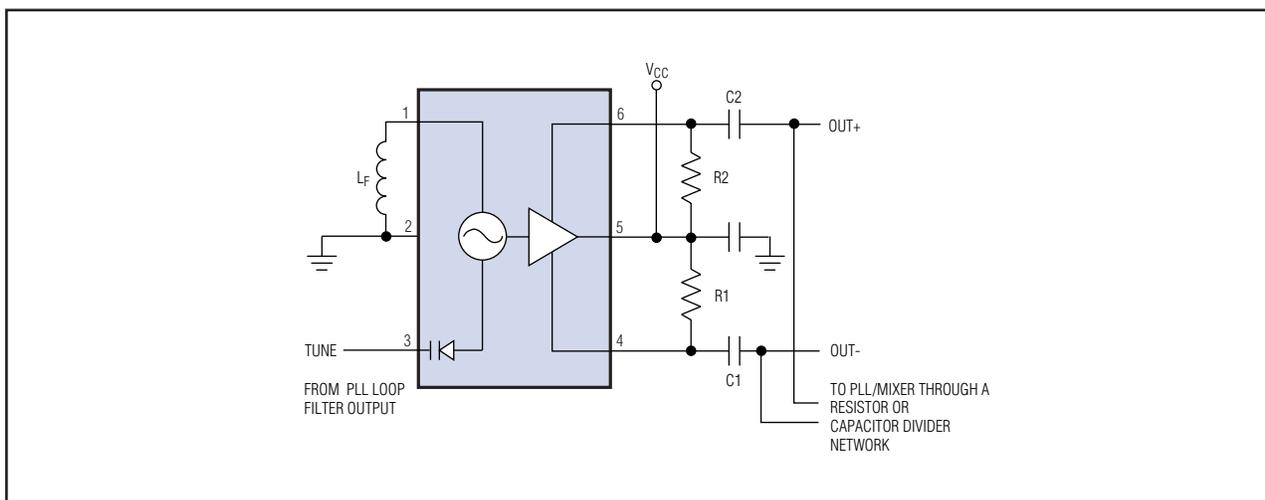


Figure 4. This simple schematic represents a typical application for the MAX2605–MAX2609 VCO IC.

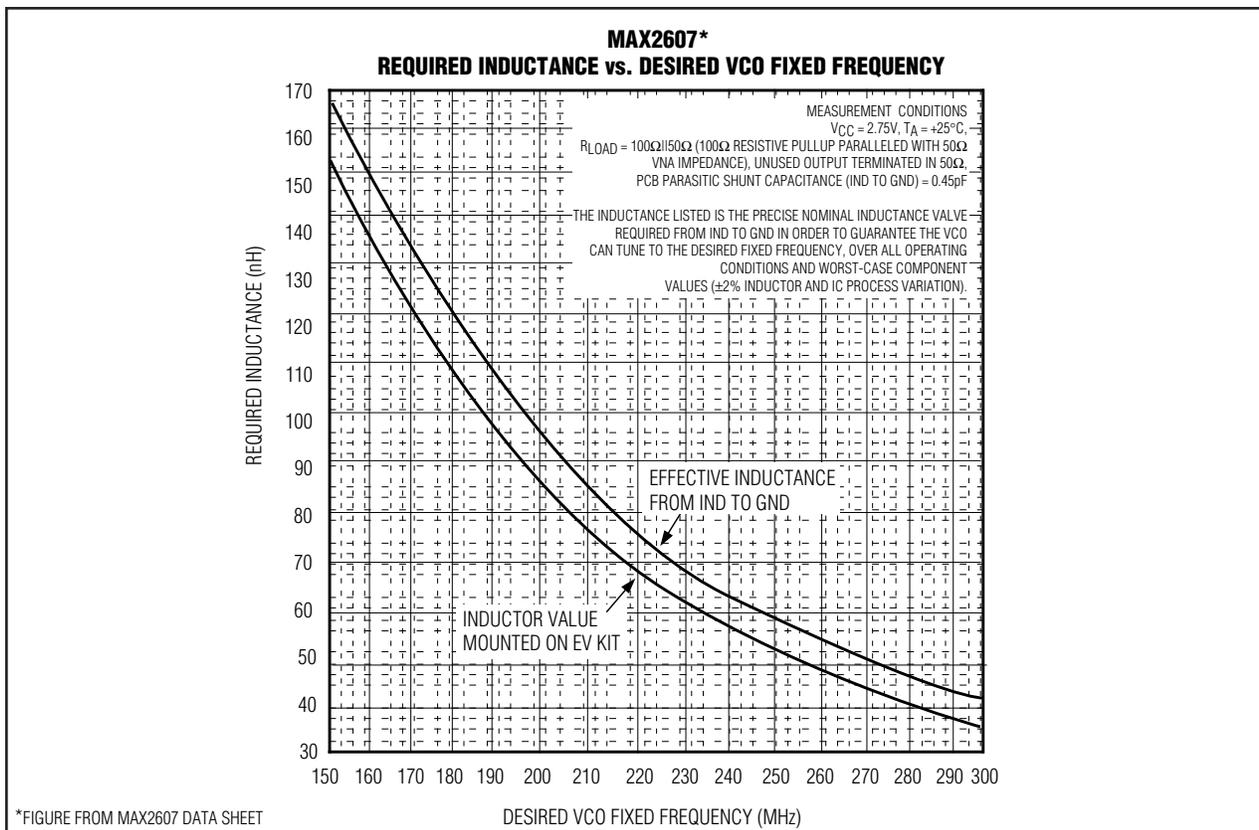


Figure 5. This plot contains values of the required total tuning inductance (L_T) as a function of desired oscillation frequency (150MHz to 300MHz) for the MAX2607 VCO IC.

The output can be taken single ended or differentially, but the maximum output power and lowest harmonic output is achieved in the differential-output mode. Both open-collector outputs (OUT- and OUT+) require a pullup element to the collector voltage (V_{CC}). The output stage may be applied with a pullup resistor or inductor. A pullup resistor is the most straightforward method of forming an interface to the output and works well in applications that operate at lower frequencies or require only a modest voltage swing.

A reactive power match is required for operating frequencies above the 3dB bandwidth of the load-resistance/capacitance network and/or when a greater voltage swing or output power is desired. The matching network is a simple circuit with a shunt inductor and series capacitor. To provide DC bias for the output stage, the inductors are connected from OUT- and OUT+ to V_{CC} , and the series capacitors are connected from OUT- and OUT+ to the load. Values for the inductor and capacitor are chosen according to the operating frequency and load impedance. The output is applied like any conventional differential output. The only constraints are the need for a pullup to V_{CC} and a limit to the voltage swing at OUT- and OUT+.

A comparison of the design time needed to apply each approach reveals a dramatic difference. The classical/discrete approach shown is very design intensive, and the successful development of a discrete IF VCO may require many weeks. Several iterations are likely before reaching a robust, manufacturable design. On the other hand, the MAX2605–MAX2609 let you design the VCO in minutes and then verify and test it in an afternoon!

Because the MAX2605–MAX2609 solve the problems of frequency tuning range, biasing, and startup, they completely eliminate the difficult tasks typically associated with a VCO design. You need only select an external inductance value based on the desired oscillation frequency, and the output load. This task is easily accomplished by reading the desired inductance value from a graph supplied on the MAX2605–MAX2609 data sheet.

In bill-of-materials cost, the MAX2605–MAX2609 are comparable to the traditional discrete IF VCOs. As for manufacturing, Maxim's parts may support even less expensive IF VCOs—as a consequence of having fewer components to place and a \$0.03 savings per component.

Maxim leads the way in ESD protection

Electrostatic discharge (ESD) is often found to be the root cause of equipment failure on the factory floor and in the field. Such failures can be difficult to track down when they masquerade as other types of failures, as they often do. In manufacturing, for instance, the yield loss at final test might be traced to a bad component or subassembly and then (with further investigation) associated with an OEM manufacturing or test process that subjects the part to ESD.

Early field failures and post-installation problems in industrial equipment are often caused by ESD during installation. The most insidious ESD damage is that which degrades the performance of an instrument but (at least initially) does not affect its operation in an obvious way. Such events can cause erratic or nonlinear operation immediately but may not produce a “hard” failure for months or years.

This article explains how to protect your products from ESD. It outlines the standard test methods required by the electronics industry, offers some common techniques to protect against ESD, and highlights some of Maxim’s ESD-protected devices. With careful design, these devices can improve product quality while saving money and your company’s reputation.

Damage potential

A photomicrograph (**Figure 1**) shows the damage sustained by a competitor’s RS-232 interface IC after exposure to an ESD strike of 15kV (a common test level). The result is a gross failure that is easily visible because the overstress actually vaporized metalization on the chip. In other cases, the investigation of invisible failures in the gate-oxide layers or buried layers requires careful removal

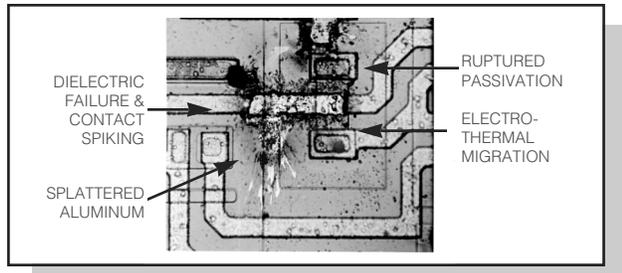


Figure 1. This photomicrograph shows gross ESD damage to an unprotected RS-232 receiver.

of metalization or other layers. ESD strikes can also find paths into the core of an instrument. Somewhat like a lightning strike, ESD will course through the circuit until its energy is dissipated, often with unexpected effects.

Where does high voltage come from?

Mechanically separating two materials creates electrostatic charge. The surfaces of these otherwise neutral materials are electrically double layered to varying degrees, meaning that the outer layer might have a majority of electrons balanced by positive charge in the bulk of the material. Other materials exhibit the opposite surface charge. When materials with opposite surface charges come in contact, a transfer of electrons leaves one material with a net negative charge and the other with a net positive charge. Called triboelectric generation, this effect is the basis of static generation and transfer.

The triboelectric series shown in **Table 1** positions materials like glass and nylon at the positive end and silicon and teflon at the negative end. The materials’ conductivity also affects their ability to build up a surface charge. For many materials, the conductivity or surface resistivity is strongly dependent on humidity. Low humidity promotes low conductivity, which maintains the localized charges by preventing them from moving.

Table 1. Triboelectric series

AIR (MOST POS.)	FUR	SEALING WAX	ORLON
HANDS	LEAD	HARD RUBBER	SARAN
ASBESTOS	SILK	NICKEL, COPPER	POLYURETHANE
RABBIT FUR	ALUMINUM	BRASS, SILVER	POLYETHYLENE
GLASS	PAPER	GOLD, PLATINUM	PVC
MICA	COTTON	SULFUR	KEL-F (CTE)
HUMAN HAIR	STEEL	ACETATE, RAYON	SILICON
NYLON	WOOD	POLYESTER	TEFLON (MOST NEG.)
WOOL	AMBER	CELLULOID	

In the real world, static high voltage is usually produced by the interaction of people and their surroundings. Imagine a person sitting at a formica table in a plastic chair, wearing wool slacks and socks, leather shoes, a cotton shirt, and silk tie. This soup of triboelectric materials defies quantitative analysis, but one can imagine it responsible for some serious charge build-up. Several accepted models describe a charged human body for different situations. The most generic model (**Figure 2**) assumes a 100pF capacitance charged to 15,000V and a 1500Ω series resistance.

