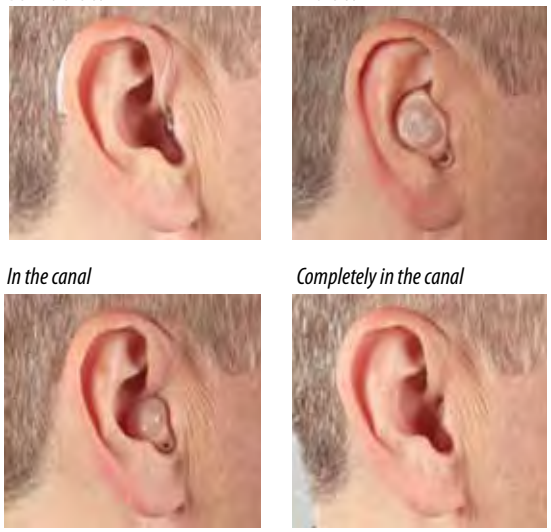
Hearing aids

Overview

An electronic hearing aid is a small device placed in or around the ear to improve the hearing of those with hearing loss. The basic components of a hearing aid are a microphone, signal conditioning, a receiver also known as a speaker, and a battery. The microphone converts the sound into an electric signal. The signal then undergoes conditioning that can be as simple as amplifying all of the sound equally, to more advanced equalization involving a digital signal processor (DSP). The receiver converts the electronic signal back to sound, and the battery powers the electronics.

Styles

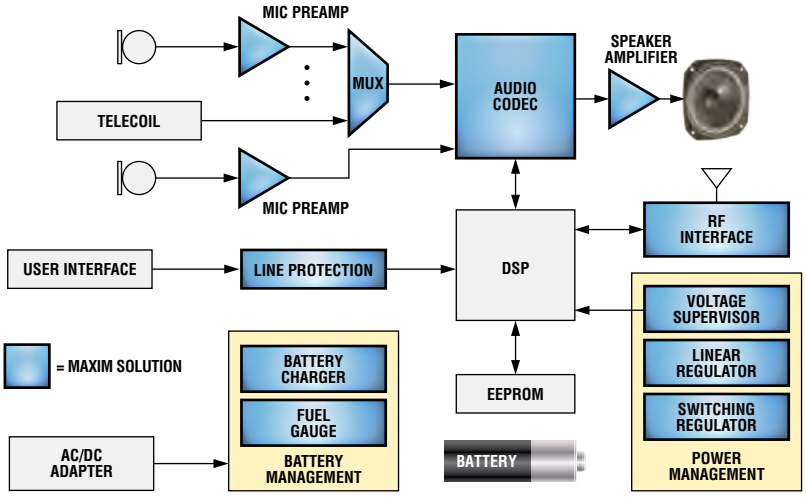
There are four main styles of hearing aids on the market today. From largest to smallest, they are behind the ear (BTE), in the ear (ITE), in the canal (ITC), and completely in the canal (CIC). The BTE style sits behind the ear with a clear tube going to an earmold in the ear to deliver the sound. A variation on this style is called an open-fit-behind-the-ear (OTE) where the earmold is replaced by a small tip, resulting in a more open feeling. Other variations include replacing the tube with wires and moving the receiver from the behind the ear to inside the ear. The ITE style moves the hearing aid into the outer ear, where it becomes a single unit with the earmold. This style fills up most of the outer ear and appears as a solid mass. The ITC style moves some of the hearing aid into the ear canal and reduces the space taken up in the outer ear, but is still plainly visible. The CIC style is the smallest of them all, as it fits completely inside the ear canal, thus nearly disappearing from view.



Behind the ear (BTE), in the ear (ITE), in the canal (ITC), and completely in the canal (CIC). Photos courtesy of Starkey Laboratories, Inc.

