

Sustainable Motion Control Solutions

Almost 70% of electricity consumed by industry is used by electric motor systems.¹ Intelligent motion control solutions are delivering and will continue to deliver significant reductions in energy consumption by moving more applications from fixed speed motors to high efficiency motors and variable speed drives, in part driven by energy efficiency regulations. This reduction in energy consumption will enable more sustainable manufacturing. Access to motion insights that optimize manufacturing flow will further reduce energy consumption in smart manufacturing. Analog Devices is empowering the Intelligent Edge through the world's most innovative analog, digital, and software solutions to unlock actionable motion insights in manufacturing to reduce global carbon emissions.

Key Advantages







Reduced Energy Agile Production Consumption





Models

¹ João Fong, Fernando J.T.E. Ferreira, André M. Silva, and Anibal T. de Almeida. "IEC 61800-9 System Standards as a Tool to Boost the Efficiency of Electric Motor Driven Systems Worldwide." Inventions, March 2020.

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From the humble pump to the cutting-edge multi-axis robot, electric motors are the backbone of industrial motion. It comes as no surprise that electric motors account for up to 70% of the electricity used in industry, which translates to up to 50% of the world's electricity consumption.

Evolution of Intelligent Motion Control



Motors and motion control has evolved over time; from basic on/off fixed speed motors to complex multi-axis servo-drive solutions in robotics. The evolution has been driven by the increasing complexity of automation required to deliver higher levels of performance and autonomy in smart manufacturing.

Adoption of high efficiency motors and variable speed drives, while adding intelligence to motion control applications, are key factors in achieving significant energy efficiency improvements in industry and infrastructure.

ADI's domain expertise and family of products enable motion control solutions with a faster response and higher precision, leading to higher quality products and motion synchronization, as well as integrated safety functions, which in turn lead to greater productivity.

Megatrends in Intelligent Motion

Sustainability and Renewability

Increased adoption of Industry 4.0 coupled with the climate change is accelerating sustainable and renewable manufacturing processes and practices.



Agile Automation

Manufacturers are adopting agile manufacturing to cope with a high degree of customization, which is driving varied and often smaller batch sizes.

Digitization

Seamless access to motion insights available via a plethora of sensors in and on the drive and the motor are enabling real-time control and optimization of motion applications. Intelligent motion control applications require power electronics to drive the motor; current sense and position sense to provide accurate motion sense data enabling precise and accurate motion control; machine health technology to provide asset health data; and industrial connectivity to enable seamless data flow for optimizing the manufacturing flow and providing system-level insights.

Typical Intelligent Motion Control System



Multi-Axis and Network Connectivity

Power Electronics

Isolated gate drivers are needed to drive high- and low-side power semiconductors to provide robust, safety compliant, and high reliability assets. High voltage inverter applications often use IGBTs, with a future trend toward SiC and GaN to increase switching frequency and/or lower switching losses

Current Feedback

Current feedback is the fundamental building block to enhancing drive performance and determines the overall control bandwidth and response time. Key requirements for current feedback include synchronized measurement with PWM cycle, isolated or high common-mode measurement, low offset drift to minimize torque ripple, and low latency simultaneous sampling at 14- to 18-bit resolution to measure phase currents.

Position Feedback

Position feedback is used for direct position control or for inferring rotational speed and implementing machine speed control. RDCs, optical encoders, and AMR position sensors provide high bandwidth position feedback data for robust performance.

Machine Health

Machine health uses vibration and shock sensors to enable real-time condition monitoring of an asset's health to eliminate unplanned downtime, extending the asset's usable lifetime while also reducing maintenance costs.

Network Connectivity

Industrial Ethernet connectivity with sub-ms cycle times network performance is required for deterministic real-time communication in motion control applications (servos and drives). Robust physical layer devices at 100 Mb and Gb speeds combined with Layer 2 Industrial Ethernet protocols such as EtherCAT, PROFINET, EtherNET/IP, and IEEE time sensitive networking (TSN) ensure deterministic Ethernet connectivity.

Motion Controller

Motion controller requires higher power density power management solutions that operate at high ambient temperatures to enable smaller form factor intelligent motion applications. It also requires RS-485 communication to the encoder to provide accurate position feedback.

Key Technologies



Precision Measurement

Precision measurement converters from Analog Devices solve challenges associated with current and voltage monitoring and position feedback applications, enabling superior motion control and reducing the burden of design.

Isolation and Interface

Safety isolation is a critical requirement in industrial designs. ADI iCoupler[®] digital isolation technology is a safe, reliable, and easy to use alternative to optocouplers.