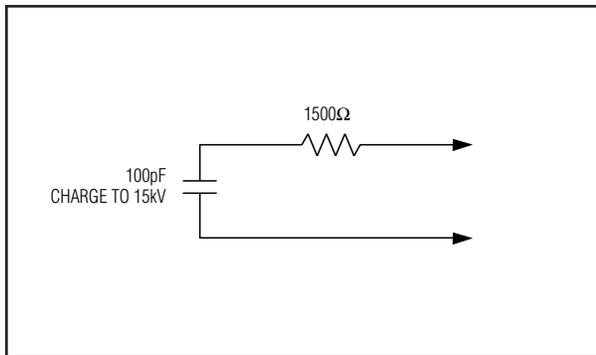


Figure 2. When discharged, this circuit (the Human Body Model) produces a very fast rise time with current peaks of 15kV/1.5kΩ—over 10A!

Test methods and standards

Two methods commonly used for testing the ESD susceptibility of integrated circuits have been adapted for end-equipment testing as outlined in the next section. The oldest method, MIL-STD-883 Method 3015.7, was developed as an aid in understanding the precautions necessary for packaging and handling ICs. This method tests each package pin against other groups of pins and classifies the device according to the lowest voltage for which failure occurs.

The applied signal in this test is a current waveform derived from a circuit called the Human Body Model (Figure 2), which simulates the capacitance and source impedance typical of a human body. Circuit layout is critical because the actual waveform delivered at the IC depends also on parasitic inductance and capacitance associated with the test connections and PC board. The resulting current waveform represents the ESD that occurs when a person touches an object such as an IC.

The other method, which differs from the above only in the values for R and C, was developed by the Electronic Industries Association of Japan (EIAJ). Called IC-121 and based on a circuit called the Machine Model (Figure 3), it applies a current waveform similar to that produced when an IC makes contact with its handling machinery. By mimicking the ESD events caused by charges that accumulate on moving parts, the waveform simulates the static discharges seen during machine assembly.

The two methods are complementary, so you shouldn't choose one over the other. Because ESD can affect ICs during manufacturing, during PC board assembly, and after the end product is put into service, a test based on the Human Body Model and the Machine Model together provides adequate assurance regarding the IC's tolerance for the rigors of manufacturing and product life.

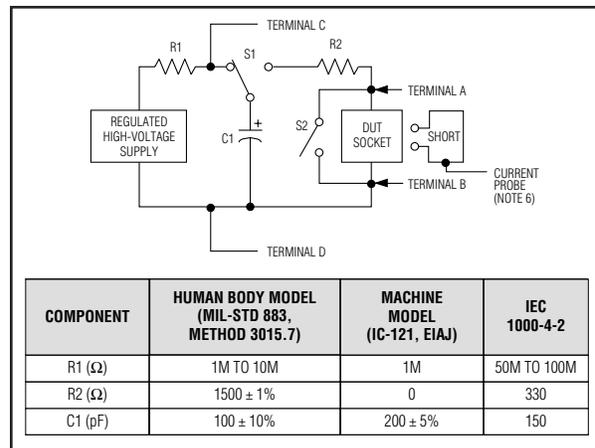


Figure 3. Substituting different component values as shown yields discharge circuits known as the Human Body Model, the Machine Model, and the IEC 1000-4-2 Model (human holding a metallic object).

These two tests are for ICs. Other specific tests govern the exposed interfaces of end equipment. For example, IC pins exposed to the outside world through connectors can encounter ESD even when mounted on a PC board within an enclosure. ESD exposure is less likely for the other pins, which are connected to circuitry on the board.

For this class of IC, a test method such as Method 3015.7 (which tests pin combinations) does not provide an adequate representation of ESD susceptibility for the input/output (I/O) pins. The Machine Model and Method 3015.7, which offer ratings according to the lowest voltage failure on any pin, may not do justice to the higher levels of internal ESD protection required by the I/O pins (and provided by some manufacturers). A device might have I/O pins that withstand ±15kV and non-I/O pins that fail at ±2kV. With the methods described above, the resulting ESD rating could be less than ±2kV. Fortunately, however, better test methods are now available for rating I/O pins.

New ESD tests for I/O ports

An I/O port allows communication with other pieces of equipment. I/O ports for ICs comprise logical groups of pins that give access to equipment external to the system containing the IC. These pins are subject to static discharge and other abuse as operators connect and disconnect cables from the system. For the I/O pins of an external interface IC, an ideal test method for ESD susceptibility should:

- Test the I/O pins only in ways that simulate exposure to ESD events in actual equipment.

- Apply test waveforms that model electrostatic discharges produced by the human body. Different circuit models specify different values of amplitude, rise/fall time, and transferred power.
- Test the IC with and without power applied.
- Define IC failures to include latchup (a momentary loss of operation) as well as catastrophic or parametric failure. Latchup is considered a failure mechanism because, if left undetected, it can lead to reliability problems and system malfunctions.

Two methods—both compliant with the requirements listed—have seen increasing use by equipment manufacturers in testing the ESD susceptibility of I/O ports (Figure 3). The first is a modification of Method 3015.7, MIL-STD-883. It makes use of the same circuit model and waveform as the original method but applies ESD pulses only to the I/O pins of a device. Its intent is to simulate the fault currents seen by an IC installed on a board and operating in the target system. The second method is IEC 1000-4-2, which has become the world standard. It specifies a higher capacitance and lower resistance than that specified in Method 3015.7. IEC 1000-4-2 is universally applied in testing end-equipment interfaces (Table 2). Note that Maxim’s analog switches and RS-232/RS-485 interface ICs comply with these ESD standards, without the need for external components.

Table 2. IEC 1000-4-2 classification of four voltage ranges

IEC 1000-4-2 COMPLIANCE LEVEL	MAX TEST VOLTAGE, CONTACT DISCHARGE (kV)	MAX TEST VOLTAGE, AIR GAP DISCHARGE (kV)
1	2	2
2	4	4
3	6	8
4	8	15

ESD-protection methods

Protecting an interface from ESD damage is the designer’s responsibility. The industry offers a choice of several methods, each with certain strengths and weaknesses. Lots of misunderstanding and black magic surround ESD remedies, and the following discussion is intended to dispel some of that mystery.

Capacitor protection

This method is common in high-volume consumer and automotive equipment. It protects the input pins with a

simple shunt capacitor from input to ground. The idea is that a capacitor of sufficient value will absorb an ESD discharge without exceeding the ESD rating of the attached IC pin. To illustrate, consider an IC pin exposed to the outside world, with an ESD rating of 2kV.

The IEC 1000-4-2 Model specifies a 150pF capacitance charged to 15kV. If a 1500pF capacitance is added to the exposed pin, it will charge to a maximum equal to 1/10 of the test voltage (1.5kV). Because this level is below the IC’s ESD-protection rating, one assumes that all is well. This method is widely used, but it involves a simplistic view of the physics involved. It provides some protection if you exercise extreme care in the circuit layout, provided that the circuit operation is not affected by either the necessary capacitance or parasitic inductance. To emphasize the sensitivity to layout, consider that a 1cm trace on a PC board has about 7nH of inductance. When a 30A current pulse with 1ns rise time (the IEC 1000-4-2 waveform, Figure 4) is applied to 7nH, it produces a voltage spike of 210V for each centimeter of ground path.

Resistor protection

Resistor protection is added in series to the interface pins. This resistance limits peak currents and helps dissipate some of the power in a transient. Similar to capacitor protection, precautions should be taken to ensure that circuit operation is not adversely affected by this increased impedance. Another caveat is that resistors themselves can be ESD sensitive. Metal-film resistors are fabricated with methods similar to semiconductor metalization and often have similar ESD limi-

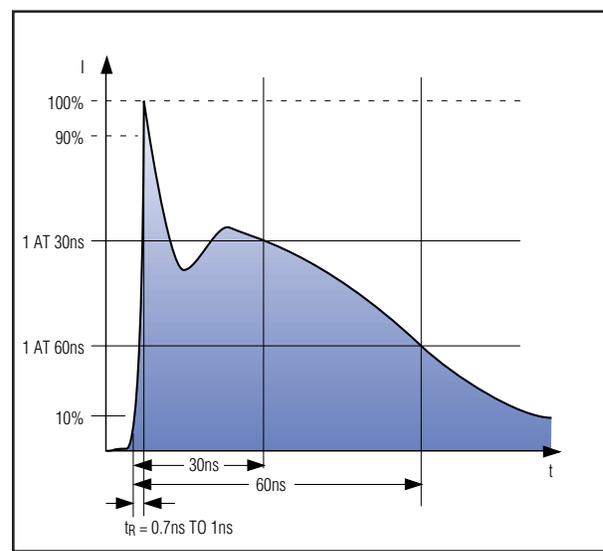


Figure 4. Parameters for this ESD waveform (rise time, peak current, amplitude at 30ns, and amplitude at 60ns) are specified by IEC 1000-4-2.

tations. The parasitic capacitance of these series resistors can also be an issue. A narrow spike, through even a few picofarads, can wreak havoc on an IC input.

Resistor-capacitor protection

This approach is a hybrid of the R and C protection techniques discussed above. Having two components per interface pin consumes PC real estate while increasing costs and decreasing reliability. RC networks are often used for EMI suppression in concert with ferrite beads or feedthroughs.

MOVs and TransZorb™ protection

Adding metal-oxide varistors (MOVs) or silicon avalanche suppressors (TransZorbs) to I/O pins can be very effective. They tend to be expensive, they can be large, and they can add unwanted capacitance to an interface. Similar to capacitor protection, these devices require low-inductance (short) paths to ground.

Layout guidelines for enhancing ESD protection

- Follow standard analog layout techniques, placing all bypass and charge-pump capacitors as close as possible to the IC (interface ICs especially).
- Include a ground plane on the PC board.
- Place the protection or IC as close to the I/O port as possible.

Protection internal to Maxim ICs

Maxim has invested a substantial effort in developing ICs with internal ESD protection. Starting with RS-232 and RS-485 interface ICs, these protected devices now include several analog switches and the MAX681_ family of switch debouncers. All withstand the application of IEC 1000-4-2 ESD events directly to their I/O pins. Maxim believes this is the best way to control ESD in a system. It is robust, readily available, requires no external real estate, and costs less than most alternatives.

Maxim offers a variety of ESD-protected RS-232 interface ICs, representing every useful combination of drivers and receivers. Included are ultra-low-power RS-232 devices incorporating Maxim's AutoShutdown™ feature. Several new innovations have been introduced in the area of ESD-protected RS-232 interface devices this year. For example, single RS-232 receivers and transmitters with full ESD protection in tiny SOT packages (the MAX318_ series) can be real problem solvers in small portable equipment.