Technology types

The two basic types of technology for hearing aids are analog and digital. The first to exist, analog hearing aids process electrical sound in the analog domain; the more recent digital hearing aids process electrical sound in the digital domain. The earliest analog hearing aids simply amplified both speech and noise, and were ordered after testing to determine the particular frequency response needed by the patient. Newer analog hearing aids can be programmed during the fitting process, and some have multiple listening profiles that the patient can select with a button on the hearing aid. Digital hearing aids are also programmable during the fitting process and have multiple listening profiles that are selectable by the patient. The digitization of sound allows more advanced signal processing such as noise reduction, filtering, and acoustic feedback (ringing) control. The vast majority of hearing aids sold today are digital because of their increased performance and flexibility over the analog versions.



Digital hearing aid functional block diagram. For a list of Maxim's recommended solutions for hearing aid designs, please go to: www.maxim-ic.com/hearing.

Features

There are many features available for today's hearing aids, including volume control, remote control, telecoil, direct audio input, FM

reception, Bluetooth® capabilities, directional microphone, compression, clipping, frequency shifting, wind-noise management, data logging, self-learning, moisture resistance, and earmold venting. Some of these features require external area to implement and become more difficult to include as the size of hearing aids shrinks, while other features can be implemented in all hearing aids.

Volume control is performed manually with buttons or a rotary dial on the hearing aid. A remote control eliminates the need for buttons and dials on the hearing aid and can be used to control all the features of the hearing aid. A telecoil is an alternate input other than the microphone. It originally picked up the magnetic signal generated by older telephones with speakers driven by magnetic coils so that listeners could hear better when talking on the telephone. Today's telephones and other alternate listening devices build-in this capability in order to work with a telecoil and specifically indicate that they are hearing aid compatible. Direct audio input and FM reception are other ways to input sound or speech into the hearing aid, the first using a wired connector as an input, and the other an FM radio receiver. An emerging trend is to include Bluetooth capability to receive sound from a cell phone or music player. The Bluetooth device can either be integral to the hearing aid or an add-on device through the telecoil or FM input.

A hearing aid with directional microphones uses two or more microphones to receive sound from multiple directions. This improves the signal-to-noise ratio (SNR) of speech when heard in a noisy environment, and enhances the quality of speech further when used with digital signal processing. Compression and clipping both increase listening comfort by reducing portions of the sound that are too loud but, in some cases, just clip or limit the sound. Frequency shifting uses digital signal processing to shift speech to a lower frequency, which is helpful for people with high-frequency hearing loss. Wind-noise management detects wind and eliminates the feedback that would otherwise cause ringing sounds to be heard by the hearing aid wearer.

Data logging records the listening environment and how the hearing aid is used. A hearing professional can use this information to fine-tune hearing aid performance. Self-learning uses the data logs and fine-tunes the performance on its own over time. Moisture resistance helps reduce repairs due to exposure to moisture, and earmold vents provide additional comfort by reducing the closed-in sensation felt when wearing an earmold type of hearing aid.

General requirements

The critical components of a hearing aid design are in the audio-processing path. The one or more microphones and the receiver are chosen in conjunction with the preamplifiers (if required) and the speaker amplifiers. Class D amplifiers are used in modern hearing aids due to their low-power operation, low distortion, and small size as compared to Class A and B amplifiers. Whether the audio bandwidth is 20kHz or limited to 8kHz, the audio codec should have a high SNR to preserve and reproduce sounds accurately.

The heart of the system is the digital signal processor (DSP), which is where all of the benefits of a digital hearing aid are implemented. The DSP implementation is manufacturer dependent. In general, it performs compression/expansion by band, positive feedback reduction, noise reduction, and speech enhancement. It also processes directional information and can generate its own signals to help improve fitting a hearing aid to a patient.

Power and battery management

Some hearing aids are beginning to use rechargeable single-cell lithium-ion (Li+) batteries, but most hearing aids are still powered by primary zinc-air batteries. There are five main sizes of zinc-air batteries used, depending on the hearing aid style or size, the power consumption of the circuitry, and the battery-life requirements. **Table 1** compares the capacity and size of the five most common zinc-air batteries, and includes their color codes for easy selection and the styles of hearing aid in which they are usually used.

