

TI Spins Motors

Motor Solutions Guide



→ Contents

Introduction	2
Complete TI Motor-Drive Solutions	
Stepper Motors	3
Brushed DC Motors	3
Brushless DC (BLDC) Motors	4
Permanent Magnet Synchronous Motors (PMSMs)	4
AC Induction Motors (ACIMs)	5
DRV8x Integrated Motor Drivers	6
Signal Chain Solutions	
Current-Sense Amplifiers	7
Industrial Communications (Interface)	7
Discrete Analog-to-Digital Converters (ADCs)	8
Digital Isolators	9

Microcontrollers for Motor Control

32-Bit Real-Time TMS320C2000™ Microcontrollers	10
Stellaris® 32-Bit ARM® Cortex®-M3 Microcontrollers	11
TMS570 ARM Cortex-R4F Microcontrollers	12
16-Bit Ultra-Low-Power MSP430™ Microcontrollers	13

Selection Guides

DRV8x Motor Drivers	14
Industrial Ethernet Physical Layer Transceiver	14
CAN Transceivers	15
Digital Isolators	15
RS-485/RS-422 Transceivers	15

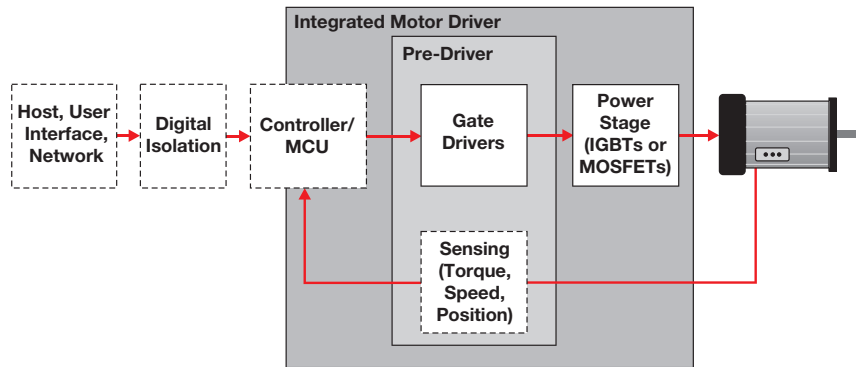
TI Worldwide Technical Support . . (back cover)

→ Introduction

Texas Instruments (TI) is a global market leader that provides complete motor-drive and control solutions along with broad analog and microcontroller portfolios. TI offers comprehensive tools, software and support to deliver efficient, reliable, cost-effective motor solutions. Customers can get the right products with the right performance to quickly spin motors such as AC induction motors (ACIMs), brushed DC motors, brushless DC (BLDC) motors, permanent-magnet synchronous motors (PMSMs) and stepper motors.

When you want the broadest motor expertise, breadth of selection and comprehensive support, you want TI as your partner for efficient, reliable and cost-effective motor-drive and control solutions.

www.ti.com/motor



Motor Control System Functions

Host – Motion profile, logic controller or user interface, often communicating over a standard or proprietary field bus (CAN, serial, Ethernet).

Digital Isolation – Protection and level shifting between different voltage levels.

Controller – Generates the proper switching patterns to control the motor's motion based on feedback and motion profile information from the host.

Gate Drivers – Generate the necessary voltage and current required to accurately and efficiently drive the MOSFETs or IGBTs.

Power Stage – IGBTs or MOSFETS

Sensing – Analog circuitry which processes/conditions the feedback from the motor to control torque, speed or position.

Pre-Driver – Gate drivers, sensing and protection circuitry integrated into a single device or package that may also include control logic.

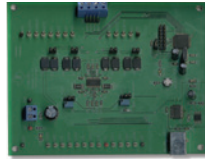
Integrated Motor Driver – Gate driver, FETs and protection circuitry integrated into a single device or package that may also include control logic and sensing circuitry.

→ Stepper Motors

Steppers are a cost-effective solution for open-loop position-control applications such as printers, scanners, home/office appliances and scientific or medical equipment.

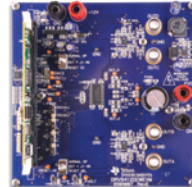
DRV8811EVM – \$149

- DRV8811-based motor driver capable of 1.7 A at 38 V
- On-board MSP430™ MCU
- Easy-to-use GUI for quick setup with most motors
- Open source: BOM, schematics, Gerbers



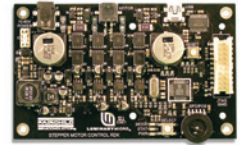
DRV8412-C2-KIT – \$299

- DRV8412-based motor driver capable of 2× 6 A at 50 V
- Includes Piccolo™ TMS320F28035 controlCARD™ and can accept any TI MCU-based controlCARD
- Professionally developed GUI and firmware
- Open source: BOM, schematics, Gerbers, controlSUITE™ software and Code Composer Studio™ Integrated Development Environment (IDE)
- Control: Outer speed, inner current closed loop



RDK-Stepper – \$199

- Fully integrated comm/indexer/ drive for NEMA23/34 motors up to 80 V at 3 A
- Step rates up to 10,000 steps/s
- Full-step, half-step and wave drive modes
- Professionally engineered software
- PC GUI for dynamic tuning and motor configuration
- 50-MHz Stellaris® LM3S617 MCU



DRV88xxEVM – \$149

- Common EVM designed to support DRV8812/13/24/25/41/43 motor drivers capable of 2.5 A at 45 V
- On-board MSP430 MCU
- Easy-to-use GUI for quick setup with most motors
- Open source: BOM, schematics, Gerbers

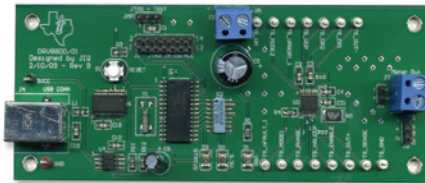


→ Brushed DC Motors

DC motors are used when simple control and cost effectiveness are required in applications such as toys and small consumer appliances.

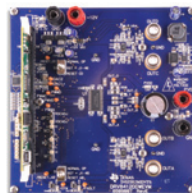
DRV8801EVM – \$99

- DRV8801-based motor driver capable of 2.0 A at 36 V
- On-board MSP430™ MCU
- Easy-to-use GUI for quick setup with most motors
- Open source: BOM, schematics, Gerbers



DRV8412-C2-KIT – \$299

- DRV8412-based motor driver capable of up to 2× 6 A or 1× 12 A at 50 V
- Includes Piccolo™ TMS320F28035 controlCARD™ and can accept any TI MCU-based controlCARD
- Professionally developed GUI and firmware
- Open source: BOM, schematics, Gerbers, controlSUITE™ software and Code Composer Studio™ IDE
- Control: Outer speed, inner current closed loop



RDK-BDC24 – \$219

- Controls brushed 24-V DC motors with up to 40 A continuous
- Three options for open-loop voltage control and two options for closed-loop, speed, position or current control
- CAN and RS-232 communication



DRV88xxEVM – \$149

- Common EVM designed to support DRV8802/14/41/43 motor drivers capable of 2.5 A at 45 V
- On-board MSP430 MCU
- Easy-to-use GUI for quick setup with most motors
- Open source: BOM, schematics, Gerbers



Easy-to-Use Graphical User Interface (GUI)

- Stand-alone GUI requires no IDE
- Immediate verification of motor-control operation
- Configurable capabilities
- Sliders and input fields
- Real-time graphing of key variables
- Free with most motor-control kits



Complete TI Motor-Drive Solutions

→ Brushless DC (BLDC) Motors

BLDC motors are widely used in speed-control applications where reliability and ruggedness are required, such as in fans, pumps and compressors.