*TransZorb is a trademark of General Semiconductor Industries, Inc.
AutoShutdown is a trademark of Maxim Integrated Products.*

Also scheduled for introduction is a unique ESD-protected interface for data cables. Data cables for cellular phones usually include an RS-232 interface in the cable rather than the phone. Thus, ESD protection for this application is required not just on the RS-232 side of the interface IC but on the logic side as well. The MAX3237E is the only IC available that offers a solution to this problem. It offers a complete 5-transmitter, 3-receiver interface (like a modem). Maxim has plans to introduce additional RS-232 interface ICs with this double ESD protection for other applications such as PDA cradles and other phone configurations.

RS-485 interfaces

Maxim is also the leader in ESD-protected RS-485 interfaces. After pioneering the use of ESD protection for such devices, Maxim offers 17 products in this area, with many more on the way. Significant in the last year was the introduction of the MAX3095/MAX3096, which extend Maxim's robust ESD structures and low-power operation to the venerable 26LS32 quad-receiver pinout. Also released in the last year is a full line of 3.3V, ESD-protected, RS-485 interface ICs. Maxim innovations for the MAX348_E family, for example, include ESD protection, fractional unit loads, slew-rate limiting, and low power.

Analog switches

Maxim was the first IC company to recognize the value of ESD protection for analog switches and multiplexers that serve as the interface to external systems in a host of applications for which ESD protection is necessary. First was a series of ESD-protected switches and multiplexers. This series includes several low-voltage ICs with $\pm 15\text{kV}$ ESD protection: an 8-to-1 CMOS analog multiplexer with 4051 pinout (MAX4558), a 4-to-1 CMOS analog multiplexer with 4052 pinout (MAX4559), a triple SPDT switch with 4053 pinout (MAX4560), and an SPST, CMOS analog switch with 4066 pinout (MAX4551).

A second series of devices, in SOT23 packages with $\pm 15\text{kV}$ ESD protection, includes a single SPST-NO switch (MAX4568), an SPST-NC switch (MAX4569), and an SPDT switch (MAX4561).

References

1. Maxim *Engineering Journal* #25, "ESD Protection for I/O Ports."
2. *Electrostatic Discharge Control*, Owen J. McAteer, McGraw Hill. 1989. ISBN 0-07-044838-8.

NEW PRODUCTS

400ksps, multichannel, 10- and 12-bit ADCs offer low-power operation

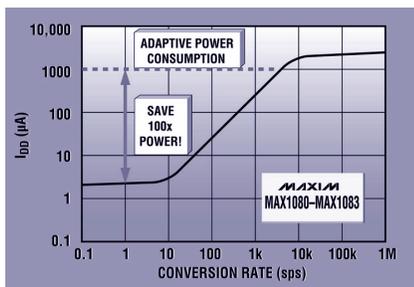
The MAX1280–MAX1287 (12-bit) and MAX1080–MAX1087 (10-bit) analog-to-digital converters (ADCs) offer 1, 4, and 8 channel options and 400ksps sampling rates. Their serial interface connects directly to SPI™, QSPI™, and MICROWIRE™ devices without external logic. Ideal for portable data acquisition and battery-powered applications, these ADCs combine low-power operation (1.5mA at 100ksps), excellent dynamic performance (SINAD > 70dB), and high speed (400ksps) in packages as small as an 8-pin SO.

The analog inputs of these ADCs are software configurable for unipolar/bipolar and single-ended/differential operation. The full-scale analog input range is set by the internal +2.5V reference or by an externally applied reference voltage between IV and VDD. Operating from an analog supply voltage in the +2.7V to +5.5V range, the ADCs draw only 2.5mA at 400ksps. Software power-down modes lower current draw to 1.5mA at 100ksps. At even lower data rates, supply current drops to <10μA.

The MAX1280–MAX1287 and MAX1080–MAX1087 ADCs are available in 8-pin SO packages and 16- and 20-pin TSSOP packages, with prices starting at \$3.88 (1000–up, FOB USA).

SPI/QSPI are trademarks of Motorola, Inc.

MICROWIRE is a trademark of National Semiconductor Corp.



12- and 10-bit ADCs include ±1°C temperature sensor

The MAX1298/MAX1299 and MAX1098/MAX1099 are the first 12- and 10-bit ADCs capable of measuring voltage, local temperature, and remote temperature without additional circuitry. Each includes a ±1°C accurate sensor for local temperature measurement as well as signal-conditioning circuitry that enables the use of diode-connected transistors for remote temperature measurements.

The analog inputs can be configured through the serial interface for temperature measurement, single-ended voltage measurement, and fully differential voltage measurement. In the temperature-sensing mode, internal bias currents pass through either the internal sensor or an external diode-connected transistor. No additional circuitry is required for temperature measurements.

The MAX1099/MAX1299 operate from a single +3V analog supply, and the MAX1098/MAX1298 operate from a single +5V analog supply. Quiescent current is only 250μA, and software power-down modes further reduce the supply current to <10μA at lower sampling rates. All are available in 16-pin SSOP packages, with prices starting at \$2.68 (1000–up, FOB USA).

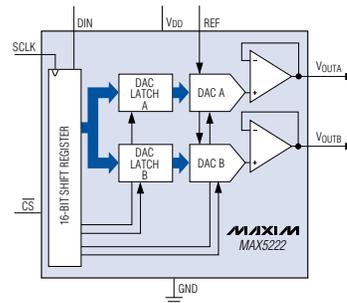
Octal, 13-bit voltage-output DAC has parallel interface

The MAX5270 includes eight 13-bit voltage-output DACs and three separate pairs of differential reference inputs on one monolithic chip. For a reference voltage of +4.096V to GND, the corresponding output voltages have a full-scale range of 0V to +8.192V. The output amplifiers remain stable while driving capacitive loads up to 10,000pF, and the output glitch amplitudes can be as low as 30mV during

Smallest available dual 8-bit DAC fits in SOT23

The MAX5222 contains two buffered, voltage-output, 8-bit DACs in a 3x3mm 8-pin SOT23 that requires 70% less board space than comparable devices in 8-pin SO packages. Operating from a single 2.7V to 5.5V supply, the MAX5222's ultra-low power consumption and small size make it ideal for portable and battery-powered applications. Supply current is <1mA and drops below 1μA in shutdown mode. Shutdown further reduces system power consumption by disconnecting the reference-input pin from the REF pin.

The MAX5222's 3-wire serial interface allows clock rates up to 25MHz. The serial input shift register is 16 bits long (8 bits of DAC input data and 8 bits for DAC selection and shutdown control). DAC registers can be loaded independently or in parallel, at the positive edge of chip select. Both DAC outputs can source and sink 1mA while swinging to within 100mV of ground or VDD. Prices start at \$1.25 (1000–up, FOB USA).



major-carry transitions. The device also offers low output noise (120nV/√Hz) and low DC crosstalk (75μV).

The MAX5270 accepts 13-bit parallel-loaded data from the external bus into one of eight input registers, under the control of WR, CS, and the DAC address pins A0–A2. The DAC outputs are updated upon receipt of new data into the DAC registers. Each DAC output is buffered with a gain-of-two amplifier, into which an external DAC offset voltage can be inserted through the SYSGND pins.

The MAX5270 is available in a space-saving 44-pin MQFP package, with prices starting at \$22.50 (1000–up, FOB USA).

NEW PRODUCTS

Single-supply, 400MHz with disable have ultra-low distortion

The MAX4265–MAX4270 are single-supply, voltage-feedback op amps capable of driving 100Ω loads while maintaining ultra-low distortion over wide bandwidths. They offer an excellent spurious-free dynamic range (SFDR): -88dBc or better below 5MHz and -59dBc at 100MHz (MAX4269). These devices operate from a single +4.5V to +8V supply or dual ±2.25V to ±4.0V supplies. The input voltage noise density is only 8nV/√Hz, making these op amps ideal for high-performance communications and signal-processing applications that require low distortion and wide bandwidth.

Dual 800kHz op amp comes in tiny 8-pin SOT23 package

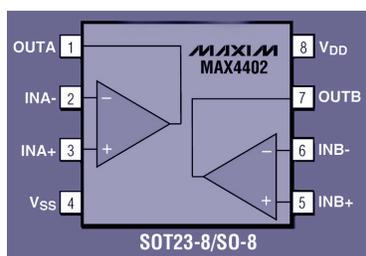
The MAX4402 dual, rail-to-rail op amp in a tiny 8-pin SOT23 package draws only 320μA of supply current per amplifier while achieving an 800kHz gain-bandwidth product. Ideal in space-limited portable and battery-powered applications that require low power without sacrificing bandwidth or gain accuracy, it operates from a single +2.5V to +5.5V supply. Its output architecture is capable of driving a 2kΩ load to within 55mV of both supply rails while maintaining a 110dB open-

The MAX4265 (single) and MAX4268 (dual) are unity-gain-stable amplifiers with gain-bandwidth products up to 400MHz. The single MAX4266 and dual MAX4269 amplifiers provide bandwidths up to 350MHz at a minimum stable gain of +2V/V. The single MAX4267 and dual MAX4270 provide a 300MHz bandwidth at a minimum stable gain of +5V/V. Other features include a 900V/μs slew rate and ±45mA output-driving capability.

For additional power savings, these amplifiers feature a low-power disable mode that reduces supply current and places the outputs in a high-impedance state. The MAX4265/MAX4266/MAX4267 come in a space-saving 8-pin μMAX package, and the MAX4268/MAX4269/MAX4270 come in a 16-pin QSOP. Prices start at \$2.05 (1000–up, FOB USA).

loop gain. The MAX4402 achieves 0.009% total harmonic distortion and is unity-gain stable with capacitive loads up to 400pF.

The MAX4402 is offered in space-saving 8-pin SOT23 and SO packages specified over the automotive temperature range (-40°C to +125°C). Prices start at \$0.45 (100,000–up, FOB USA).



1.8V, rail-to-rail I/O op amps deliver 120dB AvOL and drive 2kΩ loads

The MAX4292/MAX4294 (dual/quad) op amps have Rail-to-Rail® inputs and outputs. Operating from a single +1.8V to +5.5V supply, these op amps are ideal for one- and two-cell, low-power, portable applications. A 100dB power-supply

rejection ratio allows these op amps to be operated directly from a single lithium-ion (Li+) cell or from two to three NiCd, NiMH, or alkaline cells, without producing an excessive output error as the cell voltage decays.

The MAX4292/MAX4294 achieve a 120dB open-loop gain while drawing only 100μA of supply current per amplifier. They achieve a 500kHz gain-bandwidth product, drive 2kΩ loads, and are unity-gain stable for capacitive loads up to 100pF. Superior open-loop gain, excellent

3V/5V, 250MHz ADC buffer amplifiers achieve -87dBc SFDR at 5MHz

The MAX4285–MAX4288 and MAX4387/MAX4388 are single-supply, 250MHz op amps in a space-saving 6-pin SOT23 package. The combination of single 3V/5V operation, wide bandwidth, low -87dBc SFDR (at 5MHz), and fast 6ns settling time (to 0.1%) makes these op amps ideal for use as preamps and drivers for a variety of high-speed, single-supply ADC applications in communications and instrumentation.