Zinc-air batteries start at 1.4V and are used down to about 1.0V or lower before requiring replacement. When used for 16 hours per day, battery

Type	Capacity (mAh)	Size (d x h, mm)	Color Code	Style Usage
675	540 to 640	11.6 x 5.4	Blue	BTE (high power), cochlear implants
13	230 to 285	7.9 x 5.4	Gold	BTE, ITE
312	120 to 160	7.9 x 3.6	Burgundy	miniBTE, ITE, ITC
10	60 to 90	5.8 x 3.6	Yellow	ITC, CIC
5	30 to 40	5.8 x 2.1	Red	CIC

Zinc-air battery comparison

life ranges from a couple of days to a few weeks, depending on the battery capacity and hearing aid design. The most power-efficient design runs directly off of a single battery, but a switching regulator can be used to boost the voltage to fit design needs, whether 1.8V or 3.0V. The power dissipation is targeted to be 1mW to 10mW when running off of zinc-air batteries. Hearing aids that use rechargeable Li+ batteries may require a linear or switching regulator to step the battery voltage down if the circuitry cannot run directly from the typical 4.2V, single-cell Li+ battery's fully charged voltage. Alternatively, the battery charger can limit the charging to a lower end voltage such as 3.3V, depending on the circuitry requirements. An accurate fuel gauge is critical to provide warning before the battery is depleted so that the patient is not left with a nonfunctioning hearing aid.

Electrostatic discharge

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

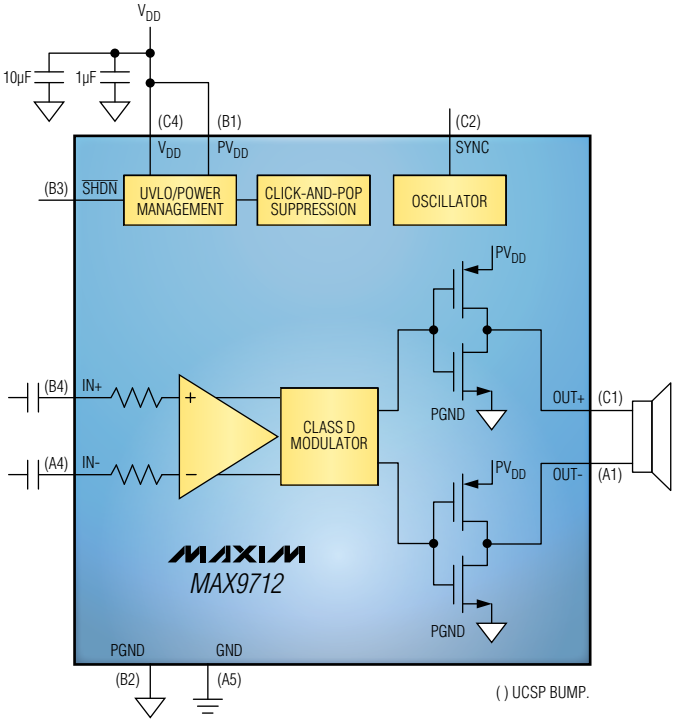
www.maxim-ic.com/hearing

Low-EMI, Class D speaker amplifier delivers high performance in a tiny space

MAX9712

The MAX9712 mono, Class D, audio power amplifier provides Class AB amplifier performance with Class D efficiency, conserving board space and extending battery life. Using the Class D architecture, the MAX9712 delivers up to 500mW into an 8Ω load while providing efficiencies above 85%. The device utilizes a fully differential architecture, full-bridge output, and comprehensive click-and-pop suppression.

The MAX9712 offers two modulation schemes: a fixed-frequency mode, and a patented spread-spectrum mode that reduces EMI-radiated emissions caused by the modulation frequency. This spread-spectrum mode* renders the traditional Class D output filter unnecessary. The external component count is further reduced as the gain is internally set to 4V/V.



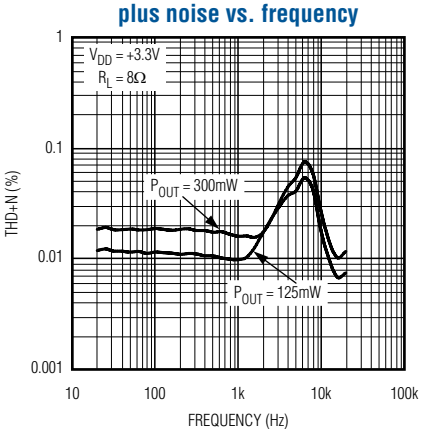
MAX9712 functional diagram

*U.S. Patent #6,847,257.

