TI Spins Motors

Texas Instruments

Motor Drive and Control Solutions

www.ti.com/motor

2015

Motor Drive and Control Solutions
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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.

Motor Control System Functions

Host – Motion profile, logic controller or user interface, often communicating over a standard or proprietary field bus (CAN, serial, and Ethernet such as EtherCAT, Ethernet POWERLINK or EtherNet/IP).

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.

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

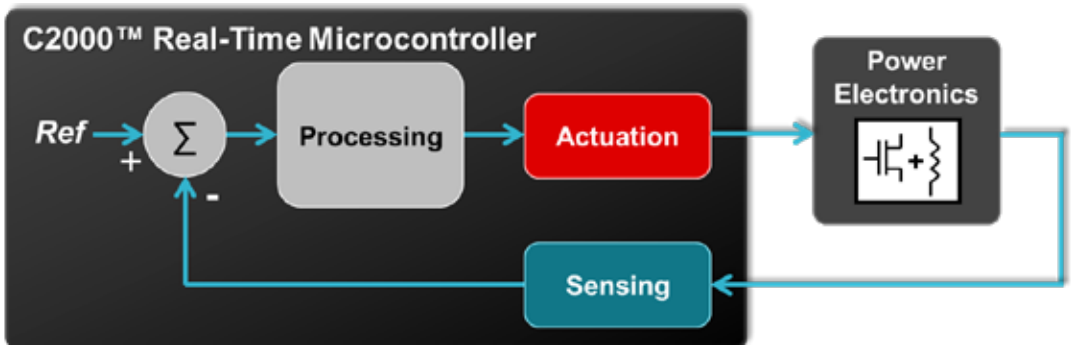
Integrated Motor Driver – Gate driver, FETs and protection circuitry integrated into a single device or package that may also include control logic and sensing circuitry.

Learn more at:
www.ti.com/motor

Microcontrollers for Motor Control
C2000™ Real-Time Microcontrollers

Microcontrollers Built for Real-Time Control

Optimized architecture for processing, sensing, and actuation to increase closed loop performance.



C2000™ Microcontroller Feature Highlights:

Sensing	Processing	Actuation
• Accurately sample signals with 12-bit and 16-bit Analog to Digital (ADC) converters • Run systems at high frequencies with ADC conversion rates up to 12.5 MSPS • Protect systems with responsive analog comparators — 30ns — that can directly shut down PWMs • Accurately measure current with Sigma Delta Filter Modules. Great for motor drives and resolver position decoding. • Interface with high performance external sensors using C2000™ high resolution captures	• Get more performance per MHz with 32-bit C28x™ DSP core optimized for complex single cycle operations common to control theory • Meet the demands of a wide range of applications with optimized processing options from 40 MIPS to 800 MIPS of performance • Add parallel loop control with the Control Law Accelerator (CLA) processing engine. Great for controlling multiple motors, power stages, and more. • Accelerate complex control theory and signal processing, such as trigonometric math, FFTs, and complex math, with built-in hardware accelerators	• Achieve higher system performance with Micro Edge Positioning of PWM outputs, including support of PWM phase, duty cycle, and period • Control a variety of applications and power stage topologies with ultra-configurable PWM generation • Minimize power losses with fully configurable, high resolution PWM dead band • Protect your system with responsive and asynchronous PWM shutdown logic

To learn more about C2000 MCUs, visit www.ti.com/C2000.

C2000™ Microcontroller Families

Piccolo™ MCUs	Delfino™ MCUs	F28M3x MCUs	InstaSPIN™ MCUs
Suitable for broad market applications, Piccolo MCUs provide powerful control while minimizing cost with a highly integrated architecture.	Designed for high performance applications, Delfino MCUs offer uncompromising technology to achieve greater application performance and power efficiency.	Perfect for industrial applications, F28M3x MCUs provide a differentiated architecture offering low latency closed loop control plus host connectivity and management.	Identify, tune and fully control any three-phase, variable speed, sensorless, synchronous or asynchronous motor control system in minutes with InstaSPIN MCUs.
From: $1.99 (1ku)	From: $8.95 (1ku)	From: $9.40 (1ku)	From: $4.45 (1ku)

Microcontrollers for Motor Control

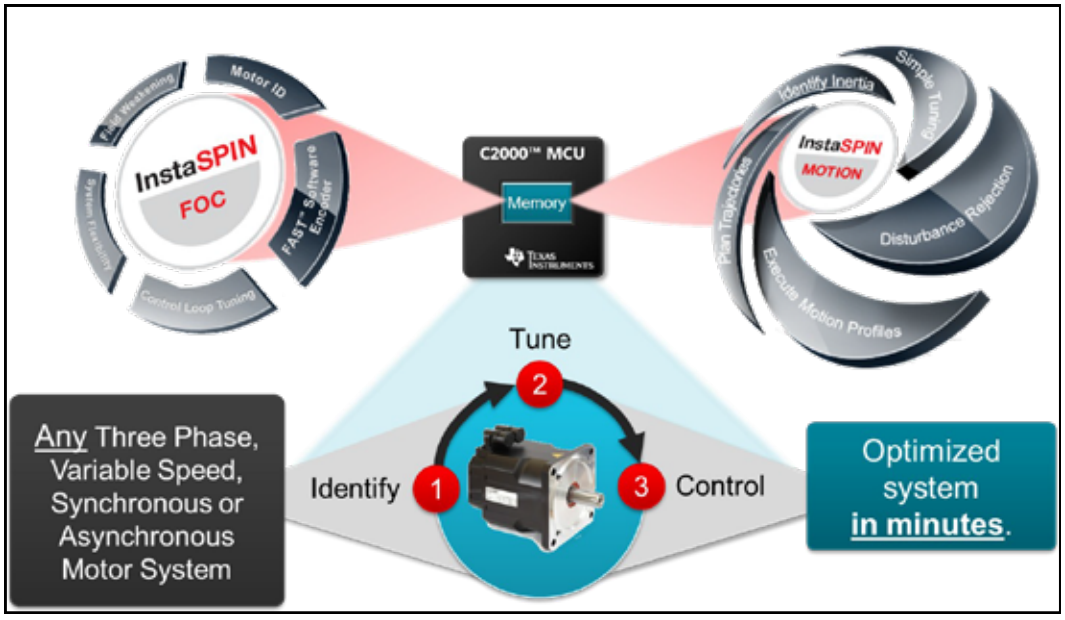
C2000™ Real-Time Microcontrollers

C2000™ MCU Software Solutions for Motor Control

Offering high performance open source motor control libraries, as well as complete-solution InstaSPIN™ microcontrollers based on the revolutionary InstaSPIN-FOC and InstaSPIN-MOTION motor control software.

InstaSPIN™ MCU Motor Software Solutions

InstaSPIN™ microcontrollers make designing motor control applications easier and faster. Identify, tune and fully control any type of three-phase, variable speed, sensorless, synchronous or asynchronous motor control system in just minutes.



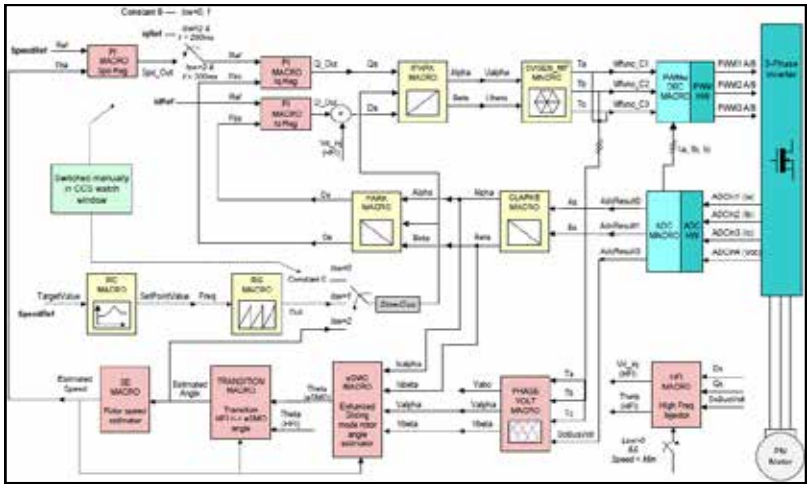
Learn more at www.ti.com/InstaSPIN

InstaSPIN-FOC software takes advantage of the revolutionary FAST™ software sensor for rotor flux measurement. It provides motor identification, automatic current control tuning and sensorless feedback in a field-oriented control (FOC) torque controller. With InstaSPIN-FOC, designers can speed deployment of efficient, sensorless, variable load, three-phase motor solutions.

InstaSPIN-MOTION software powered by SpinTAC™ technology expands on InstaSPIN-FOC and provides a high performance single tuning parameter position or speed controller as part of a suite of motion control functions: Identify, move, control, and plan.

C2000™ MCU Motor Control Software Libraries

For traditional software development, C2000™ provides optimized macro-based libraries for rapid deployment of motion control systems. This software block diagram approach makes it intuitive and easy to build out the software for your motor control system.



C2000 Motor Control Library Contents
Transformation and Observer Modules
Signal Generation and Control Modules
Peripheral Drivers
Real-Time Debugging Modules

To learn more about the motor control software solutions for C2000 MCUs, visit the Applications tab at www.ti.com/C2000.

Microcontrollers for Control

Tiva™ C Series Kits

Texas Instruments is the industry leader in bringing 32-bit capabilities and the full benefits of ARM® Cortex™-M-based microcontrollers to market. MCUs with Cortex-M offer a direct path to the strongest ecosystem of development tools, software and knowledge in the industry. Designers who migrate to MCUs will benefit from great tools, small code footprint and outstanding performance.

With large on-chip memories, enhanced power management and expanded I/O and control capabilities, 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 microcontrollers features deterministic performance and IP especially designed for simultaneous advanced motion control and real-time connectivity. These microcontrollers include up to 16 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

- Interleaved average current-mode PWM control with inherent current matching
- ARM Cortex-M4F core
- 32 to 256KB of flash
- 80-MHz CPU clock speeds
- Deterministic fast-interrupt processing (12 cycles)
- Real-time multitasking capabilities
- Integrated analog peripherals
- 12-bit analog-to-digital converter
- Pulse-width modulators (PWMs) with programmable deadband timers
- Operating modes with clock gating for lower power
- Single-cycle multiply/accumulate (MAC)
- IEEE 754 single-precision floating-point unit (FPU)

Unique MCU Capabilities

- Two CAN protocol version 2.0 part A/B
- Advanced communication capabilities, including UARTs, synchronous serial interfaces, USB, USB OTG, CAN controllers and I^2C
- 5-V tolerant GPIOs with programmable drive capability
- Single-cycle flash up to 40 MHz
- Royalty-free software with serial bootloaders and DriverLib available in ROM
- Open-tooled reference design kits and quick-start evaluation kits
- Up to two quadrature encoder inputs

Ware Software

- Extensive suite of software designed to reduce development cycle time
- Peripheral library
- USB library
- Graphics library
- Code examples
- Available as object library and source code

Hardware Kits

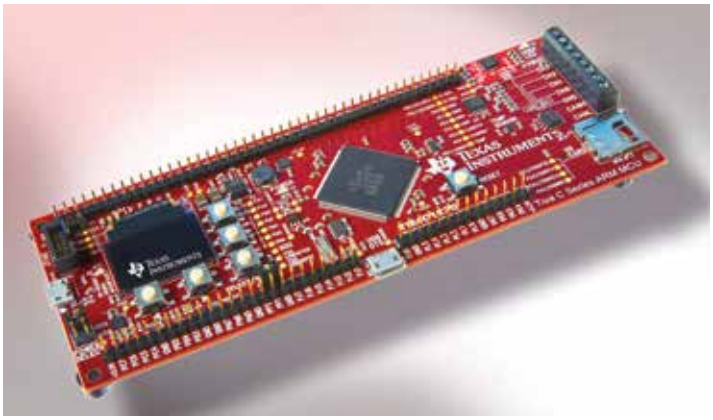
- Schematics, BOM and Gerber files are available for all hardware kits and include all accessories to start evaluation and software development.

For more information on MCUs for motor-control applications, visit **www.ti.com/c2000**

Microcontrollers for Control
Tiva™ C Series Kits

Evaluation kit

EK-TM4C123GXL LaunchPad Evaluation Kit is the perfect kit to get started with a Tiva C Series microcontroller at just U.S. $12.99.



