Overview

Electric motors consume almost 50% of the world's electricity. With the cost of energy rising steadily, industry is focused on replacing inefficient constant-speed motors and drives with microprocessor-based, variable-speed drives. This new motor-control technology will reduce energy consumption by more than 30% compared to the older drives. While these variable-speed controllers add cost to a motor, the forecasted energy savings and increased motor functionality should easily offset those initial expenses within a few years.

Popular motor designs

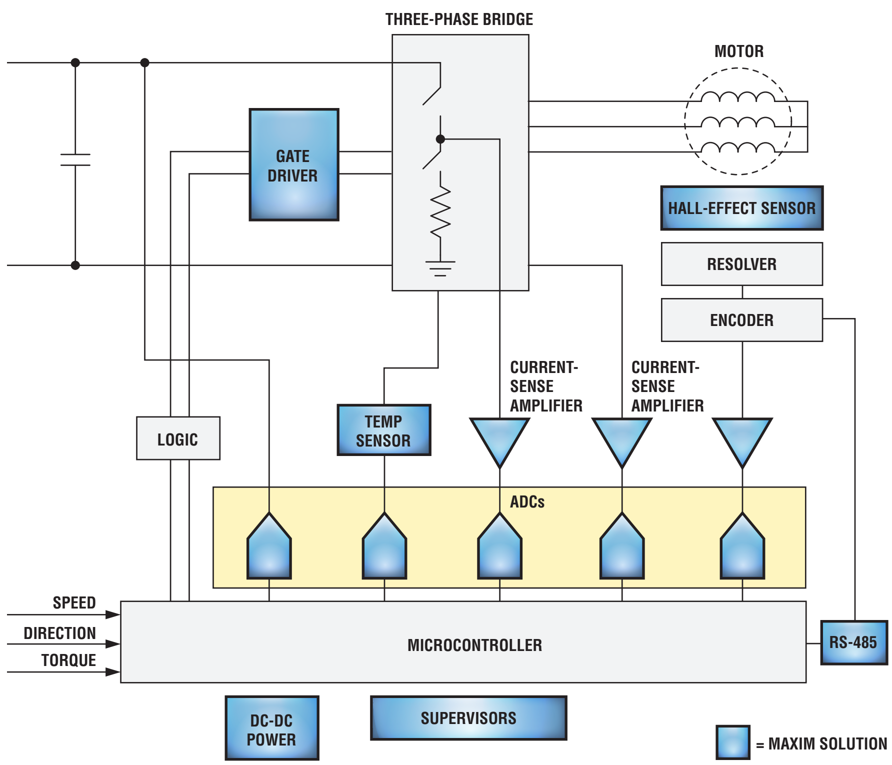
The DC motor, brushless DC, and AC induction motor are the popular motor designs used in today's industrial applications. Each of these motor types has its own unique characteristics, but they all operate on the same basic electromagnetic principle: when a conductor carrying current, such as a wire winding, is located in an external magnetic field perpendicular to the conductor, then the conductor will experience a force perpendicular to itself and to the external magnetic field.

DC motors: low cost and accurate drive performance

A DC motor was among the first motor types put to practical use, and it is still popular where low initial cost and excellent drive performance are required. In its simplest form, the stator (i.e., the stationary part of the motor) is a permanent magnet, and the rotor (i.e., the rotating part of the motor) carries an armature winding connected to a mechanical commutator which switches current on and off to the winding. The magnet establishes the field flux which interacts with the armature current to produce the electromagnetic torque, thereby enabling the motor to perform work. The motor's speed is controlled by adjusting the DC voltage applied to the armature winding.

Depending on the application, a full-bridge, half-bridge, or just a step-down converter is used to drive the armature winding. The switches in these converters are pulse-width modulated (PWMed) to achieve the desired voltage. Maxim's high-side or bridge-driver ICs like the MAX15024/MAX15025 can be used to drive the FETs in the full- or half-bridge circuit.

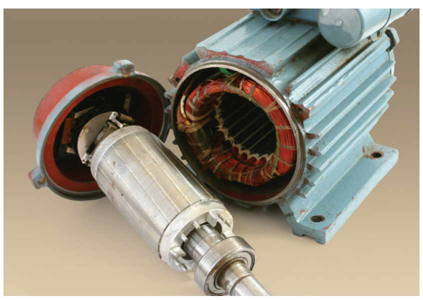
DC motors are also widely used in servo applications where speed and accuracy are important. To meet speed and accuracy requirements, microprocessor-based closed-loop control and information about rotor position are essential. Maxim's MAX9641* Hall-effect sensor provides information about rotor position.



Block diagram of a typical industrial motor control.
For a list of Maxim's recommended motor-drive solutions, please go to: www.maxim-ic.com/motordrive.

AC induction motors: simplicity and ruggedness

An AC induction motor is popular in industry because of its simplicity and ruggedness. In its simplest form, this motor is a transformer with the primary-side voltage connected to the AC-power-voltage source and the secondary side shorted to carry the induced secondary current. The name "induction" motor derives from this induced secondary current. The stator carries a three-phase winding and the rotor is a simple design, commonly called a "squirrel cage," in which the copper or aluminum bars are short-circuited at both the ends by cast-aluminum end rings. The absence of rotor windings and brushes makes this motor design especially reliable.



Rotor and stator of an induction motor.

When operated from the 60Hz voltage, the induction motor operates at a constant speed. However, when power electronics and a microprocessor-based system are used, the motor's speed can be varied. The variable-speed drive consists of an inverter, signal conditioner, and microprocessor-based control. The inverter uses three half bridges in which the top and the bottom switch are controlled in a complementary fashion. Maxim offers multiple half-bridge drivers like the MAX15024/MAX15025 which control the top and bottom FETs independently.