Power Management

Miniaturization of drives demands more efficient power management solutions to effectively reduce size and minimize thermal challenges. ADI offers a broad range of high performance power solutions.

Industrial Ethernet

The ADI Chronous[™] portfolio of robust Industrial Ethernet solutions supports all major Industrial Ethernet protocols and provides multiprotocol flexibility, ease of use, and support to deliver deterministic motion solutions.

Magnetic Sensing

From compact and high resolution solutions for space constrained applications to magnetic angle sensors, ADI is accelerating robust and accurate motion sensing.

Machine Health

Condition monitoring enables early detection and diagnosis of machine and system abnormalities via real-time monitoring. ADI's platforms and solutions are accelerating the adoption of preventative maintenance. Current feedback is the fundamental building block to enhancing drive performance as it determines overall control bandwidth and response. High bandwidth and accurate current measurement is a key requirement for precise motion control. ADI is the industry leader in precision converters and contactless AMR current measurement.

Key Advantages

- Synchronized measurement with PWM cycle
- Isolated or high common-mode measurement
- Low offset drift to minimize torque ripple
- ▶ Simultaneous sampling at 14 to 16 bits, low latency

Shunt Based

A typical shunt-based measurement involves inserting a shunt resistor in series with either a motor phase or the leg of the gate driver and measuring the differential voltage with the help of an ADC for bestin-class performance. This method is limited by the power dissipation in the shunt resistor and hence limited to low-to-medium current application.

Magnetic Sensing

Magnetic current sensing involves measuring the current by measuring magnetic field in the vicinity of the wire/PCB trace. Since there is no power dissipation constraint and inherent isolation in this topology, it is highly suitable for high current measurement.

AD8410/AD8417/AD8418	Fast Settling Op Amps for Shunt-Based Current Sensing						
ADA4807	Low Noise, 180 MHz, Rail-to-Rail Input/Output Amplifier						
AD7380	4 MSPS Dual Simultaneous Sampling, Differential Input, 16-Bit SAR ADC						
ADuM770x	Family of 16-Bit, Isolated, Sigma-Delta ADCs						
AD8515	1.8 V Low Power CMOS Rail-to-Rail Input/Output Operational Amplifier						
AD7606-4	4-Channel DAS with 16-Bit, Bipolar Input, Simultaneous Sampling ADC						
MAX4122	Single/Dual/Quad, Wide Bandwidth, Low Power, Single-Supply Rail-to-Rail Op Amp						



Position Feedback

Position sensors are widely used in closed-loop mechanical control systems across a wide variety of industries. Analog Devices provides signal chain solutions for most common, high precision position sensors such as optical encoders, resolvers, and LVDTs and magnetic sensors (AMR, TMR, Hall) that enable high bandwidth and throughput rate for robust performance.

ADI's high precision signal chain solutions enable precise measurement with minimal solution size and optimal power consumption and simplified design.

Key Advantages

- Best-in-class ADCs for optical encoders
- Highly integrated solutions for simplified design

Resolvers

Up to a 16-bit level of

angular accuracy

precision with 2.5 arcmin

Resolvers are used with RDCs for position and velocity feedback appli-

Up to a 3125 RPS tracking

fault detection

rate with programmable

cations, delivering exceptional performance in harsh environments.

- Optimized size, bandwidth, and throughput rate for robust performance
- Industry proven solutions

►

Optical Encoders

Optical encoders use a light sensor, light source, an encoder disk, and ADC to digitize angular displacement.

- Up to 4 MSPS throughput for minimal latency and fast control loop transient response
- Oversampling engines allow higher accuracy for robust performance

Magnetic Sensing

Magnetic position sensing is a robust position sensing method that typically involves an AMR sensor: delivering robust performance in harsh and dusty environments.

Key Advantages

High precision 180°C sensors

Low thermal and lifetime drift

RTD Converters

Max angular error of 0.5°
 Integrated driver drives external converters

AD2S1205	12-Bit R/D Converter with Reference Oscillator								
AD2S1210	10- to 16-Bit Resolution Tracking RTD Converter with Reference Sinusoidal Oscillator								
	AMR Sensors and Signal Conditioners								
ADA4571	Integrated AMR Angle Sensor and Signal Conditioner								
ADA4570	Integrated AMR Angle Sensor and Signal Conditioner with Differential Outputs								
	ADCs, ADC Drivers and Amplifiers								
AD7380	4 MSPS Dual Simultaneous Sampling, Differential Input, 16-Bit SAR ADC								
AD7357	Differential Input, Dual, Simultaneous Sampling, 4.25 MSPS, 14-Bit, SAR ADC								
ADA4940-2	Ultra Low Power, Low Distortion ADC Driver								
ADA4805-2	Low Offset Drift, 105 MHz, Low Power, Low Noise, Dual Rail-to-Rail Amplifier								
AD4680	Differential Inputs, 1 MSPS, Dual Simultaneous Sampling SAR ADCs								
AD7266	12-Bit, High Speed, Low Power, 2 MSPS Successive Approximation ADC								
MAX11192	12-/14-/16-Bit, 2 MSPS Dual Simultaneous Sampling SAR ADC with Internal Reference								