Development Kits

The Tiva C Series TM4C123G Development Kit is a compact and versatile evaluation platform for the Tiva C Series TM4C123G ARM® CortexTM-M4-based microcontroller (MCU). The development kit design highlights the TM4C123G MCU integrated USB 2.0 On-the-Go/Host/Device interface, CAN, precision analog, sensor hub, and low-power capabilities. The development kit features a Tiva C Series TM4C123GH6PGE microcontroller in a 144-LQFP package, a color OLED display, USB OTG connector, a microSD card slot, a coin-cell battery for the low-power Hibernate mode, a CAN transceiver, a temperature sensor, a nine-axis sensor for motion tracking, and easy-access through-holes to all of the available device signals.

The EK-LM4F232 Development Kit is a compact and versatile tool for the Tiva C Series TM4C123G ARM® Cortex™-M4F based MCU. Key highlights include a color OLED display, USB OTG, a micro SD card, a coin cell battery for use with low-power hibernate, a temperature sensor, a three axis accelerometer for motion detection, and easy-access through-holes to all of the available device signals.

Microcontrollers for Motor Control

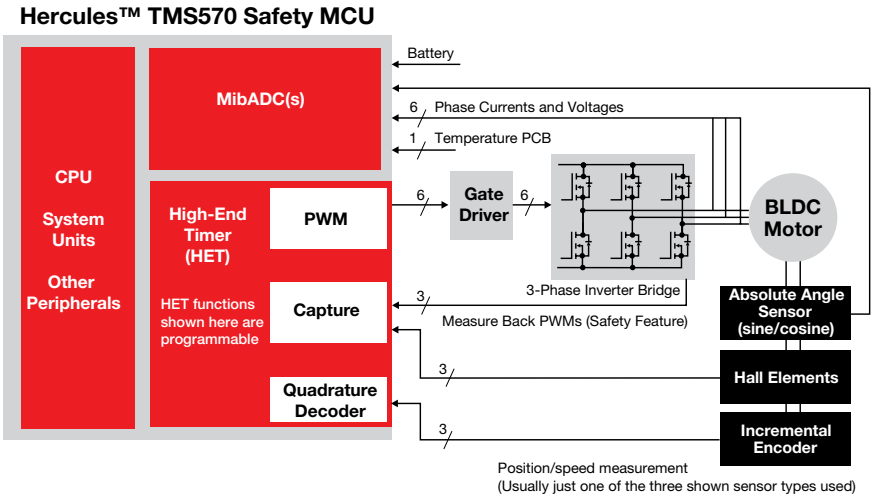
Hercules™ TMS570 32-Bit ARM® Cortex™-R4 Safety Microcontrollers

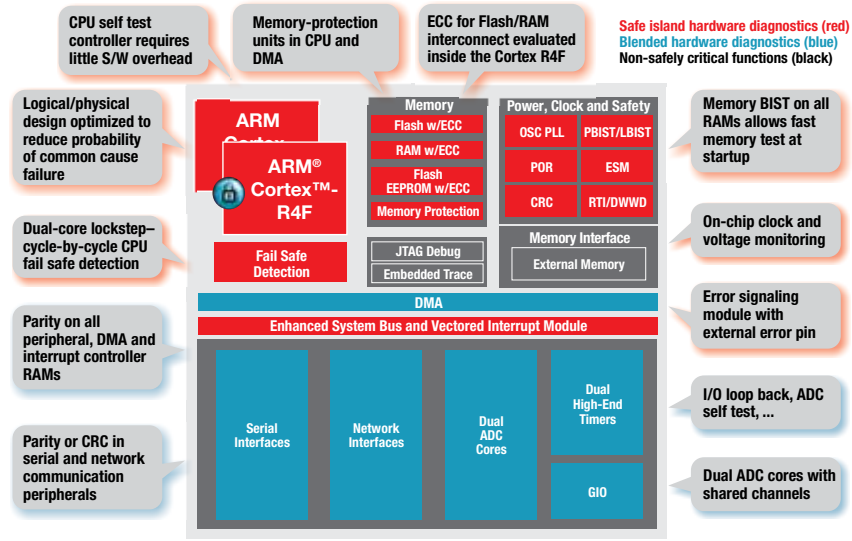
Hercules™ TMS570 Safety MCUs Enable Safe Motor Control

The Hercules TMS570 microcontroller family enables customers to easily build motor-control applications that meet specific safety standards. Devices are available today with up to 220 MHz of floating-point performance and include an integrated safety concept.

A wide choice of communication peripherals like Ethernet, CAN, USB, 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 Hercules TMS570 Cortex™-R4 microcontroller family was developed according to the ISO26262 ASIL-D and IEC 61508 SIL3 safety standards. Dual-core lockstep CPU architecture, hardware BIST, MPU, ECC and on-chip clock and voltage monitoring are some of the key functional safety features available. A safety manual is available with guidelines on how to make the safety implementation as easy as possible.





Learn more at: **www.ti.com/hercules**

Key Features

ARM® Cortex-R4 CPUs

- Up to 220 MHz with floating-point support
- Dual CPUs in lockstep

Memory

- Flash: 1MB, 2MB, and 3MB options with ECC protection
- RAM: 128KB to 256KB with ECC protection
- Roadmap from 256KB to 4MB flash

Peripheral Highlights

- 10/100 Ethernet
- USB host and device
- FlexRay with 8KB message RAM
- Three CAN interfaces
- Two 12-bit multi-buffered ADCs (MibADCs)
- Flexible timer module with up to 44 channels

Packages

- 144 QFP, 337 nFBGA (16.16 mm)

Applications

- Electronic power steering
- Hybrid and electric vehicles
- Medical pumps and blowers
- Industrial motors

Motor Control Benefits

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
  - HET can trigger the ADC(s) with many configuration possibilities

32-bit ARM Cortex-R4 with Floating-Point Unit

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

Special Purpose Processors for Motion Control
Trajectory controllers

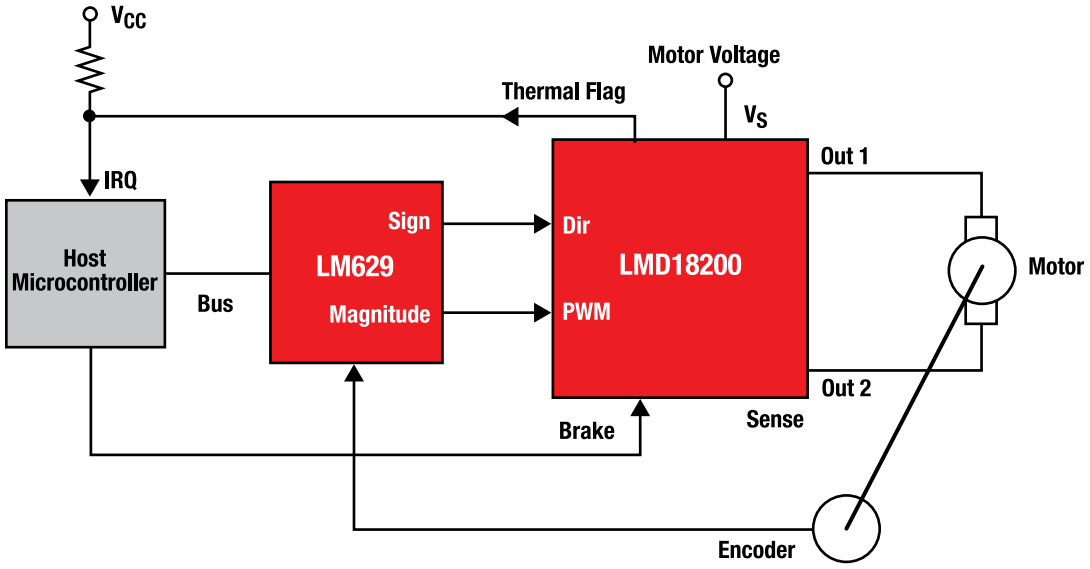
The LM628 and LM629 are dedicated motion-control processors designed for use with a variety of DC servo motors and other servo mechanisms which provide a quadrature incremental position feedback signal. The parts perform the intensive, real-time computational tasks required for high-performance digital motion control and the host software control interface is facilitated by a high-level command set. The LM628 has an 8-bit output to drive either an 8-bit or a 12-bit DAC. The LM629 has an 8-bit PWM output to directly drive LMD18200/201 H-Bridges.

Key Features

- 32-bit position, velocity, and acceleration registers
- Programmable digital PID filter with 16-bit coefficients
- Direct interface to Quadrature encoder interface
- 8- or 12-bit DAC output data (LM628)
- 8-bit sign-magnitude PWM output data (LM629)

Featured Products

Device	Clock Freq (MHz)	Host Interface	Shift Encoder Interface	Drive Interface	Package
LM628	6 or 8	8 bit, CS, RD, WR	A, B quadrature; Index	8 bit to DAC	28 PDIP
LM629	6 or 8	8 bit, CS, RD, WR	A, B quadrature; Index	PWM sign, magnitude	24 SOIC, 28 PDIP



Precision Control of DC Servo Motor

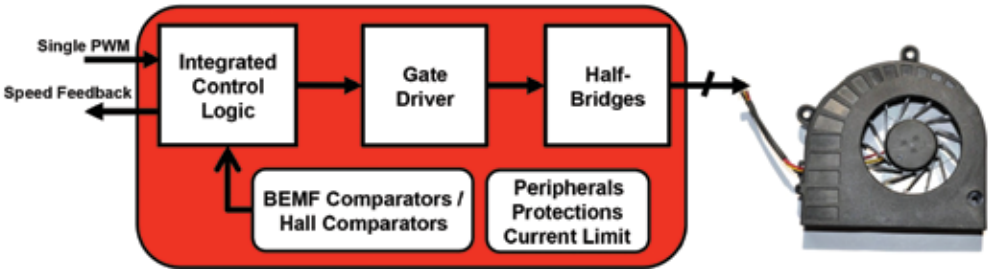
Integrated Fan Motor Drivers
The TI Advantage – Maximum Integration

TI's fan driver family integrates a fully protected drive stage or pre-drive stage with either sensored control logic or InstaSPIN™–FAN sensor-less control logic. No code or external components are required to safely and reliably spin your motor, minimizing both software and hardware design efforts. Over and under-voltage, over-temperature, and configurable current limit protection are provided. These highly integrated fan drivers enable a much simpler and safer design compared to traditional "MCU + discrete components" solutions, greatly simplifying and speeding the design process.

With both driver and pre-driver products, TI's fan driver family is able to spin not only fans in various cooling applications, but also low- to mid-voltage BLDC motors in consumer and industrial applications.

Featured Products

Product Type	Device	Voltage/Current	Description
Drivers	DRV10963	2.1V to 5.5V/500mA	180° 3-Phase sensor-less BLDC fan driver
	DRV11873	5V to 16V 1.5A	150° 3-Phase sensor-less fan driver
Pre-drivers	TMP816	6V to 16V/Ext FETs	1-Phase full-wave sensored fan pre-driver



Integrated Fan Motor Drivers

Device	Description	Supply Voltage (V)	I_{OUT} (A)	On-Chip Regulator	Price*
BLDC Fan Motor Drivers					
DRV10866	5V 3-Phase sensor-less BLDC driver (InstaSPIN™-FAN)	1.65 to 5.5	.68	No	0.39
DRV10963	5V 3-Phase sinusoidal sensor-less BLDC driver (InstaSPIN™-FAN)	2.1 to 5.5	.5	No	0.49
DRV11873	12V 3-Phase sensor-less BLDC driver (InstaSPIN™-FAN)	5 to 16	2	Yes (5V)	0.79
BLDC Fan Motor Pre-Drivers					
TMP814	1-Phase full-wave sensored BLDC fan motor pre-driver	6 to 16	Ext FETs	Yes (6V)	0.25
TMP815	1-Phase full-wave sensored BLDC fan motor pre-driver	6 to 16	Ext FETs	Yes (4.95V)	0.25
TMP816	1-Phase full-wave sensored BLDC fan motor pre-driver	6 to 16	Ext FETs	Yes (6V)	0.26
TMP821	2-Phase half-wave sensored BLDC fan motor pre-driver	4 to 28	Ext FETs	No	0.24

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

DRV8x Integrated Motor Drivers

The DRV8x family of integrated motor drivers enables manufacturers to quickly and easily spin their motors. Integrated drivers provide higher performance and better protection within a smaller board footprint versus traditional discrete solutions. Furthermore, integrated drivers are simpler and faster to design because they do not require discrete drive-stage design experience

The TI Advantage

Quicker Time to Spin

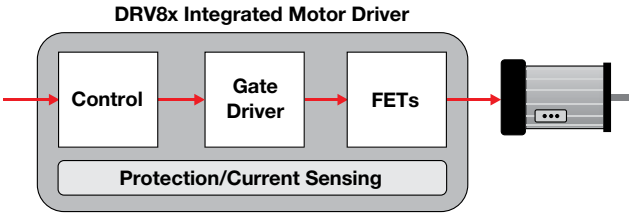
TI offers an integrated drive-stage, current sensing, on-chip control logic, simple control interfaces, easy-to-use EVMs and design-in documentation to help with all aspects of motor drive development.