TMDSHVMTRPFCKIT – \$599

- Piccolo™ controlCARD™-based hardware
- 350-V, 1.5-kW three-phase inverter
- 700-W bypassable PFC (DC bus) front end
- Isolated JTAG and CAN on board
- Open source: BOM, schematics, Gerbers, controlSUITE™ software (sensored and sensorless, trapezoidal, PFC) and Code Composer Studio™ IDE
- Control: Supports sensored (Hall)/sensorless feedback control with trapezoidal or speed closed loop



DRV8312-C2-KIT – \$299

- DRV8312-based three-phase motor driver capable of 6.5 A at 50 V
- Includes Piccolo TMS320F28035 controlCARD and can accept any MCU-based processor
- Professionally developed GUI and firmware
- Open source: BOM, schematics, Gerbers, controlSUITE software and Code Composer Studio IDE



- Control: Supports sensored/sensorless trapezoidal, current or speed closed loop

RDK-BLDC – \$219

- Advanced motor control for three-phase brushless DC motors up to 36 V, 500 W
- Uses a Stellaris® LM3S8971 microcontroller
- 10/100 Ethernet and CAN interfaces
- Hall effect, quadrature and sensorless operation modes
- JTAG/SWD port for software debugging



DRV8301-C2-KIT and DRV8301-HC-C2-KIT

- DRV8301-based pre-driver capable of driving external FETs up to 60 A at 60 V
- 6-A FET version (DRV8301-C2-KIT) and 60-A FET version (DRV8301-HC-C2-KIT)
- Includes Piccolo TMS320F28035 controlCARD and can accept any MCU-based processor
- Professionally developed GUI and firmware
- Open source: BOM, schematics, Gerbers, controlSUITE software and Code Composer Studio IDE
- Control: Supports sensored/sensorless trapezoidal, current or speed closed loop

→ Permanent Magnet Synchronous Motors (PMSMs)

PMSMs are used in applications requiring precise control and low torque ripple, such as robotics, servo systems and electric power steering.

TMDSHVMTRPFCKIT – \$599

- Piccolo™ and Delfino™ controlCARD™-based hardware
- Delfino TMS320F28335 controlCARD compatible
- 350-V, 1.5-kW three-phase inverter
- 700-W bypassable PFC (DC bus) front end
- Isolated JTAG and CAN on board
- Open source: BOM, schematics, Gerbers, controlSUITE™ software supports sensored and sensorless field-oriented control (FOC) and PFC, and Code Composer Studio™ IDE
- Sensored (encoder)/Sensorless (sliding mode observer [SMO]) FOC speed control: Inner current, outer speed closed loop



TMD51MTRPFCKIT – \$369

- Piccolo controlCARD-based hardware
- 36-V, 24-W × 2 DRV8402 drivers
- 100-W bypassable PFC (DC bus) front end
- Isolated JTAG on board
- Open source: BOM, schematics, Gerbers, controlSUITE software (sensorless FOC, PFC) and Code Composer Studio IDE



- Sensorless (SMO) FOC speed control: Inner current, outer speed closed loop
- Two-motor version available

DRV8312-C2-KIT – \$299

- DRV8312-based driver capable of up to 6.5 A at 50 V
- Includes Piccolo TMS320F28035 controlCARD and any MCU-based controlCARD
- Professionally developed GUI and firmware
- Open source: BOM, schematics, Gerbers, controlSUITE software and Code Composer Studio IDE
- Control: FOC sensored (requires shaft encoder), sensorless (SMO two-shunt current), speed and torque closed loop



DRV8301-C2-KIT and DRV8301-HC-C2-KIT

- DRV8301-based pre-driver for 8 to 60 V with 60-A MOSFETS
- 6-A FET version (DRV8301-C2-KIT) and 60-A FET version (DRV8301-HC-C2-KIT)
- Includes Piccolo controlCARD and can accept any TI MCU-based controlCARD
- Professionally developed GUI and firmware
- Open source: BOM, schematics, Gerbers, controlSUITE software and Code Composer Studio IDE
- Control: FOC sensored (requires shaft encoder), sensorless (SMO two-shunt current), speed and torque closed loop

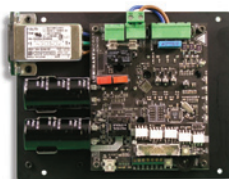
Complete TI Motor-Drive Solutions

→ AC Induction Motors (ACIMs)

The ACIM is the industrial “muscle motor” that enabled the industrial revolution. This rugged motor is used in a vast array of applications from home appliances to high-horse-power factory automation.

RDK-ACIM – \$379

- Fully integrated comm/motion controller/drive
- Up to 1-HP commercial-grade ACIMs
- Precise speed control
- Galvanic isolation of MCU-side electronics
- 115- or 230-VAC inputs
- 50-MHz Stellaris® LM3S818 MCU
- Professionally engineered software



TMDSHVMTRPFCKIT – \$599

- Piccolo™ and Delfino™ controlCARD™-based hardware
- Delfino TMS320F28335 controlCARD compatible
- 350-V, 1.5-kW three-phase inverter
- 700-W bypassable PFC (DC bus) front end
- Isolated JTAG and CAN on board
- Open source: BOM, schematics, Gerbers, controlSUITE™ software (sensored and sensorless FOC, PFC) and Code Composer Studio™ IDE
- Sensored (Hall)/sensorless (motor model) FOC speed control: Inner current, outer speed closed loop



Third-Party Network Developers

MathWorks Model-Based Design

Target for TMS320C2000™ Microcontrollers

Model-based design integrates MATLAB® and Simulink® with TI's Code Composer Studio™ IDE and C2000™ microcontrollers.

Key Features

- Generates documented, readable and editable C code in Code Composer Studio IDE project format
- Automates the testing and execution of Simulink models
- Enables the real-time evaluation of system designs on TI motor kits
- Provides block-level access to on-chip peripherals
- Provides block-level access to the TI IQMath library for simulation and code generation

www.mathworks.com/c2000

VisSim/Embedded Controls Developer™

VisSim/Embedded Controls Developer is a visual development environment for the rapid prototyping and development of motion-control systems.

Key Features

- VisSim/Motion block set that includes pre-built motor, amplifier, sensor, encoder, dynamic load and closed-loop PID models
- DMC block set includes all of the TI DMC library in block form
- Peripheral blocks generate code for C2000, MSP430™ and soon other TI MCUs
- Automatic C-code generation of production-quality fixed-point code
- Real-time visualization while code executes
- Code Composer Studio IDE plug-in for automatic project creation

www.vissim.com

TI Motor Design Network Developers

Third Party	Website	Service
Crosshairs Embedded	www.crosshairseembedded.com	GUI interface designer, remote functional debugger
D3 Engineering	www.d3engineering.com	Design services, consulting, algorithms, The MathWorks
Drivetech	www.drivetechinc.com	Design services, consulting, DMC expertise
Pentad Design	www.pentaddesign.com	Design services, DPS and CLA expertise
Powersim	www.powersimtech.com	Power electronics simulation and C2000 auto code generation
Simma Software	www.simmasoftware.com	Network protocol software
The MathWorks	www.mathworks.com	Embedded target, auto code generation
Visual Solutions	www.vissim.com	Rapid prototyper: Visual application development

DRV8x Integrated Motor Drivers

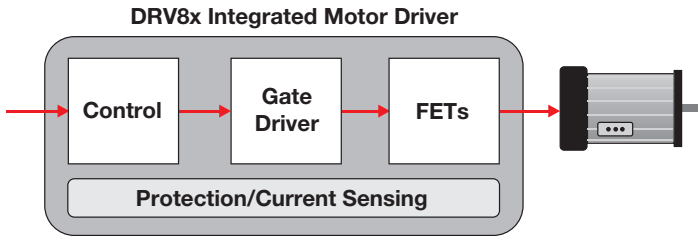


The DRV8x family of integrated motor drivers enables customers to quickly and easily spin their motors. Integrated drivers have higher performance, better protection, and require less board space than traditional discrete solutions. Furthermore, they do not require design expertise for discrete drive stages, which greatly simplifies and speeds the design process.

