Application Introduction

For motor control solutions, Analog Devices offers a complete product portfolio including data converters, amplifiers, embedded processors, iCoupler® digital isolators, a variety of power management devices, and real-time network communication solutions. Enhanced performance and system integration enable innovative design topologies, which add value and help differentiate our customers’ connected motion control systems, such as faster speed processors to run more complex algorithms, high performance ADCs to support a better performance current loop, real-time Ethernet multiprotocol switches, etc. Servo drive solutions are associated with attaining the highest performance and accuracy of a motion system. In most cases the end solution is a CNC, connected motion control system, or robot system that operates with high precision and where control of absolute position, along with optimum torque alignment and multi-axis synchronization, is required. Analog Devices offers a complete solution covering all key components in the signal chain.

System Design Considerations and Major Challenges

- High precision current and voltage detection are needed to support speed and torque control performance. Servo control needs a minimum of 12-bit ADC performance, multiple input channels, and simultaneous sampling. ADI has a full family of products to support customer needs.
- In systems using shunts as current sampling, the quality of current feedback signal has significant impacts on servo performance. ADI offers the industry’s best solutions based on our isolated Σ-Δ modulator.
- Position detection performance is key for servo control. Optical encoders and resolvers are often used to achieve that. Increased demand for motor control and efficiency is shifting technologies from analog to digital.
- For applications where safety and protection are priorities, isolation technology is used on signal isolation and gate drivers. ADI’s iCoupler® digital isolator products provide support for high voltage safety isolation.
- Reliability and the safety of servo systems rely on IGBT drive circuit performance. ADI’s IGBT gate driver solutions are integrated with full IGBT protections to provide a simpler and more reliable design choice.
- High performance processors, like DSPs, are used to implement vector control and sensorless control.
- Real-time Ethernet and motion control network connectivity with multiprotocol support are also important to motor control systems.
- Less distortion at servo’s power input end can be achieved by using integrated power factor correction (PFC) devices for design simplicity consideration.
- For industrial applications, designers are future proofed by long-term availability and reliability products.
- The industry trend is to change from standard induction machines to permanent magnet motors; this means system designers need to introduce higher efficiency and flexible algorithms for IM motors and PMSM motors.
- High performance real-time industry control networks enable better synchronization of multiple motors.

ADI Solution Value Proposition

For industrial designers building motor-based systems who are trying to achieve substantially lower power consumption and high efficiency, ADI provides components and full signal chain integration to enable rapid design of these systems. ADI demonstrates differentiation in the areas of feedback and sensing, isolation, power management, interfaces, embedded processing, and communications, where ADI products offer best-in-class performance and quality while enabling a low overall system cost. ADI’s broad technology mix, including world-class isolation, processors, converters, and mixed-signal front ends, equips design engineers with compelling technologies to cover today’s and future needs for any connected solution.
Connected Motion Control Solutions

System Block Diagram and Signal Chain

Current Sensing
- Isolated ADCs
  - AD7400A/AD7401A/AD7402/AD7403/AD7405
  - Amplifiers
    - AD8418/AD8417/AD8212/AD8479/AD8027
  - ADCs
    - AD7266/AD7356/AD7903

Voltage Sensing
- ADCs
  - AD7266/AD7352/AD7356/AD7903
  - Isolated ADCs
    - AD7400A/AD7401A

Position Sensing
- RDCs
  - AD2S1205/AD2S1210
  - Amplifiers
    - AD8662
  - Encoder ADCs
    - AD7266/AD7264/AD7903

Setpoint
- Amplifiers
  - AD8676/AD8821/AD8226/AD4096-2
  - ADCs
    - AD7680/AD7663/AD7606-4

Processors
- ADSP-CM40x/ADSP-CM419

Isolation and Gate Drivers
- Isolation
  - ADuM1411/ADuM1311
  - Gate Drivers
    - ADuM4223/ADuM3223/ADuM7223/ADuM4135/ADuM4136
    - DC-to-DC
      - ADuM5000/ADuM6000