These amplifiers operate from a single +2.85V to +6.5V supply or dual ±1.425V to ±3.25V supplies, and their input common-mode range includes ground. They have a large-signal -3dB bandwidth of 200MHz, a slew rate of 350V/μs, and an output current-drive capability up to 100mA. In addition, the MAX4285/MAX4286/MAX4288/MAX4388 have low-power disable modes that reduce supply current and place the outputs in a high-impedance state, making them ideal for multiplexing applications.

The MAX4285/MAX4286 single amplifiers with disable are offered in space-saving 6-pin SOT23 and 8-pin SO packages. The MAX4287/MAX4387 dual amplifiers are offered in 8-pin μMAX and SO packages, and the MAX4288/MAX4388 dual amplifiers (with disable) are offered in 10-pin μMAX and 14-pin SO packages. Prices start at \$0.89 (1000–up, FOB USA).

load-driving capability, and an input offset voltage of 400μV make these amplifiers ideal for use as reference buffers.

The MAX4292 is offered in space-saving 8-pin μMAX and SO packages. The MAX4294 is offered in miniature 14-pin TSSOP and SO packages. Prices start at \$0.23 per amplifier (quad, 50,000–up, FOB USA).

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

NEW PRODUCTS

5MHz, SOT23 op amp features rail-to-rail I/O operation

The MAX4321 op amp combines a 5MHz gain-bandwidth product and excellent DC accuracy with rail-to-rail operation at the output and both inputs. It draws only 650 μ A of quiescent supply current when operating from a single +2.4V to +6.5V supply or dual \pm 1.2V to \pm 3.25V supplies. (Typical operation extends as low as +1.8V or \pm 0.9V.) The MAX4321 remains unity-gain stable with capacitive loads up to 500pF and is capable of driving a 250 Ω load to within 200mV of either rail. Over-driven inputs do not produce an output phase reversal.

A rail-to-rail input common-mode voltage range and output swing make the MAX4321 ideal for low-voltage, single-supply applications. Its low input offset voltage (\pm 1.2mV) and high slew rate (2V/ μ s) make it an excellent choice in signal-conditioning stages for precision, low-voltage data-acquisition systems.

As a low-voltage, pin-for-pin upgrade for the LMC7101, the MAX4321 offers five times the bandwidth, twice the slew rate, and approximately half the input voltage noise density. It comes in a 5-pin SOT23 package specified for the extended-industrial temperature range (-40 $^{\circ}$ C to +85 $^{\circ}$ C), with prices starting at \$0.48 (1000-up, FOB USA).

2 Ω quad SPST analog switches optimized for \pm 5V applications

The MAX4677/MAX4678/MAX4679 quad analog switches exhibit 2 Ω (max) RON when operating with \pm 5V supplies. RON is matched between channels to within 0.3 Ω (max), and is flat (to within 0.4 Ω max) over the specified signal range. Each switch handles rail-to-rail analog signals, and off-leakage current is 0.1nA at +25 $^{\circ}$ C. Ideal in low-distortion applications, these switches are preferred for use in automated test equipment (instead of mechanical relays) because they have low operating power, greater reliability, and require less board space.

The MAX4677 has four NC switches, and the MAX4678 has four NO switches. The MAX4679 has two of each and guarantees break-before-make switching. Operating from a single +2.7V to +11V supply or dual \pm 2.7V to \pm 5.5V supplies, these switches are ideal for use in digital card applications and single-ended 75 Ω systems. All feature a separate logic-voltage input (+2.7V < VL < V+) that allows independence between the logic and analog supplies.

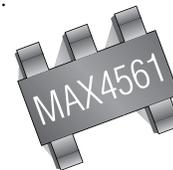
The MAX4677/MAX4678/MAX4679 are available in 16-pin DIP and TSSOP packages, with prices starting at \$1.87 (1000-up, FOB USA).

SPDT/SPST SOT23 analog switches provide \pm 15kV ESD protection

The MAX4561 and MAX4568/MAX4569 are low-voltage, ESD-protected analog switches. The MAX4568's normally open (NO) inputs, the MAX4569's normally closed (NC) inputs, and the MAX4561's single-pole/double-throw (SPDT) inputs are protected against latchup or damage for ESD up to \pm 15kV. Their COM inputs are protected to \pm 2.5kV.

These switches operate from a single +2V to +12V supply. For all, on-resistance (RON) is 70 Ω at 5V (120 Ω at 3V), matched between channels to within 2 Ω (max), and flat (over the specified signal range) to within 4 Ω (max). The switches handle rail-to-rail analog signals, and their off-leakage current is only 0.5nA at +25 $^{\circ}$ C (5nA at +85 $^{\circ}$ C).

When operating with a 5V supply, the digital inputs' 0.8V to 2.4V logic thresholds ensure compatibility with TTL/CMOS logic levels. The MAX4561 comes in a 6-pin SOT23 package, and the MAX4568/MAX4569 come in a 5-pin SOT23 package. Prices start at \$0.75 (1000-up, FOB USA).



Current-sense amplifier/comparator/reference in tiny package simplifies over/undercurrent protection

MAX4373/MAX4374/MAX4375 micro-power devices combine a high-side current-sense amplifier, a reference, and one or two internal comparators in a tiny (3mmx5mm) μ MAX (MSOP) package. By including a reference and comparators for user-programmable thresholds, these

ICs vastly simplify the design of over/undercurrent-protection circuits. The combination of factory-trimmed gain and external sense resistor allows the user to select the full range of measured current. Three factory-trimmed gains are available: +20V/V (T version), +50V/V (F version), and +100V/V (H version).

The MAX4373T/F/H set single-current thresholds; the MAX4374T/F/H and MAX4375T/F/H include an additional comparator to allow for multiple thresholds and over/under thresholds. The second comparator can also monitor a system supply voltage. All devices operate from a 2.7V to 28V supply and achieve 200kHz bandwidths (AV = +20V/V)

while drawing only 60 μ A of supply current. Circuit architecture allows the input common-mode voltage to range from 0V to 28V, independently of the supply voltage. Ground-sensing inputs maintain linearity and keep the output phase from reversing when the input common-mode voltage is near ground. This feature is useful during power-up or power-down transients and during certain input fault conditions.

The MAX4373T/F/H is offered in space-saving 8-pin μ MAX and SO packages. The MAX4374T/F/H and MAX4375T/F/H are offered in 10-pin μ MAX and 14-pin SO packages. Prices start at \$1.15 (1000-up, FOB USA).

NEW PRODUCTS

Low-voltage, High-speed SPST/SPDT analog switches have $RON \leq 4\Omega$

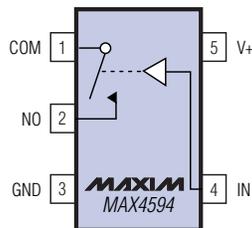
The MAX4641 and MAX4651 families of analog switches operate from a single +1.8V to +5.5V supply. The dual single-pole/single-throw (SPST) MAX4641/MAX4642/MAX4643, single-pole/double-throw (SPDT) MAX4644, and quad SPST MAX4651/MAX4652/MAX4653 switches have 4Ω (max) RON with a 5V supply (8Ω with a 3V supply). The single SPST MAX4645/MAX4646 have 2.5Ω RON with a 5V supply. All products feature RON matched between channels to within at least 0.6Ω and flat to within at least 1Ω over the specified signal range. The switches offer fast switching speeds: $t_{ON} = 18ns$ (typ) and $t_{OFF} = 12ns$ (typ). Off-leakage current is $\leq 0.1nA$ at +25°C, and quiescent power consumption is $\leq 0.01\mu W$. AC characteristics are excellent: $\leq -100dB$ crosstalk at 1MHz, $\leq -80dB$ off-isolation at 1MHz, and 0.018% THD.

The MAX4641 has two normally open (NO) switches, the MAX4642 has two normally closed (NC) switches, and the MAX4643 has one of each. The MAX4645 is a NO switch, and the MAX4646 is a NC switch. The MAX4651 has four NC switches, the MAX4652 has four NO switches, and the MAX4653 has two of each. All MAX4641 family devices are available in a small 8-pin μ MAX package, or a 6-pin SOT23 (MAX4644/MAX4645/MAX4646 only) or 5-pin SOT23 (MAX4645/MAX4646 only), with prices starting at \$0.60 (1000-up, FOB USA). All MAX4651 family devices come in 16-pin SO and TSSOP packages, with prices starting at \$1.20 (1000-up, FOB USA).

10 Ω , SPST CMOS analog switches in SC70 package

The MAX4594–MAX4597 are single-pole/single-throw (SPST) CMOS analog switches that operate from a single +2.0V to +5.5V supply. MAX4594/MAX4596 switches are NO, and MAX4595/MAX4597 switches are NC. MAX4596/MAX4597 pinouts are optimized to provide the highest off-isolation available in an SC70 package.

Each switch guarantees 10Ω (max) RON (5V operation), and 1.5Ω (max) flatness over the analog signal range. All offer low leakage current (0.5nA off-leakage), -80dB off-isolation at 1MHz, 5pC (max) charge injection, and fast switching ($t_{ON} = 35ns$ max, $t_{OFF} = 40ns$ max). MAX4594–MAX4597 switches are available in a 5-pin SC70 package, with prices starting at \$0.53 (1000-up, FOB USA).



Wideband, quad, 2:1 analog multiplexer has 5 Ω RON

The MAX4674 is a low-voltage CMOS analog switch containing four 2:1 multiplexers/demultiplexers. Operating from a single +5V supply, it exhibits a low 4Ω (max) RON . The supply range is +1.8V to +5.5V. RON matching between channels is 0.4Ω , and RON flatness over the specified signal range is 0.8Ω . Off-leakage current is only $0.5nA$ (max) at +25°C.

The MAX4674 handles rail-to-rail signals and offers fast operation ($t_{ON} = 18ns$ and $t_{OFF} = 6ns$). For 1MHz signals, crosstalk is -114dB and off-isolation is -67dB. Package options are the 16-pin QSOP, TSSOP, and narrow SO, with prices starting at \$1.45 (1000-up, FOB USA).

Upstream CATV amplifier outputs 66dBmV

The MAX3509 is a programmable power amplifier for use in CATV upstream applications. It operates in the 5MHz to 65MHz frequency range, requires a single supply, and generates up to 66dBmV QPSK through a 1:1 transformer. Its variable gain is controlled in 1dB steps through a 3-wire serial data bus.

A transmit-disable mode places the MAX3509 in a high-isolation state, shutting down all analog functions to minimize power consumption and output noise between bursts in a TDMA system. (Transmit-disable mode lowers the supply current to 7.8mA.) When entering and leaving this mode, transients are held to 25mV nominal at full gain.

An additional power-down mode (shutdown) disables all circuitry and reduces the supply current below $1\mu A$. The MAX3509 is available in a 20-pin TSSOP-EP package specified for the extended-industrial temperature range (-40°C to +85°C). Prices start at \$4.75

Fast, 4-channel analog multiplexer has 4 Ω RON

The MAX4634 is a fast (30ns t_{ON} , 13ns t_{OFF}), low-voltage (1.8V to 5.5V supply), 4-channel analog multiplexer with 4Ω (max) RON . RON matching between switches is 0.3Ω (max), and RON flatness over the specified signal range is 1Ω (max). Off-leakage current is only $0.1nA$ (max) at +25°C, and each switch handles analog signals in the V+ to ground range. All digital inputs have 0.8V and 2.4V thresholds to ensure TTL/CMOS compatibility.

