Blood glucose meters

Overview

Blood glucose meters and other home medical devices today are small, portable, and easy to use. The mark of a good meter is one that the patient will use regularly and that returns accurate and precise results. Over the past few years the trend with blood glucose meters has been to maximize patient comfort and convenience by reducing the volume of the blood sample required. The blood sample size is now small enough that alternate-site testing is possible. This eliminates the need to obtain blood from the fingers and greatly reduces the pain associated with daily testing. Accurate and precise results have been increased by using better test strips, electronics, and advanced measurement algorithms. Other conveniences include speedy results, edge fill strips, and illuminated test strip ports, to name just a few.

Meter types

There are continuous and discrete (single-test) meters on the market today, and implantable and non-invasive meters are in development. Continuous meters are by prescription only and use a subcutaneous electrochemical sensor to measure at a programmed interval. Single-test meters use electrochemical or optical reflectometry to measure the glucose level in units of mg/dL or mmol/L.

The majority of blood glucose meters are electrochemical. Electrochemical test strips have electrodes where a precise bias voltage is applied with a digital-to-analog converter (DAC), and a current proportional to the glucose in the blood is measured as a result of the electrochemical reaction on the test strip. There can be one or more channels, and the current is usually converted to a voltage by a transimpedance amplifier (TIA) for measurement with an analog-to-digital converter (ADC). The full-scale current measurement of the test strip is in the range of 10µA to 50µA with a resolution of less than 10nA. Ambient temperature needs to be measured because the test strips are temperature dependent.

Electrochemical blood glucose meter

Optical-reflectometry test strips use color to determine the glucose concentration in the blood. Typically, a calibrated current passes through two light-emitting diodes (LEDs) that alternately flash onto the colored test strip. A photodiode senses the reflected-light intensity, which is dependent on the color of the test strip, which, in turn, is dependent on the amount of glucose in the blood. The photodiode current is usually converted to a voltage by a TIA for measurement with an ADC. The full-scale current from the photodiode ranges from 1µA to 5µA with a resolution of less than 5nA. Ambient temperature is required for this method.

Optical-reflectometry blood glucose meter

Test-strip calibration

The test strips usually need to be calibrated to the meter to account for manufacturing variations in the test strips. Calibration is done by entering a code manually or by inserting a memory device from the package of test strips. An EPROM or EEPROM memory device enables additional information to be transferred, which is a significant advantage over manually entering a code. A 1-Wire® memory device provides an additional benefit, because the unique serial identification number in each 1-Wire device ensures that the proper test strip is used.

Some meters use test strips that do not require any coding by the user. This "self-calibration" can be accomplished three ways: with tight manufacturing controls, built-in calibration on each test strip, or built-in calibration on a pack of test strips loaded into the meter. A pack of test strips inside the meter also facilitates testing because these often small strips do not need to be handled and inserted by the user.

Glucose meter solutions

Accuracy and precision

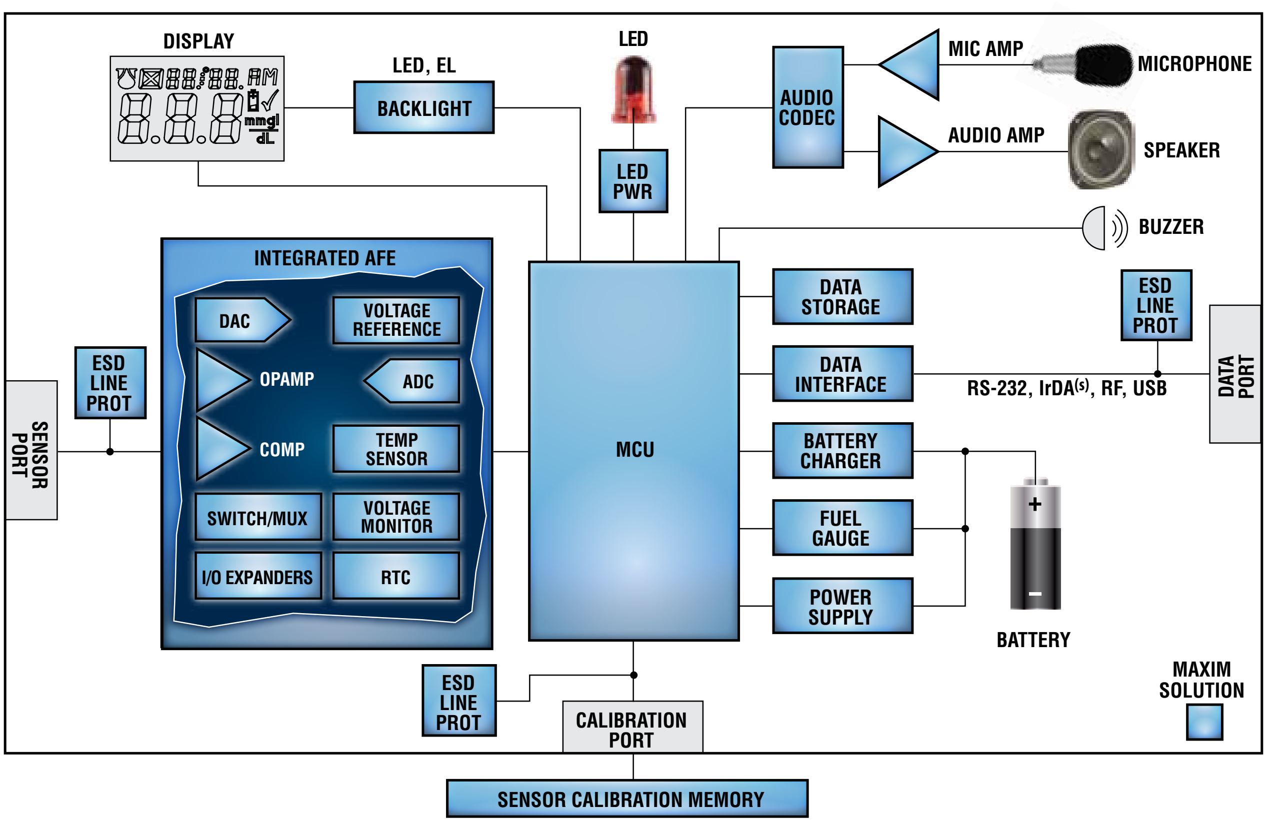
Both optical-reflectometry and electrochemical meters need to resolve currents in the single-digit nano-amp range. To meet the error budget for a meter, components must have extremely low leakage and drift over supply voltage, temperature, and time once the meter has been calibrated during manufacture. An operational amplifier's key specifications are ultra-low input bias current (< 1nA), high linearity, and stability when connected to a capacitive electrochemical test strip. The operational amplifier is typically configured as a TIA for both types of meters. A voltage reference's key specifications include a temperature coefficient less than 50ppm/°C, low drift over time, and good line and load regulation. A 10- or 12-bit DAC is used to set the bias voltage for an electrochemical test strip and to set the LED current for an optical-reflectometry test strip. Sometimes a comparator is employed with electrochemical test strips to detect when blood has been applied to the test strip. This saves power while waiting for blood to be applied to the test strip, and ensures that the reaction site is fully saturated with blood. The ADC requirements vary depending on the type of meter, but most require ≥ 14-bit resolution and low noise for repeatable results. Sometimes 12-bit resolution is used when there is a programmable gain stage before the ADC to extend the dynamic range.

Temperature measurement

Ideally, the temperature of the blood on the test strip should be measured, but usually the ambient temperature near the test strip is measured. Temperature measurement accuracy varies by test-strip type and chemistry, but is typically in the ±1°C to ±2°C range. This measurement can be accomplished with stand-alone temperature-sensor ICs, or with a remote thermistor or PN junction together with an ADC. Using a thermistor in a half-bridge configuration driven by the same reference as the ADC provides more accurate results because this design eliminates any voltage-reference errors. Remote or internal PN junctions can be measured with highly precise integrated analog front-ends (AFEs).

Electrochemical test-strip configurations

Most test strips are proprietary and vary by meter manufacturer. The variations include the reagent formulation, the number of electrodes, the number of channels, and biasing method of the reagent. The simplest configuration is a self-biased test strip (**Figure 1**) which has two electrodes with current measured at the working electrode and the common electrode grounded. There can be



Functional block diagram of a blood glucose meter. For a list of Maxim's recommended glucose-meter solutions, please go to: www.maxim-ic.com/glucose.

multiple channels on a single test strip; the additional channels are used for a reference measurement, initial blood detection, or to ensure that the blood has saturated the reaction site.

An alternate configuration actively drives both electrodes and measures at the common electrode.

Another more advanced design is a counter configuration (**Figure 2**). Here there are three electrodes with current measured at the working electrode and a force-sense circuit drives the common and reference electrodes. There is an important advantage to this configuration: the bias voltage at the reaction site on the test strip is set and maintained more accurately throughout the measurement. The disadvantage of this design is its additional complexity and the larger headroom required to allow the force-sense amplifier to swing negative to maintain the bias voltage during current flow.

Integrated AFE

Maxim's precision AFEs integrate all the functionality discussed in the previous sections, and are designed for the specifications and performance required in blood glucose meters. The AFEs are also suitable for similar applications such as coagulation and cholesterol meters.

Display and backlighting

Most blood glucose meters use a simple liquid-crystal display (LCD) with about 100 segments that can be driven with an LCD driver integrated in the microcontroller. Some meters feature a more complicated dot-matrix LCD which usually requires using a module with the glass, bias voltages, and drivers assembled together. The dot-matrix display also requires additional memory to store the messages to be displayed. There are also color displays that require additional and higher voltages than both the segment or dot-matrix LCDs. Backlighting can be added by using one or two white LEDs (WLEDs) or an electroluminescent source.

Data interface

The ability to upload test results to a computer has existed for many years, but utilization of this data interface has been low. Initially to keep the cost of the meter down, the incremental cost for this functionality was designed into a proprietary cable. Today meters are moving from proprietary data interfaces to industry-standard interfaces such as USB and Bluetooth®. The added cost of these open interfaces is now moving into the meters, a movement driven, in part, by the Continua Health Alliance and the push to conveniently upload patient data to your health-care provider.