Communications Interfaces
- RS-232
  - AD3251E
- RS-485
  - AD2486E/AD2483E/AD2582E/AD2587E/AD2682E/AD2687E
- CAN
  - AD3053
- USB
  - ADuM4160

Power Management
- micro PMUs
  - ADP5134/ADP211x
- Linear Regulators
  - ADP151/ADP7102
- Supervisory
  - AD6335/AD13307/AD13708
- DC-to-DC
  - ADP1051
- PFC
  - ADP1047
## Key Product Technologies

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
<th>Key Features</th>
<th>Benefit</th>
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</thead>
<tbody>
<tr>
<td><strong>Amplifier</strong></td>
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<tr>
<td>AD8479</td>
<td>Very high common-mode voltage precision difference amplifier</td>
<td>±600 V common-mode voltage range, rail-to-rail output, 90 dB minimum CMRR, 130 kHz bandwidth</td>
<td>Supports very high voltage, excellent ac and dc performance</td>
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<td><strong>ADCs</strong></td>
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<tr>
<td>AD7266</td>
<td>Simultaneous, 12-bit SAR ADC</td>
<td>Dual, 12-bit, 3-channel ADC, throughput rate: 2 MSPS, 70 dB SNR @ 50 kHz input frequency, accurate on-chip reference: 2.5 V ±0.2% maximum @ 25°C, 20 ppm/°C maximum, dual conversion with read 437.5 ns, 32 MHz SCLK</td>
<td>Multichannel, simultaneous, and SAR ADC</td>
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<tr>
<td>AD7401A</td>
<td>Isolated Σ-Δ modulator</td>
<td>Up to 20 MHz external clock, second-order modulator, 16-bit no missing codes, 83 dB SNR typical, on-board digital isolator, on-board reference</td>
<td>Isolated, high accuracy ADC</td>
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<tr>
<td><strong>Processor</strong></td>
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<tr>
<td>ADSP-CM408F</td>
<td>ARM® Cortex®-M4</td>
<td>240 MHz ARM Cortex-M4, 384 kB SRAM and 2 MB flash memory, dual, 16-bit SAR ADCs and 14 bits of accuracy, 2.6 MSPS, integrated sinc filters, MAC, USB</td>
<td>240 MHz, Cortex-M4, floating-point core and high performance ADC and sinc filters</td>
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<td><strong>RDC</strong></td>
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<tr>
<td>A02S1210</td>
<td>Resolver-to-digital converter</td>
<td>3125 rps maximum tracking rate (10-bit resolution), ±2.5 arc minutes of accuracy, 10-/12-/14-/16-bit resolution, set by user, parallel and serial 10-bit to 16-bit data ports</td>
<td>High accuracy</td>
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<td><strong>Isolation</strong></td>
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<tr>
<td>ADuM4135</td>
<td>Gate driver</td>
<td>Isolated IGBT gate driver, 4 A peak drive output capability, 500 V rms or 1200 Vdc working voltage, –40°C to 125°C</td>
<td>Desaturation protection, soft-shutdown on fault, Miller clamp output with gate sense input, isolated fault and ready functions</td>
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<tr>
<td>ADuM4223</td>
<td>Gate driver</td>
<td>4 A peak output current, high frequency operation: 1 MHz, high-side and low-side isolation: 537 V peak and 800 V peak for differential input, –40°C to 125°C</td>
<td>High-side and low-side isolation, high temperature operation: –40°C to 125°C</td>
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<tr>
<td>ADuM141E</td>
<td>PWM isolator</td>
<td>3.0 kW rms/3.75 kW rms quad digital isolators, 150 Mbps maximum guaranteed data rate, backward compatibility</td>
<td>High common-mode transient immunity: 100 kV/μs low propagation delay 13 ns maximum for 5 V operation</td>
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<tr>
<td>ADuM4190</td>
<td>Isolated error amplifier</td>
<td>High stability, isolation voltage: 5 kV rms reinforced, 400 kHz bandwidth, 1% accuracy over the full temperature range</td>
<td>Compatible with type II or type III compensation networks</td>
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<tr>
<td>ADN4552</td>
<td>LVDS isolator</td>
<td>5 kV rms/3.75 kV rms LVDS isolator, up to 600 Mbps switching with low jitter, 4.5 ns maximum propagation delay</td>
<td>Multiple dual-channel configurations</td>
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<tr>
<td><strong>Interface</strong></td>
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<tr>
<td>ADM483</td>
<td>RS-485/RS-422 transceiver</td>
<td>Half- or full-duplex, 250 kbps, 5 V</td>
<td>Slew-rate limited, low power, pin-compatible with MAX483</td>
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<tr>
<td>ADM3065E</td>
<td>RS-485/RS-422 transceiver</td>
<td>Half- or full-duplex, 50 Mbps, 5 V or 3.3 V operation</td>
<td>3.0 V to 5.5 V, ±12 kV IEC ESD protected</td>
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<tr>
<td>fido5200</td>
<td>Real-time Ethernet switch</td>
<td>Supporting PROFINET, EtherCAT, EtherCAT, Powerlink, Sercos III, and EtherCAT</td>
<td>IEEE 802.3, 10 Mbps/100 Mbps, half- and full-duplex, IPv6 and IPv4 communication, two independent Ethernet ports, 1 Mbit and 1 Miniature Interface per port support for all industrial protocols</td>
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<tr>
<td><strong>Power Management</strong></td>
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<tr>
<td>LTM8032</td>
<td>DC-to-DC converter</td>
<td>36 V 2 A dc-to-dc μModule® regulator</td>
<td>Digital controller and true rms ac power metering</td>
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<tr>
<td>ADP1047</td>
<td>Digital power factor correction controller</td>
<td>Flexible, single phase, digital power factor correction (PFC) controller, true rms ac power metering, enhanced dynamic response, switching frequency spread spectrum for improved EMI</td>
<td>Digital controller and true rms ac power metering</td>
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</table>
Reference Design and Demo Boards