Benefits

- **Higher audio fidelity improves quality of hearing**
  - Low 0.01% THD+N
  - SNR > 90dB
  - High PSSR (72dB at 217Hz)
- **Longer battery life reduces cost of operation**
  - 85% efficiency
  - Low quiescent current (4mA)
  - Low-power shutdown mode (0.1µA)
- **Smaller hearing aid design for more convenient, discreet operation**
  - 1.5mm x 2mm x 0.6mm, 12-bump UCSP™
  - No output filter necessary
  - Integrated short-circuit and thermal-overload protection
  - Gain set to 4V/V
- **Low-EMI modulation scheme simplifies design**
  - Unique spread-spectrum mode offers 5dB emissions improvement over conventional methods
  - Filterless amplifier passes FCC radiated-emissions standards with 100mm of unshielded speaker cable

Total harmonic distortion plus noise vs. frequency



High-efficiency, step-up converters boost a zinc-air battery to 3V, yet operate down to 0.8V, thus extending battery operating range

MAX1722/MAX1723/MAX1724

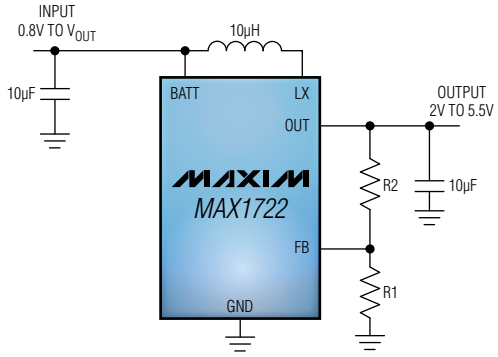
The MAX1722/MAX1723/MAX1724 compact, high-efficiency, step-up DC-DC converters are available in tiny, 5-pin, thin SOT23 packages. They feature an extremely low 1.5µA quiescent supply current to ensure the highest possible light-load efficiency. Optimized for operation from one to two alkaline, zinc-air, or nickel-metal-hydride (NiMH) cells, or a single Li+ cell, these DC-DC converters are ideal for applications where extremely low quiescent current and ultra-small size are critical.

Built-in synchronous rectification significantly improves efficiency and reduces size and cost by eliminating the need for an external Schottky diode. Also, no external FET is required, as all three devices integrate a 0.5Ω n-channel power switch.

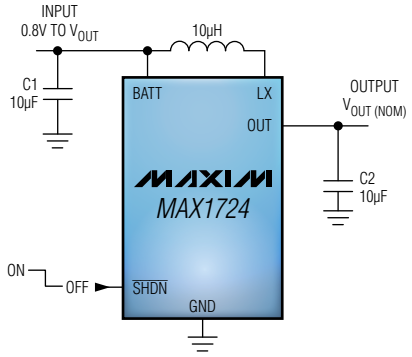
The MAX1722/MAX1724 feature proprietary noise-reduction circuitry, which suppresses EMI caused by the inductor in many step-up applications. These DC-DC converters offer various combinations of fixed or adjustable outputs, shutdown, and EMI reduction.

Benefits

- **High efficiency extends battery life**
  - Up to 90% efficiency
  - 1.5µA quiescent supply current
  - 0.1µA logic-controlled shutdown
- **Compact solution enables small hearing aid design**
  - Thin SOT23-5 package (1.1mm height, max)
  - No external diode or FETs needed
- **Low EMI simplifies design**
  - Internal EMI suppression (MAX1722/MAX1724)



MAX1722 adjustable output voltage circuit



MAX1724 standard application circuit

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

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*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/√Hz op amps	750µV (max) V_{OS}, 10MHz op amps, 4.5nV/√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	1mm² 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; I²C interface; EEPROM storage	Stand-alone solution simplifies software development
MAX17043*	Low-cost, I²C 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

(Continued on next page)

*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

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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	I^2C 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, I^2C 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	I^2C, 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	I^2C 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