Audio

Audible indicators range from simple buzzers to more advanced talking meters for the vision impaired. A simple buzzer can be driven by one or two microcontroller port pins with pulse-width modulation (PWM) capability. More advanced voice indicators and even voice recording for test result notes can be achieved by adding an audio codec along with speaker and microphone amplifiers.

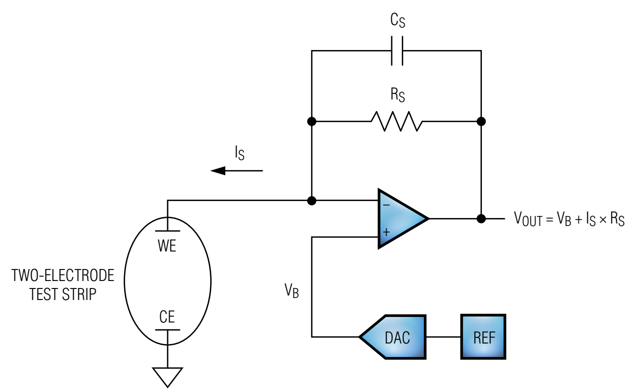


Figure 1. Electrochemical test strip in a self-biased configuration.

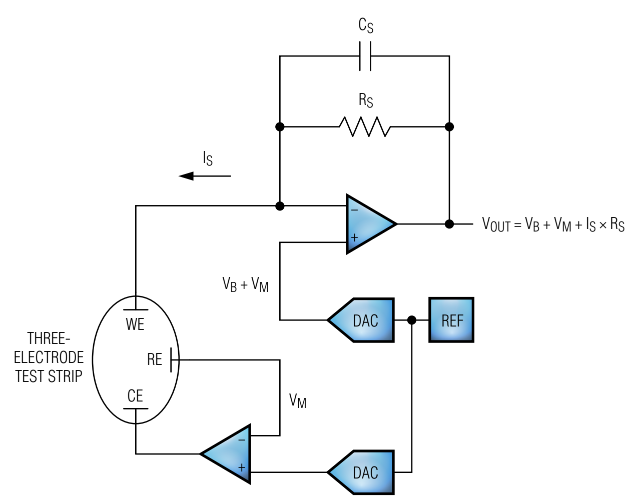


Figure 2. Electrochemical test strip in a counter configuration.

Power and battery management

Meters with simple displays can run directly off of a single lithium coin cell or two alkaline AAA primary batteries. To maximize battery life, this meter requires electronics capable of running from 3.6V down to 2.2V for the lithium coin cell or 1.8V for the alkaline AAAs. If the electronics require a higher or regulated supply voltage, then a step-up switching regulator can be used. Powering down the switching regulator during sleep mode and running directly off the batteries extends battery life, as long as the sleep circuitry can run from the lower battery voltages. Adding a backlit or a more advanced display will require higher and sometimes additional voltages. A more advanced power-management scheme may be required at this point. Rechargeable batteries such as single-cell lithium ion (Li+) can be used by adding a battery charger and fuel-gauge circuitry. Charging with USB is certainly a convenient option for the user, if USB is available in the meter. If the battery is removable, then authentication may be required for safety and aftermarket control.

Electrostatic discharge

All meters must pass 61000-4-2 electrostatic discharge (ESD) requirements. Using electronics with built-in ESD protection or adding ESD line protectors to exposed traces can help meet this requirement.

Functional scalability

Once the core meter design is complete using a precision, integrated AFE, the goal is not to redesign that portion of the meter when another feature is needed later. Instead, standard parts with a singular function targeted for portable medical devices can be used to add a feature with minimal disruption. That minimal disruption translates into lower risk, easier FDA approvals, and faster time to market. It also means that more meters will be available with the features that patients want and need. Blood glucose testing will be more frequent with the predictable result of increased compliance to acceptable glucose levels and better individual health.

www.maxim-ic.com/glucose

Integrated AFEs provide accurate and precise glucose measurements while extending battery life

MAX1358/MAX1359, MAX11359*

The MAX1358/MAX1359 and MAX11359 are low-power, precision integrated AFEs for blood glucose meters and other portable medical devices. The ICs are based on a 16-bit, sigma-delta ADC and system-support functionality for a microcontroller-based system. These devices integrate an ADC, DACs, operational amplifiers, a comparator, a selectable reference, temperature sensors, analog switches, a 32kHz oscillator, a real-time clock (RTC) with alarm, a high-frequency-locked loop (FLL) clock, four user-programmable I/Os, an interrupt generator, and 1.8V and 2.7V voltage monitors in a single chip.

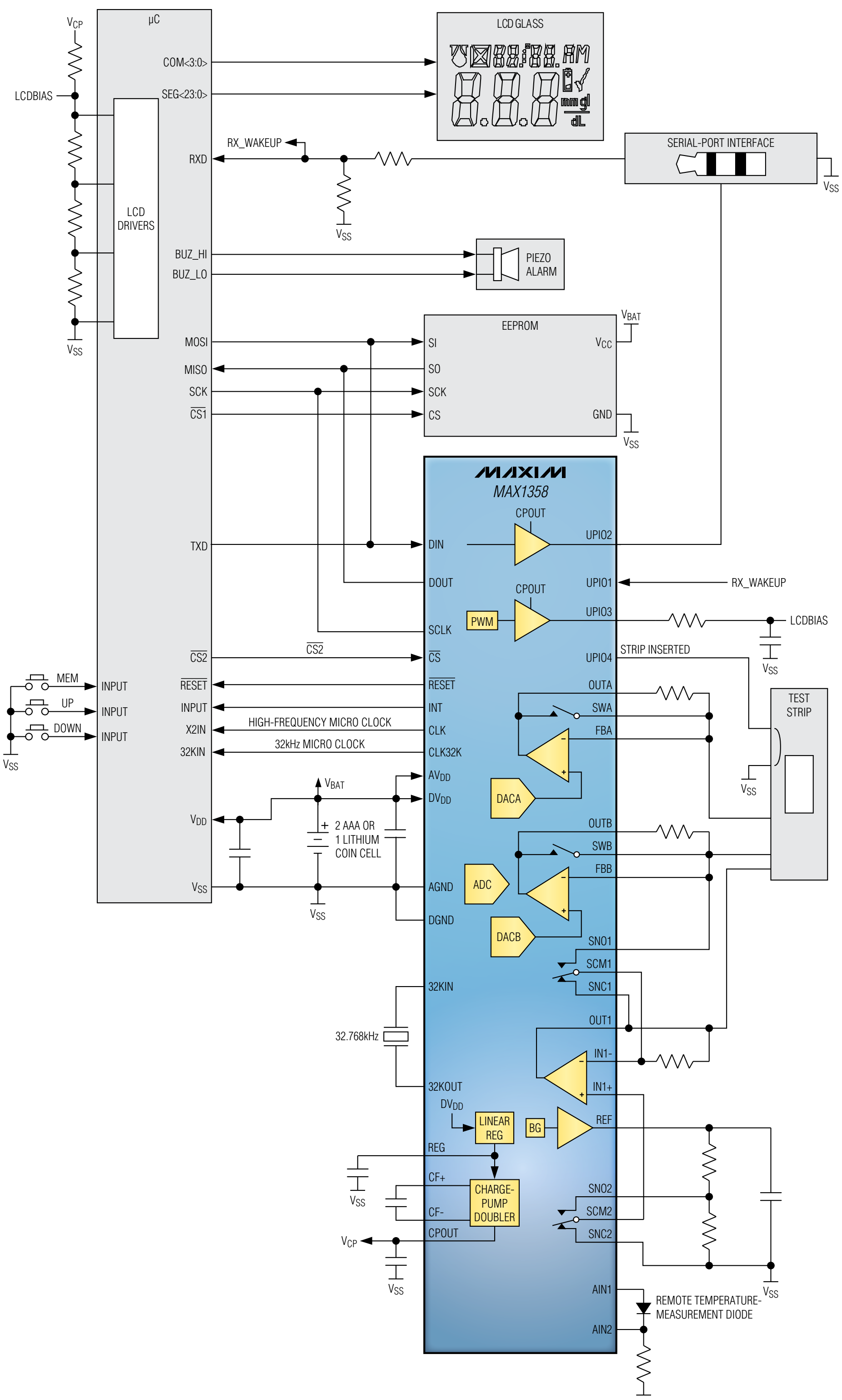
Benefits

- **Accurate and precise test results**
  - 16-bit, 10sps to 500sps, Σ-Δ ADC
  - 15ppm/°C (typ) bandgap reference
  - ±400pA (max) input bias currents
- **Highly configurable AFE for most electrochemical sensors**
  - Programmable elements such as 10-bit force-sense DACs, operational amplifiers, voltage reference, and dual SPDT analog switches
- **Longer battery life**
  - Run directly off battery down to 1.8V
  - 1.7mA (max) run mode with everything turned on
  - 4.4µA (typ) sleep mode with RTC and voltage monitor on
  - Turn microprocessor completely off during sleep mode
- **Integration lowers system cost**
  - Local/remote temperature sensors
  - 32kHz oscillator; RTC; 5MHz FLL clock drives microcontroller
  - +3.3V charge-pump power supply for display, interface, etc.

(Block diagram on next page)

* Future product—contact factory for availability.