Robust, Reliable and Fully Protected

All of TI's motor drivers include fast-acting protection against short circuits, thermal overload, under-voltage and shoot-through. When a fault condition is detected, the driver 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 interface options and a wide range of power ratings. For instance the DRV8x family includes both drivers and pre-drivers that support voltage ranges from 1.8 to 60V and load current up to 60A. This family is also capable of driving various motor types including brushed DC, brushless DC, steppers and other inductive loads, such as solenoids and relays.



For more information visit **www.ti.com/drv8x**

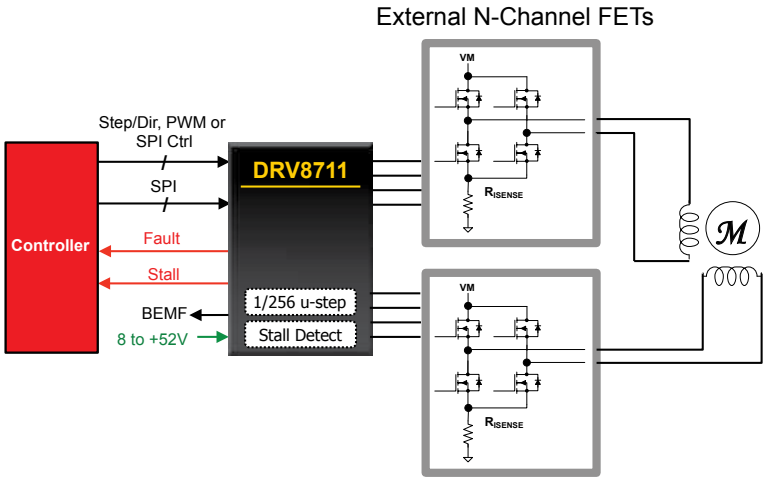
Featured Solenoid Drivers *(No catch / freewheel diodes needed)*

DriverType	Device	Voltage (V)	Description
Low-Voltage Drivers	DRV8839	1.8 to 11	2 x 1.8A driver
Dual Drivers	DRV8412	0 to 52	2 x 6A driver
	DRV8432	0 to 52	2 × 14A driver w/ heatsink
	DRV8844	8 to 60	2 x 3.5A driver w/ on-chip LDO
	DRV8816	8 to 38	2x 2.8A driver
Triple Drivers	DRV8312	0 to 52	3 × 3.5A driver
	DRV8313	8 to 60	3 × 1.75A driver w/ on-chip LDO
	DRV8332	0 to 52	3 × 8A driver w/ heatsink
Quad Drivers	DRV8412	0 to 52	4 × 3A driver
	DRV8432	0 to 52	4 × 7A driver w/ heatsink
	DRV8803	8.2 to 60	4 x 1A driver w/ PWM Ctrl
	DRV8804	8.2 to 60	4 x 1A driver w/ Serial Ctrl
	DRV8806	8.2 to 40	4 x 1A driver w/ open-load detect
	DRV8844	8 to 60	4 × 1.75A driver w/ on-chip LDO
Octal Drivers	DRV8860	8 to 38	8x 200mA driver with open load detect

Bipolar Stepper Motor driver

Key Features

- External N-channel MOSFETs
- Adjustable gate-driver parameters
- Advanced highly configurable current regulation and on-chip micro-stepping indexer
- Stall detect with optional BEMF output
- Register based SPI management interface
- Integrated protection & diagnosis



Benefits

- External FETs yields excellent thermal performance, and N-channel FETs on high-side saves system cost
- Tune gate driver performance to application needs
- Ultra-smooth motion profile
- MCU is notified and can take corrective action on a stall event either via internal stall detect or by processing the optional BEMF output
- Simple management interface and advanced protection & diagnosis reduces design complexity and enables higher system reliability

Selection Guides for Analog Motor Solutions

Stepper Motor Drivers

www.ti.com/motor

Device	Description	Supply Voltage (V)	I_{OUT} Cont. (A)	I_{OUT} Peak (A)	Control Interface	Drives Solenoids	Price*
DRV8412	6-A High-performance stepper driver	0 to 52	3	6	PWM	Yes (4x)	3.85
DRV8432	12-A High-performance stepper driver	0 to 52	7	12	PWM	Yes (4x)	5.50
DRV8812	1.6-A Stepper driver (P2P w/8813)	8 to 45	1.1	1.6	Phase/Enable	No	1.65
DRV8813	2.5-A Stepper driver (P2P w/8812)	8 to 45	1.75	2.5	Phase/Enable	No	2.25
DRV8823	Dual 1.5-A stepper driver	8 to 32	1.5	1.5	Serial	No	2.00
DRV8828	3-A Stepper driver (need 2x per motor)	8 to 45	2.1	3	Phase/Enable	No	1.65
DRV8829	5-A Stepper driver (need 2x per motor)	8 to 45	3.5	5	Phase/Enable	No	2.25
DRV8842	5-A Stepper driver (need 2x per motor)	8 to 45	3.5	5	PWM	Yes (2x)	2.25
DRV8843	2.5-A Stepper driver	8 to 45	1.75	2.5	PWM	No	2.25
Stepper Drivers w/ On-Chip Micro-Stepping Indexer							
DRV8811	1.9-A Stepper driver (8 microsteps) (P2P w/8818)	8 to 38	1.4	1.9	Indexer	No	1.80
DRV8818	2.5-A Stepper driver (8 microsteps) (P2P w/8811)	8 to 35	1.75	2.5	Indexer	No	2.25
DRV8821	Dual 1.5-A stepper driver (8 microsteps)	8 to 32	1.5	1.5	Indexer	No	2.00
DRV8824	1.6-A Stepper driver (32 microsteps) (P2P w/8825)	8 to 45	1.1	1.6	Indexer	No	1.65
DRV8825	2.5-A Stepper driver (32 microsteps) (P2P w/8824)	8 to 45	1.75	2.5	Indexer	No	2.40
Unipolar Stepper Drivers							
DRV8803	2-A Unipolar stepper driver	8 to 60	1.4	2	PWM	Yes (4x)	1.40
DRV8804	2-A Unipolar stepper driver	8 to 60	1.4	2	Serial	Yes (4x)	1.40
DRV8805	2-A Unipolar stepper driver w/indexer	8 to 60	1.4	2	Indexer	No	1.40
DRV8806	2-A Unipolar stepper driver w/open load detect	8 to 40	1.4	2	Serial	Yes (4x)	1.50
DRV8860	Dual 280mA unipolar stepper motor driver	8 to 38	280m	280m	Serial	Yes (8x)	1.50
Low-Voltage Stepper Drivers							
DRV8833	2-A Stepper driver	2.7 to 10.8	1.5	2	PWM	No	0.95
DRV8834	2.2-A Stepper driver (32 microsteps)	2.5 to 10.8	1.5	2.2	Indexer or Phase/Enable	No	1.15
DRV8835	1.5-A Stepper driver w/dual supplies	2.0 to 11	1.5	1.5	PWM or Phase/Enable	No	0.70
DRV8836	1.5-A Stepper driver	2.0 to 7	1.5	1.5	PWM or Phase/Enable	No	0.70
Stepper Pre-Driver							
DRV8711	Stepper pre-driver with on-chip 1/256 µStepping indexer and stall detect	8 to 52	Ext FETs	Ext FETs	Indexer, PWM or Serial	No	2.75

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

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

Selection Guides for Analog Motor Solutions

Brushed and Brushless DC Motor Drivers

www.ti.com/motor

Device	Description	Supply Voltage (V)	I_{OUT} Cont. (A)	I_{OUT} Peak (A)	Control Interface	Drives Solenoids	Price*
Single Brushed Drivers							
DRV8412	12-A High-performance brushed DC driver	0 to 52	6	12	PWM	Yes (4x)	3.85
DRV8432	24-A High-performance brushed DC driver	0 to 52	14	24	PWM	Yes (4x)	5.50
DRV8800	2.8-A Brushed DC driver	8 to 36	1.5	2.8	Phase/Enable	No	1.25
DRV8801	2.8-A Brushed DC driver with current-sense pin	8 to 36	1.5	2.8	Phase/Enable	No	1.25
DRV8816	2.8A Brushed DC driver with independent half bridge control	8 to 38	1.5	2.8	PWM/Enable	Yes (2x)	1.5
DRV8840	5-A Brushed DC driver	8 to 45	3.5	5	Phase/Enable	No	2.25
DRV8842	5-A Brushed DC driver	8 to 45	3.5	5	PWM	Yes (2x)	2.25
DRV8844	5-A Brushed DC driver with split supply support (+30/–30)	8 to 60	3.5	2.5	PWM	Yes (4x)	2.50
LMD18200	3A, 55V H-Bridge for DC motors	12 to 55	3	6	PWM	No	8.10
LMD18201	3A, 55V H-Bridge for DC motors	12 to 55	3	6	PWM	No	7.70
LMD18245	3A, 55V H-Bridge for DC motors	12 to 55	3	6	4 bit Digital	No	9.15
Dual/Quad Brushed Drivers							
DRV8412	Dual 6-A high-performance brushed DC driver	0 to 52	3	6	PWM	Yes (4x)	3.85
DRV8432	Dual 12-A high-performance brushed DC driver	0 to 52	7	12	PWM	Yes (4x)	5.50
DRV8802	Dual 1.6-A brushed DC driver (P2P w/8814)	8 to 45	1.1	1.6	Phase/Enable	No	1.65
DRV8814	Dual 2.5-A brushed DC driver (P2P w/8802)	8 to 45	1.75	2.5	Phase/Enable	No	2.25
DRV8823	Quad 1.5-A brushed DC driver	8 to 32	1.5	1.5	Serial	No	2.00
DRV8843	Dual 2.5-A brushed DC driver	8 to 45	1.75	2.5	PWM	No	2.25
DRV8844	Dual 2.5-A brushed DC driver w/split supply support (+30/–30)	8 to 60	1.75	2.5	PWM	Yes (4x)	2.50
Low-Voltage Brushed Drivers							
DRV8830	1-A Brushed DC driver with on-chip speed regulation	2.75 to 6.8	1	1	IN/IN	No	0.85
DRV8832	1-A Brushed DC driver with on-chip speed regulation	2.75 to 6.8	1	1	Serial	No	0.85
DRV8833	Dual 2-A or single 4-A brushed DC driver	2.7 to 10.8	3	4	PWM	No	0.95
DRV8835	Dual 1.5-A or single 3-A brushed DC driver with dual supplies	2.0 to 11	3	3	PWM or Phase/Enable	No	0.70
DRV8836	Dual 1.5-A or single 3-A brushed DC driver	2.0 to 7	3	3	PWM or Phase/Enable	No	0.70
DRV8837	1.8-A Brushed DC driver with dual supplies	1.8 to 11	1.8	1.8	PWM	No	0.45
DRV8839	Dual 1.8A or single 1.8A brushed DC driver	1.8 to 11	1.8	1.8	PWM	Yes (2x)	0.50
DRV8850	8A Low-voltage brushed DC driver	2 to 5.5	5	8	PMW	Yes (2x)	0.52
3-Phase Brushless Drivers							
DRV8301	Pre-driver with 1.5-A step-down voltage regulator and dual current-sense amps (SPI config)	6 to 60	Ext FETs	Ext FETs	PWM	No	2.50
DRV8302	Pre-driver with 1.5-A step-down voltage regulator and dual current-sense amps (H/W config)	6 to 60	Ext FETs	Ext FETs	PWM	No	2.50
DRV8303	Pre-driver with dual current-sense amps (SPI config)	6 to 60	Ext FETs	Ext FETs	PWM	No	1.95
DRV8307	Sinusoidal or trapezoidal controller + pre-driver with digital speed loop	8.5 to 32	Ext FETs	Ext FETs	PWM	No	1.20
DRV8308	Trapezoidal controller + pre-driver	8.5 to 32	Ext FETs	Ext FETs	CLK, PWM or SPI	No	TBD
DRV8312	6.5-A High-performance 3-phase driver	0 to 52	3.5	6.5	PWM	Yes (3x)	3.30
DRV8313	2.5-A 3-phase driver with 10-mA LDO	8 to 60	1.75	2.5	PWM	Yes (3x)	2.25
DRV8332	13-A High-performance 3-phase driver	0 to 52	8	13	PWM	Yes (3x)	4.70

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

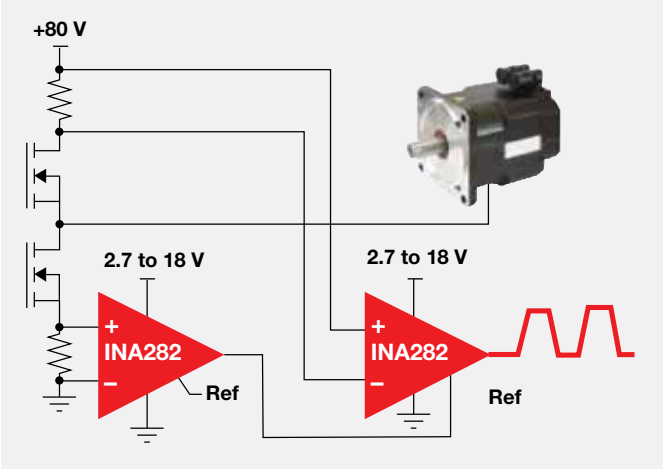
*New products are listed in **bold red**. Preview products are listed in **bold teal**.*

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 (V)	Offset	Offset Drift µV/°C	Bidirectional
INA282	–14 to 80	70 µV	0.5	Yes
INA138/INA139	2.7 to 36	1 mV	1	No
INA168/INA169	2.7 to 60	1 mV	1	No
INA170	2.7 to 60	1 mV	1	Yes
INA193-INA198	–16 to 80	2 mV	2.5	No
INA149	–275 to 275	1.1 mV	3	Yes
LMP8640HV	–2 to 76	1.16 mV	2.6	No
LMP8645HV	–2 to 76	1.7 mV	7	No
LMP8601	–22 to 60	1 mV	10	Yes
LMP8603	–22 to 60	1 mV	10	Yes

DRV5000 Hall Effect Sensors

The Hall effect is a sensing technology that detects and can measure the strength of the magnetic field as an indicator of distance or position without physical contact. Hall effect sensors are commonly used in detecting position, speed, or acceleration of an object by sensing the magnetic field generated by the object.