Isolated Gate Drivers

Analog Devices' small form factor isolated gate drivers are designed for higher switching speeds and system size constraints. These isolated gate drivers leverage ADI's proven iCoupler isolation technology combined with high speed CMOS and monolithic transformer technology to enable ultralow propagation delay without sacrificing common-mode transient immunity (CMTI) performance. High pulse fidelity architecture enables motor power efficiency to meet the new required efficiency levels.

ADI's isolated gate drivers are particularly suited to drive new generation SiC and GaN, providing the industry's fastest short-circuit protection (SCP) response time, high CMTI (>150 V/ns), and short propagation delay.

Key Advantages

- ▶ High speed, low propagation delay/delay skew
- Reliable operation with SiC and GaN
- Magnetic isolation for robust and high CM immunity solutions
- Variable slew rate switching
- ► Fast switch protection features—DESAT, soft shutdown, UVLO

ADuM4221	Isolated Half-Bridge Gate Driver with Adjustable Dead Time		
ADuM4122	Isolated Gate Driver with Slew Rate Control		
ADuM4135	13 A Isolated Bipolar Gate Driver with Fault Detection and Miller Clamp		
ADuM4136	13 A Isolated Bipolar Gate Driver with Fault Detection		
ADuM4146	11 A High Voltage Isolated Bipolar Gate Driver Optimized for SiC with Fault Detection, Miller Clamp		
ADuM6020/ADuM6028	Low Emission, 5 kV Isolated DC-to-DC Converters		
MAX22700D/MAX22701D/MAX22702D, MAX22700E/MAX22701E/MAX22702E	Family of Ultrahigh CMTI Isolated Gate Drivers		



Application Diagram of ADuM4122

Smart manufacturing requires industrial connectivity to merge assets, technologies, and insights together into an efficient, resilient, and flexible ecosystem that can easily adapt to unique manufacturing needs and pivot to embrace future trends. Complete, proven communications solutions will accelerate the deployment of these flexible ecosystems to drive new levels of productivity and efficiency in tomorrow's smart factories. Designed to operate over extended industrial ambient temperature ranges, while maximizing data transmission and signal integrity, ADI's Industrial Precertified Solution provides the highest level of reliability for the Industrial Ethernet applications of today and tomorrow.

Key Advantages

- Real-Time IT/OT Connectivity
- Up to Gb Data Rates
- Low Power

- Low Latency
- Complete Precertified Solution
- EMC Robustness and High Ambient Temperature

Featured Products

ADIN1200	100 Mbps/10 Mbps Robust, Industrial, Low Power, Ethernet Phy
ADIN1300	1 Gbps/100 Mbps/10 Mbps Robust, Industrial, Low Latency and Low Power Ethernet PHY
fido5100/fido5200	100 Mbps/10 Mbps Real-Time Ethernet Multiprotocol (REM) Switch
ADIN2299BCZ	A Complete Off-the-Shelf Ready to Use Network Interface Module
EV-RPG2	A Complete Off-the-Shelf Ready to Use Network Interface Module

Secure Authenticators

Intelligent motion systems often manage critical infrastructure such as water distribution. In order to defend critical infrastructure, robust and secure authentication is needed.

ADI's DeepCover[®] secure authenticators meet and exceed these requirements with features including cryptography based on symmetric key SHA-256 (secure hash algorithm) or asymmetric key ECDSA (elliptic-curve digital signature algorithm).

DS28S60	DeepCover Cryptographic Coprocessor with ChipDNA [™]						
MAXQ1065	Ultra Low Power Cryptographic Controller with ChipDNA for Embedded Devices						
MAXQ1061	DeepCover Cryptographic Controller for Embedded Devices						



Isolated Interfaces

ADI has been pioneering advances in digital isolation technology for over 20 years with both iCoupler digital isolation ICs and µModule[®] BGA digital isolation.