The TI Advantage

Quicker Time to Spin

With an integrated drive stage, current sensing, on-chip control logic, simple control interfaces, easy-to-use EVMs and design-in documentation, customers can quickly get their motors up and spinning.



Robust, Reliable and Fully Protected

All of TI's motor drivers include fast-acting protection against short circuits, thermal overload, undervoltage and shoot-through. When a fault condition is detected, the H-Bridge is quickly shut down to protect the motor and driver IC.

The Right Part for Each Application

TI has a broad portfolio of motor drivers with different levels of integration, multiple control interfaces and a wide range of power ratings. The DRV8x family includes both drivers and pre-drivers and supports voltage ranges from 2.75 to 60 V and load current from 100 mA to 24 A.

www.ti.com/drv8x

Latest DRV8x Motor Drivers Reduce $R_{DS(on)}$ by 60%

Motor Type	Device	Voltage	Current (Peak)	Current Levels	Control
Brushed	DRV8814	8.2 to 45 V	2.5 A	–	PH/EN
	DRV8840	8.2 to 45 V	5.0 A	–	PH/EN
Stepper	DRV8813	8.2 to 45 V	2.5 A	4×	PH/EN
	DRV8825	8.2 to 45 V	2.5 A	1/32 μ -step	Indexer
	DRV8829	8.2 to 45 V	5.0 A	32×	PH/EN
Brushed and Stepper	DRV8841	8.2 to 45 V	2.5 A	4×	PWM
	DRV8843	8.2 to 45 V	2.5 A	4×	PWM
	DRV8842	8.2 to 45 V	5.0 A	32×	PWM

See selection table on page 14 for a complete list of DRV8x motor drivers.

New products are listed in bold red.

3-Phase Brushless Motor Pre-Driver

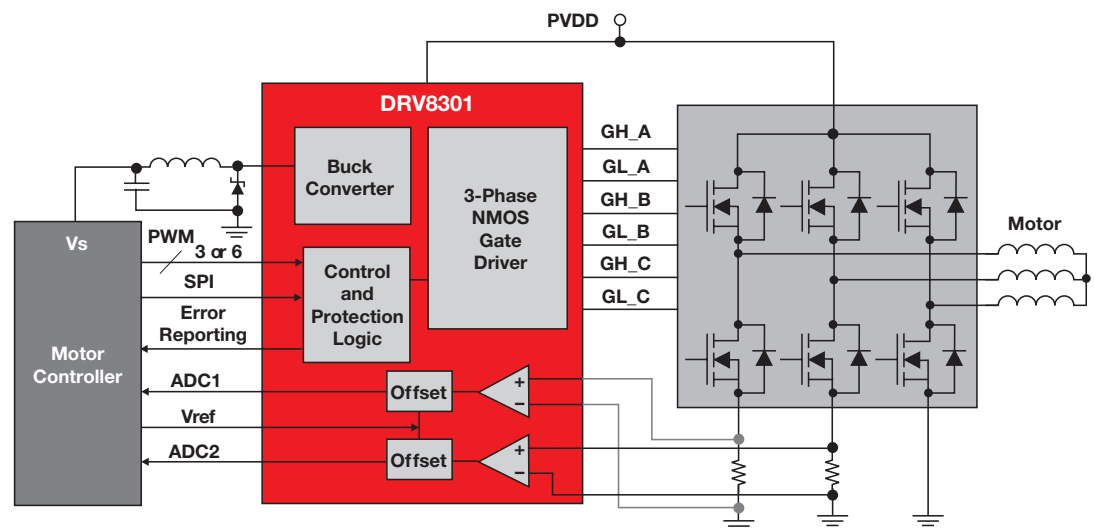
DRV8301

Key Features

- Integrated three-phase gate driver with dual current-shunt amplifiers and buck converter for MCU or system power needs
- Wide input-voltage range (8 to 60 V)
- Supports up to 1.7-A gate current
- Intelligent gate drive and cross-conduction prevention
- Overcurrent (OC) protection of external FETs with programmable cycle-by-cycle current limit
- SPI interface for programmability

Benefits

- Reduced board space and improved performance
- Automatic handshake of high-side and low-side FET transition to prevent shoot-through, simplify gate control and improve system reliability
- External FETs improve thermal performance and efficiency and can easily scale to support both low- and high-current platforms



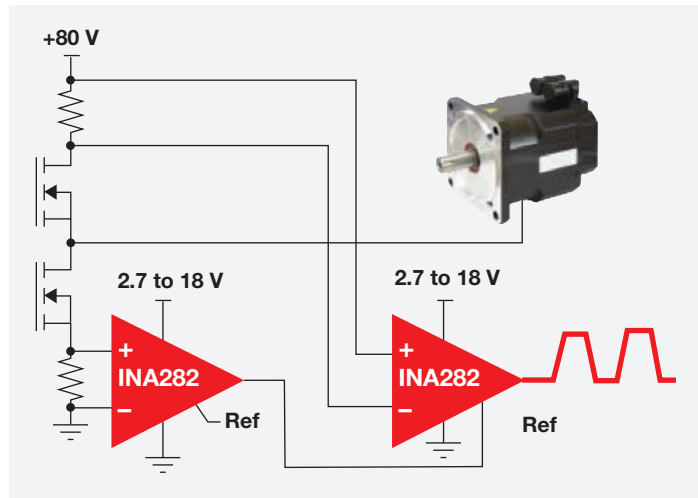
→ Current-Sense Amplifiers

Low Offset is the TI Advantage

Offset and offset-drift performance are factors that determine the full-scale input voltage to the current-sense amplifier and, subsequently, the size of the shunt resistor. Lower offset allows for smaller shunt resistors and results in less voltage drop and power loss.

To avoid errors introduced by external gain resistors, all TI current-sense amplifiers have gain set internally through TI's precision manufacturing processes. Total component count and board space are reduced as well. In addition to the standard configuration of current-sense amplifiers, TI has a line of digital-output current-sense devices. These devices make isolation easy by limiting the interface to two digital lines, which frees embedded data converters for other system activities.

High Precision for Large Common-Mode Current Measurements



Wide Common-Mode Current-Sense Amplifiers

Device	CMR	Offset	Offset Drift	Bidirectional
INA282	-14 to 80 V	70 μ V	0.5 μ V/ $^{\circ}$ C	Yes
INA138/ INA139	2.7 to 36 V	1 mV	1 μ V/ $^{\circ}$ C	No
INA168/ INA169	2.7 to 60 V	1 mV	1 μ V/ $^{\circ}$ C	No
INA170	2.7 to 60 V	1 mV	1 μ V/ $^{\circ}$ C	Yes
INA193- INA198	-16 to 80 V	2 mV	2.5 μ V/ $^{\circ}$ C	No

→ Industrial Communications (Interface)

RS-485/RS-422

- Broad portfolio
- Improved speed, performance and robustness

Speed

- Speeds of up to 50 Mbps

Functionality

- Lower unit load: Up to 256 devices on bus
- 3.3-V supply: No need for extra voltage regulators
- True fail-safe: No need for external biasing resistors
- Slow-rate control reduces EMI
- Receiver equalization enables long cable transmission

Robustness

- Best-in-class ESD protection: Improved reliability
- 400-W transient voltage protection: No need for external components
- Extended common mode: Extends transmission distance

CAN

- Broad portfolio of standard industry upgrades and TI-unique CAN devices
- 5-V CAN transceiver offers the highest ESD protection in the industry: 14 kV

Second-Generation 3.3-V CAN Transceivers

- Lowest power and \pm 36-V protection
- Low-power standby with bus wake-up
- 5- μ A standby power