The MAX4634 comes in a 10-pin μ MAX package, with prices starting at \$0.95 (1000-up, FOB USA).

NEW PRODUCTS

High-power step-up DC-DC converter integrates 10A switch

The MAX1709 step-up DC-DC converter sets a new standard of space savings for high-power devices of its type. Packing a 22m Ω , 10A power MOSFET in a small 16-pin narrow SO package, it delivers up to 4A of output current (20W) when stepping up from 3.3V to 5V. It accepts inputs in the 0.7V to 5V range, and generates either a fixed 3.3V or 5V, or an adjustable output in the 1.25V to 5V range.

For applications that require less than full-power capability, the MAX1709's programmable soft-start and current limiting let you save size and cost by scaling down the external components. Low quiescent power consumption (<1mW) extends the MAX1709 operating time in battery-powered systems. In addition to conventional on/off logic control, two on/off control inputs allow simple push-on/push-off control through a momentary pushbutton switch.

By constraining the switching-noise spectrum to the 600kHz fundamental and its harmonics, the MAX1709's fixed-frequency PWM operation enables easy postfiltering for noise reduction. For even tighter control of the noise spectrum, you can synchronize the clock to an external frequency in the 350kHz to 1MHz range.

Preassembled evaluation kits with recommended components are available to help reduce design time. The MAX1709 is specified for the extended-industrial temperature range (-40°C to +85°C), with prices starting at \$3.57 (1000-up, FOB USA).

12V, low-dropout linear regulators have low 2 μ A I_Q

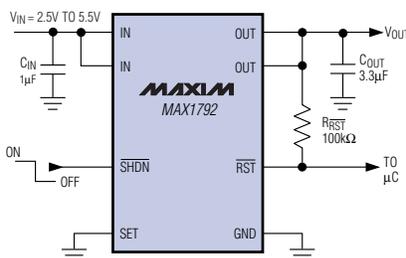
The MAX1725/MAX1726 are linear regulators ideal for low-power applications that demand the longest possible battery life. These devices offer ultra-low supply current (2 μ A) and low dropout voltage. Unlike PNP-based designs, the MAX1725/MAX1726 have PMOS pass elements that

Linear regulator in μ MAX package has 130mV dropout at 500mA

The MAX1792 low-dropout linear regulator (LDO) operates from a 2.5V to 5.5V supply and delivers a guaranteed 500mA load current with low 130mV dropout voltage. The output voltage has high accuracy ($\pm 1\%$). It comes preset to 1.5V, 1.8V, 2.5V, 3.3V, or 5V, or can be adjusted from 1.25V to 5.0V with an external resistor divider.

An internal PMOS pass transistor allows the low supply current (80 μ A) to remain independent of load, making this device ideal for portable battery-operated equipment, such as personal digital assistants (PDAs), cellular phones, cordless phones, base stations, and notebook computers.

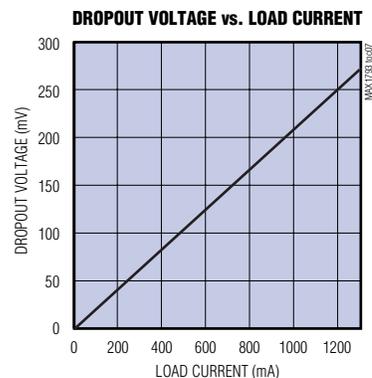
Other features include an active-low, open-drain reset output with 4ms timeout period (indicating when the output is out of regulation), a 0.1 μ A shutdown mode, and short-circuit and thermal-overload protection. The MAX1792 comes in a miniature, 1.3W, 8-pin power- μ MAX package with metal pad underneath. Prices start at \$1.15 (1000-up, FOB USA).



1A linear regulator offers low dropout and low I_Q

The MAX1793 LDO operates from 2.5V to 5.5V and delivers a guaranteed 1A load current with a low 210mV dropout voltage. The high-accuracy output voltage ($\pm 1\%$) is preset to 5V, 3.3V, 2.5V, 2V, 1.8V, or 1.5V, or can be adjusted with an external resistor divider.

An internal PMOS pass transistor allows the MAX1793 to draw only 125 μ A of supply current, making it ideal for use in battery-powered equipment. Shutdown current is 0.1 μ A, and output noise is only 115 μ V_{RMS}. Other features include a built-in reset output, low-power shutdown, and protection against short circuits and thermal overload. The MAX1793 comes in a 1.5W, 16-pin power TSSOP package, which is only 1.1mm high and 30% smaller than a SOT223 package. Prices start at \$1.50 (1000-up, FOB USA).



maintain an ultra-low 2 μ A supply current throughout their operating range, including dropout. Despite their low power consumption, they have tight output accuracy (1.5%), and they achieve good load-transient response with just 1 μ F of output capacitance.

The wide input voltage range of MAX1725/MAX1726 regulators (2.5V to 12V) makes them an excellent choice for systems powered by a 9V battery or by two Li+ cells. The regulators include

protection against reversed batteries, short circuits, and high temperature. Output currents are guaranteed to 20mA.

The MAX1725 output is adjustable from 1.5V to 5V using an external resistor divider, and the MAX1726 comes with its output factory preset to 1.8V, 2.5V, 3.3V, or 5V. Both devices come in a miniature 5-pin SOT23 package, with prices starting at \$0.82 (1000-up, FOB USA).

NEW PRODUCTS

World's smallest power ICs for CDMA handsets

The MAX1798/MAX1799 system power supplies are designed specifically for CDMA cellular/PCS handsets and are compatible with a variety of CDMA chipsets. Each IC includes five low-noise LDOs, a serial interface for controlling and programming the output voltages, a reset timer (140ms min), a watchdog input, optional push-on/push-off power control, and two high-current, open-drain outputs for driving a vibrator motor and/or LEDs. The two devices differ only in their serial interface: the MAX1798 is compatible with the 3-wire SPI interface, and the MAX1799 is compatible with the 2-wire I²C™ interface.

The main regulator output (LDO1) is rated for 300mA, and the other four are rated for 150mA. All are optimized for high

accuracy, high channel-to-channel isolation, low noise, and low dropout voltage. At two-thirds of rated output current, the dropout voltage is 75mV for LDO1 and 50mV for LDO2–LDO5. Each output voltage can be independently enabled, disabled, and programmed (to any of 32 levels from 1.8V to 3.3V) through the serial interface. For added protection, each LDO includes independent current limiting and thermal overload circuitry.

The MAX1798/MAX1799 package—a 2.1W, space-saving 20-pin TSSOP specified for the extended-industrial temperature range (-40°C to +85°C)—makes these devices the most compact available for CDMA handset applications. Prices start at \$2.30 (1000–up, FOB USA). Software and a preassembled evaluation kit (MAX1799EVKIT) are available to help reduce design time.

I²C is a trademark of Philips Corp.

LDOs feature ultra-low IQ and POK

The MAX8880/MAX8881 LDOs have ultra-low supply currents of 3.5μA, yet are capable of delivering up to 200mA. These low-dropout devices operate with inputs up to 12V and feature automatic reverse-battery protection, making them ideal for applications that require long battery life.

Low supply current extends battery life in applications with long standby periods. Unlike PNP-based designs, these maintain ultra-low supply current throughout the operating range and in dropout. They include protection against output short circuits, reverse-battery connections, and thermal overload. An internal power-OK comparator (POK) indicates when the output is out of regulation.

The MAX8880 output is adjustable from 1.25V to 5V using an external resistor divider. The MAX8881 provides factory-preset output voltages of 1.8V, 2.5V, 3.3V, or 5V. Both are available in a miniature 6-pin SOT23 package, with prices starting at \$0.86 (2500–up, FOB USA).

MicroCap, low-dropout linear regulator delivers 1A

The MAX8869 LDO operates from a 2.7V to 5.5V input and delivers a guaranteed 1A load current with 200mV dropout. Its ±1% accurate output voltage level is preset at the factory for 5V, 3.3V, 2.5V, 1.8V, or 1.0V, or is adjustable from 0.8V to 5V using an external resistor divider.

Internal MicroCap™ technology provides stability using only a small 1μF output capacitor. The internal PMOS pass transistor provides exceptionally low 200mV dropout voltage at 1A and suits the device for use in networking and telecom hardware as well as battery-operated equipment. Other features include soft-start capability, low-power shutdown, short-circuit protection, and thermal-shutdown protection. The MAX8869 is available in a 1.7W, 16-pin TSSOP package, only 1.1mm high and 30% smaller than a SOT223. Prices start at \$1.65 (1000–up, FOB USA).

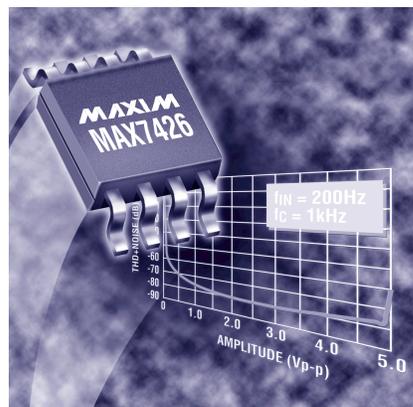
MicroCap is a trademark of Maxim Integrated Products.

Smallest 5th-order filters have lowest power

The MAX7426/MAX7427 5th-order, switched-capacitor, lowpass elliptic filters are available in 8-pin μMAX and DIP packages. The proprietary μMAX package, 80% smaller than an 8-pin DIP, provides the smallest 5th-order switched-capacitor filters available. They operate from a single supply of 5V (MAX7426) or 3V (MAX7427), while drawing only 0.8mA of supply current. While in shutdown, the quiescent current drops to 0.2μA. Low cost, small size, and low power make these filters ideal for cost-sensitive portable equipment that requires post-DAC or anti-aliasing filtering.

The MAX7426/MAX7427 provide 37dB stopband rejection with sharp rolloffs and a 1.25 transition ratio. Corner frequencies are clock tunable from 1Hz to 9kHz (MAX7426) and 1Hz to 12kHz (MAX7427). Two clocking options are available: self-clocking by means of an external capacitor, or external clocking (for tighter control of the cutoff frequency). The offset adjust pin can either null the output offset (4mV typ) or introduce a DC level shift at the output.

The MAX7426/MAX7427 are specified for the commercial (0°C to +70°C) or extended-industrial (-40°C to +85°C) temperature range, with prices starting at \$0.70 (100,000–up, FOB USA).



NEW PRODUCTS

World's smallest Li+ battery charger in SOT23

The MAX1736 is a stand-alone charger for single-cell Li+ batteries. Powered by an inexpensive current-limited wall cube, it operates with an external PFET switch in a gated control scheme that allows the entire charging circuit to remain cool—unlike circuits based on heat-producing linear-mode regulators. It fits in cellular/PCS phone handsets and low-power hand-held equipment, such as PDAs and portable digital-audio players.

The MAX1736 offers better than 0.5% accuracy for battery-regulation voltage. It includes a complete state machine to safely control the charging sequence and an on-board precharge circuit that prevents damage by charging near-dead cells prior to the fast charge. Once the battery-regulation voltage is reached, the cell is topped off using a hysteretic algorithm. This algorithm fully charges the cell while eliminating errors due to series resistance.