**HV MPC Platform**

![HV MPC Platform](image1)


**LV MPC Platform**

![LV MPC Platform](image2)


**ADI Servo Development Platform**

![ADI Servo Development Platform](image3)

Design by ADI.

**Isolated Inverter Platform**

![Isolated Inverter Platform](image4)

Design by ADI.
Design Resources
- Support MATLAB® Simulink—complete scalability and flexibility
  - High level system block level development with functional block definition
  - Alignment with functionality of each element
  - Complete flexibility of design flow and structure
- FOC, vector control, sensorless controllers, and standard motor control libraries
- Absolute encoder interface solutions
- Reference design including PCB, SCH, documents, and source code examples
- MPC platform and EZ-KIT®

Third Party—Boston Engineering
- ADI servo development platform

Circuits from the Lab® Reference Circuits for Motor Control
Reference circuits are subsystem-level building blocks that have been engineered and tested for quick and easy system integration.

- A Novel Analog-to-Analog Isolator Using an Isolated Sigma-Delta Modulator, Isolated DC-to-DC Converter, and Active Filter—
  analog.com/en/CN0185
- High Current Driver for the AD2S1210 Resolver-to-Digital Reference Signal Output—
  analog.com/en/CN0192
- High Performance, 10-Bit to 16-Bit Resolver-to-Digital Converter—
  analog.com/en/CN0276
- High Voltage, High Precision Current Sensing with Output Level Shifting Using the AD8210 Current Sense Amplifier and the AD8274 Difference Amplifier—
  analog.com/en/CN0116
- 500 V Common-Mode Voltage Current Monitor—
  analog.com/en/CN0218
- H-Bridge Driver Circuit Using Isolated Half-Bridge Drivers—
  analog.com/en/CN0196
- More reference circuits are available at analog.com/circuits

More Detail on ADI Motor Control Web Site:
analog.com/en/motor-control-pavilion