Modern day silicon-based Hall effect sensors for commutation in sensored-brushless DC motors as well as object recognition, index counting, open and close door applications and more in a wide range of industrial and automotive applications. TI's DRV5000 Hall sensors are rugged and fully-protected with digital latch, digital switch, and analog bipolar outputs to suit a diverse range of applications.

Hall Sensors

Device	Description	Supply Voltage (V_{CC}) (Min)(V)	Supply Voltage (V_{CC}) (Max)(V)	Output	Type	Operating Temperature Range (°C)	Package	Price*
DRV5013	2.5V to 38V Digital latch hall effect sensor	2.5	38	Open drain	Latch	–40 to 125	SOT-23, TO-92	0.26
DRV5023	2.5V to 38V Digital switch hall effect sensor	2.5	38	Open drain	Switch	–40 to 125	SOT-23, TO-92	0.26
DRV5033	2.5V to 38V Digital omnipolar-switch hall effect sensor	2.5	38	Open drain	Omnipolar switch	–40 to 125	SOT-23, TO-92	0.26
DRV5053	2.5V to 38V Analog bipolar hall effect sensor	2.5	38	0.2V to 1.8V	Analog bipolar	–40 to 125	SOT-23, TO-92	0.31

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

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

Signal Chain Solutions
Industrial Communications

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 ±36-V protection
- Low-power standby with bus wake-up
- 5-µA 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

PROFIBUS
- Certified PROFIBUS solution
- PROFIBUS transceiver with isolation

Industrial Ethernet
- Broad portfolio of Ethernet transceivers
- Support for standards such as EtherCAT, Ethernet POWERLINK, EtherNet/IP and more

Industrial Interface Transceivers

Part Number	Description	Bus Fault Voltage (V)	I_{CC} (Max) (mA)	Number of Nodes	Date Rate	Duplex	ESD	Supply Voltage(s) (V)	Special Features	Operating Temperature Range (°C)	Pin/Package	Price*
SN65HVD257	CAN transceiver with fast loop times for highly loaded networks and features for functional safety	–27 to 40	85	—	10kbps to 1Mbps	Half	±12kV HBM protection	4.5 to 5.5	High-speed, Turbo short prop delay, Redundancy and functional safety	–40 to 125	8/SOIC	0.60
SN65HVD72/75/78	3.3V, Half-duplex RS-485, high IEC ESD	–13 to 16.5	1	256	250kbps, 20Mbps, 50Mbps	Half	+12kV IEC and +15kV HBM protection	3 to 3.6	High IEC ESD, Large receiver hysteresis (80mV)	–40 to 125	8/SOIC, 8/SON, 8/MSOP	0.70
SN65HVD76/1476 SN65HVD77/1477	3.3V, Half-duplex RS-485, high IEC ESD	–13 to 16.5	1.1	256	400kbps, 20Mbps, 50Mbps	Full	+16kV IEC and +30kV HBM protection	3 to 3.6	High IEC ESD, Large receiver hysteresis (70mV)	–40 to 125	8/SOIC, 14/SOIC, 8/MSOP, 10/MSOP	1.90 / 2.25
SN65HVD1176	PROFIBUS® RS-485 transceiver	–9 to 14	6	160	40Mbps	Half	+10kV HBM	4.75 to 5.25	Optimized fro PROFIBUS® networks	–40 to 85	8/SOIC	1.54
SN65HVD1780/1/2	70-V Fault-protected RS-485 transceiver	–70 to 70	6	256	115kbps, 1Mbps, 10Mbps	Half	+16kV HBM	3.15 to 5.5	High Fault protection	–40 to 85	8/SOIC, 8/DIP	1.85

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

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

Signal Chain Solutions

Industrial Ethernet

Device	Interface	Cable Lenth (m)	No. LEDs	JTAG	Cable Diagnostics	FX Support	IEEE1588 HW Support	25MHz Clock Out	Temp Range (°C)	Package
DP83848I	MII, RMII, SNI	150	3	Yes	—	—	—	Yes	–40 to 85	QFP-48
DP83848Q*	MII, RMII	150	1	—	—	—	—	Yes	–40 to 105	QFP-40
TLK110	MII, RMII	150	3	Yes	Yes	—	—	Yes	–40 to 85	QFP-48
DP83630	MII, RMII	150	3	Yes	Yes	Yes	Yes	Yes	–40 to 85	QFP-48
TLK105	MII, RMII	150	1	—	—	—	—	—	–40 to 85	QFP-32
TLK105L*	MII, RMII	150	2	—	—	—	—	—	–40 to 85	QFP-32
TLK106	MII, RMII	150	1	—	Yes	—	—	—	–40 to 105	QFP-32
TLK106L	MII, RMII	150	2	—	Yes	—	—	—	–40 to 105	QFP-32
TLK111	MII, RMII	150	3	—	—	—	SDF	—	–40 to 8	QFP-48
DP83848K	MII, RMII	137	2	—	—	—	—	—	–40 to 85	QFP-40
DP83848T	MII, RMII	137	1	—	—	—	—	Yes	–40 to 85	QFP-40
DP83848H	MII, RMII	137	1	—	—	—	—	Yes	–40 to 125	QFP-40
DP83620	MII	150	3	Yes	Yes	Yes	—	Yes	–40 to 85	QFP-48
DP83640	MII, RMII	150	3	Yes	Yes	Yes	Yes	Yes	–40 to 85	QFP-48
DP83848VYB	MII, RMII, SNI	150	3	Yes	—	—	—	Yes	–40 to 105	QFP-48
DP83848YB	MII, RMII, SNI	150	3	Yes	—	—	—	Yes	–40 to 125	QFP-48

**AEC-Q100 Grade 2, FX support for TLK105L.*

Signal Chain Solutions

Digital Isolators

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.

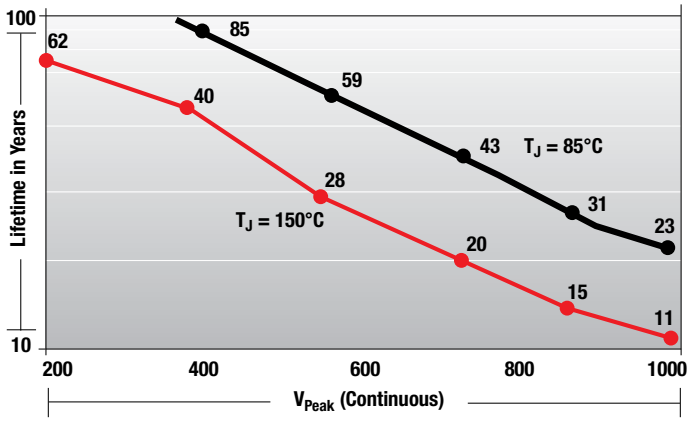
Signaling Rate

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

Digital Isolators

Part Number	Description	Isolation Rating (Vrms)	Peak Isolation Rating (Vpk)	Working Voltage (Vpk)	Forward / Reverse Channels	Speed (Max) (Mbps)	V_{CC} (Min) (V)	V_{CC} (Max) (V)	Default Output	Propagation Delay (Typ) (ns)	Operating Temperature Range (°C)	Pin/Package	Price*
ISO7842	High-immunity, 5.7kVRMS reinforced quad-channel 2/2 digital isolator, 100Mbps	5700	8061	2121	2/2	100	2.25	5.5	High	11	–55 to 125	16/SOIC	3.49
ISO7342C	Robust EMC, low power, quad-channel 2/2 digital isolator	3000	4242	1414	2/2	25	3	5.5	High/Low (F)	31	–40 to 125	16/SOIC	1.80
ISO7140/1(F)CC ISO7142CC	4242-VPK Small-footprint and low-power quad channel digital isolators with noise filter	2500	4242	560	4/0, 3/1, 2/2	50	2.7	5	High/Low (F)	23	–40 to 125	16/SSOP	1.90
ISO7131CC	4242-VPK Small-footprint and low-power 2/1 triple channel digital isolator with noise filter	2500	4242	560	2/1	50	2.7	5	Low	23	–40 to 125	16/SSOP	1.60

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

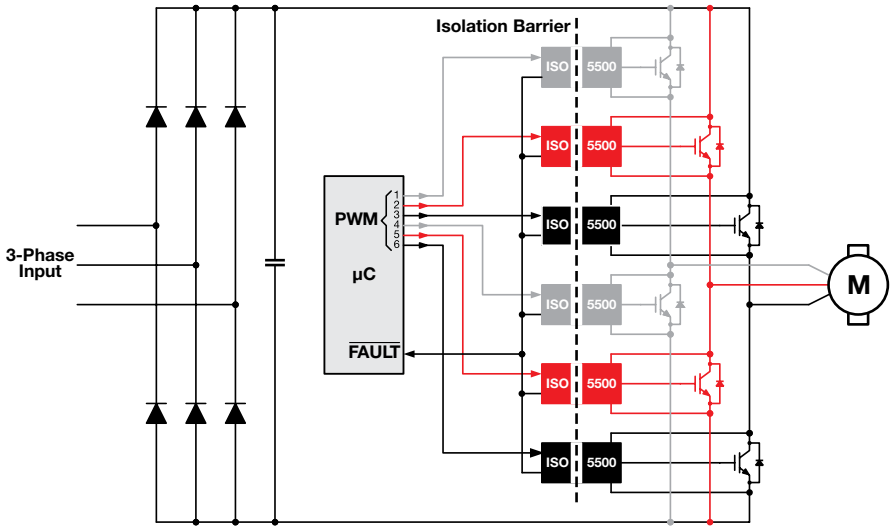
*New products are listed in **bold red**. Preview products are listed in **bold teal**.*

Signal Chain Solutions

ISO5500 Family Isolated Gate Drivers

TI's ISO5500 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.dards or specifications.

Key Features

- Soft IGBT turn-off
- Isolated fault feedback
- VCE DESAT protection/adjustability
- Undervoltage lock-out (UVLO) protection with hysteresis
- ±50-kV/µs typical transient immunity
- 6000-Vpeak maximum isolation per UL
- Operates with 3.3- or 5-V input supply
- –40 to 125°C operating range

Isolated IGBT Gate Drivers

Part Number	Description	Isolation Rating (Vrms)	Input V_{CC} (Min) (V)	Input V_{CC} (Max) (V)	Output V_{CC} (Min) (V)	Output V_{CC} (Max) (V)	Output Current (Min)(A)	Propagation Delay (Max) (ns)	Operating Temperature Range (°C)	Pin/Package	Price*
ISO5500	2.5-A isolated IGBT/MOSFET gate driver	3	3	5.5	15	30	2.5	300	–40 to 125	16/SOIC	3.00

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

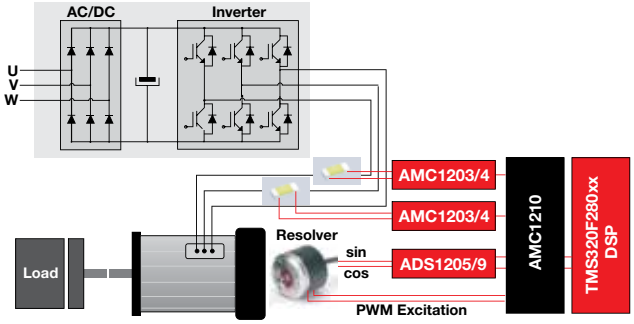
Signal Chain Solutions

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.