Integrated AFEs provide accurate and precise glucose measurements while extending battery life *(continued)*

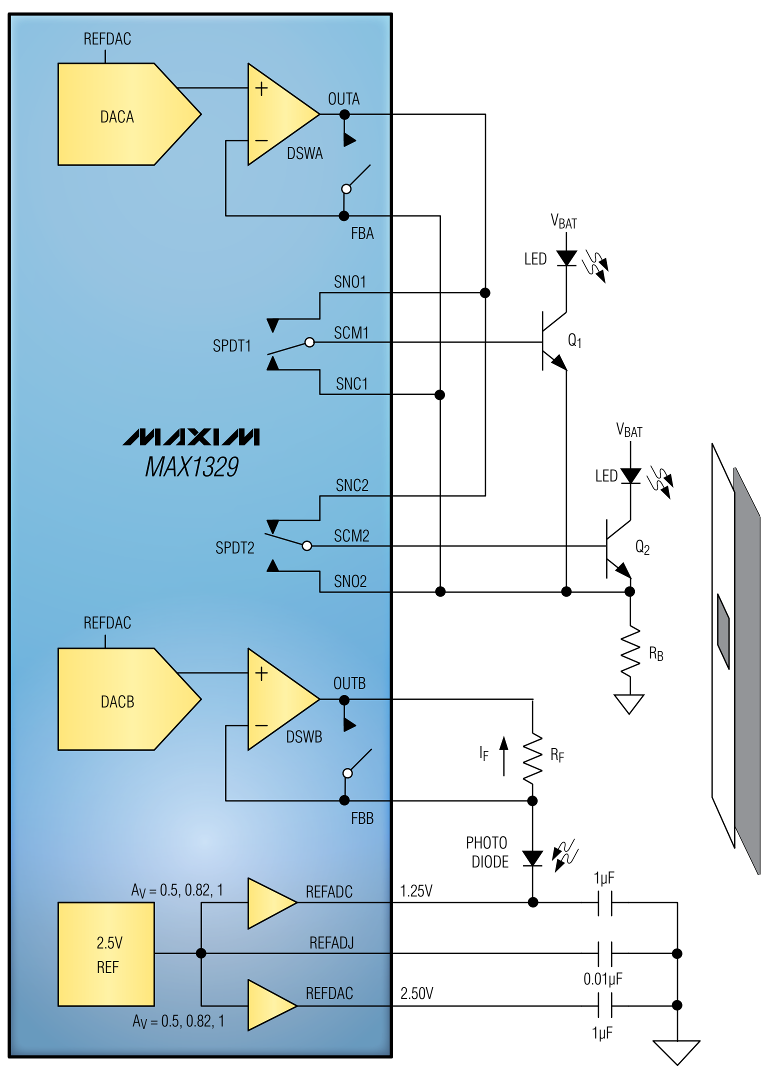


MAX1358 in an electrochemical glucose meter application.

Highly integrated AFE for AC-excitation systems delivers accurate results in a smaller meter

MAX1329

The MAX1329 is a low-power, precision integrated AFE for blood glucose meters and other portable medical devices. It is optimized for optical-reflectometry and electrochemical applications using AC excitation. The MAX1329 integrates a 12-bit SAR ADC, 12-bit DACs, operational amplifiers, voltage references, a temperature sensor, and analog switches. The on-chip programmable gain amplifier (PGA) extends the ADC's dynamic range up to 15 bits. In DSP mode the ADC provides up to 16 bits of resolution at 1ksps. The MAX1329 operates from a 1.8V to 3.6V digital power supply. Under normal operation, an internal charge pump boosts the supply voltage for the analog circuitry when the supply is < 2.7V.



MAX1329 as an analog interface to an optical-reflectometry glucose meter.

Benefits

- **Optimized to simplify design for optical-reflectometry and electrochemical AC-excitation meters**
  - 12-bit SAR ADC with many DSP features to off-load the microcontroller
  - 12-bit force-sense DACs with automated waveform generation
  - Independent programmable voltage references for ADC and DACs
- **Accurate and precise test results**
  - SAR ADC with up to 15-bit dynamic range and up to 16-bit resolution
  - 10ppm/°C (typ) bandgap reference
  - ±1nA (max) input bias current over -40°C to +85°C
- **Longer battery life**
  - Runs off a battery down to 1.8V (2.7V without enabling charge pump)
  - 7.5mA (max) run mode with everything on except charge pump
  - 1µA (typ) sleep mode with voltage monitor on
- **Integration lowers system cost**
  - Local/remote temperature sensors
  - 3.6864MHz internal clock with input/output to/from microcontroller
  - 3V/4V/5V internal power supply for display, backlighting, interface, etc.

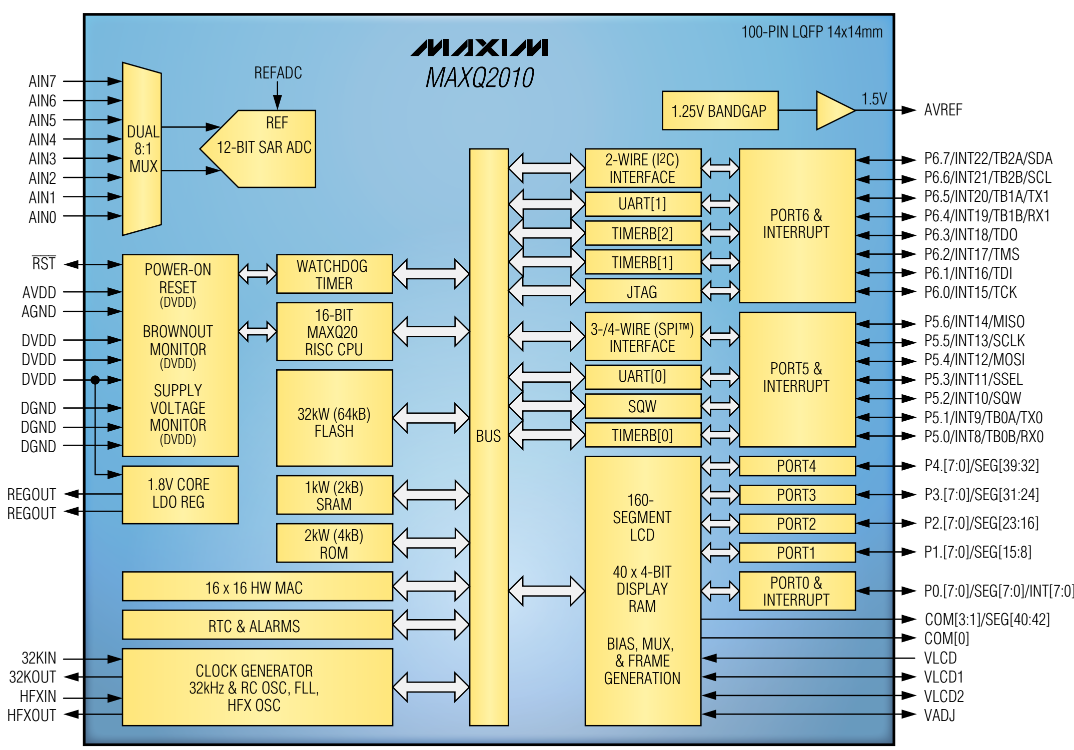
Mixed-signal microcontroller with LCD interface achieves near 1MIPS/MHz performance to extend battery life

MAXQ2010

The MAXQ2010 is a low-power, 16-bit microcontroller that incorporates a high-performance, 12-bit, multichannel ADC and an LCD interface. High performance, low power, and mixed-signal integration make the MAXQ2010 ideal for portable medical devices. The MAXQ2010 has 64KB of flash memory, 2KB of RAM, three 16-bit timers, and two universal USARTs. For the best low-power performance, the MAXQ2010 provides both a low-power sleep mode with the ability to selectively disable peripherals and multiple power-saving operating modes.

Benefits

- **Low power and efficient 16-bit MAXQ® RISC core increases battery life**
  - 1mA (typ) at 1MHz flash operation at 2.7V
  - Low-power modes, 370nA (typ) in stop mode
  - 33 instructions, most single cycle
- **Flexibility and scalability reduces design time**
  - Customer-requested memory size and LCD segments
  - Many peripherals (including timers, serial interfaces, RTC, WDT, HMAC)
- **Fast wake up from sleep and stop modes makes meter more responsive**



MAXQ2010 functional block diagram.

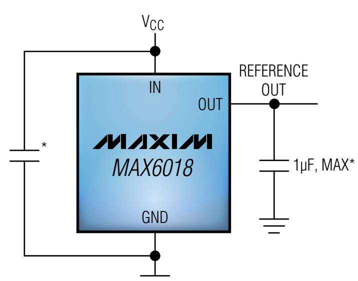
Micropower 1.6V voltage reference operates from a 1.8V supply and increases measurement precision

MAX6018A/MAX6018B

The MAX6018 is a precision, low-voltage, low-dropout, micropower voltage reference in a SOT23 package. This three-terminal reference operates with an input voltage from (V_{OUT} + 200mV) to 5.5V, and is available with output voltage options of 1.2V, 1.6V, 1.8V, and 2.048V. The MAX6018 consumes less than 5µA (max) of supply current and can source and sink up to 1mA of load current. The device has initial accuracies of 0.2% (A grade) and 0.4% (B grade) and temperature drift of 50ppm/°C (max). The low-dropout voltage and the ultra-low supply current make this device ideal for two-cell alkaline, end-of-life, battery-monitoring systems.

Benefits

- **Accurate and precise test results**
  - ±0.2% (max) initial accuracy
  - 50ppm/°C (max) low temperature drift
  - 700µV/mA (max) load regulation (1mA source)
  - 250µV/V (max) line regulation ([V_{OUT} + 200mV] to 5.5V)
- **Eliminates regulated power supply by running directly off of batteries without sacrificing ADC dynamic range**
- **Longer battery life**
  - 5µA (max) ultra-low supply current
  - 1.6V output from 1.8V input
- **Small meter design with ultra-small, 3-pin SOT23 package**



Typical operating circuit for the MAX6018.