In today's increasingly digitalized industrial applications, ADI is the expert where electrical meets electronic.

Our innovative portfolio delivers best-in-class patented digital isolation technology for data communication protocols ranging from SPI, I²C, USB, and CAN to gigabit LVDS and isolated amplifiers. For trusted safety and data integrity, partner with Analog Devices' digital isolation technology solutions.

Data Isolators

Analog Devices' digital isolators enable robust motion control with our magnetically isolated iCoupler products with the flexibility of up to 6 channels, with data rates up to 150 Mbps and isolation up to 7.5 kV rms.

SPI Isolators

Our dedicated SPIsolators[®] are built with our proven iCoupler technology and offer a small footprint, simple design-in, fast speeds, and high data integrity.

I²C Isolators

Analog Devices' cutting edge technology enables a complete, isolated I²C interface with a small form factor by integrating iCoupler channels with semiconductor circuitry.

ADuM3150	3.75 kV, 6-Channel, SPIsolator Digital Isolator for SPI with Delay Clock							
ADuM4150	5 kV, 6-Channel, SPIsolator Digital Isolator for SPI with Delay Clock							
ADuM1250	2.5 kV Hot Swappable, Dual I ² C Isolators							
ADuM2250	5 kV Hot Swappable, Dual I ² C Isolators							
ADuM141E	Robust, Quad-Channel Isolator with Output Enable and One Reverse Channel							
ADuM121N	Robust 3.0 kV rms Dual-Channel Digital Isolator and One Reverse Channel							
ADuM6421A	Quad-Channel Isolator with Integrated DC-to-DC Converter (3:1 Directionality)							
LTM2887	6-Channel Logic Isolator with Dual Adjustable 5 V Regulators							
ADuM341E	5.7 kV rms Quad Digital Isolator							



NIC = No internal connection. Leave this pin floating.

RS-485/RS-422

Industrial environments are challenging for data communications, because electrical noise and long cable lengths affect the stability and reliability of communications. In intelligent motion control applications, high speed, low latency, and reliable communications are required to provide accurate and timely feedback for precise and robust position control. Analog Devices transceivers are designed for reliable operation in these harsh environments, with added noise immunity and robustness.

Analog Devices offers a wide range of RS-232, RS-422, and RS-485 transceivers to suit applications for nonisolated interfaces, as well as digital isolation requirements using iCoupler technology.

Key Advantages

- High data rate
- Low propagation delay

Ultralow skew

Robust EMC and ESD performance

Long cable length

ADM3066E	±12 kV IEC ESD Protected, Half-Duplex 50 Mbps RS-485 Transceiver							
ADM2567E	3 kV rms Signal and Power Isolated RS-485 Transceiver with ± 15 kV IEC ESD							
ADM3065E	±12 kV IEC ESD Protected, Half-Duplex 50 Mbps RS-485 Transceiver							
ADM4168E	±15 kV ESD Protected Dual RS-422 Transceiver							
ADM3061E	$\pm 12~\text{kV}$ IEC ESD Protected, Half-Duplex 500 kbps RS-485 Transceiver							
MAX22507E/ MAX22508E	±15 kV ESD Protected, Full-Duplex 50 Mbps RS-485/RS-422 Transceivers							

Featured Products

LVDS and M-LVDS

LVDS (low voltage differential signaling) drivers and receivers from Analog Devices offers robust, high speed signaling for single-ended to differential solutions for point-to-point applications. ADI M-LVDS products offer the industry's highest ESD performance transceivers with high noise immunity receivers and extended common-mode range. It has become one of the key technologies as industrial automation systems are growing more interconnected and intelligent, and they require high speed data transmission to accommodate the demand for centralized control and optimized production.

Key Advantages

- Integrated ESD protection
- Low power consumption
- Extended temperature range operation
- Superior timing performance
- Low jitter
- High noise immunity

ADN4693E-1	3.3 V, 200 Mbps, Full-Duplex, High Speed M-LVDS Transceiver						
ADN4680E	250 Mbps, Half-Duplex, Quad M-LVDS Transceivers						
ADN4694E	100 Mbps Half-Duplex, High Speed M-LVDS Transceiver with Type 2 Receiver						

Power Management

Analog Devices' power management ICs and power modules provide the foundation for powering today's and tomorrow's innovations for intelligent motion control applications.

Our high performance power management solutions meet stringent power requirements with leading-edge design and packaging technologies, including unmatched power densities, ultralow noise technology, and superior reliability.

Analog Devices: Your Trusted Power Solutions Partner

These features ensure systems operate at their optimal efficiency, speed, and power levels, while increasing feature density and reducing cost of ownership.