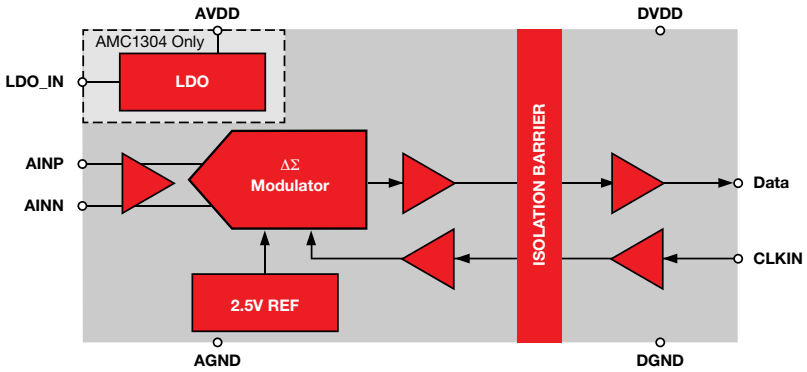
Analog Front End Solution for Motor Control



20MHz, Second-Order, Isolated Delta-Sigma Modulators for Current-Shunt Measurement

AMC1304/1305

The AMC1304/1305 delivers the industry's highest reinforced isolation ratings and precision performance for current measurement in high voltage industrial applications such as motor drives, photovoltaic inverters, and uninterruptible power supplies. Additionally, the AC and DC performance of the AMC1304/1305 enables levels of precision current measurement in applications requiring reinforced isolation that were previously unachievable. These devices also help designers achieve the lowest power consumption in the industry by 2.25 times less than the nearest competitor. In addition to being the lowest power consumption devices available in the market today, they are also the first to offer a ±50mV shunt input range – enabling a 5x reduction in power consumed by the shunt resistor.



Key Features

- ± 50mV and ± 250mV input ranges for current shunt resistors
- 5-20MHz external clock input enables synchronization of multiple devices
- Certified Digital Isolation: UL1577 and IEC60747-5-5 approved:
  - Working voltage: 1.5kVRMS, 1.5kVDC
  - Isolation voltage: 7kVPEAK/ 10kVSURGE (reinforced isolation)
  - Transient Immunity: 15kV/µs (min.)
- Integrated LDO allows extremely wide input supply range of 4V to 18V (AMC1304)
- Extended Industrial Temperature range of –40 to +125˚C
- CMOS and LVDS interface options both available

Modulators for Current Measurement Applications

Device	Description	Input Voltage Range (mV)	Isolation Rating (Vpeak)	Min Transient Immunity (kV/uS)	Supply Voltage (V)	Interface	Package	Price*
Isolated Delta-Sigma Modulator								
AMC1204/1204B	Isolated 20 MHz ΔΣ modulator	±250	4000/4250	15	3.3 / 5	Serial CMOS	SOIC-16	3.45
AMC1304/05	Isolated 20 MHz ΔΣ modulator with reinforced isolation	±50 or ±250	7000	15	4.0-18.0 / 3.0-5.5	Serial CMOS and LVDS	SOIC-16	TBD / 3.50
Isolated Amplifier								
AMC1200/1200B	Isolated amplifier with G=8	±250	4000/4250	10	3.3 / 5	N	SOP-8	2.20
Non-Isolated Delta-Sigma Modulator								
ADS1204	4-ch, 10 MHz ΔΣ modulator	±2000	N/A	N/A	5	Serial CMOS	QFN-32	6.75
ADS1205	2-ch, 10 MHz ΔΣ modulator	±2000	N/A	N/A	5	Serial CMOS	QFN-24	4.95
ADS1209	2-ch, 10 MHz ΔΣ modulator	±2300	N/A	N/A	5	Serial CMOS	TSSOP-24	4.50
Digital Filter								
AMC1210	Quad digital filter for 2nd-order ΔΣ modulator	—	—	—	—	—	—	1.34

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

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

Simultaneous-Sampling ADCs for High-End Motor Drives

Offering up to eight simultaneously sampled channels, up to 3-MSPS sampling rate, dual independently controlled internal references, small packages, and extended specified temperature range, TI's portfolio of high-performance ADCs are designed to meet the needs of the most demanding high-precision Motor Drive applications.

ADCs for Motor Control

Device	Res. (Bits)	Max Sample Rate	No. of Input Channels	Interface	Input Voltage Range (V)	V_{REF}	Power (mW)	Design Tools	Package	Price*
ADS7223	12	1MSPS	4	Serial SPI	$\pm V_{REF}$	Int/Ext	47.2	—	32VQFN	3.95
ADS7263	14	1MSPS	4	Serial SPI	$\pm V_{REF}$	Int/Ext	47.2	—	32VQFN	6.95
ADS8361	16	500kSPS	4	Serial SPI	±2.5 @ ±2.5	Int/Ext	150	ADS8361EVM	24SSOP/32VQFN	9.19
ADS8363	16	1MSPS	4	Serial SPI	$\pm V_{REF}$	Int/Ext	47.2	ADS8363EVM	32VQFN	9.95
ADS8528	12	650kSPS	8	Parallel or SPI	V_{REF}, $2V_{REF}$	Int/Ext	335	ADS8568EVM-PDK	64LQFP/64VQFN	9.50
ADS8548	14	600kSPS	8	Parallel or SPI	V_{REF}, $2V_{REF}$	Int/Ext	335	ADS8568EVM-PDK	64LQFP/64VQFN	12.50
ADS8556	16	630kSPS	6	Parallel or SPI	±1 to ±12	Int/Ext	251.7	ADS8556EVM	64LQFP	12.95
ADS8557	14	670kSPS	6	Parallel or SPI	±1 to ±12	Int/Ext	253.2	ADS8557EVM	64LQFP	10.95
ADS8558	12	730kSPS	6	Parallel or SPI	±1 to ±12	Int/Ext	262.2	ADS8558EVM	64LQFP	8.95
ADS8568	16	500kSPS	8	Parallel or SPI	V_{REF}, $2V_{REF}$	Int/Ext	335	ADS8568EVM-PDK	64LQFP/64VQFN	15.90
ADC3221	12	25MSPS	2	Serial LVDS	2Vp-p	Int/Ext	60	ADC3224EVM	48QFN	14.25
ADC3241	14	25MSPS	2	Serial LVDS	2Vp-p	Int/Ext	60	ADC3244EVM	48QFN	21.75
ADC3421	12	25MSPS	4	Serial LVDS	2Vp-p	Int/Ext	44.25	ADC3424EVM	48QFN	21.38
ADC3441	14	25MSPS	4	Serial LVDS	2Vp-p	Int/Ext	44.25	ADC3444EVM	48QFN	32.63
ADS7850	14	750kSPS	2	Serial SPI	0 to 5.5	Ext	40	ADS8350EVM-PDK	16WQFN	5.00
ADS7851	14	1.5MSPS	2	Serial SPI	0 to 5.5	Int	50	ADS7851EVM-PDK	16WQFN	7.00
ADS7852	12	500kSPS	8	Parallel CMOS	+5	Int/Ext	13	—	32TQFP	3.40
ADS7854	14	1MSPS	2	Serial SPI	0 to 5.5	Ext/Int	45	ADS7854EVM-PDK	16TSSOP/16WQFN	6.50
ADS7861	12	500kSPS	4	Serial SPI	±2.5 @ ±2.5	Int/Ext	25	ADS7861EVM	24SSOP/32VQFN	4.05
ADS7862	12	500kSPS	4	Parallel CMOS	±2.5 @ ±2.5	Int/Ext	25	—	32TQFP	5.70
ADS8350	16	750kSPS	2	Serial SPI	0 to 5.5	Ext	40	ADS8350EVM-PDK	16WQFN	8.00
ADS8353	16	600kSPS	2	Serial SPI	0 to 5.5	Ext/Int	42.5	ADS8353EVM-PDK	16TSSOP/16WQFN	9.00
ADS8354	16	700kSPS	2	Serial SPI	0 to 5.5	Ext/Int	45	ADS8354EVM-PDK	16TSSOP/16WQFN	9.50
ADS7251	12	2MSPS	2	Serial SPI	0 to 5.5	Int	55	ADS7851EVM-PDK	16TSSOP/16WQFN	4.50

**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 teal**.*

Selection Guides for Power Management Solutions

Input Power Protection

Part Number	Description	V_{IN} (Min) (V)	V_{IN} (Max) (V)	Current Limit Threshold (A)	Enable	Fault Response	Special Features	Operating Temperature Range (°C)	Pin/Package	Price*
LM5060	High-side protection controller with low quiescent current	5.5	65	Externally adjustable	Yes	Latch off	No external RSENSE	–40 to 125	10/VSSOP	1.09
LM5069	Positive high voltage hot swap / Inrush current controller with power limiting	9	80	Externally adjustable	Yes	Latch off/Retry	Reverse hookup protection	–40 to 125	10VSSOP	1.47
TPS24750/1	12A Integrated hot-swap protector with current monitor	2.5	18	Externally adjustable	Yes	Latch off/Retry	Programmable fault timer	–40 to 85	36VQFN	1.65

Window Comparator

Part Number	Description	Vs (Min) (V)	Vs (Max) (V)	t_{RESP} Low-to-High (µs)	Vos (Offset Voltage @ 25 (°C) (Max) (mV)	Iq per Channel (Max) (mA)	Output Type	Input Bias Current (±) (Max) (nA)	Number of Channels	Special Features	Rail-Rail	Operating Temperature Range (°C)	Pin/Package	Price*
LMV762	Low voltage, precision comparator with push-pull output	2.7	5	0.12	1	0.7	Push-pull	0.005	2	—	—	–40 to 125	8/SOIC, 8/VSSOP	0.85
TPS3700	High-voltage (18V) window comparator with over- and undervoltage detection	1.8	18	29	5.5	0.013	Open drain	25	1	Hysteresis, Internal reference, Window comparator	In	–40 to 125	6/SOT, 6/WSON	0.70

.

LDO Linear Regulators

Part Number	Description	Output Options	I_{OUT} (Max) (A)	V_{IN} (Min) (V)	V_{IN} (Max) (V)	V_{OUT} (Min) (V)	V_{OUT} (Max) (V)	Iq (Typ) (mA)	Vdo (Typ) (mV)	Noise (uVrms)	Additional Features	Operating Temperature Range (°C)	Pin/Package	Price*
TPS7A3001	V_{IN} 3V to 36V, 150mA, ultra-low noise, high PSRR, low-dropout linear regulator	Adjustable output, Negative output	0.2	–36	–3	–33	–1.2	0.05	216	15	Enable, Overcurrent protection, Soft start, Thermal shutdown, Fast transient response	–40 to 125	MSOP-PowerPAD	1.50
TPS7A4901	V_{IN} –3V to –36V, –200mA, ultra-low noise, high PSRR, low-dropout linear regulator	Adjustable output	0.15	3	36	1.2	33	0.06	260	15	Enable, Overcurrent protection, Soft start, Thermal shutdown, Fast transient response	–40 to 125	MSOP-PowerPAD	1.10
TPS70933	150-mA, 30-V, 1-µA IQ voltage regulator with enable	Fixed output	0.15	2.7	30	3.3	3.3	0.001	300	—	Enable, Overcurrent protection, Soft start, Thermal shutdown, Fast transient response	–40 to 125	SON/ SOT-23	0.39
TLV73333P	Capacitor-free, 300-mA, low-dropout regulator with foldback current limit	Fixed output	0.3	1.4	5.5	3.3	3.3	0.034	122	—	Enable, Foldback overcurrent protection, Output discharge, Thermal shutdown	—	—	—
TPS75005	Dual, 500mA low-dropout regulators and triple voltage rail monitor	Adjustable output, Fixed outputs 1.8, 1.9, 3.3	0.5	4	6.5	Fixed outputs	Fixed outputs	0.175	300	—	Enable, Over current protection, Thermal shutdown, PG, Sequencing and monitoring, Soft start	–40 to 125	20/VQFN	1.90
LP5907	250mA, Ultra-low noise low-dropout regulator	Fixed output	0.25	2.2	5.5	1.2	4.5	0.012	50	6.5	Enable, Overcurrent protection, Thermal shutdown, Output discharge	–40 to 125	DSBGA/ SOT-23/ X2SON	0.14
LP38691	500mA Low dropout CMOS linear regulators	Fixed output	0.5	2.7	10	1.8	5	0.055	250	—	Enable, Overcurrent protection, Thermal shutdown, Foldback overcurrent protection	–40 to 125	TO-252/ WSON	0.50