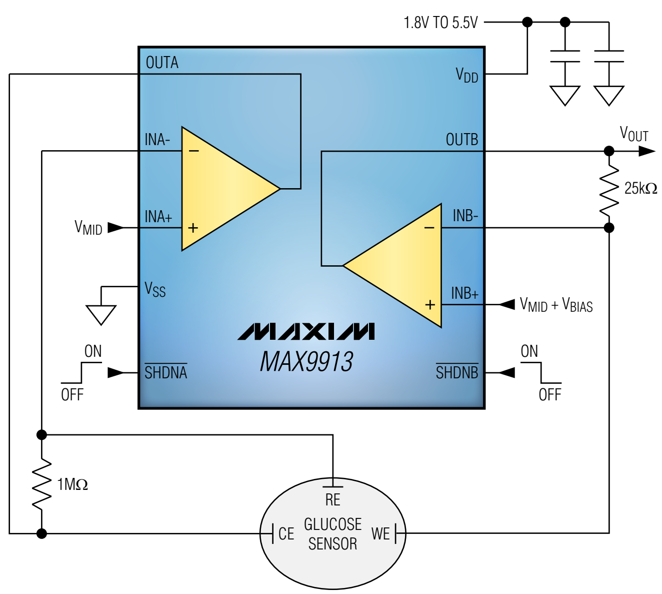
200kHz, 4µA, rail-to-rail I/O op amps with shutdown easily interface to sensors and minimize measurement errors

MAX9910–MAX9913

The MAX9910/MAX9911 (single) and MAX9912/MAX9913 (dual) op amps feature a maximized ratio of gain bandwidth (GBW) to supply current and are ideal for battery-powered applications such as portable instrumentation and portable medical equipment. These CMOS op amps feature an ultra-low input-bias current of 1pA, rail-to-rail inputs and outputs, a low 4µA supply current, and a 1.8V to 5.5V single-supply range. For additional power conservation, the MAX9911/MAX9913 have a low-power shutdown mode that reduces supply current to 1nA and puts the amplifiers' outputs in a high-impedance state. These devices are unity-gain stable with a 200kHz GBW product.

Benefits

- **Fewer sensor-measurement errors**
  - Ultra-low 1pA input bias current
  - Rail-to-rail input and output voltage ranges
  - Low ±200µV input offset voltage
- **High-output impedance during shutdown allows blood to saturate reagent**
- **Power conservation and extended battery life**
  - Ultra-low 4µA supply current and 200kHz GBW
  - 1.8V to 5.5V operation
  - 1pA shutdown current
- **Pin-compatible 1MHz GBW versions provide upgrade path**



MAX9913 in a three-electrode, electrochemical glucose meter application.

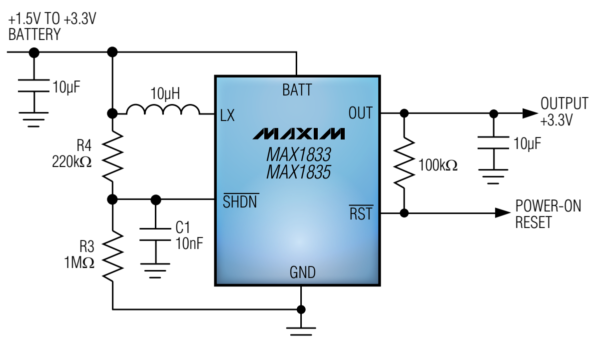
Simplify meter design with reverse-battery protection, and extend battery life by connecting battery to load in shutdown

MAX1832–MAX1835

The MAX1832–MAX1835 are high-efficiency step-up converters with complete reverse-battery protection that protects the device and the load when the battery is reversed. A built-in synchronous rectifier allows for over 90% efficiency and reduces size and cost by eliminating the need for an external Schottky diode. These step-up converters operate from a 1.5V to 5.5V input voltage range and deliver up to 150mA of load current. They are available with a fixed 3.0V/3.3V output voltage or adjustable output from 2V to 5.5V. In shutdown, the battery input is connected to the voltage output, thereby allowing the input battery to be used as a backup or RTC supply.

Benefits

- **Integrated reverse-battery protection simplifies mechanical/electrical design**
- **Longer battery life**
  - < 1µA shutdown supply current
  - BATT connected to OUT in shutdown for backup power
  - Up to 90% efficiency and 4µA quiescent current
- **Family of pin-compatible power supplies simplifies design changes**
  - Fixed 3.3V/3.0V or adjustable output voltage
- **Flexibility to work with a single lithium coin cell or two alkaline batteries**
  - 1.5V to 5.5V input voltage range
  - Accurate active-low SHDN threshold for low-battery cutoff



Typical operating circuit for the MAX1833/MAX1835.

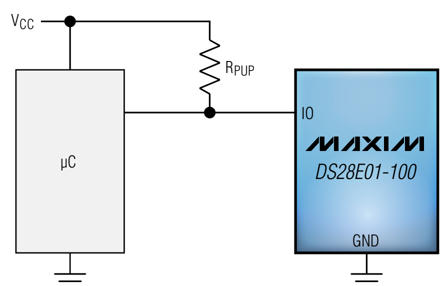
1Kb-protected 1-Wire EEPROM with SHA-1 engine calibrates test strip securely and reliably

DS28E01-100

The DS28E01-100 combines 1024 bits of EEPROM with challenge-and-response authentication security implemented with the ISO/IEC 10118-3 Secure Hash Algorithm (SHA-1). The 1024-bit EEPROM array is configured as four pages of 256 bits with a 64-bit scratch-pad to perform write operations. All memory pages can be write protected, and one page can be put in EPROM-emulation mode, where bits can only be changed from a 1 to a 0 state. Each DS28E01-100 has its own guaranteed, unique 64-bit ROM registration number that is factory lasered into the chip. The DS28E01-100 communicates over the single-contact 1-Wire bus. The communication follows the standard 1-Wire protocol with the registration number acting as the node address in the case of a multidevice 1-Wire network.

Benefits

- **Prevents test-strip cloning**
  - On-chip 512-bit SHA-1 engine
  - Unique, factory-lasered and tested 64-bit registration number assures absolute traceability because no two parts are alike
- **Robust and reliable operation**
  - Single-contact 1-Wire interface
  - Switchpoint hysteresis and filtering optimize performance in the presence of noise
  - High-ESD protection
- **Turnkey solution available**



Typical operating circuit for the DS28E01-100.

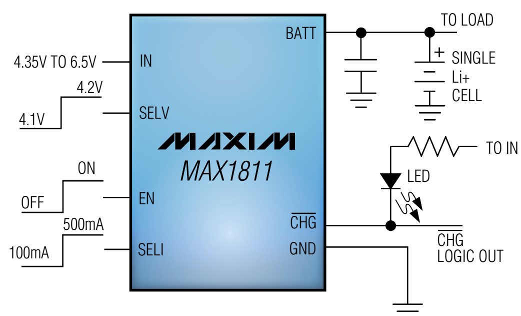
USB-powered Li+ charger safely charges directly from USB port and eliminates the need for an AC-DC adapter

MAX1811

The MAX1811 is a single-cell Li+ battery charger that can be powered directly from a USB port* or from an external supply up to 6.5V. The MAX1811 has a 0.5% overall battery-regulation voltage accuracy to allow maximum utilization of the battery capacity. The charger uses an internal FET to deliver up to 500mA charging current to the battery. The device can be configured for either a 4.1V or 4.2V battery by using the SELV input. The SELI input sets the charge current to either 100mA or 500mA. An open-drain output (active-low CHG) indicates charge status. The MAX1811 has preconditioning that soft starts a near-dead battery cell before charging. Other safety features include continuous monitoring of voltage and current, and initial checking for fault conditions before charging.

Benefits

- **Flexible and convenient use of a single USB connector for data interface and battery charging**
  - Charges single-cell Li+ batteries directly from USB port
- **Safe and easy charging**
  - Automatic IC thermal regulation
  - Preconditions near-depleted cells
- **Low-cost solution**
  - Minimal external components



Typical operating circuit of the MAX1811 charging from a USB port.

*Protected by U.S. Patent #6,507,172.

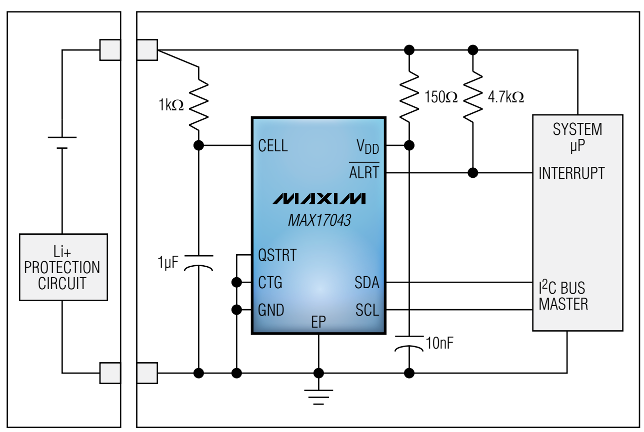
Compact fuel gauges reliably determine remaining battery capacity

MAX17043

The MAX17043 is an ultra-compact, low-cost, 1-cell, host-side fuel-gauge system for Li+ batteries in handheld and portable equipment. A sophisticated Li+ battery-modeling scheme called ModelGauge is used to track the battery's relative state-of-charge/discharge profile. Unlike traditional fuel gauges, the ModelGauge algorithm eliminates the need for battery relearn cycles and an external current-sense resistor. Temperature compensation is possible in the application with minimal interaction between a microcontroller and the device. A quick-start mode provides a good initial estimate of the battery's state of charge (SOC). This feature allows the IC to be located on the system side, thus reducing the cost and supply-chain constraints on the battery.

Benefits

- **Flexible, works with removable and nonremovable batteries**
  - Host-side or battery-side fuel gauging
- **Reliable low-battery indicator for customer**
  - Accurate relative capacity (RSOC) calculated from ModelGauge algorithm
  - No sense resistor required
  - No offset accumulation on measurement
  - No full-to-empty battery relearning necessary
- **Simple and reliable interface to microcontroller**
  - External alarm/interrupt for low-battery warning
  - 2-wire interface



Simplified operating circuit for single-cell Li+ battery using the MAX17043.