Precise measurement of three-phase motor current, rotor position, and rotor speed are necessary for efficient closed-loop control of an induction motor. Maxim offers many high-side and low-side current amplifiers, Hall-effect sensors, and simultaneous-sampling analog-to-digital converters (ADCs) to accurately measure these parameters in the harshest environments.

A microprocessor uses data on the current and position to generate logic signals for the three-phase bridge. A popular closed-loop control technique called vector control decouples the vectors of field current from the stator flux so that it can be controlled independently to provide a fast transient response.

Brushless DC motors: high reliability and high-output power

A brushless DC (BLDC) motor has neither commutator nor brushes, so it requires less maintenance than a DC motor. It also offers more output power per frame size compared to induction and DC motors.

The stator of the BLDC motor is quite similar to that of the induction motor. The BLDC motor's rotor, however, can take different forms, but all are permanent magnets. Air-gap flux is fixed by the magnet and is unaffected by the stator current. The BLDC motor also requires some form of rotor position sensing. A Hall-effect device embedded in the stator is commonly used to sense the rotor's position. When the rotor's magnetic pole passes near the Hall-effect sensors, a signal indicates whether the north or the south pole passed. Maxim offers several Hall-effect sensors like the MAX9641*, which simplifies designs and reduces system costs by integrating two Hall-effect sensors and digital logic to provide both positional and directional outputs of the magnet.

The importance of sensors, signal conversion, and data interfaces

Several types of sensors provide feedback information in the motor-control loop. These sensors also improve reliability by detecting fault conditions that can damage the motor. The following sections examine the role of sensors in motor control in greater detail. Specific attention will be given to current-sense amplifiers, Hall-effect sensors, and variable-reluctance (VR) sensors. Other important topics include monitoring and controlling multi-channel currents and voltages with high-speed analog-to-digital signal conversion (ADCs), and the encoder data interfaces needed for high-accuracy motor control.

www.maxim-ic.com/motordrive

* Future product—contact factory for availability.

Monitoring and measuring current for optimal motor control

Current monitoring

Current is a common signal to be sensed, monitored, and fed back to the motor-control loop. Current-sense amplifiers make it easier to monitor the current into and out of the system with a high level of precision. If current-sense amplifiers are used, no transducer is needed, as the electrical signal itself is being measured. Current-sense amplifiers detect shorts and transients, and they monitor power and reverse-battery conditions.

Current measurement

There is a variety of techniques to measure current, but by far the most popular uses a current-sense resistor. In this technique the voltage drop across the current-sense resistor is first amplified by an op amp set up in a differential gain stage, and then measured. Traditionally, this approach has been implemented with discrete components. However, discrete solutions also introduce some disadvantages such as the requirement for matched resistors, poor drift, and a larger solution area. Fortunately, these multiple and varied disadvantages can be overcome by integrating current-sense amplifiers into the design. Not only do the amplifiers measure the current, but they also sense the direction of current, accommodate wide common-mode ranges, and provide more precise measurement.

Current measurement employs either the low-side principle in which the sense resistor connects in series with the ground path, or the high-side principle in which the sense resistor connects in series with the hot wire. In low-side measurement, the circuit has a low-input common-mode voltage, and the output voltage is ground referenced. The low-side resistor adds undesirable extraneous resistance in the ground path. In high-side measurement, the load is grounded, but the high-side resistor must cope with relatively large common-mode signals. High-side sensing also allows detection of fault conditions such as the motor case or winding that shorts to ground.

High-side current-sense amplifiers like the MAX4080/MAX4081 employ a current-sensing resistor placed between the positive terminal of the power supply and the supply input of the monitored circuit. This arrangement avoids extraneous resistance in the ground plane, greatly simplifies the layout, and generally improves the overall circuit performance. Maxim's unidirectional and bidirectional current-sense ICs like the MAX9918/MAX9919/MAX9920 are available with or without internal sense resistors. This variety of parts adds considerable flexibility to designs and simplifies part selection for a wide variety of ADCs and applications.

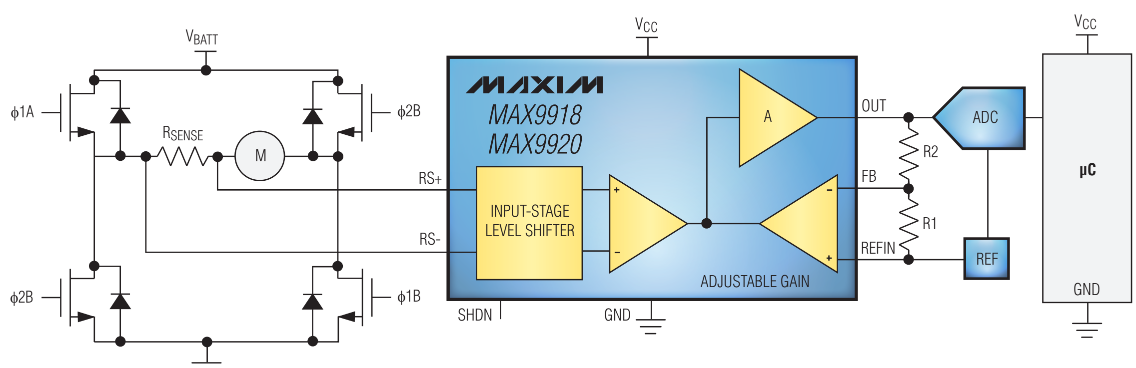
Precise current measurements ensure better motor control

MAX9918/MAX9919/MAX9920

The MAX9918/MAX9919/MAX9920 are current-sense amplifiers with a -20V to +75V input range. The devices provide unidirectional/bidirectional current sensing in very harsh environments where the input common-mode range can become negative. Uni-/bidirectional current sensing measures charge and discharge current in a system. The single-supply operation shortens the design time and reduces the cost of the overall system.