To accommodate a variety of wall cubes and other input supplies, the MAX1736 operates with a wide 4.7V to 22V input-voltage range. It automatically detects the presence of an input supply, and if the input power is removed, it automatically powers down to minimize current drain from the battery. A single ENABLE pin permits simple charge control by an optional microcontroller (μ C).

For a similar Li+ charger that includes an LED drive, internal safety counters, and thermistor temperature monitoring, consider the MAX1679 (available in an 8-pin μ MAX package). The MAX1736 comes in a tiny 6-pin SOT23 package specified for the extended-industrial temperature range (-40°C to $+85^{\circ}\text{C}$), with prices starting at \$1.50 (1000-up, FOB USA). A preassembled evaluation kit with recommended external components (MAX1736EVKIT) is available to help reduce design time.

Stand-alone switchmode controller charges Li+ batteries

The MAX1737 switchmode controller charges one to four Li+ cells in series. It provides a regulated charging current and charging voltage, with a total voltage error of only $\pm 0.8\%$ at the battery terminals. An external N-channel switch and synchronous rectifier provide high efficiency for input voltages up to 28V. The built-in safety timer automatically terminates charging when the adjustable time limit has been reached.

Regulation of the voltage set point and charging current is accomplished by two control loops, which work together to effect a smooth transition between voltage and current regulation. To prevent overload of the input supply and enable use of a low-cost wall adapter, an additional control loop monitors and limits the total current drawn from that supply.

The limit for battery-voltage regulation is set between 4.0V and 4.4V per cell, and the number of cells is set from one to four by pin strapping. An external thermistor monitors the battery temperature to prevent charging when this temperature is outside the acceptable range.

An evaluation kit (MAX1737EVKIT) is available to help reduce design time. The MAX1737 is available in a space-saving 28-pin QSOP package, with prices starting at \$2.85 (1000-up, FOB USA).

Low-power watchdog timers come in SOT23

The MAX6369–MAX6374 watchdog timer supervisory circuits are designed to increase system reliability by supervising microprocessor (μ P) activity and detecting code-execution errors. When a system is not operating properly, these devices signal a fault condition by resetting or interrupting the μ P. Low supply current ($5\mu\text{A}$) makes them ideal for battery-operated applications.

These watchdog timers provide 24 pin-selectable timing combinations, and the

Quad voltage monitor requires no external components

The MAX6338 quad voltage monitor is designed to monitor multivoltage systems in telecommunications, networking equipment, storage devices, high-end printers, and computers. When a monitored voltage falls below its preset threshold, the corresponding open-drain output notifies the system by asserting an active-low signal. The monitor deasserts when the input voltage rises above the threshold.

A variety of voltage thresholds and tolerances are available to accommodate the standard logic levels found in today's applications. These preset threshold options include +5.0V, +3.3V, +3.0V, +2.5V, +1.8V, and -5V. User-adjustable options are also available to monitor voltages different than those listed above. Voltages of +5.0V, +3.3V, +2.5V, and +1.8V can be monitored without adding external components.

The internally trimmed thresholds and weak internal pullups to VCC minimize the need for external components. To provide an easy interface to other devices, the four independent open-drain outputs can be overdriven by external voltages ranging from 0V to +5.5V.

The MAX6338 operates from 2.5V to 5.5V and draws only $25\mu\text{A}$ of supply current. It is available in a small 10-pin μ MAX package fully specified over the extended temperature range. Prices start at \$2.50 (1000-up, FOB USA).

watchdog timeout period can be adjusted from 1ms to 60s to accommodate most systems. To allow for full initialization of the system, a startup delay disables the watchdog during power-up or during a change in the watchdog timeout period. Startup delays also range from 1ms to 60s.

The MAX6369–MAX6374 come in an 8-pin SOT23 package and require no external components, making them ideal for use in hand-held instruments and other space-limited systems. Other applications include embedded control systems, industrial controllers, and automotive systems. Prices start at \$0.98 (2500-up, FOB USA)

NEW PRODUCTS

First backup-battery reset ICs with chip-enable gating in SOT packages

The MAX6365–MAX6368 are μ P-supervisory ICs for digital systems that monitor supply rails in the 2.5V to 5.0V range, with $\pm 2.5\%$ reset-threshold accuracy over temperature. When VCC falls below the reset threshold, reset is asserted and maintained for at least 150ms after VCC rises above the reset threshold. If VCC falls below the reset threshold and is also less than the battery backup voltage, the output automatically switches from VCC to the backup battery to power the system RAM and/or real-time clock (RTC). Chip-enable gating write-protects the RAM data during these conditions.

These ICs are the first such devices with chip-enable gating available in SOT packages, which are approximately 70% smaller than alternative packages. Miniature packages and low supply current (10 μ A) make the parts ideal for portable applications. All devices are available with a push-pull active-low reset output, open-drain active-high reset output, or open-drain active-low reset output. Additional functionality includes a manual-reset input (MAX6365), watchdog input (MAX6366), battery-on output (MAX6367), and auxiliary-reset input (MAX6368). Available in an 8-pin SOT package, they draw only 10 μ A of supply current. Prices start at \$1.88 (2500–up, FOB USA).

New SC70 power-on reset ICs include manual reset

The MAX6711/MAX6712/MAX6713 μ P supervisory circuits monitor supply rails of 2.5V to 5V in μ P and digital systems. Available in the miniature 4-pin SC70 package (half the size of a SOT package), they reduce cost by eliminating external components and adjustments. Each device also includes a debounced manual-reset input.

Tiny, ultra-low-power SC70 voltage detectors ideal for portable equipment

The MAX6375–MAX6380 voltage detectors monitor battery, power-supply, and regulated system voltages. Each detector contains a precision bandgap reference, comparator, and internally trimmed resistors that set specified trip threshold voltages. By monitoring nominal system voltages from +2.5V to +5.0V without the need for external components or adjustments, they also provide excellent circuit reliability and low cost.

The voltage detectors are differentiated by their output logic configurations and preset voltage thresholds. The MAX6375/MAX6378 (push-pull) and MAX6377/MAX6380 (open-drain) devices have active-low outputs. The MAX6376/MAX6379 have active-high push-pull outputs. The MAX6375/MAX6376/MAX6377 provide voltage thresholds between 2.20V and 3.08V, in approximate increments of 100mV. The MAX6378/MAX6379/MAX6380 have voltage thresholds between 3.30V and 4.63V in approximate 100mV increments.

Ultra-low supply current (500nA) makes the MAX6375/MAX6376/MAX6377 ideal for use in portable equipment. All six devices are available in a miniature SC70 package, with prices starting at \$0.90 (2500 or 10,000 piece minimum, FOB USA).

These ICs feature 2.5% reset-threshold accuracy over temperature. When supply voltage declines below the device threshold, the device asserts a reset signal and maintains it for at least 140ms after VCC returns above the reset threshold (or until the manual reset is deasserted). The MAX6711 has a push-pull active-low reset output, the MAX6712 has a push-pull active-high reset output, and the MAX6713 has an open-drain active-low reset output. These ICs draw only 12 μ A supply current, and the reset outputs are guaranteed valid to 1.0V.

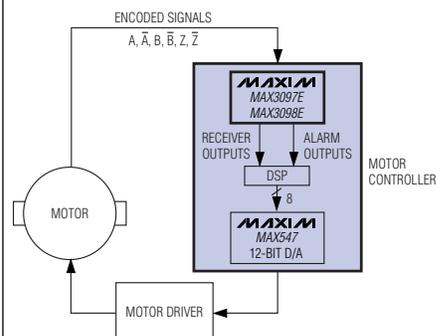
Prices start at \$0.98 (2500 or 10,000 piece minimum, FOB USA).

Triple RS-485 receivers include fault detection and ± 15 kV ESD protection

The MAX3097E/MAX3098E triple RS-422/RS-485 receivers target motor-control applications. Each receiver has an independent alarm output that warns of fault conditions at the receiver inputs. This alarm is asserted when the receiver inputs are shorted, open, out of their common-mode range, or have a low differential voltage. The MAX3097E and MAX3098E (A and B grades) differ in the accuracy of their differential fault thresholds. The devices also feature capacitor-programmable, delayed-alarm outputs to ensure error-free fault detection even at slow transition rates.

The MAX3097E/MAX3098E operate from a single 3.0V to 5.5V supply and guarantee data transfers up to 32Mbps. To ensure compliance with strict international ESD requirements, the receiver inputs are ESD protected up to ± 15 kV using the IEC 1000-4-2 Air-Gap Discharge method, to ± 8 kV using the IEC 1000-4-2 Contact Discharge method, and to ± 15 kV using the Human Body Model.

MAX3097E/MAX3098E devices are available in space-saving 16-pin QSOP, SO, and DIP packages specified for the commercial and extended temperature ranges. Prices start at \$3.56 (1000–up, FOB USA).



NEW PRODUCTS

Complete 3.3V multiprotocol chipset supports V.10, V.11, V.28, and V.35 protocols

The MAX3170, MAX3171/MAX3173*, and MAX3172/MAX3174* form a multiprotocol chipset. This chipset is ideal for networking applications, such as switches and routers, that require compatibility with many different protocols from a single connector. The chipset provides pin- and software-selectable DCE and DTE ports compatible with protocols such as V.10, V.35, V.28 (RS-232), and V.11 (RS449/V.36, EIA530, EIA530-A, X.21). In addition to these standards, the devices have undergone compliance testing performed and verified by an outside test facility and compatible with the NET1, NET2, TBR-1, and TBR-2 telecommunication standards.

Single +3.3V supply operation makes this chipset ideal for low-voltage systems. The MAX3170 is a 3Tx/3Rx transceiver for

transmitting high-speed clock and data signals: to 10Mbps in V.11 or V.35 modes, and to 240kbps in V.28 mode. The MAX3171/MAX3173 are also 3Tx/3Rx transceivers, but they transmit lower speed control signals. The MAX3172/MAX3174 contain five termination networks designed for use with the MAX3170, plus a fourth transceiver for transmitting control signals.

The MAX3171/MAX3172 receiver inputs have 10 μ s deglitching circuitry that enables unterminated operation. All devices have true fail-safe receiver inputs that guarantee logic high outputs when the bus is idle or when the inputs are open or shorted. The MAX3170, MAX3171/MAX3173, and MAX3172/MAX3174 are available in a 28-pin SSOP package, with prices for the complete 3-piece chipset starting at \$18.33 (1000-up, FOB USA).

*Future product

1 μ A, 460kbps, RS-232-compatible transceiver has ESD protection to \pm 15kV

The MAX3314E is a \pm 5V powered transceiver compatible with the EIA/TIA-232 standard. Its flow-through architecture features one transmitter and one receiver, protected to \pm 15kV using IEC 1000-4-2 Air-Gap Discharge, to \pm 8kV using IEC 1000-4-2 Contact Discharge, and to \pm 15kV using the Human Body Model.

The transmitter's low-dropout output stage provides \pm 3.7V (min) RS-232-compatible output levels, while driving a load of 3k Ω and 1000pF at 460kbps. Supply voltages of +5V and -5V must be provided externally. The MAX3314E's SHDN input enables an external signal to disable and three-state the transmitter (receiver remains active), while reducing the supply current to 1mA. The MAX3314E is available in 8-pin μ MAX and SO packages, with prices starting at \$1.18 (1000-up, FOB USA).