Recommended solutions

Part	Description	Features	Benefits
1-Wire® products			
1-Wire memory			
DS2502	1-Wire 1024-bit OTP EPROM	Single-dedicated-contact operation, programmable data protection, ±8kV HBM ESD protection	Minimal contact requirement to add nonvolatile memory for ID, calibration, or authentication; simplifies design
DS28E01-100/ DS28E02*	1-Wire 1024-bit EEPROM with SHA-1 authentication	Single-dedicated-contact operation, SHA-1 secure authentication and data protection, 1.8V operation (DS28E02), ±8kV HBM/±15kV IEC ESD protection	Ensure consumables are OEM with crypto-strong SHA-1 authentication; increase performance and reliability
DS2431	1-Wire 1024-bit EEPROM	Single-dedicated-contact operation, programmable data protection, ±8kV HBM/±15kV IEC ESD protection	High ESD performance typically eliminates the need to add protection to sensors, thus saving cost and space
1-Wire masters			
DS2460	SHA-1 coprocessor with EEPROM	Hardware-accelerated SHA-1 computation engine, secure memory to store three 64-bit master secrets for use with authenticating 1-Wire SHA-1 slaves, I^2C interface	Simplifies host system implementation of SHA-1 authenticated sensors and probes
DS2480B	Single-channel 1-Wire master with UART/RS-232 interface	UART/RS-232 to 1-Wire protocol bridging, supports standard and overdrive 1-Wire speeds, low-impedance strong pullup on 1-Wire I/O	Generates 1-Wire waveforms from UART/RS-232 command/communication, greatly simplifying host software development
DS2482-100	Single-channel 1-Wire master with I^2C interface	I^2C to 1-Wire protocol bridging, supports standard and overdrive 1-Wire speeds, low-impedance strong pullup on 1-Wire I/O	Generates 1-Wire waveforms from I^2C interface, greatly simplifying host software development
Analog front-ends (AFEs)			
MAX1329	12-/16-bit data-acquisition system with ADC, DACs, DPIOs, APIOs, reference, voltage monitors, and temp sensor	1.8V to 3.6V digital supply; internal charge pump for analog circuits (2.7V to 5.5V); 12-bit SAR ADC; dual, 12-bit force-sense DAC; integrated voltage references, op amps, analog switches, temp sensor, interrupts, and voltage monitors	Integrated solution and precision measurement simplify design for optical reflectometry and electrochemical AC-excitation meters
MAX1358/MAX1359, MAX11359*	16-bit data-acquisition systems with ADC, DACs, UPIOs, RTC, voltage monitors, and temp sensor	1.8V to 3.6V supply; multichannel, 16-bit sigma-delta ADC; 10-bit force-sense DACs; integrated op amps, analog switches, voltage reference, RTC with alarm, temp sensor, maskable interrupts, and dual V_{DD} monitors	Highly configurable AFEs provide accurate results and are compatible with most electrochemical test strips
MAX1407–MAX1409, MAX1414	Low-power, 16-bit multichannel data-acquisition systems with internal reference, 10-bit force-sense DACs, and RTC	1.15mA during operation; 2.5µA in sleep mode; 18ppm/°C (typ) reference; 2.4576MHz PLL clock output; integrated RTC and alarm, dual voltage monitors, comparator, interrupts, and wake-up circuitry	Very low operating current delivers over 1500 tests and greater than one year of battery life from a single coin-cell battery
Amplifiers			
Current-sense amplifiers			
MAX9634	1µA, precision current-sense amp	28V (max) common-mode voltage, 250µV (max) V_{OS}, 1µA (max) quiescent current, small UCSP™ and SOT23 packages	Very low supply current reduces battery drain; tiny package reduces solution size
MAX9918–MAX9920	Bidirectional current-sense amps with wide -20V to +75V common-mode voltage	-40°C to +125°C temperature range, precision 400µV (max) V_{OS}, ±0.45% gain error, shutdown mode	High precision and shutdown allow small sense resistors, which reduce power loss and BOM cost; wide input range eliminates protection devices

(Continued on next page)

*Future product—contact factory for availability.

Recommended solutions *(continued)*

Part	Description	Features	Benefits
Current-sense amplifiers (continued)			
MAX9928F/ MAX9929F	Bidirectional current-sense amps with wide 0 to 28V common-mode voltage	Precision 400µV (max) V_{OS}, ±1% gain error, sign output, current output, 1mm x 1.5mm UCSP	Sign output enables full use of ADC range; precision and small package reduce size and cost of solution
Instrumentation amplifiers			
MAX4194–MAX4197	Micropower, three-op-amp instrumentation amps	450µV (max) V_{OS}, 93µA quiescent current, adjustable and fixed (1, 10, 100V/V) gain versions, shutdown mode	Shutdown function and low-current operation save power, thus extending battery runtime
MAX4208/MAX4209	Ultra-low offset/drift, precision instrumentation amps with REF buffer	20µV (max) input V_{OS} with "zero drift," 1pA input-bias current, 1.4µA shutdown current, fixed and programmable gain versions available	Near-ground sensing simplifies design, while zero-drift offset preserves accuracy
Operational amplifiers			
MAX4464, MAX4470–MAX4472, MAX4474	Single/dual/quad, 1.8V/750nA, SC70, rail-to-rail op amps	1.8V to 5.5V supply, 750nA/ch quiescent current, rail-to-rail outputs, ground-sensing inputs	Low voltage, ultra-low current, and rail-to-rail outputs extend battery life
MAX4475–MAX4478	Precision, low-distortion, 4.5nV/$\sqrt{Hz}$ op amps	750µV (max) V_{OS}, 10MHz op amps, 4.5nV/$\sqrt{Hz}$ noise, CMOS inputs, SOT23	Improve measurement accuracy when used for gain, filtering, or driving ADC inputs
MAX9617–MAX9620	High-efficiency, 1.5MHz op amps with rail-to-rail inputs and outputs	10µV (max) V_{OS} with "zero drift," 0.42µV_{P-P} noise, 59µA quiescent current, tiny 8-pin SC70	Improve measurement accuracy and reduce calibration requirements
MAX9910–MAX9913	Low-power, high-bandwidth, single/dual, rail-to-rail I/O op amps with shutdown	4µA quiescent current, 1pA I_{BIAS}, 200kHz GBW, 1.8V to 5.5V supply, MOS inputs, 1mV (max) V_{OS}, SC70 package, independent shutdowns (dual)	4µA quiescent current extends battery life
MAX9914–MAX9917	Low-power, high-bandwidth, single/dual, rail-to-rail I/O op amps with shutdown	20µA quiescent current, 1pA I_{BIAS}, 1MHz GBW, 1.8V to 5.5V supply, MOS inputs, 1mV (max) V_{OS}, SC70 package, independent shutdowns (dual)	20µA quiescent current extends battery life
Comparators			
MAX9060–MAX9064	Ultra-low-power single comparators	50nA/400nA comparators with and without internal 0.2V reference in space-saving UCSP	1mm^2 package saves space, while 400nA current saves power
MAX9065	Ultra-small, low-power window comparator in UCSP/SOT23	1.0V to 5.5V supply, 1µA (max) quiescent current, preset 3V and 4.2V thresholds	Monitoring Li+ battery voltage improves reliability in portable applications
Analog switches and multiplexers			
Analog switches			
MAX4575–MAX4577	±15kV ESD-protected, low-voltage, dual SPST, CMOS analog switches	IEC 1000-4-2 compliant, 0.5nA (max) leakage, 2V to 12V supply	Integrated ESD protection and low leakage improve analog sensor measurement accuracy
MAX4624/MAX4625	1Ω, low-voltage, single-supply, SPDT, CMOS analog switches	1Ω (5V) and 2Ω (3V) max R_{ON}, 1.8V to 5.5V supply, SOT23	Small package enables compact design
MAX4751–MAX4753	0.9Ω, low-voltage, single-supply, quad SPST, CMOS analog switches	0.9Ω (3V) and 2.5Ω (1.8V) max R_{ON}, 1.6V to 5.5V supply, 1µA quiescent current	Wide operating range down to 1.6V simplifies design and extends battery life
MAX4754–MAX4756*	0.85Ω, low-voltage, single-supply, quad SPDT, analog switches in UCSP/TQFN	2mm x 2mm UCSP, 1.8V to 5.5V supply	High integration and small package shrink design
Analog multiplexers			
MAX4558–MAX4560	±15kV ESD-protected, low-voltage, CMOS analog multiplexers/switches	Single 8:1 or dual 4:1 muxes, IEC 1000-4-2 compliant, 1.0nA (max) leakage, single 2V to 12V supply	Integrated ESD protection simplifies design and saves cost

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*Future product—contact factory for availability.