**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 teal**.*

Selection Guides for Analog Motor Solutions

DC/DC Regulators

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Part Number	Description	V_{IN} (Min) (V)	V_{IN} (Max) (V)	V_{OUT} (Min) (V)	V_{OUT} (Max) (V)	I_{OUT} (A)	Topology	Switch Current Limit (Typ) (A)	Iq (Typ) (mA)	Duty Cycle (Max) (%)	Soft Start	Compensation	Special Features	Operating Temperature Range (°C)	Pin/ Package	Price*
TPS55010	2.95V to 6V Input, 2W, isolated DC/DC converter with integrated FETs	2.95	6	3.3	20	0.4	Fly-buck	2.75	0.575	—	Adjustable	External	Enable, Synchronous rectification, Isolated, Power good, Frequency synchronization	–40 to 150	16/WQFN	0.99
TPS62404	Dual, 400mA and 600mA, 2.25MHz step-down converter with 1-wire interface in QFN	2.5	6	1.2	1.9	0.4	Buck, Synchronous buck	1	0.032	100	Fixed	Internal	Enable, Light load efficiency	–40 to 85	10/SON	0.90
TPS62150	3V to17V 1A Step-down converter with DCS-control™	3	17	0.9	6.3	1	Buck, Synchronous buck	1.7	0.017	100	Adjustable	Internal	Enable, Light load efficiency, Power good, Tracking, Voltage margining	–40 to 85	16/QFN	0.98
LMZ34002	4.5V to 40V Input, up to 15W negative-output integrated power solution	4.5	40	–3	–17	2	Boost, Synchronous buck module	3	—	—	Adjustable	External	Integrated inductor, EMI tested, Negative output, Soft start, Overcurrent protection, Remote sense, External clock sync	–40 to 85	41B1QFN	6.75
TPS40210	Wide input range current mode boost controller	4.5	52	5	260	6	Boost	NA	1.5	95	Adjustable	Internal	Enable, Frequency synchronization	–40 to 125	10/MSOP-PowerPAD, 10/SON	0.80
TPS54160A	3.5V to 60V Input, 1.5A step-down converter with eco-mode	3.5	60	0.8	58	1.5	Buck, Inverting buck boost	1.8	0.116	98	Adjustable	External	Enable, Frequency synchronization, Light load efficiency, Power good, Tracking	–40 to 150	10/MSOP-PowerPAD, 10/SON	1.58
TPS54061	4.7V to 60V Input, 200mA synchronous step-down converter	4.7	60	0.8	58	0.2	Buck, Inverting buck boost	0.35	0.09	98	Fixed	External	Adjustable UVLO, Enable, Frequency synchronization, Light load efficiency, Synchronous rectification	–40 to 150	8/SON,	1.04
TPS54260	3.5V to 60V Input, 2.5A step-down converter with eco-mode	3.5	60	0.8	58	2.5	Buck, Inverting buck boost	3.5	0.138	98	Adjustable	External	Enable, Frequency synchronization, Light load efficiency, Power good, Tracking	–40 to 150	10/MSOP-PowerPAD, 10/SON	1.86
TPS54361	4.5V to 60V Input, 3.5A step-down converter	4.5	60	0.8	59	3.5	Buck	5.5	0.152	98	Adjustable	External	Enable, Frequency Synchronization, Light Load Efficiency, Power Good, Tracking, Adjustable UVLO	–40 to 150	10/WSON	2.60
TPS55340	Wide input range boost/SEPIC/ flyback DC/DC converter with integrated FET	2.9	32	3	38	2	Boost, SEPIC, Flyback	6.6	0.5	90	Adjustable	External	Enable, Frequency synchronization, Light load efficiency	–40 to 150	14/HTSSOP, 16/WQFN	1.85
LM5017	Family of 100V regulators enhance reliability for high-voltage systems	7.5	100	1.25	90	0.6	Fly-buck	1.3	1.75	90	External	No compensation needed	Intelligent current limit, Primary-side fly-buck regulation	–40 to 125	8/SO PowerPAD, 8/WSON	1.57

AC/DC (Offline) Chargers/Auxilliary Power Supplies

Part Number	Description	Features	Operating Temperature Range (°C)	Pin/Package	Price*
UCC28700/01/02/03	Constant voltage, constant current PWM Controller with primary-side regulation	<30mW no load power for 5 star EC IPP rating, Primary Side Regulation (PSR) eliminates opto-coupler, Quasi-resonant valley switching operation for highest overall efficiency	–20 to 125	6/SOT-23	0.35
UCC28710/11/12/13/14/15	Constant voltage, constant current PWM controller with primary-side regulation with high voltage startup	<10mW no load power, Internal 700V HV Start-up JFET, Primary Side Regulation (PSR) eliminates opto-coupler, Quasi-resonant valley switching operation for highest overall efficiency	–40 to 125	7/SOIC	0.42
UCC28630	CCM/DCM with primary-side CV and CC regulation	Primary Side Regulation (PSR) eliminates opto-coupler, X-capacitor discharge for improved standby power, Best in class 10% efficiency performance — >86% for 65W, Integrated 700V JFET for fast startup and low standby power	–40 to 125	7/VSSOP	0.60
LM5021	Highly efficient off-line single-ended flyback and forward power converter using current-mode control	Ultra low start-up current (25 µA maximum), Current mode control, Skip cycle mode for low standby power, Single resistor programmable oscillator, Synchronizable oscillator	–40 to 125	8/VSSOP	0.50
LM5023	Quasi-resonant current mode PWM AC/DC controller	1% Voltage output regulation over line, Load, temp, Low power operation: skip mode for low standby power <10mW at $230V_{AC}$, Critical conduction mode control, ±5% Current limit accuracy over PVT, Peak current mode control when operating in CV operation	–40 to 125	8/VSSOP	0.38
LM5030	100V push pull converter	Current control mode, Shutdown feature to incorporate STO functionality, Operates from 24V supply, Defined dead time to avoid cross conduction	–40 to 125	10/VSSOP	0.99
LM5032	High voltage dual interleaved current mode controller	Two independent PWM current mode controllers, Integrated high voltage startup regulator	–40 tp 125	16/VSSOP	1.40

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

Selection Guides for Analog Motor Solutions

Non-Isolated Gate Drivers

Part Number	Description	Driver Configuration	Peak Source/ Sink Output Current (A)	V_{CC} (Min) (V)	V_{CC} (Max) (V)	Rise Time (ns)	Fall Time (ns)	Prop Delay (ns)	Input Threshold	Operating Temperature Range (°C)	Pin/ Package	Price*
UCC27531	2.5-A and 5-A, 35-VMAX VDD FET and IGBT single-gate drive	Single, Non-inverting	2.5/5	10	35	15	7	17	TTL	–40 to 140	6/SOT-23	0.75
UCC27511	4A/8A Single-channel high-speed low-side gate driver	Single inverting, Non-inverting	4/8	4.5	18	9	7	13	TTL	–40 to 140	6/SOT-23	0.52
UCC27517A	4A/4A Single-channel high-speed low-side gate driver with 5V negative input voltage handling ability	Single inverting, Non-inverting	4/4	4.5	18	9	7	13	TTL	–40 to 140	5/SOT-23	0.49
UCC27524A	Dual, 5A, high-speed low-side power MOSFET driver with negative input voltage ability	Dual, Non-inverting	5/5	4.5	18	7	7	14	TTL	–40 to 140	8/MSOP-PowerPAD, 8/SOIC	0.75
UCC27511	Single-channel high-speed low-side gate driver with split output	Inverting, Non-inverting	4/8	4.5	18	9	7	13	TIL	–40 to 140	6/SOT-23	0.75
UCC27517A	Single-channel 4A high-speed, low-side gate driver with inverting or non-inverting configuration with 5V negative input voltage handling ability	Inverting, Non-inverting	4/4	4.5	18	9	7	13	TIL	–40 to 140	5/SOT-23	0.52
UCC27518/19	Single-channel 4A high-speed, low-side gate driver with CMOS input	Inverting (18), Non-inverting (19)	4/4	4.5	18	9	7	13	CMOS	–40 to 140	5/SOT-23	0.49
UCC27524A	Dual-channel 5A high-speed, low-side gate driver with negative input voltage capability	Dual, Non-inverting	5/5	4.5	18	7	7	14	TIL	–40 to 140	8/MSOP, 8/SOIC	0.75
UCC27531/32	Single-channel 2.5A/5A, 35V max V_{DD} FET and IGBT gate driver with split output and with 5V negative input voltage handling ability (32 includes CMOS input)	Non-inverting	2.5/5	10	35	15	7	17	TIL / 31 CMOS / 32	–40 to 140	6/SOT-23	0.75
LM5112	Tiny 7A single channel MOSFET gate driver	Inverting, Non-inverting	3/7	3.5	14	14	12	25	TIL	–40 to 125	6/WSON	0.45
UCC27201A/211A	120V boot, 3A/4A peak (201A/211A), High frequency, high-side/low-side driver with negative voltage handling	High side, Low side	3/3 / 201A 4/4 / 211A	8 / 201A 7.8 / 211A	20	8	7	20	TTL	–40 to 140	10/WSON / 201A, 8/SOIC / 201A/211A, 8/SO PowerPAD / 201A, 8/VSON/201A / 211A, 9/SON / 201A	1.30/ 201A 1.50/ 211A
LM5104/5/6	High voltage bridge gate drivers with programmable dead-time control	Bridge	2	7.5	14	10 / 4/5 15 / 6	10	35 / 4/5 32 / 6	TTL	–40 to 125	8/SOIC, 8/WSON	1.10 / 4 0.90 / 5 0.64 / 6
LM5109	100V boot, 1A peak, high frequency, high-side/low-side driver	High side, Low side	1/1	7.5	14	15	15	25	TTL	–40 to 125	8/SOIC, 8/WSON	0.50

Voltage Monitor and Reset ICs

Part Number	Description	# of Supplies Monitored	V_{CC} (min) (V)	V_{CC} (max) (V)	Iq (typ) (uA)	Threshold Voltage (typ) (V)	Operating Temperature Range (°C)	Output Driver Type/Reset Output	Special Features	Time Delay (ms)	Pin/Package	Price*
TPS3700	Window comparator for over- and undervoltage detection	2	1.8	18	5.5	Adjustable	–40 to 125	Active-low/ Open-drain	Over voltage sense	0	6SOT/6WSON	0.69
TPS3847085	18-V, 380-nA Voltage monitor	1	4.5	18	0.38	Fixed: 8.5	–40 to 85	Active-low/ Push-pull	Manual reset	5	5SOT-23	0.79
TPS386000	Quad supply voltage supervisor with adjustable delay and watchdog timer	4	1.8	6.5	12	Adjustable	–40 to 125	Active-low/ Open-drain	Manual reset/ Negative voltage monitoring/Over voltage sense/ Watchdog timer	20/300/ Programmable	20QFN	0.95
TPS3808	Low quiescent current, programmable-delay	1	1.7	6.5	2.4	Adjustable, Fixed: 0.84, 1.12, 1.16, 1.40, 1.67, 1.77, 2.33, 2.79, 3.07, 4.65	–40 to 125	Active-low/ Open-drain	Manual reset	Programmable	6SON/6SOT-23	0.68
TPS3831A09	Supervisory circuit	1	0.6	6.5	0.15	Fixed: 0.9, 1.1, 1.52, 1.67, 2.63, 2.93, 3.08, 4.38	–40 to 85	Active-low/ Push-pull	Manual reset	200	4X2SON	0.30

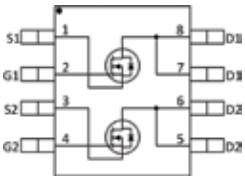
**Suggested resale price in U.S. dollars in quantities of 1,000.*