16-bit signal conditioner for smart sensors operates at 2.4V

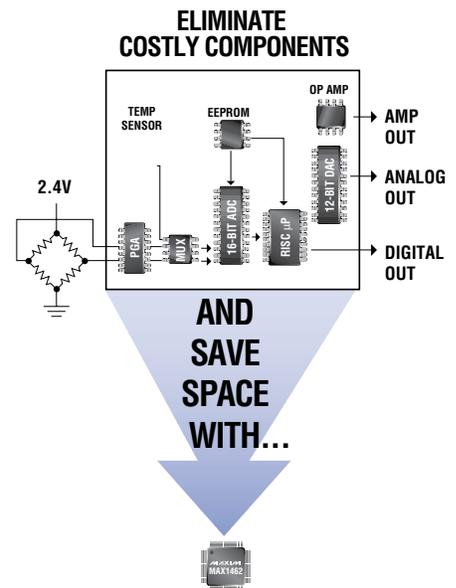
The low-power MAX1462 is a highly integrated, 16-bit signal conditioner for smart sensors, capable of digitally correcting sensor outputs over a wide temperature range. It operates at 2.4V and draws only 310 μ A of supply current.

Internal to the chip is an RISC μ P, EEPROM, 16-bit ADC, 12-bit DAC, programmable-gain amplifier (PGA), temperature sensor, and auxiliary op amp. To produce the conditioned output, the DSP combines the digitized input signal, temperature-sensor output, and user-programmed calibration coefficients stored in the internal EEPROM. The result is available both as a 12-bit digital word and as a ratiometric analog voltage generated by the internal 12-bit DAC. The uncommitted op amp can be used for filtering the analog output or implementing a 2-wire, 4-20mA transmitter. The high-precision front end,

which includes a 16-bit ADC, 2-bit PGA, and 3-bit coarse-offset DAC, resolves differential input signals below 1 μ V.

The MAX1462 is perfect for hand-held, low-power applications such as pressure sensors, humidity sensors, and smart batteries. It is readily adaptable for use in automotive, industrial, and medical applications as well. Test features built into the MAX1462 are designed to automate and integrate the pretest, calibration, compensation, and final-test operations of traditional sensor manufacturing. By eliminating manual calibration methods, the device saves significant manufacturing costs.

A dedicated cell library of more than 500 sensor-specific functional blocks enables Maxim to quickly customize the MAX1462 for unusual requirements associated with high-volume applications. The MAX1462 is available in a space-saving, 9mmx9mm 48-pin TQFP package. Prices start at \$6.50 (1000-up, FOB USA).



NEW PRODUCTS

Current-limiting hot-swap controllers include autoretry and DualSpeed/BiLevel fault protection

The MAX4271/MAX4272/MAX4273 ICs make up a complete family of integrated 3V to 12V hot-swap controllers. They enable safe insertion and removal of circuit cards from a live backplane. Because the circuit card's discharged filter capacitors provide a low impedance to the live backplane, high-level inrush currents from backplane to circuit card can burn up connectors and components, or cause a system reset by momentarily collapsing the backplane power supply. By regulating inrush current to a preset limit, these hot-swap controllers allow the system to stabilize safely.

After the startup cycle is completed, two internal comparators provide DualSpeed/BiLevel™ protection against short circuits, load glitches, and overcurrents. The ICs respond to faults by disconnecting the load. They handle fault recovery by unlatching (MAX4271), autoretry (MAX4272), or programming methods (MAX4273).

Additional features include an internal charge pump that provides gate drive for an external N-channel FET, startup current regulation, and current-glitch protection. Open-drain status outputs indicate fault conditions.

The MAX4271 with latched fault protection and the MAX4272 with autoretry fault protection are available in a space-saving 8-pin SO package, and the full-function MAX4273 comes in 16-pin QSOP and SO packages. All devices are specified for the extended-industrial temperature range (-40°C to +85°C) and have an absolute maximum rating of 15V for extra protection against inductive kickback during board removal. Prices start at \$1.95 (1000-up, FOB USA).

DualSpeed/BiLevel is a trademark of Maxim Integrated Products.

Low-voltage SIM/smart-card level translators in μ MAX package

The MAX1840/MAX1841 are level translators for smart cards and subscriber identity modules (SIMs). They provide level shifting and protection against ESD for SIM and smart-card ports. The devices integrate two unidirectional level shifters for the reset and clock signals, a bidirectional level shifter for the serial data stream, and ± 10 kV ESD protection for all card contacts.

The MAX1840 SHDN control input aids insertion and removal of SIM and smart cards, and the MAX1841 system-side data

driver supports system controllers that lack open-drain outputs. Logic-supply voltage ranges are 1.4V to 5.5V for the controller side and 1.7V to 5.5V for the card side. Total supply current is 1.0 μ A. Both devices shut down automatically when either supply voltage is removed. For a complete SIM card interface, combine the MAX1840 or MAX1841 with the MAX1686H regulated charge pump, which provides 0V, 3V, and 5V outputs.

The MAX1840/MAX1841 are compliant with GSM test specifications 11.11 and 11.12. They are available in an ultra-small 10-pin μ MAX package that is only 1.09mm high and occupies half the area of an 8-pin SO. Prices start at \$1.55 (1000-up, FOB USA).

3.3V smart regulator for PCI-compliant NICs requires only 1 μ F output capacitor

The MAX1810 smart regulator is suitable for use in Ethernet network interface cards (NICs), modem cards, and other devices compliant with peripheral component interconnect (PCI) components. The MAX1810 delivers an uninterrupted 3.3V, with output currents up to 500mA, from a 5V main supply, a 5V standby supply, or a 3.3V auxiliary supply. When the main and standby supplies both drop below 4.1V, an internal switch connects the PCI system's 3.3V auxiliary input to the MAX1810

output. Low resistance in this internal switch (only 0.18 Ω) minimizes voltage drop from the auxiliary supply.

The main and standby inputs generate the 3.3V output through CMOS linear regulators that feature excellent line and load regulation. Their stability is guaranteed by a 1 μ F ceramic output capacitor, and the short-circuited output current is limited to 900mA. Thermal-overload protection turns the MAX1810 off when the chip temperature exceeds +170°C. Special circuitry also prevents a flow of reverse current from the output to any inactive or low-voltage input.

The MAX1810 is available in a compact, high-power (capable of dissipating 0.9W), 8-pin SO package specified for the extended-industrial temperature range (-40°C to +85°C). Prices start at \$1.25 (1000-up, FOB USA).

Low-dropout, 20ppm/°C SOT23 references deliver 5mA and require no output capacitors

The MAX6061-MAX6067 family of three-terminal, series-mode precision voltage references can save board space by operating without an output capacitor. Otherwise, they remain stable with output/load capacitors as high as 1 μ F. These seven new devices have output

voltages of 1.250V, 2.048V, 2.500V, 3.000V, 4.096V, 4.500V, and 5.000V. Each is available in two grades of output temperature coefficient (20ppm/°C or 30ppm/°C), with initial accuracy grades of 0.2% and 0.4%.

Quiescent supply currents are low (90 μ A) and virtually immune to voltage variations, making these SOT23 voltage references ideal for battery-powered instruments. Usable as precision voltage regulators, the MAX6061-MAX6067 references can source 5mA of load current and sink 2mA. Prices start at \$1.35 (1000-up, FOB USA).

NEW PRODUCTS

3-pin SC70 voltage references are smallest available

The LM4040/LM4041 are shunt-mode, 2-terminal precision voltage references. Ideal for space-critical portable applications, they fit in a 3-pin SC70 package that requires 40% less space than the already tiny 3-pin SOT23 package.

Advanced design ensures stability with any capacitive load, yet also ensures ease of use by eliminating the need for an external stabilizing capacitor. For an LM4041-1.2, the minimum operating current is 60 μ A, and the maximum is 12mA.

To ensure that the prime (A grade) parts have an accuracy better than $\pm 0.1\%$ at +25°C, the reference voltage is trimmed during wafer sort using fuse and zener-zap techniques. Each device offers four grades (A, B, C, and D). The highest (A grade) has 0.1% initial accuracy, B grade has 0.2%, and C grade has 0.5%. All have a 100ppm/°C tempco guaranteed from -40°C to +85°C. The low-cost D-grade devices have 1% initial accuracy with 150ppm/°C tempco.

The LM4041 has a fixed breakdown voltage of 1.225V, and the LM4040 versions have breakdown voltages of 2.048V, 2.5V, 3.0V, 4.096V, and 5.0V. Prices start at \$0.45 (1000-up, FOB USA)

2.7Gbps multiplexer/buffer simplifies redundant systems

The MAX3781 dual multiplexer/buffer is used in redundant high-speed serial data paths. Each half of the dual part provides a 1:2 buffer for creating duplicate output-data paths, and a 2:1 multiplexer for selecting from two alternate input-data paths. This capability makes the device ideal for implementing redundancy in

serial-backplane and system-interconnect applications up to 2.7Gbps.

Low total output jitter (only 15ps) preserves data integrity. Signal output levels are 1600mV (typ) for inputs as low as 200mV. The MAX3781 operates with a 3.3V power supply and has a power-down mode that disables unused buffer outputs.

The MAX3781 dual multiplexer/buffer comes in a compact 48-pin TQFP package and has on-chip terminations at all ports compatible with 50 Ω transmission lines. Prices start at \$6.49 (1000-up, FOB USA).

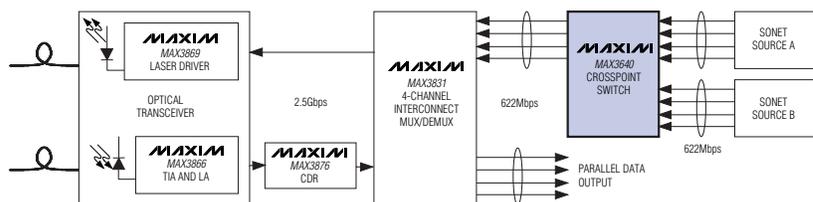
Dual 3.3V, 622Mbps, 4:2 crosspoint switch enables flexible interconnections

The MAX3640 is a 3.3V dual-path crosspoint switch for use at OC-12 (622Mbps) data rates. It can receive and transmit 622Mbps LVDS signals across a backplane with minimum jitter accumulation. The device offers signal-path redundancy for critical data streams, making it ideal for SONET/SDH backplanes, digital crossconnects, and high-speed parallel links.

Each path in the MAX3640 incorporates input buffers, multiplexers, a 2x2 cross-

point switch, and output drivers. The four output channels have redundant outputs for test or fanning purposes. When four output channels have been deselected, the output drivers power down to reduce power consumption by 165mW—a unique power-saving feature. Power consumption with four output channels enabled is only 257mW. A fully differential architecture ensures minimum crosstalk, signal skew, and jitter accumulation. The MAX3640 exhibits only 2.8psRMS random output jitter and 42ps deterministic output jitter.

The MAX3640 is available in a 48-pin TQFP package and operates from a 3.3V supply over a temperature range of 0°C to +85°C. Prices start at \$9.99 (1000-up, FOB USA). An evaluation kit is available.