Isolated Interface

- Integrated interface with isolation
- Uses TI's new differential capacitive technology
- High performance, superior to optical and magnetic isolation
- Integrated design saves board space and simplifies board design

Signal Chain Solutions

Discrete Analog-to-Digital Converters (ADCs)

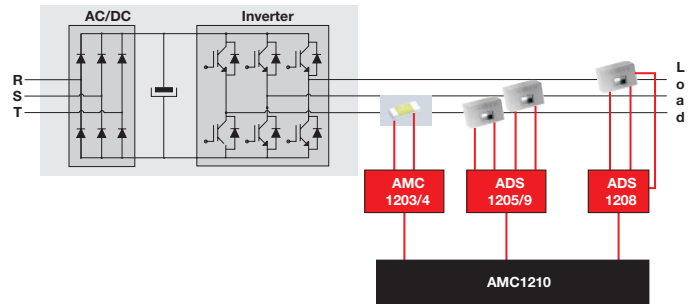
Delta-Sigma Modulators in Current Measurement and Motor Control

TI's portfolio of delta-sigma modulators offers both isolated and non-isolated modulators enabling both direct measurement of current through shunt resistors and indirect measurement with Hall or magnetic sensors. The AMC1210 provides a quad-programmable digital filter enabling a seamless interface to the modulators, including a fast over-current detection path. Additionally, the AMC1210 provides PWM excitation for resolvers to enable an analog front-end solution for motor control.

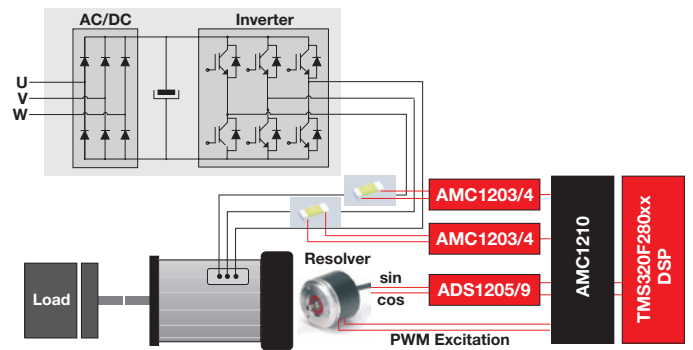
TI's 16-Bit Delta-Sigma Modulators

Device	Channels	Style	Input Range
AMC1203	1	10-MHz isolated	± 280 mV
AMC1204	1	20-MHz Isolated	± 280 mV
ADS1203	1	10-MHz non-isolated	± 250 mV
ADS1204	4	10-MHz non-isolated	± 2.0 V
ADS1205	2	10-MHz non-isolated	± 2.0 V
ADS1208	1	10-MHz non-isolated	± 100 mV
ADS1209	2	10-MHz non-isolated	± 2.3 V
AMC1210	4	Digital filter	

Current-Measurement Applications



Delta-Sigma Modulators



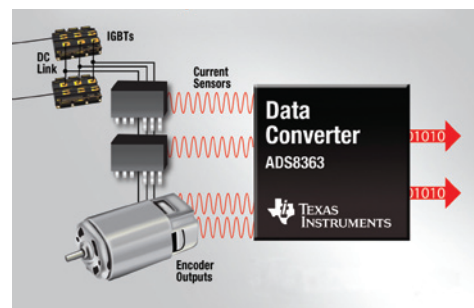
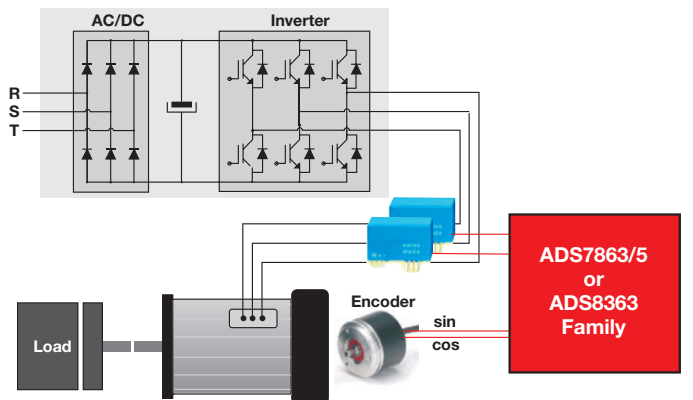
Simultaneous-Sampling ADCs for High-End Motor Drives

With up to six simultaneously sampled channels and up to 2-MSPS sampling rate, TI's simultaneous-sampling ADC portfolio provides a wide range of ADCs for the most demanding high-end motor-drive applications. An integrated programmable reference simplifies system-level gain calibration without compromising the dynamic range.

TI's Newest Simultaneous Sampling ADCs

Device	Resolution	Speed	Channels
ADS8556	16	800 kSPS/ADC	6
ADS8557	14	800 kSPS/ADC	6
ADS8558	12	800 kSPS/ADC	6
ADS7863/5	12	2 MSPS/ADC	3x2, 2x2
ADS8363	16	1 MSPS/ADC	4x2, 2x2
ADS7263	14	1 MSPS/ADC	4x2, 2x2
ADS7223	12	1 MSPS/ADC	4x2, 2x2

Simultaneous-Sampling SAR ADCs



→ Digital Isolators

The TI Edge

Reliability

TI offers proven reliability of silicon-dioxide (SiO₂) insulation that is stable over temperature and moisture and has a life span of over 25 years.

Highest Noise Immunity

TI uses differential signals to cross the isolation barrier, giving the highest immunity from external magnetic and electric fields to prevent data corruption.

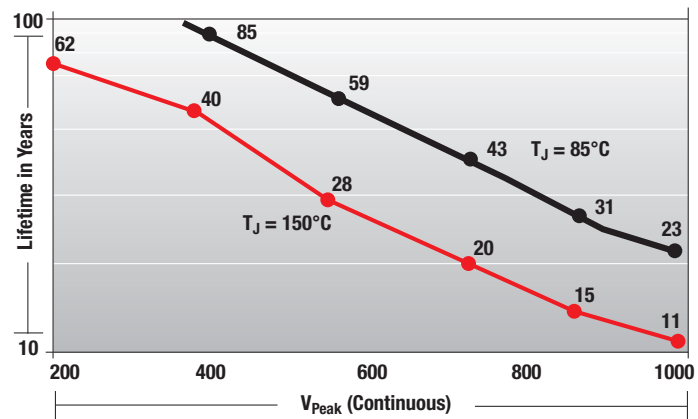
Signaling Rate

TI offers digital isolators with high signaling rates of up to 150 Mbps, with low skew and pulse-width distortion.

Lowest Jitter

To ensure signal integrity, jitter reduction is a priority. ISO7xxx products offer the lowest jitter of 1-ns jitter at 150-Mbps PRBS NRZ data input.