Recommended solutions *(continued)*

Part	Description	Features	Benefits
Analog multiplexers (continued)			
MAX4638/MAX4639	6Ω, low-voltage, analog multiplexers	Single 8:1 or dual 4:1 muxes, single 1.8V to 5.5V supply, -80dB crosstalk, -60dB off-isolation	Guaranteed specs deliver more-reliable measurements, providing higher customer satisfaction
MAX4734	0.8Ω, low-voltage, 4:1 analog multiplexer in TQFN	0.8Ω (3V) and 2Ω (1.8V) max R_{ON}, single 1.6V to 3.6V supply, 3mm x 3mm TQFN	Guaranteed specs deliver more-reliable measurements, providing higher customer satisfaction
MAX4781–MAX4783	0.7Ω, high-speed, low-voltage, CMOS analog switches/multiplexers	Excellent on/off performance up to 10MHz, 8:1 configuration, 1.6V to 3.6V supply	Wide operating range allows use in many applications, increasing design reuse
Audio solutions			
Audio codecs			
MAX9851/MAX9853	Stereo audio codecs with microphone, DirectDrive® headphone amps, speaker amps, or line outputs	1.7V to 3.3V digital supply, 2.6V to 3.3V analog supply, 26mW playback power	Flexible solutions simplify audio design
MAX9856	Low-power audio codec with DirectDrive headphone amps	1.71V to 3.6V supply, 30mW DirectDrive headphone amp, 9mW playback power consumption, low noise, clickless/popless operation, 36mm^2 footprint	Complete audio-path solution improves audio quality and extends battery life; small footprint saves PCB space
MAX9860	16-bit, mono, audio voice codec	1.7V to 1.9V supply, 1.7V to 3.6V digital I/O supply, 30mW BTL headphone amp, dual low-noise microphone inputs, clickless/popless operation, 16mm^2 footprint	Complete audio-path solution improves audio quality; extra-small footprint enables smaller designs
MAX9867	Ultra-low-power stereo audio codec	1.65V to 1.95V supply, 1.65V to 3.6V digital I/O supply, 6.7mW playback power consumption, auxiliary battery-measurement ADC, < 6mm^2 footprint	Complete audio-path solution improves audio quality and provides longest battery life; super-small footprint enables smallest designs
Audio DAC			
MAX9850	Stereo audio DAC with DirectDrive headphone amp	Integrated volume control, 1.8V to 3.6V supply, clickless/popless operation	DirectDrive architecture eliminates DC-blocking capacitors, saving board space
Microphone preamplifiers			
MAX4060–MAX4062	Differential microphone preamplifiers with internal bias and complete shutdown	2.4V to 5.5V supply, adjustable or fixed-gain options, low input noise, 300nA shutdown, 0.04% THD+N, TQFN	Shutdown and low supply voltage extend battery life
MAX9810	Electret condenser-microphone cartridge preamplifier	2.3V to 5.5V supply, 82dB PSRR, three gain options, 1mm x 1mm UCSP	Tiny package shrinks design size
MAX9812/MAX9813	Tiny, low-cost, single-/dual-input, fixed-gain microphone amps with integrated bias	230µA quiescent current, 20dB gain, 0.015% THD+N, 100nA shutdown, SC70 and SOT23	Built-in bias and small package reduce solution size; low noise and low distortion improve listening experience
Headphone amplifiers			
MAX4409–MAX4411	80mW, DirectDrive stereo headphone amps with shutdown	1.8V to 3.6V supply, fixed or external gain options, common-mode sensing option	Elimination of output capacitors improves low-frequency audio response
MAX9720	50mW, DirectDrive stereo headphone amp with SmartSense™ and shutdown	Auto mono/stereo detection, shutdown, fixed-gain options, 0.003% THD+N, 1.8V to 3.6V supply	Integrated features save space and simplify design

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Recommended solutions *(continued)*

Part	Description	Features	Benefits
Headphone amplifiers (continued)			
MAX9723	Stereo DirectDrive headphone amp with bass boost, volume control, and I²C interface	1.8V to 3.6V supply, 62mW DirectDrive headphone amp, 32-level volume control, 0.006% THD+N, shutdown, UCSP and TQFN	Elimination of output capacitors improves low-frequency audio response
MAX9724	60mW, fixed-gain, DirectDrive, stereo headphone amp with low RF susceptibility and shutdown	Click-and-pop suppression, 0.003% THD+N, short-circuit and thermal protections, < 100nA shutdown, UCSP and TDFN	DirectDrive architecture eliminates the need for DC-blocking capacitors, saving board space and cost
MAX9820	DirectDrive headphone amp with external gain	95mW output power, high RF noise immunity, clickless/popless operation, 3mm x 3mm TDFN	High RF immunity simplifies design
Speaker amplifiers			
MAX9700	Mono, 1.2W, Class D audio amp	Up to 94% efficiency, filterless operation, 1.5mm x 2mm UCSP	High efficiency extends battery life; small package minimizes solution size
MAX9705	2.3W, ultra-low-EMI, filterless, Class D audio amp	Class D gives better efficiency, yet delivers 0.02% THD+N	Small, efficient solution to drive headphones/ speakers
MAX9718/MAX9719	Low-cost, mono/stereo, 1.4W, differential audio power amps	Class AB with superior THD+N down to 0.002%	Simple, high-fidelity solution reduces cost
MAX98000*	I²S, mono, Class D amp with FLEXSOUND™ advanced audio processing	Low EMI; 5-band parametric EQ; automatic level control; speaker-excursion, power, and distortion limiters	High-efficiency Class D extends battery life
Battery management			
Battery chargers			
MAX1736	Single-cell Li+ battery charger for current-limited supply	Single-cell Li+, pulse topology, 4.7V to 22V input, stand-alone or MCU controlled, 9mm² SOT23	Smallest solution; minimal external components saves board space and cost
MAX1811	USB-powered Li+ charger	Single-cell Li+; linear topology; charges from USB port; 4.35V to 6.5V input	Simplest solution when USB is available
MAX8606	Dual-input (USB/AC adapter), linear Li+ battery charger with integrated 50mΩ battery switch in TDFN	Selectable current limits, overvoltage protection, USB or AC adapter input	Enables charging from USB or AC adapter
MAX8900A/ MAX8900B	1.2A switch-mode Li+ chargers with ±22V input rating and JEITA-compliant battery temperature monitoring	Single-cell Li+, switching topology, 3.4V to 6.3V or 8.7V input, 3.25MHz, small external inductor	Safest solution, less heat, highly reliable
MAX1551/MAX1555	Dual-input (USB/AC adapter), single-cell Li+ battery chargers in SOT23	Linear topology; automatic switchover when AC adapter is plugged in; power-present and charge-status indicators	Simplify design
Fuel gauges			
DS2745	Low-cost, I²C battery monitor	Single-cell Li+; precision voltage, current, and temperature monitor; works with MCU	Precision measurements increase runtime between charges
DS2756	High-accuracy battery fuel gauge with programmable suspend mode	Precision voltage, current, and temperature monitor; 96 bytes of EEPROM	Programmable suspend mode extends battery runtime per charge
DS2780	Stand-alone, 1-Wire fuel-gauge IC	Single-cell Li+; FuelPack™ algorithm with precision voltage, current, and temperature monitor; 1-Wire multidrop interface; EEPROM storage	Stand-alone solution simplifies software development

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*Future product—contact factory for availability.

Recommended solutions *(continued)*

Part	Description	Features	Benefits
Fuel gauges (continued)			
DS2782	Stand-alone fuel-gauge IC	Single-cell Li+; FuelPack algorithm with precision voltage, current, and temperature monitor; I^2C interface; EEPROM storage	Stand-alone solution simplifies software development
MAX17043*	Low-cost, I^2C fuel-gauge IC	ModelGauge™ algorithm, 2mm x 3mm footprint, low-battery alert, no sense resistor	Allows system µC to remain in sleep mode for longer, thus saving power
Data converters			
Analog-to-digital converters (ADCs)			
MAX1162	16-bit, 200ksps SAR ADC with serial interface	10-pin µMAX® package, 10µA in shutdown	Small package saves space, while low-power operation reduces battery drain
MAX1226–MAX1231	12-bit, 12-channel, 300ksps SAR ADCs with serial interface	Internal reference, internal temperature sensor, 5mm x 5mm 28-TQFN	Small package saves space for compact designs
MAX1391–MAX1396	8-/10-/12-bit SAR ADCs with serial interface	1.5V to 3.6V supply, 305µW at 100ksps, 3.1µW at 1ksps, 3mm x 3mm TDFN	Supply voltage range eliminates regulated power supply; low power consumption extends battery life
MAX1415/MAX1416	16-bit, 500sps sigma-delta ADCs with serial interface	16-bit, 2-channel ADCs with PGA gains between 1 and 128; low power (1mW, max); 2µA in shutdown	Low-power operation extends battery life
MAX11600–MAX11605	8-bit, 12-channel, 188ksps SAR ADCs with serial interface	Internal reference	Flexible interface reduces design time and saves space
Digital-to-analog converters (DACs)			
MAX5510–MAX5515	Ultra-low-power, single/dual 8-bit DACs	1.8V to 5.5V operation, 4µA/ch (max), internal or external voltage reference, 30ppm/°C (max) tempco, voltage or force-sense outputs	Complete electrochemical sensor solutions simplify design, increase accuracy, and extend battery life
MAX5520–MAX5525	Ultra-low-power, single/dual 10-bit DACs	1.8V to 5.5V operation, 4µA/ch (max), internal or external voltage reference, 30ppm/°C (max) tempco, voltage or force-sense outputs	Complete electrochemical sensor solutions simplify design, increase accuracy, and extend battery life
MAX5530–MAX5535	Ultra-low-power, single/dual 12-bit DACs	1.8V to 5.5V operation, 4µA/ch (max), internal or external voltage reference, 30ppm/°C (max) tempco, voltage or force-sense outputs	Complete electrochemical sensor solutions simplify design, increase accuracy, and extend battery life
Digital potentiometers			
MAX5160/MAX5161	Low-power digital potentiometers in SOT23/µMAX	32 tap positions, 2.7V to 5.5V supply	Enable digital calibration at low power to save battery life
Display			
LED backlight drivers			
MAX1574	180mA, 1x/2x, white LED charge pump in 3mm x 3mm TDFN	3 LEDs (max), up to 60mA/LED, 5% to 100% dimming via single wire, 100nA in shutdown, soft-start limits inrush current	Integrated dimming saves space
MAX1848	White LED step-up converter in SOT23	2.6V to 5.5V supply, switching topology, constant-current regulation, analog- or logic-controlled intensity, soft-start	Uniform brightness provides better viewing experience in low-light conditions
MAX1916	Low-dropout, constant-current, triple white LED bias supply	3 LEDs (max), up to 60mA/LED, linear topology, 50nA in shutdown, SOT23	Tiny, low-cost, high-efficiency solution saves board space and extends battery life

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*Future product—contact factory for availability.