First SOT23 dual-temperature comparators need no external components

The MAX6505-MAX6508 family of dual thermal comparators is the latest addition to an industry-leading line of temperature switches. These ICs are the smallest and lowest power dual-temperature switches available.

Combining two temperature comparators on a single chip, each device simplifies the incorporation of reliability-enhancing temperature-control, protection, and warning functions in a system. Because temperature thresholds are preset at the factory, no external components are required to set the temperature trip points. Each device asserts an ALARM when the temperature exceeds the factory-set trip temperature. The MAX6505/MAX6506 also have a WARN output. Trip temperature for the WARN output is pin selected by the user to equal 5°C, 10°C, 20°C, or 30°C below the ALARM trip temperature.

The MAX6507/MAX6508 also have two logic outputs, OK and OVER. OK indicates whether the device temperature falls within the range bounded by the factory-set upper and lower trip temperatures. OVER indicates when temperature exceeds the upper trip temperature.

MAX6505/MAX6507 outputs are open drain, and MAX6506/MAX6508 outputs are push-pull. All four devices come in a 6-pin SOT23 package and operate from a +2.5V to +5.5V supply. Prices start at \$0.79 (1000-up, FOB USA).

NEW PRODUCTS

3.3V quad-port bypass IC operates at 2.125Gbps/1.063Gbps

The MAX3752 quad-port bypass IC consists of four serially connected port-bypass circuits (PBCs) and a repeater that provides clock and data recovery (CDR). It operates with a single 3.0V to 3.6V supply and is designed for use in the Fibre Channel Arbitrated Loop topology.

The port-bypass circuits allow connection to as many as four Fibre Channel L-ports, each of which can be enabled or bypassed through the PBC-select inputs. Additional quad PBCs can be cascaded in applications that require more than four L-ports. To minimize the external parts count, all signal inputs and outputs have internal termination resistors compatible with 75 Ω transmission lines.

The MAX3752 complies with the Fibre Channel jitter-tolerance requirements and is capable of recovering data signals with up to 0.7 unit intervals (UIs) of high-frequency jitter. When not needed, the repeater can be disabled to reduce power consumption. Frequency-lock indication is provided by a fully integrated phase-locked loop (PLL), which does not need an external reference clock.

The MAX3752 is optimized for 2.125Gbps or 1.063Gbps operation. It is packaged in a 48-pin TQFP-EP (with exposed paddle), and prices start at \$11.00 (1000-up, FOB USA).

Tiny chip-scale power amplifier for Bluetooth Class I applications

The MAX2240 is the first power amplifier (PA) designed specifically for Bluetooth radios and is also the smallest such PA available for Bluetooth Class I radios. The 2.4GHz, 100mW device comes in a 0.5mm pitch, 9-pin (3x3 array) ultra-chip-scale package (UCSP)—the latest technology in RFIC packaging. It occupies only 16% of the space required by the 8-pin MSOP package of competitive devices. Its +20dBm output power allows the user to extend radio link range to 100 meters, a capability ideal for notebook PCs, cellular phones, and other Bluetooth devices operating in changing environments.

The MAX2240 is also suitable for use in HomeRF, 802.11 FHSS, and other 2.4GHz proprietary ISM-band radio applications. Its digital power-control function, a unique feature in the marketplace, allows the user to reduce transmit power in four 6dB steps, down to +4dBm or less, as required in Bluetooth Power Class I specifications. The MAX2240 features an integrated 50 Ω input match that further reduces the external component count and required board space.

The MAX2240 operates on a single 2.7V to 5.0V supply and draws only 105mA. A 1 μ A low-power shutdown mode helps to reduce power consumption and extend battery life. Prices start at \$1.75 (1000-up, FOB USA). A fully assembled evaluation kit (MAX2240EVKIT) is available to help reduce design time.

Dual-band SiGe LNA/mixer ICs offer adjustable gain and high linearity

The MAX2320–MAX2324 and MAX2326/MAX2327 SiGe ICs comprise high-performance receiver front ends that set new industry standards for low noise and high linearity at low supply current. Features include an LO frequency doubler (MAX2321), LO frequency divider (MAX2326), LO output buffers, adjustable gain settings for the dual low-noise amplifiers (LNAs), and a low-current paging mode that extends the handset standby time.

All devices operate with a single 2.7V to 3.6V supply, with a 0.1 μ A standby current. One operates at cellular frequencies, one at PCS frequencies, and four at both cellular and PCS frequencies (see the *Product Selector Guide* available from Maxim). To minimize intermodulation and crossmodulation in the presence of large interfering signals, each device includes an LNA with high input third-order intercept point (IIP3). The LNA is bypassed in low-gain mode to provide a higher cascaded IIP3 at lower current. Each device provides a low-current, high-gain mode for paging.

Internal CDMA mixers for the cellular and PCS bands have high linearity, low noise, and differential IF outputs. The FM mixers, designed for lower current, have single-ended outputs. All devices come in a 20-pin TSSOP-EP (with exposed paddle), specified for the extended-industrial temperature range (-40 $^{\circ}$ C to +85 $^{\circ}$ C). Prices start at \$3.00 (1000-up, FOB USA).

Miniature VCOs suit 45MHz to 650MHz applications

The MAX2605–MAX2609 family of miniature VCOs is designed for IF and RF applications such as cellular phones, wireless LANs, cordless phones, and other equipment requiring a fixed oscillator frequency between 45MHz and 650MHz.

Unlike discrete designs, which require up to 15 components and long design times, the MAX2605–MAX2609 are simple to use and require only one external inductor to set the oscillation frequency.

MAX2605–MAX2609 VCOs integrate varactors, core transistors, bias circuitry, coupling capacitors, and a differential output buffer in a miniature 6-pin SOT23 package, offering ease of use, a small footprint, and low cost. The internal

varactor's tuning range is factory tested to guarantee startup and proper operation over temperature. Depending on the operating frequency, these devices draw between 2.1mA and 3.7mA of supply current and achieve between -112dBc/Hz and -107dBc/Hz phase noise (at 100kHz offset from the carrier). Prices start at \$0.83 (1000-up, FOB USA).

NEW PRODUCTS

1.8GHz to 2.5GHz direct-conversion receivers simplify wideband WLL designs

MAX2700/MAX2701 ICs are the first available direct-conversion receivers designed for wideband wireless local-loop (WLL) systems. (This architecture allows single-chip integration by eliminating the IF SAW filter, RF downconverter, and IF VCO components.) Direct conversion (zero-IF) architectures reduce cost and component count by eliminating one or two of the frequency downconversions typically found in today's superheterodyne systems. They also improve system reliability and manufacturing yield—two key factors in lowering the cost of WLL subscriber equipment. When combined with MAX2720/MAX2721 direct I/Q transmitters, they form a complete chipset for WLL systems operating in the 1.8GHz, 1.9GHz, 2.1GHz, 2.3GHz, and 2.4GHz frequency bands, with channel bandwidths exceeding 50MHz.

The MAX2700 is optimized for operation in the 1.8GHz to 2.1GHz band, and the MAX2701 is optimized for the 2.1GHz to 2.5GHz band. Both receiver ICs include three main blocks: LNA, quadrature downconverter, and baseband variable gain amplifiers (VGAs). The LNA provides 17dB gain, 2.3dB noise figure, and +4dBm input IP3 at 2.4GHz. (High

input IP3 helps minimize cross modulation and gain compression due to high-level RF interference.)

The quadrature downconverter consists of two highly linear double-balanced mixers driven by an external LO, a selectable LO doubler, and a wideband LO quadrature generator. The double-balanced mixers are optimized for high input IP2, IP3, and minimum added noise. The MAX2701 provides a mixer input IP2 of +38dBm and an IP3 of +6dBm. The high input IP2 helps to minimize desensitization in the receiver, caused by in-band AM-modulated high-level interferers.

The two baseband VGAs in each channel provide 80dB of total maximum gain and >60dB of gain control. External lowpass filters connected in the baseband interstages provide the necessary channel selectivity. Integrated into the MAX2700/MAX2701 is an amplitude/gain-correction loop, which guarantees the match between I and Q channel amplitudes to be <0.7dB.

The MAX2700/MAX2701 are also suitable for 2-way MMDS and 2.4GHz ISM wideband systems. Both ICs are available in a small 48-pin TQFP package with exposed paddle, which optimizes high-frequency performance. Prices start at \$4.95 (1000-up, FOB USA). A fully assembled evaluation kit (MAX2700/MAX2701EVKIT) is available to help reduce design time.

GPS receiver IC provides <0.5 meter accuracy and 5ns timing resolution

The MAX2740 GPS receiver IC offers the best timing resolution (5ns) and the most competitive positional accuracy (<0.5 meter) in the industry. Typical GPS receivers offer 300ns timing resolution and positional accuracy >1 meter.

The MAX2740 is a complete GPS/GLONASS receiver from antenna to digitizer input. It allows the use of a multi-level digitizer for high receiver sensitivity

and good immunity to in-channel jammers. Including all filter losses, the total receiver gain is >100dB, with >50dB of automatic gain-control range. Requiring minimal external components, the MAX2740 with its unique frequency plan is suitable for use in joint GPS/GLONASS receivers.

An RF-only multichip module and several complete modules that incorporate the MAX2740 are available through Parthus, Ltd. (See www.parthus.com.) MAX2740 devices come in a small 48-pin TQFP package with exposed paddle, which provides optimum high-frequency performance. Prices start at \$13.90 (100-up, FOB USA).

Tiny, 900MHz SiGe LNA offers variable IP3 and gain-step control

The 900MHz MAX2642/MAX2643 are the world's smallest SiGe LNAs. The first available in a tiny 6-pin SC70 package measuring only 2.0mmx2.1mm, they also pack the most features in a 6-pin package: variable IP3, gain-step control, and low-power shutdown. Variable IP3 and gain-step control allow users to maximize the receiver linearity without wasting supply current. At 5mA, the NF and IP3 for these devices (1.3dB, 0dBm) outperforms the HP MGA-87563 GaAs PHEMT (1.9dB, -7dBm) and the Infineon BGA427 Si BJT (2dB, -5dBm).

MAX2642/MAX2643 LNAs provide 17dB gain, 1.3dB noise figure, and 0dBm input IP3, using only 5mA of current. By varying the resistor connected to the BIAS pin, you can adjust the input IP3 from -11dBm to +1dBm, while the supply current varies from 2mA to 6mA. This capability allows users to dial in the required IP3 without wasting supply current. The MAX2642's 13dB gain-step control helps to extend the LNA's dynamic range. MAX2643 gain remains fixed. The MAX2643 shuts down by logic control, and the MAX2642 shuts down by disconnecting the BIAS pin. Both amplifiers incorporate on-chip output matching, which reduces the number of external components.

The MAX2642/MAX2643 are ideal for cellular and cordless phone applications, PMR/SMR, 868MHz/900MHz ISM, and general-purpose buffers or driver amplifiers. Both devices operate from a single 2.7V to 5.5V supply. Prices start at \$0.89 (1000-up, FOB USA). A fully assembled evaluation kit (MAX2642/MAX2643EVKIT) is available to help reduce design time.