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

NexFET Power MOSFET
N-Channel

Single N-Channel

Device	V_{DS} (V)	V_{GS} (V)	$V_{GS(TH)}$ Typ (V)	I_D Max @ T_C= 25°C (A)	$R_{DS(ON)}$ @ V_{GS} = 10V (mΩ)	Q_G (nC)	Q_{GD} Typ (nC)	Q_{GS} (nC)	Configuration	Package	Operating Temp Range (°C)
CSD18501Q5A	40	20	1.8	155	2.5	42	5.9	8.1	Single	SON5x6	–55 to 150
CSD18502KCS	40	20	1.8	200	2.4	52	8.4	10.3	Single	SON5x6	–55 to 150
CSD18502Q5B	40	20	1.8	204	1.8	52	8.4	10.3	Single	SON5x6	—
CSD18503KCS	40	20	1.9	130	3.6	30	4.6	7.7	Single	SON5x6	–55 to 150
CSD18503Q5A	40	20	1.8	145	3.4	26	4.3	4.5	Single	SON5x6	–55 to 150
CSD18504KCS	40	20	1.9	85	5.5	19	3.5	4.4	Single	TO-220	–55 to 150
CSD18504Q5A	40	20	1.8	75	5.3	16	2.4	3.2	Single	TO-220	–55 to 150
CSD18509Q5B	40	20	1.9	299	1	150	17	29	Single	TO-220	—
CSD18531Q5A	60	20	1.8	134	3.5	36	5.9	6.9	Single	TO-220	–55 to 150
CSD18532KCS	60	20	1.8	169	3.3	44	6.9	10	Single	TO-220	–55 to 150
CSD18532NQ5B	60	20	2.8	163	2.7	49	7.9	16	Single	TO-220	–55 to 150
CSD18532Q5B	60	20	1.8	172	2.5	44		10	Single	TO-220	–55 to 150
CSD18533KCS	60	20	1.9	114	5	28	3.9	9.4	Single	SON5x6	–55 to 150
CSD18533Q5A	60	20	1.9	103	4.7	29	5.4	6.6	Single	SON5x6	–55 to 150
CSD18534KCS	60	20	1.9	71	7.6	19	3.1	4.8	Single	SON5x6	–55 to 150
CSD18534Q5A	60	20	1.9	69	7.8	17	3.5	3.2	Single	SON5x6	–55 to 150
CSD18537NKCS	60	20	3	54	11	14	2.3	5.2	Single	SON5x6	–55 to 150
CSD18537NQ5A	60	20	3	62	10	14	2.3	4.7	Single	SON5x6	–55 to 150
CSD18540Q5B	60	20	1.9	221	1.8	41	6.7	8.8	Single	SON5x6	—
CSD18563Q5A	60	20	2	91	5.7	15	2.9	3.3	Single	SON5x6	–55 to 150
CSD19501KCS	80	20	2.6	121	5.5	38	5.8	12.4	Single	SON5x6	–55 to 175
CSD19502Q5B	80	20	2.7	138	3.4	48	8.6	14	Single	TO-220	–55 to 150
CSD19503KCS	80	20	2.8	94	7.6	28	5.4	9.8	Single	TO-220	–55 to 150
CSD19505KCS	80	20	2.6	208	2.6	76	11	25	Single	TO-220	–55 to 175
CSD19506KCS	80	20	2.5	273	2	120	20	37	Single	TO-220	–55 to 175
CSD19531KCS	100	20	2.7	105	6.4	38	7.5	11.9	Single	TO-220	–55 to 175
CSD19531Q5A	100	20	2.7	110	5.3	37	6.6	10.5	Single	TO-220	–55 to 150
CSD19532Q5B	100	20	2.6	124	4	48	8.7	13	Single	TO-220	–55 to 150
CSD19533KCS	100	20	2.8	86	8.7	27	5.4	9	Single	TO-220	–55 to 175
CSD19533Q5A	100	20	2.8	75	7.6	27	4.9	7.9	Single	SON5x6	–55 to 150
CSD19534Q5A	100	20	2.8	44	12.6	17	3.2	5.1	Single	SON5x6	–55 to 150
CSD19535KCS	100	20	2.7	187	3.1	78	13	25	Single	SON5x6	–55 to 175
CSD19536KCS	100	20	2.5	259	2.3	118	17	37	Single	SON5x6	–55 to 175



Dual N-Channel

Device	V_{DS} (V)	V_{GS} (V)	$V_{GS(TH)}$ Typ (V)	I_D Max @ T_C= 25°C (A)	$R_{DS(ON)}$ @ V_{GS} = 10V (mΩ)	Q_G (nC)	Q_{GD} Typ (nC)	Q_{GS} (nC)	Configuration	Package
CSD88537ND	60	20	3	16	12.5	14	2.3	4.6	Dual	SO-8
CSD88539ND	60	20	3	11.7	23	7.2	1.1	2.7	Dual	SO-8

TI Designs for Motor Drives

TI Design	Description	Key Features
Reference Design: Isolated IGBT Gate-Drive Fly-Buck™ Power Supply with 4 Outputs	The TIDA-00174 reference design is a 4-output isolated Fly-Buck power supply for IGBT gate drive bias. It generates two sets of (+16V, –9V) voltage output with 100mA output current capability. The positive/negtaive bias voltages are used to power the high power IGBT gate drivers, and the design is suitable to support driving IGBTs. The Fly-Buck having the nature of primary side regulation can achieve better regulation and line/load response over other open-loop or aux winding feedback topologies. It is capable of operating from a loosely regulated 24V input (±20%). The board comes with plug-in header pins, and it is compatible with the C2000 HV inverter kit.	• Fly-Buck power supply for IGBT gate drive bias, primary side regulation without opto or aux winding feedback • 2 pair of isolated positive/negative voltage rails suitable for biasing two IGBTs • Output 2x (+16V, –9V), 100mA each, 2.5W per IGBT driver • Operates from unregulated 24V ±20% input • 87% peak efficiency, <55mV output ripple • This design is compatible and tested with the C2000 HV inverter kit
Interface to a 5V BiSS Position Encoder Reference Design	This TI Design implements a hardware interface solution based on the BiSS standard for position or rotary encoders. It supports both BiSS Point-to-Point and BiSS Bus configurations. The building blocks include the power supply for a 5V BiSS encoder — with innovative smart e-Fuse technology — and robust full-duplex RS485 transceivers, including line termination and EMC protection. An auxiliary power supply and logic level interface with adjustable I/O voltage level is provided to connect to subsequent MCUs and MPUs that would run the BiSS (or SSI) Master protocol stack. This design is fully tested to meet EMC immunity requirements for ESD, Fast Transient Burst and Surge according to IEC61800-3.	• 3.3V RS-485 full-duplex transceivers with IEC-ESD meets BiSS clock frequency (10Mhz) • Design meets EMC immunity requirements for ESD, fast transient burst and surge according to IEC61800-3 • Wide input (15-30VDC) high-efficiency (>85%) DCDC power supply for 5V BiSS (or SSI) encoders with 350mA, lowest-ripple (<20mVpp) output • Protected power supply with innovative eFuse technology with inrush current limitation and protection against over-current, over- and under-voltage and disconnect in case of fault • Option to shut down encoder power supply in case of fault or to save power when no encoder is connected. • 3.3V interface with level shifter to also support 2.5V or 1.8V I/O interface to processors to run the BiSS (or SSI) Master
Isolated IGBT Gate-Drive Push-Pull Power Supply with 4 Outputs	This reference design provides isolated positive and negative voltage rails required for Insulated Gate Bipolar Transistor (IGBT) gate drivers from a single 24-volt DC input supply. IGBTs are used in three phase inverters for variable-frequency drives to control the speed of AC motors. This reference design uses a push-pull isolated control topology and provides isolation compliant to IEC61800-5 and is intended to operate from a pre-regulated $24V_{DC}$ input. With a regulated (within 5%) input source, a simple open-loop, free-running oscillator can be implemented with a push-pull PWM controller. This topology is essentially a forward converter with two primary windings used to create a dual-drive winding. This fully utilizes the transformer core's magnetizing current more efficiently than flyback or the forward topologies. Another advantage this configuration has over flyback and forward configurations is that the supply output can be scaled up for higher power drives. This reference design also takes advantage of another benefit of the push pull topology in that multiple transformers can be controlled in parallel from a single controller to generate all the isolated voltage rails required for 3-phase IGBT inverters. Lastly, larger IGBTs for higher power drives sometimes require more gate drive current than what is provided by a typical IGBT gate driver, for which designers often use additional transistors for gate current boosting. This reference design provides +16V on the positive outputs and –8V on the negative outputs to compensate for the added voltage drop in those transistors	• Supports 6 IGBT gate drivers for 3 arms of inverter (each arm in half-bridge configuration) • Push-pull topology enables parallel transformer stages from a single controller for 3-phase power • Operates with pre-regulated 24V input • Two reinforced isolated, low-ripple (<200mV) outputs for each IGBT: +16V (x2) and –8V (x2) • Output power: 2W per IGBT and scalable to support higher power IGBTs • Option to shut down the power supply to facilitate Safe Torque Off (STO) feature • Output capacitors rated to support up to 6A peak gate drive current • Designed to meet IEC61800-5

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

TI Designs for Motor Drives (continued)

TI Design	Description	Key Features
High Performance Bipolar Stepper Drive Stage Reference Design with 256 Microstep Support	The TIDA-00261-BOOST-DRV8711 is an 8-52V, 4.5A, bipolar stepper motor drive stage based on the DRV8711 Stepper Motor Pre-driver and CSD88537ND Dual N-Channel NexFET™ Power MOSFET. The module contains everything needed to drive many different kinds of bipolar stepper motors and can also be repurposed as a dual brushed DC motor driver. The BOOST-DRV8711 is ideal for those wishing to learn more about stepper motor control techniques and drive stage design. This kit was designed to be compatible with all TI LaunchPads following the LaunchPad Pinout Standard, with primary software/firmware support being provided for the MSP-EXP430G2 LaunchPad with a MSP430G2553.	• 8V to 52V supply input with up to 4.5A continuous output current from each H-bridge • Built in 1/256-step microstepping indexer for ultra-smooth movement • SPI interface for driver settings and status reporting • Complete stepper motor drive stage in ultra-small form factor (1.75" x 2.00") • Fully protected drive stage including overcurrent, overtemperature, and under voltage protection
Current Controlled Driver for AC Solenoids with Plunger Fault Detection for 24V DC Solenoids, with Plunger Fault Detection	This reference designs provide solutions to control AC or 24V DC solenoid current using a PWM based controller along with hall sensor techniques to detect plunger movement and switch from peak current mode to hold current mode.	• Uses DRV110 Power saving solenoid current controller with integrated supply regulation • Solenoid current is controlled during peak and hold mode for lower power and thermal dissipation using PWM technique with external MOSFET • Peak current, keep time at peak current, hold current and PWM clock frequency are adjustable through external components • Feature to interface HALL sensor to detect plunger movement and switch to hold mode • Provides logic EN pin for the PLC to activate/deactivate the solenoid • Provides 0V to 10V analog output, scaled to solenoid current to interface with PLC
Sercos III Communications Development Platform	The TIDEP0010 Sercos III communication development platform combines the AM335x Sitara processor family from Texas Instruments (TI) and the Sercos III media access control (MAC) layer into a single system-on-chip (SoC) solution. Targeted for Sercos III slave communications, the TIDEP0010 allows designers to implement the real-time Sercos III communication standard for a broad range of industrial automation equipment. The design is based on the TMDSICE3359 Industrial Communications Engine (ICE).	• Sercos III conformance tested • Sercos III firmware for PRU-ICSS with Sercos MAC compliant register interface • Board support package and industrial software development kit available from TI and 3rd party • Development platform which includes schematics, BOM, user guides, application notes, white paper, software, demos and more • Supports other industrial communications with the same hardware (e.g., EtherCAT, Profinet, Ethernet/IP and more)
Washing Machine Control Reference Design	This solution is designed for the inverter front-loading washing machine. It includes three parts: the main control board for the whole washing process control, the motor control board for DD VF motor control, and the user inference board. This solution can implement different washing programs and realize failure detection.	• Uses InstaSPIN™ estimator for sensorless PMSM control • Online parameter identification • The motor can continue to run in the same direction and with the same speed after the motor stall recovers • Includes agitate washing mode
Three-Phase Brushless/PMSM Low-Current Motor Control Solution with InstaSPIN™ Software	This reference design demonstrates a motor control solution for spinning three-phase brushless DC (BLDC) and brushless AC (BLAC) — often referred to as permanent magnet synchronous (PMSM) — motors featuring the C2000™ Piccolo™ microcontroller and the DRV8312 3-phase motor driver. The reference design features a high-performance, power-efficient, cost-effective sensorless field-oriented control (FOC) and sensored/sensorless trapezoidal commutation platform that speeds development for quicker time to market. This reference design is based on the DRV8312 evaluation kit.	• Full digital control of dual interleaved PFC power converter topology • Worldwide voltage input of $95V_{AC}$ to $265V_{AC}$ • $400V_{DC}$ bus operating up to 700W • C2000 Piccolo TMS320F28069M MCU digitally controls three-phase motors • Supports power metering of rectified input voltage, RMS input voltage, RMS input power, and input line frequency • Includes software, hardware design files, quick start graphical interface, and step-by-step documentation
Three-Phase Brushless/PMSM High-Current Motor Control Solution with InstaSPIN™ Software	This reference design demonstrates a motor control solution for spinning three-phase brushless DC (BLDC) and brushless AC (BLAC) — often referred to as "permanent magnet synchronous (PMSM)" — motors featuring the C2000™ Piccolo™ microcontroller enabled with InstaSPIN-FOC and InstaSPIN-MOTION in ROM and the DRV8301 three-phase motor driver. It provides three half-bridge drivers, each capable of driving two N-type MOSFETs, one for the high side and one for the low side. It supports up to 2.3A sink and 1.7A source peak current capability and only needs a single power supply with a wide range from 6V to 60V. The reference design features a high-performance, power-efficient, cost-effective platform that speeds development for quicker time to market. Applications include CPAP and pumps, e-bikes, e-scooters, medical pumps and drills, power tools, and robotics. This reference design is based on the DRV8301 evaluation kit.	• Operating supply voltage 6V to 60V • 2.3A sink and 1.7A source gate drive current capability • Integrated dual-shunt current amplifiers with adjustable gain and offset • Integrated buck converter to support up to 1.5A external load • Isolated SPI and CAN interfaces • Fully-functional evaluation board includes software, hardware design files, quick start graphical interface, and step-by-step documentation