Recommended solutions *(continued)*

Part	Description	Features	Benefits
LED backlight drivers (continued)			
MAX1984–MAX1986	Ultra-efficient white LED drivers	1 to 8 LEDs; selectively enable LEDs; switching topology; open-LED detection	Open-LED detection increases reliability
MAX8630	125mA, 1x/1.5x charge pump for 5 white LEDs in 3mm x 3mm TDFN	Up to 93% efficiency; charge-pump topology; PWM dimming; factory-trimmed, full-scale LED current	Integrated derating function protects LEDs from overheating, thus increasing reliability
LED display drivers			
MAX6950/MAX6951	Serially interfaced, 2.7V to 5.5V, 5- and 8-digit LED display drivers	Slew-rate-limited driver ICs include blinking control and PWM dimming with low EMI in a small 16-pin package	Lower system cost by using simpler MCU and offloading display control
MAX6952	4-wire-interfaced, 2.7V to 5.5V, 4-digit, 5 x 7 matrix LED display driver	Slew-rate-limited driver IC for alphanumeric displays includes blinking control and PWM dimming with low EMI	Lowers system cost by using simpler MCU and offloading display control
MAX6954	4-wire-interfaced, 2.7V to 5.5V LED display driver with I/O expander and keyscan	Slew-rate-limited driver IC includes blinking control, PWM dimming, and keyscan	Compact, low-EMI solution for medium-sized displays and switch arrays shortens design time and approvals
MAX6978	8-port LED driver with fault detection and watchdog	8 constant-current LED outputs; up to 55mA per output; ±3% matching; serial interface; reports open-circuit LED faults	Meets self-test requirements for displays in medical devices, speeding design approval
MAX6979	16-port LED driver with fault detection and watchdog	16 constant-current LED outputs; up to 55mA per output; ±3% matching; serial interface; reports open-circuit LED faults	Meets self-test requirements for displays in medical devices, speeding design approval
Touch-screen controllers			
MAX11800–MAX11803	Low-power, ultra-small, 4-wire resistive touch-screen controllers with I²C/SPI™ interface	12-bit SAR ADC, 1.7V to 3.6V supply, direct and autonomous modes, 1.6mm x 2.1mm WLP	Tiny wafer-level package enables small designs; integration reduces cost
MAX11811	4-wire touch-screen controller with integrated haptic motor driver	12-bit ADC, I²C interface, proximity driver, automatic power-down, direct and autonomous modes	Autonomous mode reduces processor burden; automatic power-down extends battery life
MAX1233/MAX1234	±15kV ESD-protected, 4-wire touch-screen controllers include DAC and keypad controller	12-bit SAR ADC, SPI interface, keypad controller, low power	Combine touch-screen and keypad controller, which simplifies design and saves board space; low power extends battery life
Interface			
Current limiters			
MAX4995	50mA to 600mA adjustable current limiter	Adjustable current limit, up to +125°C operation	Adjustability allows precision current limits, thus enabling smaller power-supply solutions
MAX14523	250mA to 1.5A adjustable current limiter	Adjustable current limit, up to +125°C operation	Adjustability allows precision current limits, thus enabling smaller power-supply solutions
I/O expanders			
MAX7310	2-wire-interfaced, 8-bit I/O port expander with reset	Bus timeout, 2.0V to 5.5V supply	Lockup-free operation increases reliability; low supply voltage simplifies design
MAX7315	8-port I/O expander with LED intensity control, interrupt, and hot-insertion protection	2.0V to 3.6V supply, 50mA output drive, global and individual PWM intensity control with blinking	Ability to drive heavier loads makes designs more robust

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Recommended solutions *(continued)*

Part	Description	Features	Benefits
I/O expanders (continued)			
MAX7318	2-wire-interfaced, 16-bit, I/O port expander with interrupt and hot-insertion protection	Bus timeout, 2.0V to 5.5V supply	Lockup-free operation improves reliability; lower supply voltage simplifies design
MAX7323	I^2C port expander with four push-pull outputs and four open-drain I/Os	1.71V to 5.5V supply, I^2C interface, 20mA sink, 10mA source	Low-voltage operation and I/O flexibility make design easier
MAX7328–MAX7329	I^2C port expanders with eight I/O ports	2.5V to 5.5V supply; address up to 16 devices with 100kHz I^2C interface; 10µA quiescent current	Expand port pins without having to switch to a more costly microcontroller
Logic-level translators			
MAX13030E	6-channel, high-speed logic-level translator	100Mbps (max) data rate, bidirectional, ±15kV HBM ESD protection on I/O V_{CC} lines, 2mm x 2mm UCSP	ESD protection with low capacitance enables high data rates
MAX13101E	16-channel logic-level translator	20Mbps (max) data rate, bidirectional, ±15kV HBM ESD protection on I/O V_{CC} lines, 3mm x 3mm WLP	Integrates level translation with ESD protection in a space-saving package
USB transceivers			
MAX3349E	Full-speed USB transceiver with UART multiplexer	Full-/low-speed USB, ±15kV ESD protection on D+/D- lines	Increases reliability and reduces size by functionally sharing a USB connector
MAX3453E–MAX3456E	±15kV ESD-protected USB transceivers	Full-/low-speed USB, ±15kV ESD protection on D+/D- lines, 1.65V to 3.6V logic supply	Increase reliability by protecting high-data-rate interfaces
MAX13481E–MAX13483E	±15kV ESD-protected USB transceivers with external/internal pullup resistors	Full-speed USB, ±15kV ESD protection on D+/D- lines, 1.6V to 3.6V logic supply	Compatible with low-voltage ASICs and ASSPs, thus eliminating the need to add an interface chip
IrDA℠ product			
MAX3120	Low-profile, 3V, 120µA, IrDA infrared transceiver	IrDA 1.2 compatible, 115.2kbps (max), 120µA (typ) supply current, 10nA (typ) shutdown current	Infrared transceiver allows for optimal placement of optical components
RS-232 drivers/receivers			
MAX3221E/ MAX3223E/ MAX3243E	±15kV ESD-protected RS-232 transceivers	1/1, 2/2, and 3/5 driver/receiver options	AutoShutdown™ extends battery life
MAX3224E–MAX3227E, MAX3244E/ MAX3245E	±15kV ESD-protected, 1µA, 1Mbps RS-232 transceivers with AutoShutdown Plus™	1/1, 2/2, and 3/5 driver/receiver options; UCSP option; 2.35V, 2.5V, or 3.0V to 5.5V supply options	Increased reliability; small solution size can be located on main board or in cable
ESD/line protection			
MAX3202E–MAX3204E, MAX3206E	Low-capacitance, 2-/3-/4-/6-channel, ±15kV ESD protection arrays	5pF input capacitance, 1nA input-leakage current, 1nA supply current, tiny footprint	Easily comply with IEC 61000-4-2 ESD protection
MAX3205E/ MAX3207E/ MAX3208E	Low-capacitance, 2-/4-/6-channel, ±15kV ESD protection arrays with TVS	2pF input capacitance, integrated transient-voltage suppressor	Increase reliability by protecting high-data-rate interfaces
MAX9940	Signal-line overvoltage protector	Small SC70, low supply current, ±4kV IEC Contact protection	Protects low-voltage circuitry from high-voltage faults, thus improving reliability

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Recommended solutions *(continued)*

Part	Description	Features	Benefits
ESD/line protection (continued)			
MAX13202E/ MAX13204E/ MAX13206E/ MAX13208E	Low-capacitance, 2-/4-/6-/8-channel, ±30kV ESD protection arrays	6pF input capacitance, 1nA input-leakage current, ±30kV ESD protection	Increase reliability by protecting high-data-rate interfaces
Keyboard scanners			
MAX7347–MAX7349	2-wire-interfaced, low-EMI key-switch controllers	Monitor up to 24, 40, or 64 keys; low-voltage design; key debounce	Independent key controllers free up microcontroller I/O and reduce software complexity
MAX7359	2-wire-interfaced, low-EMI key-switch controller/GPO	Monitors up to 64 keys, low-voltage design, key debounce, key-release detection	Independent key controller frees up microcontroller I/O and reduces software complexity
Switch debouncers			
MAX6816–MAX6818	Single, dual, and octal switch debouncers	±15kV ESD protection	Improve reliability; ease of use simplifies design
MAX16054	Pushbutton on/off controller	±15kV ESD protection	Improves reliability; small size saves space
Microcontrollers			
MAXQ610	Low-power, 16-bit microcontroller with IR module	1.7V to 3.6V supply, up to 32 GPIOs, IR module, ring oscillator, wakeup timer, 200nA stop-mode current	Low operating voltage for longer battery life
MAXQ612/MAXQ622	Low-power, 16-bit microcontrollers with IR module and optional USB	1.7V to 3.6V supply, 128KB flash, USB 2.0 transceiver, IR module, up to 52 GPIOs	Extended battery life and easier data transfer from portable device
MAXQ2000	Low-power, 16-bit LCD microcontroller	20MHz operation, 64KB flash, hardware multiplier, 132-segment LCD controller, 32-bit RTC, 700nA stop-mode current	High integration saves board space; low-power architecture extends battery life
MAXQ2010	Low-power, 16-bit mixed-signal LCD microcontroller	8-channel, 12-bit SAR ADC; 64KB flash; supply voltage monitor; hardware multiplier; 160-segment LCD controller; 370nA stop-mode current	Powerful, integrated microcontroller saves space in battery-powered applications
MAXQ8913	16-bit mixed-signal microcontroller	7-channel, 12-bit SAR ADC; 64KB flash; two 10-bit DACs; two 8-bit DACs; four op amps; temp sensor; two current sinks	Single chip integrates multiple functions to minimize solution size
Power management			
Switching regulators			
MAX1722–MAX1724	1.5µA I_Q, step-up DC-DC converters in thin 5-SOT23	0.91V startup, 150mA output current, 90% efficiency, internal EMI suppression, 100nA in shutdown	0.91V startup enables single-cell operation, saving space, weight, and cost
MAX1832–MAX1835	High-efficiency step-up converters with reverse-battery protection	4µA quiescent current, 1.5V startup, 150mA output current, 90% efficiency, < 100nA in shutdown, battery connected to OUT in shutdown	Simplify electromechanical design with integrated reverse-battery protection; turn off power supply when not in use to save power
MAX1947	Boost regulator for single alkaline-battery input	Low 0.7V input, internal synchronous switches, 2MHz switching, 94% efficiency, True Shutdown™, reset flag	Harvests more energy from alkaline cells to extend battery life; high switching frequency reduces external component size
MAX8569	200mA step-up converter in 6-pin SOT23 and TDFN	1.5V startup, 200mA output current, 95% efficiency, < 100nA in shutdown, battery connected to OUT in shutdown	Turns off power supply when not in use to save power; increases efficiency by running directly off of batteries
MAX8625	High-efficiency, seamless-transition, step-up/down DC-DC converter	2.5V to 5.5V supply, glitch-free buck-boost transitions, 92% efficiency, PWM or skip modes, output overload protection	Wide input range maximizes battery life from single-cell Li+