TI ISO Life Expectancy vs. Voltage



Resources Available

- EVMs
- IBIS models
- Application notes on high-voltage lifetime and magnetic-field immunity

Isolated Gate Drivers

PREVIEW

ISO55xx Family

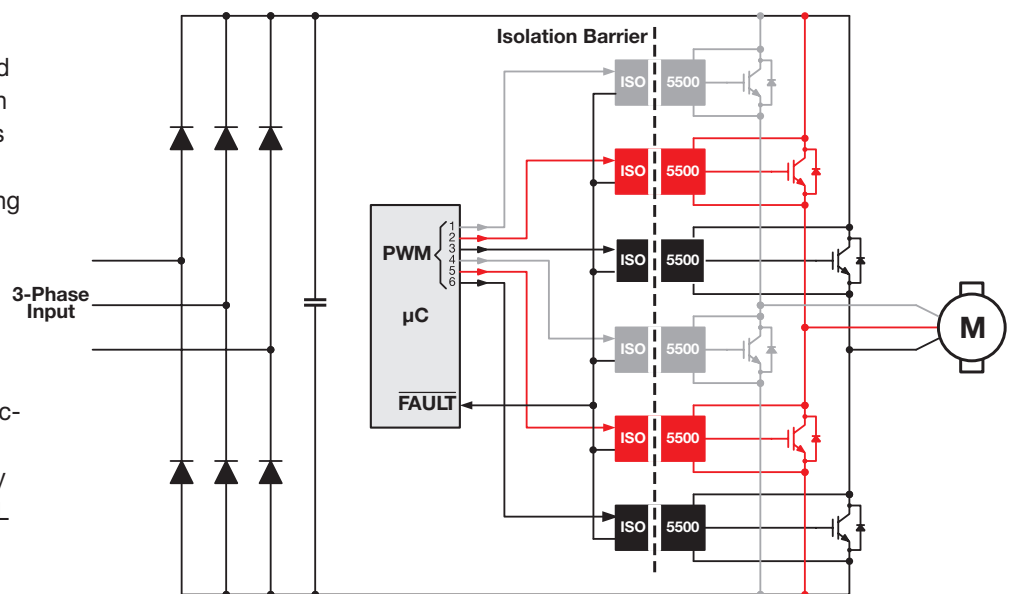
TI's ISO55xx products are isolated gate drivers for IGBTs with power ratings up to 150 A and 1200 V.

The input TTL logic and output power stage are separated by TI's silicon-dioxide (SiO₂) isolation barrier.

When used in conjunction with isolated power supplies, the device blocks high voltage, isolates grounds and prevents noise currents from entering the local ground and interfering with or damaging sensitive circuitry.

Key Features

- Soft IGBT turn-off
- Isolated fault feedback
- V_{CE} DESAT protection/adjustability
- Undervoltage lock-out (UVLO) protection with hysteresis
- ±50-kV/μs typical transient immunity
- 5000-V_{rms} maximum isolation per UL
- Operates with 3.3-V or 5-V input supply
- -40 to 125°C operating range



→ 32-Bit Real-Time TMS320C2000™ Microcontrollers

Broadest MCU Architecture

- 40- to 300-MHz TMS320C28x™ CPU
- Built-in DSP functions
- Single-cycle 32×32-bit MAC

Real-Time Control

- Optimized core
- Fast interrupts
- Flexible interrupt system
- Best-in-class ADC performance
- Real-time debugging
- Flexible, high-resolution PWMs
- Sensor interfaces
- CAN, serials

Overall System-Performance Optimization

- High level of integration
- Control and supervision
- Variable-speed real-time control
- Better dynamic and transient control
- Simulation, prototyping and automatic code generation from The MathWorks, VisSim and PowerSim
- Software libraries for industrial safety certification such as IEC60730 and IIEC61508

Piccolo™ MCU Family for Lowest System Cost

- Integrated OSC, watchdogs
- Analog comparators
- Fault detection
- Limited life support
- No external GPIO filters needed

Application Libraries

Specialized, application-specific software functions:

- Modular macros with variable I/Os
- At initialization, all variables are defined and outputs of one block are set as inputs to the next
- Complete documentation – including source code, use and technical theory – is provided for every module

Applications

- HVAC compressors and blowers
- Industrial motors
- Variable-speed fans and pumps
- Automotive power steering, traction and pumps
- Premium e-bikes
- Laundry machines
- Medical pumps and blowers

IQMath Library

The IQMath library is a library and compiler intrinsic that allows you to select your range and resolution by choosing which bits of your binary represented number are the integer (I) and which are the quotient (Q). It also allows you to write C functions in floating point instead of dealing with fixed-point scaling.

- Change numerical range on the fly
- Tune for best resolution and dynamic range
- Remove quantization effects
- Reduce scaling and saturation
- Better integration with simulation and code-generation tools
- Single source set between fixed and floating point

C2000™ Device Features

www.ti.com/c2000

Feature	Fixed-Point			Delfino™ Series		Piccolo™ Series		
	F281x	F280x	F2823x	F2833x	C2834x	F2802x	F2803x	F2806x
Mass Production	2003	2005	2008	2008	2009	2009	2010	2011
C28x™ CPU	Fixed	Fixed	Fixed	Float	Float	Fixed	Fixed + CLA Option	Floating Point + CLA + VCU
MHz	150	60 to 100	100 to 150	100 to 150	200 to 300	40 to 60	60	80
Pins	128 to 179	100	176 to 179	176 to 179	176 to 256	38 to 56	64 to 80	80 to 100
Flash (KB)	128 to 256	32 to 256	128 to 512	128 to 512	0	16 to 64	32 to 128	128 to 256
RAM (KB)	36	12 to 36	52 to 68	52 to 68	196 to 516	4 to 12	12 to 20	52 to 100
Budgetary Pricing	\$13 to \$15	\$3 to \$13	\$13 to \$14	\$14 to \$16	\$9 to \$16	\$1.85 to \$3	\$3 to \$4.50	\$4.95 to \$7

Digital Motor Control (DMC) Library

Transforms and Estimators

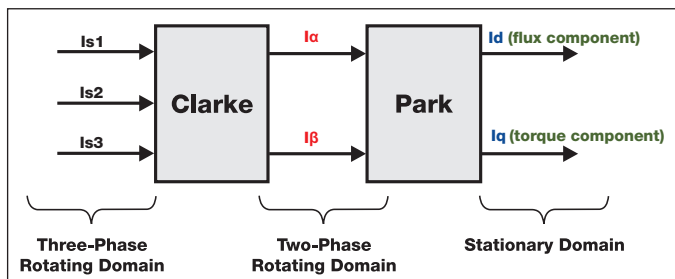
- Clarke, Park, sliding mode observer (SMO), phase voltage, resolver, flux, speed calculators and estimators

Control

- Signal generation, closed-loop PID, BEMF commutation, space vector generators, microstep SIN/COB tables

Peripheral Drivers

- Different modes and topology support
- ADC, PWM, encoders, sensor captures, DAC outputs



www.ti.com/c2000dmc

Ex: Using "Park" from DMC Library

```
//initialization code, define macro per library
#define PARK_MACRO(v)
v.Ds = _IQmpy(v.Alpha,v.Cosine) + _IQmpy(v.Beta,v.Sine);
v.Qs = _IQmpy(v.Beta,v.Cosine) - _IQmpy(v.Alpha,v.Sine);

//incremental build code, connect outputs and inputs
park1.Alpha = clarke1.Alpha;
park1.Beta = clarke1.Beta;

//run-time code, call the function
PARK_MACRO(park1)
```

Microcontrollers for Motor Control

→ Stellaris® 32-Bit ARM® Cortex®-M3 Microcontrollers

Texas Instruments is the industry leader in bringing 32-bit capabilities and the full benefits of ARM Cortex-M3-based microcontrollers to market. Stellaris MCUs with Cortex-M3 offer a direct path to the strongest ecosystem of development tools, software and knowledge in the industry. Designers who migrate to Stellaris MCUs will benefit from great tools, small code footprint and outstanding performance. Even more important, designers can enter the ARM ecosystem with full confidence in a compatible roadmap from \$1 to 1 GHz. You will never need to change architectures again.

With large on-chip memories, enhanced power management and expanded I/O and control capabilities, Stellaris MCUs are optimized for industrial applications requiring reliable connectivity, precise motor/motion control and remote monitoring. Some typical applications are factory automation, HVAC and building control, gaming equipment, medical instrumentation, consumer appliances, CCTV monitoring and fire security.

Precision Motion Control

The Stellaris family of ARM Cortex-M3 microcontrollers features deterministic performance and IP especially designed for simultaneous advanced motion control and real-time connectivity. These microcontrollers include up to eight full

channels of control with deadband generators and shoot-through protection for applications such as three-phase inverter bridges. Fault-condition handling in hardware quickly provides low-latency shutdown and synchronization of timers to enable precise alignment of all edges.