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

TI Designs for Motor Drives (continued)

TI Design	Description	Key Features
Three-Phase Brushed and Stepper Motor Control Solution	This reference design demonstrates a motor control solution for spinning three-phase brushed DC or single stepper motor — featuring the C2000™ Piccolo™ microcontroller and the DRV8412 three-phase motor driver. This highly integrated, robust motor control and driver solution speeds development time for brushed and stepper motors running up to 6A continuous/12A peak at 50V. Typical applications include medical pumps, gate openers, stage lighting, textile manufacturing tools, and industrial or consumer robotics. This reference design is based on the DRV8412 evaluation kit.	• High-efficiency power stage (up to 97%) with low RDS(on) MOSFETs (110 mΩ at TJ = 25°C) • Operating supply voltage up to 52V • Integrated self-protection circuits including undervoltage, over-temperature, overload, and short circuit • Closed-loop digital control with feedback using the C2000's on-chip PWM and ADC peripherals • High precision low-side current sensing using the C2000's high-performance ADC, Texas Instruments OPA2350 high speed op-amps and Texas Instrument REF3025 high precision voltage reference chip • Fully-functional evaluation board includes software, hardware design files, quick start graphical interface, and step-by-step documentation
Three-Phase Brushless DC Motor Driver	The Thee-Phase Brushless DC Motor Driver reference design is a 10A, 3-phase brushless DC drive stage based on the DRV8301 pre-driver and CSD18533Q5A NextFET™ power MOSFET. It has three low side current sense amps (two internal to DRV8301, one external). The design also leverages a 1.5A step down buck converter, is fully protected with short circuit, thermal, and shoot-through protection, and is easily configured via a SPI interface. It is ideal for sensorless, brushless control techniques and drive stage design.	• Complete brushless DC drive stage in ultra-small form factor (2.2" x 2.3") • Supports up to 14A peak, 10A continuous current output • Supports voltage and current feedback for InstaSPIN-FOC sensorless control solution • 3x low side current sense amps, 6x Power FETs (< 6.5mΩ) and 1.5A step down buck converter • Drive stage is fully protected including short circuit, thermal, shoot-through, and under voltage protection • C2000™ Piccolo™ F28027F MCU with InstaSPIN™-FOC technology
Analog Front End for Motor Electronic Overload Relays with Enhanced Current Range	This reference design is the analog front end (AFE) for an electronic overload relay, used for monitoring and protecting motors from overcurrent or undercurrent events. It is an ideal tool for developers creating overload relays for senstive AC motors in industrial applications. This progrmmable gain amplifier (PGA) based analog front end is intended to be an easy evaluation platform for an accurate, industry-leading 10:1 full load ampere (FLA) range and is repeatible over a –10 to +70°C temperature range.	• Wide FLA of 10:1 which dramatically reduces the number of units required on-hand • Current measurement accuracies of <2% over entire 10:1 measurement range from no load to locked rotor current • Ambient insensitivity from –10 to +70°C • Robust design that prevents phase reversal in overdrive conditions and high electrostatic discharge (ESD) protection (3-kV HBM)
Speed-Controlled 24V Brushless DC Outrunner Motor Reference Design	This advanced motor implements closed-loop speed control to maintain an exact RPM across the load torque profile. The magnetic rotor position is sensed by the DRV5013 Hall-effect sensors, and the DRV8308 controller decides when to drive the CSD88537ND FETs that energize the coils. No microcontroller or firmware is used, and the intelligent sinusoidal current drive minimizes acoustic noise and torque ripple to maximize motor performance.	• Speed controlled at 2054 RPM for any torque load up to 118mNm (16.7 oz-in) • Power input supports 24V to 32V and more than 5A • Outrunner style provides good power density in 6x6x3 cm3 form • Easy to modify RPM and max current with resistor changes • Design features up to 71% efficiency
EN55011 Compliant, Industrial Temperature, 10/100Mbps Ethernet PHY Brick Reference Design	This Ethernet PHY reference design demonstrates the advanced performance of the DP83848K Ethernet PHY transceiver, supports 10/100 Base-T and is compliant with IEEE 802.3 standard. The design is also fully compliant to EN5501 Class A EMI requirements and operates from a single power supply (5V with On-Board regulator or 3.3V). The board has been designed in a small form factor (2 inches x 3 inches) which makes it easier to fit into existing products.	• Meets EN55011 class A radiated emission requirements • Low power consumption = 264mW • DP83848K Ethernet PHY configured for MII interface • Programmable LED support for link and activity • External isolation transformer with common-mode choke on PHY side for improved • EMI and EMC performance • HBM ESD protection on RD± and TD± of 4kV

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

Complete TI Motor Drive Solutions

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.

DRV8711EVM - $99

- DRV8711-based motor controller capable of up to 10A at 52V
- Excellent thermal performance with external NextFET power MOSFETs
- Stepper motor included and the GUI defaults to optimum settings matched to the included motor.
- Configurable for dual DC motor control
- Open source: BOM, Schematics, Gerbers

DRV8818EVM – $99

- DRV8818-based motor driver capable of 2.5 A at 35 V
- Updated user interface for acceleration and deceleration profiles
- Open source: BOM, schematics, Gerbers

DRV8412-C2-KIT – $199

- 52V, 3.5A 3-phase motor driver stage
- Quadrature encoder interface
- Piccolo F28035 microcontroller control
- Includes two brushed DC and one stepper motor

DRV8829EVM – $149

- Two 5-A H-bridge motor drivers
- Phase/enable control interface and low component count
- 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.

DRV8839EVM – $25

- Low-voltage DRV8839 evaluation module spins dual brushed motors, operates from 1.8V to 11V, and delivers up to 2× 1.8A
- On-board speed and direction controls; Micro-USB connection for easy evaluation / power up
- Open source: BOM, Schematics, Gerbers

DRV8412-C2-KIT – $199

- 52V, 3.5A 3-phase motor driver stage
- Quadrature encoder interface
- Piccolo F28035 microcontroller control
- Includes two brushed DC and one stepper motor
-

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

DRV8801EVM – $99

- DRV8801-based motor driver capable of 2.8A peak at 36 V
- 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
TMDSHVMTRINSPIN - $699

- Piccolo™ controlCARD-based hardware
- 350-V, 1.5-kW three-phase inverter
- 700-W bypassable PFC (DC bus) front end
- Isolated JTAG, UART, SPI, and CAN
- Free Code Composer Studio™ development environment
- Software support through controlSUITE™ or MotorWare™
- Sensors: Hall, Encoder, Software (sensorless)
- Control: Torque, Speed, Position, PFC

DRV8312-Based Kits – $299 Each

- 50V, 3.5A 3-phase motor driver stage
- NEMA17 BLDC/PMSM 55W motor Spin your own motor instantly with InstaSPIN™-BLDC, InstaSPIN-FOC and InstaSPIN-MOTION software
- Hall and Quadrature encoder interfaces
- Isolated SPI and CAN interfaces

DRV8301/2-Based Kits – $299 to $499 Each

- 60V, 60A 3-phase motor driver stage
- NO motor included
- Spin your own motor instantly with InstaSPIN-BLDC, InstaSPIN-FOC and InstaSPIN-MOTION software
- Hall and Quadrature encoder interfaces
- Isolated SPI and CAN interfaces
- Includes Piccolo F28035, Hercules™ RM48 or TMS570LS31 controlCARD and can accept many TI MCU-based controlCARDs

Learn more about the DRV8312-based kits and DRV8301/2-based kits at:

DRV8312-C2-KIT: **www.ti.com/tool/drv8312-c2-kit**
DRV8312-69M-KIT: **www.ti.com/tool/drv8312-69m-kit**
DRV8301-HC-C2-KIT: **www.ti.com/tool/drv8301-hc-c2-kit**
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DRV8301-LS31-KIT: **www.ti.com/tool/drv8301-ls31-kit**

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.

DRV8312-Based Kits – $299 Each

- 50V, 3.5A 3-phase motor driver stage
- NEMA17 BLDC/PMSM 55W motor
- Spin your own motor instantly with InstaSPIN™-BLDC, InstaSPIN-FOC and InstaSPIN-MOTION software
- Hall and Quadrature encoder interfaces
- Isolated SPI and CAN interfaces

TMDSHVMTRPFCKIT - $599
TMDSHVMTRINSPIN - $699

- Piccolo(tm) controlCARD-based hardware
- 350-V, 1.5-kW three-phase inverter
- 700-W bypassable PFC (DC bus) front end
- Isolated JTAG, UART, SPI, and CAN
- Free Code Composer Studio™ development environment
- Software support through controlSUITE™ or MotorWare™
- Sensors: Hall, Encoder, Software (sensorless)
- Control: Torque, Speed, Position, PFC

DRV8301/2-Based Kits – $299 to $499 Each

- 60V, 60A 3-phase motor driver stage
- NO motor included
- Spin your own motor instantly with InstaSPIN™-BLDC, InstaSPIN-FOC and InstaSPIN-MOTION software
- Hall and Quadrature encoder interfaces
- Isolated SPI and CAN interfaces
- Includes Piccolo F28035, Hercules™ RM48 or TMS570LS31 controlCARD and can accept many TI MCU-based controlCARDs

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.

TMDSHVMTRPFCKIT - $599
TMDSHVMTRINSPIN - $699

- Piccolo™ controlCARD-based hardware
- 350-V, 1.5-kW three-phase inverter
- 700-W bypassable PFC (DC bus) front end
- Isolated JTAG, UART, SPI, and CAN
- Free Code Composer Studio™ development environment
- Software support through controlSUITE™ or MotorWare™
- Sensors: Hall, Encoder, Software (sensorless)
- Control: Torque, Speed, Position, PFC

Third-Party Network Developers

MathWorks Model-Based Design

Target for C2000™ 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

Learn more at: **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 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

Learn more at: **www.vissim.com/c2000**

TI Motor Design Network Developers

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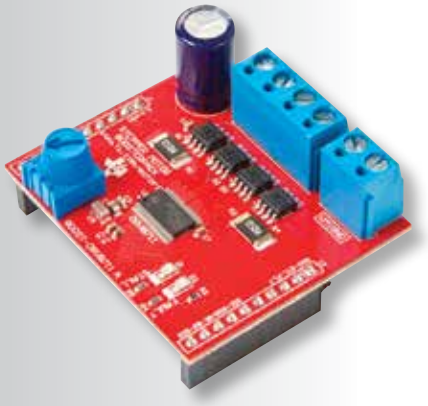
Drivetech	www.drivetechinc.com	Design services, consulting, DMC expertise
Pentad Design	www.pentaddesign.com	Design services, DPS and CLA expertise
Powersim	www.powersimtech.com	Power electronics simulation and C2000 auto code generation
Simma Software	www.simmasoftware.com	Network protocol software
The MathWorks	www.mathworks.com	Embedded target, auto code generation
Visual Solutions	www.vissim.com	Rapid prototyper: Visual application development

TI Motor Drive and Control Solutions



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- Scalable
- Complete solution compatible with TI's MSP430™ Launchpad
- High performance current regulation control
- Fully configurable, fully protected drive stage

Learn more at: **www.ti.com/motor**

Get in control

BLDC outrunner designs offer standard PWM or closed-loop speed control

- 12V and 24V brushless DC motor reference design
- Speed-controlled 24V brushless DC motor reference design

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