Benefits

- **Provide reliable operation in harsh motor-control environments**
  - 400µV (max) input offset voltage (V_{OS})
  - -20V to +75V common-mode voltage range provides reliability for measuring the current of inductive loads
  - -40°C to +125°C automotive temperature range
- **Integrated functionality reduces system cost and shortens design cycle**
  - Uni-/bidirectional current sensing
  - Single-supply operation (4.5V to 5.5V) eliminates the need for a second supply
  - 400µV (max) input offset voltage (V_{OS})
  - 0.6% (max) gain accuracy error



The MAX9918/MAX9920 current-sense amplifiers provide precise uni-/bidirectional current sensing in very harsh environments.

Sensing motor speed, position, and movement

Overview

Hall-effect sensors are used to sense the speed, position, and direction of motors. With integrated device logic, the sensors then communicate that data to the system for real-time feedback. The sensor also detects and reports any interruption to the motor so corrective action can be taken. Typically, to detect the direction of movement two Hall-effect sensors are used.

Commutation can be synchronized to Hall edges if the system has the same number of Hall-effect devices as motor phases, and if the mechanical geometry of the Hall-effect devices is correlated with the electrical geometry of the motor phases. Maxim's MAX9641* combines two Hall-effect sensors and sensor signal conditioning to provide both positional and directional outputs.

Hall-effect sensors can also be used with special Hall-effect sensor interface products like the MAX9621. The interface devices provide several functions: protect against supply transients, sense and filter the current drawn by the Hall-effect sensors, and diagnose and protect against faults.

Hall-effect sensors improve robustness and repeatability, compared to mechanical photointerrupter-based systems which are compromised in environments with dust and humidity. Since Hall-effect sensors detect the magnetic field produced by a magnet or current, they can operate continuously in such harsh environmental conditions.

In some applications vibration, dust, and high temperature cause active sensors to operate improperly. In these situations passive elements can be used to sense the motor's operation and feed that data to the system with an interface IC. Alternatively, variable-reluctance (VR) sensors can be used in these extreme operating conditions.

VR sensors like the MAX9924–MAX9927 have a coil to sense the speed and rotation of motors. When the toothed wheel of the shaft attached to a motor passes by the face of the magnet, the amount of magnetic flux passing through the magnet and, consequently, the coil varies. When the tooth is close to the sensor, the flux is at a maximum. When the tooth is further away, the flux drops off. The rotating toothed wheel results in a time-varying flux that induces a proportional voltage in the coil. Subsequent electronics then process this signal to get a digital waveform that can be counted and timed more readily. Integrated VR-sensor interface solutions possess many advantages over other solutions, including enhanced noise immunity and accurate phase information.

*Future product—contact factory for availability.

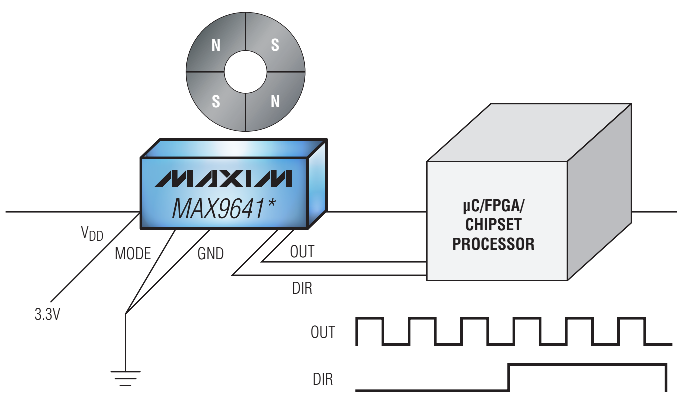
Simplify system design with flexible operating inputs

MAX9641*

The MAX9641 is an ultra-low-power, dual Hall-effect switch. Three programmable sampling periods of 160µs, 500µs, and 50ms give the designer flexibility to choose the operating speed. By setting the adjust pin, the MAX9641's operating point can be easily adjusted to three points which accommodate many different magnetic materials. Integrating two Hall-effect sensors into one chip reduces the overall system's cost. The user retrieves the information about the speed and direction of the magnet's movement with built-in logic communication.

Benefits

- **Enhanced functionality simplifies motor-control design**
  - Select the sampling period of 160µsec, 500µs, and 50ms by simply adjusting the RATE pin
  - Choose the threshold point of the switch by setting the ADJ pin
- **High integration simplifies measurement of speed and direction and reduces system cost**
  - Two Hall-effect sensors in a single IC
  - Direction and speed information is gathered simultaneously
  - 1.7V to 5.5V supply voltage range is compatible with many system designs



Dual Hall-effect switch solution.

*Future product—contact factory for availability.