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Recommended solutions *(continued)*

Part	Description	Features	Benefits
Linear regulators			
MAX6469–MAX6484	300mA LDO linear regulators with internal microprocessor-reset circuit	114mV dropout at 300mA, preset 1.5V to 3.3V in 100mV steps, 82µA supply current, 100nA shutdown current	Integrated reset saves cost and space by eliminating need for a separate voltage supervisor
MAX8860	300mA LDO linear regulator in µMAX®	60µV_{RMS} output noise, 105mV dropout at 200mA, 120µA quiescent current, reverse-battery protection, small 2.2µF I/O capacitor	Reverse-battery protection simplifies design; small input and output capacitors save board space
MAX8902A/ MAX8902B	Low-noise, 500mA LDO linear regulators in a 2mm x 2mm TDFN	16µV_{RMS}; 100mV (max) dropout at 500mA; ±1.5% accuracy over load, line, and temperature; shutdown mode; soft-start	Low noise and high accuracy enable optimal performance from sensitive analog circuits
Power-management IC (PMIC)			
MAX1565	Five-output power-supply IC	Five switching regulators at 1MHz; 1µA in shutdown; supplies for motor, main, core, and LCD from supply down to 0.7V	Complete power-management solution in one IC saves board space
Voltage references			
MAX6006–MAX6009	Precision shunt voltage references in SOT23	1µA operating current, ±0.2% accuracy, wide operating range (1µA to 2mA)	Ultra-low operating current saves battery life
MAX6018	Precision, micropower, low-dropout, series voltage reference in SOT23	1.263V to 2.048V V_{OUT}, ±0.2% to ±0.4% accuracy, 1.8V supply, 5µA quiescent current	Low operating current extends battery life
MAX6023	Precision, low-power, low-dropout voltage reference in UCSP	1.25V to 5V V_{OUT}, ±0.2% initial accuracy, 30ppm/°C tempco, 1mm x 1.5mm x 0.3mm package	Small package fits in space-constrained designs
MAX6029	Ultra-low-power, precision series voltage reference	5.25µA quiescent current, 30ppm/°C tempco, no external capacitors needed	Ultra-low operating current saves power; stability over temperature increases reliability
MAX6034	Precision, micropower, series voltage reference in small SC70	2.048V to 4.096V V_{OUT}, ±0.2% accuracy, 30ppm/°C tempco, 90µA quiescent current	Small SC70 package eases layout and saves board space
Voltage supervisors			
MAX6381–MAX6390	Single/dual, low-power µP reset circuits in SC70/µDFN	Multiple thresholds and timeout options; only a few external components	Versatility eases design reuse; small package saves space in small systems
MAX6443–MAX6452	Single/dual µP reset circuits with manual-reset inputs	Two manual-reset inputs with extended setup period (6.72s), precision voltage monitoring down to 0.63V	Avoid nuisance resets; eliminate the need for a pinhole in the equipment case
MAX16056–MAX16059	Ultra-low-power supervisory ICs with watchdog timer	125nA supply current, capacitor-adjustable timing	Save power and battery life; adjustable timeouts allow one IC to be used across multiple applications
MAX16060–MAX16062	Quad-/hex-/octal-voltage µP supervisors	Fixed and adjustable thresholds and timeouts, margin-enable and tolerance-select inputs, watchdog timer	Breadth of features and options provides flexibility to meet many design needs, increasing design reuse
MAX16072–MAX16074	µP supervisory circuits in chip-scale package	1mm x 1mm UCSP, 0.7µA supply current	Small package saves space, while low-power operation extends battery life
RF solutions			
ISM transceivers			
MAX2830	2.4GHz to 2.5GHz RF transceiver with power amplifier	2.4GHz to 2.5GHz ISM band operation; IEEE® 802.11g/b compatible; complete RF transceiver, PA, and crystal oscillator	Saves space by eliminating the need for an external SAW filter
MAX7030	Low-cost, 315MHz, 345MHz, and 433.92MHz ASK/OOK transceiver with fractional-N PLL	2.1V to 3.6V or 4.5V to 5.5V supply, no programming required, low current (< 6.7mA Rx, < 12.5mA Tx), 5mm x 5mm TQFN	Factory programmed for faster and simpler product design; low-voltage operation and low current for long battery life

(Continued on next page)

Recommended solutions *(continued)*

Part	Description	Features	Benefits
ISM transceivers (continued)			
MAX7031	Low-cost, 308MHz, 315MHz, and 433.92MHz FSK transceiver with fractional-N PLL	2.1V to 3.6V or 4.5V to 5.5V supply, no programming required, low current (< 6.7mA Rx, < 12.5mA Tx), 5mm x 5mm TQFN	Factory programmed for faster and simpler product design; 5mm x 5mm package enables small form factor
MAX7032	Low-cost, crystal-based, programmable ASK/FSK/OOK transceiver with fractional-N PLL	2.1V to 3.6V or 4.5V to 5.5V supply, no programming required, low current (< 6.7mA Rx, < 12.5mA Tx), 5mm x 5mm TQFN	Factory programmed for faster and simpler product design; low-voltage operation and low current for long battery life
ISM transmitters			
MAX2900–MAX2904	200mW single-chip transmitter ICs for 868MHz and 915MHz ISM bands	Compliant with FCC CFR 47 Part 15.247 for the 902MHz to 928MHz ISM band and/or ETSI EN330-220 for the European 868MHz ISM band	High level of integration minimizes the number of external components, thus saving board space and simplifying design
MAX1472	Low-power, 300MHz to 450MHz, crystal-based ASK transmitter	Wide frequency range, low-current operation (5.3mA, operating), 3mm x 3mm package	Crystal stability increases performance, while low power consumption increases battery life
MAX1479	Low-power, 300MHz to 450MHz, crystal-based ASK/FSK transmitter	Wide frequency range, low-current operation (6.7mA in ASK mode, 10.5mA in FSK mode)	Crystal stability increases performance, while low power consumption increases battery life
MAX7057	300MHz to 450MHz, crystal-based ASK/FSK transmitter	Wide frequency range, programmable synthesizer, antenna-matching network	High efficiency in the 300MHz to 450MHz band reduces transmit time, saving power and extending battery life
ISM receivers			
MAX1471	Programmable, 300MHz to 450MHz ASK/FSK receiver	High sensitivity, built-in image rejection, and separate ASK/FSK data paths in a 5mm x 5mm package	High sensitivity simplifies design while keeping power low
MAX1473	300MHz to 450MHz ASK receiver with AGC	High sensitivity, AGC, and built-in image rejection in a 5mm x 5mm package	Built-in image rejection provides a more-reliable wireless link
MAX7042	300MHz to 450MHz FSK receiver	Best FSK sensitivity and built-in image rejection in a 5mm x 5mm package	FSK sensitivity improves wireless reception; saves board space
Real-time clocks (RTCs)			
DS1337	I²C RTC with time-of-day alarm and trickle charger	Single 1.8V to 5.5V supply, 1.3V timekeeping voltage, two time-of-day alarms, leap-year compensation, 32kHz square-wave output, integrated-crystal option	Single supply reduces pin count where small packages and simple routing are the primary concerns
DS1341	Low-current, I²C RTC for high-ESR crystals	Compatible with crystal ESR up to 100kΩ; low timekeeping current of 250nA (typ)	Ability to drive high-ESR crystals allows use of any commercially available crystal including smallest surface-mount form factors, thus reducing cost and board space
DS1372	I²C, 32-bit binary counter clock with 64-bit ID	Unique 64-bit serial number and a programmable alarm	Serial number provides a method of identifying systems without adding an extra component or programming step, thus reducing board size and simplifying design
DS1388	I²C RTC/supervisor with trickle charger and 512 bytes of EEPROM	High level of integration (RTC, supervisor, watchdog timer), 512 bytes of EEPROM, backup supply voltage, trickle-charge capability	High level of integration saves board space and cost
DS1390–DS1394	Low-voltage, SPI/3-wire RTCs with trickle charger	Separate SQW and INT outputs, trickle-charge capability, UL® recognized, time-of-day alarm, automatic backup power switching	Automatic backup power switching ensures reliable timekeeping when main power fails

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Recommended solutions *(continued)*

Part	Description	Features	Benefits
Sensors			
Temperature sensors			
DS18B20	±0.5°C accurate, 1-Wire digital temperature sensor	±0.5°C accuracy, 1-Wire interface, unique 64-bit serial number	Simplifies interface when deploying multiple distributed precision sensors
DS600	±0.5°C accurate analog-output temperature sensor	Industry's most accurate analog temperature sensor: ±0.5°C accuracy from -20°C to +100°C	Improves system temperature-monitoring accuracy and is easy to design with
DS75LV	Low-voltage, ±2.0°C accurate digital thermometer and thermostat	±2°C accuracy from -25°C to +100°C, 1.7V to 3.7V operation, industry-standard pinout and registers	Industry-standard pinout facilitates migration from LM75 to lower supply voltage
DS7505	Low-voltage, ±0.5°C accurate digital thermometer and thermostat	±0.5°C accuracy from 0°C to +70°C, 1.7V to 3.7V operation, industry-standard pinout and registers	Industry-standard pinout allows easy accuracy upgrade and supply voltage reduction from LM75
MAX6612	Small, low-power analog temperature sensor	19.5mV/°C slope, ±3°C accuracy from 0°C to +70°C, SC70, 35µA (max) quiescent current	Small, low-power solution saves board space and extends battery life
Hall-effect sensor interface			
MAX9921	Dual, 2-wire Hall-effect sensor interface with diagnostics	Withstands 60V voltage transients and ±15kV ESD spikes; built-in diagnostics; controlled ramp for Hall-effect sensor power	Integrated ESD and diagnostics increase product reliability while saving space