- Motion-control PWMs with deadband and fault detection support safe and efficient operation of motors
- Quadrature encoder inputs (QEIs) support incremental encoders, tachometers, generators/resolvers and TDC detectors
- High-speed ADCs support current measurement using Hall sensors or shunts to optimize algorithms
- Independent integrated analog comparators can be configured to drive an output or generate an ADC interrupt event

Key Features

- Industry-leading ARM Cortex-M3 core
- 8 to 512KB of flash
- 20- to 80-MHz CPU clock speeds
- Deterministic fast-interrupt processing (12 cycles)
- Real-time multitasking capabilities
- Integrated analog peripherals
- 10-bit and 12-bit analog-to-digital converter
- Pulse-width modulators (PWMs) with programmable deadband timers
- Operating modes with clock gating for lower power

Unique Stellaris MCU Capabilities

- Advanced communication capabilities, including 10/100 Ethernet MAC/PHY, USB, USB OTG, CAN controllers, I²C, I²S and extended peripheral interfaces
- 5-V tolerant GPIOs with programmable drive capability
- Single-cycle flash up to 50 MHz
- Royalty-free StellarisWare® software
- Open-tooled reference design kits and quick-start evaluation kits
- Up to two quadrature encoder inputs

StellarisWare Software

- Extensive suite of software designed to reduce development cycle time
- Stellaris peripheral libraries
- Stellaris USB libraries
- Stellaris graphics libraries
- Stellaris code examples
- Stellaris IEC 60730 library
- Available as object library and source code

Hardware Kits

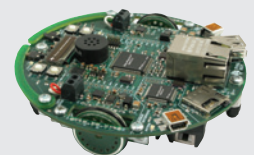
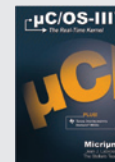
- Schematics, BOM and Gerber files are available for all hardware kits and include all accessories to start evaluation right out of the box.

Reference Designs

Design	Description
RDK-Stepper	Stepper Motor Reference Design Kit
RDK-ACIM	AC Induction Motor Reference Design Kit
RDK-BLDC	Brushless DC Motor Reference Design Kit
RDK-BDC	Brushed DC Motor Reference Design Kit
RDK-S2E	Serial-to-Ethernet Reference Design Kit
RDK-IDM	Intelligent Display Module Reference Design Kit

For more information on Stellaris MCUs for motor-control applications, visit www.ti.com/stellarismotorcontrol

Stellaris® Robotic Evaluation Boards



A fun way for serious embedded-systems programmers, consumers, hobbyists and students to work with and learn Stellaris ARM® Cortex®-M3 embedded programming with a variety of operating systems and ARM tool options. Order now at www.ti.com/evalbot

Microcontrollers for Motor Control

→ TMS570 ARM[®] Cortex[®]-R4F Microcontrollers

TMS570 Enables Safe Motor Control

The TMS570 microcontroller family enables customers to easily build safety-related motor-control applications. Devices are available today with up to 160 MHz of floating-point performance and an integrated safety concept.

A wide choice of communication peripherals like CAN, FlexRay[®] and LIN in combination with a powerful high-end timer (HET) coprocessor module makes the family a flexible solution for safety-critical control applications.

The exida partnership has assessed the TMS570 family against the IEC 61508 safety standard and has certified that it is suitable for use in SIL 3-based systems.

The complete TMS570 Safety Manual with FMEDA, FIT rates and several guidelines about how to make the safety implementation as easy as possible is available on demand.

The TMS570 family is used in a variety of safety-related motor-control applications like braking and steering.

Key Features

ARM Cortex-R4F CPUs

- Up to 160 MHz with floating-point support
- Dual CPUs in lockstep

Memory

- Flash: 1MB and 2MB with ECC protection
- RAM: 128KB and 160KB with ECC protection
- Roadmap from 768KB to 4MB flash

Peripheral Highlights

- FlexRay with 8KB message RAM
- Three CAN interfaces
- Three multi-buffered SPIs (MibSPIs)
- Two UARTs – both with LIN 2.1
- Two 12-bit multi-buffered ADCs (MibADCs)
- Flexible timer module with up to 32 channels
- Trace and calibration interfaces

Packages

- 144 QFP, 337 nFBGA (16x16 mm)

Motor Control Benefits

32-bit ARM Cortex-R4F with Floating-Point Unit

- IEEE 754 compliant floating point unit (ARM VFPv3D16)
- Supports both single and double precision

High-End Timer (HET) Coprocessor

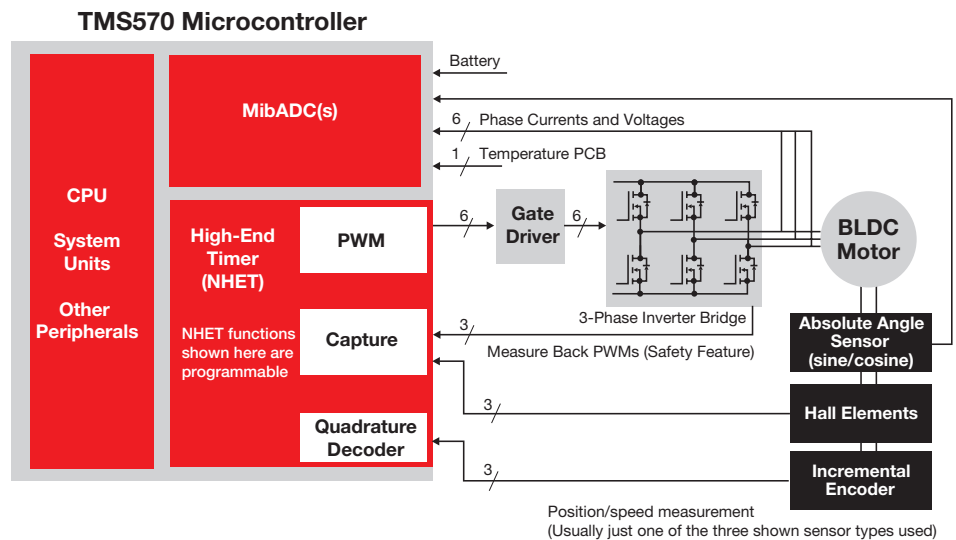
- Effective support of many motor control concepts due to HET programmability
 - PWM generation – symmetric, asymmetric, deadband
 - Single- or multiple-shunt systems

- Quadrature decoding
- NHET can trigger the ADC(s) with many configuration possibilities

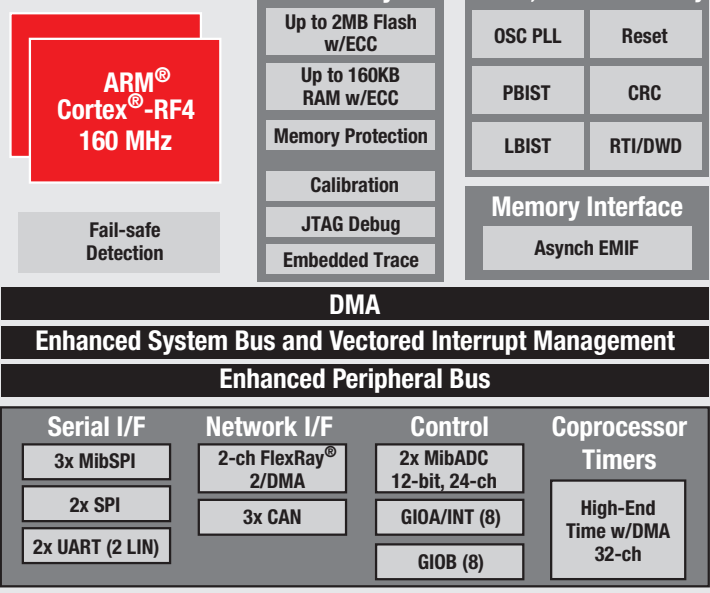
Dual 12-bit Buffered ADCs

- 12-bit resolution SAR
- 400-ns conversion time and 200-ns sampling time
- 24 total channels (MibADC1=8, MibADC2=8, Shared=8)
 - Shared channels can be used for oversampling using both ADCs
 - Continuous multi- or single-channel conversion modes

www.ti.com/TMS570



TMS570LS20216



→ 16-Bit Ultra-Low-Power MSP430™ Microcontrollers

The MSP430 family offers the world's leading ultra-low-power microcontrollers (MCUs) with a 16-bit RISC CPU architecture. These MCUs are optimized for C and assembler programming with ultra-low-power architectures. The ultra-low-power capabilities are available in active, standby and sleep modes. The MCUs are mostly used as general host controllers in simple motor-control applications such as toys.