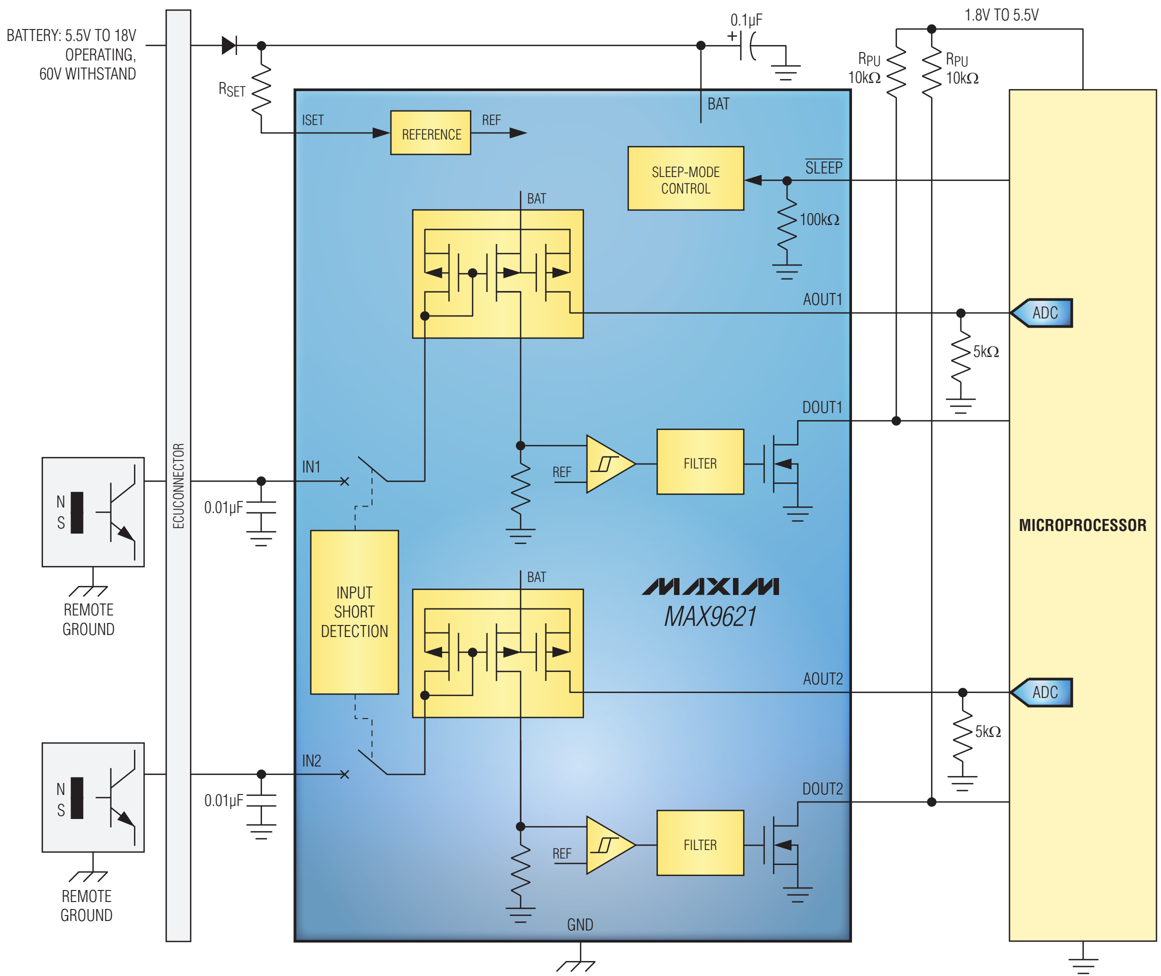
Highly accurate, reliable monitoring of motor speed and position with a sensor interface

MAX9621

The MAX9621 is a dual, 2-wire Hall-effect sensor interface with analog and digital outputs. This device enables a microprocessor to monitor the status of two Hall-effect sensors, either through the analog output by mirroring the sensor current for linear information, or through the filtered digital output. The input current threshold can be to the magnetic field. The MAX9621 provides a supply current to two 2-wire Hall-effect sensors and operates in the 5.5V to 18V voltage range. The high-side current-sense architecture eliminates the need for a ground-return wire without introducing ground shift. This feature saves 50% wiring cost.

Benefits

- **Integrated functionality eases motor-control design, reduces system cost**
  - Select the analog or digital output to monitor the Hall-effect sensor's condition
  - High-side current-sense architecture eliminates the need for a ground-return wire and saves 50% wiring cost
- **Reliable operation in a harsh environment**
  - Protects against up to 60V supply voltage transients
  - Detects a short-to-ground fault condition to protect the system



Functional diagram of the MAX9621 Hall-effect sensor interface.

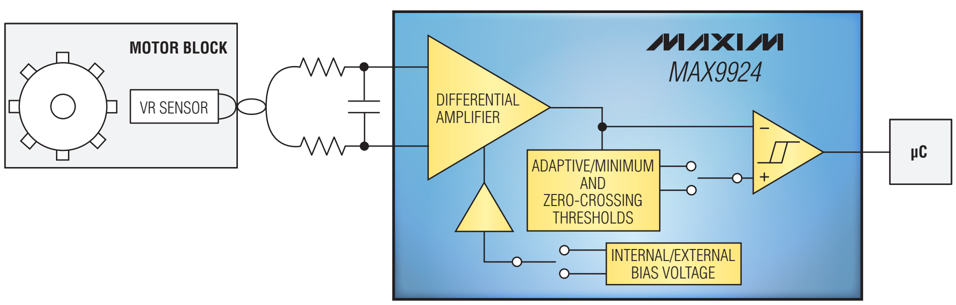
Improve performance and reliability in motor applications with a differential VR sensor interface

MAX9924–MAX9927

The MAX9924–MAX9927 VR, or magnetic coil, sensor interface devices are ideal for sensing the position and speed of motor shafts, camshafts, transmission shafts, and other rotating wheel shafts. These devices integrate a precision amplifier and comparator with selectable adaptive peak threshold and zero-crossing circuit blocks that generate robust output pulses, even in the presence of substantial system noise or extremely weak VR signals. The MAX9924–MAX9927 interface to both single-ended and differential-ended VR sensors.

Benefits

- **High integration provides accurate phase information for precise sensing of rotor position**
  - Differential input stage provides enhanced noise immunity
  - Precision amplifier and comparator allow small-signal detection
  - Zero-crossing detection provides accurate phase information



Simplified block diagram of the MAX9924 VR sensor interface to a motor.