ADI's low complexity power management solutions help our customers accelerate time to market while delivering best-in-class performance for intelligent motion applications.



Power Management–Design in Support Tools



Featured Products

LT8604

LT8618

MAX17541G

LT8301	42 V _{IN} Micropower No-Opto Isolated Flyback Converter with 65 V/1.2 A Switch
LT8302	42 V _™ Micropower No-Opto Isolated Flyback Converter with 65 V/3.6 A Switch
LT8316	560 V _{IN} Micropower No-Opto Isolated Flyback Controller
MAX17690/ MAX17691/ MAX17692	Family of No Opto Isolated Flyback Converters
	isoPower®
ADuM6020/ ADuM6028	Low Emission, 5 kV Isolated DC-to-DC Converters
ADuM4070	Isolated Switch Regulator with Integrated Feedback
ADuM4470	Isolated Switch Regulator with Quad-Channel Isolators (4/0 Channel Directionality)
ADuM3070	Isolated Switch Regulator with Integrated Feedback
ADuM3470	Isolated Switching Regulators with Quad-Channel Isolators (4/0 Channel Directionality)
	DC-to-DC Converters
LT8471	Dual Multitopology DC-to-DC Converters with 2 A Switches and Synchronization
LT8609S	42 V, 2 A/3 A Peak Synchronous Step-Down Regulator
ADP5054	4.5 V to 15.5 V Quad Buck Regulator

High Efficiency 42 V/120 mA Synchronous Buck

High Efficiency 65 V/100 mA Synchronous Buck

42 V, 500 mA, High Efficiency, Ultrasmall Synchronous Step-Down DC-to-DC Converter

No-Opto Isolated Flybacks

Linear Regulators					
LT3080	Adjustable 1.1 A Single Resistor Low Dropout Regulator				
LT3045	20 V, 500 mA, Ultralow Noise, Ultrahigh PSRR Linear Regulator				
	µModule Regulators				
LTM4622	Dual Ultrathin 2.5 A or Single 5 A Step-Down DC-to-DC µModule Regulator				
LTM8074	40 $V_{\mbox{\tiny IN}}$ 1.2 A Silent Switcher* $\mu Module$ Regulator				
MAXM15068	7.5 V to 60 V, 200 mA Himalaya Step-Down Power Module				
Power Protection					
MAX17561/ MAX17562/ MAX17563	36 V, Overvoltage and Overcurrent Protectors with High Accuracy				
MAX17608/ MAX17609/ MAX17610	60 V, Current Limiter with OV, UV, and Reverse Protection				
MAX14721/					
MAX14722/ MAX14723	60 V, Adjustable Overcurrent and Overvoltage Protectors with Thermal Foldback				

Machine Health/Condition Monitoring MEMS

Real-time, continuous, condition monitoring and predictive maintenance solutions continue to grow in importance as manufacturers and plant operators look to increase throughput while reducing maintenance costs and asset downtime. Access to high quality motion insights will extend equipment lifespans, reduce maintenance costs, and eliminate unscheduled downtime while maintaining the highest levels of manufacturing quality and safety in smart factories. Advancements in sensing, signal processing, connectivity, mechanical packaging techniques, and artificial intelligence at the edge are enabling new condition monitoring solutions and predictive maintenance services that will unlock significant savings and productivity improvements in smart manufacturing.



ADI Technology and Platforms for Condition Monitoring



ADI CbM Reference Designs and Platforms

	Sensor	Signal Chain	Signal Processing	Communications	Mechanical Sensor Attach	System Enclosure Rating	Machine Learning/ Algorithms	AI	Design Files
CN0533	ADXL1002	 	 	4 mA to 20 mA					\checkmark
CN0549—CbM Vibration Development Platform	ADXL1002	~	~	IEPE	~				~
EVAL-CN0532-EBZ	ADXL1002	~		Wired-EPE					
EVAL-CN0540-ARDZ	ІЕРЕ Туре	~		Wired–IEPE, SPI					~
EV-CBM-PIONEER1-1Z	ADcmXL3021	~	✓	Wired-RS-485	 				~
EV-CBM-VOYAGER3	ADXL356	~	~	Wireless— ADI SmartMesh [®]	 				~
ADI OtoSense [™] SMS	ADXL1002			Wireless-Wi-Fi	✓	\checkmark	\checkmark	\checkmark	

Circuits from the Lab[®] reference designs are built and tested by ADI engineers with comprehensive documentation and factory-tested evaluation hardware.

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