The highly integrated MSP430 MCUs are ideal for stepper and DC-motor-control applications. Customers have the option to select from low- or high-pin-count MCUs along with different communication and analog peripherals.

MSP430 MCUs offer many different communication peripherals such as USB 2.0, SPI, I²C, IrDA and UART/LIN. In addition, there are timers offering capture/compare/PWM outputs and a wide choice of analog peripherals such as comparators, 10-/12-bit ADCs (up to 200 kSPS), 12-bit DACs and 16-bit sigma-delta modules. These MCUs can be used to control stepper and DC motors in printers, fans, antennas, toys and many other applications.

TI provides robust design support for the MSP430 MCUs in the form of technical documents, training, tools and software.

Key Features

- 0.5 to 256KB flash
- RAM up to 16KB
- Up to 25-MIPS operation
- 12- and 10-bit ADCs
- 12-bit DACs
- Integrated intelligent peripherals including high-performance analog and digital peripherals
- 16-bit and 8-bit timers with PWM capability
- Integrated LCD drivers
- Communication peripherals: UART, SPI, I²C
- 14- to 113-pin package options

Benefits

- Can be used as low-cost solution to drive a stepper motor with DRV8x drivers
- Flexibility to program for optimal motor control
- On-board comparators and op amps
- Ideal for trapezoidal control of low-power BLDC motors

Hardware Kits

- Brushed DC motor EVM with DRV8801
- Stepper motor EVM with DRV8811

Application Notes

- PWM DC Motor Control Using Timer_A of the MSP430 (SLAA120)
- MSP430 Stepper Motor Controller (SLAA223)

www.ti.com/msp430

MSP430F51x2 Devices Feature New High-Resolution Timer_D for Finer Motor Precision

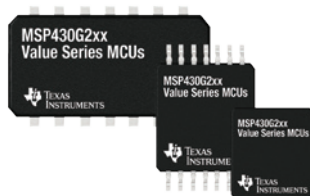
- Timer_D is a 16-bit timer/counter with multiple capture/compare registers
- Supports up to 256-MHz/4-ns resolution
- Suitable for precision motor control
- Supports PWM outputs and interval timing and has extensive interrupt capabilities. (Interrupts may be generated from the counter on overflow conditions and from each of the capture/compare registers.)

www.ti.com/timerd
www.ti.com/5xx

Value Line Series = Low Cost and Low Power

MSP430G2xx

TI's new Value Line of MSP430™ MCUs allows customers to take advantage of this family's ultra-low power (ULP) and 16-bit performance for cost-sensitive applications, which traditionally have depended on 8-bit microcontrollers.



ULP Features

- 300- μ A active current (1 MHz, 3 V)
- 0.5- μ A standby current (LPM3)
- 0.1- μ A power-down current (LPM4)
- 1- μ s wake-up time and integrated brownout reset (BOR)
- Watchdog timer (WDT)

Integrated Peripherals

- Comparators, 10-bit ADCs; and SPI, I²C and UART communications. Some Value Line devices also feature integrated capacitive sense I/Os to enable low-cost touch-pad implementations (reduced PCB BOM).

LaunchPad Development Kit

- Meet the lowest-cost and most complete development kit in the industry. LaunchPad includes all of the hardware and software that developers need to start creating applications.



Learn more at
www.ti.com/launchpadwiki



DRV8x Motor Drivers

Device	Description	Supply Voltage (V)	I _{OUT} RMS (A)	I _{OUT} Peak (A)	Control Interface	Configurations	Price*
Stepper Motors							
DRV8803	Single unipolar motor driver	8 to 60	1.5	1.5	PWM	1× unipolar stepper, 4× solenoids	TBD
DRV8804	Single unipolar motor driver	8 to 60	1.5	1.5	Serial	1× unipolar stepper, 4× solenoids	TBD
DRV8805	Single unipolar motor driver w/full step, ½ step and wave-drive stepping	8 to 60	1.5	1.5	Indexer	1× unipolar stepper	TBD
DRV8811	Dual H-bridge w/ 1/8 microstepping	8 to 38	1.75	2.5	Indexer	1× stepper	1.80
DRV8812	Dual H-bridge w/ 4× current-regulation levels	8.2 to 45	1.1	1.6	PH/EN	1× stepper	1.65
DRV8813	Dual H-bridge w/ 4× current-regulation levels	8.2 to 45	1.75	2.5	PH/EN	1× stepper	2.25
DRV8821	Quad H-bridge w/ 1/8 microstepping	8 to 32	1	1.5	Indexer	2× stepper	2.00
DRV8824	Dual H-bridge w/ 1/32 microstepping	8.2 to 45	1.1	1.6	Indexer	1× stepper	1.65
DRV8825	Dual H-bridge w/ 1/32 microstepping	8.2 to 45	1.75	2.5	Indexer	1× stepper	2.40
DRV8828	Single H-bridge w/ 32× current-regulation levels	8.2 to 45	2.1	3	PH/EN	½ stepper	1.65
DRV8829	Single H-bridge w/ 32× current-regulation levels	8.2 to 45	3.5	5	PH/EN	½ stepper	2.25
Brushed DC Motors							
DRV8800	Single H-bridge	8 to 36	2	2.8	PH/EN	1× brushed DC	1.25
DRV8801	Single H-bridge w/ current sense	8 to 36	2	2.8	PH/EN	1× brushed DC	1.25
DRV8802	Dual H-bridge	8.2 to 45	1.1	1.6	PH/EN	2× brushed DC	1.65
DRV8814	Dual H-bridge	8.2 to 45	1.75	2.5	PH/EN	2× brushed DC	2.25
DRV8830	Low-voltage, single H-bridge w/voltage regulation for longer battery life. I ² C control I/F supports up to 9× devices per bus	2.75 to 6	1	1	Serial (I ² C)	1× brushed DC, 2× solenoids	0.85
DRV8832	Low-voltage, single H-bridge w/voltage regulation for longer battery life	2.75 to 6	1	1	IN/IN	1× brushed DC, 2× solenoids	0.85
DRV8840	Single H-bridge	8.2 to 45	3.5	5	PH/EN	1× brushed DC	2.25
Stepper and Brushed DC Motors							
DRV8412	High-current, dual H-bridge stepper or 2× 6 A or 1× 12 A DC motor driver	0 to 52	3	6	PWM	1 to 2× brushed DC, stepper, 4× solenoids	3.85
DRV8432	High-current, dual H-bridge stepper or 2× 12 A or 1× 24 A DC motor driver (heat sink required)	0 to 52	7	12	PWM	1 to 2× brushed DC, stepper, 4× solenoids	5.50
DRV8823	Quad H-bridge stepper or DC motor driver w/ SPI and 8× current-regulation levels	8 to 32	1.5	1.5	Serial SPI	4× brushed DC, 2× stepper	2.00
DRV8833	Low-voltage, dual H-bridge stepper or brushed DC motor driver	2.7 to 10.8	1	2	PWM	1 to 2× brushed DC, stepper, 4× solenoids	TBD
DRV8841	Dual H-bridge stepper or DC motor driver w/ 4× current-regulation levels	8.2 to 45	1.75	2.5	PWM	2× brushed DC, stepper, 4× solenoids	2.25
DRV8842	Single H-bridge stepper or DC motor driver w/ 32× current-regulation levels	8.2 to 45	3.5	5	PWM	1× brushed DC, ½ stepper, 2× solenoids	2.25
DRV8843	Single H-bridge stepper or DC motor driver w/ 4× current-regulation levels	8.2 to 45	1.75	2.5	PWM	2× brushed DC, stepper, 4× solenoids	2.25
3-Phase Brushless Motors							
DRV8301	3-phase brushless pre-driver with 2× sense amps and buck converter; drives up to 60-A external FETs	8 to 60	Ext. FETs	Ext. FETs	PWM	1× PMSM, 1× BLDC	2.50
DRV8312	3-phase brushless high-current motor driver	0 to 52	3.5	6.5	PWM	1× PMSM, 1× BLDC	3.30
DRV8332	3-phase brushless pre-driver with 2× current sense amps and buck converter	0 to 52	8	13	PWM	1× PMSM, 1× BLDC	4.70