Monitoring and controlling multichannel currents and voltages

Overview

To monitor and control a motor, multiple currents and voltages need to be measured and the phase integrity between the channels preserved. Designers are faced with two choices for the ADC architecture: use multiple single-channel ADCs in parallel, a design that makes it very difficult to synch up the conversion timing; or use a simultaneous-sampling ADC. The simultaneous-sampling architecture uses either multiple ADCs in a single package, all with a single conversion trigger, or with multiple sample-and-hold amplifiers (also referred to as track-and-hold amplifiers) on the analog inputs. In the case of multiple sample-and-hold amplifiers, a multiplexer is still used between the multiple analog inputs and the single ADC. Simultaneous sampling eliminates the need for complicated digital-signal-processing algorithms.

Sampling speeds of 100ksps or more are common for motor-control applications. At these speeds the ADC continuously monitors the motor for any indication of errors or potential damage. At the first sign of trouble, the system can correct itself or shut down when necessary. If the ADC does not sample fast enough, an error condition might not be identified early enough to be addressed.

The amount of dynamic measurement range varies for each motor-control application. In some cases 12 bits of resolution are sufficient. For the more precise motor-control

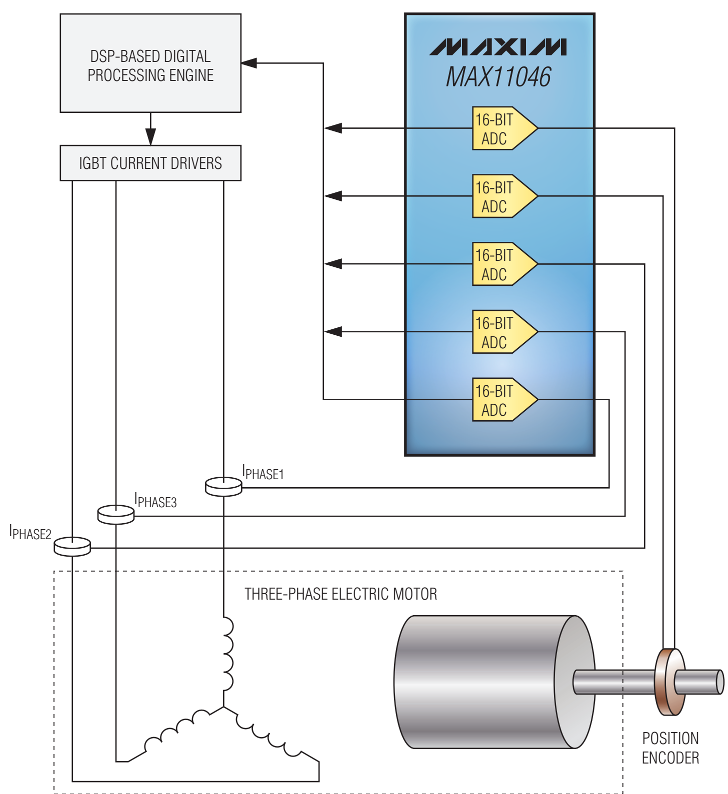
applications, however, 16 bits of resolution are a more common standard. A high-performance 16-bit ADC like the MAX11044 or MAX11049 allows a system to achieve better than 90dB of dynamic range.

Maxim offers a broad portfolio of simultaneous-sampling ADCs designed for motor control. Devices have both serial and parallel interfaces, and 12-, 14-, or 16-bit operation.

Resolve very fine motor adjustments and operate higher accuracy systems with simultaneous-sampling ADCs

MAX11044/MAX11045/MAX11046 MAX11047/MAX11048/MAX11049

The MAX11044–MAX11049 ADCs are an ideal fit for motor-control applications that require a wide dynamic range. With a 93dB signal-to-noise ratio (SNR), these ADCs detect very fine changes to motor currents and voltages, which enables a more precise reading of motor performance over time. The MAX11046/MAX11045/MAX11044 simultaneously sample eight, six, or four analog inputs, respectively. All ADCs operate from a single 5V supply. The MAX11044–MAX11046 ADCs measure ±5V analog inputs, and the MAX11047–MAX11049 measure 0 to 5V. These ADCs also include analog input clamps which eliminate an external buffer on each channel.



The MAX11046 ADC simultaneously samples up to 8 analog-input channels.

Benefits

- **Industry-leading dynamic range allows early detection of error signals**
  - 93dB SNR and -105dB THD
- **Simultaneous sampling eliminates phase-adjust firmware requirements**
  - 8, 6, or 4-channel ADC options
- **Lower system cost by as much as 15% over competing simultaneous-sampling ADCs**
  - High-impedance input saves costly precision op amp
  - Bipolar input eliminates level shifter
  - Single 5V voltage supply
  - 20mA surge protection
- **Eliminate external protection components, saving space and cost**
  - Integrated analog-input clamps and small 8mm x 8mm TQFN package provide the highest density per channel

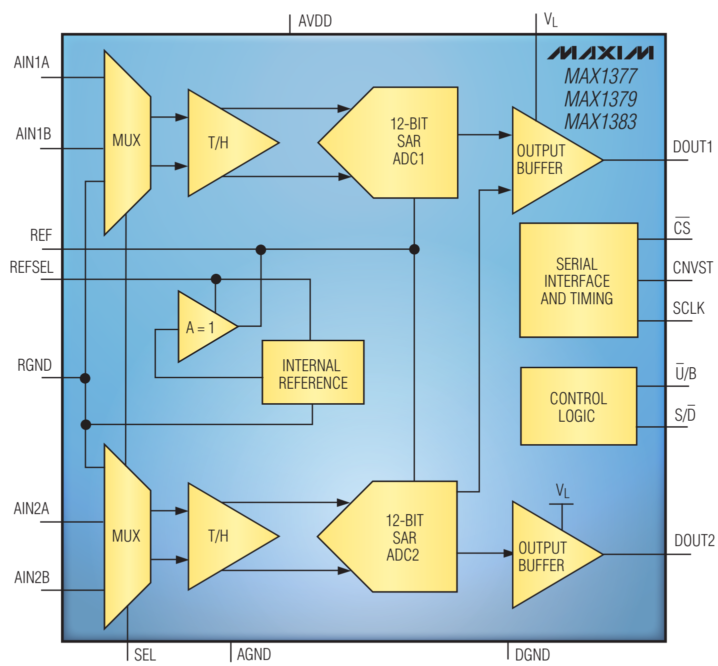
Detect errant motor shifts quickly by sampling at 1.25Msps

MAX1377/MAX1379/MAX1383

The MAX1377/MAX1379/MAX1383 integrate a pair of successive approximation register (SAR) ADCs that simultaneously sample a pair of differential inputs. This design allows a voltage and current pair to be sampled with the phase integrity between the two channels preserved. The MAX1377 (0 to 5V), MAX1379 (0 to 10V), and MAX1383 (±10V) sample up to 1.25Msps, allowing constant monitoring of the motor's health at various analog-input ranges. These ADCs communicate over a 4-wire SPI™ serial interface that saves cost and space on the external isolation components compared to similar high-speed ADCs with parallel interfaces.

Benefits

- **Preserve phase integrity, save space**
  - Simultaneous sampling on multiple channels
  - Two differential or four single-ended input channels
- **Simplify data transmission, save cost and space on isolators**
  - 4-wire SPI interface reduces number of isolation components needed compared to ADCs with parallel data interfaces
- **Monitor constantly with a fast sampling speed**
  - Dual integrated ADCs sample at up to 1.25Msps



The MAX1377/MAX1379/MAX1383 integrate two ADCs for true simultaneous sampling.

High-accuracy motor control with encoder data interfaces

Overview

The accuracy with which a motor needs to be controlled depends on the system requirements. In some applications the accuracy requirements are very high, as in industrial robotics or in bottling. A welding robot, for example, is expected to operate with high speed and high precision. Similarly, the motors in a bottling factory must be controlled accurately so that bottles are stopped at the right position for filling, capping, and labeling. To control a motor precisely, the rotor's speed, direction, and position have to be determined. These can be monitored with analog sensors like resolvers, synchros, RVDTs, or rotary potentiometers. High accuracy is obtained with the use of encoders like optical encoders and Hall-effect sensors. Encoders provide the controller with incremental and/or absolute shaft-angle information.

A motor controller, commonly implemented algorithmically by a digital signal processor (DSP), calculates the rotor's present speed and angle. It adjusts the actuating power stages to achieve the desired response efficiently and optimally. This feedback control loop requires robust and reliable information from the sensor, typically communicated over long cables from the encoder to the controller.

Incremental information is typically transmitted to the controller by quadrature signals, i.e., two signals phase shifted by 90°. These signals can be in analog form (sine + cosine) or in binary form. Absolute position information, in contrast, is only communicated by a serialized binary data stream through RS-482 or RS-422.

As the working environments are harsh, the data paths need to be robust and reliable. EMI levels are high, which explains the use of differential

signaling. High temperatures are commonly encountered due to the proximity to the motor.

Maxim's extensive range of RS-485/RS-422 and PROFIBUS interface devices are targeted for these motor-control applications. Interface devices like the MAX14840E high-speed RS-485 transceiver exhibit the high-signal integrity and robustness expected for stringent safety control and for sustaining the up-time of large capital investments.

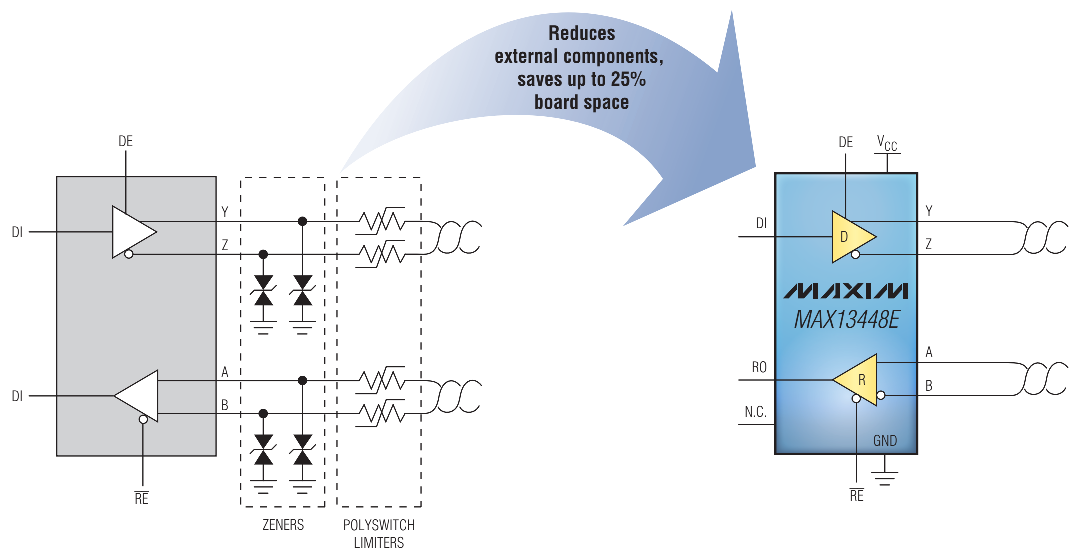
Make equipment more robust with fault-protected RS-485 transceivers

MAX13448E, MAX3440E–MAX3444E, MAX13442E/MAX13443E/MAX13444E, MAX3430

In applications where power and data are distributed over the same cable, there is a potential for miswiring, cable shorts, or surges on the communication bus. Maxim's fault-protected RS-485 MAX13448E, MAX3440E, MAX13442E, and MAX3430 transceiver families offer fault protection up to ±80V_{DC} .