*Suggested resale price in U.S. dollars in quantities of 1,000.

New products are listed in **bold red**. Preview products are listed in **bold blue**.

Industrial Ethernet Physical Layer Transceiver

Device	Description	Supply Voltage (V)	Cable Reach (m)	Power (mW)	ESD (kV)	Operating Temp. Range (°C)	HiRel Avail.	Package	Price*
TLK100	Single-port 10/100-Mbps Ethernet PHY	3.3, 1.8, 1.1	200	189**	±16	-40 to +85	N	TQFP-48	2.25

*Suggested resale price in U.S. dollars in quantities of 1,000.

**Triple supply power

Selection Guides



CAN Transceivers

Device	Description	Isolated	Supply Voltage (V)	I/O Levels	Short-Circuit Protection (V)	ESD (kV)	Operating Temp Range (°C)	HiRel Avail.	Price*
SN65HVD251	Improved replacement for PCA82C250 and PCA82C251/small QFN package	No	5	5-V CMOS	-36 to 36	±14	-40 to 125/ -55 to 125	Y	0.90
SN65HVD1040	Improved TJA1040 with better ESD and bus wake-up	No	5	5-V TTL	-27 to 40	±12	-40 to 125	Y	0.60
SN65HVD1050	Improved TJA1050 with better ESD	No	5	5-V TTL	-27 to 40	±8	-40 to 125	Y	0.45
ISO1050DUB	2.5-kV _{rms} isolated CAN transceiver	Yes	5	5-V TTL	-27 to 40	±4	-55 to 105	N	1.55
ISO1050DW	5-kV _{rms} isolated CAN transceiver	Yes	5	5-V TTL	-27 to 40	±4	-55 to 105	N	1.95
SN65HVD232	Cost-effective	No	3.3	3.3-V TTL	-4 to 16	±16	-40 to 85	Y	1.10

*Suggested resale price in U.S. dollars in quantities of 1,000. See www.ti.com/hirel for HiRel options.

New products are listed in **bold red**.

Digital Isolators

Device	Description	Isolation Rating (V _{rms}) (UL, VDE, CSA)	Channel Direction	Data Rate (max) Mbps	Transient Immunity (min) (kV/μs)	Supply Voltage (V)	HiRel Avail.	Price*
ISO721/M	Single channel	2500	1/0	100/150	25	3.3, 5	Y	1.40
ISO7230A/C/M	Triple channel	2500	3/0	1/25/150	25	3.3, 5	N	1.40
ISO7231A/C/M	Triple channel	2500	2/1	1/25/150	25	3.3, 5	N	1.40
ISO7240A/C/M	Quad channel (F = Fail-safe low)	2500	4/0	1/25/25/150	25	3.3, 5	Y	1.75
ISO7241A/C/M	Quad channel	2500	3/1	1/25/150	25	3.3, 5	Y	1.75
ISO7242A/C/M	Quad channel	2500	2/2	1/25/150	25	3.3, 5	N	1.75
ISO7420/OF/1/1F	Gen II dual-channel (F = Fail-safe low)	2500	2/0 and 1/1	1	25	3.3, 5	Y	1.50
ISO55xx	Isolated gate drivers	5000	N/A	10	25	3.3, 5	N	TBD

*Suggested resale price in U.S. dollars in quantities of 1,000. See www.ti.com/hirel for HiRel options.

Preview products are listed in **bold blue**.

RS-485/RS-422 Transceivers

Device	Description	DR/RX	Duplex	Supply (V)	Isolated	Signaling Rate (Mbps)	ESD (kV)	Receiver Fail-safe	Nodes	HiRel Avail.	Package(s)	Price*
SN65HVD10/11/12	High/mid/low-speed slew-rate control	1/1	Half	3.3	No	32/10/1	16	Short, Open, Idle	256	Y	PDIP/SOIC-8	1.50
SN65HVD30/31/32	No enables	1/1	Full	3.3	No	26/5/1	16	Short, Open, Idle	256	Y	SOIC-8	1.45
ISO35	Isolated 3.3-V full-duplex transceiver	1/1	Full	3.3	Yes	1	16	Short, Open, Idle	256	N	SOIC-16	3.00
ISO35T	Isolated 3.3-V transceiver with transformer driver	1/1	Full	3.3	Yes	1	16	Short, Open, Idle	256	N	SOIC-16	TBD
SN65HVD08	Wide supply range: 3 to 5.5 V	1/1	Half	3 to 5.5	No	10	16	Short, Open, Idle	256	N	PDIP/SOIC-8	1.65
SN65HVD1785/6/7	±70-V protected, wide -20 to +25-V common mode	1/1	Half	5	No	0.115/1/10	16	Short, Open, Idle	256	N	PDIP/SOIC-8	1.85
SN65HVD3082E/5E/8E	Ultra-low-power, optimized for low, medium and high speeds	1/1	Half	5	No	0.2/1/20	16	Short, Open, Idle	256	Y	SOIC/PDIP/MSOP-8	0.90
SN65HVD20/21/22	±27-V protected and -20 to +25-V common mode	1/1	Half	5	No	25/5/0.5	16	Short, Open, Idle	256	N	PDIP/SOIC-8	1.40
SN65LBC184	ESD protection, IEC 4-2 air, contact and IEC 4-5 surge	1/1	Half	5	No	0.25	30	Open	128	N	PDIP/SOIC-8	1.30
SN65HVD1791/2/3	±70-V protected, wide -20 to +25-V common mode	1/1	Full	5	No	0.115/1/10	16	Short, Open, Idle	256	N	SOIC-14	1.90
SN65HVD3080E/3E/6E	Ultra-low-power, optimized for low, medium and high speeds	1/1	Full	5	No	0.2/1/20	15	Short, Open, Idle	256	N	SOIC-14, MSOP-10	1.20
ISO3086	±4-kV isolated, optimized for low and high speeds	1/1	Full	5	Yes	0.2/20	16	Short, Open, Idle	256	N	Wide SOIC-16	2.60
ISO3086T	Isolated 5-V transceiver with transformer driver	1/1	Full	5	Yes	20	16	Short, Open, Idle	256	N	Wide SOIC-16	TBD

PROFIBUS Transceivers

SN65HVD1176	PROFIBUS (EN 50170) transceiver	1/1	Half	5	No	40	10	Short, Open, Idle	160	N	SOIC-8	1.55
ISO1176	Isolated PROFIBUS transceiver	1/1	Half	5	Yes	40	16	Short, Open, Idle	160	N	SOIC-16	3.35
ISO1176T	Isolated PROFIBUS transceiver with transformer driver	1/1	Half	5	Yes	40	4	Short, Open, Idle	160	N	SOIC-16	TBD

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New Zealand 0800-446-934
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