Benefits

- **Integrated fault protection to ±80V_{DC} allows smaller encoder designs**
  - Saves board space and cost of discrete protection circuitry
  - High-speed RS-485 requirements are met despite fault protection
  - Reduces field returns due to misconnection
- **Multiple configurations increase design flexibility**
  - 3.3V/5V versions allow modern low-voltage supplies
  - Full- and half-duplex operation covers all encoder needs
  - 250kbps and 10Mbps versions support modern encoder speed requirements
- **ESD protection up to ±15kV (HBM) reduces cost and size**
  - Reduces the need for external ESD protection



Part	V_{CC} Supply (V)	Configuration	Fault Protection (V)
MAX13448E	3.3 to 5	Full	±80
MAX3440E–MAX3444E	5	Half	±60
MAX13442E–MAX13444E	5	Half	±80
MAX3430	3.3	Half	±80

Maxim's RS-485 family offers high levels of integration which saves board space and cost.

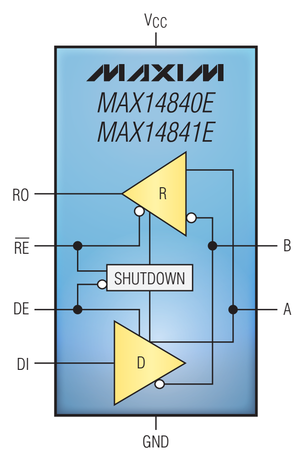
Extend cable lengths in harsh motor-control environments with high-speed RS-485 transceivers

MAX14840E/MAX14841E

The MAX14840E/MAX14841E are 3.3V high-speed (40Mbps), half-duplex RS-485 transceivers ideally suited for industrial applications where extended-cable-length communication is required. The MAX14840E features a symmetrical fail-safe receiver and larger receiver hysteresis. It provides improved noise rejection and improved recovered signals in high-speed and long-cable applications. The MAX14841E has true fail-safe receiver inputs, guaranteeing a logic-high receiver output when inputs are shorted or open. The MAX14840E/MAX14841E are ideal for harsh motor-control environments.

Benefits

- **Improve reliability during handling and installation in environments with high-static charge**
  - Industry's highest ESD protection
  - ±35kV Human Body Model (HBM)
  - ±20kV IEC 61000-4-2 (Air Gap)
  - ±10kV IEC 61000-4-2 (Contact)
- **Rugged performance in housings near motors running at high temperatures and in the harshest environments**
  - Wide -40°C to +125°C operating temperature range
- **Allow smaller encoder enclosures**
  - Space-saving tiny 8-pin (3mm x 3mm) TDFN package



Functional diagram of the MAX14840E/MAX14841E transceivers.

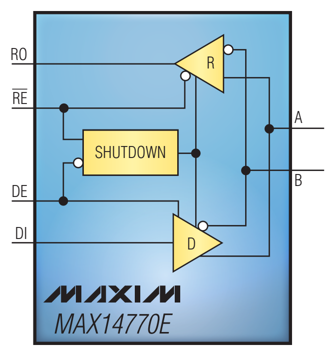
Transceiver meets PROFIBUS DP standards and protects against ±35kV ESD

MAX14770E

The MAX14770E PROFIBUS DP transceiver meets strict PROFIBUS standards with a high-output-drive differential (greater than 2.1V) and an 8pF bus capacitance. The high-ESD protection (±35kV, HBM), high-automotive-temperature grade, and space-saving 8-pin TQFN package make the MAX14770E ideal for space-constrained, harsh industrial environments.

Benefits

- **Easy to connect to PROFIBUS networks**
  - Meets EIA 61158-2 Type 3 PROFIBUS DP specifications
  - -40°C to +125°C temperature range for use in extreme conditions
- **Space saving**
  - Tiny 8-pin, 3mm x 3mm TDFN package
- **Industry's highest ESD protection improves reliability**
  - ±35kV Human Body Model (HBM)
  - ±20kV IEC 61000-4-2 (Air Gap)
  - ±10kV IEC 61000-4-2 (Contact)



Block diagram of the MAX14770E.

Recommended solutions

Part	Description	Features	Benefits
ADCs			
MAX11044/45/46 MAX11047/48/49	16-bit, 4-/6-/8-channel, simultaneous-sampling SAR ADCs	93dB SNR; -105dB THD; 0 to 5V or ±5V inputs; parallel interface outputs, all eight data results in 250ksps; high-input impedance (> 1MΩ)	High-impedance input saves the cost and space of external amplifier
MAX1377/MAX1379/ MAX1383	12-bit, 1.25Msps, 4-channel, simultaneous-sampling SAR ADCs	0 to 5V, 0 to 10V, or ±10V inputs; 70dB SNR; four single-ended or two differential inputs; SPI interface	Serial interface saves cost and space on digital isolators
MAX11040	24-bit, 4-channel, simultaneous-sampling, sigma-delta ADC	117dB SNR; 64ksps; internal reference; SPI interface; 38-pin TSSOP package	Reduces motor-control firmware complexity; captures accurate phase and magnitude information on up to 32 channels
MAX11103*	12-bit, 3Msps, 2-channel SAR ADC	73dB SNR; SPI interface; high 1.7MHz full linear bandwidth; single-channel (SOT23) and 2-channel (µMAX®, TDFN) options	Tiny SOT23, µMAX, and TDFN packages save space; serial interface simplifies data transmission
Current-sense amplifiers			
MAX9918/19/20	75V precision current sources	-20 to +75V input sensing range	Wide dynamic range supports wide range of motor current-sensing applications
MAX4080/81	75V uni-/bidirectional current sources	High-input voltage; bidirectional current source	Monitor current direction (sink or source) across a wide input-voltage range
MAX4210	Power and current-sense amp with fault detection and alert flag	Continuously monitors power consumption and system current levels with report out	Integrated functionality reduces design time in motor-control applications
Operational amplifiers			
MAX9943/44	High-voltage, precision, low-power op amps	Wide 6V to 38V supply range; 2.4 MHz gain bandwidth (GBW); withstands 40V transient on any pin	Robust performance in harsh environmental conditions
MAX9945	Low-noise, MOS-input, low-power op amp	4.75V to 38V supply voltage range; low input-bias current; low input-current noise; withstands 40V transient on any pin	Robust performance in harsh environmental conditions
MAX9650/51	20V high-output-drive op amps	1.3A output current drive	Reliable and robust design; improve noise immunity in motor-control loop
Variable-reluctance (VR) sensor interface			
MAX9924–MAX9927	Reluctance (VR or magnetic coil) sensor interface devices	Integrated precision amplifier and comparator for small-signal detection; user-enabled, internal adaptive peak threshold or flexible external threshold	Accurately detect position and speed of motors and turning shafts; improve performance and reliability in motor applications
Hall-effect sensor and interface			
MAX9641*	Dual Hall-effect sensor	Three programmable sampling periods (160µs, 500µs, and 50ms); adjustable threshold levels	Simplifies motor-control designs; provides system flexibility
MAX9621	Dual, 2-wire Hall-effect sensor interface	Monitors the status of Hall-effect sensor either through the analog output or through the filtered digital output	Provides system design flexibility through analog and digital outputs
Thermal management			
DS7505	Low-voltage, precision digital thermometer and thermostat	±0.5°C accuracy from 0°C to +70°C; 1.7V to 3.7V operation; industry-standard pinout	Industry-standard pinout allows easy accuracy upgrade and supply voltage reduction from LM75
MAX6675	K-type thermocouple-to-digital converter	Built-in cold-junction compensation	Simplest thermocouple interface; no external components needed

(Continued on next page)

*Future part—contact factory for availability.

Recommended solutions *(continued)*

Part	Description	Features	Benefits
Voltage supervisors			
MAX6381	Single-voltage supervisor	Multiple threshold and timeout options	Versatile for easy design reuse; SC70 package saves board space
MAX6495	72V overvoltage protector	Protects against transients up to 72V; small 6-pin TDFN-EP package	Increases system reliability by preventing component damage from high-voltage transients; saves space; easy to use
MAX6720	Triple-voltage supervisor	Two fixed and one adjustable thresholds	Integration shrinks design size and increases reliability compared to multiple components
MAX6746	Capacitor-adjustable watchdog timer and reset IC	Capacitor-adjustable timing; 3µA supply current	Versatile for easy design reuse; SOT23 package saves board space
MAX6816/17/18	Single/dual/octal switch debouncers	±15kV ESD (HBM) protection	High reliability; easy to use; ESD protection makes designs more robust
Interface transceivers			
MAX14840E	High-speed RS-485 transceiver	40Mbps data rates; ±35kV (HBM) ESD tolerance; 3.3V; +125°C operating temperature; small 3mm x 3mm TQFN package	High receiver sensitivity and hysteresis extend cable lengths in harsh motor-control environments
MAX13448E	Fault-protected RS-485 transceiver	±80V fault protected; full-duplex operation; 3V to 5.5V operation	Makes equipment more robust and tolerant to misconnection faults
MAX14770E	PROFIBUS transceiver	±35kV (HBM) ESD protection; -40°C to +125°C temperature range; small 3mm x 3mm TQFN package	Industry's highest ESD protection; makes motor control more robust
MAX3535E	Isolated RS-485 transceiver	3V to 5V operation; 2500V_{RMS} isolation; ±15kV ESD (HBM) protection	Simple solution for isolating data and power supply
MAX253	Transformer driver for isolated power supply for RS-485/PROFIBUS interfaces	Single 5V or 3.3V supply; 0.4µA low-current shutdown mode; pin-selectable 350kHz or 200kHz frequency; µMAX package	Simple open-loop circuit speeds power-supply design; shortens time to market
DC-DC converters and controllers			
MAX5080/81	Step-down DC-DC converters with integrated switch	4.5V/7.5V to 40V V_{IN}; 1.23V to 32V V_{OUT}; switch to pulse-skip mode at light loads; integrated high-side switch	Save cost with integrated DC-DC converters that power directly off an industrial bus
MAX5072	Dual-output buck or boost converter with integrated switch	4.5V to 5.5V or 5.5V to 23V V_{IN}; 0.8V (buck) to 28V (boost) V_{OUT}; configure each output as buck or boost	Improves reliability with controlled inrush current, thermal shutdown, short-circuit protection
MAX15023	Wide 4.5V to 28V input, dual-output, synchronous buck controller	4.5V to 28V V_{IN}; V_{OUT} = 0.6V to 0.85 x V_{IN}; hiccup mode	Thermal shutdown and short-circuit protection for the system
MAX15034	Single-/dual-output synchronous buck controller for high-current applications	4.75V to 5.5V or 5V to 28V V_{IN}; V_{OUT} = 0.61V to 5.5V; 25A or 50A output	Thermal shutdown and monotonic start protect devices; improves reliability
MAX15048/49	3-channel DC-DC controllers with tracking/sequencing	4.7V to 23V V_{IN}; V_{OUT} = 0.6V to 19V; tracking across the three outputs; power sequencing	Saves space and cost by integrating three switching controllers
MOSFET/rectifier drivers			
MAX15024/25	FET drivers	Single/dual operation; 16ns propagation delay; high sink/source current; 1.9W thermally enhanced TDFN package	Simplify design with a very low propagation delay and a thermally enhanced package
MAX5048 MAX5054–MAX5057 MAX5078	FET drivers	4A to 7.6A; 12ns to 20ns; single/dual MOSFET drivers	Increase flexibility with inverting/noninverting inputs to control the MOSFET

For a list of Maxim's recommended motor-drive solutions, please go to: www.maxim-ic.com/motordrive.